An angle joint between two sandwich panels, wherein the sandwich panels each have a first outer layer and a second outer layer spaced from the first outer layer by a panel core, and an angle edge including an edge portion of the panel core and an edge portion of the first outer layer. The joint has an interface between the panel cores and the interface has an entranceway at an inner corner comprised of the edge portions of the first outer layers. A cavity in the panel cores is defined by a portion of the second outer layers and a portion of each panel core. The cavity spans across a second entranceway to the interface between panel cores. Bonding material applied in the cavity and at the inner corner connects the sandwich panels together in a manner that maintains an area of dead air space at the interface to inhibit or to reduce thermal transmissions across the joint.
ANGLE JOINT FOR SANDWICH PANELS
AND METHOD OF FABRICATING SAME

TECHNICAL FIELD OF THE INVENTION

[0001] The present invention relates generally to constructing buildings, and more particularly, to connecting adjacent sandwich panels with an angle joint that reduces or minimizes thermal bridging across the joint.

DESCRIPTION OF THE RELATED ART

[0002] There is an increasing global demand for lower cost buildings such as houses, warehouses and office space. The demand for lower cost buildings is particularly strong in developing countries where economic resources may be limited and natural resources and raw materials may be scarce. For example, in areas of the Middle East or Africa, conventional building materials such as cement, brick, wood or steel may not be readily available or, if available, may be very expensive. In other areas of the world, poverty may make it too costly for people to build houses or other buildings with conventional materials.

[0003] The demand for lower-cost housing also is high in areas afflicted by war or natural disasters, such as hurricanes, tornadoes, floods, and the like. These devastating events often lead to widespread destruction of large numbers of buildings and houses, especially when they occur in densely populated regions. The rebuilding of areas affected by these events can cause substantial strain on the supply chain for raw materials, making them difficult or even impossible to obtain. Furthermore, natural disasters often recur and affect the same areas. If a destroyed building is rebuilt using the same conventional materials, it stands to reason that the building may be destroyed or damaged again during a similar event.

[0004] It is generally desirable to increase speed of construction and to minimize construction costs. Prefabricated or preassembled components can streamline production and reduce both the time and the cost of building construction. Prefabricated buildings, however, are made from conventional materials that may be scarce or expensive to obtain. Thus, there exists a need for alternative materials and techniques for constructing buildings that use advanced material technologies to increase the speed of construction and to reduce or to lower ownership costs.

SUMMARY

[0005] The present invention provides an alternative to conventional construction materials and techniques. Buildings, such as houses, commercial buildings, warehouses, or other structures can be constructed by composite sandwich panels (also referred to as “sandwich panels” or “composite panels”), which have an insulative core and one or more outer layers. The buildings can be constructed by gluing several sandwich panels together, and usually traditional fasteners, such as screws, rivets, nails, etc., are not needed for such connections. Generally, composite sandwich panels offer a greater strength to weight ratio over traditional materials that are used by the building industry. Because they weigh less than traditional building materials, the handling and transport of composite sandwich panels is generally less expensive. The composite sandwich panels are generally as strong as, or stronger than, traditional materials including wood-based and steel-based structural insulation panels, while being lighter in weight. The composite sandwich panels also can be used to produce light-weight buildings, such as floating houses or other light-weight structures.

[0006] Sandwich panels generally are more elastic or flexible than conventional materials such as wood, concrete, steel or brick and, therefore, monolithic buildings made from sandwich panels are more durable than buildings made from conventional materials. For example, sandwich panels may be non-flammable, waterproof, very strong and durable, and in some cases able to resist hurricane-force winds (up to 300 Kph (kilometers per hour) or more). The sandwich panels also may be resistant to the detrimental effects of algae, fungicides, water, and osmosis. As a result, buildings constructed from sandwich panels may be better able to withstand earthquakes, floods, tornadoes, hurricanes, fires and other natural disasters than buildings constructed from conventional materials.

[0007] Two construction elements, e.g., two composite sandwich panels, can be connected together by an angle joint. It is generally desirable to avoid creating a thermal bridge across the joint from one side of the construction elements to the other. Generally speaking, a thermal bridge is a pathway for bypassing an insulation system to allow heat to pass from one side of the wall to the other. Thermal bridges are particularly undesirable for external walls of a structure where temperatures may vary greatly from the outside of the structure to the inside of the structure.

[0008] As described in more detail below, two sandwich panels can be connected together to minimize or to reduce thermal bridging across the joint between the panels, by cutting and removing an edge portion of the sandwich panels, e.g., by a miter cut. The angle joint is formed by aligning the edges of the panel cores such that the core of one panel is in physical contact with the core of the adjacent panel. A cavity is formed by removing a portion of the sandwich panel cores. A pathway to the cavity is formed, for example, by making a hole through at least one of the outer layers of the sandwich panels or by removing a strip of the outer layer near the edge of the panel to form a gap between the edges of the outer layers of the panels. Bonding material is injected through the pathway and into the cavity to seal an entranceway to the area of contact between the panel cores and to secure or to bond the panels to one another.

The resulting angle joint minimizes, reduces or eliminates thermal transmissions from one side of the panel to the other side of the panel.

[0009] According to one aspect of the invention, an angle joint between a first sandwich panel and a second sandwich panel, has a first sandwich panel having a first outer layer and a second outer layer spaced from the first outer layer by a panel core, and an angle edge comprised of an edge portion of the panel core and an edge portion of the first outer layer; a second sandwich panel having a first outer layer and a second outer layer spaced from the first outer layer by a panel core, and an angle edge comprised of an edge portion of the panel core and an edge portion of the first outer layer, wherein the angle edges of the sandwich panels are in contact with one another at an interface between the panel cores, an entranceway to the interface between the panel cores at an inner corner comprised of the edge portions of the first outer layers; a cavity in the panel cores, the cavity defined by a portion of the second outer layers and a portion of each panel core, the cavity spanning across a second entranceway to the interface
between panel cores; and bonding material in the cavity and at
the inner corner to connect the first sandwich panel to the
second sandwich panel.

(0010) According to another aspect of the invention, the
joint further includes a pathway through at least one of the
second outer layers to the cavity and through which the bond-
ing material is injectable.

(0011) According to another aspect of the invention, the
pathway is a gap between an edge of the second outer layer of
the first sandwich panel and an edge of the second outer layer
of the second sandwich panel.

(0012) According to another aspect of the invention, the
joint includes an outer corner comprised of bonding material
between the edges of the second outer layers.

(0013) According to another aspect of the invention, the
pathway is a hole formed in the second outer layer of at least
one of the sandwich panels.

(0014) According to another aspect of the invention, the
angle edge of each sandwich panel further includes an edge
portion of the second outer layer of the sandwich panel, and
the joint further comprises an outer corner comprised of the
dge portions of the second outer layer of each sandwich panel.

(0015) According to another aspect of the invention, the
cavity extends along a length of the second outer layer of each
sandwich panel, wherein the length of the cavity along the
second outer layer is at least seven times greater than a thickness
of the second outer layer.

(0016) According to another aspect of the invention, the
cavity extends perpendicularly from the second outer layer of
each sandwich panel along a length of the panel core, wherein
the length of the cavity extending perpendicularly into the
panel core is at least seven times greater than the thickness of
the second outer layer.

(0017) According to another aspect of the invention, the
bonding material in the cavity and at the inner corner seals
entranceway to the interface between the panel cores, and the
interface is dead air space.

(0018) According to another aspect of the invention, the
interface between the sandwich panel cores inhibits thermal
transmissions across the joint from the first outer layer to the
second outer layer.

(0019) According to another aspect of the invention, the
bonding material at the inner corner has a radius.

(0020) According to another aspect of the invention, the
panel cores are comprised of insulating materials and the first
and second outer layers are comprised of composite materi-
als.

(0021) According to another aspect of the invention, a
method of joining two sandwich panels in a non-linear orien-
tation, the sandwich panels having a core, an outer layer
covering at least one surface of the core, an angle edge and a
cavity, the method includes placing the panels edge to edge
to form an interface in an area between the panel cores and a
combined cavity, and applying bonding material in the cavity
to hold the panels together and to block thermal transmis-
sions across the joint.

(0022) According to another aspect of the method, the
applying step further includes injecting bonding material into
the cavity through a gap in the edges of the outer layers of the
sandwich panels.

(0023) According to another aspect of the method, the
applying step further includes injecting bonding material into
the cavity through at least one hole in at least one of the outer
layers.

(0024) According to another aspect of the method, the
sandwich panels have a second outer layer covering at least
one surface of the core, and wherein the placing step further
includes placing the second outer layers edge to edge to form
an inner corner of the joint.

(0025) According to another aspect of the method, the
method includes applying bonding material at the inner cor-
ner of the joint.

(0026) According to another aspect of the method, a
method of joining two sandwich panels with an angle joint,
wherein each sandwich panel includes a first outer layer and a
second outer layer spaced from the first outer layer by a panel
core, the method including removing an edge portion of each
panel to form an angle edge, the angle edge comprising a
portion of the panel core and an edge of the first outer layer;
placing the angle edges in contact with one another, such that
there is an interface between the panel cores and the edges of
the first outer layers are in contact with one another to form an
inner corner and an entranceway to the interface; forming a
cavity by removing a portion of the panel core, the cavity
developed by a portion of the second outer layer of each sand-
wich panel and a portion of the core; filling the cavity with a
bonding material that spans across a second entranceway to
the interface; and applying bonding material that spans across
the entranceway at the inner corner.

(0027) According to another aspect of the method, a
method of forming a cavity includes removing a portion of the
core near the second outer layer of each sandwich panel and a
portion of the panel core extending perpendicularly from the
second outer layer of each sandwich panel.

(0028) According to another aspect of the method, a
method of forming a cavity includes removing a portion of the
panel near the second outer layer of each panel that has a
length that is at least seven times a thickness of the second
outer layer.

(0029) According to another aspect of the method, a
method of forming a cavity includes removing a portion of the
panel core extending perpendicularly from the second outer layer
each sandwich panel that has a length that is at least seven
times the thickness of the second outer layer.

(0030) According to another aspect of the method, the
method includes the step of forming a pathway to the cavity
by removing a portion of the second outer layer of at least one
of the sandwich panels.

(0031) According to another aspect of the method, the
method includes removing a portion from the second outer
layer of at least one of the sandwich panels to form a hole.

(0032) According to another aspect of the method, the
step of forming a pathway includes removing a strip of the second
outer layer from each of the sandwich panels to form an edge
of the second outer layer of each sandwich panel, wherein
the edges of the second layers are spaced from one another
to form a gap.

(0033) According to another aspect of the method, the
method further includes spreading bonding material between
the edges of the second outer layers to form an outer corner.

(0034) According to another aspect of the method, the
method further includes installing the sandwich panels as
part of a monolithic building.
According to another aspect of the invention, a sandwich panel includes a first outer layer and a second outer layer, the outer layers separated from one another by an insulative core; an angle edge comprised of a portion of the insulative core and a portion of the first outer layer; a cavity in the insulative core, the cavity defined by a portion of the second outer layer and a portion of the core; and a pathway through the second outer layer to the cavity through which a bonding material may be injected to form an angle joint between the sandwich panel and an adjacent construction element, wherein the insulative core inhibits thermal transfer across the joint from the first outer layer to the second outer layer.

According to another aspect of the invention, a method of forming a sandwich panel including mounting a first outer layer to a core; mounting a second outer layer to the core; forming an angle edge of the sandwich panel, the angle edge comprising a portion of the first outer layer and a portion of the core; forming a cavity between a portion of the second outer layer and a portion of the core; and providing access to the cavity through the second outer layer with a pathway through which bonding material is injectable to form a joint between the angle edge of the sandwich panel and a construction element in a manner that inhibits thermal transmissions across the joint.

These and further features of the present invention will be apparent with reference to the following description and attached drawings. In the description and drawings, particular embodiments of the invention have been disclosed in detail as being indicative of some of the ways in which the principles of the invention may be employed, but it is understood that the invention is not limited correspondingly in scope. Rather, the invention includes all changes, modifications and equivalents coming within the spirit and terms of the claims appended hereto.

It should be emphasized that the term "comprises/comprising" when used in this specification is taken to specify the presence of stated features, integers, steps or components but does not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof.

Features that are described and/or illustrated with respect to one embodiment may be used in the same way or in a similar way in one or more other embodiments and/or in combination with, or instead of, the features of the other embodiments.

**BRIEF DESCRIPTION OF THE DRAWINGS**

**FIG. 1** is an environmental view of an exemplary monolithic structure built from composite materials.

**FIG. 2** is an isometric view of two sandwich panels connected by an angle joint.

**FIG. 3** is an isometric view of an exemplary sandwich panel.

**FIG. 4** is a fragmentary schematic sectional top view of an edge portion of an exemplary sandwich panel.

**FIG. 5** is a fragmentary schematic sectional top view of an embodiment of an angle joint between two sandwich panels.

**FIG. 6** is a fragmentary schematic sectional top view of an embodiment of an angle joint between two sandwich panels.

**FIG. 7** is a fragmentary schematic sectional top view of an edge portion of a sandwich panel.

**FIG. 8** is a fragmentary schematic sectional top view of an embodiment of an angle joint between two sandwich panels.

**FIG. 9** is a fragmentary schematic sectional top view of an embodiment of an angle joint between two sandwich panels.

**DETAILED DESCRIPTION OF EMBODIMENTS**

In the detailed description that follows, like components have been given the same reference numerals regardless of whether they are shown in different embodiments of the invention. To illustrate the present invention in a clear and concise manner, the drawings may not necessarily be to scale and certain features may be shown in somewhat schematic form. Certain terminology is used herein to describe the different embodiments of the invention. Such terminology is used only for convenience when referring to the figures. For example, "upward," "downward," "above," or "below" merely describe directions in the configurations shown in the figures. Similarly, the terms "interior" and exterior" or "inner" and "outer" are used for convenience to describe the orientation of the components in the figures. The components can be oriented in any direction and the terminology should therefore be interpreted to include such variations. The dimensions provided herein are exemplary in nature and are not intended to be limiting in nature. Furthermore, while described primarily with respect to house construction, it will be appreciated that all of the concepts described herein are equally applicable to the construction of any type of structure or building, such as warehouses, commercial buildings, factories, apartments, etc.

The structures described herein are built with composite materials, such as composite sandwich panels. Sandwich panels, which may be formed from synthetic or natural materials, provide a light-weight and potentially less expensive alternative to conventional raw materials, e.g., wood, concrete, metal, etc. If desired, natural materials may be used in the sandwich panels, as described in more detail below. The sandwich panels may be connected or joined together with a high-strength bonding material, such as epoxy or glue, and conventional fasteners, such as nails and screws, are not usually needed. The result is a strong and durable monolithic (e.g., single unit) structure, as is described further below.

Referring to **FIG. 1**, an exemplary monolithic structure 10, for example, a house, is built from a number of sandwich panels. As illustrated, the house 10 includes a number of sandwich panels, for example, two sandwich panels 11, 12 connected with a straight joint 13 to form a front wall 10f and two sandwich panels 14, 15 connected with a straight joint 16 to form a side wall 10s. The front wall 10f and side wall 10s are connected to one another by an angle joint 20. The house 10 has another side wall, a rear wall, and possibly other walls, which may not be shown, and may be, for example, on the interior or exterior of the house. Also, while illustrated as having walls that are formed from two sandwich panels, it will be appreciated that the respective walls may be formed from a single sandwich panel or may include a number of sandwich panels.

It generally is desirable to reduce or to minimize thermal transmissions through the walls of the house 10, for example, to improve energy efficiency and to reduce heating or electrical costs. The angle joint 20, therefore, is formed to
minimize thermal transmissions across the joint, for example, from an exterior 10e of the house 10 to an interior 10i of the house 10.

[0053] An exemplary embodiment of the angle joint 20 is shown in FIG. 2. Two sandwich panels 12, 14 are connected to one another in a linear or non-linear orientation to form the angle joint 20. The first sandwich panel 12 has two outer layers 21, 22 separated by a generally planar, insulative core 23. The outer layers 21, 22 generally cover at least one surface of the core 23. Similarly, the second sandwich panel 14 has two outer layers 24, 25 separated by a generally planar, insulative core 26. The outer layers 22, 24 generally cover at least one surface of the core 26. The sandwich panels 12, 14 each have respective angle edges 23a, 26a that abut one another at the joint 20. The angle edges 23a, 26a abut or contact one another to create an interface 30.

[0054] The joint 20 has an inner corner 32 and an outer corner 33. The inner corner 32 is formed by the junction of the outer layers 22, 25 of the sandwich panels 12, 14. The outer corner 33 is formed by the junction of the outer layers 21, 24 of the sandwich panels 12, 14. The terms “inner” and “outer” are used herein for convenience to describe the several embodiments or aspects of the angle joint. The joint 20 is not limited to a joint separating the exterior 10e and interior 10i of the house, and the joint may be, for example, located at any area of the house, including between walls solely on the interior of the house.

[0055] The interface 30 extends between the panel cores 23, 26 between the inner corner 32 to the outer corner 33. The interface 30 has an entranceway or edge 30a near the inner corner 32, and another entranceway or edge 30b near the outer corner 33.

[0056] The entranceways 30a, 30b to the interface 30 are sealed by bonding material 34, 35. The entranceway 30a is sealed by bonding material 34 spread or applied at the inner corner 32, and the entranceway 30b is sealed by bonding material 35 spread or applied at the outer corner 33. The bonding material 34, 35 spans across the edges 30a, 30b to create an area of dead air space at the interface 30 between the edges 23a, 26a of the panel cores 23, 26. The bonding material 34, 35 also is in contact with the outer layers of each of the panels and securely holds or connects the sandwich panels 12, 14 to one another. The resulting joint 20 inhibits or reduces thermal transmissions across the joint 20.

[0057] Referring briefly to FIG. 3, an exemplary sandwich panel is shown, e.g., the sandwich panel 14. The sandwich panel 14 includes two outer layers 24, 25 separated by a core 26. The core 26 is formed from a generally planar, insulative material. The outer layers 24, 25 are rigidly bonded or adhered to the core 26 with bonding material. Further details of the sandwich panel are presented below. The sandwich panels 12, 14 used in the angle joint 20 are modified or prepared as is described with respect to the several embodiments below to form a joint that minimizes or reduces thermal bridging across the joint.

[0058] FIG. 4 illustrates the preparation of an edge 40 of the sandwich panel, e.g., sandwich panel 14, prior to connection with another sandwich panel, e.g., sandwich panel 12, which may be prepared in a similar manner. FIGS. 5 and 6 illustrate the angle joint 20 formed by connecting the sandwich panels 12, 14 to one another.

[0059] Referring initially to FIG. 4, the edge 40 of the sandwich panel 14 is modified by cutting and removing a portion 41 of the panel 14. The edge 40 is cut at an angle, e.g., by a miter cut. The miter cut forms a new, angle edge 26a to the sandwich panel 14. The miter cut also creates a new edge 24a to outer layer 24 and a new edge 25a to outer layer 25.

[0060] The angle of the edge 40 may be modified based upon the desired angle of the resulting joint 20 when the sandwich panels 12, 14 are connected to one another. For example, if a 90-degree resultant angle is desired, then the edge 26a is cut at an angle α (alpha) that is 45-degrees. Similarly, the edge 23a of the adjacent sandwich panel 12 would be cut at a 45-degree angle, such that when the edges 23a, 26a are aligned with one another, a 90-degree joint is formed. It will be appreciated that the edges 22a, 26a may be cut at any desired angle to form an angle joint 20 that is larger than 90-degrees (e.g., obtuse) or smaller than 90-degrees (e.g., acute).

[0061] Continuing to refer to FIG. 4, a portion 42 of the outer layer 24 is cut or removed from the panel 14. The removal of the portion 42 creates a new edge 24b of the outer layer 24. The portion 42 may be, for example, a strip of the outer layer 24 that may be removed by cutting the outer layer 24 with a blade or other cutting implement. The portion 42 removed from the outer layer 24 may be one or more millimeters in length and may be, for example, about 1-10 mm (millimeters), or larger. The portion 42 may include the edge 24a of the outer layer 24 that was formed by the miter cut.

[0062] A portion 43 of the core 26 is removed from the panel 14 near the new edge 24b to form a cavity 44. The cavity 44 extends generally along the inner surface of the outer layer 24 as indicated generally by dimension “A.” The cavity 44 also extends generally perpendicular from or normal to the outer layer 24 and towards the center of the core 26, as indicated generally by dimension “B.” The cavity 44, therefore, is defined by a portion of the outer layer 24 near the edge 24a and a sloped edge 45 of the core 26, which is formed when the portion 43 is removed.

[0063] The cavity 44 may be of another size or proportion and/or shape. For example, more core material may be removed for larger (e.g., thicker) outer layers 24, 25 or less core material may be removed for smaller (e.g., thinner) outer layers 24, 25. It will be appreciated that while the cavity 44 is illustrated as triangular in shape, numerous other configurations may be possible. For example, the cavity 44 may not be triangular in shape and may be similar to another shape, such as a curved shape, a circular (or partial circular) shape, a rectangular shape or a square shape, etc. It also will be appreciated that the core 26 and outer layers 24, 25 may be formed or molded in the configuration of FIG. 4, e.g., during manufacturing the shape of the mold in which the core 26 is formed may form the edge 26a and sloped edge 45, and the outer layer 24 may be applied such that a portion of the outer layer 42 extends over the area of the portion 43 of the core 26 to form the cavity 44.

[0064] As shown in FIGS. 5 and 6, sandwich panel 12 is prepared or shaped in a similar manner to sandwich panel 14. The miter cut on the edge of sandwich panel 12 forms a new edge 22a to the outer layer 22 and new edge 23a to the core 23. A portion of the outer layer 21 is removed to form a new edge 21b. A portion of the core 23, similar to the portion 43 removed from the sandwich panel 12) is also removed from sandwich panel 14 to form a cavity in the sandwich panel 14 that is defined by a portion of the outer layer 21 near the edge 21b and portion 46 of the core 23.

[0065] Referring to FIG. 6, the sandwich panels 12, 14 are arranged to form the interface 30 between the edges 23a, 26a
of the panel cores 23, 26. The insulative panel cores 23, 26 are placed or pressed into contact with one another at the interface 30 such that there is little or no gap between the edges 23a, 26a of the panel cores 23, 26. The edges 22a, 25a of the outer layers 22, 25 are aligned with one another to form the inner corner 32, while the respective cavities are aligned with one another to form a combined cavity 47 (also referred to as a “cavity”).

[0066] Due to the removal of the portion or strip of the outer layers 21, 24, the edges 21b, 24b of the outer layers 21, 24 are separated from one another to form a gap 50 at the outer corner 33. The gap 50 provides a pathway to the cavity 47 through which the bonding material 35 may be injected or applied to seal the edge 30b of the interface 30. In one embodiment, the gap 50 is about 2-20 mm (millimeters) wide. It will be appreciated that a larger or smaller gap 50 may be formed by removing more or less of the outer layers 21, 24, which would result in the edges 21b, 24b being spaced closer or further apart from one another, as may be desired.

[0067] Continuing to refer to FIG. 6, bonding material 34 is applied to the inner corner 32 to close the edge 30a of the interface 30 near the inner corner 32. The bonding material 34 may be shaped or molded to form a round corner having a radius R. The rounded bonding material 34 at the inner corner 32 directs or distributes the forces over an area and to the outer layers 22, 25, which may be stronger or more rigid than the panel cores 23, 26.

[0068] The length of the radius R may be about 1.5 mm (millimeters)-40 mm (millimeters) in length. The length of the radius R may be selected based upon the thicknesses of the outer layers, e.g., the outer layers 22, 25, according to a desired ratio. The desired ratio of the radius R to the thickness of the outer layers may be about seven to one (7:1), or more, e.g., 8:1 or an even larger ratio. For instance if the outer layers 22, 25 are about 2 mm (millimeters) thick, the radius R would be at least about 14 mm (millimeters), and may be thicker, if desired, or adjusted based upon a desired strength or other factor, such as the strength of the bonding material. In another example, the outer layers 22, 25 may be about 3 mm (millimeters) thick and the radius R is at least about 21 mm (millimeters) or more.

[0069] Bonding material 35 also is applied to the outer corner 33 by injecting or otherwise applying the bonding material 35 through the gap or pathway 50 and into the cavity 47. The bonding material 35 fills the cavity 47 and seals the outer corner 33 of the joint 20 and seals the interface 30 by spanning across the edge 30b. The bonding material 35 also transmits or distributes loads to the outer layers 21, 24. The bonding material 35 may be molded or shaped to form a smooth edge 51 to the outer corner 33. The new outer edge 51 may be, for example, about 2-20 mm (millimeters) in length, and it will be appreciated that it may be larger or smaller as desired and/or dependent on the size of the portion(s) or strips removed from the outer layers 21, 24, e.g., portion 42 (FIG. 4).

[0070] The bonding material 34, 35 may be any suitable bonding material such as epoxy, epoxy resin, glue, cement, adhesive, adhering material or another bonding material (these terms may be used interchangeably and equivalently herein).

[0071] Because there is little or no gap between the panel cores 23, 26 at the interface 30, the bonding material 34 at the inner corner 32 tends not to seep into or through the edge 30a into the interface 30 between the edges 23a, 26a of the sandwich panel cores 23, 26. Similarly, the bonding material 35 fills the cavity 47 but generally tends not to seep into or through the edge 30b. Thus, the bonding material 34 at the inner corner 32 is separate or isolated from the bonding material 35 at the outer corner 33.

[0072] The bonding material 34, 35 maintains the interface 30 to eliminate a direct pathway from one side of the joint (e.g., the inner corner 32) to the other side of the joint (e.g., the outer corner 33) and maintains the interface 30 as a region of dead air space to achieve a thermal insulating effect that minimizes or reduces thermal transmissions across or through the joint 20. The bonding material 34, 35 also is applied such that it overlaps the outer layers of the sandwich panels 12, 14 and holds or connects the panels 12, 14 rigidly to one another. The resulting angle joint 20, therefore, is a rigid joint that provides a thermal barrier to inhibit, reduce, or eliminate thermal transmissions across the joint 20.

[0073] An alternative embodiment is illustrated in FIGS. 7-9. The alternative embodiment is similar to the embodiment described above with respect to FIGS. 4-6 except that the pathway to the cavity is formed by making one or more holes in the outer layers 21, 24 rather than removing a strip of the outer layers (e.g., strip 42 (FIG. 4)) to form a gap 50. The various parts of the embodiment of FIGS. 7-9 correspond with the parts described in FIGS. 4-6.

[0074] FIG. 7 illustrates the preparation of the edge 40 of the sandwich panel, e.g., sandwich panel 14, prior to connection with another sandwich panel, e.g., sandwich panel 12, which is prepared in a similar manner. FIGS. 8 and 9 illustrate the alternative embodiment of the angle joint 20 formed by connecting the sandwich panels 12, 14 to one another.

[0075] Referring initially to FIG. 7, the edge 40 of the sandwich panel 14 is modified by cutting and removing a portion 41 of the panel 14. The edge 40 is cut at an angle, e.g., by a miter cut. The miter cut forms a new edge 26a to the sandwich panel 14. The miter cut also creates a new edge 24a to outer layer 24 and a new edge 25a to outer layer 25.

[0076] Rather than removing a portion 42 or strip from the outer layer 24 to form the pathway to the cavity, one or more holes 52 are formed in the outer layer 24. The holes 52 provide the pathway to the cavity 44. The holes 52 may be circular in shape and may have a diameter that is several millimeters in length. The diameter of the holes 52 may be, for example, about 1 mm-10 mm (millimeters). In one embodiment, the diameter of the holes 52 is about 3 mm (millimeters). In the illustrated embodiment, the holes 52 are located at or near the edge 24a of the outer layer 24. It will be appreciated, however, that the holes 52 may be formed anywhere in the outer layer 24 and may not be circular in shape. It also will be appreciated that a number of holes may be formed in the outer layer 24 to provide multiple pathways to the cavity 44. For instance, two or more holes 52 may be evenly spaced (or unevenly spaced or staggered) along the length of the outer layer 24. It also will be appreciated that the core 26, outer layers 24, 25 and holes 52 may be formed or molded in the configuration of FIG. 7, e.g. by a mold or by forming the holes during the manufacturing process.

[0077] As shown in FIGS. 8 and 9, sandwich panel 12 is prepared or shaped in a similar manner to sandwich panel 14, with a hole 52 or multiple holes, which provide a pathway to the cavity of the sandwich panel 14. The respective cavities (e.g., cavity 44 (FIG. 7)) of the panels 12, 14 also are aligned with one another to form a combined cavity 47 (also referred to as a “cavity”). The holes 52 may be aligned with one
another to form one or more pathways to the combined cavity 47. Although the holes 52 are shown as being located at or near the outer corner 33, it will be appreciated that the holes 52 may be located anywhere in the outer layers 21, 24. It also will be appreciated that the holes 52 may be formed in only one of the outer layers (e.g., outer layer 24) and not in the other outer layer (e.g., outer layer 21).

Bonding material 35 is injected through the holes 52 in the outer layers 21, 24 and into the cavity 47. The bonding material 35 fills the cavity 47 and spans across the edge 30b of the interface 30 to seal the entranceways 30a, 30b to the interface 30. The bonding material 35 also securely connects the sandwich panels 12, 14 to one another.

In the embodiments of FIGS. 6 and 9, the panels 12, 14 are arranged such that there is no gap between the panel cores 23, 26 at the interface 30 of the joint 20. As will be appreciated, a thermal insulating property of foam material is achieved due to the numerous dead air spaces in the foam material. It is desirable to avoid collapsing walls forming such dead air spaces to maintain such thermal insulation property. In the illustrated embodiments of the invention the edges 23a, 26a of the adjacent cores abut each other in a manner such that a substantially continuous dead air space and thermal insulating effect is achieved on both sides of the joint 20 where the edges 23a, 26a abut. Moreover, as the foam material of which the cores are made may have some capability of being compressed when pressed, e.g., by a compressive force as the edges 23a, 26a are urged into engagement with each other, there may be some extent of compression of the foam material of the respective cores at the abutting surfaces thereof, and, in a sense, this affords a forgiveness to allow for intimate engagement of the two abutting cores even if the edges 23a, 26a are not perfectly straight. Such intimate engaging of the edges 23a, 26a help to assure maintaining of continuity of thermal insulating property of a wall that is made of adjacent sandwich panels.

Referring back to FIG. 3, the core 26 of the sandwich panel, e.g., the sandwich panel 14, may be formed from a light-weight, insulative material, for example, polyurethane, expanded polystyrene, polystyrene hard foam, Styrofoam® material, phenol foam, a natural foam, for example, foams made from cellulose materials, such as a cellulosic corn-based foam, or a combination of several different materials. Other exemplary core materials include honeycomb that can be made of polypropylene, non-flammable impregnated paper or other composite materials. It will be appreciated that these materials insulate the interior of the structure and also reduce the sound or noise transmitted through the panels, e.g., from one outer surface to the other or from an exterior 10c to an interior 10b of the building, etc. The core may be any desired thickness and may be, for example, 20 mm (millimeters)-100 mm (millimeters) thick, however, it will be appreciated that the core can be thinner than 20 mm (millimeters) or thicker than 100 mm (millimeters) as may be desired. In one embodiment, the core is about 40 mm (millimeters) thick.

The outer layers 24, 25 of a sandwich panel, e.g., sandwich panel 14, are made from a composite material that includes a matrix material and a filler or reinforcement material. Exemplary matrix materials include a resin or mixture of resins, e.g., epoxy resin, polyester resin, vinyl ester resin, natural (or non oil-based) resin or phenolic resin, etc. Exemplary filler or reinforcement materials include fiberglass, glass fabric, carbon fiber, or aramid fiber, etc. Other filler or reinforcement materials include, for example, one or more natural fibers, such as, jute, cocoa, hemp, or elephant grass, balsa wood, or bamboo.

The outer layers 24, 25 (also referred to as laminate) may be relatively thin with respect to the panel core 26. The outer layers 24, 25 may be several millimeters thick and may be, for example, between about 1 mm-12 mm (millimeters) thick, however, it will be appreciated that the outer layers can be thinner than 1 mm (millimeter) or thicker than 12 mm (millimeters) as may be desired. In one embodiment, the outer layers are about 1-3 mm (millimeters) thick.

It will be appreciated that the outer layers 24, 25 may be made thicker by layering several layers of reinforcement material on top of one another. The thickness of the reinforcement material also may be varied to obtain thicker outer layers 24, 25 with a single layer of reinforcement material. Further, different reinforcement materials may be thicker than others and may be selected based upon the desired thickness of the outer layers.

The outer layers 24, 25 are adhered to the core 26 with the matrix materials, such as a resin mixture. Once cured, the outer layers 24, 25 of the sandwich panel 14 are firmly adhered to both sides of the panel core 26, forming a rigid building element. It will be appreciated that the resin mixture also may include additional agents, such as, for example, flame retardants, mold suppressants, curing agents, hardeners, etc. Coatings may be applied to the outer layers 24, 25, such as, for example, finish coats, paint, etc.

The core 26 may provide good thermal insulation properties and structural properties. The outer layers 24, 25 may add to those properties of the core and also may protect the core 26 from damage. The outer layers 24, 25 also provide rigidity and support to the sandwich panel.

The sandwich panels may be any shape. In one embodiment, the sandwich panels are rectangular in shape and may be several meters, or more, in height and width. The sandwich panels also may be other shapes and sizes. The combination of the core 26 and outer layers 24, 25 create sandwich panels with high ultimate strength, which is the maximum stress the panels can withstand, and high tensile strength, which is the maximum amount of tensile stress that the panels can withstand before failure. The compressive strength of the panels is such that the panels may be used as both load bearing and non-load bearing walls. In one embodiment, the panels have a load capacity of at least 50 tons per square meter in the vertical direction (indicated by arrows V in FIG. 3) and 2 tons per square meter in the horizontal direction (indicated by arrows H in FIG. 3). The sandwich panels may have other strength characteristics as will be appreciated in the art.

Internal stiffeners may be integrated into the panel core 26 to increase the overall stiffness of the sandwich panel 14. In one embodiment, the stiffeners are made from materials having the same thermal expansion properties as the materials used to construct the panel, such that the stiffeners expand and contract with the rest of the panel when the panel is heated or cooled.

The stiffeners may be made from the same material used to construct the outer layers of the panel. The stiffeners may be made from composite materials and may be placed perpendicular to the top and bottom of the panels and spaced, for example, at distances of 15 cm (centimeters), 25 cm, 50 cm, or 100 cm. Alternatively, the stiffeners may be placed at
different angles, such as a 45-degree angle with respect to the top and bottom of the panel, or at another angle, as may be desired.

[0089] The bonding material used to connect the panels together has the same general thermal expansion characteristics as the materials used to construct the sandwich panel. In one embodiment, the glue is more flexible or bendable than the sandwich panels, and may be, for example, four or five times more flexible than the panels. The flexibility of the glue, therefore, reduces the likelihood than the joints of the monolithic structure will break or split, and also transmits loads from one panel to another, across the joint. The bonding material may include filling components, such as, fiberglass or a fiberglass and resin mixture, and may be, for example, microfiber and Aerosil®.

[0090] As is described herein the angle joint, e.g. angle joint 20, generally does not create a thermal bridge from one side of the panel to the other side of the panel. The joint is formed by the cores of adjacent panels, which are in contact with one another. The glue or bonding material in the cavity and at the inner corner holds or secures the panels to one another and also seals the entranceways to the interface 30 between the panel cores 23, 26. The resulting joint minimizes, reduces or eliminates thermal transmissions from one side of the panel to the other side of the panel.

[0091] Although the invention has been shown and described with respect to a certain preferred embodiment or embodiments, it is obvious that equivalent alterations and modifications will occur to others skilled in the art upon the reading and understanding of this specification and the annexed drawings.

What is claimed is:

1. An angle joint between a first sandwich panel and a second sandwich panel, the angle joint comprising:
   a first sandwich panel having a first outer layer and a second outer layer spaced from the first outer layer by a panel core, and an angle edge comprised of an edge portion of the panel core and an edge portion of the first outer layer;
   a second sandwich panel having a first outer layer and a second outer layer spaced from the first outer layer by a panel core, and an angle edge comprised of an edge portion of the panel core and an edge portion of the first outer layer, wherein the angle edges of the sandwich panels are in contact with one another at an interface between the panel cores, an entranceway to the interface between the panel cores at an inner corner comprised of the edge portions of the first outer layers;
   a cavity in the panel cores, the cavity defined by a portion of the second outer layers and a portion of each panel core, the cavity spanning across a second entranceway to the interface between panel cores; and
   bonding material in the cavity and at the inner corner to connect the first sandwich panel to the second sandwich panel.

2. The joint of claim 1, further comprising a pathway through at least one of the second outer layers to the cavity and through which the bonding material is injectable.

3. The joint of claim 2, wherein the pathway is a gap between an edge of the second outer layer of the first sandwich panel and an edge of the second outer layer of the second sandwich panel.

4. The joint of claim 3, further comprising an outer corner comprised of bonding material between the edges of the second outer layers.

5. The joint of claim 2, wherein the pathway is a hole formed in the second outer layer of at least one of the sandwich panels.

6. The joint of claim 5, wherein the angle edge of each sandwich panel further comprises an edge portion of the second outer layer of the sandwich panel, and the joint further comprises an outer corner comprised of the edge portions of the second outer layer of each sandwich panel.

7. The joint of claim 1, wherein the cavity extends along a length of the second outer layer of each sandwich panel, wherein the length of the cavity along the second outer layer is at least seven times greater than a thickness of the second outer layer.

8. The joint of claim 7, wherein the cavity extends perpendicularly from the second outer layer of each sandwich panel along a length of the panel core, wherein the length of the cavity extending perpendicularly into the panel core is at least seven times greater than the thickness of the second outer layer.

9. The joint of claim 1, wherein the bonding material in the cavity and at the inner corner seals entranceway to the interface between the panel cores, and the interface is dead air space.

10. The joint of claim 9, wherein the interface between the sandwich panel cores inhibits thermal transmissions across the joint from the first outer layer to the second outer layer.

11. The joint of claim 1, wherein the bonding material at the inner corner has a radius.

12. The joint of claim 1, wherein the panel cores are comprised of insulating materials and the first and second outer layers are comprised of composite materials.

13. A method of joining two sandwich panels in a non-linear orientation, the sandwich panels having a core, an outer layer covering at least one surface of the core, an angle edge and a cavity, the method comprising:
   placing the panels edge to edge to form an interface in an area between the panel cores and a combined cavity; and
   applying bonding material in the cavity to hold the panels together and to block thermal transmissions across the joint.

14. The method of claim 13, wherein the applying step further comprises injecting bonding material into the cavity through a gap in the edges of the outer layers of the sandwich panels.

15. The method of claim 13, wherein the applying step further comprises injecting bonding material into the cavity through at least one hole in at least one of the outer layers.

16. The method of claim 13, wherein the sandwich panels have a second outer layer covering at least one surface of the core, and wherein the placing step further comprises placing the second outer layers edge to edge to form an inner corner of the joint.

17. The method of claim 16, further comprising applying bonding material at the inner corner of the joint.

18. A method of joining two sandwich panels with an angle joint, wherein each sandwich panel has a first outer layer and a second outer layer spaced from the first outer layer by a panel core, the method comprising:
   removing an edge portion of each panel to form an angle edge, the angle edge comprising a portion of the panel core and an edge of the first outer layer;
placing the angle edges in contact with one another, such that there is an interface between the panel cores and the edges of the first outer layers are in contact with one another to form an inner corner and an entranceway to the interface;

forming a cavity by removing a portion of the panel core, the cavity defined by a portion of the second outer layer of each sandwich panel and a portion of the core;

filling the cavity with a bonding material that spans across a second entranceway to the interface; and

applying bonding material that spans across the entranceway at the inner corner.

19. The method of claim 18, wherein the step of forming the cavity comprises removing a portion of the core near the second outer layer of each sandwich panel and a portion of the panel core extending perpendicularly from the second outer layer of each sandwich panel.

20. The method of claim 18, wherein step of forming a cavity comprises removing a portion of the panel core near the second outer layer of each sandwich panel that has a length that is at least seven times a thickness of the second outer layer.

21. The method of claim 20, wherein step of forming a cavity comprises removing a portion of the panel core extending perpendicularly from the second outer layer of each sandwich panel that has a length that is at least seven times the thickness of the second outer layer.

22. The method of claim 18, further comprising the step of forming a pathway to the cavity by removing a portion of the second outer layer of at least one of the sandwich panels.

23. The method of claim 22, comprising removing a portion from the second outer layer of at least one of the sandwich panels to form a hole.

24. The method of claim 22, wherein the step of forming a pathway comprises removing a strip of the second outer layer from each of the sandwich panels to form an edge of the second outer layer of each sandwich panel, wherein the edges of the second layers are spaced from one another to form a gap.

25. The method of claim 22, further comprising spreading bonding material between the edges of the second outer layers to form an outer corner.

26. The method of claim 18, further comprising installing the sandwich panels as part of a monolithic building.

27. A sandwich panel comprised of:
a first outer layer and a second outer layer, the outer layers separated from one another by an insulative core;
an angle edge comprised of a portion of the insulative core and a portion of the first outer layer;
a cavity in the insulative core, the cavity defined by a portion of the second outer layer and a portion of the core; and
a pathway through the second outer layer to the cavity through which a bonding material may be injected to form an angle joint between the sandwich panel and an adjacent construction element, wherein the insulative core inhibits thermal transfer across the joint from the first outer layer to the second outer layer.

28. A method of forming a sandwich panel comprising:
mounting a first outer layer to a core;
mounting a second outer layer to the core;
forming an angle edge of the sandwich panel, the angle edge comprising a portion of the first outer layer and a portion of the core;
forming a cavity between a portion of the second outer layer and a portion of the core; and
providing access to the cavity through the second outer layer with a pathway through which bonding material is injectable to form a joint between the angle edge of the sandwich panel and a construction element in a manner that inhibits thermal transmissions across the joint.

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