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(54) **PROTECTIVE WALL PANEL ASSEMBLY**

(76) Inventor: **Jeffrey Alan Hanks**, Midlothian, VA (US)

Correspondence Address:
E I DU PONT DE NEMOURS AND COMPANY
LEGAL PATENT RECORDS CENTER
BARLEY MILL PLAZA 25/1128
4417 LANCASTER PIKE
WILMINGTON, DE 19805 (US)

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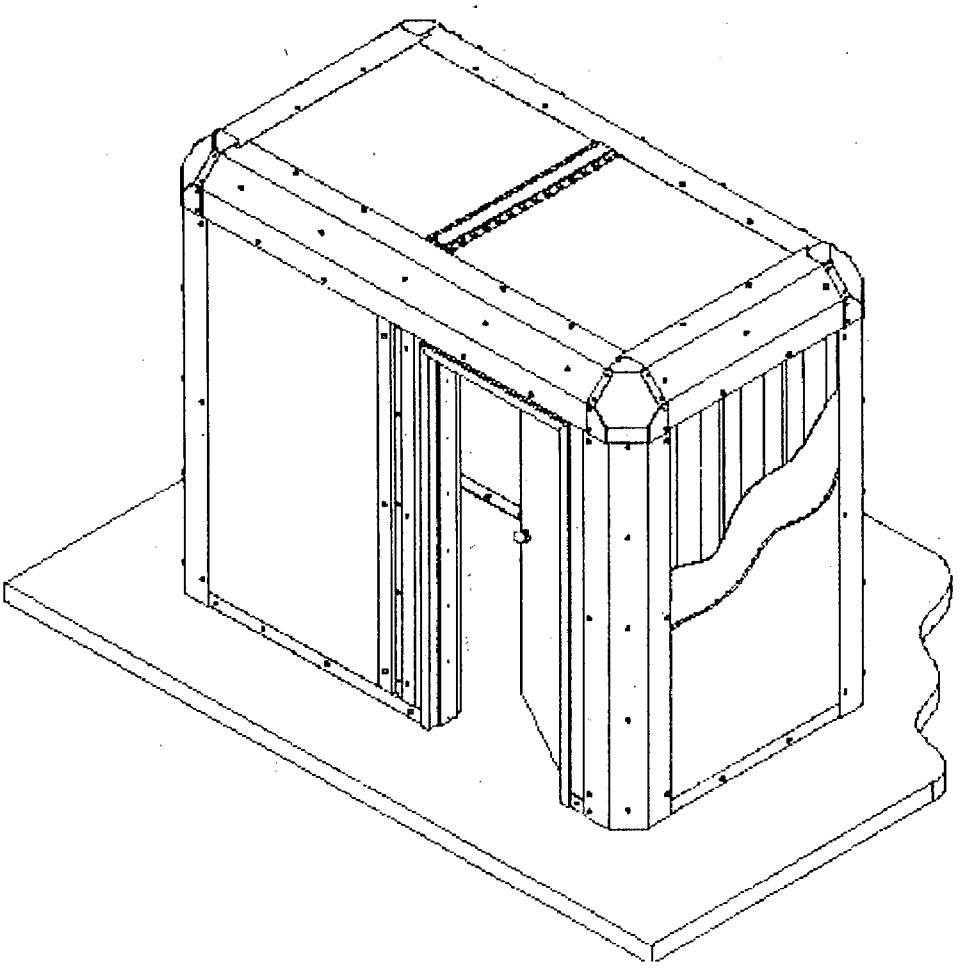
(57) **ABSTRACT**

An assembly of wall panels particularly suitable for protection against wind blown debris or an explosion includes a bent strap connecting an air gap between adjacent wall panels with the bent strap capable of flexing due to a sudden external force.



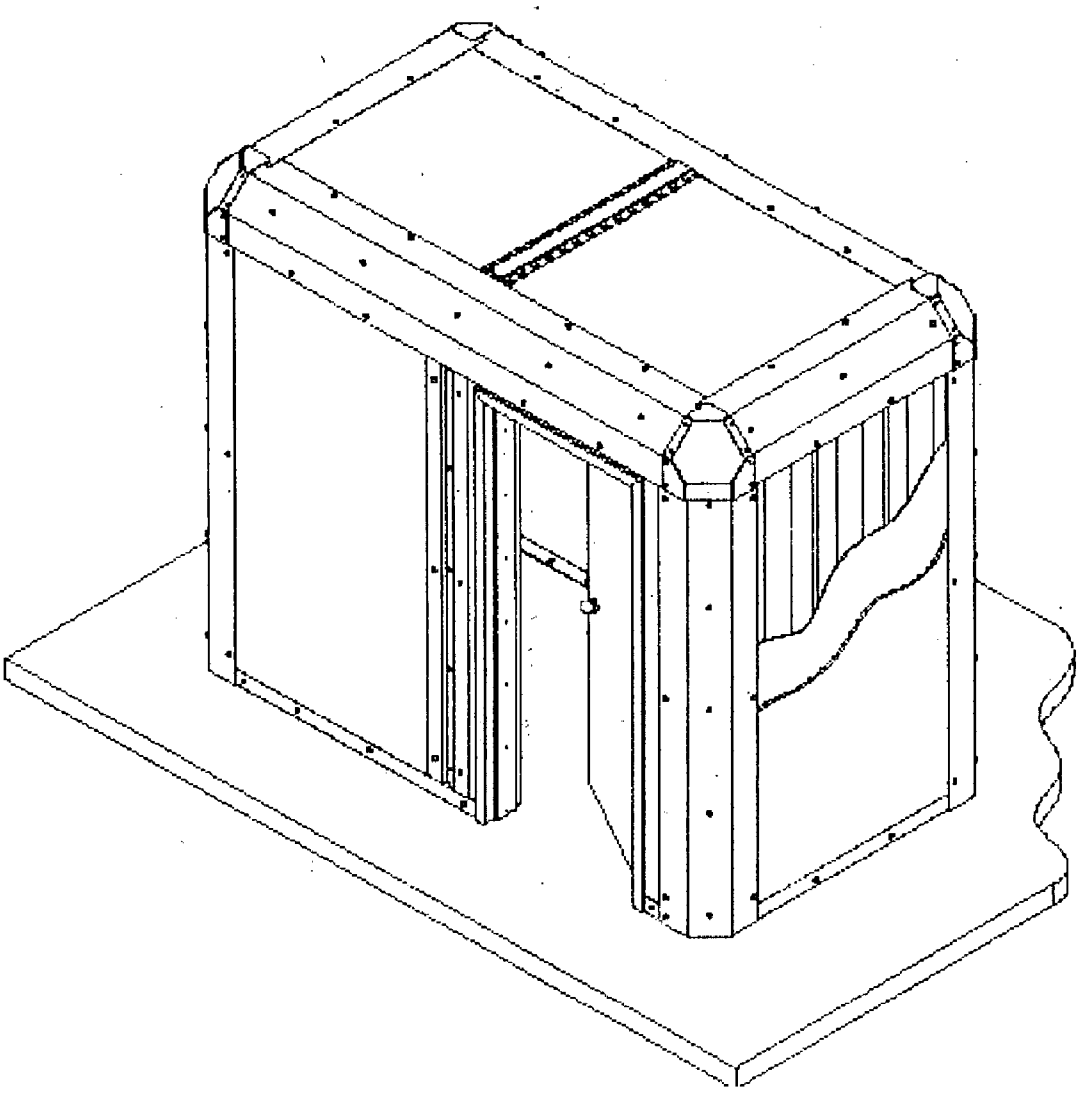


FIG. 1

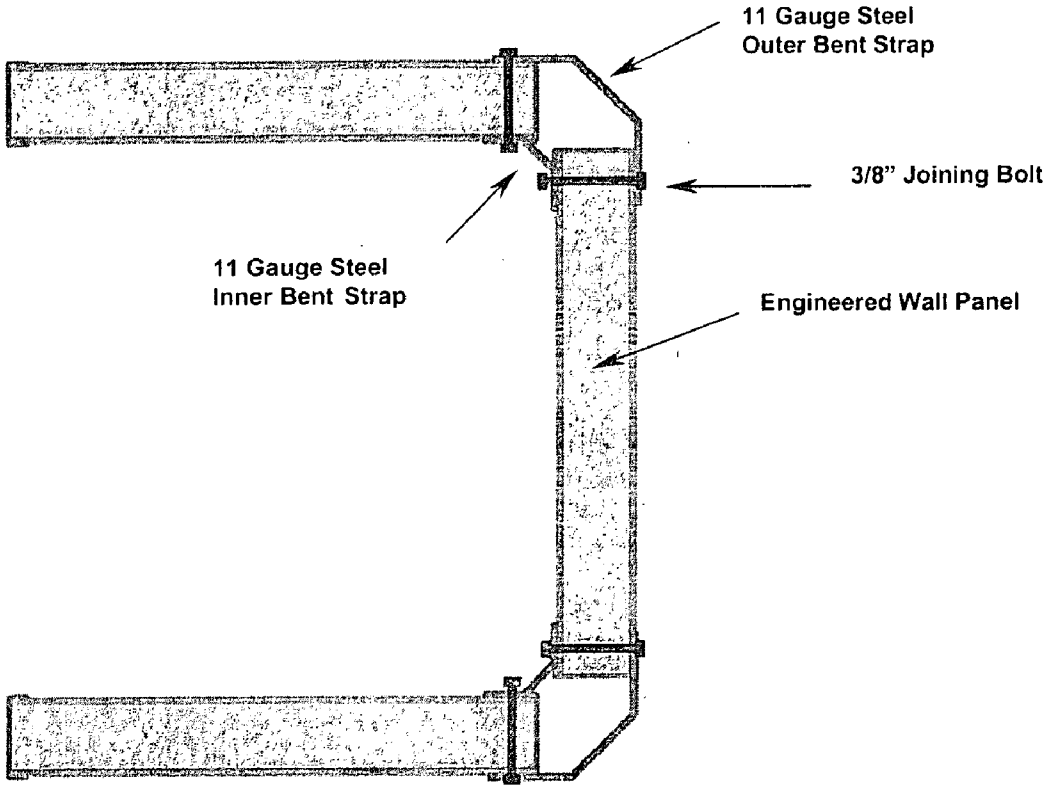

11 Gauge Steel
Outer Bent Strap
3/8" Joining Bolt
11 Gauge Steel
Inner Bent Strap
Engineered Wall Panel

FIG. 2

PROTECTIVE WALL PANEL ASSEMBLY

TECHNICAL FIELD

[0001] The invention relates to a method for the assembly of protective wall panels using a bent strap-joint to provide improved resistance to impact loads such as generated by severe storm events and explosive blasts.

BACKGROUND OF THE INVENTION

[0002] Storm and blast shelters are necessary to provide a safe haven for civilian protection against severe storm events in regions prone to tornado or hurricane activity and military protection from explosive blast events. Protective wall and building designs are known in the art and take on various forms. Wall designs proposed for severe storm events are detailed in various reports developed for, or by, the Federal Emergency Management Agency (FEMA). Various wall designs for blast resistant shelters are detailed in patent art.

[0003] In Taking Shelter from the Storm (FEMA Publication 320) and Design and Construction Guidance for Community Shelters—(FEMA Publication 361) design for construction of walls and buildings to resist tornado generated wind loads and debris impact are described. Wind impact resistant walls of other designs are detailed in a report dated May 31, 2000 by Clemson University submitted to the Federal Emergency Management Agency entitled "Enhanced Protection for Severe Wind Storms. While these designs do not meet Tornado Impact criteria, they do provide enhanced protection from less severe storms.

[0004] U.S. Pat. No. 3,994,105, U.S. Pat. No. 4,143,501, U.S. Pat. No. 4,566,237, U.S. Pat. No. 4,691,483, U.S. Pat. No. 4,748,790 and U.S. Pat. No. 4,937,125 each detail some of the various forms for blast and bullet resistant walls and buildings.

[0005] Many of these engineered wall systems provide the capability to produce modular wall systems that are subsequently assembled in the field for use. When such modular approaches are used, a simple field joint that enables easy assembly provides for structural load transfer and yet provides impact resistance is desirable.

[0006] It is well known in the art that if some flexibility can be engineered in the direction of impact, that such flexibility will improve overall impact resistance. The various wall designs in the art that have such flexibility must be joined together in a manner that does not restrain the movement of these wall systems, especially near the point of attachment. This is most critical near joints where walls abut one another at corners or other non-planer joints where one wall can substantially restrain the movement of the other.

[0007] A substantial need exists for a method for the assembly of protective wall systems for wind and blast resistance that provides improved flexibility between wall segments. A particular need exists for a joint between non-planer wall segments that is easily assembled in the field and provides improved flexibility.

SUMMARY OF THE INVENTION

[0008] The present invention is directed to an assembly of wall panels particularly suitable for protection against wind blown debris or an explosive blast comprising;

[0009] (a) at least two wall panels positioned in a non-planer orientation to one another wherein an air gap is present between two adjacent wall panels;

[0010] (b) at least one bent strap spanning the air gap between two adjacent wall panels wherein the bent strap is rigidly connected to adjacent wall panels and wherein the strap is capable of flexing due to an external force on a wall panel such as from an impact resulting from wind blown debris or an explosive blast.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] **FIG. 1** is a schematic of a shelter system of Example 1.

[0012] **FIG. 2** is a schematic of wall positions connected by strapping of Example 1.

DETAILED DESCRIPTION OF THE INVENTION

[0013] In the present invention it is necessary to employ at least one wall panel capable of withstanding a force generated from a sudden impact such as wind blown debris of from an explosion. The types of wall panels are varied and can be formed from a metal such as steel, from wood or from a composite of several different materials. Although typically there will be wall damage due to an impact, the purpose of the wall is to maintain its integrity such as to protect a person within a room of a building. Although only one impact resistant wall panel can be employed to protect against an external force, it is desirable for greater protection to employ two adjacent wall panels to have impact resistance.

[0014] The protection from a wall panel will depend on its construction. The greater the ability to withstand force will in turn offer a greater protection. An example of a test procedure to determine impact resistance is ASTM procedure E 1886-97. Illustratively a 33 kilogram (15 pound) 2×4 lumber projectile is employed to impact a wall. The ability of the wall to withstand a projectile speed is a measure of determining its resistance. A desirable resistance is an at an impact speed of 161 kilometers (100 miles) an hour. Less resistance would be at failure at impact speeds above 80 or 90 miles an hour.

[0015] In similar fashion to determining resistance in accordance to ASTM procedure E 1886-97 test procedures to obtain a desired resistance to a force generated from an explosion can be used to determine the type of wall panel to be employed.

[0016] For windblown debris a suitable wall constructions are described in U.S. patent application 09/977,648 filed 15 Oct. 2001 and 10/308,492 filed 3 Dec. 2002 incorporated by reference herein. An example of a construction is a composite comprising in order:

[0017] (a) a layer of material having a density not greater that 0.10 grams per cubic centimeter,

[0018] (b) a layer of a fabric containing fibers bonder with a resin and

[0019] (c) a layer of structural sheathing.

[0020] A necessary portion of the construction of the wall assembly is the use of a strap to connect adjacent wall panels. As employed herein the term strap means a band or plate for holding an object in a fixed position. Although the strap may be of metal construction, such as steel or aluminum, other materials are suitable such as plastic or a composite of different materials.

[0021] The strap is rigidly connected to adjacent wall panels and holds the panels in place. However, the strap is capable of flexing due to a force on a wall panel. It is directly understood that the amount of flex of the strap will be determined by its end use. Illustratively, a need for a greater resistance to an impact will determine a greater resistance to flex. Also the amount of stap flex will be determined by the number of straps connecting adjacent wall panel. The greater number of straps, the lesser is a need for resistance to flexing.

[0022] For purposes of illustration both single and double straps are suitable. An example of a suitable thickness for a metal strap is from 0.06 inches (1.5 mm) to 0.375 inches (9.5 mm) such as 0.075 inches (0.19 mm) to 0.150 inches (3.8 mm).

[0023] Although a strap may be employed on only an inner or outer wall portion, preferably individual straps are present to connect adjacent wall panels on inner and outer walls. As employed the term inner means portions of wall which face one another, such as walls that form the interior of a room. The term outer means portions of a wall which do not face one another, such as walls that form the exterion of a room. The strap or straps connect walls in a non-planer orientation, i.e. the wall are at an angle to one another. For purpose of illustration most walls are joined at an angle of 90 degrees. An example of two walls joining one another is an angle within a range from 30 to 120 degrees. Also generally there will be an air gap between adjacent wall since if the wall touch there may be an inability for the strap to flex properly upon a sudden impact. A typical air gap is considered to be at least 3 mm (0.125 inches). In a preferred construction a wall capable of withstanding a sudden impact is joined to two adjacent wall with straps on both on inner and outer wall surfaces connecting adjacent walls.

[0024] In the above disclosure the combination of a wall assembly with use of straps has been describe in relationship to resistance and protection of a sudden impact such as from wind blown debris and an explosion. However it is within the scope of the present invention that a wall assembly need not possess such resistance. Therefore, wall panels can be employed with such resistance to an excess sudden impact. In turn the staps would have the ability to flex under a minimum amount of force upon one of the wall panels.

[0025] To further illustrate the present invention the following example is provided.

EXAMPLE 1

[0026] A shelter system shown in **FIG. 1** with external dimensions of 115 inches long by 64 inches wide by 94 high was assembled from engineered wall and roof panels designed to protect occupants from windborne debris generated by tornadic winds. Five wall panels and a modular door unit, each 48-in wide by 88-in high were used. Two ceiling panels that were 48-in wide by 48-in long were used for the roof. Panels were produced using, in order, 1 layer of 3/4-in plywood, followed by a 5-1/2 inch thick steel reinforced expanded polystyrene core with a density of 1 lb/cu-ft (0.016 gm/cc), followed by a laminated fabric made from 3 layers of a 13 oz/sq-yd aramid cloth that was bonded together with a polyethylene co-polymer resin, followed by one 1 layer of 1/2-in plywood. Steel reinforcement within the core, was done with 24-gauge 2×4 common metal framing studs on 16-inch centers that were laid flat on each face of the panel. Reinforcement was added during the foaming process as described in U.S. Pat. No. 4,241,555. The layers of material were joined together by fastening with power driven knurled nails driven on each face of the panel, around the perimeter on 3-in centers and along the field studs on 6-in centers.

[0027] The panels were assembled as shown in **FIG. 2**, using two, 11 gauge (0.12-inch thick) sheet metal brackets that were bent in two places with 45° angles to create the 90° corner connections required to assemble the rectangular shelter. The 1/2 plywood face was oriented outwardly. Three, 3/8-in diameter bolts were used to fasten the edges of each panel to the metal strap connector. A space of 3/8-in was present between the corners of any adjacent panels that were connected.

[0028] The shelter was impacted in several locations with a 15-lb 2×4 (inches) timber projectile traveling at 100 mph, to access ability to meet the "Windborne Missile Impact Resistance on Shelter Wall and Ceiling" provisions of the National Performance Criteria for Tornado Shelters, First Addition, FEMA, May 28, 1999. Cannon set-up and firing was done in accordance with ASTM E 1886-97.

[0029] All projectiles fired at the shelter were stopped from passing through it, as required by the FEMA provisions, and the projectile was rebounded back. High speed photography taken during the event showed the joints to flex inwardly upon impact, helping to absorb a portion of the energy from the projectile. The plywood layer on the backside showed only very minor cracking around the impact point. The shelter assembly was deemed compliant with the provisions of the National Performance Criteria for Tornado Shelters.

What is claimed:

1. An assembly of wall panels comprising;

(a) at least two wall panels positioned in a non-planer orientation to one another wherein an air gap is present between two adjacent wall panels;

(b) at least one bent strap spanning the air gap between two adjacent wall panels wherein the bent strap is rigidly connected to adjacent wall panels and

wherein the strap is capable of flexing due to a force on a wall panel.

2. The assembly of claim 1 with individual straps connecting inner and outer surfaces of adjustment wall panels.

3. The assembly of claim 1 with one wall panel connecting to two wall panels with individual straps.

4. The assembly of claim 1 where the strap comprises a band.

5. The assembly of claim 1 wherein the straps comprises a plate.

6. The assembly of claim 1 wherein the strap comprises metal.

7. The assembly of claim 6 wherein the strap comprises steel.

8. The assembly of claim 6 wherein the strap comprises aluminum.

9. The assembly of claim 1 wherein the strap comprises a composite.

10. The assembly of claim 1 wherein wall panels are positioned at an angle between 30 and 120 degrees on to another.

11. The assembly of claim 1 wherein with a gap of at least 0.125 inches (3 mm) between adjoining wall panels.

12. The assembly of claim 1 wherein a single metal strap is used.

13. The assembly of claim 1 wherein a double metal strap is used.

14. The assembly of claim 1 wherein the straps are between 0.075 inches (0.19 mm) and 0.150 inches (3.8 mm).

15. The assembly of claim 1 wherein one wall panel comprises in order:

(a) a layer of material having a density not greater than 0.10 grams per cubic centimeter,

(b) a layer of a fabric containing fibers bonded with a resin,

(c) a layer of structural sheathing.

wherein the fabric layer will deflect in a range from 5.0 to 17.5 centimeters when impacted by a 33 kilogram (15 pound) projectile at a speed of 161 kilometers (100 miles) per hour in accordance with ASTM test procedure E1886-97 with said composite mounted on a rigid frame.

16. The assembly of claim 1 wherein the strap is capable of flexing due to an external force from wind blown debris or an explosive blast.

17. The assembly of claim 16 wherein the stap is capable of flexing due to debris at a wind speed of 100 miles per hour.

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