PHOTOVOLTAIC TILE AND METHOD OF MANUFACTURING THE SAME

Field of the Invention

The present invention relates to a photovoltaic tile. The invention also relates to a method of manufacturing a base substrate of the tile.

Background of the Invention

It is well known to use solar electric panels mounted onto a roof of a house or building to provide electrical energy to supplement the energy needs of the house or building. Such panels are placed on and overlie an existing roof covering. That is, the panels themselves do not replace or act as a roof covering.

Applicant has previously devised a photovoltaic tile assembly that can act as a roof covering and provide electrical energy. The assembly comprises a base tile through which one or more mechanical fasteners are driven to fasten the base tile to a roof structure. The base tiles together form a water proof covering for the roof. Photovoltaic tiles are then electrically and mechanically coupled to the base tiles by connection posts. Further details of the above described photovoltaic tile assembly as set out in Applicant's US Patent Application Nos. US 20090120484A and US 20100068926A1.

The present invention arises from continued research and development of roof based photovoltaic systems.

Summary of the Invention

A first aspect of the invention provides a photovoltaic tile comprising:

a base tile made of a curable or settable mixture of constituents one of which comprises cement, the base tile having an upper planar surface and a peripheral edge surrounding the upper planar surface;

an electrical system comprising a photovoltaic layer adhered to the upper planar surface; and,

a transparent cover adhered to the base tile and the electrical system, the cover overlying the upper planar surface and photovoltaic layer.

A second aspect of the invention provides a photovoltaic tile comprising:

a base tile having an upper planar surface and a peripheral edge surrounding the upper planar surface;

a first layer of adhesive material laid on the upper surface;

an electrical system comprising a photovoltaic layer laid on and adhered to the first layer of adhesive material;

a second layer of adhesive material laid on the electrical system; and,

a transparent cover adhered to second layer of adhesive material and overlying the base tile and the photovoltaic layer.

In the second aspect the base tile may be made of a curable or settable mixture of constituents one of which comprises cement.

A further constituent of the base tile may comprises silica or a silica compound.

A further constituent of the base tile may comprise wollastonite.

A further constituent of the base tile may comprise cellulose fibre.

A further constituent of the base tile may comprise water.

The cement may be provided in a quantity of 35% to 55% by weight of the mixture prior to curing.

The silica or a silica compound may be provided in a quantity of 20% to 40% by weight of the mixture prior to curing.

The wollastonite may be provided in a quantity of 8% to 16% by weight of the mixture prior to curing.

The cellulose fibre may be provided in a quantity of 6% to 10% by weight of the mixture prior to curing.

The water may be provided in a quantity sufficient to wet the mixture to form a slurry prior to curing of the mixture. In this regard the water may be provided in a quantity of 2% to 8% by weight of the mixture prior to curing.

In one embodiment of the photovoltaic tile the constituents may comprise, as percentage by weight of the mixture prior to curing:

about 45% cement, about 8% cellulose fibre, about 30% silica or silica compound , about 12% wollastonite, and about 5% water.

The base tile and the photovoltaic layer may be of substantially the same colour.

The photovoltaic layer may comprise a plurality of photovoltaic cells electrically connected together the electrical system comprise two conductors that enable electric current produced by the photovoltaic cells to flow from the photovoltaic tile.

The electrical system may comprise one or more bypassed diodes shunted across one or both of:

a. one or more of the photovoltaic cells; and,
b. the two conductors.

The base tile may be provided with one or more electrical connection through holes passing between the planar upper surface and an opposite lower surface of the base tile, and wherein the conductors are electrically connectable to a device through the one or more electrical connection through holes.

The electrical connector may be disposed on the lower surface of the base tile and electrically connected to the one or more conductors through the one or more electrical connection through holes.

In the first aspect of the invention the photovoltaic may comprise a first layer of adhesive material provided on the upper planar surface of the base tile wherein the photovoltaic layer is adhered to the base tile by the first adhesive layer. Further in this aspect photovoltaic may comprise a second layer of adhesive material applied to the photovoltaic layer and wherein the cover layer is adhered to the photovoltaic layer by the second layer of adhesive.

In an alternate form of the first aspect the photovoltaic tile may comprise a layer of adhesive material between the base tile and the cover layer, the layer of

adhesive material adhering the base tile, photovoltaic layer, and cover together.

In either aspect of the invention adhesive material may comprise an ethylene vinyl acetate based adhesive.

The adhesive may comprise by weight 20 – 50% ethylene vinyl acetate copolymer.

The adhesive may comprise by weight 20% to 50% resin.

The adhesive may comprise up to 20% tackifier.

The adhesive may comprise by weight up to 20% wax.

The adhesive may comprise by weight 0.1% to 0.2% antioxidant.

The adhesive may comprise up to 20% by weight filler.

The resin may be selected from the group comprising:

- wood resin derivatives;
- hydrocarbon resins;
- polyterpene resins;
- low molecular weight styrene and styrene copolymers; and
- phenolic resins.

The tackifier may be selected from the group consisting of:

- C – 5 to C – 9 hydrocarbon resins,
- polyterpenes, and,
- rosin esters of pentaerylthritol and glycerol.

The photovoltaic tile may comprise a sealant layer applied wholly about a side surface circumscribing the photovoltaic tile.

The photovoltaic tile may comprise at least one through hole passing in a direction perpendicular to the upper planar face and inboard of the peripheral edge.

The photovoltaic tile may comprise a cover strip for each conductor, each cover strip having a surface visible though the cover layer which has an appearance substantially the same as the upper planar surface of the base tile.

The photovoltaic tile may comprise at least one fastener through hole extending through the cover layer and base tile and capable of receiving a fastener to fasten the photovoltaic tile to a support

A third aspect of the invention provides a method of constructing a photovoltaic tile comprising:

providing a base tile;

placing a first layer of adhesive material on an upper surface of the base tile;

providing a photovoltaic layer comprising at least one of photovoltaic cell and placing the photovoltaic layer on the first layer of adhesive material;

placing a second layer of adhesive material on the photovoltaic layer; and,

placing a transparent cover having a shape and configuration the same as the base tile on the second layer of adhesive material and in alignment with the base tile.

A fourth aspect of the invention provides a method of constructing a photovoltaic tile comprising:

forming a base tile made from a cured mixed of constituents wherein at least one of the constituents comprises cement;

providing a photovoltaic layer comprising at least one of photovoltaic cell photovoltaic tile;

providing a transparent cover having a shape and configuration the same as the base tile ;

forming a laminate structure comprising the base tile, the photovoltaic layer and the transparent cover where the photovoltaic layer is supported on the base tile and the transparent cover overlies the photovoltaic layer and the base tile; and,

adhering the laminate structure together using an adhesive material which is substantially transparent when cured.

The method may comprise: providing the base tile with one or more conductor

holes; providing at least two conductors that enable electrical current produced by the at least one photovoltaic cell to flow from the photovoltaic tile; and, passing the at least two conductors through the one or more conductor holes.

The method may comprise, prior to adhering the transparent cover, concealing the conductors wherein the conductors and the upper surface of the base tile have substantially the same appearance.

The method may comprise forming one or more fastener holes in each of the base tile and the transparent cover at locations wherein the holes in the transparent cover register with corresponding holes in the base tile when the transparent cover is adhered to the base tile.

The adhering laminate structure together comprises laying a first sheet of adhesive material on the base tile; placing the photovoltaic layer on the first sheet of adhesive material; laying a second sheet of adhesive material on the photovoltaic layer; and, placing the transparent cover on the second sheet of adhesive material.

The method may comprise applying pressure to the photovoltaic tile while the adhesive material cures.

The method may comprise applying a layer of sealant wholly about a peripheral side surface of the photovoltaic tile.

The method may comprise electrically connecting a connector to the electrical conductors of the photovoltaic layer and attaching the connector to an under surface of the base tile.

A fifth aspect of the invention provides a method of manufacturing a base tile for a photovoltaic tile comprising:

preparing a mixture comprising by weight:

35% to 55% cement
20% - 40% quartz sand
6% - 10% cellulose fibre
8% - 16% wollastonite
2% - 8% water;

forming the mixture into a plurality of planar tiles having a planar upper surface and an opposite planar under surface;

curing the tiles; and,

subjecting the upper planar surface to a surface treatment.

The surface treatment may comprise a mechanical abrasion process.

The mechanical abrasion process may comprise one or both of sand blasting and polishing.

The surface treatment may comprise application of one or more chemicals to the upper planar surface or an atmospheric plasma treatment.

Applying a chemical may comprise applying a mineral spirit or paint thinner and one of:

a. applying a primer comprising a mixture of acrylic latex or alkyde (oil base) resin and fluoro-carbon paint having a colour substantially the same as a colour of the photovoltaic layer; or
b. a ceramics primer or KURARAY R-polymer or silicon-based primer.

Brief Description of the Drawings

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

Figure 1 is a representation of an embodiment of a photovoltaic tile in accordance with the present invention showing an upper surface of the tile;
Figure 2 is a representation of an embodiment of the photovoltaic tile illustrated in Figure 1 but showing a bottom surface of the tile;
Figure 3 illustrates a method of fixing components of the photovoltaic tile together;
Figure 4 is an exploded view of the photovoltaic tile;
Figure 5 is an enlarged view of a electrical system incorporated in the photovoltaic tile; and,
Figure 6 is a representation of a base slab assembly to which a plurality of the photovoltaic tile can be mechanically and electrically connected.

Description of Preferred Embodiments

In broad terms, an embodiment of the present invention comprises a photovoltaic tile having an appearance and physical properties comparable to a conventional roofing slate, tile or shingle. This is achieved by providing a photovoltaic tile with a base tile which is constructed to mimic the appearance and physical properties of a conventional roofing slate, tile or shingle, applying a photovoltaic layer to the base tile and subsequently placing a waterproof transparent cover over the base tile to sandwich the photovoltaic layer there between. An electrical connector is fixed to a base surface of the photovoltaic tile and electrically connects with the photovoltaic layer to enable electric current produced by the photovoltaic tile to be harnessed. Fastener through holes are formed in the photovoltaic tile for receiving fasteners to fasten the photovoltaic tile to a support such as, but not limited to, a base assembly described in applicants co-pending application No. ....

The photovoltaic layer comprises at least one, but more practically a plurality of, photovoltaic cells and is disposed on a lower portion for example a bottom half to a bottom third of the base tile. The holes for the fasteners and the electrical connector are located in an upper portion of the base tile. Thus, when the photovoltaic tiles are connected to a support in an overlapping arrangement similar to normal roofing tiles and slates, where tiles are arranged in an overlapping and underlapping arrangement, the through holes are covered by an overlying row of tiles while the photovoltaic cells are left exposed. The base tile, photovoltaic layer and transparent cover are connected together to form a laminate structure by a transparent adhesive material. The adhesive material can be provided as two separate sheets or layers of adhesive material. A first laid on the upper surface of the base tile and on which the photovoltaic layer is placed, and a second laid on the photovoltaic layer and on which the transparent cover is placed. The laminate structure can be placed under pressure while the adhesive material is curing. Also embodiments envisage the application of a sealant wholly about the peripheral side surface of the photovoltaic tile to minimise the risk of water ingress between the layers of the laminate structure.

The figures 1-5 depict an embodiment of a photovoltaic tile 10 and a method of

construction. The depicted embodiment of photovoltaic tile 10 comprises a base tile 12 having an upper planar surface 14, and an electrical system 16 which incorporates a photovoltaic layer 18; and, a transparent weatherproof cover 20. The base tile 12, photovoltaic layer 16 and transparent cover 20 are arranged as a laminate structure and adhered together to form the photovoltaic tile 10.

With particular reference to figures 3 and 4 the base tile 12 in this embodiment is of a substantial rectangular shape having a peripheral edge 22 surrounding the upper planar surface 14. Base tile 12 also has a planar under surface 24 which is parallel to upper surface 14 so that the tile 12 is of uniform thickness. Two small conductor holes 26 are formed through the base tile 12 near an upper edge 28 of tile 12. This term "upper edge" is used in the context of photovoltaic tile 10 to denote the edge of the tile that lies vertically above an opposite bottom edge 30. Conductor holes 26 are relatively close together and arranged symmetrically about a longitudinal centre line of base tile 12.

Two fastener through holes 32a are also formed in base tile 12 for receiving fasteners capable of holding photovoltaic tile 10 to a substrate such as a base slab assembly 34 shown in figure 6a and 6b. Corresponding fastener through holes 32b are formed on transparent cover 20. The holes 32b are located in a position to register with the holes 32a when transparent cover 20 is fixed to base tile 12. The registering holes 32a and 32b form a fastener through holes 32 of the photovoltaic tile 10 as depicted in Figure 1.

With preference to Figure 5, the electrical system 16 and more particularly the photovoltaic layer 18 is shown as comprising a plurality of photovoltaic cells 36a-36l (hereinafter referred to in general as photovoltaic cells 36), and electrical conductors 40a and 40b. The cells 36 are which are electrically connected in series together by a plurality of bus bars 38, in turn coupled to the conductors 40a and 40b each having bent ends forming respective output terminals 42a and 42b. The output terminals 42a and 42b are fed through the conductor holes 26 so as to feed through to the under surface 24 of base tile 12. In this embodiment, the photovoltaic cells 36 cover approximately a third of the surface area of upper surface 14 and are located near lower edge 30.

In this particular embodiment electrical system 16 and moreover photovoltaic

layer 18 is attached to base tile 12 by a first or lower layer of adhesive material 44. This layer is formed as a sheet of adhesive material of the same configuration as base tile 12 and provided with holes 46 which register with holes 26; and, holes 48 which register with holes 32a. The adhesive layer 44 is typically provided with release film on opposite sides. When applying the layer 44, the release film on one side is first removed so that the layer can be adhered onto base tile 12. Subsequently, the release film on the opposite side of layer 44 is removed. Alternately the adhesive layer 44 may be in the form of a roll of single sided adhesive sheet with a release film on only one side with exposed adhesive on the other, and cut from the roll as required. In yet a further the adhesive layer 44 can be a single sided sheet pre-cut to the required shape and configuration with release film on one side only. In this arrangement a plurality of individual sheets can be supplied as a stack and peel from the stack when required. The output terminals 42a and 42b are then referred to through holes 46 and 26 and then the electrical system 16/photovoltaic layer 18 is laid on the adhesive layer 44.

A second or upper adhesive layer 50 is then applied over the electrical system 16. Adhesive layer 50 is also in the form of a sheet of adhesive material provided with release films on opposite sides. Although the layer 50 may also be in one of the alternate forms described above in relation to adhesive layer 44. Layer 50 is provided with holes 52 that register with the holes 48 and 32a. To apply adhesive layer 50, a release film on a lower surface is removed and the layer 50 then laid on top of the electrical system 16 and base tile 12. Next a release film on an opposite side of the layer 50 is removed and cover 20 can be laid over the adhesive layer 50 and onto the base tile 12. During this process, holes 32b are aligned with holes 52, 48 and 32a.

To assist in adhering the layers of photovoltaic tile 10 together, the assembled tile 10 may be placed in a press for a period of time. Additionally, in order to prevent deterioration and ingress of liquid in between layers, a sealant is applied wholly about the peripheral side surface of the photovoltaic tile 10.

An electrical connector in the form of plug 54 is electrically connected to the output terminals 42a and 42b and subsequently the plug 54 is fixed to the under surface 24 of base tile 12. Plug 54 electrically connects with an electrical connection system disposed within base tile 34.

The base tile 12 is made from a mixture of constituents which provide the base tile 12 with the appearance and mechanical and thermal characteristics similar to a conventional slate or tile. To this end, the base tile 12 is made of a mixture of constituents which include, cement, silica or silica compound, cellulose fibre, wollastonite and water. Pigment may be provided in the cement or indeed as a further constituent to provide the base tile with a desired colour. For example, the cement used to make the tile may be black cement. Table 1 below presents possible proportions of the constituents of the mixture in terms of percentage by weight of the mixture.

Constituent	**Percentage by weight**
Cement	35-55
Cellulose Fibre	6-10
Silica or Silica compound	20-40
Wollastonite	8-16
water	Sufficient to form a slurry

Table 1

Table 2 below sets out a more specific composition of the mixture of constituents forming the base tile 12.

Constituent	**Percentage by weight**
Cement	45
Fibre	8
Silica or Silica compound	30
wollastonite	12
water	5

Table 2

The cellulose fibre may be provided as wood fibre and the silica as quartz sand. The constituents are mixed to form a slurry or pulp which may then be formed

into a plurality of planar tiles and subsequently cured. More particularly, one embodiment the tile 12 can be manufactured by the following process steps:

a) Place the constituents of the mixture in a mixing machine and mix until a slurry or pulp of even consistency is produced.
b) Pour the slurry or pulp into a feeder.
c) Feed the slurry/pulp from the feeder and deposited onto a rotating drum in successive continuous layers until a cylindrical sheet of desired thickness is produced on the rotating drum.
d) Upon reaching the required thickness, which may be detected by a proximity sensor, using a blade to cut the cylindrical sheet in direction parallel to a longitudinal axis of the drum. A conveyor belt is positioned below the drum so that when the blade is used to cut the cylindrical sheet, the sheet is directed by the blade onto the underlined conveyor belt. This process unwraps the cylindrical sheet to form a rectangular sheet having a width equal to a longitudinal dimension of the drum, and a length determined by the diameter of the drum.
e) Cut the rectangular sheet into separate planar tiles.
f) Allow preliminary drying/hardening of the tiles in a clean room.
g) After drying, the tiles are placed in an autoclave in which they are subjected to high temperature and pressurised steam.
h) Drying of the autoclaved tiles in an oven.
i) Trimming of individual tiles to the required dimension.
j) The surfaces of the tiles are now subjected to passive mechanical surface treatment comprising mechanical abrasion processes such as sand blasting and polishing particularly to remove boundary layers and contaminants thereby exposing a fresh clean surface.
k1) Active surface treatment may now be applied to improve condition of the upper surface for receiving the adhesive. The active surface treatment may comprise one of the following two steps:

Step 1: rubbing the upper surface with a cloth dampened with mineral spirits or paint thinner (acrylic latex or alkyd (oil based) resin) over the tile surface and allow it to dry.

Step 2: (option 1) mix thinner (acrylic latex or alkyd (oil based) resin) and fluoro-carbon paint to form a primer that has the same colour as the photovoltaic cells. Spray the primer onto upper surface 14 to form a waterproof coat which is also highly receptive to the adhesive. After

allowing the first layer of primer to dry, a second layer may be applied. Step 2: (option 2) this option is adopted to preserve tile colour. This process involves spraying either ceramics primer or KURARAY or R-polymer or silicon-based primer onto the tile to form a waterproof coat. After an initial coat has dried a second primer coast may be applied.

k2) as an alternate to step k1) the active surface treating process can be performed using atmospheric plasma treatment. Atmospheric plasma treatment is a process that allows plasma to be sustained at atmospheric pressure at the upper surface 14 of the base tile 12. The plasma may be formed in a gas of oxygen, hydrogen, nitrogen or fluoride.

One possible adhesive material used in the photovoltaic tile 10 is a composition of various ingredients including ethylene vinyl acetate, resin, wax, filler and antioxidant. T able 3 below sets out a range of ingredients which form the adhesive in terms of percentage by weight.

Ingredient of adhesive	**Percentage by weight**
Ethylene vinyl	45
Acetate copolymer	20-50
Modifying resin	20-50
Tackifyier	Up to 20
wax	Up to 20
Filler	Up to 20
Antioxidant	0.1-0.2

Table 3.

The modifier resin may comprise wood resin derivatives; hydrocarbon resins; polyterpene resins; low molecular weight styrene and styrene copolymers; and phenolic resins.

Tackifiers are used to reduce viscosity and improve wetting. Possible tackifiers include C-5 to C-9 hydrocarbon resins, polyterpenes, and resin esters of pentaerylthritol glycerol.

Wax may be added to lower the cost and also reduce viscosity. In addition, fillers such as calcium carbonate may be added to lower cost and increase

viscosity. Antioxidants are provided to protect the adhesive during application and service life.

The photovoltaic cells 36 may comprise a crystalline (mono) or polycrystalline solar cell; a substrate solar cell; or a thin film (crystalline) or amorphous (solar cell). The photovoltaic layer 16 may also incorporate one or more bypass diodes. The diodes may be shunted across one or more photovoltaic cells 36, and/or shunted across the conductors 40.

The transparent cover 20 may be made from a number of different transparent weather proof materials such as polytetrafluoroethylene; glass, low-ion enhanced glass, or tempered glass.

When constructing the photovoltaic tile 10 action can be taken to conceal the conductors 40. This may comprise applying a film over the conductors 40 where the film has an appearance that is substantially the same as that of the base tile 12.

Now that embodiments of the present invention have been described in detail it will be apparent to those skilled in the relevant arts that numerous modifications and variations may be made without parting from the relevant concepts. For example, the method described above utilises two separate sheets or films of adhesive material 34 and 50 to adhere the electrical system 16 to the base tile 12, and the cover layer 20 to the electrical system 16 and base tile 12. However, in an alternative embodiment, a clear setting liquid adhesive may be used which is initially applied to the upper surface of base tile 12 and between the photovoltaic layer 16 and the transparent cover 20.

All such modifications and variations together with others that would be obvious to persons of ordinary skill in the art are deemed to be within the scope of the present invention the nature of which is to determine from the above description.

Claims:

1. A photovoltaic tile comprising:

a base tile made of a curable or settable mixture of constituents one of which comprises cement, the base tile having an upper planar surface and a peripheral edge surrounding the upper planar surface;

an electrical system comprising a photovoltaic layer adhered to the upper planar surface; and,

a transparent cover adhered to the base tile and the electrical system, the cover overlying the upper planar surface and photovoltaic layer.

2. A photovoltaic tile comprising:

a base tile having an upper planar surface and a peripheral edge surrounding the upper planar surface;

a first layer of adhesive material laid on the upper surface;

an electrical system comprising a photovoltaic layer laid on and adhered to the first layer of adhesive material;

a second layer of adhesive material laid on the electrical system; and,

a transparent cover adhered to second layer of adhesive material and overlying the base tile and the photovoltaic layer.

3. A photovoltaic tile according to claim 2 wherein the base tile is made of a curable or settable mixture of constituents one of which comprises cement.

4. The photovoltaic tile according to claim 1 or 3 wherein a further constituent comprises silica or a silica compound.

5. The photovoltaic tile according to any one of claims 1, 3 or 4 wherein one of the constituents comprises wollastonite.

6. The photovoltaic tile according to any one of claims 1 or 3 to 5 wherein one of the constituents is cellulose fibre.

7. The photovoltaic tile according to any one of claims 1 or 3 to 6 wherein one of the constituents is water.

8. The photovoltaic tile according to claim 1 or 3 wherein the cement

provided in a quantity of 35% to 55% by weight of the mixture prior to curing.

9. The photovoltaic tile according to claim 8 wherein one of the constituents comprises silica or a silica compound and provided in a quantity of 20% to 40% by weight of the mixture prior to curing.

10. The photovoltaic tile according to claim 8 or 9 wherein one of the constituents comprises wollastonite in a quantity of 8% to 16% by weight of the mixture prior to curing.

11. The photovoltaic tile according to any one of claims 8 to 10 wherein one of the constituents comprises cellulose fibre in a quantity of 6% to 10% by weight of the mixture prior to curing.

12. The photovoltaic tile according to any one of claims 8 to 11 wherein one of the constituents is water provided in a quantity sufficient to wet the mixture to form a slurry prior to curing of the mixture.

13. The photovoltaic tile according to claim 12 wherein the water is provided in a quantity of 2% to 8% by weight of the mixture prior to curing.

14. The photovoltaic tile according to claim 1 or 3 wherein the constituents comprise, as percentage by weight of the mixture prior to curing:
about 45% cement, about 8% cellulose fibre, about 30% silica or silica compound , about 12% wollastonite, and about 5% water.

15. The photovoltaic tile according to any one of claims 4, 9 or 14 wherein the silica or silica compound comprises quartz sand.

16. The photovoltaic tile according to any one of claims 6 to 15 wherein the cellulose fibre is wood fibre.

17. The photovoltaic tile according to any one of claims 1 to 16 wherein the base tile and the photovoltaic layer are of substantially the same colour.

18. The photovoltaic tile according to any one of claims 1 to 17 wherein the photovoltaic layer comprises a plurality of photovoltaic cells electrically

connected together the electrical system comprise two conductors that enable electric current produced by the photovoltaic cells to flow from the photovoltaic tile.

19. The photovoltaic tile according to claim 18 wherein the electrical system comprises one or more bypassed diodes shunted across one or both of:

a. one or more of the photovoltaic cells; and,
b. the two conductors.

20. The photovoltaic tile according to claim 18 or 19 wherein the base tile is provided with one or more electrical connection through holes passing between the planar upper surface and an opposite lower surface of the base tile, and wherein the conductors are electrically connectable to a device through the one or more electrical connection through holes.

21. The photovoltaic tile according to claim 20 comprising an electrical connector disposed on the lower surface of the base tile and electrically connected to the one or more conductors through the one or more electrical connection through holes.

22. The photovoltaic tile according to claim 1 or any one of claims 4 to 21 when dependant directly or indirectly on claim 1, comprising a first layer of adhesive material provided on the upper planar surface of the base tile wherein the photovoltaic layer is adhered to the base tile by the first adhesive layer.

23. The photovoltaic tile according to a claim 1 or any one of claims 4 to 22 when dependant directly or indirectly on claim 1, comprising a second layer of adhesive material applied to the photovoltaic layer and wherein the cover layer is adhered to the photovoltaic layer by the second layer of adhesive.

24. The photovoltaic tile according to claim 1 or any one of claims 4 to 21 when dependant directly or indirectly on claim 1, comprising a layer of adhesive material between the base tile and the cover layer, the layer of adhesive material adhering the base tile, photovoltaic layer, and cover together.

25. The photovoltaic tile according to any one of claims 2 or 22 to 24 wherein the adhesive material is ethylene vinyl acetate based adhesive.

26. The photovoltaic tile according to claim 25 wherein the adhesive comprises by weight 20 – 50% ethylene vinyl acetate copolymer.

27. The photovoltaic tile according to claim 26 wherein the adhesive comprises by weight 20% to 50% resin.

28. The photovoltaic tile according to claim 26 or 27 wherein the adhesive comprises up to 20% tackifier.

29. The photovoltaic tile according to any one of claims 26 to 28 wherein the adhesive comprises by weight up to 20% wax.

30. The photovoltaic tile according to any one of claims 26 – 29 wherein the adhesive comprises by weight 0.1% to 0.2% antioxidant.

31. The photovoltaic tile according to any one of claims 26 to 30 wherein the adhesive comprises up to 20% by weight filler.

32. The photovoltaic tile according to any one of claims 27 to 31 wherein the resin is selected from the group comprising:

wood resin derivatives;
hydrocarbon resins;
polyterpene resins;
low molecular weight styrene and styrene copolymers; and
phenolic resins.

33. The photovoltaic tile according to any one of claims 28 to 32 wherein the tackifier is selected from the group consisting of:

C – 5 to C – 9 hydrocarbon resins,
polyterpenes, and,
rosin esters of pentaerylthritol and glycerol.

34. The photovoltaic tile according to any one of claims 1 to 33 comprising a sealant layer applied wholly about a side surface circumscribing the photovoltaic tile.

35. The photovoltaic tile according to any one of claims 1 to 34 comprising at least one through hole passing in a direction perpendicular to the upper planar face and inboard of the peripheral edge.

36. The photovoltaic tile according to any one of claims 18 to 35 comprising a cover strip for each conductor, each cover strip having a surface visible though the cover layer which has an appearance substantially the same as the upper planar surface of the base tile.

37. The photovoltaic tile according to any one of claims 1 to 36 comprising at least one fastener through hole extending through the cover layer and base tile and capable of receiving a fastener to fasten the photovoltaic tile to a support

38. A method of constructing a photovoltaic tile comprising:
providing a base tile;
placing a first layer of adhesive material on an upper surface of the base tile;
providing a photovoltaic layer comprising at least one of photovoltaic cell and placing the photovoltaic layer on the first layer of adhesive material;
placing a second layer of adhesive material on the photovoltaic layer; and,
placing a transparent cover having a shape and configuration the same as the base tile on the second layer of adhesive material and in alignment with the base tile.

39. A method of constructing a photovoltaic tile comprising:
forming a base tile made from a cured mixed of constituents wherein at least one of the constituents comprises cement;
providing a photovoltaic layer comprising at least one of photovoltaic cell photovoltaic tile;
providing a transparent cover having a shape and configuration the same as the base tile ;
forming a laminate structure comprising the base tile, the photovoltaic layer and the transparent cover where the photovoltaic layer is supported on the base tile and the transparent cover overlies the photovoltaic layer and the base tile; and,
adhering the laminate structure together using an adhesive material

which is substantially transparent when cured.

40. The method according to claim 38 or 39 comprising: providing the base tile with one or more conductor holes; providing at least two conductors that enable electrical current produced by the at least one photovoltaic cell to flow from the photovoltaic tile; and, passing the at least two conductor through the one or more conductor holes.

41. The method according to claim 40 comprising, prior to adhering the transparent cover, concealing the conductors wherein the conductors and the upper surface of the base tile have substantially the same appearance.

42. The method according to any one of claims 38 to 41 comprising forming one or more fastener holes in each of the base tile and the transparent cover at locations wherein the holes in the transparent cover register with corresponding holes in the base tile when the transparent cover is adhered to the base tile.

43. The method according to any one of claims 39 to 42 wherein adhering the laminate structure together comprises laying a first sheet of adhesive material on the base tile; placing the photovoltaic layer on the first sheet of adhesive material; laying a second sheet of adhesive material on the photovoltaic layer; and, placing the transparent cover on the second sheet of adhesive material.

44. The method according to any one of claims 38 to 43 comprising applying pressure to the photovoltaic tile while the adhesive material cures.

45. The method according to any one of claims 33 to 44 comprising applying a layer of sealant wholly about a peripheral side surface of the photovoltaic tile.

46. The method according to any one of claims 40 to 45 comprising electrically connecting a connector to the electrical conductors of the photovoltaic layer and attaching the connector to an under surface of the base tile.

47. A method of manufacturing a base tile for a photovoltaic tile comprising: preparing a mixture comprising by weight:

35% to 55% cement
20% - 40% quartz sand
6% - 10% cellulose fibre
8% - 16% wollastonite
2% - 8% water;

forming the mixture into a plurality of planar tiles having a planar upper surface and an opposite planar under surface;

curing the tiles; and,

subjecting the upper planar surface to a surface treatment.

48. The method according to claim 47 wherein the surface treatment comprises a mechanical abrasion process.

49. The method according to claim 48 wherein the mechanical abrasion process comprises one or both of sand blasting and polishing.

50. The method according to claims 48 or 49 wherein the surface treatment comprises application of one or more chemicals to the upper planar surface or an atmospheric plasma treatment.

51. The method according to claim 50 wherein applying a chemical comprises applying a mineral spirit or paint thinner and one of:

a. applying a primer comprising a mixture of acrylic latex or alkyde (oil base) resin and fluoro-carbon paint having a colour substantially the same as a colour of the photovoltaic layer; or

b. a ceramics primer or KURARAY R-polymer or silicon-based primer.