An insulation sheet for concrete sandwich wall panels comprising a sheet base composed substantially of expanded cellular foam and having opposed base surfaces. Protrusions on rigid plastic inserts molded into the sheet base extend from each of the base surfaces. Each of the protrusions has a narrow waist into which concrete flows to anchor the concrete onto the sheet. Narrow ducts extend through the insulation sheet.
INSULATION SHEET STRUCTURE AND CONCRETE SANDWICH WALL PANEL ASSEMBLY CONSTRUCTED THEREWITH

CROSS-REFERENCES TO RELATED APPLICATIONS

[0001] The present application is a continuation-in-part of application Ser. No. 10/965,049, filed Oct. 14, 2004 for INSULATION SHEET STRUCTURE AND CONCRETE SANDWICH WALL PANEL ASSEMBLY CONSTRUCTED THEREWITH in the name of Peter Fleischhacker.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] Not Applicable

REFERENCE TO A SEQUENCE LISTING, A TABLE, OR A COMPUTER PROGRAM LISTING COMPACT DISK APPENDIX

[0003] Not Applicable

BACKGROUND OF THE INVENTION

[0004] 1. Field of the Invention

[0005] The present invention relates to building construction, more particularly, to pre-cast, insulated, concrete panels.

[0006] 2. Description of the Related Art

[0007] Concrete sandwich wall panels are well known in the building construction art. They typically consist of an insulation layer sandwiched between two concrete layers with ties extending through the insulation layer and into the concrete layers to secure the three layers together. In one method of manufacturing, the first concrete layer is poured in a horizontal form and the insulation is placed on the concrete. Before the concrete sets, the ties are pushed through pre-drilled holes in the insulation and into the concrete. The ties have surface irregularities so that, after the concrete flows around the ties and cures, a secure attachment is provided between the concrete and ties. Finally, the second concrete layer is poured on the insulation. The concrete flows around the surface irregularities of the ties to secure the layers together after the concrete cures.

[0008] The above-described method has a number of shortcomings. First, it is very labor intensive because a large number of ties must be individually installed before the bottom concrete layer cures. Second, the purpose of the insulation is to minimize thermal transfer between the concrete layers. In order to minimize thermal transfer, the ties need to be poor heat conductors. However, because the ties support the weight of the concrete, the embedded portions of the ties are steel or other metal alloy, which are very good heat conductors. Consequently, the portion of the ties that reside in the insulation layer needs to be poor conductors. This means that the ties cannot be of a single material, which adds complexity and cost to the manufacturing process. Third, the insulation is composed of extruded polystyrene (XPS), which can only be extruded with a rectangular, board-like cross section, profiled cross sections are not possible. Although XPS is a very good insulator, it does not "breath", that is, its vapor impermeability is too high, and water vapor can be trapped within the building.

BRIEF SUMMARY OF THE INVENTION

[0009] An object of the present invention is to provide an insulation sheet for insulated concrete panel assemblies that minimizes construction labor.

[0010] Another object is to provide an insulation sheet for insulated concrete panel assemblies that is vapor permeable.

[0011] A further object is to provide an insulation sheet for insulated concrete panel assemblies that can be manufactured at or close to the job site.

[0012] The present invention is an insulation sheet for concrete sandwich wall panels and comprises a sheet base composed substantially of expanded cellular foam and having opposed base surfaces, and a plurality of protrusions extending from each of the base surfaces to a distal surface away from said base surface, each of the protrusions having a cross-sectional shape such that a width of the distal surface is greater than a width of the footprint.

[0013] A concrete panel employing the insulation sheet of the present invention is made by pouring a first concrete layer into a horizontal form, pushing the insulation sheet into the concrete layer before the concrete sets, and then pouring the second concrete layer onto the insulation sheet.

[0014] The insulation sheet of the present invention is composed of an expanded cellular foam (ECF), which can be molded with surface features and is generally vapor permeable. The insulation sheet has a base and protrusions extending from both base surfaces. The protrusions have two embodiments. In one embodiment, the protrusions are integral with the sheet base and are generally mushroom-shaped so that the concrete flows around and surrounds the protrusions as to be anchored in the concrete after it sets. The protrusions can be any shape, such as circular and ring-shaped, although any shape or combinations thereof may be employed. In the second embodiment, the protrusion are on inserts that are embedded in the sheet base during molding. The protrusion has a waist into which the concrete flows, anchoring the concrete to the sheet.

[0015] In the first embodiment, so that stacked insulation sheets can slide easily on one another, the surface area of the smallest protrusions is greater than any area of the same shape between protrusions. This means that the protrusions of adjacent stacked sheets will slide on each other rather than falling in between the protrusions. Optionally, in order to facilitate sheets sliding on each other and pushing the sheet into the first concrete layer, the surface of the protrusions are rounded.

[0016] In the second embodiment, the protrusions are two parts of separately produced inserts that are embedded in the sheet base. Each protrusion has opposed notches that form a waist for concrete to flow into. The inserts can be anchored into the sheet base in one of two ways. In the first, the sheet base material extends through holes in the insert when the sheet is being produced. In the second, anchor facings sandwich the sheet base therebetween.

[0017] Narrow ducts extend through the insulation sheet to allow air between the first concrete layer and the insulation
sheet to escape while pushing the sheet into the concrete and to facilitate vapor permeability of the panel.

[0018] Other objects of the present invention will become apparent in light of the following drawings and detailed description of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] For a fuller understanding of the nature and object of the present invention, reference is made to the accompanying drawings, wherein:

[0020] FIG. 1 is a prospective view of a concrete sandwich of the present invention;

[0021] FIG. 2 is a perspective view of a section of the insulation sheet of the present invention;

[0022] FIG. 3 is a top view of a section of the sheet of FIG. 2;

[0023] FIG. 4 is a cross-sectional view of the sheet of FIG. 3 along the line A-A;

[0024] FIG. 5 is a cross-sectional view of the concrete sandwich of FIG. 1;

[0025] FIG. 6 is an enlarged view of a portion of a protrusion;

[0026] FIG. 7 is a perspective view of an insert of the present invention;

[0027] FIG. 8 is a cross-sectional view of an insulation sheet of the present invention with the insert of FIG. 7;

[0028] FIG. 9 is a cross-sectional view of the concrete sandwich using the insulation sheet of FIG. 8;

[0029] FIG. 10 is a perspective view of another insert of the present invention; and

[0030] FIG. 11 is a cross-sectional view of an insulation sheet of the present invention with the insert of FIG. 10.

DETAILED DESCRIPTION OF THE INVENTION

[0031] The present invention is an insulation sheet for use in concrete sandwich wall panels and a concrete sandwich wall panel assembly that employs the insulation sheet.

[0032] A concrete sandwich wall panel 10 of the present invention is shown in FIG. 1. The basic method of making the panel 10 is similar to that of the prior art. The first concrete layer 14 is poured to the desired thickness in a horizontal form. This layer 14 is typically a structural component, that is, it bears the weight of other components. The parameters of the first layer 14 are dependent upon the use to which the panel 10 is being put and the strength needed. As a structural component, the thickness of the first layer 14 will typically be in the range of six to twelve inches. The layer 14 may also include re-enforcement bars as needed according to architectural specifications.

[0033] Before the concrete set, the insulation sheet 12 is pushed into the concrete layer 14, as explained below. Then the second concrete layer 16 is poured onto the insulation panel 12 in the desired thickness. The second layer 16 is typically of a lighter weight aggregate about one to six inches thick, again depending upon the use to which the panel 10 is put. Re-enforcement bars and/or wire mesh may be included according to architectural specifications. The concrete layers 14, 16 may be symmetrical, that is, both have the same thickness and composition, or asymmetrical, that is, different thicknesses and/or compositions. The surface finishes of the concrete layers 14, 16 depend on the use to which the panel 10 is put.

[0034] The insulation sheet 12 of the present invention is composed of expanded cellular foam (ECF), rather than the extruded polystyrene (XPS) of the prior art. Examples of ECFs are expanded polystyrene (EPS), expanded polypropylene (EPP), expanded polyethylene (EPE), and expanded copolymers such as polystyrene/polyphenylene oxide and modified polyphenylene oxide and polyphenylene ether. The density of the ECF will vary depending upon the application and will typically be in the range of from one to twelve pounds per cubic foot.

[0035] ECF is not restricted to a flat shape, as is XPS. ECF can be molded to include surface features. ECF has some vapor permeability so that water vapor is not trapped within the building. In other words, a panel 10 made with the insulation sheet 12 of the present invention "breathes". Additionally, a "shape-molding" installation is more easily available to a concrete pre-caster, either by in-house investment and in-house production, or by tapping into one of hundreds of local ECF converters that already have ECF manufacturing know-how and an existing ECF infrastructure. Long-term savings would be in either greatly reduced or eliminated costs associated with transporting XPS sheets from one of the relatively few number of supplier plants around the country.

[0036] The insulation sheet of the present invention has two embodiments 12, 112. Both embodiments have a sheet base 18, 118 and a plurality of protrusions 20a, 20b(collectively, 20), 120 extending from the base surfaces 22, 24, 122, 124 of the sheet base 18, 118. The thickness of the base sheet 18, 118 will depend upon how much insulation is desired and can typically be in the range of from one to twelve inches.

[0037] The difference between the two embodiments lies in the protrusions. In the first embodiment 12 of FIGS. 2-6, the protrusions 20 are integrally molded as elements of the sheet 12. In other words, the sheet 12 is produced in one step as a unitary construct. In the second embodiment 112 of FIGS. 7-11, the protrusions 120 are two parts of separately produced inserts 128 that are added to the sheet base 118 during the molding process. In other words, the sheet 112 is produced in two steps, where the inserts 128 are produced in the first step and the sheet base 118 is molded around the inserts 128 in the second step.

[0038] In the first embodiment of the protrusions 20, the width of the distal surface 26 of the protrusion 20 is generally larger than the width of the protrusion footprint 28, the area of the protrusion 20 at the base surface 22, as shown in the cross-section of FIG. 4. In other words, the protrusion cross-section is generally mushroom-shaped. The idea is that, when the sheet 12 is pushed into unset concrete, the concrete flows around and surrounds the protrusions 20, as at 30 in FIG. 5. When the concrete sets, the protrusions 20 are anchored in the concrete. With protrusions extending from both base surfaces 22, 24, the concrete layers 14, 16 are interlocked via the insulation sheet 12, thereby creating an
insulated concrete sandwich. The height of the protrusion 20 and the angle 42 of the protrusion side wall 40 are dependent on the density of the ECF used for the insulation sheet 12 and to the weight and density of the concrete layers 14, 16. Consequently, these parameters will vary according to the application. The protrusions 20 can typically range in height from ½ inch to two inches and the side wall angle 42 can typically range from one to ten degrees.

[0039] Because of the integral protrusions, there is no need to manually insert individual ties, like the panels of the prior art. Consequently, manufacturing labor cost is greatly reduced.

[0040] FIGS. 2-5 show two different shapes for the protrusions 20: a ring protrusion 20a and a circular protrusion 20b. These are merely illustrative shapes and the present invention contemplates that any protrusion shape or combinations of protrusion shapes that have the characteristics described herein may be employed. For example, all the protrusions can be circular or the protrusions can be other shapes, such as squares and rectangles. The size of the protrusions can vary greatly depending upon the application. The ring protrusions 20a can be, for example, three to ten inches in diameter and the circular protrusions 20b can be, for example, one to five inches in diameter.

[0041] Typically, the insulation sheets 12 are stacked for delivery to where the panels are manufactured. It is desirable that, as an insulation sheet 12 is needed for a panel 10, the sheet 12 be easily slid from the top of the stacked sheets 12. Because the XPS insulation sheets of the prior art are flat, they can be slid off quite easily. The insulation sheet of the present invention solves this issue by using protrusions 20 with a smallest distal surface area that is greater than any area of the same shape between distal surfaces 26. For example, in FIG. 3, the smallest protrusion 20 is circular and the distal surface diameter 34 is greater than the largest circular space 36 between distal surfaces 26. This means that the distal surfaces 26 of protrusions 20 of adjacent sheets 12 will slide on each other rather than falling in between the protrusions 20.

[0042] If the distal surfaces 26 are flat, slight irregularities in the protrusions 20 may cause the protrusions 20 of adjacent sheets 12 to catch each other when trying to slide one sheet 12 off a stack. To solve this issue, the distal surface 26 of the protrusions 20 are optionally rounded, as in FIG. 4. In the case of the ring protrusions 20a, the protrusion 20a has a raised ridge in the center of the distal surface 26 that is rounded to the two edges 36. In the case of the circular protrusions 20b, the protrusion 20b is domed. The rounded distal surface 26 facilitates sliding the sheets 12 along each other because the edges 38 of the protrusions 20 will not catch on each other.

[0043] Another advantage of the rounded distal surface 26 is that it is easier to push into the first concrete layer 14. The present invention contemplates other shapes for the distal surface, for example, pointed, that facilitate pushing the insulation sheet 12 into the concrete layer 14.

[0044] In the second embodiment, the protrusions 120 are two parts of separately produced inserts 128. Two examples of inserts 128 of the present invention are shown in FIGS. 7-11. The insert 128 has an embedded section 134 and two protrusions 120. The embedded section 134 is that part of the insert 128 that is embedded within the sheet base 118. Consequently, the length of the embedded section 134 is the same as the thickness of the sheet base 118.

[0045] The protrusions 120 extend from both ends of the embedded section 134. Each protrusion 120 has a distal surface 126 away from the embedded section 134 and a pair of opposed notches 142 that form a waist 140 that is narrower than the distal surface 126. The idea is that, when the sheet 12 is pushed into unset concrete, the concrete flows into the waist 140 and surrounds the protrusions 120, as at 130 in FIG. 9. When the concrete sets, the protrusions 120 are anchored in the concrete. With protrusions 120 extending from both base surfaces 122, 124, the concrete layers 14, 16 are interlocked via the insulation sheet 112, thereby creating an insulated concrete sandwich.

[0046] Because of the protrusions 120 are integral parts of the sheet 112 at the construction site, there is no need to manually insert individual ties, like the panels of the prior art. Consequently, manufacturing labor cost is greatly reduced.

[0047] The parameters of the insert 128 (height, thickness, diameter, waist size, etc.) depend upon the application, for example, the weight and density of the concrete layers 14, 16, and the material from which the insert 128 is constructed. Obviously, the stronger the material is, the thinner the insert 128 can be while maintaining the same strength. In addition, because the sheet 112 is insulating, the insert material is expected to have a low heat conductivity. Contemplated materials for the inserts 128 include materials that are of similar a similar chemical composition as the sheet base 118, for example, polystyrene. Using a similar chemical composition facilitates recycling. Other rigid, low-conducting materials are contemplated, such as other plastics and carbon composites.

[0048] FIGS. 7 and 10 show two different shapes for the inserts 128: a basic two-dimensional shape in FIG. 7 and the basic three-dimensional shape in FIG. 10. These are merely illustrative shapes and the present invention contemplates that any insert shape or combinations of insert shapes that have the characteristics described herein may be employed. For example, all the inserts can be two-dimensional or the inserts can be other shapes.

[0049] The protrusion 20 the first embodiment optionally have rounded distal surfaces 26 so that the sheet 12 can be more easily pushed into the first concrete layer 14. The protrusions 120 of the second embodiment are generally thin enough that there is no need to shape the distal surface 126 to make it easier to push the sheet 112 into the first concrete layer 14, although for especially large protrusions 120 or heavy concrete it may be desirable to do so.

[0050] The present invention contemplates two basic ways of anchoring the insert 128 in the sheet base 118, either of which can be used with any insert configuration. In the first anchor configuration, shown in FIGS. 7-9, the embedded section 134 includes one or more holes 136 through which the sheet base material extends, anchoring the insert 128 in the sheet base 118. The number and size of the holes 136 can depend on the size of the inserts 128 and the thickness of the sheet base 118.

[0051] The second anchor configuration, shown in FIGS. 10 and 11, has an anchor face 138 at the base of each
protrusion 120. The anchor faces 138 extend outwardly from the embedded section 134 over the sheet base outer surfaces 122, 124 to sandwich the sheet base 118 therebetween.

[0052] The present invention contemplates that a sheet 12 may include both protrusions of the first embodiment and protrusions of the second embodiment.

[0053] Narrow ducts 32, 132 extend through the sheet 12, 112 at various locations, providing two functions. First, they allow air between the first concrete layer 14 and the insulation sheet 12, 112 to escape while pushing the sheet 12, 112 into the concrete, thereby reducing the possibility of air bubble formation. Second, the ducts 32, 132 facilitate vapor permeability of the final product. The ducts 32, 132 are small enough so that concrete will not fill them. Because a thinner concrete mix would more easily fill larger ducts, the diameter of the ducts 32, 132 is dependent on the viscosity and aggregate mix of the concrete.

[0054] Thus it has been shown and described an insulation sheet and a concrete sandwich assembly constructed thereon that satisfies the objects set forth above.

[0055] Since certain changes may be made in the present disclosure without departing from the scope of the present invention, it is intended that all matter described in the foregoing specification and shown in the accompanying drawings be interpreted as illustrative and not in a limiting sense.

1 claim:

1. An insulation sheet comprising:

a) a sheet base composed substantially of expanded cellular foam and having opposed base surfaces;

b) a plurality of rigid inserts embedded in said sheet base;

c) each of said inserts including an embedded section embedded in said sheet base and protrusions extending away from said opposed base surfaces; and

d) each of said protrusions having a distal surface and a waist that is narrower than said distal surface.

2. The insulation sheet of claim 1 wherein each of said inserts includes an anchor to retain said insert in said sheet base.

3. The insulation sheet of claim 1 wherein said sheet includes ducts that extend through said insulation sheet.

4. The insulation sheet of claim 1 wherein said expanded cellular foam is selected from the group consisting of expanded polystyrene, expanded polypropylene, expanded polyethylene, and expanded copolymers.

5. An insulation sheet comprising:

a) a sheet base composed substantially of expanded cellular foam and having opposed base surfaces;

b) a plurality of rigid inserts embedded in said sheet base;

c) each of said inserts including an embedded section embedded in said sheet base, an anchor to retain said insert in said sheet base, and protrusions extending away from said opposed base surfaces;

d) each of said protrusions having a distal surface and a waist that is narrower than said distal surface; and

e) said sheet including ducts that extend through said insulation sheet.

6. The insulation sheet of claim 5 wherein said expanded cellular foam is selected from the group consisting of expanded polystyrene, expanded polypropylene, expanded polyethylene, and expanded copolymers.

7. A concrete sandwich assembly comprising a first concrete layer, a second concrete layer, and an insulation sheet therebetween, said insulation layer comprising:

a) a sheet base composed substantially of expanded cellular foam and having opposed base surfaces;

b) a plurality of rigid inserts embedded in said sheet base;

c) each of said inserts including an embedded section embedded in said sheet base and protrusions extending away from said opposed base surfaces; and

d) each of said protrusions having a distal surface and a waist that is narrower than said distal surface.

8. The insulation sheet of claim 7 wherein said sheet includes ducts that extend through said insulation sheet.

9. The insulation sheet of claim 7 wherein said expanded cellular foam is selected from the group consisting of expanded polystyrene, expanded polypropylene, expanded polyethylene, and expanded copolymers.

10. A method of constructing a concrete sandwich assembly comprising the steps of:

a) providing an insulation sheet comprising a sheet base composed substantially of expanded cellular foam and having opposed base surfaces, a plurality of rigid inserts embedded in said sheet base, each of said inserts including an embedded section embedded in said sheet base and protrusions extending away from said opposed base surfaces, and each of said protrusions having a distal surface and a waist that is narrower than said distal surface;

b) pouring a first concrete layer into a form;

c) pushing said protrusions of a first of said opposed base surfaces of said insulation sheet into said first concrete layer; and

d) pouring a second concrete layer onto a second of said opposed base surfaces of said insulation sheet.

11. The method of claim 10 wherein said sheet includes ducts that extend through said insulation sheet.

12. The method of claim 10 wherein said expanded cellular foam is selected from the group consisting of expanded polystyrene, expanded polypropylene, expanded polyethylene, and expanded copolymers.