An insulated panel structure and method of making the same are provided for enhancing the thermal efficiency in a building structure. The insulated panel structure includes a foam member, multiple brace members, and a reflective layer. The multiple brace members are coupled to the foam member to provide strength to the foam member and structural integrity to the panel structure. Such foam member is configured to resist conductive heat flow therethrough. Further, the reflective layer includes an interior facing surface and an exterior facing surface. The reflective layer is positioned alongside an interior side of the foam member such that the exterior facing surface faces the interior side of the foam member. With this arrangement, the interior facing surface is configured to reflect radiation heat toward an interior of the building structure and the exterior facing surface is configured to reflect radiation heat toward an exterior of the building structure.
FIG. 1
SYSTEMS, DEVICES, AND METHODS OF AN INSULATED PANEL STRUCTURE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims the benefit of U.S. Provisional Patent Application No. 61/906,884, filed on Nov. 20, 2013, the disclosure of which is incorporated by reference herein in its entirety.

TECHNICAL FIELD

[0002] The present invention relates generally to insulated panel structures and, more particularly, the present invention relates to a system, device and method for enhancing the structural characteristics and/or the thermal efficiency of a building structure.

BACKGROUND

[0003] Synthetic panel structures with favorable insulating characteristics, designed to form walls for residential housing or industrial buildings, are known in the art. For example, U.S. Pat. Nos. 5,943,775 and 6,167,624 both to Lanahan et al. disclose such synthetic panel structures that provide a polymeric foamed material in the panel that provides excellent thermal efficiency. However, it would be advantageous to improve the thermal efficiency of known synthetic panel structures, which in turn will be better for the environment and will further reduce the heating and cooling costs for residential housing and industrial buildings.

[0004] A variety of features and advantages will be apparent to those of ordinary skill in the art upon reading the description of the various embodiments set forth below.

BRIEF SUMMARY OF THE INVENTION

[0005] Embodiments of the present invention are directed to various systems, devices and methods for an insulated panel structure with enhanced thermal efficiency. In accordance with one embodiment of the present invention, an insulated panel structure is configured to be positioned as a portion of a wall of a building structure. The insulated panel structure includes a foam member, multiple brace members, and a reflective layer. The foam member includes an interior side and an exterior side each extending between opposing top and bottom ends. Further, the interior side includes slots defined therein extending between the opposing top and bottom ends. Such foam member is configured to resist conductive heat flow therethrough. Each brace member is partially positioned within one of the slots defined in the interior side of the foam member such that the brace members extend substantially parallel relative to each other with a portion of each brace member extending away from and alongside a portion of the interior side of the foam member. The reflective layer includes an interior facing surface and an exterior facing surface. Further, the reflective layer is positioned alongside the interior side of the foam member such that the exterior facing surface faces the interior side of the foam member. With this arrangement, the interior facing surface is configured to reflect radiation heat toward an interior of the building structure and the exterior facing surface is configured to reflect radiation heat toward an exterior of the building structure.

[0006] In one embodiment, the panel structure further includes elongated strips positioned over the exterior side of the foam member such that the elongated strips are spaced parallel relative to each other. Further, the elongated strips may be spaced from the multiple brace members with a portion of the foam member therebetween. In another embodiment, the exterior side of the foam member defines strip channels sized and configured to receive one of the elongated strips. In still another embodiment, the strip channels include a channel depth substantially similar to a strip depth such that an outer surface of the strips is substantially flush with a surface of the exterior side of the foam member.

[0007] In another embodiment, the reflective layer includes a sheet material. In another embodiment, the reflective layer directly contacts the interior side of the foam member. Such reflective layer may include slits defined therein that correspond with the slots defined in the foam member such that edges defining the slits are configured to contact, or extend directly adjacent to, an intermediate portion of a corresponding brace member partially disposed within the slot.

[0008] In another embodiment, the reflective layer directly contacts an outer surface of the multiple brace members to provide an air gap between the reflective layer and the foam member. In still another embodiment, the reflective layer is suspended alongside the foam member with an air gap therewith such that the reflective layer extends through an elongated slot defined in each of the brace members.

[0009] In another embodiment, the reflective layer includes a coating material layered against the interior side of the foam member. In yet another embodiment, the reflective layer includes at least one of an aluminum material and a copper material. In another embodiment, the insulated panel structure further includes an anti-mold layer disposed on at least one of the interior facing surface and the exterior facing surface of the reflective layer. In another embodiment, the insulated panel structure further includes a solution integrated with at least one of the foam member and the reflective layer, the solution having at least one of an anti-mold component and an anti-boring insect component.

[0010] In accordance with another embodiment of the present invention, an insulated panel structure configured to be positioned as a portion of a wall of a building structure is provided. The insulated panel structure includes a foam member and multiple brace members, the foam member including an interior side having slots defined therein that extending between opposing top and bottom ends of the foam member. Each brace member is partially positioned within one of the slots defined in the foam member such that a portion of each brace member extends away from and alongside a portion of the foam member. The above described insulated panel structure further includes a reflective layer integrated therewith. The reflective layer includes an interior facing surface and an exterior facing surface. Further, the reflective layer is positioned alongside the interior side of the foam member such that the exterior facing surface faces the interior side of the foam member. With this arrangement, the interior facing surface is configured to reflect radiation heat toward an interior of the building structure and the exterior facing surface is configured to reflect radiation heat toward an exterior of the building structure.

[0011] In one embodiment, the reflective layer includes a sheet material. In another embodiment, the reflective layer directly contacts the interior side of the foam member. In still another embodiment, the reflective layer includes slits defined therein that correspond with the slots defined in the foam member such that edges defining the slits are configured
to contact an intermediate portion of a corresponding brace member partially disposed within the slot.

**[0012]** In another embodiment, the reflective layer directly contacts an outer surface of the multiple brace members to provide an air gap between the reflective layer and the foam member. In another embodiment, the reflective layer is suspended alongside the foam member with an air gap therebetween. In still another embodiment, such reflective layer may extend through an elongated slot defined in each of the brace members.

**[0013]** In another embodiment, the reflective layer includes a coating material layered over the interior side of the foam member. In yet another embodiment, the reflective layer includes at least one of a copper material and an aluminum material.

**[0014]** In accordance with another embodiment of the present invention, a method of making an insulated panel structure for enhancing thermal efficiency within a building structure is provided. The method includes the following steps: forming a foam member having an interior side and an exterior side each extending between opposing top and bottom ends such that the interior side includes slots defined therein and formed to extend between the top and bottom ends; sliding multiple brace members into the slots such that each brace member is partially positioned within one of the slots and such that a portion of each brace member extends away from and alongside a portion of the of the foam member; and positioning a reflective layer alongside the interior side of the foam member such that an exterior facing surface of the reflective layer faces the interior side of the foam member so that an interior facing surface of the reflective layer reflects radiation heat toward an interior of the building structure and the exterior facing surface reflects radiation heat toward an exterior of the building structure.

**[0015]** In one embodiment, the method of making an insulated panel structure further includes positioning elongated strips over the exterior side of the foam member such that the elongated strips are spaced parallel relative to each other and spaced from the multiple brace members with a portion of the foam member therebetween. In another embodiment, the positioning step includes positioning the reflective layer to directly contact the interior side of the foam member. In another embodiment, the method further includes, prior to the sliding step, cutting slits in the reflective layer to correspond with the slots defined in the foam member.

**[0016]** In still another embodiment, the positioning step includes extending the reflective layer to directly contact an outer surface of the multiple brace members to provide an air gap between the reflective layer and the foam member. In another embodiment, the positioning step includes suspending the reflective layer to extend alongside the foam member with an air gap therebetween. In a further embodiment, the suspending step includes extending the reflective layer through an elongated slot defined in each of the brace members.

**[0017]** In another embodiment, the positioning step includes spraying a coating of reflective material to form the reflective layer on the interior side of the foam member. In another embodiment, the positioning step includes positioning the reflective layer as a flat sheet positioned alongside the interior side of the foam member.

**[0018]** In another embodiment, the positioning step includes positioning the reflective layer having at least one of an aluminum material and a copper material. In still another embodiment, the method further includes the step of spraying an anti-mold solution to at least one of the interior facing surface and the exterior facing surface. In another embodiment, the method for making an insulated panel structure further includes applying at least one of an anti-mold solution and an anti-boring insect solution to at least one of the foam member and the reflective layer.

**[0019]** In accordance with another embodiment of the present invention, a modular panel structure system configured to form walls of a building structure is provided. The modular panel structure system includes multiple insulated panel structures configured to be coupled together to collectively form the wall of the building structure. Each insulated panel structure includes a foam member, multiple brace members, and a reflective layer. The foam member includes an interior side and an exterior side each extending between opposing top and bottom ends. The interior side includes slots defined therein extending between the opposing top and bottom ends. Such foam member is configured to resist conductive heat flow therethrough. Each brace member is partially positioned within one of the slots defined in the interior side of the foam member such that the brace members extend substantially parallel relative to each other with a portion of each brace member extending away and alongside a portion of the interior side of the foam member. The reflective layer includes an interior facing surface and an exterior facing surface. The reflective layer is positioned alongside the interior side of the foam member such that the exterior facing surface faces the interior side of the foam member. With this arrangement, the interior facing surface is configured to reflect radiation heat toward an interior of the building structure and the exterior facing surface is configured to reflect radiation heat toward an exterior of the building structure.

**[0020]** In one embodiment, the insulated panel structures include elongated strips positioned over the exterior side of the foam member such that the elongated strips are spaced parallel relative to each other and spaced from the multiple brace members with a portion of the foam member therebetween.

**[0021]** In accordance with another embodiment of the present invention, an insulated panel structure configured to be positioned as a portion of a wall of a building structure is provided. The insulated panel structure includes a foam member, multiple brace members, and elongated strips. The foam member includes an interior side and an exterior side each extending between opposing top and bottom ends and opposing side ends. The interior side includes slots defined therein extending between the opposing top and bottom ends such that the foam member is configured to resist conductive heat flow therethrough. Each of the brace members are partially positioned within one of the slots defined in the interior side of the foam member such that the brace members extend substantially parallel relative to each other with a portion of each brace member extending away from and alongside a portion of the interior side of the foam member. The elongated strips are positioned over the exterior side of the foam member such that the elongated strips are spaced parallel relative to each other and spaced from the multiple brace members with a portion of the foam member therebetween.

**[0022]** In one embodiment, the insulated panel structure includes a reflective layer. The reflective layer includes an interior facing surface and an exterior facing surface, the reflective layer positioned alongside the interior side of the foam member such that the exterior facing surface faces the
interior side of the foam member, the interior facing surface configured to reflect radiation heat toward an interior of the building structure and the exterior facing surface configured to reflect radiation heat toward an exterior of the building structure. In another embodiment, the insulating panel structure includes a solution integrated with at least one of the foam member and the reflective layer, the solution having at least one of an anti-mold component and an anti-boring insect component.

In accordance with another embodiment of the present invention, an insulating panel structure configured to be positioned as a portion of a wall of a building structure is provided. In this embodiment, the insulating panel structure includes a foam member, multiple brace members, and a solution. The foam member includes an interior side and an exterior side each extending between opposing top and bottom ends and opposing side ends, the interior side including slots defined therein extending between the opposing top and bottom ends, the foam member configured to resist conductive heat flow therethrough. Each of the multiple brace members is partially positioned within one of the slots defined in the interior side of the foam member such that the brace members extend substantially parallel relative to each other with a portion of each brace member extending away from and alongside a portion of the interior side of the foam member. The solution is integrated with the foam member, the solution having at least one of an anti-mold component and an anti-boring insect component.

In one embodiment, the insulating panel structure includes a reflective layer. The reflective layer includes an interior facing surface and an exterior facing surface, the reflective layer positioned alongside the interior side of the foam member such that the exterior facing surface faces the interior side of the foam member, the interior facing surface configured to reflect radiation heat toward an interior of the building structure and the exterior facing surface configured to reflect radiation heat toward an exterior of the building structure. In another embodiment, the insulating panel structure includes elongated strips positioned over the exterior side of the foam member such that the elongated strips are spaced parallel relative to each other and spaced from the multiple brace members with a portion of the foam member therebetween.

In accordance with another embodiment of the present invention, a wall structure for increasing thermal properties of a building structure is provided. The wall structure includes multiple brace members, an insulating member, and a reflective layer. The brace members are configured to be vertically positioned and spaced in a parallel arrangement. The insulating member is positioned at least partially between the brace members such that the insulating member has an interior side and an exterior side. The reflective layer includes an interior facing surface and an exterior facing surface, the reflective layer positioned alongside the interior side of the insulating member such that the exterior facing surface faces the interior side of the insulating member. With this arrangement, the interior facing surface is configured to reflect radiation heat toward an interior of the building structure and the exterior facing surface is configured to reflect radiation heat toward an exterior of the building structure.

In one embodiment, the wall structure includes a solution integrated with at least one of the insulating member and the reflective layer. The solution may include at least one of an anti-mold component and an anti-boring insect component. In another embodiment, the insulating member may be a foam member, such as expanded polystyrene or any other suitable foam member.

These various embodiments may include other components, features or acts as will be apparent from the detailed description set forth below. Additionally, other embodiments, configurations and processes are set forth below in the detailed description of the invention.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

The foregoing and other advantages of the invention will become apparent upon reading the following detailed description and upon reference to the drawings in which:

FIG. 1 is a perspective view of a building structure with multiple panel structures coupled together to form walls of the building structure, according to an embodiment of the present invention;

FIG. 2 is a perspective view of an interior side of a panel structure, depicting portions of the panel structure removed to illustrate the various components of the interior side of the panel structure, according to one embodiment of the present invention;

FIG. 2A is a cross-sectional view of a brace member of the panel structure taken along section line 2A of FIG. 2, according to another embodiment of the present invention;

FIG. 3 is a perspective view of an exterior side of the panel structure, depicting the various components of the exterior side of the panel structure, according to another embodiment of the present invention;

FIGS. 4A-4D are simplified partial side views of components of a panel structure, depicting a method for assembling the panel structure with a reflective layer being attached to a foam member of the panel structure, according to another embodiment of the present invention;

FIGS. 5A-5C are simplified partial side views of components of a panel structure, depicting another embodiment for assembling the panel structure with a reflective layer being attached to brace members of the panel structure, according to the present invention;

FIGS. 6A-6C are simplified partial side views of components of a panel structure, depicting another embodiment for making the panel structure with a reflective layer being coated over a foam member of the panel structure, according to the present invention;

FIG. 7 is a perspective view of a brace member, depicting the brace member with a longitudinally extending slot defined therein, according to another embodiment of the present invention;

FIG. 7A is a simplified partial side view of a panel structure, depicting a reflective layer suspended above the foam member and extending through the slot defined in the brace members, according to another embodiment of the present invention;

FIG. 8 is a simplified side view of a reflective layer, depicting the reflective layer receiving a treatment, according to another embodiment of the present invention;

FIG. 9 is a perspective view of an exterior side of a panel structure, depicting vertically extending strips integrated with the panel structure, according to another embodiment of the present invention;

FIG. 10 is a simplified partial side view of the panel structure with the strips, according to another embodiment of the present invention; and
FIG. 11 is a perspective view of an exterior side of a panel structure, depicting horizontally extending strips integrated with the panel structure, according to another embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring first to FIG. 1, a building structure 10 with walls 12 made of multiple panel structures 14 is depicted. To best illustrate the panel structures 14, the building structure 10 depicted is shown during the construction phase. Such panel structures 14 forming the walls 12 of the building structure 10 each include a foam member 16 (or, in one embodiment, a typical insulating member), brace members 18 partially disposed in the foam member 16, and a reflective layer 20. The foam member 16 of each panel structure 14 provides insulating characteristics to the panel structure 14 so as to resist the conduction of heat through the panel structure 14 or walls 12 of the building structure 10. The brace members 18 provide structural integrity to the walls 12 of the building structure 10 so as to provide strength to the foam member 16 as well as act as load bearing walls in the building structure 10. The reflective layer 20 integrated with each of the panel structures 14 is configured to reflect radiant heat so as to, for example, substantially reflect heat back into the building structure 10 when it is desired to maintain the interior of the building structure 10 warm as well as substantially reflect radiant heat away from the interior of the building structure 10 when it is desired to maintain the interior cool. With this arrangement, the panel structures 14 of the present invention provide enhanced thermal characteristics of resisting conductive heat as well as reflecting radiation heat.

Now referring to FIGS. 2 and 3, perspective views of respective interior and exterior sides 22, 24 of a panel structure 14 are provided. As illustrated in FIG. 2, the interior side 22 of the panel structure 14 exhibits the foam member 16, brace members 18, and the reflective layer 20 such that the brace members 18 are partially disposed within the foam member 16 with a portion of each brace member 18 exposed or extending away from and/or over the foam member 16. The reflective layer 20 may be pre-formed on the panel structures 14 or added to the panel structures 14 upon the panel structures being formed as walls 12 of the building structure 10 (see FIG. 1), discussed in further detail herein. In either case, once the panel structures 14 are positioned and secured to form the walls 12 of the building structure 10, drywall 26 or gypsum board or the like may be placed and secured over the reflective layer 20, as illustrated.

As depicted in FIG. 3, the exterior side 24 of the panel structure 14 may exhibit a continuous surface along the foam member 16 without exposed brace members 18. Such an arrangement is advantageous since any conductive heat transfer through the brace members 18 may be limited as they are not exposed or directly contacting the exterior portions of the final building structure. Upon the panel structures 14 being formed as walls 12 of the building structure 10, a cementitious undercoat 28 and then an elastomeric finish 30 may be applied to the exterior side 24 of the panel structures 14 (or foam member 16), together of which forms an exterior insulation finish system. Once the exterior insulation finish system is completed, an exterior structure of the building structure may be formed with, for example, brick, stucco, wood, paneling, etc. using exterior finish systems known to one of ordinary skill in the art.

With respect to FIGS. 2 and 3, the foam member 16 may include a first interior side 32 and a second exterior side 34. The first interior side 32 of the foam member 16 may include various notches, channels or slots formed and defined therein so as to facilitate housing various components integrated subsequently into the walls of the building structure. For example, the first interior side 32 of the foam member 16 may include one or more horizontally extending channels 36 extending between opposing side ends, which may be employed to run, for example, electrical wiring, piping and like components therealong. Further, the first interior side 32 of the foam member 16 may include multiple slots 38 (see also FIG. 4A) formed therein extending from opposing top and bottom ends 40, 42 of the foam member 16. Such slots 38 may be sized and configured to receive the brace members 18, discussed in further detail herein.

The foam member 16 may be formed of a polymeric foam material, such as, expanded polystyrene (“EPS”) or any other suitable foam material, such as, polyethylene, polyurethane, polypropylene or polyvinylchloride, that includes the density to provide excellent thermal insulation as well as maintain its structural integrity and strength over long periods of time. Such EPS may be formed by, for example, various steam processes, as known to one of ordinary skill in the art. Further, in another embodiment, the foam member may be a typical insulating member positioned between brace members.

As set forth, the brace members 18 may be disposed within the foam member 16. Such brace members 18 may extend longitudinally between top and bottom sides 44, 46 of the panel structure 14 and may be spaced relative to each other in a parallel arrangement. Further, the panel structure 14 may include a top track 48 and bottom track 50 sized and configured to receive opposing ends of the brace members 18 and a portion of respective top and bottom ends 40, 42 of the foam member 16. Such top and bottom tracks 48, 50 may be secured to the brace members 18 with, for example, fasteners 52.

As depicted in FIG. 2A, the brace members 18, as well as the top and bottom tracks 48, 50, may include a c-shaped cross-sectional profile. In another embodiment, the brace members 18 may include an l-shaped cross-sectional profile. In still another embodiment, the brace members 18 may include two c-shaped brace members 18 positioned back-to-back so as to exhibit an l-shaped cross-sectional profile. In an embodiment where the brace members 18 include an l-shaped cross-sectional profile, the slots 38 defined in the foam member 16 will be sized and configured to receive the brace members having such l-shaped profile. Such brace members 18 or studs may be formed of a metallic material, such as steel, and include a thickness 54 sufficient to be sized and configured to withstand the loads placed thereon and to meet the necessary building code requirements, as known to one of ordinary skill in the art.

With respect to FIGS. 2 and 2A, the c-shaped profile of the brace members 18 may include an intermediate portion 56, and a first and second extension 58, 60. The first and second extensions 58, 60 may each extend transverse or substantially orthogonal relative to the intermediate portion 56. Further, the first and second extensions 58, 60 may extend substantially parallel relative to each other as well as extend from the intermediate portion 56 in a common direction relative to the intermediate portion 56. Further, the first and second extensions 58, 60 may each extend to a free end that may each include a lip 62. Such lip 62 at each free end may
slightly curve inward toward each other. In addition, each of the intermediate portion 56 and the first and second extensions 58, 60 may extend along the longitudinal length 64 of each brace member 18. The intermediate portion 56 of each of the brace members 18 may include one or more openings 66 defined therein and extend through the intermediate portion such that the one or more openings 66 of a given brace member 18 correspond with the one or openings 66 of an adjacent brace member 18. With this arrangement, the one or more openings 66 of adjacent brace members 18 may correspond with the one or more channels 36 formed in the foam member to readily facilitate running electrical wire or piping through the one or more openings 66 and along the one or more channels 36 defined in the foam member 16.

[0049] Now with reference to FIGS. 2 and 4D, as set forth, the reflective layer 20 may be disposed over or alongside the foam member 16 (or, in another embodiment, any known insulating member). The reflective layer 20 may be referenced as a reflective member, a radiant barrier, or reflective sheet and is sized and configured to reflect radiation heat, as indicated by arrows 73, from both an underside surface 70 and a topside surface 71 of the reflective layer 20. The underside surface 70 of the reflective layer 20 may be an externally facing surface, relative to the building structure, so as to reflect radiation heat from an external source, such as from the heat of the sun, so as to substantially prevent radiation heat from coming within the building structure. Similarly, the topside surface 71 of the reflective layer 20 may be an internally facing surface, relative to the building structure, such that radiation heat within the building structure reflects from the internally facing surface or topside surface 71 to substantially maintain radiation heat within the building structure.

[0050] Such reflective layer 20 is preferably a metallic or metallic based material, such as aluminum or copper, or combinations thereof. The reflective layer 20 may be in the form of a sheet or laminate. In another embodiment, the reflective layer 20 may be a coating that may be layered via spraying, brushing, or rolling the reflective layer 20 to the foam member 16. The reflective layer 20 may act as and be a radiant barrier or radiant thermal barrier, reflecting radiation heat, as shown by arrows 73, from both the underside surface 70 and the topside surface 71 of the reflective layer 20. The reflective layer 20 may be configured to reflect substantially all radiation heat coming in contact with the reflective layer 20.

[0051] For example, in one embodiment, the reflective layer 20 may include a thermal emissivity value of about or at 0.1 or less and a thermal reflectance value of about or at 90% or greater. In other words, the reflective layer 20 may reflect about or 90% or more of radiant heat or radiant thermal energy and emits about or 10% or less. In another embodiment, the reflective layer 20 may include a thermal emissivity value in the range of about or at 0.05 to 0.05 and a thermal reflectance value in the range of about or at 95% to 97%. In another embodiment, the reflective layer 20 may include a thermal emissivity value of about or at 0.05 or less and a thermal reflectance value of about or at 95% or greater. In another embodiment, the reflective layer 20 may include a thermal emissivity value of about or at 0.05 or less and a thermal reflectance value of about or at 97% or greater. In still another embodiment, the reflective layer 20 may include a thermal emissivity value in the range of about or at 0.01 to 0.04 and a thermal reflectance value in the range of about or at 96% to 99%. Such various ranges may be relevant to the particular material employed for the reflective layer 20. Further, such thermal reflectance value provided by the reflective layer 20, in combination with the foam member 16 configured to resist conductive thermal energy, equates to extraordinary efficiency and cost savings relative to substantially maintaining the interior of a building structure at warm or cool temperatures, depending on the season. In this manner, the insulated panel structures 14 with the reflective layer 20 of the present invention maximizes the thermal efficiency of a building structure and is an extraordinary improvement over insulated panels in the prior art.

[0052] Now with reference to FIGS. 4A through 4D, the various method steps for manufacturing or assembling a panel structure 14 are provided. As illustrated, only a portion of the panel structure 14 and components thereof are shown for simplification purposes. With respect to FIG. 4A, the foam member 16 may be formed employing hot wire techniques. Such hot wire techniques may be used to size and shape the dimensions of the foam member 16 as well as be utilized to cut the slots 38 for receiving the brace members 18. As depicted, the slots 38 defined through the foam member 16 may be formed with an L-shaped slot so as to receive a portion of the C-shaped profile of the brace members 18, discussed in detail below. Other cuts with a hot wire process may be used, such as cutting the one or more channels 36 that correspond with the openings 66 defined in the intermediate portion 56 of the brace member 18 (see FIG. 2), as previously set forth. Detailed disclosures of such hot wire techniques to form the foam member are found in U.S. Pat. Nos. 5,943,775 and 6,167,624, the disclosures and contents of which are incorporated herein by reference in their entirety.

[0053] With respect to FIG. 4B, once the foam member 16 has been shaped and cut as desired, the foam member 16 may be prepared for receiving the reflective layer 20. As depicted with arrows 68, the reflective layer 20 may be positioned over the foam member 16 and then attached thereto, as shown in FIG. 4C. With respect to FIGS. 4B and 4C, in one embodiment, the reflective layer 20 may be cut and sized for a given panel structure and receive an adhesive layer (not shown) along portions of the underside 70 of the reflective layer 20 such that the reflective layer 20 may then be pressed directly against the first interior side 32 of the foam member 16 to, thereby, adhesively attach the reflective layer 20 to the foam member 16. In another embodiment, the foam member 16 may receive the adhesive layer (not shown) to then receive the reflective layer 20 to be bonded thereto. In another embodiment, the foam member 16 may receive an adhesive layer and then the reflective layer 20 may be rolled-out from a reflective layer roll to adhesively attach the reflective layer 20 to the foam member 16.

[0054] In another embodiment, the reflective layer 20 may be heat bonded to the foam member 16. In one embodiment, the reflective layer 20 may include an heat activated adhesive (not shown) such that once the reflective layer 20 is properly positioned over foam member 16, the heat activated adhesive can be heated for bonding the reflective layer 20 to the foam member 16. In another embodiment, the reflective layer 20 may include a porous material. With a porous reflective layer, the reflective layer 20 may be attached using heat such that the surface of the foam member 16 may slightly melt to flow within the pores of the reflective layer and, upon cooling, attach or bond to the foam member 16. With respect to FIG. 4C, once the reflective layer 20 is attached to the foam member 16, the reflective layer 20 may fully cover the first interior side 32 of the foam member 16, covering the slots 38 of the
foam member 16. As such, the reflective layer 20 may then be sliced to form slits 72 along the slots 38 defined in the foam member 16 to, thereby, re-expose the slots 38 on the first interior side 32 of the foam member 16. Such cutting of the reflective layer 20 to form the slits 72 may be employed using automated cutting processes or may be implemented manually.

[0055] Now with reference to FIG. 4D, upon the reflective layer 20 being attached to the foam member 16, the brace members 18 may be inserted into the slots 38. As previously set forth, the slots 38 are sized and configured to receive the brace members 18 such that the brace members 18 slide therein and fit in a relatively tight and snug manner. Further, with the slits 72 formed in the reflective layer 20 over the slots 38, the edges defining the slits 72 formed in the reflective layer 20 abut against the brace members 18. With this arrangement, a portion of the intermediate portion 56 and the second extension 60 of the brace member 18 may be fully enclosed within the foam member 16 with the remaining portion of the intermediate portion 56 and the first extension 58 of the brace member 18 being exposed and extending from the foam member 16. In this manner, the brace members 18 are partially disposed within the foam member 16. Once each of the brace members 18 are inserted into their corresponding slots 38, the before-discussed top and bottom tracks 48, 50 may be secured over the opposing ends of the brace members 18 and over a portion of the corresponding top and bottom ends 40, 42 of the foam member 16, as depicted in FIGS. 2 and 3. In this manner, the panel structures 14 may be formed and assembled with the reflective layer 20 integrated there-with.

[0056] Now with reference to FIGS. 5A through 5C, another embodiment depicting method steps for forming panel structures 15 and integrating the reflective layer 20 therewith is provided. With respect to FIG. 5A, similar to the previous embodiment described relative to FIG. 4A, the foam base layer 16 may be cut and sized to the desired dimensions for a given panel structure as well as the foam member 16 receiving cuts to form the slots 38 and the one or more channels (not shown) employing hot wire techniques. As depicted in FIG. 5B, in this embodiment, once the appropriate cuts are made in the foam member 16, the brace members 18 may be inserted and slid into the corresponding slots 38, after which, the top and bottom tracks 48, 50 may be secured and fastened to the opposing ends of the brace members 18 (see FIGS. 2 and 3). At this juncture, the incomplete panel structures 15 may then be moved to the on-site construction of the building structure to form the walls thereof. Once the incomplete panel structures 15 are coupled to each other to form the walls of the building structure, the reflective layer 20 may then be attached to an outer surface 74 of the first extension 58 of the brace members 18, as depicted in FIG. 5C. Upon attaching the reflective layer 20 to the brace members 18, the panel structures 15 are then considered complete or finished relative to the panel structures having the integrated reflective layer 20. Such attachment of the reflective layer 20 may be employed by applying, for example, an adhesive layer (not shown) to the outer surface 74 of the brace members 18. In this manner, the reflective layer 20 may then be adhesively attached and bonded to the first extension 58 of the brace members 18. In this embodiment, the reflective layer 20 may be separated from the foam member 16 with a gap 76 therewith. Such gap 76 provides an air space, which further increases the resistive value for resisting heat conduction, thereby, enhancing the insulating characteristics of the panel structures 14 along with providing the reflective thermal characteristics of the reflective layer 20, as previously set forth.

[0057] With reference to FIGS. 6A through 6C, another embodiment depicting method steps for forming the panel structures 17 with an integrated reflective layer 21 therewith is provided. With respect to FIGS. 6A and 6B, similar to the previous embodiment described relative to FIGS. 5A and 5B, the foam member 16 may be prepared with hot wire cutting techniques, after which, the brace members 18 may be inserted to slide into the slots 38 formed in the foam member 16.

[0058] In this embodiment, as depicted in FIG. 6C, a reflective layer 21 may then be applied to the first interior side 32 of the foam member 16 with the brace members 18 inserted therein within the foam member 16. In one embodiment, such layered application may be employed as a coating by spraying the reflective layer 21 over the foam member 16 from a spray nozzle 78. In another embodiment, the layered application of the reflective layer 21 may be applied with a brush or roller. In either embodiment, a thickness 80 of the reflective layer 21 in the form of a coated layer is substantially less than the thickness of the reflective layer 20 in the form of a sheet set forth in previous embodiments. As such, in another embodiment, the step of applying the coating to form the reflective layer 21 over the foam member 16 may be implemented prior to the method step of inserting the brace members 18 into the slots 38 defined in the foam member 16 (shown in FIG. 6B) and, further, may be implemented prior to the method step of cutting the slots 38 into the foam member 16 (shown in FIG. 6A) since the thickness 80 of the reflective layer 21 being applied as a coating may readily be slit or cut through to insert the brace members 18 or to form the slots 38 defined in the foam member 16. The reflective layer 21 applied as a coating may be a composite material with a metallic base, such as aluminum or copper, or any other suitable material that provides reflective characteristics similar to the previous embodiments of the reflective layer 20 in the form of a sheet. In this manner, the panel structures 17 may be formed with a coating with the reflective layer 21 formed thereon.

[0059] Now with reference to FIGS. 7 and 7A, another embodiment of the panel structures 14 integrating the reflective layer 20 therewith is provided. In this embodiment, the brace members 18 may be substantially similar to the brace members 18 of previous embodiments except the brace members 18 of this embodiment include an elongated slot 82 defined therein. Such elongated slot 82 may extend longitudinally along the length 64 of the intermediate portion 56 of the brace members 18. For example, the elongated slot 82 may be defined in each of the brace members 18 along the portion of the intermediate portion 56 of the brace member 18 that is exposed or extends away from the foam member 16. With this arrangement, the panel structures 14 may be formed and assembled similar to the previous embodiment described relative to FIGS. 5A and 5B. As in previous embodiments, opposing ends of the brace members 18 may be secured to the respective top and bottom tracks 48, 50 with the foam member 16 therewith (see FIGS. 2 and 3). The incomplete panel structures may then be moved to the on-site construction of the building structure to form the walls thereof. Once the incomplete panel structures are coupled to each other to form the walls of the building structure, the reflective layer 20 may then be inserted through the elongated slot 82 defined in each of the brace members 18 with opposing ends of the reflective
layer 20 fastened to, for example, a portion of the brace members 18. With this arrangement, the reflective layer 20 is spaced from the foam member 16 so as to provide an air gap 84 therebetween. Such an air gap 84, similar to the embodiment depicted in FIG. 5C, further increases the resistive value for resisting heat conduction, thereby, enhancing the insulating characteristics of the panel structures 14. Furthermore, the reflective layer 20 integrated with the panel structures 14 provides an enhanced thermal reflectance value so as to reflect about 97% of radiant thermal energy coming in contact with the reflective layer 20 from both the underside surface 70 and the topside surface 71, as previously set forth.

[0060] With respect to FIGS. 2 and 8, according to any one of the embodiments set forth herein, the reflective layer 20 may be treated. For example, the reflective layer 20 may receive an anti-mold and/or anti-boring insect solution 86. Such solution 86 may be applied to the reflective layer by, for example, spraying the solution 86 onto at least one of the face surfaces of the reflective layer 20. Such anti-mold and/or anti-boring insect solution 86 may be applied together or separately. Further, the solution 86 may be applied to the reflective layer prior to, or subsequent to, integrating the reflective layer 20 with the foam member 16 or with the base members 18 of the panel structure 14. In another embodiment, the solution 86 may also be applied with, for example, a steam process of forming expanded polyethylene foam of the foam member 16. In another embodiment, the solution 86 may also be applied by directly spraying the completed panel structures 14, including each of the foam member (and components attached thereto), the brace members 18, and reflective layer 20. In one embodiment, the anti-boring insect component of the solution 86 may be any known anti-boring insect component, such as a solution with a borate salt component, or any other component known by one of ordinary skill in the art to inhibit boring insects, such as termites or the like. In another embodiment, the anti-mold component may be any known anti-mold component, such as an anti-mold component configured to inhibit and substantially prevent black mold or the like.

[0061] With respect to FIGS. 9 and 10, another embodiment of a panel structure 23 is provided. As in previous embodiments, the panel structure 23 may include the foam member 16 with multiple brace members 18 positioned therein or therewith and the reflective layer 20 positioned over the first interior side 32 of the foam member 16. In this embodiment, the panel structure 23 may include multiple strips 102 positioned on or over the second exterior side 34 of the panel structure 23. The strips 102 may be an elongated structure positioned over the foam member 16 of the panel structure 23. The strips 102 may be employed with the panel structure 23 and, upon the panel structures 23 being assembled to form the walls 12 of the building structure 10 (FIG. 1), such strips 102 may be integrated with the panel structures 23 to facilitate securing an exterior structure (not shown) to the walls 12 of the building structure 10.

[0062] In one embodiment, the strips 102 may be vertically positioned over the foam member 16 in a spaced and parallel manner. The strips 102 may each include a strip length 104, a strip width 106, and a strip depth 108 to exhibit a generally rectangular cross-section or similar cross-section, such as a trapezoidal cross-section, or the like. Further, the strips 102 may each include a strip interior side 110 and a strip exterior side 112. The strips 102 may each be positioned over the second exterior side 34 of the foam member 16 to correspond and align with the brace members 18 such that the strip length 104 of each strip 102 extends at least partially, along a length of the brace member 18 with a portion of the foam member 16 therewithin. In this manner, the strips 102 may act to receive fasteners for fastening the exterior structure thereto such that the fasteners may extend through the strip 102 and may also extend into a portion of the brace member 18, such as, the second extension 60 of the brace member 18. In another embodiment, the strip 102 may be sized and configured to hold the exterior structure, without fasteners extending into the brace member 18. In this embodiment, the strips 102 may be positioned and spaced vertically over the foam member 16 such that the strips 102 may not necessarily be aligned with the brace members 18.

[0063] In one embodiment, the second exterior side 34 of the foam member 16 may define multiple vertically extending strip channels 116. Such strip channels 116 may be formed by employing the hot-wire techniques, as previously set forth. Each strip channel 116 may be sized and configured to receive one of the strips 102 such that the strip interior side 110 may be directly positioned against a bottom channel surface 118 of the given strip channel 116. Further, the strip channels 116 may each include a channel depth (substantially corresponding to the strip depth 108) so that upon the strips 102 being positioned within the strip channel 116, the strip exterior side 112 may be flush with an exterior surface or second exterior side 34 of the foam member 16. The strips 102 may each be fastened to the foam member 16 with an adhesive or any other suitable fastening structure or material.

[0064] In another embodiment, the strips 102 may each include a flange 122 (shown in outline form) that may extend from lateral sides and/or the strip interior side 110 of the strip 102. With this arrangement, the flange 122 may be a lip or extension that extends along the strip length 104 so that a lateral width of the strip interior side 110 may be larger than the lateral width of the strip exterior side 112. In this embodiment, the strip channels 116 may be formed to define a corresponding shape sized and configured to receive the strips 102 such that the strips 102 may slide within the strip channels 116 from the top end 40 or bottom end 42 of the foam member 16.

[0065] In another embodiment, the strips 102 may be sized to overlay the outer surface or the second exterior side 34 of the foam member 16. In this embodiment, the foam member 16 may not include strip channels 116 such that the strips 102 may be directly attached with, for example, adhesive, for fastening to the outer surface of the foam member 16. As such, the strip exterior side 112 may be disposed above the outer surface of the foam member 16 in a non-flush manner. In this embodiment, the strips 102 may be thinner or may include a smaller strip depth than the embodiment described above. In another embodiment, the strip channels 116 may include a depth sized such that the strip exterior side 112 of the strips 102 may be disposed above the outer surface of the foam member 16 in a non-flush manner.

[0066] With respect to FIG. 11, another embodiment of strips 132 attached to a panel structure 25 is provided. This embodiment may be similar to the previous embodiment described relative to FIGS. 9 and 10, in any one of its alternative forms, except in this embodiment, the strips 132 may be positioned horizontally, rather than vertically. Similar to that depicted, the horizontally extending strips 132 may be positioned and spaced parallel relative to each other over the outer surface of the foam member 16. In this manner, the
strips 132 may be arranged over the panel structure 25 in an alternative arrangement that may be advantageous depending upon the exterior structure employed with the building structure. Other arrangements for the strips 132 may also be employed, such as a combination of vertically and horizontally extending strips 132.

[0067] The strips, as described relative to FIGS. 9-11, may be formed of a solid wood material or compressed wood material, such as oriented strand board or OSB material or the like. Other suitable materials for the strips may include a polymeric material or a metallic material or combinations of wood, polymeric, and/or metallic materials or any other suitable material, as known to one of ordinary skill in the art, for securing an exterior structure thereto. Further, it should be noted that the strips may be employed with any one of the embodiments of the panel structures described herein.

[0068] While the invention may be susceptible to various modifications and alternative forms, specific embodiments have been shown by way of example in the drawings and have been described in detail herein. However, it should be understood that the invention is not intended to be limited to the particular forms disclosed. Rather, each embodiment disclosed herein may incorporate portions of the various embodiments disclosed herein. As such, the invention includes all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the following appended claims.

What is claimed is:

1. An insulated panel structure configured to be positioned as a portion of a wall of a building structure, the insulated panel structure comprising:

   a foam member including an interior side and an exterior side each extending between opposing top and bottom ends and opposing side ends, the interior side including slots defined therein extending between the opposing top and bottom ends, the foam member configured to resist conductive heat flow therethrough;

   multiple brace members, each brace member partially positioned within one of the slots defined in the interior side of the foam member such that the brace members extend substantially parallel relative to each other with a portion of each brace member extending away from and alongside a portion of the interior side of the foam member;

   a reflective layer including an interior facing surface and an exterior facing surface, the reflective layer positioned alongside the interior side of the foam member such that the exterior facing surface faces the interior side of the foam member, the interior facing surface configured to reflect radiation heat toward an interior of the building structure and the exterior facing surface configured to reflect radiation heat toward an exterior of the building structure.

2. The insulated panel structure of claim 1, further comprising elongated strips positioned over the exterior side of the foam member such that the elongated strips are spaced parallel relative to each other.

3. The insulated panel structure of claim 2, wherein the exterior side of the foam member defines strip channels sized and configured to each receive one of the elongated strips.

4. The insulated panel structures of claim 3, wherein the strip channels include a channel depth substantially similar to a strip depth such that an outer surface of the strips is substantially flush with a surface of the exterior side of the foam member.

5. The insulated panel structure of claim 1, wherein the reflective layer comprises a sheet material.

6. The insulated panel structure of claim 1, wherein the reflective layer directly contacts the interior side of the foam member.

7. The insulated panel structure of claim 6, wherein the reflective layer comprises slits defined therein that correspond with the slots defined in the foam member such that edges defining the slits are configured to extend directly adjacent to an intermediate portion of a corresponding brace member partially disposed within the slot.

8. The insulated panel structure of claim 1, wherein the reflective layer directly contacts an outer surface of the multiple brace members to provide an air gap between the reflective layer and the foam member.

9. The insulated panel structure of claim 1, wherein the reflective layer is suspended alongside the foam member with an air gap therebetween such that the reflective layer extends through an elongated slot defined in each of the brace members.

10. The insulated panel structure of claim 1, wherein the reflective layer comprises a coating material layered over the interior side of the foam member.

11. The insulated panel structure of claim 1, wherein the reflective layer comprises at least one of a copper material and an aluminum material.

12. The insulated panel structure of claim 1, further comprising a solution integrated with at least one of the foam member and the reflective layer, the solution having at least one of an anti-mold component and an anti-boring insect component.

13. A method of making an insulated panel structure for enhancing thermal efficiency within a building structure, the method comprising:

   forming a foam member having an interior side and an exterior side each extending between opposing top and bottom ends such that the interior side includes slots defined therein and formed to extend between the top and bottom ends;

   sliding multiple brace members into the slots such that each brace member is partially positioned within one of the slots and such that a portion of each brace member extends away from and alongside a portion of the of the foam member; and

   positioning a reflective layer alongside the interior side of the foam member such that an exterior facing surface of the reflective layer faces the interior side of the foam member so that an interior facing surface of the reflective layer reflects radiation heat toward an interior of the building structure and the exterior facing surface reflects radiation heat toward an exterior of the building structure.

14. The method according to claim 13, further comprising positioning elongated strips over the exterior side of the foam member such that the elongated strips are spaced parallel relative to each other and spaced from the multiple brace members with a portion of the foam member therebetween.

15. The method according to claim 13, wherein the positioning step comprises positioning the reflective layer to directly contact the interior side of the foam member.
16. The method according to claim 15, further comprising, prior to the sliding step, cutting slits in the reflective layer to correspond with the slots defined in the foam member.

17. The method according to claim 13, wherein the positioning step comprises extending the reflective layer to directly contact the multiple brace members to provide an air gap between the reflective layer and the foam member.

18. The method according to claim 13, wherein the positioning step comprises spraying a coating of reflective material to form the reflective layer on the interior side of the foam member.

19. The method according to claim 13, further comprising applying at least one of an anti-mold solution and an anti-boring insect solution to at least one of the foam member and the reflective layer.

20. An insulated panel structure configured to be positioned as a portion of a wall of a building structure, the insulated panel structure comprising:

   a foam member including an interior side and an exterior side each extending between opposing top and bottom ends and opposing side ends, the interior side including slots defined therein extending between the opposing top and bottom ends, the foam member configured to resist conductive heat flow therethrough;

   multiple brace members, each brace member partially positioned within one of the slots defined in the interior side of the foam member such that the brace members extend substantially parallel relative to each other with a portion of each brace member extending away from and alongside a portion of the interior side of the foam member;

   and elongated strips positioned over the exterior side of the foam member such that the elongated strips are spaced parallel relative to each other and spaced from the multiple brace members with a portion of the foam member therebetween.

21. The insulated panel structure of claim 20, further comprising a reflective layer including an interior facing surface and an exterior facing surface, the reflective layer positioned alongside the interior side of the foam member such that the exterior facing surface faces the interior side of the foam member, the interior facing surface configured to reflect radiation heat toward an interior of the building structure and the exterior facing surface configured to reflect radiation heat toward an exterior of the building structure.

22. The insulated panel structure of claim 20, further comprising a solution integrated with at least one of the foam member and the reflective layer, the solution having at least one of an anti-mold component and an anti-boring insect component.

23. An insulated panel structure configured to be positioned as a portion of a wall of a building structure, the insulated panel structure comprising:

   a foam member including an interior side and an exterior side each extending between opposing top and bottom ends and opposing side ends, the interior side including slots defined therein extending between the opposing top and bottom ends, the foam member configured to resist conductive heat flow therethrough;

   multiple brace members, each brace member partially positioned within one of the slots defined in the interior side of the foam member such that the brace members extend substantially parallel relative to each other with a portion of each brace member extending away from and alongside a portion of the interior side of the foam member;

   and a solution integrated with the foam member, the solution having at least one of an anti-mold component and an anti-boring insect component.

24. The insulated panel structure of claim 23, further comprising a reflective layer including an interior facing surface and an exterior facing surface, the reflective layer positioned alongside the interior side of the foam member such that the exterior facing surface faces the interior side of the foam member, the interior facing surface configured to reflect radiation heat toward an interior of the building structure and the exterior facing surface configured to reflect radiation heat toward an exterior of the building structure.

25. The insulated panel structure of claim 23, further comprising elongated strips positioned over the exterior side of the foam member such that the elongated strips are spaced parallel relative to each other and spaced from the multiple brace members with a portion of the foam member therebetween.

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