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Dicker

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[45] **Dec. 2, 1975**

[54] **CONSTRUCTION METHOD OF ASSEMBLING BAGGED, SETTABLE MODULES**

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[22] Filed: **July 23, 1973**

[21] Appl. No.: **381,727**

Related U.S. Application Data

[63] Continuation of Ser. No. 162,490, July 14, 1971, abandoned, which is a continuation-in-part of Ser. No. 767,071, Aug. 26, 1968, abandoned, which is a continuation-in-part of Ser. No. 736,538, April 5, 1968, abandoned, which is a continuation-in-part of Ser. No. 668,575, Sept. 18, 1967, abandoned.

[52] **U.S. Cl.** **52/742;** 52/169; 52/173; 52/295; 52/585; 52/608; 52/747

[51] **Int. Cl.**[2] **E04B 1/04;** E04B 1/48; E04B 2/06

[58] **Field of Search** 52/173, 293, 294, 295, 52/585, 744, 444, 742; 61/37, 38

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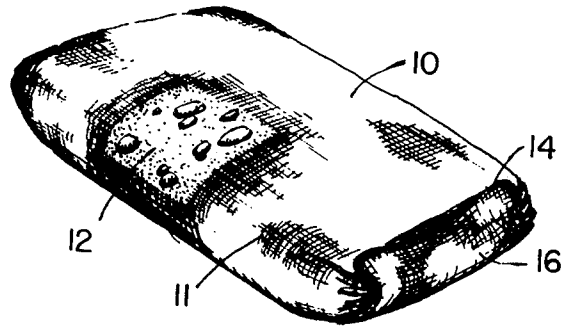
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[57] **ABSTRACT**

Discrete structural construction units comprising porous sacks containing a dry premixed fill of aggregate, sand and cement are arranged in juxtaposed relation to form a horizontal course of a wall, and water is applied to the units to activate the fill therein to form an integrated structure. Successive courses of the structural units are superimposed on each other, including wetting the units in the courses, to form a completed, integrated structural wall. A building structure is constructed by excavating suitable trenches for the foundation, filling the trenches to ground level with concrete to form foundation beams, arranging at least one course of the structural units on the outer foundation beams, including wetting the units of this course to set up, pouring a concrete slab floor within the confines of the outer foundation beam using the course of structural units as a form, laying successive courses to complete the structural walls of the building, blowing a concrete skin on the surfaces of the wall, and adding a roof thereto.

22 Claims, 16 Drawing Figures



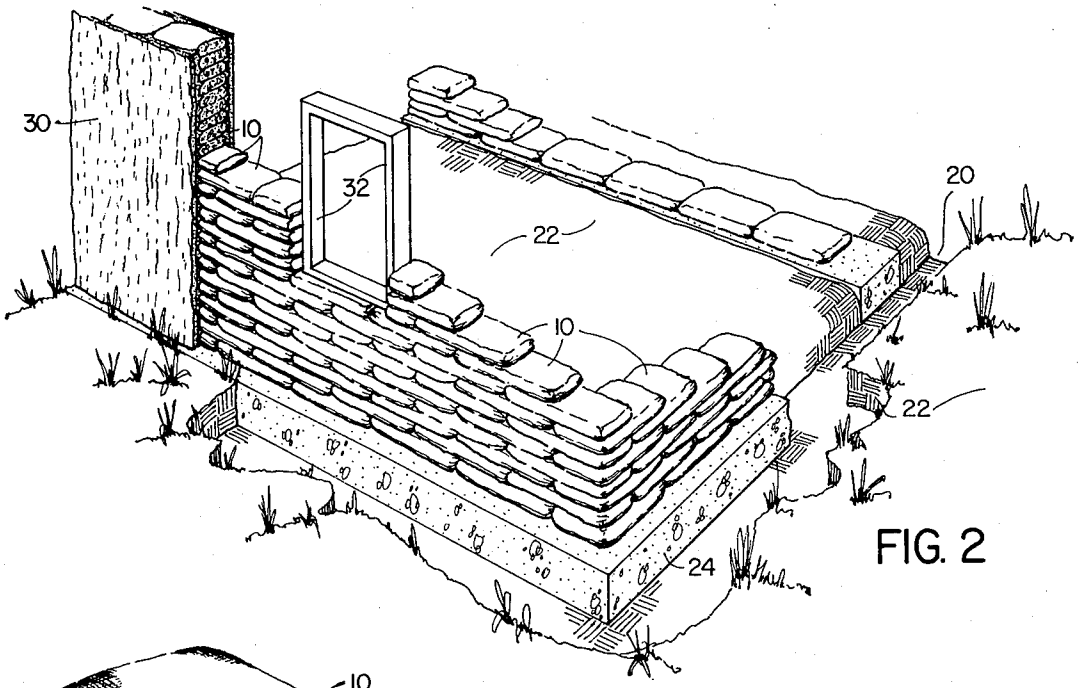


FIG. 2

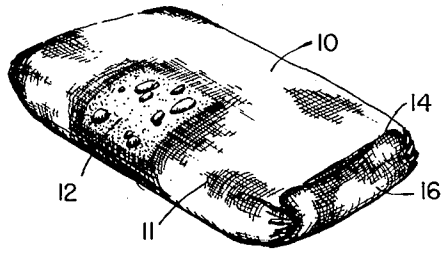


FIG. 1

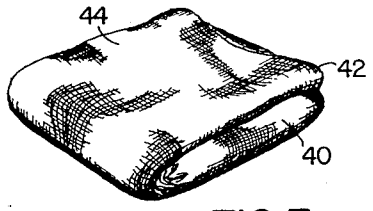


FIG. 3

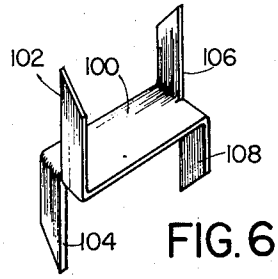


FIG. 6

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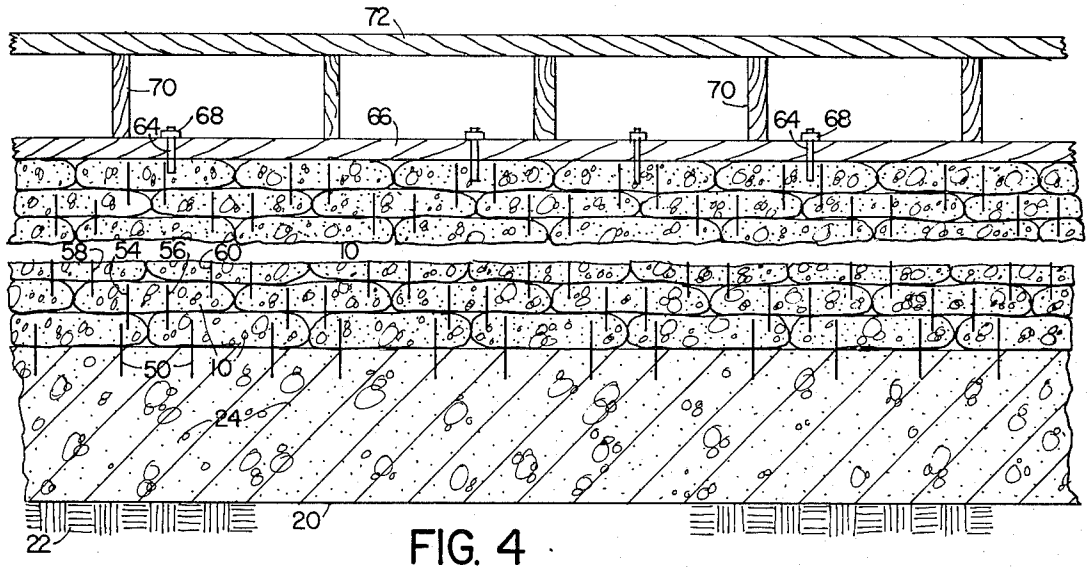


FIG. 4

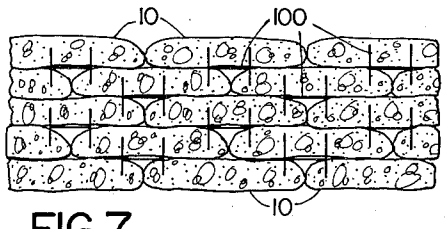


FIG. 7

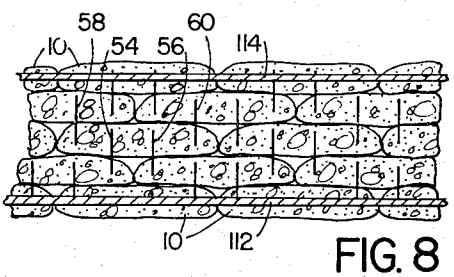


FIG. 8

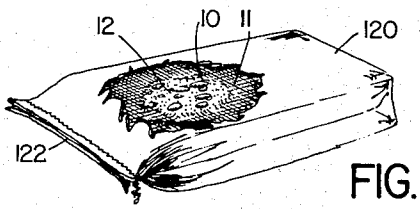


FIG. 9

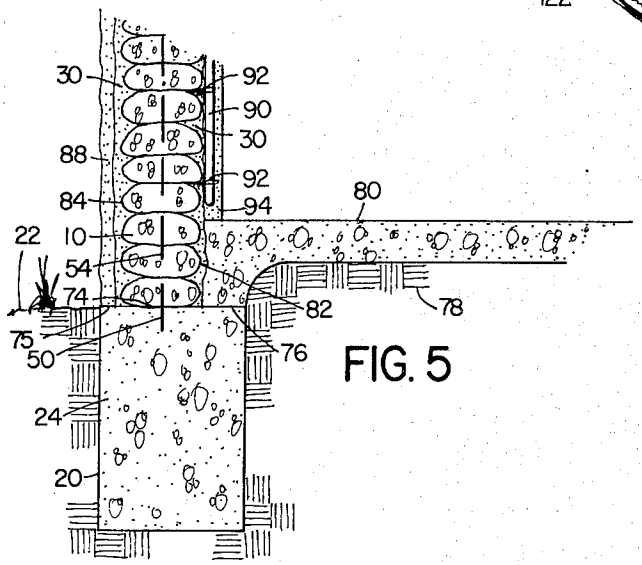


FIG. 5

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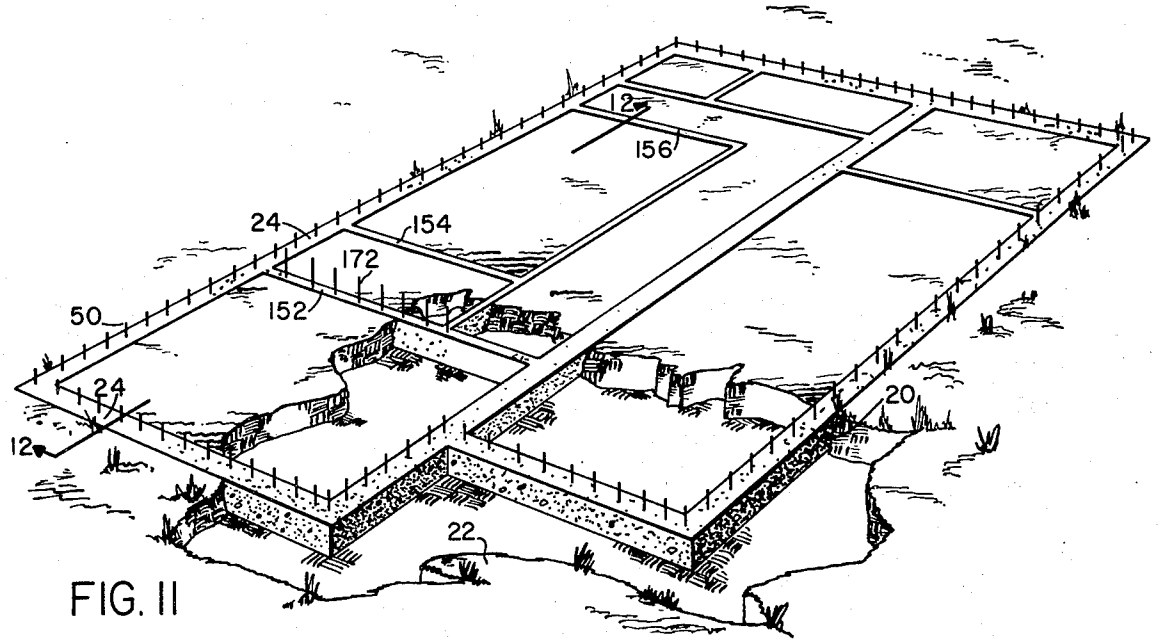


FIG. 11

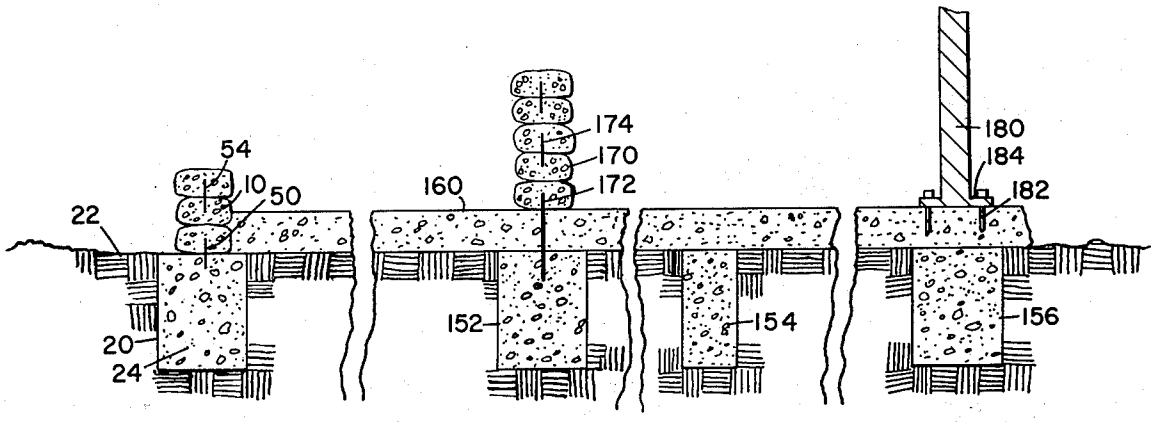


FIG. 12

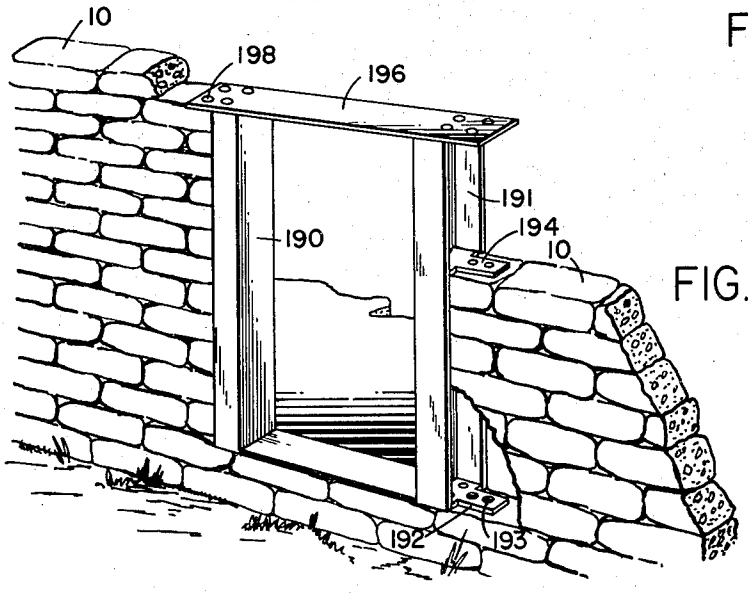


FIG. 13

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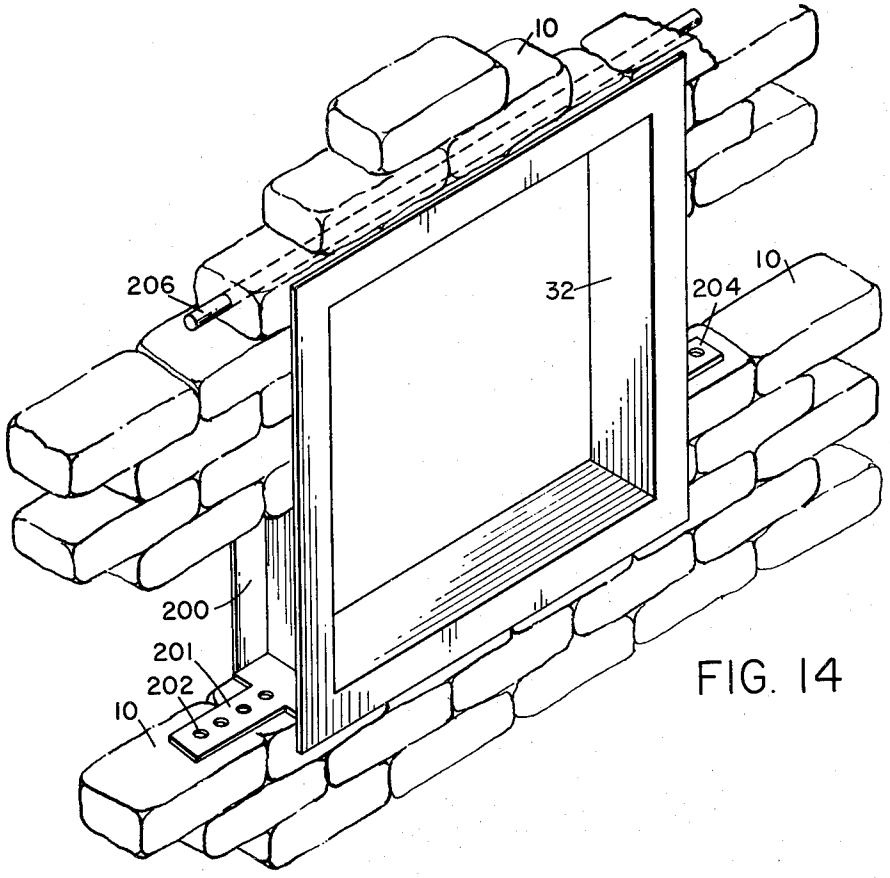


FIG. 14

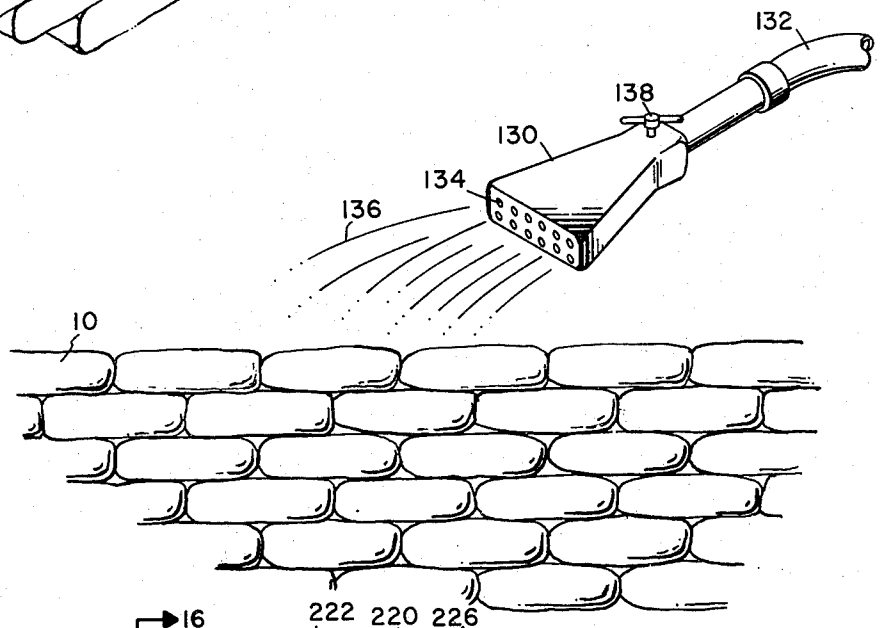


FIG. 10

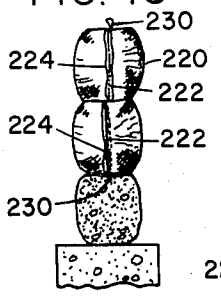


FIG. 16

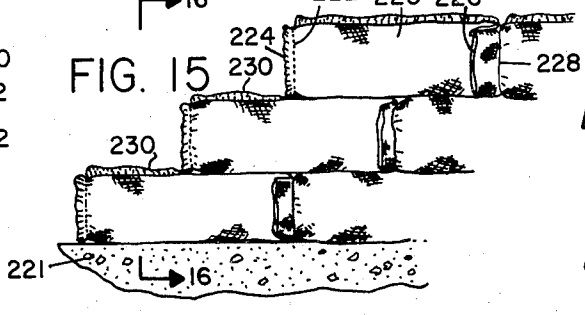


FIG. 15

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CONSTRUCTION METHOD OF ASSEMBLING BAGGED, SETTABLE MODULES

CROSS REFERENCES

This application is a continuation of the copending application of Edward T. Dicker entitled BUILDING STRUCTURE AND METHOD OF CONSTRUCTION, Ser. No. 162,490, filed July 14, 1971 (now abandoned) which is a continuation-in-part of the application of Edward T. Dicker entitled BUILDING STRUCTURE AND METHOD OF CONSTRUCTION, Ser. No. 767,071, filed Aug. 26, 1968 (now abandoned) which is a continuation-in-part of the application of Edward T. Dicker entitled BUILDING STRUCTURE AND METHOD OF CONSTRUCTION, Ser. No. 736,538, filed Apr. 5, 1968 (now abandoned) which is a continuation-in-part of the application of Edward T. Dicker entitled BUILDING STRUCTURE AND METHOD OF CONSTRUCTION, Ser. No. 668,575, filed Sept. 18, 1967 (now abandoned).

There is presently a very considerable need for low cost construction methods which result in structures suitable for human habitation and which pass specifications set forth both for financing and by certain building codes. Reference is especially had to the lower income and poverty groups, and the government's concern with adequate housing requirements for these groups. However, conventional construction methods result in costs above that for which these groups can qualify for loans based upon their incomes, and still achieve adequate housing. Furthermore, conventional construction which is designed to be inexpensive enough to qualify for low cost housing requirements is generally of such poor quality that the structures will not pass the more stringent building codes in hurricane and earthquake areas.

This invention is primarily directed to the solution of this problem by providing a construction method and building structure which permits the construction of adequate housing in a cost range within which lower income groups can qualify based upon their incomes.

An object of this invention, therefore, is the elimination, as far as possible, of the requirement for skilled labor normally required in building construction which, as is commonly known, is a major cost of construction.

A particular feature of the construction of this invention is the provision of a structure which not only may be built inexpensively and quickly, but which is sturdy enough to pass even the most rigorous building codes for hurricane and earthquake areas. Furthermore, the process eliminates the need for temporary forms to shape and confine the concrete walls during construction.

Briefly, the invention contemplates a novel method of building construction and a novel building structure. Discrete structural units are employed which comprise a porous sack containing a dry, premixed fill. The fill, when wetted, is activated to set up to form a hardened structural unit. For most construction, the fill preferably comprises a mixture in the proper ratios of aggregate, sand and cement; and the sack within which it is contained is porous to permit water to penetrate the mixture when the unit is wetted so as to activate the mixture. The construction units are best utilized as forming packages of a uniform size and shape to adapt themselves to the desired wall width. Preferably, a first horizontal course of the structure is formed by laying a

plurality of the units in successive abutting relations; including wetting the units in the course with water to activate the mixture. This causes the setting up of the units in a hardened state in which the units become bound together as an integrated structure. Thereafter, another course is laid on top of the first and wetted. The second course is normally laid immediately after the first course is laid out and before it has set up; although the second course can be laid after the first has already set up. Wetting of the units in the second course activates the latter to set up and form a continuation of the integrated structure with the first course. Successive courses are added in superimposed relation until the desired size and height of the structure is achieved.

In accordance with the invention, reinforcing members, such as "deformed" or "corrugated" steel reinforcing bars or rods, are driven or pushed through the sacks in the dry, inactivated state after a course is laid so as to interconnect adjacent units.

For better appearance and to further strengthen the structure either as the construction proceeds or after a wall structure is completed, in addition to sealing the walls of the structure, a skin such as comprised of concrete or other suitable structural skin material, is applied under pressure to either or both sides of a wall structure by any suitable means, such as by spraying or blowing under pressure.

In a preferred method of construction a building employing this invention, a trench is excavated corresponding to the outside walls of the building to be formed, and concrete is poured into the trench to approximately ground level. The concrete is then leveled and allowed to set up to form supporting concrete beams for the foundation. Reinforcing rods are included in the poured concrete and project upwardly out of the concrete beams. The first course employing the discrete building units is formed on the concrete beams after the latter hardens by impaling the sacks on the protruding reinforcing rods. When the desired height of the wall is attained by superimposing the required number of courses, bolts or dowels are inserted in the top course which protrude thereabove so that a top plate drilled with corresponding holes may be secured on top of the wall. A suitable roof structure then is installed.

To provide a slab flooring for the building, one or more courses of the building units are laid on the outer concrete foundation beams and allowed to set up. The one or more courses act not only as a part of the wall structure, but as a form against which a concrete slab flooring can by poured. Concrete is then poured within the confines of the outer beams against the hardened courses of building units. This method eliminates the necessity of forms requiring skilled labor. Thereafter, the structure is completed as above set forth.

Many other objects, advantages and features of the invention will become apparent from the following detailed description taken in connection with the appended claims and the attached drawings wherein like reference numerals refer to like parts throughout the several figures, and in which:

FIG. 1 is a perspective view of one of the discrete building units with part of the container sack shown broken away to illustrate the dry, premixed contents thereof;

FIG. 2 is a fragmentary, perspective view showing a wall structure constructed according to the invention

with the building units arranged in superimposed courses on a concrete beam;

FIG. 3 is a perspective view of a building unit of different dimensions prepared by putting less premixed material into the porous sack;

FIG. 4 is a fragmentary, side elevational view in section of a wall structure showing the details of construction thereof, including a concrete supporting beam and roof structure;

FIG. 5 is a fragmentary, end elevational view in section of a wall structure illustrating a finishing material such as sprayed concrete applied to the two sides of the wall and showing a concrete slab flooring poured between the outer walls;

FIG. 6 is a perspective view of a reinforcing and connecting device that can be employed with the construction units;

FIG. 7 is a fragmentary, side elevational view in section of a wall structure employing the device shown in FIG. 6;

FIG. 8 is a fragmentary, side elevational view in section of a wall structure employing horizontal steel reinforcing rods;

FIG. 9 is a perspective view, partly broken away showing a construction unit packaged in a water repellent bag for packaging purposes;

FIG. 10 is a fragmentary, side elevational view of a wall structure illustrating one method of wetting from the top only of each course of construction units as they are laid;

FIG. 11 is a perspective view, showing the earth partly broken away, of an integrated or monolithic foundation of a building comprising concrete beams illustrating the excavation of trenches in the earth to coincide with the walls of the building into which concrete is poured to form the foundation thereof;

FIG. 12 is a fragmentary, side elevational view in section of the concrete beam foundation taken across section lines 12—12 of FIG. 11, also illustrating a slab flooring formed within the confines of the building units laid on the outer concrete beams, including wall structures constructed over concrete beams;

FIG. 13 is a fragmentary, perspective view of the wall structure including a door frame around which the wall is constructed;

FIG. 14 is a fragmentary, perspective view of the wall structure including a window frame around which the wall is constructed;

FIG. 15 is a fragmentary, elevational view showing a preferred embodiment of the porous sacks and a preferred method of arranging the sacks in superimposed courses; and

FIG. 16 is a sectional view taken along section lines 16—16 of FIG. 15.

A preferred embodiment of a discrete building unit employed in the invention is shown in FIG. 1 and comprises a porous sack 10 within which is contained a dry mixture 12 of sand, aggregate and cement as shown exposed in the broken away portion. The contents are premixed in the proper ratios to yield the desired structural strength when activated by water to set up in a hardened form. Although the sack can be tied off at its open end after filling, this is usually unnecessary and mere lapping the open end 14 over to form a flap 16 is sufficient. The sack is preferably of woven fabric, such as burlap, whereby the woven fabric defines uniformly distributed pores 11 in all surfaces so that application of an amount of water to the top surface of the sack is effective to permit the water to penetrate the contents to activate them to form concrete.

The sack can be of any size and shape to form the desired construction unit. As will be seen hereinafter, the flexible sack and the ability to control the amount of contents in any one sack lend themselves to facilitating construction when the sizes of the units need to be varied. This eliminates the equivalent of breaking concrete blocks and bricks in conventional construction techniques at termination points. The sack can be constituted of many different materials such as burlap, cheesecloth or other suitable fabrics just to mention a few. Moreover, the sack can also comprise moisture absorptive pulp products, such as paper, in addition to others.

As already stated, the material with which the sack is filled is, for most construction purposes, a dry, premixture of sand, aggregate and cement which forms concrete when activated with water. However, there are cases where other construction compositions are desirable or preferred. To mention a few, rock, dirt, mud, clay, straw, sawdust, paper and combinations thereof included with a suitable cement are contemplated, in addition to others that will occur to those skilled in construction materials. Moreover, any suitable acoustical or insulating material can be incorporated in the mix for acoustical or insulating purposes, respectively, wherein the amount of cement in its ratio to other constituents can be varied, if necessary, to maintain the desired strength when the unit is activated to harden.

A fragmentary perspective view of a building wall constructed according to the invention is shown in FIG. 2. A trench 20 is excavated in the earth 22 to correspond to the wall to be built. Concrete is then poured into the trench to approximately ground level to form a concrete beam 24. This wall foundation can also be poured, without forms, to a level about that of ground level by piling up the dirt removed from the trench at the edges of the trench. Pouring concrete in a trench eliminates the necessity for concrete forms for foundations so that skilled labor need not be employed. A concrete slab flooring can also be poured between the beams as will be described later with reference to FIG. 5.

Detailed steps of the preferred process for laying the various horizontal courses of superimposed construction units will be described in conjunction with FIG. 4, although reference to FIG. 2 illustrates the appearance of the construction. The construction units 10 are laid on top of the concrete beam 24 in juxtaposed relations, or in end to end relation, until a first horizontal course is laid along the length of one wall, or along the length of all of the walls as the case may be. The units can be arranged in a course before wetting or can be wet just prior to being laid. When laid dry, an amount of water is then added or poured onto the top only of the first horizontal course of construction units in a quantity just sufficient to activate the dry premixed material throughout the construction unit. This water can be added by any suitable means or method, such as by applying the water on top of the construction units from any suitable container or source. The amount of water that is applied is not in an amount great enough, however, to allow more than a predetermined maximum "slump" in the construction units when wetted, wherein the term slump is well understood in the concrete construction business and very generally means that the concrete when activated will slump to some ex-

tent and tend to spread out. This predetermined amount of slump is detected visually by the worker and is limited to an extent which can be initially detected visually.

It has been found that when wetting the units after they have been laid, the building units should be wetted with water from the top of each unit of each course only. On the other hand, wetting one or more courses from the sides, or from the sides and top, such as by spraying water thereon, weakens the wall structure to the extent that, in most cases, the weight causes it to collapse. Moreover, only a predetermined maximum amount of water can be added to the top of the course to result in the superior results provided by the invention.

It is well known that the addition of an excessive amount of water to the dry constituents of concrete causes the setting up or hardening of concrete of inferior strength. To guard against this, engineers at construction sites ordinarily test samples of the wet concrete for slump before it is poured. If the concrete slumps more than it should, the engineer knows that an excessive amount of water has been added. Unfortunately, with conventional construction methods, an excessive amount of water must be added to the dry constituents to maintain the concrete in a fluid state between the time it is activated with water, or batched, and the time it is poured, and the engineer can only minimize against this.

To control the amount of water that is applied or added to the building units when laid dry in a course, water is applied to the top only as illustrated in FIG. **10.** It has been found convenient to use a spray head **130** having spray holes **134** through which the water emerges as the spray **136.** The spray head conveniently has a width approximating that of the width of the wall so that the entire width of a unit is wetted at one time. The spray is connected to a pressurized water source and a cut off valve is included in the spray head which is operated by means of handle **138.** Water is accurately applied as to quantity to the construction units from the top only as the worker observes the water penetrating the sacks and further observes any slump that takes place. The water penetrates throughout the dry constituents in the bag primarily by capilliary action. For building construction units of about 24 inches by 6 inches by 6 inches thick, it has been found that permitting the unit to slump by a maximum amount of about ¾ of one inch vertically will yield a wall construction of superior strength but in which sufficient water is added to activate the entire unit. Thus this method provides for the construction of a wall structure having superior or maximum strength in the concrete, primarily because of the ability to control the water added to activate the concrete. As already noted, this degree of control is not possible when mixing large batches of concrete since an excessive amount of water must be added so that the concrete remains fluid between batching and pouring. It will again be emphasized that water cannot be applied to the sides of the bag to activate the units, since the natural gravity flow of water is downward, and an excessive amount of water would have to be added in this manner to activate the entirety of the constituents within the construction unit. In fact, actual attempts to add water in this manner have resulted in wall structures of such inferior strength that the walls collapsed under their own weight.

The individual construction units can also be wetted prior to being laid in a course. This is done by immersing the entire unit (porous sack and contents) in water for a short period, such as about 3 to about 25 seconds for example, to permit the water to penetrate to the center or core of the unit. This gives complete wetting. The unit is immediately thereafter laid in a course.

After the first course of construction units has been laid, another course is laid on top thereof in superimposed relation, also in juxtaposed positions, wherein the units are staggered in relation to the underlying units such as is done when laying brick. This horizontal course is also wetted either before or after laying to activate the dry premixture therein. The result of wetting the construction units, as noted above, activates the cement in the dry premixture to set up as concrete with the sand and aggregate. Since the sacks are porous, this permits the "latents" of the concrete to permeate the sides of adjacent sacks so that the superimposed courses will be bound together as will adjacent units in the same course forming a continuous bond between adjacent sacks. The first course is also bound to the concrete beam **24.** All of this forms an integrated homogeneous concrete structure.

The successive superimposed courses are laid one on top of the other until a height is reached at which it is desirable, in the preferred embodiment of the method of the invention, to apply a tack coat or skin **30** of a reinforcing material on either or both the inside and outside surfaces of the wall structure. This coating preferably comprises concrete and is applied to the surfaces by blowing or forcing under substantial pressure fluid concrete against the wall surfaces. By blowing an initial coating of concrete on the surfaces of the wall structure, the wall structure is reinforced and strengthened to more nearly hold the desired vertical shape. The skin can be blown on after the desired wall height is obtained, or applied at successive heights as the wall construction progresses.

Additional horizontal courses are laid until the height is reached at which windows are to be installed. A suitable window frame **32** is installed directly on top of a horizontal course of the construction units and secured thereto, such as by fastening the frame by flanges or reinforcing rods inserted in the construction units. It will be understood that the construction units are also built up around the sides of the window frame and wetted to activate them as each course is laid. The rods holding the window frame are secured within the construction units when the construction units set up to a hardened state and, in addition, the courses seals to the window frame to further secure it. It will be understood that door frames are installed in a similar fashion.

Concrete coatings are applied to the surfaces of the wall structure as the wall height progresses, and when the desired height of the wall is reached, a roof structure is installed as will be described hereinafter with reference to FIG. **4.**

The flexible sacks in which the dry premixture is contained and the characteristic of the dry premixture to conform to any shape lend themselves to the prepackaging of construction units of any desired shape and size. For exmple, it is sometimes preferable to employ a smaller sized construction unit to fit into spaces adjacent door frames, window frames and other places constituting termination points where space does not permit the utilization of one of the more standard size units. A construction unit **40** of reduced size is shown

in the perspective view of FIG. 3 in which a smaller amount of the dry premixture is placed in a standard size sack and larger flap 44 at the open end 42 is folded over. This essentially provides a shorter construction unit. The thickness or width of the construction unit can be varied as desired by shaping the sack and its contents accordingly. It will also be apparent that some of the fill within the sack can be removed by the construction worker on the site when a variation in the size of the unit is required. This can be performed immediately by the worker on the unit with which he is presently working without stopping his labor and securing a unit of different size.

A more detailed illustration of the method of construction is shown in the fragmentary, side elevation view in section of FIG. 4, wherein there is shown the concrete beam 24 poured into a trench 20 excavated in the earth 22. In the preferred method of construction, steel reinforcing bars or rods are inserted in the construction units to interconnect adjacent units to form a greatly strengthened and integrated structure when set up. According to this method, steel reinforcing rods 50 are inserted in the concrete beam before the latter sets up to provide a structural tie to the first course of construction units. After the concrete beam has set up, the first course of construction units are impaled on the steel reinforcing rods. The latter are so positioned that a pair of the reinforcing rods are inserted in each of the construction units adjacent the opposing ends thereof. These construction units are wetted just prior to laying or after laying to activate the mixture to form a structural tie or bond by means of the concrete setting up around the steel reinforcing rods. The "latents" of the wetting mixture also permeate the sacks to form a bond with the concrete beam. There is, of course, no necessity for waiting until the first course of construction units has set up before the second course is superimposed thereon. The second course is laid in staggered relation, as shown, on the first course in juxtaposed positions. As the courses are laid, another pair of steel reinforcing rods 54 and 56 are inserted through each construction unit adjacent the opposite ends thereof. The rods are of sufficient length to penetrate the adjacent construction units immediately therebeneath and across which the construction units span. This course is then wetted to activate the fill mixture, and a third course is laid on top of the second employing reinforcing rods as described. Units of the third course are connected to immediately underlying units of the second course through steel reinforcing rods 58 and 60 penetrating the construction units over which it spans. It will then be seen that each construction unit is tied to four other adjacent construction units through steel reinforcing rods 54, 56, 58 and 60, in addition to which, each unit is also structurally bound to the two opposite adjacent units in the same course by means of the concrete latents permeating the sack and binding to these units.

The superimposed courses of the construction units are laid until the desired height of the wall is attained, it being understood that a concrete skin is blown onto the wall surfaces at intervals during the construction as the height increases. At this level, bolts 64 are inserted in predetermined spaced apart units in the top course. These bolts are threaded on their top ends and are left protruding above the top course. A suitable top plate 66 having holes drilled therein corresponding to the bolts 64 is seated over the bolts, and suitable nuts 68 or other suitable fastening means, are employed to secure the top plate to the top course. This provides means by which the roof structure can be added and secured to the building. The roof structure can be of any suitable or conventional construction, such as that comprising roof joints 70 secured to the top plate by conventional means and which span between the walls of the building. Thereafter, a conventional roof 72 can be applied to the top of the roof joists. Of course, truss structures or other roof constructions can be employed.

Some of the more important features of the construction method described herein will now become more apparent. The characteristic of the flexible sack and its contents to conform to the surface on which it is laid to form an integrated part of a course, both in the dry state and especially in the wetted condition, is of considerable importance. By so conforming, no stress points or lines are introduced in the structure between adjacent units when the structure sets up in a hardened form as is so often the case of conventional inflexible masonry units. However, the sacks or units should not be kneaded after wetting, as this causes the separation of the concrete constituents to weaken the structure. The constituents are initially well mixed in the dry state and should be left alone as far as possible after wetting. No mortar is used since it is invariably of a different material than that of the masonry units with which it is employed. This eliminates weaknesses due to mismatching materials. Since no mortar is used, water cannot be absorbed therefrom by the construction units which is a typical cause of weak joints. In the present method, concrete is bound to concrete in an integrated structure but without the necessity of using concrete forms. The steel reinforcing rods serve to secure adjacent construction units together to greatly increase the strength of the structure. In the preferred practice of the invention, the sacks are porous enough to permit the penetration by water and by the latents or wetted "fines" of the mixture, but not so porous to allow the wetted mixture as concrete to penetrate to any great extent. Therefore, the reinforcing rods, or other suitable means, are employed as a structural means to which the concrete is secured and by which adjacent units are further secured together.

A fragmentary, end elevational view in section of a wall structure is shown in FIG. 5 which illustrates the additional reinforcing and finishing material added to the surfaces of the wall structure and the details of a slab floor. This figure shows the concrete beam 24 poured to ground level and can include therein suitable steel reinforcing means (not shown) other than rods 50. Since the first course of the wall structure is laid after the concrete beam is set up, a "cold" joint 74 is formed between this course and the beam. The steel reinforcing rods 50 serve to secure the wall structure to the beam with sufficient structural strength. A concrete slab 80 can be poured between beams after at least a sufficient number of wall courses have been laid to provide a form 82 against which the slab can be poured. It will be seen that the concrete beam 24 is preferably wider that the construction units to provide an outside base or surface 75 the width of which an outside surfacing material fills and an inner base surface 76 on which the slab floor is partially supported. The slab can also be poured after completion of the courses. It will be seen that another cold joint is formed between the concrete beam 24 and slab 80 on surface 76 which is desirable, so that shifting of the slab floor does not tend to

crack or weaken the wall structure, or at least this effect is minimized.

A fill **78** also can be provided, if necessary, beneath the slab flooring **80** before the latter is poured to level the earth beneath the flooring should the lot on which the building is constructed have substantial grade. By providing this fill, a uniform thickness slab **80** can be poured for the floor of the building. It will be seen hereinafter, however, that such a fill is unnecessary, especially when the building site has no substantial grade.

Additional reinforcing and surfacing material is applied to the wall surfaces to serve the multiple purposes of an additional reinforcing means, a surface finishing means, and a layer beneath which there can be contained pipes and electrical conduits to provide utilities to the building. As already noted in conjunction with FIG. **2,** additional reinforcing of the wall structure is achieved by applying an initial coating or skin of concrete sprayed or blown under pressure onto the inner and outer surfaces **82** and **85,** respectively, of the wall structure at various successive heights during erection of the wall structures. This initial coating is denoted by numeral **30** in FIG. **5.** The skin is blown on under substantial pressure, such as, for example, 60–80 psi, to achieve the effects enumerated below. Any suitable apparatus may be employed for this purpose, wherein a nozzle having a reduced diameter orifice at the outlet is preferably employed so that the velocity of the spray is increased as it emerges from the orifice. Concrete comprising sand, water and cement is usually employed as the skin material. Insulating and acoustical materials can also be added to the mixture. By blowing the skin on under pressure, the skin fills any holes, cracks or crevices that exist between concrete units to seal the wall. Another important aspect is to be noted here. Since there will be some voids between the construction units **10,** the concrete sprayed onto the surfaces will fill these voids to as to "key" into the walls as structural member themselves to strengthen the wall structure. Since the sacks are also porous and expose the concrete therein, the surfacing material is bonded directly thereto and keys to the sacks themselves. The rough surface of the sacks facilitates this bonding process. In addition, the rough surface onto which the concrete is blown and the fact that this material keys into this surface means that very little, or negligible, shear or lateral stress is present in the surface material that would tend to cause it to become loose or crack off. This method of applying a skin to a structural wall having the particular characteristics noted also contributes to a wall structure of superior strength, utility and appearance. The skin or tack coat also provides a moisture proof barrier for sealing the wall and the construction units.

When the wall structure is completed to the desired height with the construction units, an additional coating of concrete can be sprayed onto the surfaces to finish the wall. A coating **88** can be sprayed onto the initial coating **30** on the outside wall and left in a rough, textured condition for appearance. On the inside surface of the wall, it is usually necessary to install pipes and electrical conduits **90** against the inner surface which can be held in place temporarily by wire ties **92** or other suitable means. Then a finishing surface **94** is sprayed onto the inner surface of the wall and can be left in the rough, textured condition or leveled to a smooth surface as shown in FIG. **5.** Any suitable means may be employed to smooth the surface, such as by screeding the surface with a level board. Coloring may be added to the concrete before spraying the wall surface, or the surfaces may be painted as a last step.

Another reinforcing device to connect adjacent construction units in a structural manner is shown in FIG. **6,** and as applied in FIG. **7.** This device comprises an elongated steel member **100** pointed on each end and having a cleft in each end medially of the sides thereof, so that the two sides of each end can be bent oppositely at 90° to the main body. Thus, a pair of opposing barbs or pointed members **102** and **104** are formed at one end, and similarly, a pair of opposing barbs **106** and **108** are formed at the other end. As the courses of units are laid as shown in FIG. **7,** one of the reinforcing devices is inserted into the ends of adjacent units spanning the two units and on each top end of each unit, all as shown. The central portions of the units of the next course are impaled on the protruding barbs so that the units are staggered, and additional reinforcing devices are inserted in the tops of these units as just described. Therefore, each unit is reinforced by four barbs and tied to four adjacent units as before when the mixture sets up in a hardened state.

Additional reinforcing can be provided by inserting elongated steel reinforcing rods horizontally through at least part of the length of a course as shown in FIG. **8.** Here, vertical reinforcing members are likewise employed. An elongated steel reinforcing rod **112** is inserted through several units in a course along one direction to form continuous reinforcement. These rods can be employed at each course or, as shown, at predetermined spaced apart courses as denoted by reinforcing rod **114** to further strengthen the structure.

The construction units described herein can be packaged as shown in FIG. **9,** which allows the unit to be shipped, displayed and transported without loss of the fill material. The packaging also prevents moisture in the ambient atmosphere from activating the contents. The basic construction unit is packaged in a water repellant bag **120** similar or the same as that employed in packaging cement, and sealed by any suitable means at the open end **122** thereof, such as by stitching.

The method of erecting a structural wall, including the provision of a foundation and concrete slab flooring has been described above. The following is a more detailed description of the method of constructing a complete building.

There is shown in FIG. **11** a perspective view of the concrete beam foundation for an entire building with part of the earth broken away to show the concrete beams. To erect a building or house, the lot on which the building is to be erected is staked out to determine the height of the floor for drainage. Normally the highest point of the lot is selected for one corner of the building and from which the construction is started. After this spot is selected, a determination is made of any fill that will be required to level or elevate the lot, or alternatively any excavation or earth moving to establish the house and the floor thereof at the desired elevation. Next, all of the corners and edges of the building are staked or marked, and all beams constituting the foundation of the building are laid out as to their location with stakes and strings, or the like. The main foundation for the building constitutes a concrete beam corresponding to the outside or exterior wall structure. Preferably, concrete beams corresponding to the interior walls also constitute the foundation for the building. When all of the concrete foundation beams

are laid out, corresponding trenches are excavated within wich concrete is to be poured to form the foundation.

Referring to FIG. 11, a trench 20 is excavated corresponding with the exterior walls of the building. In addition, trenches correponding to the interior walls of the building, and which intersect the exterior wall trench, are excavated. Concrete is then poured to ground level in all of the trenches to form a monolithic foundation structure comprising the several concrete beams. This foundation comprises what will be referred to as the grade beam 24 providing the major foundation of the building and corresponding to the outside walls thereof, and several other foundation beams corresponding to the various interior walls of the building such as the beams 152, 154 and 156. When the concrete beams are poured, reinforcing rods 50 are inserted in the outside concrete grade beam 24 for tying the first course of construction units to this grade beam. In addition, reinforcing rods 172 can be provided in one or more of the interior foundation beams should it be necessary to construct over this beam an interior structural wall such as would be required to help support the roof structure, as compared to a partition wall that is not load bearing.

A fragmentary side elevational view in section taken across section lines 12—12 of FIG. 11 is shown in FIG. 12, which illustrates a concrete slab flooring poured over the concrete foundation beams and wall structures erected thereover. Concrete beams 24, 152, 154 and 156, in addition to the other interior foundation beams of the building, are poured to ground level. Then, at least one course of construction units is laid on the outer grade beam 24 by impaling them on the reinforcing rods 50 and then wetting the units to produce concrete that will harden. A sufficient number of courses of the units are laid on the outside grade beam 24 to act as a form against which the concrete slab flooring can be poured. In the particular example shown, no dirt fill is required within the confines of the outside grade beam 24, as it is assumed that the building site is substantially level. The concrete slab is then poured between the confines of the partially erected wall structure atop the outside grade beam 24 and which directly overlies the interior foundation beams. As already noted, the concrete slab floor rests on a ledge of the outside grade beam 24, and is further supported by the interior foundation beams. The outside wall structure is then completed according to the foregoing description.

It may be necessary to provide structural or load bearing walls in the interior of the building for any number of purposes, such as, for example, to additionally support the roof structure. For this purpose, reinforcing rods 172, which protrude above an interior foundation beam 152 sufficiently to also protrude above the concrete slab floor 160 after it is poured, are provided as an added measure for securing a structural wall to the concrete slab flooring. Thereafter, construction units 170 are laid on the floor directly overlying the concrete beam 152, and additional reinforcing rods 174 are employed to further reinforce the wall structure. It will be noted that the reinforcing rods 172 can be eliminated in many, if not all, instances since this wall is not a load bearing wall to the extent as are the outside walls. The outside walls primarily support the roof structure and withstand wind and other external forces. If the reinforcing rods 172 are eliminated in the interior wall, the weight of the interior wall is sufficient in conjunction with the concrete bond between the lowest course and the concrete floor.

In most instances the interior walls are for partition purposes only. A metal or wood partition 180 can be erected above an interior concrete foundation beam 156 and sheetrock or other suitable panelling material can be installed in the wall, all as is well known. Such partition wall can be secured in place by any suitable means, such as by securing the partition to the floor with suitable pins 182 shot through an apertured flange 184.

The interior concrete foundation beams also underlie openings in the interior walls and partitions constituting door. Such is the case as shown with interior concrete foundation beam 154 wherein no wall or partition is erected over that portion of the beam as shown in FIG. 12.

A detailed illustration of a door frame as installed within a load bearing wall structure is shown in FIG. 13. The door frame 190 comprises a pair of spaced apart vertical side frames connected together at the bottom by a base frame or plate. The two vertical side frames include laterally, outwardly opening channels 191, and suitable T flanges 192 and 194 held in the channel of the door frame are employed for securing the frame to the wall structure. Assuming that the door frame illustrated in FIG. 13 is provided in an exterior wall of the building, the bottom plate of the door frame is placed directly on top of a course of the construction units that is level with the inside concrete slab flooring. The door frame is secured in place by inserting reinforcing rods through suitable openings, such as through holes 193 in the lower flange 192. Thereafter, the wall is erected around the door frame by the successive laying of courses of the construction units, wherein the construction units are laid directly in the channels 191 directly against the door frame. This locks the door frame in place as the construction units set up. As many securing flanges can be employed as desired. Another flange 194 is shown intermediate the height of the door frame and which is secured to the construction unit directly underlying the flange.

Since most door frames are not substantial enough to constitute a load bearing member, it is desirable to eliminate any substantial load bearing down on the door frame itself. To avoid such a load, the wall structure is laid flush with the top of the door frame, at which level a load bearing plate or lintel 196 is employed to span across the top of the door frame and act as the top portion of the frame. The lintel has suitable holes 198 through the ends thereof and through which reinforcing rods can be inserted into the construction unit directly underlying the ends of the lintel. After the structure has set up, substantially all of the weight of the wall directly above the door frame will be carried by the lintel, and which weight is transferred to the structural wall itself.

A more detailed illustration of installing a window frame in the wall structure as the latter is erected is shown in FIG. 14. The window frame 32 constitutes a rectangular framework having an outwardly opening channel 200 provided about the entire perimeter thereof. When the level of the wall is attained during erection that corresponds to the lower sill of the window, the window frame is installed by setting it down directly over this particular course of construction units so that the channel 200 spans the wall, as shown. Suitable T flanges 202 and 204 are employed to secure

the frame to the various underlying construction units by inserting reinforcing rods through holes **202** in flange **201**, for example. Again, as many of these flanges can be employed up the side of the frame as desired. The wall is successively laid about the window frame so that the construction units key into the channel **200** at the sides thereof, as shown. As with the door described in FIG. **13**, it is desirable to transfer the weight of the wall above the window away from the window frame. As one example, a lintel was employed to bear this load over the door frame in FIG. **13**. As another example, a horizontal reinforcing rod or member **206** can be inserted through a plurality of the construction units that directly overlie the window frame adjacent the top thereof so that this reinforcing rod takes the load of the wall above the window frame and transfers it to that part of the wall adjacent the sides of the frame.

It has been found advantageous to employ elongated porous sacks for most building construction as will be described in conjunction with FIGS. **15** and **16**. In addition, a preferred method of stacking the sacks will be described with reference to these figures. As shown in FIG. **15**, an elongated porous sack **220**, such as comprised of burlap for example, is filled with a dry mixture of sand, aggregate and cement as earlier described. The sack is stitched along the bottom in a seam **222**, thus leaving a short tail **224**. Similarly, the sack is stitched along one side in a seam to leave an edge **230** running along the side. As before, it is unnecessary to sew up or permanently close the open end of the sack, wherein the open end **26** is folded over to abut against the adjacent sack end **228**.

When the sacks are filled with the dry constituents, the sacks tend to become circular shaped in cross section, but because of the seams in the sack, the shape is actually oval having its widest dimension intersecting the seam along the side of the sack. There is shown in FIG. **15** an array of these sacks stacked on each other in superimposed courses, and FIG. **16** is an end section view taken through section lines **16—16** of FIG. **15**. This slightly greater dimension in cross section will be seen more clearly from FIG. **16**. It will also be seen that the sacks are not turned inside out after being stitched, since more mixture can be placed in each sack when the edges are left on the outside as shown.

A preferred method of stacking the sacks comprises arranging a first course of the sacks **220** on a concrete beam **221** with the longest cross sectional dimension of the sack being arranged vertically. That is to say, the seam along the side of the sack is faced directly upward, and the seam **222** at the end of the sack is arranged as nearly as possible along the vertical. The next course of sacks is laid on top of the first course so that the end seams **222** of the next course of sacks is aligned vertically with the end seams of the sacks directly beneath this course. This is more clearly seen in FIG. **16**. Thus, as the wall height progresses, the wall remains straight and vertical and does not get out of plumb. Thus, the seams become an aid for visual alignment for erecting vertical walls. It will be understood that suitable reinforcing rods (not shown) are employed between adjacent sacks, wherein these reinforcing rods are inserted directly through the top seams of the sack.

It has been found that housing structures constructed in accordance with the invention described above cost from 20% to 60% less than equivalent sized housing structures constructed by conventional techniques. Furthermore, wall structures constructed in accordance with the invention have been found to have highly superior structural integrity and strength.

To determine the structural characteristics of wall panels constructed in accordance with the invention, nine test panels were constructed and tested. Three of the panels were 8 ft. × 8 ft. and six were 4 ft. × 8 ft. A 2 inch × 6 inch top plate was fastened to the top of each wall section using L type bolts on 4 foot centers. Both faces of the wall were coated using Portland cement plaster applied in two courses. The test walls were cured after the final plaster coat by a water spray applied twice a day for two days.

The test walls were constructed on a foundation having No. 3 reinforcing bars extending vertically 12 inches from the foundation on 12 inch centers.

Burlap sacks 6 inches in diameter and 24 inches long were filled with a **5** sack concrete mixed dry using equal parts of sand and pea gravel. The filled bags were submerged in water for a period of approximately 20 seconds. The first two courses were impaled on the No. 3 reinforcing steel extending from the foundation. Two more courses were laid and then pieces of No. 3 reinforcing steel (24 inches long) were driven through the four courses. All joints were staggered as in masonry construction. This process was repeated until the eight foot height was reached. An L type ½ inch bolt was placed on 4 foot centers, the foot being driven into the end of a sack below the top course. Prior to coating, a No. 3 reinforcing bar was placed along the joint one sack down from the top and parallel on each side of the wall. The finish consisted of a Portland cement plaster coat applied in two courses. The panels were then subjected to the following tests.

I. TRANSVERSE LOAD TEST

A special steel rack was constructed to apply the transverse load to each of the three 4 ft. × 8 ft. panels which had been constructed in a normal vertical position. Two point loading was used with the two equal loads being applied at a distance of one quarter of the span from the supports, toward the middle of the span. Two dial indicators (A & B) were placed on the center line of the panel, one near each longitudinal edge of the test panel to measure the deflection. The dial indicators were graduated to 0.001 inch. The load was applied uniformly through a calibrated hydraulic jack.

TEST DATA
PANEL NO. 1

Total Load in Pounds	Dial Indicators A	B	Total Load in Pounds	Dial Indicators A	B
0	0.000	0.000	1,200	0.026	0.028
50	0.000	0.000	1,250	0.027	0.029
100	0.000	0.000	1,300	0.028	0.031
150	0.001	0.001	1,350	0.030	0.033
200	0.002	0.002	1,400	0.032	0.034
250	0.003	0.003	1,450	0.033	0.034
300	0.004	0.004	1,500	0.034	0.036
350	0.005	0.006	1,550	0.037	0.039
400	0.006	0.007	1,600	0.040	0.042
450	0.007	0.009	1,650	0.046	0.048
500	0.008	0.010	1,700	0.053	0.054
550	0.009	0.011	1,750	0.059	0.059
600	0.010	0.012	1,800	0.062	0.062
650	0.012	0.014	1,850	0.066	0.066
700	0.013	0.015	1,900	0.082	0.080
750	0.014	0.016	1,950	0.091	0.089
800	0.015	0.017	2,000	0.096	0.094
850	0.015	0.017	2,050	0.100	0.097
900	0.017	0.020	2,100	0.104	0.100
950	0.019	0.021	2,150	0.109	0.106
1,000	0.020	0.022	2,200	0.115	0.111

-continued

TEST DATA
PANEL NO. 1

Total Load in Pounds	Dial Indicators A	Dial Indicators B	Total Load in Pounds	Dial Indicators A	Dial Indicators B
1,050	0.021	0.024	2,250	0.120	0.116
1,100	0.023	0.026	2,300	Horizontal cracking-failure	
1,150	0.025	0.027			

PANEL NO. 2

Total Load in Pounds	Dial Indicators A	Dial Indicators B	Total Load in Pounds	Dial Indicators A	Dial Indicators B
0	0.000	0.000	1,600	0.042	0.038
100	0.002	0.003	1,700	0.044	0.039
200	0.007	0.008	1,800	0.047	0.042
300	0.010	0.010	1,900	0.049	0.043
400	0.012	0.012	2,000	0.052	0.045
500	0.016	0.015	2,100	0.056	0.047
600	0.018	0.017	2,200	0.058	0.050
700	0.021	0.019	2,300	0.060	0.052
800	0.023	0.021	2,400	0.064	0.055
900	0.025	0.023	2,500	0.067	0.058
1,000	0.028	0.026	2,600	0.073	0.064
1,100	0.031	0.028	2,700	0.079	0.069
1,200	0.034	0.030	2,800	0.085	0.074
1,300	0.035	0.032	2,900	0.095	0.084
1,400	0.037	0.033	3,000	Failure	
1,500	0.040	0.035			

Horizontal cracking was first observed at 2,700 pounds.

PANEL NO. 3

Total Load in Pounds	Dial Indicators A	Dial Indicators B	Total Load in Pounds	Dial Indicators A	Dial Indicators B
0	0.000	0.000	1,300	0.033	0.030
100	0.001	0.001	1,400	0.036	0.032
200	0.004	0.004	1,500	0.040	0.035
300	0.006	0.006	1,600	0.043	0.038
400	0.009	0.009	1,700	0.047	0.043
500	0.011	0.011	1,800	0.053	0.048
600	0.014	0.013	1,900	0.060	0.054
700	0.016	0.015	2,000	0.072	0.064
800	0.019	0.018	2,100	0.084	0.075
900	0.021	0.020	2,200	0.096	0.086
1,000	0.024	0.022	2,300	0.109	0.098
1,100	0.027	0.024	2,400	0.122	0.113
1,200	0.030	0.027	2,500	Horizontal cracking-failure	

The loading was continued after failure until the cracks were opened ½ inch wide. The load was removed and the cracks closed.

II. COMPRESSIVE LOAD TEST

A special welded steel rack was constructed to apply the load as specified in ASTM E-72 to each of the three test panels. The compressive load was applied at the top of the panel along a line from the panel face ⅓ of the panel thickness giving an eccentricity of T/6.

Two compressometers (C & D) were mounted on the longitudinal center line of each panel face. Two dial indicators (A & B) were mounted on the face of the panel at mid-point near the longitudinal edge. Each dial indicator was graduated to 0.001 inch.

TEST DATA
PANEL NO. 4

Total Load in Pounds	Dial Indicators A	Dial Indicators B	Dial Indicators C	Dial Indicators D
0	0.000	0.000	0.000	0.000
100	0.000	0.001	0.000	0.000
200	0.004	0.005	0.000	0.000
300	0.006	0.007	0.000	0.000
400	0.007	0.008	0.000	0.000
500	0.008	0.009	0.000	0.000
600	0.009	0.010	0.000	0.000
700	0.009	0.010	0.000	0.000
800	0.009	0.011	0.000	0.000
900	0.009	0.011	0.000	0.000
1,000	0.010	0.011	0.000	0.000
1,200	0.010	0.011	0.000	0.000
1,400	0.011	0.012	0.000	0.000
1,600	0.012	0.014	0.000	0.000
1,800	0.013	0.014	0.000	0.000
2,000	0.013	0.015	0.000	0.000
2,200	0.014	0.016	0.000	0.000
2,400	0.014	0.016	0.000	0.000
2,600	0.014	0.016	0.000	0.000
2,800	0.014	0.016	0.000	0.000
3,000	0.015	0.017	0.000	0.000
3,500	0.015	0.017	0.000	0.000
4,000	0.015	0.017	0.000	0.000
4,500	0.015	0.017	0.000	0.000
5,000	0.015	0.017	0.000	0.000
5,500	0.015	0.017	0.000	0.000
6,000	0.015	0.017	0.000	0.000
7,000	0.015	0.017	0.000	0.000
8,000	0.015	0.017	0.000	0.000
9,000	0.014	0.016	0.000	0.000
10,000	0.013	0.015	0.000	0.000
11,000	0.013	0.015	0.000	0.000
12,000	0.012	0.014	0.000	0.000
13,000	0.011	0.013	0.000	0.000
14,000	0.010	0.012	0.000	0.000
15,000	0.009	0.011	0.000	0.000
16,000	0.008	0.010	0.000	0.000
17,000	0.007	0.009	0.000	0.000
18,000	0.007	0.009	0.001	0.000
19,000	0.006	0.008	0.001	0.000
20,000	0.005	0.007	0.001	0.000
21,000	0.005	0.007	0.002	0.000
22,000	0.005	0.006	0.002	0.000
23,000	0.005	0.006	0.002	0.000
24,000	0.005	0.006	0.002	0.000
25,000	0.005	0.006	0.002	0.000
26,000	0.005	0.006	0.002	0.000
27,000	0.005	0.006	0.003	0.000
28,000	0.005	0.006	0.003	0.000
29,000	0.005	0.006	0.003	0.000
30,000	0.005	0.006	0.003	0.000
31,000	0.005	0.006	0.004	0.000
32,000	0.005	0.006	0.004	0.000
33,000	0.005	0.006	0.004	0.000
34,000	0.006	0.006	0.005	0.000
35,000	0.007	0.007	0.006	0.000
36,000	0.007	0.007	0.006	0.000
37,000	0.008	0.007	0.006	0.000
38,000	0.009	0.008	0.007	0.000
39,000	0.010	0.009	0.008	0.001
40,000	0.012	0.011	0.009	0.001
41,000	0.012	0.011	0.010	0.001
42,000	0.015	0.013	0.021	0.001
43,000	0.016	0.014	0.025	0.002
44,000	0.019	0.016	0.031	0.002
45,000	0.020	0.018	0.036	0.003
46,000	0.022	0.020	0.040	0.003
47,000	0.023	0.021	0.045	0.004
48,000	0.024	0.021	0.048	0.004
49,000	0.026	0.023	0.052	0.005
50,000	0.028	0.025	0.057	0.005
51,000	0.029	0.026	0.060	0.005
52,000	0.031	0.028	0.065	0.006
53,000	0.033	0.029	0.069	0.006
54,000	0.034	0.030	0.072	0.006
55,000	0.036	0.032	0.077	0.007
0	0.036	0.032	0.077	0.007

At 55,000 pounds there was no indication of any failure.

PANEL NO. 5

Total Load in Pounds	Dial Indicators A	B	C	D
0	0.000	0.000	0.000	0.000
200	0.001	0.001	0.000	0.000
400	0.003	0.003	0.000	0.000
600	0.005	0.005	0.000	0.000
800	0.006	0.006	0.000	0.000
1,000	0.007	0.007	0.000	0.000
1,500	0.010	0.010	0.000	0.000
2,000	0.011	0.011	0.000	0.000
3,000	0.013	0.013	0.001	0.000
4,000	0.019	0.019	0.003	0.000
5,000	0.024	0.024	0.005	0.000
6,000	0.025	0.025	0.006	0.000
7,000	0.028	0.028	0.007	0.000
8,000	0.030	0.030	0.007	0.000
9,000	0.031	0.031	0.008	0.000
10,000	0.032	0.032	0.009	0.000
12,000	0.035	0.035	0.012	0.001
14,000	0.035	0.036	0.014	0.001
16,000	0.036	0.038	0.016	0.001
18,000	0.036	0.038	0.018	0.001
20,000	0.036	0.038	0.020	0.001
22,000	0.036	0.038	0.021	0.002
24,000	0.036	0.038	0.022	0.002
26,000	0.036	0.038	0.024	0.002
28,000	0.036	0.038	0.025	0.002
30,000	0.036	0.038	0.025	0.002
32,000	0.035	0.036	0.026	0.002
34,000	0.034	0.035	0.027	0.002
36,000	0.033	0.033	0.028	0.002
38,000	0.030	0.030	0.028	0.003
40,000	0.028	0.027	0.029	0.003
42,000	0.025	0.024	0.030	0.003
44,000	0.024	0.023	0.030	0.003
46,000	0.021	0.020	0.031	0.003
48,000	0.019	0.018	0.032	0.003
50,000	0.017	0.015	0.032	0.003
52,000	0.014	0.012	0.034	0.003
54,000	0.011	0.009	0.035	0.003
55,000	0.010	0.008	0.035	0.003
0	0.004	0.005	0.008	0.001

At the total load of 55,000 pounds, there was no indication of any failure.

PANEL NO.

Total Load in Pounds	Dial Indicators A	B	C	D
0	0.000	0.000	0.000	0.000
200	0.001	0.000	0.000	0.000
400	0.002	0.000	0.000	0.000
600	0.003	0.000	0.001	0.000
800	0.003	0.001	0.001	0.000
1,000	0.004	0.001	0.001	0.000
1,200	0.004	0.001	0.002	0.000
1,400	0.004	0.001	0.002	0.000
1,600	0.004	0.001	0.002	0.000
1,800	0.004	0.002	0.002	0.000
2,000	0.004	0.002	0.002	0.000
3,000	0.005	0.002	0.003	0.000
4,000	0.005	0.003	0.004	0.000
5,000	0.006	0.003	0.005	0.000
6,000	0.008	0.004	0.006	0.000
7,000	0.010	0.005	0.007	0.000
8,000	0.011	0.006	0.008	0.001
9,000	0.016	0.012	0.009	0.001
10,000	0.016	0.012	0.010	0.001
12,000	0.017	0.013	0.011	0.001
14,000	0.019	0.015	0.012	0.001
16,000	0.020	0.016	0.013	0.001
18,000	0.023	0.018	0.015	0.001
20,000	0.026	0.022	0.017	0.001
22,000	0.028	0.024	0.018	0.002
24,000	0.030	0.026	0.020	0.002
26,000	0.032	0.028	0.022	0.002
28,000	0.034	0.030	0.023	0.002
30,000	0.036	0.032	0.025	0.002
32,000	0.037	0.034	0.027	0.002
34,000	0.038	0.035	0.028	0.003
36,000	0.037	0.036	0.030	0.003
38,000	0.041	0.043	0.032	0.003
40,000	0.041	0.043	0.035	0.003
42,000	0.040	0.043	0.037	0.003

-continued

PANEL NO.

Total Load in Pounds	Dial Indicators A	B	C	D
44,000	0.040	0.043	0.039	0.004
46,000	0.037	0.040	0.042	0.004
48,000	0.016	0.014	0.058	0.005
50,000	0.012	0.014	0.060	0.005
52,000	0.011	0.013	0.063	0.006
54,000	0.010	0.012	0.067	0.006
55,000	0.009	0.011	0.069	0.006
0	0.003	0.005	0.031	0.002

At maximum load, there was no indication of failure in the test wall.

III. RACKING LOAD TEST

A steel rack was constructed around the 8 ft × 8 ft panels to implement loading in accordance with standard racking load tests. Three dial indicators were positioned to measure panel deformation as in standard racking tests at points designated A, B and C.

The dial indicators used could be read directly to 0.001 of an inch. The test results were as follows:

TEST DATA
PANEL NO. 7

Total Load in Pounds	Dial Indicators A	B	C	Net Deformation C −(A+B)
0	0.000	0.000	0.000	0.000
100	0.000	0.000	0.001	0.001
200	0.000	0.000	0.002	0.002
300	0.000	0.000	0.005	0.005
400	0.000	0.000	0.007	0.007
500	0.000	0.000	0.008	0.008
600	0.000	0.000	0.009	0.009
700	0.000	0.000	0.011	0.011
800	0.000	0.000	0.012	0.012
900	0.000	0.000	0.014	0.014
1,000	0.000	0.000	0.015	0.015
1,500	0.000	0.000	0.022	0.022
2,000	0.000	0.000	0.029	0.029
2,500	0.000	0.000	0.036	0.036
3,000	0.000	0.000	0.043	0.043
3,500	0.000	0.000	0.049	9.049
4,000	0.000	0.000	0.055	0.055
4,500	0.000	0.001	0.061	0.060
5,000	0.001	0.002	0.068	0.065
5,500	0.001	0.002	0.072	0.069
6,000	0.002	0.002	0.078	0.074
6,500	0.002	0.003	0.084	0.079
7,000	0.003	0.003	0.090	0.084
7,500	0.003	0.004	0.095	0.088
8,000	0.004	0.005	0.101	0.092
8,500	0.005	0.005	0.107	0.097
9,000	0.005	0.006	0.113	0.102
9,500	0.006	0.006	0.119	0.107
10,000	0.007	0.007	0.125	0.111
10,500	0.007	0.008	0.131	0.116
11,000	0.007	0.008	0.137	0.122
11,500	0.008	0.009	0.142	0.127
12,000	0.008	0.009	0.147	0.130
12,500	0.009	0.010	0.153	0.134
13,000	0.010	0.011	0.160	0.139
13,500	0.011	0.012	0.167	0.144
14,000	0.012	0.014	0.174	0.148
14,500	0.013	0.016	0.182	0.153
15,000	0.015	0.020	0.200	0.165
15,500	0.015	0.023	0.209	0.171
16,000	0.015	0.027	0.221	0.179
16,500	0.016	0.030	0.232	0.184
17,000	0.017	0.036	0.253	0.200
17,500	0.019	0.040	0.265	0.206
18,000	0.020	0.044	0.280	0.216
18,500	0.021	0.047	0.292	0.224
19,000	0.023	0.050	0.307	0.234
19,500	0.024	0.052	0.320	0.244
20,000	0.024	0.054	0.340	0.262

PANEL NO. 8

Total Load in Pounds	Dial Indicators A	B	C	Net Deformation C − (A + B)
0	0.000	0.000	0.000	0.000
200	0.000	0.000	0.000	0.000
400	0.000	0.000	0.001	0.001
600	0.000	0.000	0.002	0.002
800	0.000	0.000	0.004	0.004
1,000	0.000	0.000	0.006	0.006
1,500	0.000	0.000	0.008	0.008
2,000	0.000	0.000	0.011	0.011
2,500	0.000	0.000	0.014	0.014
3,000	0.000	0.000	0.017	0.017
3,500	0.000	0.001	0.020	0.019
4,000	0.000	0.001	0.024	0.023
4,500	0.000	0.001	0.027	0.026
5,000	0.000	0.001	0.030	0.029
5,500	0.000	0.001	0.033	0.032
6,000	0.000	0.001	0.037	0.036
6,500	0.000	0.001	0.040	0.039
7,000	0.000	0.002	0.045	0.043
7,500	0.001	0.002	0.047	0.044
8,000	0.002	0.002	0.051	0.047
8,500	0.003	0.002	0.055	0.050
9,000	0.005	0.003	0.060	0.052
9,500	0.008	0.004	0.066	0.054
10,000	0.010	0.004	0.072	0.058
10,500	0.014	0.005	0.078	0.059
11,000	0.017	0.005	0.085	0.063
11,500	0.021	0.007	0.092	0.064
12,000	0.025	0.008	0.100	0.067
12,500	0.030	0.010	0.110	0.070
13,000	0.037	0.012	0.123	0.074
13,500	0.040	0.014	0.130	0.076
14,000	0.045	0.017	0.140	0.078
14,500	0.050	0.020	0.151	0.081
15,000	0.060	0.026	0.171	0.085
15,500	0.070	0.031	0.190	0.089
16,000	0.075	0.035	0.200	0.090
16,500	0.078	0.038	0.209	0.093
17,000	0.081	0.040	0.217	0.096
17,500	0.085	0.043	0.226	0.098
18,000	0.090	0.046	0.238	0.102
18,500	0.095	0.050	0.249	0.104
19,000	0.100	0.053	0.261	0.108
19,500	0.105	0.058	0.274	0.111
20,000	0.112	0.062	0.288	0.114

PANEL NO. 9

Total Load Pounds	Dial Indicators A	B	C	Net Deformation C − (A + B)
0	0.000	0.000	0.000	0.000
200	0.000	0.000	0.000	0.000
400	0.000	0.000	0.002	0.002
600	0.000	0.000	0.004	0.004
800	0.000	0.000	0.006	0.006
1,000	0.000	0.000	0.008	0.008
1,500	0.000	0.000	0.012	0.012
2,000	0.000	0.000	0.017	0.017
2,500	0.000	0.000	0.022	0.022
3,000	0.000	0.000	0.025	0.025
3,500	0.000	0.000	0.030	0.030
4,000	0.000	0.000	0.034	0.034
4,500	0.000	0.000	0.037	0.037
5,000	0.000	0.000	0.040	0.040
5,500	0.000	0.000	0.045	0.045
6,000	0.000	0.000	0.049	0.049
6,500	0.000	0.000	0.052	0.052
7,000	0.000	0.000	0.056	0.056
7,500	0.000	0.000	0.058	0.058
8,000	0.001	0.000	0.061	0.060
8,500	0.001	0.000	0.064	0.063
9,000	0.002	0.001	0.072	0.069
9,500	0.002	0.001	0.074	0.071
10,000	0.002	0.001	0.076	0.073
10,500	0.002	0.001	0.080	0.077
11,000	0.003	0.001	0.084	0.080
11,500	0.003	0.001	0.088	0.084
12,000	0.003	0.001	0.091	0.087
12,500	0.004	0.001	0.096	0.091
13,000	0.004	0.001	0.100	0.095
13,500	0.005	0.001	0.105	0.099
14,000	0.005	0.001	0.108	0.102
14,500	0.006	0.001	0.113	0.106
15,000	0.007	0.002	0.116	0.107
15,500	0.007	0.002	0.120	0.111
16,000	0.008	0.002	0.124	0.114

-continued

PANEL NO. 9

Total Load Pounds	Dial Indicators A	B	C	Net Deformation C − (A + B)
16,500	0.009	0.002	0.129	0.118
17,000	0.009	0.002	0.133	0.122
17,500	0.010	0.003	0.137	0.124
18,000	0.014	0.004	0.145	0.127
18,500	0.015	0.004	0.152	0.133
19,000	0.017	0.005	0.157	0.135
19,500	0.018	0.005	0.164	0.141
20,000	0.020	0.006	0.170	0.144
21,000	0.022	0.007	0.182	0.153
22,000	0.028	0.009	0.197	0.160
23,000	0.032	0.012	0.211	0.167
24,000	0.040	0.015	0.234	0.179
25,000	0.045	0.019	0.252	0.188
26,000	0.052	0.024	0.270	0.194
27,000	0.060	0.030	0.296	0.206
28,000	0.070	0.038	0.325	0.227
29,000	0.088	0.050	0.369	0.231
30,000	0.100	0.060	0.399	0.239
31,000	0.120	0.070	0.444	0.254
32,000	0.145	0.082	0.492	0.265
33,000	0.164	0.095	0.535	0.276
34,000	0.178	0.105	0.574	0.291
35,000	0.195	0.120	0.629	0.314
36,000	0.214	0.150	0.700	0.336
37,000	Failed			

At a total load of 37,000 pounds, a diagonal crack developed running from the top corner where the horizontal load was applied to the bottom corner where dial indicator B was located on approximately a 45° angle. This, of course, is considered the classic failure made and further demonstrated the structural integrity of the finished panel.

In addition to the standard tests indicated above, tests were performed to determine the force required to pull the L bolts out of the tops of the panels and to pull the reinforcing bars from the panels. The panels were 28 days old when tested. The L bolts had ten inches of embedment. A direct pull-out force was applied to the bolt. The results of this test are shown below:

Bolt No.	Force Required To Remove Bolt
1	5,408 lbs.
2	5,060 lbs.
3	4,577 lbs.

In each case the concrete did not break at failure. Instead, the bolt straightened and followed the hole in the concrete.

A direct pull-out force was also applied to three separate No. 3 reinforcing steel bars which had been embedded in the test panels. Each bar had twenty-one inches of embedment. The results are shown below:

Bar No.	Force Required To Remove Bar
1	5,198 lbs.
2	5,796 lbs.
3	5,635 lbs.

Compressive strength of construction units after set-up was determined using bags as described above and a filler of five sack mix using 50% pea gravel and 50% sand. The filled sacks were immersed in water for 15 seconds, 20 seconds, and 25 seconds, respectively. The units were cured by sprinkling with water twice a day for two days immediately following construction. Three 3 inch × 3 inch × 3 inch cubes were cut from the units

and placed in a fog room at 5 days. The compressive strength of the cubes was determined as indicated below:

15 Second Soak Time	Total Load Pounds	PSI	Corrected PSI
7 Day 20 Second Soak Time	8,300	922	839
28 Day 25 Second Soak Time	16,500	1,833	1,668
28 Day	16,000	1,778	1,618

From the foregoing test results it will readily be apparent that structures suitable for human habitation which meet or exceed even the most stringest building code requirements for hurricane and earthquake areas may be constructed in accordance with the invention. Furthermore, since no skilled labor is required and the need for retaining forms and the like is virtually eliminated, the total cost per square foot of habitable structure may be less than 50% of the cost of similar or equivalent structures constructed by conventional methods.

The invention has been described with reference to specific embodiments thereof. However, modifications and substitutions that do not depart from the true scope thereof are contemplated. For example, it may be desirable in the construction of some buildings to space apart adjacent construction units contained within one or more courses to provide a partially open construction. Other variations will undoubtedly occur to those skilled in the art. Therefore, it is intended that the invention be limited only as defined in the appended claims.

What is claimed is:

1. The method of building a monolithic homogeneous structural wall suitable for housing structures comprising the steps of:

a. forming a horizontally disposed foundation beam having vertically extending rods protruding therefrom;

b. forming discrete construction units comprising a dry mixture contained within uniformity porous containers which, when wetted, are activated to set up as hardened structural members;

c. arranging said construction units in superimposed courses on said horizontal foundation beam, said vertically extending rods extending through at least the first course of said construction units;

d. wetting each of said construction units to activate said mixture to set up and form an integrated homogeneous structure with continuous bonds between adjacent containers;

e. driving vertical reinforcing rods into the construction units in the later formed courses so that said reinforcing rods overlap the said vertically extending rods protruding from the foundation beam within the wall structure; and

f. applying a skin of concrete onto at least one side of the superimposed courses under substantial pressure so that the skin bonds to said mixture through the pores in the containers, whereby said skin and said superimposed courses form an integral, homogenous monolithic structure.

2. The method set forth in claim **1** wherein said discrete construction units are wetted immediately prior to arranging them in superimposed coursed by immersing said construction units in water for a period of time ranging from about 3 seconds to about 25 seconds.

3. The method set forth in claim **1** wherein said discrete construction units are wetted after arranging said units in courses by applying water to the top only of the units in each course before arranging each succeeding course thereon.

4. The method set forth in claim **1** wherein said horizontal foundation beam defines the outer walls of a habitable structure and is wider than the width of said construction units, including the steps of:

a. positioning the first course of said construction units near the center of said foundationn beam, thereby leaving a portion of the surface of the foundation beam within the confines of the wall exposed; and

b. pouring concrete within the area defined by said first course of construction units to provide a concrete slab overlying the portion of the surface of said foundation beam within the confines of said wall structure.

5. The method set forth in claim **1** wherein said horizontally disposed foundation beams are formed by:

a. excavating a trench over which said structural wall is to be constructed;

b. filling said trench to approximately ground level with concrete;

c. inserting said vertically extending rods into said concrete before said concrete hardens;

d. allowing the concrete in said trench to harden; and

e. wetting the surface of said foundation beams immediately prior to arranging said construction units thereon.

6. The method set forth in claim **1** including the step of spraying said wall with water at least four times within the first 48 hours after its construction.

7. The method set forth in claim **3** wherein said dry mixture comprises aggregate, sand and cement, and said units are wetted by applying water to the top only of said units in an amount sufficient to activate said cement throughout said units but to permit only a predetermined maximum amount of slump in said units when activated.

8. The method set forth in claim **1** wherein said skin of concrete is sprayed onto said superimposed sources under a pressure of about 60 to 80 psi.

9. A method of constructing a monolithic wall suitable for housing structures using discrete construction units comprising a dry mixture contained within porous containers which, when wetted, are activated to set up as hardened structural members, comprising the steps of:

a. arranging said construction units in superimposed courses;

b. wetting each of said units to activate said mixture to set up and form an integrated structure; and

c. applying a skin of finishing material onto the side of the superimposed courses under substantial pressure so that said finishing material is bonded directly to said mixture through the pores in said containers and said skin and said superimposed courses form an integral monolithic structure.

10. A method as set forth in claim **9** wherein said construction units are arranged in juxtaposed positions along each course.

11. A method as set forth in claim **9** including the step of inserting reinforcing members in said construction units when arranged in said courses to intercon-

nect adjacent units with said reinforcing members.

12. A method as set forth in claim **9** including the step of driving a plurality of reinforcing rods through each of said construction units when arranged in a course so that said rods protrude into adjacent units in an underlying course.

13. The method as set forth in claim **9** wherein said units comprising a dry mixture contained within porous containers are arranged in juxtaposed positions along each course and water is applied to the entire course to wet each of said units.

14. A method as set forth in claim **9** including the steps of excavating a trench over which said integrated structure is to be constructed as a wall, pouring concrete in said trench to form a concrete beam, arranging said construction units in juxtaposition in said superimposed courses on said concrete beam, the wet mixture permeating the containers and bonding with the concrete beam so that said beam constitutes an integral part of said structure, and securing a roof structure to the top of said wall structure.

15. A method as set forth in claim **14** including the step of inserting steel reinforcing members in said concrete beam to protrude thereabove, impaling the construction units of the first course on said rods, and inserting additional reinforcing members in said units when arranged in succeeding courses to interconnect adjacent units with said additional reinforcing members.

16. A method as set forth in claim **9** wherein said mixture comprises aggregate, sand and cement, said courses are wetted by applying water to the top only of said units in an amount sufficient to activate said cement throughout said units but to permit only a predetermined maximum amount of slump in said units when activated.

17. A method as set forth in claim **16** wherein said slump is detected visually so that the amount of water applied to said units can be controlled.

18. A method as set forth in claim **9** including the steps of inserting a first pair of reinforcing rods in each construction unit that are also inserted in an adjacent pair of said units, respectively, immediately underlying said each construction unit to tie said each construction unit to each of said adjacent pair of said underlying units, and inserting a second pair of reinforcing rods in said each construction unit that are also inserted in an adjacent pair of said units, respectively, immediately overlying said each construction unit to tie said each construction unit to each of said adjacent pair of said overlying units.

19. A method as set forth in claim **9** wherein said mixture comprises aggregate, sand and cement, including the steps of blowing onto the sides of a first plurality of said superimposed courses after being arranged and wetted a skin of concrete under substantial pressure so that said skin penetrates voids in said sides and keys to the concrete through said porous containers to reinforce said first plurality of superimposed courses, and thereafter successively arranging and wetting further superimposed courses thereabove and blowing said skin onto the sides thereof to progressively construct a wall structure.

20. A method as set forth in claim **19** including the step of applying a finishing coat of material onto said skin.

21. A method as set forth in claim **9** wherein said porous containers comprise sacks having seams along the end and said superimposed courses of said units are arranged by positioning said sacks with said seams being vertical.

22. A method of constructing a building using discrete construction units comprising a dry mixture of sand, aggregate and cement contained within porous containers that upon wetting are activated to set up as hardened structural members, comprising the steps of:

a. excavating trenches over which the exterior and interior walls of said building are to be erected;

b. filling said trenches to ground level with concrete to form concrete foundation beams;

c. arranging said construction units in juxtaposed positions on the foundation beam corresponding to the exterior walls of said building to form at least one course of said exterior walls thereon;

d. wetting each of said construction units so arranged to activate said mixture to set up as hardened structural members, the wet mixture permeating the containers and forming a continuous integral monolithic structure through the pores of adjacent containers and with said concrete foundation beams;

e. pouring concrete within the confines of said foundation beam corresponding to said exterior walls against said at least one course of structural members acting as a form to provide a slab overlying said foundation beams corresponding to said interior walls;

f. arranging additional of said construction units in juxtaposed positions and in superimposed courses on said at least one course to form said exterior walls of the desired height;

g. blowing onto the sides of a first plurality of said superimposed courses after being arranged on said foundation beam corresponding to said exterior walls and wetted a skin of concrete under substantial pressure so that said skin penetrates voids in said sides and keys to the concrete through said porous containers to reinforce said plurality of superimposed courses, and thereafter blowing said skin onto the sides of successively arranged pluralities of said courses as said exterior walls are erected; and

h. constructing a roof structure over said exterior walls.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,922,832 Dated December 2, 1975

Inventor(s) Edward T. Dicker

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 17, line 42, "PANEL NO." should read --PANEL NO. 6---.

Column 18, line 2,"PANEL NO." should read --PANEL NO. 6--.

Column 21, line 44, "uniformity" should be --uniformly--.

Column 22, line 13, "foundationn" should read --foundation--.

Signed and Sealed this

second Day of March 1976

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks