US 20020184846A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2002/0184846 A1**

Crowder (43) **Pub. Date: Dec. 12, 2002**

(54) **INSULATED BUILDING PANEL AND METHOD**

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(21) Appl. No.: **09/877,327**

(22) Filed: **Jun. 11, 2001**

Publication Classification

(51) **Int. Cl.**[7] **E04B 2/00**; E04B 1/38

(52) **U.S. Cl.** **52/507**; 52/762

(57) **ABSTRACT**

Disclosed is a building system with an unusual combination of foam plastic and common structural members. Flanged steel structural members are inserted through openings in wire trusses and the resulting assembly is fused together with foam plastic inside a large mold. Multiple copies of said assemblies are molded into a single large block of polystyrene. This method provides for subsequent separation of the panels using conventional hot wire cutting equipment. The separated assemblies have flat flanges that project toward the panel faces but are hidden under a thin layer of foam plastic. Access to these flanges allows mechanical attachment of panel-joining membranes and a wide variety of surface finish materials. This method simultaneously provides smooth polystyrene surfaces for adhesive attachment of some finishes, including those that utilize glass fiber mesh.

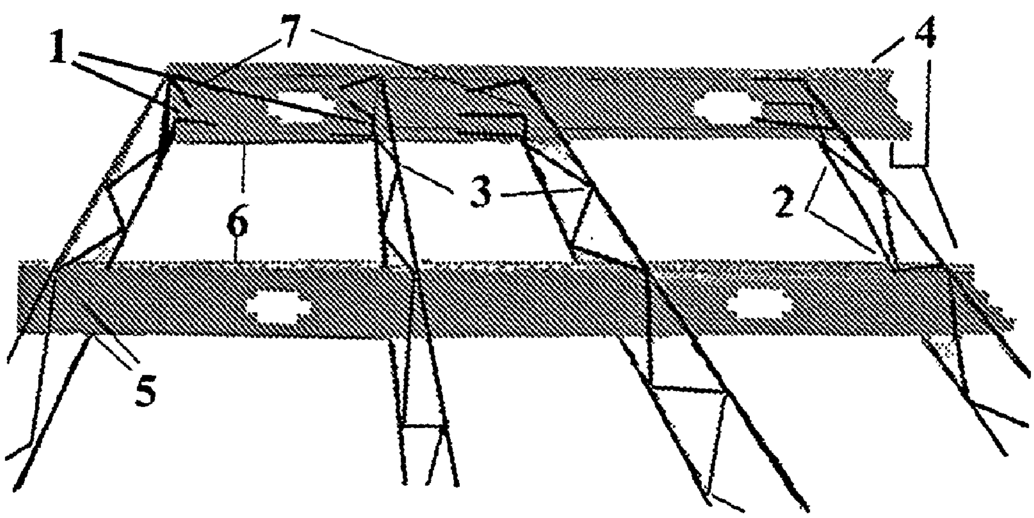


FIG. 1

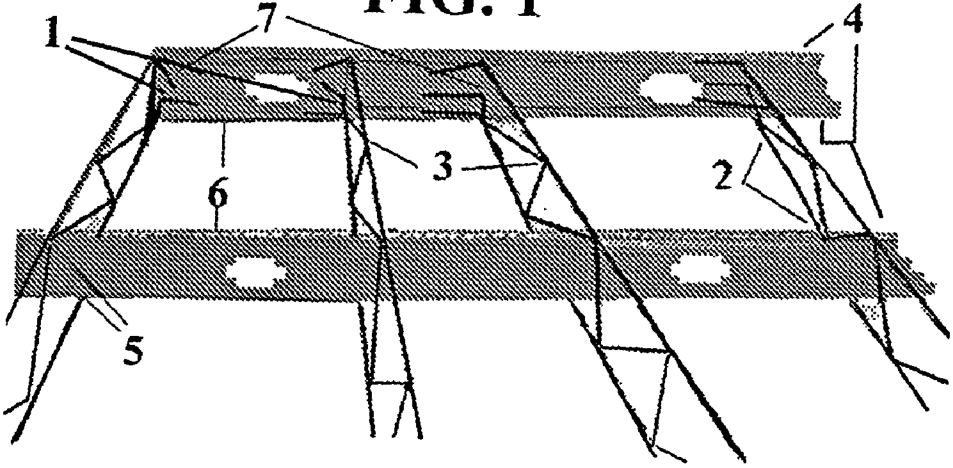


FIG. 2

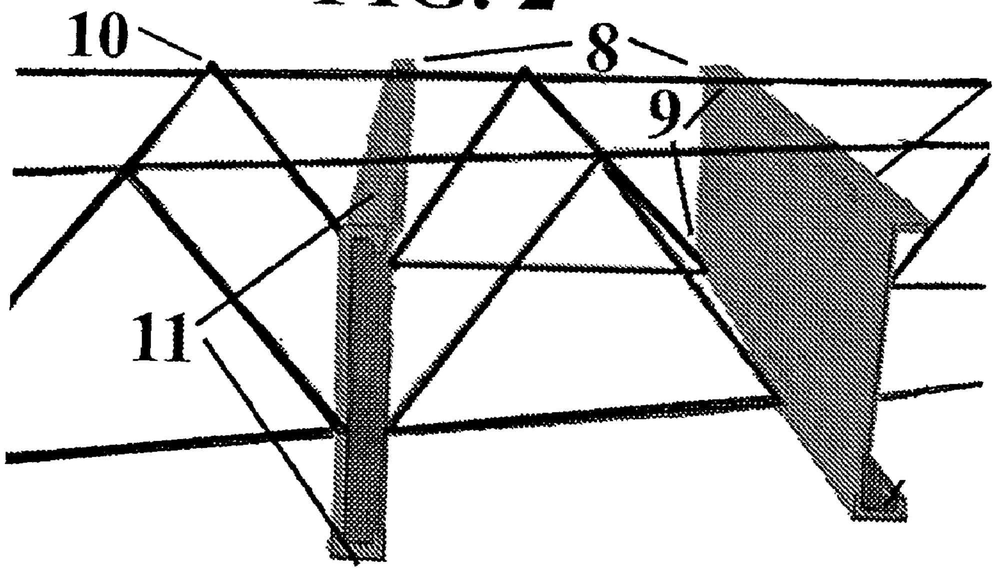


FIG. 3

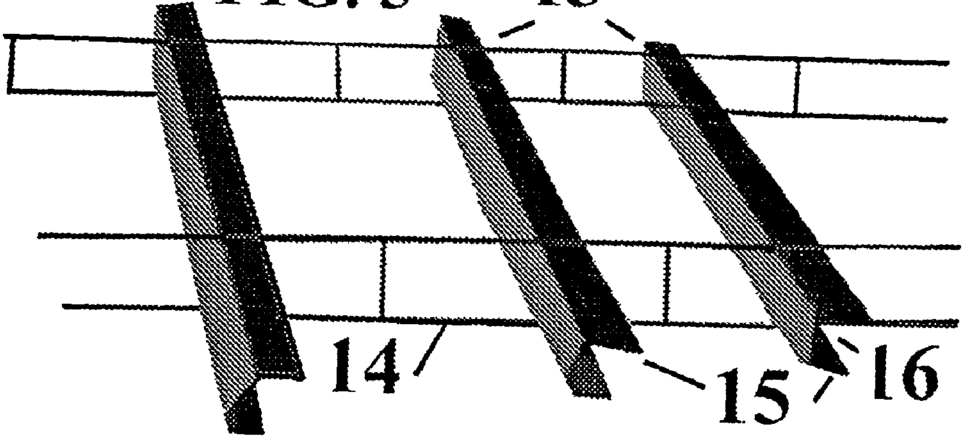


FIG. 4

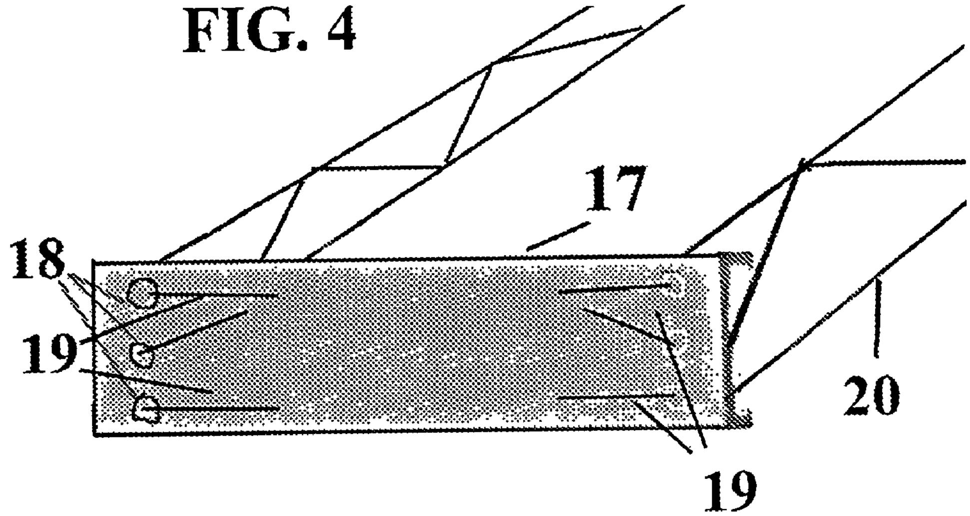


FIG. 5

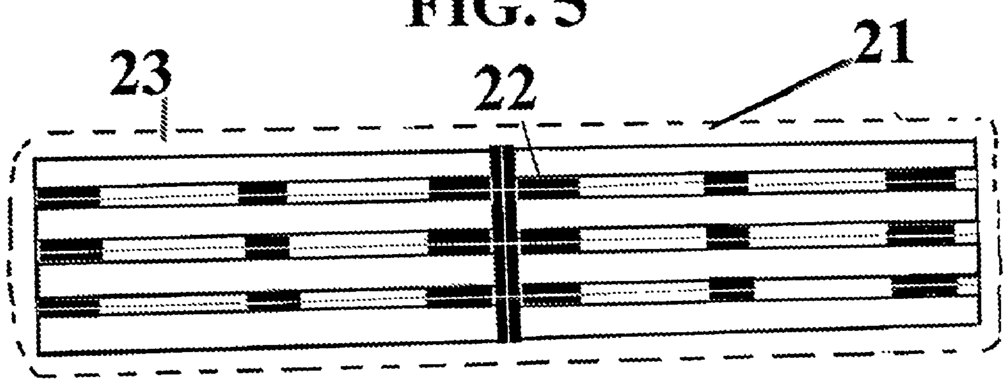
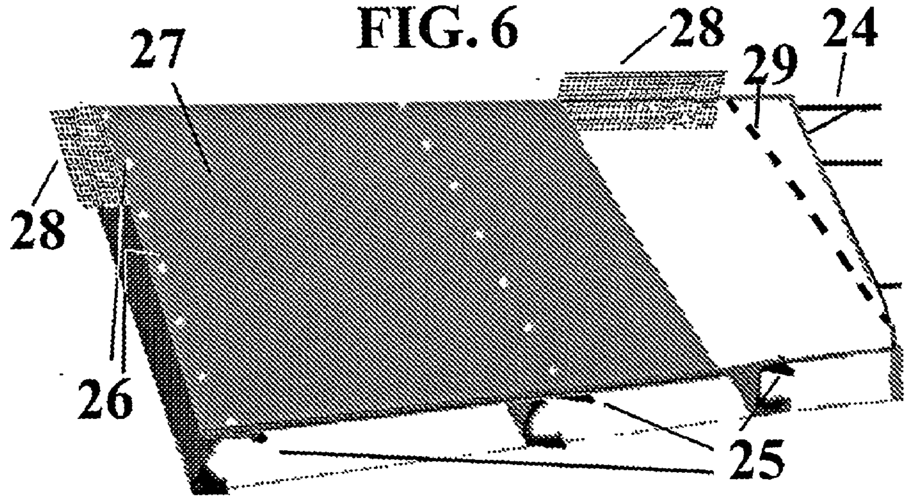


FIG. 6



INSULATED BUILDING PANEL AND METHOD

BACKGROUND

[0001] The invention relates to wall, roof and floor panels used in buildings.

[0002] Description of Prior Art

[0003] EIFS

[0004] The building industry has developed what is known as Exterior Insulation and Finish Systems,(EIFS) which are primarily non-loadbearing curtain walls. A descriptive monograph by the Construction Specifications Institute is cited. EIFS panels typically consist of steel or wood studs, exterior and interior gypsum boards with polystyrene boards attached with an adhesive to the exterior face. The polystyrene boards are covered with a lightweitht glass fiber mesh, a polymer-based adhesive and synthetic stucco. The stud cavity is filled with fiberglass insulation. These systems are found to deteriorate due to the formation of moisture inside the stud cavity, which has caused the water-sensitive gypsum to deteriorate. Corrective measures include drainage systems, such as that disclosed by U.S. Pat. No. 5,826,388.

[0005] Foam Plastic Concrete Forms.

[0006] Many wall systems consist of concrete molds made of polystyrene to hold columns of concrete. In U.S. Pat. No. 4,879,855 Berrenberg discloses fusing polystyrene to steel diamond mesh inside special molds. Other patents have been granted that disclose similar end products and methods, with novel differences in the reinforcing members and their relationship to other members. Each design uses a custom mold in factories with procedures for controlling variables in raw materials and the environment. Building Code acceptance of these products generally requires special factory inspections by approved inspection agencies. The continuing acceptance of the products of the Berrenberg and similar patents teach that steel reinforcing members can be successfully bonded to polystyrene in molds.

[0007] TRIANGULAR WIRE TRUSS SYSTEMS similar to those in this invention are used with other foam plastic systems. U.S. Pat. No. 4,297,820 describes one of these systems. The trusses are typically not more than 4 inches deep and vertically spaced 3 to 6 inches apart with strips of polystyrene manually placed between the trusses. The relatively low load resistance of the individual trusses dictates this close spacing of the trusses. After installation of the polystyrene wire mesh is clipped or welded onto the truss wires to cover both faces of the panels. The panels are joined together at the building site with strips of wire mesh, typically using "C" rings crimped onto the mesh covering the panel faces. The mesh is then covered with sprayed concrete to create load-bearing panels. The panels are heavy, strong, lightweight and provide good insulation, but the wire mesh is typically installed at the factory without a weather barrier, and field attachment is not possible because the round wire mesh does not accept required mechanical fasteners. Sprayed concrete has been known to crack, and water has penetrated through these systems. U.S. Pat. No. 6,202,375 criticizes these systems, and references U.S. Pat. No. 4,297,820. The criticism includes the requirement for expensive manufacturing machinery to make the trusses and the special wire mesh.

[0008] U.S. Pat. No. 5,085,345, discloses a series of "zigzag shaped reinforcing rods" which are inserted into slits cut or melted into foam plastic panels prior to attachment of wire mesh. The tips of the rods are joined to a wire mesh that is sprayed with a cementitious material in the end use configuration. Use of weather barrier and choice of surface finish materials are both inhibited by the difficulty in attaching screws or other fasteners to round wires.

[0009] Steel Bonded to Foam Plastic

[0010] U.S. Pat. No. 4,241,555 discloses a panel with steel members bonded onto surfaces of a foam plastic panel. In this invention one panel is molded at time in a special mold. This disclosure demonstrates that thin strips of metal adhere to previously cured polystyrene when both are placed in a special mold.

[0011] U.S. Pat. No. 4,409,768 discloses a panel with steel structural members and wire-reinforced paper bonded to foam plastic that is in a liquid state prior to molding. Urethane foam may be the only foam plastic suitable for this process. These panels have vertical and horizontal support members exposed on the exterior faces. One panel is produced from each molding cycle.

[0012] U.S. Pat. No. 4,653,718 discloses a special mold that produces a single panel with steel reinforcing members molded inside. The process includes the attachment of metal strips pre-treated with an heat-activated adhesive and a wire mesh extending from the foam plastic core into a cavity formed on 1 panel surface. This patent demonstrates the validity of fusing a variety of metal reinforcing members with polystyrene in a special mold.

[0013] U.S. Pat. No. 4,620,569 discloses a method of fusing structural members with polystyrene to make a single panel in a special mold. The use of a supplemental adhesive to ensure effective bonding is described. Part of the panel framing members are utilized as the mold assembly, becoming part of the panel, and remaining exposed in the end use configuration.

[0014] U.S. Pat. No. 6,205,728 discloses a building panel utilizing folded metal sheets, wires, wire mesh, steel ribbons and other components assembled and combined either with foam plastic in a special mold or laminated together. The process includes an automated system of spool feeding wires, which may be computerized, pins, adhesives and other complexities. One claim discloses use of a synthetic corrugated structural sheet that is first coated with a heat-activated adhesive and fused inside a special mold that is described as being portable. The disclosure claims use of any generic or custom structural shapes, a wide variety of membranes for use on panel exteriors. This disclosure teaches that a wide variety of rigid shapes can be successfully bonded with foam plastic in a mold, including many of the shapes bonded inside molds in patents cited above. This disclosure does not claim any combination of wire trusses with flanged reinforcing members, the option of using either mechanical or adhesive attachment methods, the use of standard equipment to make and separate multiple panels, and other novel features of the present invention.

OBJECTS AND ADVANTAGES OF THE INVENTION

[0015] It is the object of this invention to provide novel solutions to a variety of problems that have been recognized in the following described systems since the building industry began extensive use of foam plastics.

[0016] EIFS

[0017] The problem of moisture in EIFS panels is overcome by this invention because the stud cavity, with its condensation, is replaced with reinforced foam plastic.

[0018] Concrete Forms

[0019] This invention provides adequate structural strength, acceptance of a wide variety of wall, floor and roofing finish materials without the need for heavy concrete required by the concrete forms systems.

[0020] Structural Members Bonded to Foam Plastic

[0021] Problems inherent in these systems include quality control of the bonding process, which, if done in molds, requires highly specialized equipment and careful quality control by highly experienced personnel. The typical process used to bond structural members involves use of adhesives on foam plastic panel exteriors. An adhesive coating is placed on one or both surfaces being joined, pressure is applied, and curing time is allowed before the panels are moved. The materials and the processes require skilled workers capable of making adjustments to problems which inevitably arise. Some systems require complex cutting and shaping of the foam plastic in order to properly insert the steel members. These systems are typically have limited applications due to rigidity of the designs. In this invention building panels with adequate strength to resist a variety of axial, transverse and racking load requirements are produced without detailed fitting and bonding of each structural member. The load resistance and insulation values of the panels in this invention are altered according to the materials selected. The steel industry produces many sizes of wire trusses and flanged structural members that fit into the design of this invention. In this invention larger trusses, with larger flanged members fitted into them provide increased load-carrying capacity and greater resistance to heat transfer without adversely effecting the versatile attachment advantages or limiting choices of finish materials.

[0022] Wire Truss Triangle Systems

[0023] This invention overcomes multiple problems inherent in systems using wire trusses and round wire mesh on panel exteriors, such systems being generally limited to one finish material, which is concrete. The need for custom-cutting foam plastic segments and hand-fitting them between closely spaced trusses is overcome in this invention by fusing the foam plastic around the structural members and producing a monolithic panel. The use of reinforcing members provide support in the spaces between the trusses, allowing wider spacing.

[0024] In the typical wire truss systems the vertical joints that occur at each truss provide a path for water leakage, which problem is aggravated by the omission of a weather barrier. The outer surface of these systems is typically wire mesh, which does not allow screw attachment of weather barriers or conventional siding using mechanical fasteners.

[0025] Such systems depend on specialized wire-bending and fabricating machinery at each factory. This invention uses wire trusses and common steel framing members that are mass-produced for other uses and available at building material outlets all over the world.

[0026] This invention provides flat surfaces ideal for the installation of a weather barrier. In this invention the foam plastic is quickly molded around the steel structural members, eliminating joints inside each panel to invite water penetration.

[0027] The construction of special molds is eliminated by using the same molds that regularly make large foam plastic blocks. The same cutting equipment used to segment the blocks is used to separate the panels in this invention.

[0028] This invention provides convenient use of screws or other mechanical fasteners at proper spacing for the installation of gypsum boards, expanded metal lath, stucco, vinyl siding, hardboard siding and many other common mechanically fastened finish materials.

[0029] In this invention the insulation is not hand-placed but is properly located and firmly retained in place by total encapsulation in foam plastic. This invention also invites the use of adhesive finishes that serve as a weather barrier. Adhesive attachment is obtained because the flat steel screw bases (flanges) are concealed under a thin layer of foam plastic, and do not interrupt the smooth panel surfaces. The present invention comprises only 3 parts: 1. Off-the-shelf wire triangular trusses, 2: off -the-shelf steel flanged members, and 3: foam plastic. The machinery required to produce the panel in the present invention is the same foam plastic molding equipment used to produce and cut large foam plastic blocks, which are primarily polystyrene and urethane. Because expanded foam plastic is relatively inexpensive and bulky it is not economically feasible to ship it over long distances. The unexpanded styrene monomer and liquid urethane components are twenty 5 to 40 times more dense than the expanded end-use product. Consequently, foam plastic concentrates are shipped in the dense form to local plants where they are expanded and molded into large blocks. The blocks are then cut into marketable board sizes. The standardized foam plastic molding and cutting equipment used to produce the panels in this invention are located in permanent factories with effective quality control programs. The equipment used in this invention is widely distributed and in daily use. It is highly developed and efficiently operated with trained crews who overcome numerous quality-control problems caused by variables in raw materials, temperature, humidity, and other unpredictable circumstances.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] **FIG. 1** displays a structural framework consisting of welded wire trusses with steel studs inserted into wide-angle triangular openings. At the ends the truss wires are bent and inserted into the end-plate cavity.

[0031] **FIG. 2** is a view of studs inserted into truss triangles with 45-degree openings.

[0032] **FIG. 3** is a view of an "H" truss with steel studs inserted at the center point between welded cross wires.

[0033] **FIG. 4** is a view of an alternate method of joining wire trusses to end plates.

[0034] **FIG. 5** is a view of 8 steel reinforcing assemblies held into position for molding by foam plastic spacer blocks.

[0035] **FIG. 6** is a view of a finished panel with sections cut away for clarity.

DETAILED DESCRIPTION OF THE INVENTION

[0036] With reference to **FIG. 1, a** structural framework is displayed, consisting of steel studs **4**, fitted into welded wire trusses **3**. The truss wires spread from the apex **3** to spacing 16 inches wide **2**. These 4 inch-deep wide angle triangle trusses are manufactured for reinforcing masonry walls, in which application they are embedded in wet mortar placed between horizontal layers of concrete blocks. When hardened, the mortar braces the trusses. In this invention steel structural members **4** brace the triangles at the point of widest span **5**. The structural members in this example are 3⅝-inch "C" studs **4** that, by coincidence, closely fit into this particular truss at point **5**. Other structural members of the correct dimensions, having **2** flat flanges **6**, including the track made to fit over the ends of studs, perform satisfactorily. In addition to bracing the trusses the studs provide resistance to loads in the area between the trusses allowing wider truss spacing. The studs also provide flat flanges **6** for attachment of metal self-tapping screws. These flanges project toward the two faces of the panels for attaching a wide variety of interior and exterior finish materials. At the ends of the trusses the truss wires **1** are bent ninety degrees and fitted into the cavity of the end plates **7** at both ends of the panel assembly. Friction against the end plate cavity **7** holds the trusses in position until the assembly is fused together in a foam plastic mold. This fusing holds the end plates to the body of the panel during transport and installation. Mechanical fastening of interior and exterior finish materials, which span multiple structural members, augments the attachment of the trusses to the end plates. This attachment is further illustrated in **FIG. 6**.

[0037] **FIG. 2** is a view of structural members **8** inserted into 45-degree truss triangles **9**. The studs in this example are placed in alternating triangles, but spacing is a useful option of the builder. The economy of wider spacing is acquired at the cost of reduced load resistance. Trusses with different dimensions are readily available, as are a wide variety of other structural members with two flanges **11**. The triangles are closed with 10-gauge wire **10**, which is welded to the apex of each triangle. The triangular trusses displayed were manufactured for reinforcing concrete masonry walls, in which application they are embedded in wet mortar placed between horizontal layers of concrete blocks. In this example the trusses are 10 inches deep.

[0038] **FIG. 3** is a view of flanged reinforcing members **13** installed through "H" trusses **14**. The reinforcing member flanges **15** fit tightly into the truss opening **16** at the point of widest span, bracing the truss and providing load resistance in the space between the trusses. The flat flanges **15** project toward the **2** faces of the panel. The truss wires **14** and the reinforcing member flanges are hidden under a thin layer of foam plastic after molding, but accessible for installing screws that easily penetrate through the finish material and into the flanges **15**. **FIG. 4** is a view of another method of joining wire trusses **20** to end plates **17**, in which holes **18** are drilled through the end plates with truss wires **19** inserted through the holes and bent ninety degrees. **FIG. 5** is a view of panels stacked into position in a mold, wherein the checked line on the outside of the drawing **21** represents the interior of the mold. Molded blocks are made with one or more inches of excess material, represented by the space **23** that is irregularly shaped and trimmed away from the central block. The dark sections of the drawing **22** represent cured foam plastic spacer blocks that hold the structural steel assemblies in place during molding. The spacing is enlarged for clarity. Actual spacing is less than one inch. After molding the panels are separated using conventional hot wire or other cutting equipment which cuts the new foam plastic and the spacer blocks with equal ease. The molding operation illustrated in this figure produces eight panels measuring 4 feet wide by 8 feet long and less than 6 inches thick.

[0039] **FIG. 6** is a view of a partially dissected panel reinforced with 4 inch-deep truss wires **24**. This panel has been separated from other panels that were molded simultaneously in a typical polystyrene mold. Using the hot wire method that routinely cuts large polystyrene logs into segments, multiple panels 4 feet wide, 8 feet long and less than 6 inches thick were produced. Wire trusses and steel structural members are hidden inside. The stud flanges **25** were hidden beneath smooth polystyrene nominally ½ inch thick after separation, allowing the use of short metal screws **26** to attach finish materials **27** and panel joining devices **28**. The ends of the studs **25** were also concealed, but have been cut away to allow viewing. Finish materials are displayed **27**, with lines of screw heads visible along the studs **26**. The end plate is mechanically fastened to the next stud **25** by the finish material **27**. In this example the finish material substrate is steel metal lath **28**, also called diamond mesh. It is attached with self-tapping metal screws **26** spaced 8 inches apart in accordance with building code standards. Joining plates **28** are used to connect adjacent panels. These plates augment the attachment of the end plates to other panel structural members. The plates shown are wire mesh. Other substrate materials include stucco netting, plywood, gypsum sheathing and expanded metal lath. The exposed polystyrene surface in this example reveals markings **29** applied at the factory to locate hidden stud flanges.

[0040] The descriptions provided have disclosed components and methods that reveal a general description of this invention. It is reasonable to assume that other components and methods that perform like or similar functions are also within the sphere of this invention.

What is claimed is:

1. A structural building panel and the method of simultaneously manufacturing multiple copies of it wherein multiple assemblies of wire trusses and steel reinforcing members are embedded inside a foam plastic block in large molds.

2. The building panel of claim 1, wherein the wire trusses are comprised of multiple triangles made of round wire with the wide segment on each triangle and the apex of an adjacent triangle having straight wires welded across them to form multiple aligned triangles into a longitudinal truss, and the reinforcing members comprising flanged structural members with the correct dimensions to fit into and through the truss triangles to form a structural assembly with the structural members being strategically spaced to strengthen the triangle at its point of widest span, and the reinforcing member flanges positioned for use as a screw base when attaching siding to both panel faces.

3. The building panel of claim 1, wherein the wire trusses are comprised of "H" or "ladder" trusses made of round wire with each segment having multiple straight wires welded across them to form multiple rectangles of a longitudinal truss, and with flanged reinforcing members of correct dimensions to fit into and through the truss openings, with the reinforcing members positioned to strengthen the truss at the point of widest span, and the reinforcing member flanges situated for use as a screw base when attaching siding to both panel faces.

4. The building panel of claim 1, wherein the multiple copies of said structural assembly are placed inside a mold, separated and held in position from each other by spacer blocks made of the same foam plastic in a cured state, and fused inside a molded block of foam plastic.

5. The building panel of claim 1, wherein the foam plastic molding machinery is comprised of the common and widely distributed machinery used in factories to make large blocks of foam plastic.

6. The building panel of claim 1, wherein the multiple copies of said panels are separated from each other by the same methods and equipment routinely used to cut foam plastic blocks into marketable segments.

7. The building panel of claim 1, comprising a separated panel with concealed structural members inside, said members being wire trusses and reinforcing members with 2 flanges projecting toward the 2 faces of the panel, said flanges being hidden under a thin layer of foam plastic, the foam plastic being configured with smooth surfaces.

8. The building panel of claim 1, comprising a method of joining separate panels together in a building structure by adhesively attaching 1 or more layers of a membrane such as glass fiber mesh over the smooth faces of the foam plastic and onto adjacent panels, the membrane, adhesive and process developing the full strength of the membrane and exceeding the tensile strength of the foam plastic, said adhesive and membrane also comprising a weather barrier.

9. The building panel of claim 1, comprising a method of joining separate panels to adjacent panels in a building structure by mechanically attaching steel mesh or other membrane to multiple reinforcing member flanges on the panels using a plurality of mechanical fasteners such as self-tapping screws, the membrane being capable of resisting stresses at least equal to the design loads of the end use configuration of the panel in the building structure.

10. The building panel of claim 1, wherein the locations of the hidden flanges are identified by markings using a stencil on both faces of the panel.

11. The building panel of claim 1, comprising the adaptation and joining together of 4-inch-deep wire triangular trusses with nominally 16 inch spacing on the wide segment of the triangles, and common steel "C" studs, 3⅝ inches wide, both said trusses and said studs being manufactured and widely used for different and separate functions, and fusing the joined assembly with multiple copies of it together with foam plastic in a mold.

12. The building panel of claim 11, wherein the multiple copies of said panels are separated from each other by the same methods and equipment routinely used to cut foam plastic blocks into marketable segments

13. The panel configuration of claim 11, wherein the finish system on **1** face of the panel is gypsum wall board, and the finish on the other face is stucco, and providing temporary mechanical attachment of a weather barrier on the face receiving stucco, such as asphalt-impregnated paper, and providing for permanent attachment of exterior finish system components such stucco lath, woven wire netting or diamond mesh by inserting sheet metal screws through the mesh, weather barrier and the concealing layer of foam plastic into the hidden stud flanges.

14. The building panel of claim 11, comprising a method of joining a separate panel to adjacent panels by mechanically attaching steel mesh or other membrane to multiple stud flanges on the panels using a plurality of fasteners such as self-tapping screws, the membrane being capable of resisting stresses at least equal to the design loads of the end use configuration of the panel in the building structure.

15. The building panel of claim 11, comprising a method of joining panels together by adhesively attaching **1** or more layers of a membrane such as glass fiber mesh over the smooth faces of the foam plastic and onto adjacent panels, the adhesive and process developing the full strength of the membrane and exceeding the tensile strength of the foam plastic, said adhesive and membrane also comprising a weather barrier.

16. The building panel of claim 11, wherein the locations of the hidden flanges are identified by markings using a stencil on both faces of the panel.

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