

HOLLOW BUILDING BLOCK AND
PROTECTIVE WALL CONSTRUCTION THEREWITH

FILED OF THE INVENTION

The present invention relates to novel hollow building blocks, in general, and in particular, to their use in the construction of bomb-blast and gas permeably resistant walls.

BACKGROUND OF THE INVENTION

Traditionally, bomb shelters are steel reinforced concrete structures, usually built at ground or below-ground level, having especially thickened and reinforced concrete walls. A disadvantage of conventional bomb shelters is, however, that as they are located at or below ground level, they are particularly susceptible to chemical attack, as the chemicals normally used may have a density greater than that of air, and they thus accumulate in low places close to ground level. This problem was faced by authorities in Israel during the Gulf War of 1990-1991, when it was necessary to advise civilian populations how best to take cover when under missile attack, as it was suspected that the missiles carried chemical warheads.

It would thus be desirable to construct the upper stories of buildings, such as apartments and offices, so as to be blast resistant. This, however, is impractical as concrete reinforced walls constructed to the thickness conventionally required would present an acute weight burden on the structure and if a number of such walls were to be erected in a building, the additional weight may necessitate costly enlargement of structural elements.

Moreover, there is a serious problem with existing buildings that do not have bomb shelters to retrofit them

with blast resistant rooms, preferably on each floor or even in each apartment.

Varying methods, techniques and building materials have been suggested for imparting particular properties to walls. Thus composite structures including an arrangement of hollow blocks having a plurality of communicating voids filled with a reinforced concrete construction are known, per se. Such constructions, employing cinder or concrete blocks, are disclosed in USP 1,884,319 to Smith and USP 2,994,162 to Frantz. Smith describes his structure as being employed to provide insulation against "heat, cold and moisture". Frantz states that his construction is simply easier to erect than other block wall constructions. USP 4,577,447 to Doran discloses a similar construction to those in the above-referenced patents, but employing expanded polystyrene blocks.

USP 4,167,840 to Ivany discloses improving the reinforcement of hollow-concrete-block masonry walls with vertical and horizontal reinforcing bars while pouring concrete into the hollow voids of the blocks. The wall thus becomes a solid reinforced wall with the wall surfaces being of concrete masonry.

French Patent No. 2,612,971 describes a well-known DURISOL® building block made from 'wood concrete', which is essentially a mixture of treated wood shavings and concrete. As indicated in an article by Ralph Ironman, entitled "Wood Concrete Branches Out", published in the August 1988 edition of CONCRETE PRODUCTS, these wood concrete building blocks are known to be lightweight, have thermal and acoustic insulation properties, fire retardant, frost resistant and rot-proof and are used to impart one or more of these specific properties to structures built with them.

My earlier patent publictation W093/14281 discloses constructing a high energy-absorbing and bomb blast resistant wall with known Durisol ® building blocks. These blocks, however, are gas permeable because of the nature of the mineralized wood shavings from which they are made.

U.S. Patent No. 4,371,968 to Obino discloses a formwork component for the formation of shuttering for use in concrete construction the framework comprising parallel hardened foamed plastic panels such as from polystyrene and polyurethane connected by vertical rigid metal cross members embedded in the panels. The framework of this patent does not provide any energy absorbing properties and therefore is unsuitable for a blast resistant wall construction. Furthermore, the framework is manufactured as a complete unit and each such unit occupies substantial space during storing and shipping.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a blast resistant and gas impermeable building block for constructing a barrier wall which can be constructed in place of or in addition to substantially any selected wall portion of a building, thereby providing bomb blast protection and gas impermeability to the interior side of that wall portion.

A further object of the present invention is to provide a lightweight, easy-to-erect wall construction having blast resistance and gas impermeable properties, and which substantially maintains its structural integrity in the face of a bomb blast.

In particular, it is sought to employ specially constructed mineralized hollow wood concrete blocks in

composite construction with a reinforced concrete core, such a construction having been found by the Inventor to achieve the above-stated objects of the present invention. The Inventor discovered that the flexibility of the composite blocks of mineralized wood shavings and concrete is substantially greater than that of a standard masonry building block, and the energy absorption of these blocks results in a major improvement in blast resistance characteristics. Furthermore, such wood concrete blocks are gas impermeable because of a gas impermeable partition within the block. The wood-concrete blocks of this invention are about 25% less fragment penetrable than ordinary masonry blocks. Thus a 15 cm thick wood-concrete block can substitute for a 20 cm thick ordinary masonry block.

In accordance with a preferred embodiment of the invention, there is thus provided, for absorbing blast energy and imparting gas impermeability in a composite block and reinforced concrete wall construction, a lightweight hollow building block for constructing a blast resistant and gas impermeable barrier wall comprising oppositely disposed spaced apart walls connected by bridging elements forming interconnected horizontal and vertical voids characterized in that the walls are formed of a mixture of mineralized wood shavings and concrete having a density of no more than approximately 1 ton per cubic meter and bridging elements that are gas impermeable.

The gas impermeable bridging element may comprise metal or other rigid gas impermeable plates or bars permanently embedded in the opposite parallel walls, or rods journaled through holes in the walls and capped on the exterior side of the walls. Such caps may be nuts, threaded onto terminal ends of the metal rod spacers.

In accordance with another embodiment of the invention, there is provided a bomb blast and gas impermeable barrier wall and a method of constructing such a wall by using the above blocks so as to impart blast and gas resistance to the wall. The barrier wall comprises a construction of lightweight hollow building blocks placed in direct contact on top of and next to one another, said blocks having formed therein interconnected vertical and horizontal voids and an interconnected core of vertical and horizontal steel reinforced concrete beams disposed in said voids, characterized in that said hollow blocks have oppositely disposed walls formed of a mixture of mineralized wood shavings and concrete having a density of no more than approximately 1 ton per cubic meter, said oppositely disposed walls being connected by gas impermeable bridging elements, said construction providing energy absorption to resist forces resulting from an explosive blast and prevent permeation of gases therethrough.

The method of constructing such a wall includes the following steps:

assembling in a wall arrangement a plurality of the above hollow blocks, so as to place the blocks in direct contact on top of and next to one another such that the vertical and horizontal voids of adjacent blocks are interconnecting; and

forming an integral web of concrete and steel reinforcement in the interconnecting vertical and horizontal voids, forming a composite wall construction of the hollow blocks and reinforced concrete which impart to the composite wall construction the ability to substantially retain its structural integrity in the presence of blast forces of a magnitude sufficient to destroy a block and reinforced concrete wall employing

conventional hollow masonry blocks and also provides gas impermeability.

Additionally in accordance with one embodiment of the invention, the method includes the additional step of embedding the steel reinforcement extending beyond the wall in the reinforced concrete structure, thereby to attach the composite wall construction to the reinforced concrete structure so as to protect the selected portion of the reinforced concrete structure from blast forces.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be more fully understood and appreciated from the following detailed description taken in conjunction with the drawings, in which:

Figure 1 is a front elevational view of a protective wall constructed in accordance with this invention;

Figures 2a, 2b and 2c are respectively a perspective, top and end view of one embodiment of a wood concrete block according to this invention;

Figures 3a, 3b and 3c are respectively perspective, top and end view of another embodiment of a wood-concrete block in accordance with this invention;

Figure 4 is a cross-sectional view of the front of the wall of Figure 1; and

Figure 5 is a cross-sectional view as seen from the top of the wall of Figure 1.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to Figure 1, there is shown a composite wall construction 1 formed of an assembly of building blocks 2 which are made of a mixture of mineralized wood shaving and concrete as illustrated in Figures 2a-2c and 3a-3c and an integral web of reinforced concrete extending

within the block assembly. This is described in detail below in conjunction with Figures 4 and 5.

The hollow building blocks shown in Figures 2a-2c and 3a-3c are composed of mineralized wood shavings and concrete, as discussed later on. These blocks are lightweight, having a density of approximately 0.9 tons per cubic meter, as opposed to approximately 2.4 tons per cubic meter for conventional masonry blocks. They also have desirable characteristics with respect to fire resistance, sound absorption, thermal insulation and gas and radiation impermeability.

Composite walls constructed with blocks and having internal reinforced concrete beams are known as such in conventional construction. However, the combination of wood-concrete blocks with an integral reinforced concrete web such as described herein for providing blast-proof and gas impermeable protective walls is unknown. Furthermore, notwithstanding the various qualities attributed to wood-concrete material in the art, the Inventor is not aware of any disclosure indicating blast resistance and gas impermeable qualities either of an individual block per se, or of a composite block and reinforced concrete construction as described. The Inventor was thus surprised to learn, upon comparative testing of different wall constructions, including that of the present invention, that the present composite construction using the wood-concrete blocks disclosed provided the only substantial resistance to blast forces and gas impermeability. These comparative tests are discussed hereinbelow.

Furthermore, it was surprisingly found that walls can be constructed in accordance with this invention as internal double walls in existing buildings, thus making it possible to provide blast and gas shelters in every

apartment on every floor by merely constructing such walls up against any outside wall in any room.

It was also found that construction of a barrier wall with blocks according to this invention is made much easier. This is because the concrete poured into the voids of the blocks flows more rapidly and can be poured faster since the bridging elements, for example thin plates and especially rods, do not offer any significant resistance to the flow and even spread of the poured concrete. This is not the case with conventional Durisol ® blocks which have substantially thick bridges connecting the block walls which impede rapid flow and complete spreading of the concrete.

Another advantage found with barrier walls constructed with the blocks of this invention is that there is no possibility for bullets or fragments to penetrate the wall, since there are no "soft" bridges through which bullets can penetrate, as is the case with conventional Durisol ® blocks.

Referring once again to Figure 1, the illustrated wall is typically constructed within a frame 3 of reinforced concrete. The surface finish on the blocks 2 is naturally decorative enough to be suitable for the interior of an apartment, without requiring further finishing.

The wall consists of blocks 2 placed on top of one another 4 and next to each other 5 without any spaces left between blocks, thus not requiring any caulking or grouting which would detract from the attractive natural surface of the wall.

The blocks 2 are composed, as stated above, of a mixture of mineralized wood shaving and concrete, and they have been found to have a high energy absorption capability. They may have very good characteristics with

respect to fire resistance, sound absorption, thermal insulation and gas impermeability.

For a better understanding of the construction of this wall, we refer to Figures 2a, 2b and 2c, which illustrate the basic building blocks suitable for the construction of wall 1.

The block 10 is comprised of two parallel walls 12 and 14 made of mineralized wood shaving-concrete which are connected by metal plate bridging elements 16. The bridging elements 16 form partitions between walls 12 and 14. Elements 16 do not bridge the walls 12 and 14 along their entire height, but rather leave spaces between the top 6 and bottom 8 of bridge 16 (see Figure 2c) and the top 17 and bottom 18 of the walls 12 and 14 respectively, so that reinforcing rods (not shown) can be placed therein. Optionally block 10 may have apertures 19 in the bridging elements 16 to allow concrete poured into the block 10 to flow more freely to fill the entire interior of the block 10. The advantage of using metal bridges 16 rather than bridges of the same wood-concrete material as the walls 12, 14, as is known in the art, is because wood-concrete is porous in nature and thus permeable to gases. Walls constructed with blocks made entirely with this material, even when filled with concrete, provide a porous path via the wood-cement bridge from one side of the block through to the other side of the block. However, the block according to the present invention provides a complete concrete and metal separation between block walls once concrete is poured therein, so that gases cannot permeate through the block.

In Figures 3a-3c there is shown another embodiment of a wood-concrete block 10a according to the invention. The block 10a has two parallel walls 32, 34 that are connected with a space between them by four bolts 36. The bolts 36

are throughgoing through walls 32, 34 and are capped by nuts 38. The spacing of the bolts 36 is such as to leave spaces 40 between the bolts 36 and the edges 42 of walls 32 and 34. This is to enable reinforcing rods (not shown) to be laid across a row of blocks 10a within the volume of the blocks.

The novel block illustrated in Figures 3a-3c has another advantage not found in conventional blocks in that it can be assembled in situ. Thus many more disassembled blocks comprising walls 32, 34, bridging rods 36 and capping nuts 38 can be transported per carrier, whether containers or truck, than conventional blocks. These disassembled parts can be then assembled at the construction site.

Other means of connecting the walls 32 and 34 are also contemplated within the ambit of this invention, the only requirement being that the bridging element is made of a material that is non-pervious to gases.

In constructing a wall according to this invention, for example, in the case of a free-standing wall, there is first poured a reinforced concrete frame bottom 20, as shown in Figure 4, and the blocks 2 are placed thereon in a row adjacent one another. Steel reinforcement 21 is then placed horizontally on top 6 of bridging element 16 (see Figure 2a) of the blocks 10, extending 22 (Figure 4) beyond the terminal blocks 2E and 2F.

A second layer of blocks 2 is placed staggered on top of the first layer, leaving vertical cavities. Further rows of blocks are added up to the desired height of the wall. Steel reinforcing rods 24 are introduced vertically into the cavities 13 and concrete is then poured into these cavities 13 to fill the voids and form a web of vertical and horizontal steel reinforced concrete beams within the blocks.

In the illustrated embodiment, the terminal ends 22 of the steel reinforcing rods are then embedded in concrete which completes the reinforcing frame 3 around the wall 1.

Alternatively, a vertical steel reinforcing rod 24 can be inserted into the cavities 13 of the blocks 2 after the first layer of blocks and horizontal steel rods 21 have been placed in position and tied to the horizontal steel rods 21 where they cross each other 25. Subsequent layers of blocks are then slipped over the vertical steel reinforcing rods 24 and placed in position with the vertical and horizontal steel bars being tied together wherever they cross each other.

When such a protective wall is constructed in an existing apartment, the core is connected via the reinforcing steel to the reinforced concrete framework of the building.

Additional strengthening of the protective wall may be accomplished by providing prestressing (or post-tensioning) at the top and bottom and on either side of the wall. This strengthens the membrane or wall formed by the DURISOL® blocks and also strengthens its connection to the framework.

In order to test the blast resistance of different types of wall, the Inventor conducted comparative tests. Five types of wall were tested, including -

- a) A wall consisting of conventional masonry building blocks internally reinforced with concrete and steel bars similar to Ivany, US 4,167,840;
 - b) A wall constructed of conventional building blocks to which plates of ferro-cement were glued on their inside surface to provide reinforcement;
 - c) A wall made of solid blocks of silicate;
 - d) A wall made of ITONG® blocks reinforced with beams;
- and

e) A wall made of wood-concrete blocks according to this invention.

All these walls were approxiamtely 3.6 m long and 2.75 m high and reinforced with concrete beams all around.

An explosive device was detonated equidistant from all the walls. Examination of the walls subsequent to the testing showed that the wall constructed of wood-concrete blocks in accordance with the present invention had sufficient elasticity to absorb the blast, making the wall completely blast resistant. The other walls were all deformed or crumbled. This showed that the present wall construction proved far superior to the other walls a)-d) constructed in accordance with prior art, and which underwent varying degrees of destruction. Furthermore, the wall e) according to this invention did not allow gas to permeate therethrough.

It will be appreciated by persons skilled in the art that the scope of the present invention is not limited to what has been shown and described hereinabove, merely by way of example. Rather, the scope of the invention is limited solely by the claims which follow.

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CLAIMS

1. A lightweight hollow building block for constructing a blast resistant and gas impermeable barrier wall comprising oppositely disposed spaced apart walls connected by bridging elements forming interconnected horizontal and vertical voids characterized in that the walls are formed of a mixture of mineralized wood shavings and concrete having a density of no more than approximately 1 ton per cubic meter and the bridging elements are gas impermeable.
2. A hollow building block according to Claim 1 wherein said gas impermeable bridging elements are gas impermeable plates.
3. A hollow building block according to Claim 1 wherein said gas impermeable bridging elements are gas impermeable rods.
4. A hollow building block according to Claim 1 wherein the bridging elements are made of metal.
5. A blast resistant energy absorbing gas impermeable barrier wall comprising:
 - a construction of lightweight hollow building blocks placed in direct contact on top of and next to one another, said blocks having formed therein interconnected vertical and horizontal voids; and
 - an interconnected core of vertical and horizontal steel reinforced concrete beams disposed in said voids, characterized in that said hollow blocks have oppositely disposed walls formed of a mixture of mineralized wood shaving and concrete having a density of no more than approximately 1 ton per cubic meter, said oppositely

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disposed walls being connected by gas impermeable bridging elements;

said construction providing energy absorption to resist forces resulting from an explosive blast and prevent permeation of gases therethrough.

6. A blast resistant and gas impermeable wall according to Claim 5, further comprising a reinforced concrete frame, said construction of hollow blocks being erected within said frame, said reinforcement of said core of reinforced concrete being anchored to said frame.

7. A blast resistant wall according to claim 5, and wherein said steel reinforcement is pre-stressed.

8. A blast resistant and gas impermeable wall according to Claim 5 wherein said gas impermeable bridging elements are gas impermeable plates.

9. A blast resistant wall according to Claim 5 wherein said gas impermeable bridging elements are gas impermeable rods.

10. A method of constructing a wall so as to impart thereto energy absorbing elasticity providing blast resistant and gas impermeability said method including the following steps:

assembling in a wall arrangement a plurality of hollow blocks, said blocks having formed therein vertical and horizontal voids, including placing the blocks in direct contact on top of and next to one another such that the vertical and horizontal voids of adjacent blocks are interconnecting; and

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forming an integral core of concrete and steel reinforcement in the interconnecting vertical and horizontal voids, thereby to form a composite wall construction of the hollow blocks and reinforced concrete, characterized in that each block has oppositely disposed walls formed of a mixture of mineralized wood shavings and concrete having a density of no more than approximately 1 ton per cubic meter, said oppositely disposed walls being bridged by gas impermeable bridging elements,

wherein said steps of assembling the plurality of hollow blocks and forming an integral core impart to the composite wall construction the ability to substantially retain its structural integrity in the presence of blast forces of a magnitude sufficient to destroy a concrete and steel reinforced masonry wall not employing said hollow blocks and prevent the penetration of gases.

11. A method according to Claim 10, and wherein said step of assembling a plurality of hollow blocks includes assembling said plurality of hollow blocks adjacent to a selected portion of an existing reinforced concrete structure.

12. A method according to Claim 11, wherein said step of forming an integral core includes:

placing steel reinforcement in the interconnecting vertical and horizontal voids such that ends of the reinforcement protrude beyond the block assembly, and

pouring the concrete in the vertical and horizontal voids,

wherein said method further comprises the step of embedding the steel reinforcement extending beyond the wall in the reinforced concrete structure, thereby to attach the composite wall construction to the reinforced concrete





structure to protect the selected portion of the reinforced concrete structure from blast forces and gas permeation.

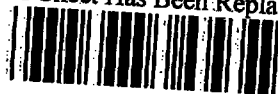
13. A method according to Claim 10, further comprising the step of pre-stressing the steel reinforcement.

14. A method according to any of Claims 1-4 and substantially as described in conjunction with any of Figures 1-5.

15. A wall according to any of Claims 5-10 and substantially as shown in and described in conjunction with any of Figures 1-5.

16. A hollow building block according to any of Claims 11-13 and substantially as shown in and described in conjunction with any of Figures 1-5.

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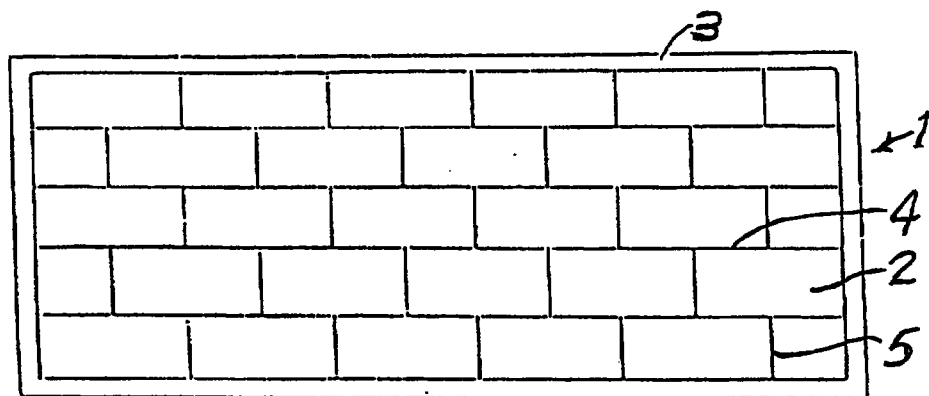


FIG. 1

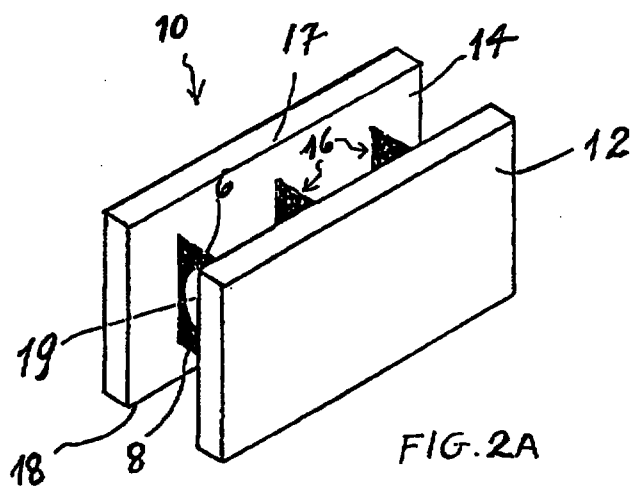


FIG. 2A

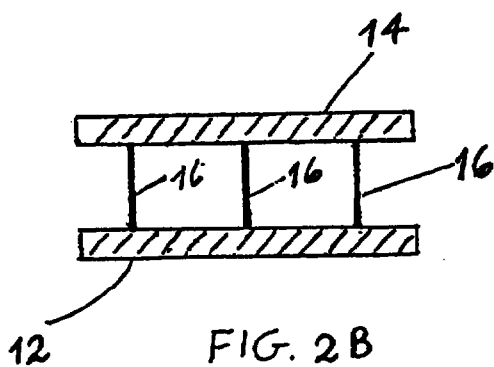


FIG. 2B

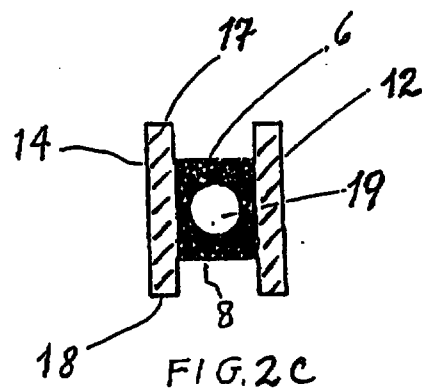


FIG. 2C

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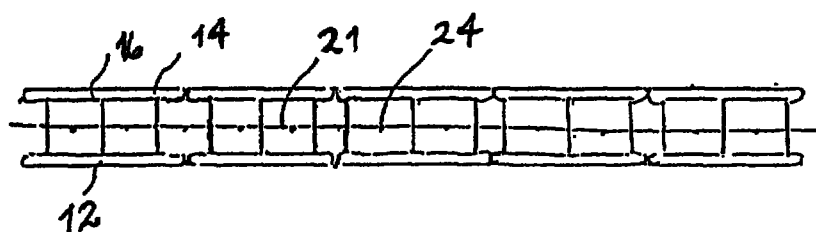
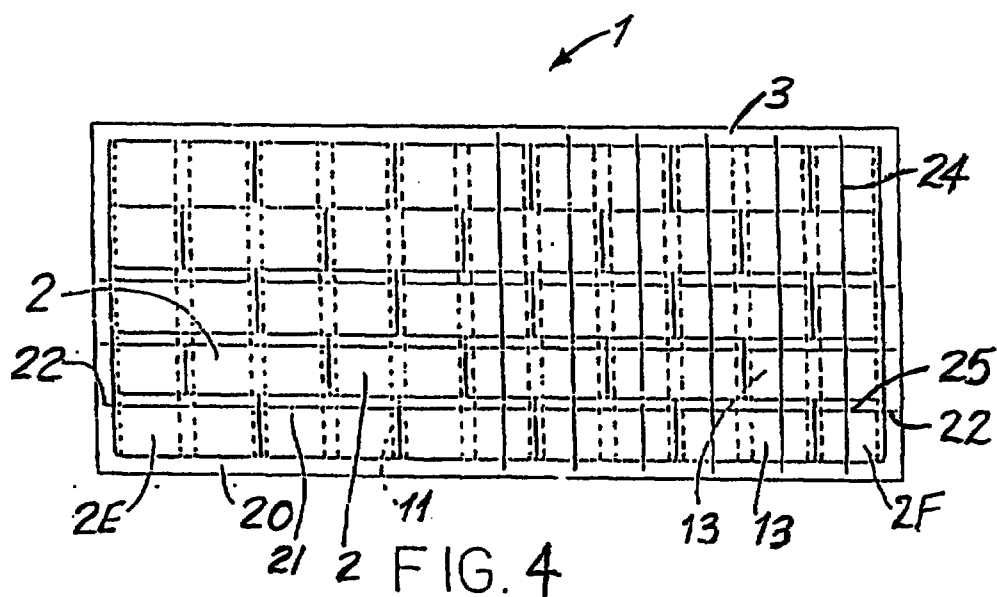
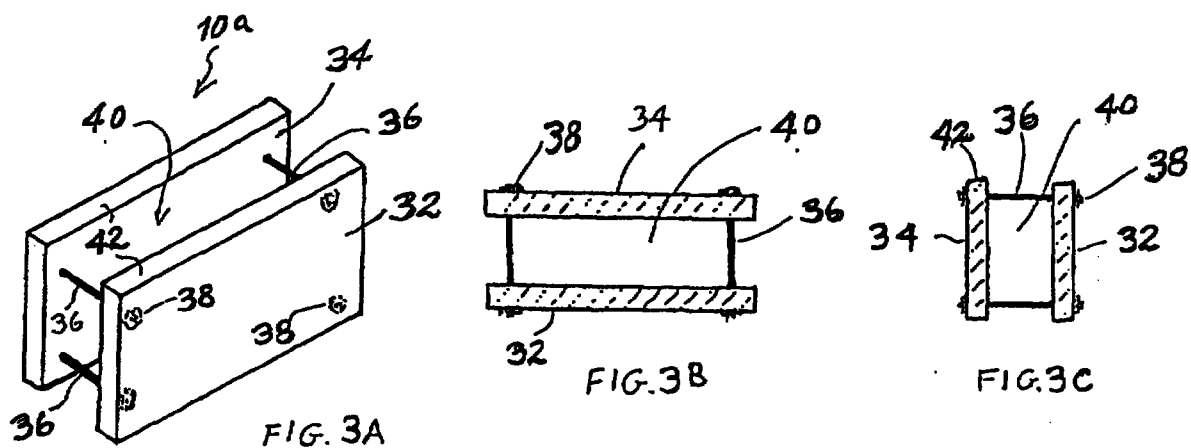


FIG. 5

e) A wall made of wood-concrete blocks according to this invention.

All these walls were approximately 3.6 m long and 2.75 m high and reinforced with concrete beams all around.

An explosive device was detonated equidistant from all the walls. Examination of the walls subsequent to the testing showed that the wall constructed of wood-concrete blocks in accordance with the present invention had sufficient elasticity to absorb the blast, making the wall completely blast resistant. the other walls were all deformed or crumbled. This showed that the present wall construction proved far superior to the other walls a)-d) constructed in accordance with prior art, and which underwent varying degrees of destruction. Furthermore, the wall e) according to this invention did not allow gas to permeate therethrough.

The blocks according to this invention can have any desired dimension. Thus such blocks can comprise conventional masonry size building blocks for placing on top of one another or large blocks, each of which forms a panel in a wall construction.

It will be appreciated by persons skilled in the art that the scope of the present invention is not limited to what has been shown and described hereinabove, merely by way of example. Rather, the scope of the invention is limited solely by the claims which follow.

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CLAIMS

1. A hollow building block comprising oppositely disposed spaced apart walls connected by bridging elements forming interconnected horizontal and vertical voids characterized in that the walls are formed of a mixture of mineralized wood shavings and concrete having a density of no more than approximately 1 ton per cubic meter and the bridging elements are gas impermeable.
2. A hollow building block according to Claim 1 wherein said gas impermeable bridging elements are gas impermeable plates.
3. A hollow building block according to Claim 1 wherein said gas impermeable bridging elements are gas impermeable rods.
4. A hollow building block according to claim 1 wherein the bridging elements are made of metal.
5. A hollow building block according to Claim 1 comprising walls and bridging elements to be assembled into said block at a construction site.
6. A barrier wall comprising:
 - a construction of hollow building blocks placed in direct contact on top of and/or next to one another, said blocks having formed therein interconnected vertical and horizontal voids; and
 - an interconnected core of vertical and horizontal steel reinforced concrete beams disposed in said voids, characterized in that said hollow blocks comprise



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oppositely disposed walls formed of a mixture of mineralized wood shaving and concrete having a density of no more than approximately 1 ton per cubic meter, said oppositely disposed walls being connected by gas impermeable bridging elements;

said construction providing energy absorption to resist forces resulting from an explosive blast and prevent permeation of gases therethrough.

7. A wall according to Claim 6, further comprising a reinforced concrete frame, said construction of hollow blocks being erected within said frame, said reinforcement of said core of reinforced concrete being anchored to said frame.

8. A wall according to Claim 6, and wherein said steel reinforcement is pre-stressed.

9. A wall according to Claim 6 wherein said gas impermeable bridging elements are gas impermeable plates.

10. A wall according to Claim 6 wherein said gas impermeable bridging elements are gas impermeable rods.

11. A method of constructing a wall comprising the following steps:

assembling in a wall arrangement a plurality of hollow blocks, said blocks having formed therein vertical and horizontal voids, including placing the blocks in direct contact on top of and/or next to one another such that the voids of adjacent blocks are interconnecting; and

forming an integral core of concrete and steel reinforcement in the interconnecting voids, thereby to form a composite wall construction of the hollow blocks and



reinforced concrete, characterized in that each block has oppositely disposed walls formed of a mixture of mineralized wood shavings and concrete having a density of no more than approximately 1 ton per cubic meter, said oppositely disposed walls being bridged by gas impermeable bridging elements.

12. A method according to Claim 11 wherein the hollow blocks are assembled at the construction site.

13. A method according to Claim 11, and wherein said step of assembling a plurality of hollow blocks includes assembling said plurality of hollow blocks adjacent to a selected portion of an existing reinforced concrete structure.

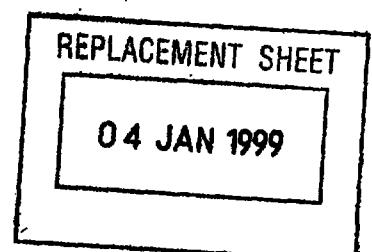
14. a method according to Claim 13 wherein said step of forming an integral core includes:

placing steel reinforcement in the interconnecting vertical and/or horizontal voids such that ends of the reinforcement protrude beyond the block assembly, and

pouring the concrete in the vertical and horizontal voids,

wherein said method further comprises the step of embedding the steel reinforcement extending beyond the wall in the reinforced concrete structure, thereby to attach the composite wall construction to the reinforced concrete structure to protect the selected portion of the reinforced concrete structure from blast forces and gas permeation.

15. A method according to Claim 11, further comprising the step of pre-stressing the steel reinforcement.



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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : E04B 1/04	A1	(11) International Publication Number: WO 98/00612 (43) International Publication Date: 8 January 1998 (08.01.98)
(21) International Application Number: PCT/IL97/00207 (22) International Filing Date: 22 June 1997 (22.06.97) (30) Priority Data: 08/673,293 120058 28 June 1996 (28.06.96) 23 January 1997 (23.01.97) US IL (71)(72) Applicant and Inventor: NEGRI, Yermiyahu [IL/IL]; 4 Recanati Street, Tel Aviv 69494 (IL). (74) Agent: SELIGSOHN & GABRIEL; P.O. Box 1426, 61013 Tel Aviv (IL).		(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KB, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i>

(54) Title: **HOLLOW BUILDING BLOCK AND PROTECTIVE WALL CONSTRUCTION THEREWITH**

(57) Abstract

A lightweight hollow building block (2, 10) for constructing a blast resistant and gas impermeable barrier wall (1) comprising oppositely disposed spaced apart walls (12, 14, 32, 34) connected by bridging elements (16) forming interconnected horizontal and vertical voids (13, 19, 40) characterized in that the walls (12, 14, 32, 34) are formed of a mixture of mineralized wood shavings and concrete having a density of no more than approximately 1 ton per cubic meter and bridging elements (16) are gas impermeable.

