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(54) METHOD FOR MAKING CAST-IN-PLACE CONCRETE STRUCTURES

(71) We, INTERNATIONAL HOUSING LIMITED, a Bermuda Corporation, of P.O. Box 1379, Pembroke, Bermuda, do hereby declare the invention, for which we pray that

a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a method for producing buildings, and more specifically, a method of making a monolithic cast-in-place house, building or like structure, wherein, in a series of steps, the foundation, walls and roof are formed. The method involves the construction of a foundation, walls, and a roof, each of which is formed by temporarily interconnecting a series of relatively small lightweight concrete forms and pouring concrete therein.

One of mankind's most pressing problems is the development of a system for producing low-cost housing capable of providing security against the adverse elements of weather, earthquake, fire and vermin. In conventional building systems of the present day, even the so-called prefabricated systems, use is made of thousands of individual pieces of many materials involving many separate processes and employing several skilled crafts and many skilled men. As a result, building construction, be it for a house, industrial building, warehouse, etc., is expensive, time-consuming, requires skilled labour, and in many cases requires the use of heavy construction equipment.

In spite of the limited success that has been achieved with prefabricated wood and other construction materials in adapting mass production techniques to the production of houses, most people still prefer a house made of brick, stone or concrete, which for convenience will hereinafter be referred to as masonry materials. The reason for this is simple: concrete masonry is the strongest, most durable building material known to man, and is the cheapest material for effectively combatting the adverse effects of weather, earthquake, fire and vermin. However, known techniques for the construction of masonry houses have many of the same

limitations as techniques for constructing timber frame or similar structures. More particularly, masonry houses made of brick or stone require the individual laying of many bricks, stones or the like along with the construction of the structural members of the house, the plastering of in the interior walls for appearance purposes, the laborious chiselling out of the windows and door frames, and the additional chiselling of the masonry materials for accommodating plumbing, electric and gas conduits. As a result, known techniques for forming a masonry house are expensive, time-consuming and require skilled craftsmen.

Faced with the alternative techniques mentioned above, the construction industry has long sought a system for creating a commercially acceptable built "in-place" house made of concrete material. To this end, the construction industry has attempted, without success, to develop a system of making a house by casting concrete. One technique involves the preliminary erection of a structural steel skeleton arrangement made of I-beams, followed by the placing of large slabs of concrete panels (which are pre-cast at a factory) between the beams. The concrete panels are usually very large, in order to minimize the cost of construction, and hence resort must be made to the use of heavy equipment to transport the panels and to position the panels between the I-beams. One of the primary disadvantages of this type of system is that the result of this technique is the completion of only the wall portions of the building. Conventional building roof techniques must then be resorted to in order to complete the building. Hence, this construction technique has the disadvantages of requiring heavy equipment, involving piecemeal construction, and requiring a large capital investment in a factory for producing the pre-cast panels.

A second known technique involves the use of extremely large concrete forms, some large enough to complete major wall portions of a building structure. One obvious disadvantage of this system is the requirement for heavy equipment for transporting and

[Price 33p]

Price 75p

positioning the forms. After the forms are in position, moist concrete is poured or cast-in-place at the site of the building structure. Besides the disadvantage attendant with the weight and bulk of the forms, which necessitates heavy construction equipment and thereby increases the cost of construction, this technique has the disadvantages of only being capable of producing one type of design of building. Also, as in the previously described prior art technique, the roof structure was often constructed using standard techniques which employed many different building materials, such as wood, structural members, planking or sheathing, and a conventional roofing material.

Another known technique for forming cast-in-place masonry buildings was to employ a plurality of individual forms which are temporarily secured together to form two spaced wall form members providing a form for casting concrete. Often these individual forms were made of heavy metal which necessitated the use of construction equipment, with the forms being so constructed that only one design or type of structure could be made. Furthermore, the forms were employed for making the walls of the building, after which conventional techniques were employed for completing the structure. In addition, the appearance of the resulting wall was frequently unacceptable because of the joint lines formed in the concrete, and hence finishing of the wall (e.g. plastering) was often added as an additional step of construction; hence, the cost of construction was increased by the requirement for additional construction materials and skilled labour.

Concrete is the most desirable construction material because it is the most inexpensive and readily available permanent building material, and it is fireproof, rot-proof, vermin-proof, earthquake-proof, and weatherproof. Furthermore, concrete may be poured or cast in place. Prior systems for concrete masonry structures often require heavy construction equipment, additional finishing processes, and, most importantly, do not result in a low-cost, complete masonry structure. More particularly, thousands of attempts have been made by giants of the construction industry to perfect a commercially acceptable built-in-place house of concrete, and a system to produce the house, including such names as Thomas A. Edison (see U.S. Letters Patent 1,123,266 which issued on January 5, 1915), and many others. None of these systems were successful as to commercial success, for the following primary reasons:—

The appearance of the built-in-place concrete house produced with the previous systems was unacceptable because of many ugly imperfections of the concrete. In order to cure these defects, further finishing opera-

tions were required, thereby increasing the cost of construction. Furthermore, the prior art systems were difficult to erect and were incomplete, and this further reduced the economy of the cast-in-place concrete house. The present invention provides a method of making a complete cast-in-place concrete structure utilising a plurality of architectural forms which can be of small size and can be designed to economically produce beautiful designs and architectural results in the concrete, while requiring no further finishing to the concrete surface after the initial casting.

According to the invention, a method of making a cast-in-place concrete structure comprises the separate and sequential steps of:—

(a) levelling the ground area on which the concrete structure is to be constructed and forming a foundation form by temporarily interconnecting a plurality of architectural forms to define the area of the foundation;

(b) forming the foundation and floor of the concrete structure by pouring uncured concrete into the confines of said foundation form and allowing said concrete to cure;

(c) removing said foundation form;

(d) forming on the foundation an arrangement of pairs of opposed spaced concrete wall forms by temporarily interconnecting a plurality of architectural forms, said pairs of concrete wall forms being interconnected by a plurality of upper and lower wall form ties, said arrangement of wall forms defining the upstanding exterior and interior walls of the said concrete structure;

(e) forming the upstanding exterior and interior walls of the concrete structure by pouring uncured concrete into the space defined between said pairs of opposed concrete wall forms, and allowing said concrete to cure;

(f) removing said concrete wall forms;

(g) removing said lower wall form ties and leaving the upper wall form ties for subsequently supporting brackets for a roof form;

(h) constructing the roof form of the concrete structure by,

(i) providing a temporary arrangement of shoring members within the enclosure defined by said exterior walls;

(ii) securing outwardly overhanging brackets to said upper wall form ties externally of the exterior walls in order to provide a temporary support for the roof form; and

(iii) forming the roof form by temporarily interconnecting a plurality of architectural forms, and supporting said roof form on said arrangement of shoring members and said brackets, with the peri-

pheral edge of said roof form being defined by a continuous up-standing member;

- (i) forming the roof of the concrete structure by pouring uncured concrete into the confines of said roof form and allowing said concrete to cure; and

- (j) removing said temporary arrangement of shoring members, brackets, upper wall form ties, and said roof form, leaving the roof supported on the upstanding walls.

The term "architectural form" is used to indicate a form or mould part which can be interconnected with other similar parts to define foundation, wall or roof forms, and which has a surface designed to produce an architecturally attractive appearance in the masonry formed in such forms.

The prior art systems required large forming surfaces which necessitated heavy, expensive machinery and were limited to a few plans or designs, etc. The method of the present invention preferably employs forms which go together like a huge constructional toy set, and requires no members larger than one man can handle. The members employed in the method of the present invention can be put together by unskilled men using mass production techniques. In addition, the members used in the method of the present invention render the system simplicity itself.

The method of the present invention solves the many problems of the erection of a complete built-in-place structure, and will produce an economical low-cost house. It allows for adaptability to any plan, dimension and architectural style desired. This is quite remarkable, considering the many thousands of different plans, with openings of various sizes, intermediate floors of all sizes and requirements, roofs of various pitches and sizes, etc. All this can be accomplished with a simple basic architectural form forming a basic module employed in the method of the present invention. The method of the present invention can also accommodate window and door openings, electrical work, plumbing work, and other service lines. When the walls are cast, for example, they may be formed complete, with all the window and door frames in, the electrical wiring in, plumbing conduits in, and the walls finished on both surfaces. In addition to the form used in the method of the present invention, specially developed hardware and accessory items have been developed to accomplish a rapid, simple erection of the forms. These items of hardware and accessory as described herein-after are important to the success of the method of the invention.

A majority of the people in the world today live in countries where masonry construction is essential. It is highly significant that there is no system in use today that will produce masonry housing on an industrial

scale necessary to solve the critical housing problem. Without exception, these countries are still using methods employed for centuries to produce their housing. The system of the present invention will industrialize masonry construction techniques, and solve the critical housing problem for social interest construction.

The present invention thus overcomes the problems associated with prior art techniques and provide a method for building commercially acceptable, complete cast-in-place building structures; it being understood that the term building structure should not be interpreted to be limited to a residential dwelling, but may also encompass industrial buildings, apartments buildings, warehouses, and other similar enclosed structures.

The method can readily be carried out using unskilled labour, and can be used to produce a cast-in-place masonry building structure, having attractive and acceptable interior and exterior surfaces which do not require further finishing operations or processes, other than painting if desired.

The method does not require the use of heavy construction equipment in that all of the forms and hardware used in the system may be easily handled by a single labourer. The method can be used to make a cast-in-place masonry building structure in a minimum amount of time, and with a minimum amount of materials in order to ensure an attractive and structurally sound building.

The method of the present invention may employ a plurality of small (ranging from 2" X 2" to 24" X 24") architectural forms, along with associated specifically developed hardware for temporarily securing the architectural forms together to define the foundation, wall and roof forms into which moist concrete material is cast-in-place.

In a particular embodiment of the invention, first the site on which the building is to be constructed is prepared by levelling and compacting, along with the temporary inter-connection of an array of architectural forms (of a size which is easily handled by a single labourer) to define the foundation form. The various service lines such as plumbing, electricity and gas are positioned within the foundation form, as well as the requisite structural reinforcing bars which extend within the plane of the foundation and the upstanding reinforcing bars which will subsequently be embedded within the wall structure. Moist concrete is then poured into the foundation form and allowed to cure. In like manner a group of architectural forms are temporarily secured together to define two spaced wall forms, including both interior and exterior walls, and including suitable openings for holding frames for windows and doors. The spaced wall forms rest on the slab of the foundation, and are held in spaced

relationship by a plurality of wall tie members extending between said wall forms. The wall forms are constructed, and are interconnected, such that both sides of the resulting masonry walls are architecturally acceptable, without unsightly joint lines or concrete imperfections. As in the case of the foundation, the various service lines are positioned between the wall forms prior to the pouring of moist concrete. After the masonry walls have cured, the architectural wall forms are removed, and a temporary arrangement of shoring members, designed for the system of the present invention, is placed within the building structure. Specially designed roof-supporting brackets are secured to the wall ties on the exterior of the building for supporting overhanging portions of the roof form. The latter is constructed by temporarily interconnecting a series of architectural forms, and is supported by the shoring arrangement and the roof supporting brackets. Similar to the previous steps, moist concrete is poured in the roof forms and allowed to cure, after which the roof form, temporary shoring arrangement, and the roof supporting brackets are removed.

At this time, the masonry building is structurally complete. Various ancillary items such as the windows, doors, and service fixtures are then installed in the structure thereby completing the construction of the building. The resulting monolithic masonry building structure made according to the method of the present invention is structurally sound, attractive, economical to manufacture, and adaptable to mass production techniques by unskilled labour.

Specific embodiments of the invention will now be described by way of example and with reference to the accompanying drawings in which:—

FIG. 1 is a partial perspective view of two architectural forms used in the method of the present invention, and shows the inside surfaces of the forms;

FIG. 2 is a perspective, partial sectional view of the foundation of the house made according to the method of the present invention, and shows the array of architectural forms used for defining the foundation;

FIG. 2A is a sectional view taken along line 2A-2A in FIG. 2;

FIG. 3 is a perspective view, partially in section, of the interior and exterior walls of the house made according to the method of the present invention, and shows the groups of architectural forms which are temporarily secured together to define the arrangement of pairs of opposed spaced wall forms;

FIGS. 3A to 3K are detailed views of the various pieces of specially developed hardware used in the method of the present invention;

FIG. 4 is an exploded perspective view of

a portion of the groups of architectural forms which are temporarily secured together to define the wall forms for use in the method of the present invention;

FIG. 5 is an elevation of the outside portions of a group of architectural forms which are temporarily secured together to define one of the two spaced wall forms for use in the method of the present invention, and shows the openings in the wall form for a window and a door;

FIG. 5A is a sectional plan view taken along line 5A-5A in FIG. 5 and includes the interior wall forms;

FIG. 6 is a perspective view, partially in section, of a roof form in use in the method of the invention;

FIGS. 6A to 6H are detailed views of various pieces of specially developed hardware used in the system of the present invention;

FIGS. 7, 8 and 9 illustrate in sequence a modified embodiment of the method of the present invention in which a two-storey building structure is formed; and

FIG. 9A is a detailed view of a specially developed roof bracket used in the method of the present invention.

Before describing the several embodiments of the present invention, it should be noted that although the detailed description will refer to the building structure as a house, any other type of enclosure having a foundation, walls and a roof may be made according to the teaching of the invention. Accordingly, it is contemplated that building structures such as industrial buildings, warehouses, apartment houses, hospitals, and the like are included within the scope of the invention.

FIG. 1 illustrates two architectural forms 10 and 10a which are of the type which may be used in the method of the present invention. Forms 10 and 10a form the subject matter of United States Letters Patent No. 3,307,822 entitled "CONCRETE WALL CONSTRUCTION FORM" which issued on May 7, 1967, to the inventor of the present application, Robert K. Stout. Although the invention will be described with respect to the architectural forms 10 and 10a, it is readily apparent that any type of masonry form capable of producing an architectural masonry structure may also be employed. Along these lines, it should be noted that the use of forms as disclosed in the above-identified patent, as well as other concrete forms, has been extremely limited in that, heretofore, the construction industry has lacked a system for building a complete structure. Hence, such forms have been primarily employed for building walls, fences and the like, after which conventional processes were employed for completing the structure. The method of the present invention is the first system to employ the forms

to completely construct a building structure.

Each architectural form, 10 and 10a, is preferably constructed of cast aluminium, but magnesium or other lightweight metal or plastics can be used. These forms are preferably made in a wide variety of sections (square or rectangular) ranging from 2" X 2" to 24" X 24", so as to facilitate handling by a labourer, and to allow for adaptability of the present system to any desired plan, dimension and architectural style of the resulting monolithic building structure. Of course, larger architectural forms may also be used when warranted in light of the resulting building structure.

Each architectural form comprises a relatively thin sheet 12 of metal which has the overall dimensions of the desired form. Sheet 12 includes an outside surface 14 and an inside surface 16. A flange 18 on the perimeter of sheet 12 extends outwardly from the inside surface 16 of sheet 12 and protrudes beyond the outside surface 14 at a right angle thereto. A plurality of slot indentations 20 are imposed on the outside surface of flange 18 and these slot indentations are perpendicularly disposed with respect to the plane of sheet 12. Holes 22 can extend through flange 18 in each one of the slot indentations 20 for a reason to be seen hereafter.

Reinforcing bar members 24 (see FIG. 2) project from the outside surface 14 of metal sheet 12 and have a width substantially equal to the width of flange 18, which extends around the periphery of sheet 12. The function of the bar members 24 is to reinforce metal sheet 12 and this reinforcement could obviously assume several different patterns.

The inside surfaces of forms 10 and 10a are substantially identical, and each comprises an architectural brick arrangement formed by a plurality of elongated narrow bars 30 horizontally extending across the inside surface 16, and a plurality of non-continuous vertical bars 32 on the same surface to complete the brick pattern. It should be noted that the vertical bars 32' adjacent the side edges of surface 16 have a width equal to only half that of the vertical bars 32. Similarly the bars 30' at the top and bottom of surface 16 are half the width of the horizontal bars 30. It should also be noted that the bars 32 have been alternately discontinued. The areas of the inside surface 16 between the bars 30 and 32 is shown to be rough and irregular, and is comprised of a plurality of small arcuate indentations and protruding portions of different sizes located in an irregular and non-symmetrical pattern. By this arrangement, as shown in FIG. 1, the adjacent side edges of the forms 10 and 10a match and register with each other to better hide any seam between adjacent forms. Furthermore, the indentations and protruding portions are substantially arcuate in shape

to avoid any sharp lines or edges. It is preferred that the vertical side edges of each form be identical so that when a plurality of such forms are aligned in side by side abutting relation, the adjacent vertical side edges of the forms will register with each other. The registration of adjacent side forms ensures that the resulting concrete structure provides an architectural finish which will not necessitate further finishing processes.

Also formed in the flange 18 of each architectural form are a plurality of holes 23 which are employed for securing adjacent forms together and to ensure alignment of said forms. In general, the architectural forms which are employed for forming the outer periphery of a surface such as the foundation and the roof do not include the slot indentations 20. The latter are provided in an architectural form in order to accommodate a wall tie for maintaining the spacing between two spaced wall forms that are employed for forming the upstanding walls of a building structure. In addition to the slot indentations 20, such wall forms also include holes 23 for maintaining alignment and securing together adjacent architectural forms. Further details relative to the type of form used during the several steps of the present method will be discussed hereinafter.

The first step in the method of the present invention, as applied to the construction of a monolithic masonry house, comprises the formation of the floor or foundation. Referring to FIG. 2, the site on which the masonry house is to be constructed is first levelled, after which the ground G is compacted, and a peripheral trench 40 is dug for defining the peripheral footing of the resulting floor structure. In addition, interior trenches 40' may also be prepared for providing footings for the interior walls of the structure. Next, an array of architectural forms 10 are temporarily interconnected by means of suitable pin and wedge arrangements (to be described with reference to FIG. 3E hereinafter) and provided about the entire periphery of the floor area, with the array of architectural forms being fixed in place by means of stakes 42. The various service conduits, including electrical wiring (not shown) and plumbing lines 44 are placed within the confines of the floor area, as well as a network of reinforcing bars 46, the extent of which is determined by the desired structural characteristic of the resulting structure. In addition, upstanding reinforcing bars 48 are provided about the periphery of the floor structure, as well as within the interior of the floor structure corresponding to the location of the interior walls. Next, moist concrete 50 is poured and levelled within the confines of the foundation forms, and it is suggested that a V-groove 52 be provided about the periphery of the floor generally parallel to and spaced from

the form to cooperate with the upstanding walls to define a moisture joint or barrier for the resulting house structure. After the concrete has cured, the foundation forms may be removed, preparatory to the erecting of the wall forms.

The next step in the method of the present invention is the erection of the wall forms which are mounted on the concrete floor, preferably spaced within an inch or two of the outer periphery of the floor area. The architectural forms employed for forming the wall forms are of the type which include the slot indentations 20 in order to receive wall ties that function to maintain the proper spacing between the interior and exterior wall forms as described hereinafter.

Basically, this step in the method of the present invention involves the formation of a continuous arrangement of pairs of spaced concrete wall forms by the temporary interconnection of a group of architectural forms, with the arrangement defining the upstanding exterior and interior walls of the house. As shown in FIG. 3, the wall forms comprise an interior group 60 of wall forms and an exterior group 62 of wall forms, with the inside surfaces 16 of the forms facing toward the area where the concrete is to be poured. As a result, the resulting wall structure, as shown at the top of FIG. 3, is architecturally finished both on the exterior surface thereof and the interior surface thereof. The arrangement of the groups of wall forms 60 and 62 is continuous to include, besides the outer peripheral wall of the house, an interior wall, designated by numeral 64, and an extension of the house, generally designated by numeral 66. In interconnecting the various wall forms, openings are left for the windows 68 and doors, one of which is shown at 70.

FIG. 3A illustrates in detail the interconnection between two adjacent architectural forms or panels 10 and 10a. In order to form a temporary interconnection between said panels, fastening means including a pin 76 (see detail FIG. 3E) having a slot 77 and cooperating wedge 78 (see detail FIG. 3F) are employed. Extending between the interior 60 and exterior 62 wall forms are a plurality of wall ties 74 (see detail FIG. 3G). In the interconnection of architectural panels 10 and 10a, a wall tie 74 is positioned within the aligned slot indentations 20 in the respective panels, after which the pin 76 is positioned within the aligned holes 22 and the hole 75 in the wall tie 74, and the wedge 78 is then positioned within the slot 77 of pin 76. The wedge is forced into slot 77 in order to form a tight interconnection between the architectural forms. Additional pins 80 are then passed through the aligned holes 23 in order to insure proper alignment between the adjacent forms. In like manner, additional pins are provided between the adjacent forms dis-

posed above and below said panels 10 and 10a. If desired, the additional pins may be in the form of nuts and bolts.

Referring to FIG. 3B, a modified form of temporary interconnecting fastening means is illustrated for those instances wherein a smaller architectural form 10b is to be provided between forms 10 and 10a. Form 10b is generally similar to forms 10 and 10a, apart from being much narrower, and includes slot indentations 20. Instead of providing two temporary fastening means of the type illustrated in FIG. 3A, resort is made to a fastener comprising an elongated pin 90 which is slotted as at 92, 92 at its opposite ends, and a pair of wedges 94 and 94 are employed. Pin 90 is long enough to extend through the two pairs of abutting slot indentations of the adjacent panels, so that a single temporary fastening means is employed for securing the three panels together. As in the structure of FIG. 3A, suitable wall ties 74 are employed, as well as aligning pins 80.

FIG. 3C illustrates in detail a device employed in the method of the present invention in order to ensure the alignment of the wall forms. More particularly, a roughly Y-shaped member 100, having a square U-shaped upper part and a depending stem part, is provided with suitable apertures in its stem part for cooperating with the reinforcing bar members 24 of the architectural forms, so that its upper part forms a bracket for holding a straight edge, such as a 4" X 4" wood member. As illustrated in FIG. 3, a plurality of the Y-shaped members 100 are fixed to rows of upper and lower panels on the exterior wall form 62, and a straight-edge 102 is slipped into each row of the members 100, and is effective to maintain the alignment of the wall form during the concrete pouring operation. A similar arrangement may be provided on the interior wall form 60. The Y-shaped members may be secured to the architectural forms by temporary fastening means of the type illustrated in FIG. 3A. Alternatively, the Y-shaped members may be secured to the architectural forms by a quick clamp 104 of the type illustrated in FIG. 3I, which can also be employed for maintaining adjacent architectural forms together. The quick clamp 104 comprises a U-shaped member having an upstanding pin 106 for passage through a hole 23 in the associated form. One leg 108 of the quick clamp 104 is inclined relative to the other leg 110 whereby, after the pin 106 is inserted through a hole 23 in the form, the quick clamp can be rotated about the pin 106 until the surfaces 108 and 110 embrace the stem part of member 100 and the adjacent flange 18 of the form, or two abutting flanges 18, and the relative incline between surfaces 108 and 110 results in a wedging action thereby

securely holding the abutting members together.

Referring again to FIG. 3, it is noted that the wall form for the interior wall 64 is additionally connected to the wall form 60 by means of corner braces 114. As shown in detail in FIG. 3D, each corner brace 114 includes a turnbuckle 116 terminating in opposed pins 118 which are adapted to fit within the holes 23 in adjacent architectural forms.

In order to facilitate the erection of a building structure or house made according to the method of the present invention, the window frames and door jambs are temporarily connected to the wall forms for use as part of the form structure preparatory to the pouring of concrete. The window and door frames are held in openings 68, 70 in the architectural forms by means of specially designed waler clamps, designated by the numeral 120, one of which is illustrated in detail in FIG. 3H. The waler clamp 120 is generally U-shaped in configuration, and includes a pin 122 adapted to fit within a hole 23 in the associated architectural form. The opposite leg portion of the waler clamp is inclined so as to frictionally grip the adjacent frame member of the window or door frame. After the wall structure has been formed, the waler clamps are removed, but the window and door frames remain in place for easy attachment to the door and window structures, respectively. Waler clamps are also employed for securing the end plate to the form for the interior wall 64.

FIG. 3J illustrates a scaffold bracket 130 which may be secured to the wall forms 60, 62 for providing support for a scaffold platform 132. The scaffold bracket 130 includes a U-shaped edge portion 134 which attaches to one of the architectural forms, with the lower end 136 of the scaffold bracket 130 resting against a lower portion of the form.

FIG. 4 illustrates an exploded view of the various architectural forms which are temporarily assembled in order to form the interior and exterior groups of wall forms 60 and 62. As clearly illustrated in FIG. 4, the architecturally finished or inside surfaces 16 of the forms are in facing relationship whereby both the interior and exterior surfaces of the resulting wall structure are architecturally finished, and do not require additional finishing processes. FIG. 4 also illustrates an exterior angle bracket 140 which is employed for connecting at the junction of the exterior wall forms 62. Angle bracket 140 is provided with a plurality of holes 142 corresponding to the holes 22 and 23 in the adjacent architectural forms. In addition, FIG. 4 illustrates the various different sized architectural forms which may be employed for forming the wall forms 60, 62.

FIGS. 5 and 5A illustrate an assembled

wall form, including openings for a door and a window. The arrangement of the architectural forms as shown in FIGS. 3-5 provides a continuous arrangement of pairs of spaced concrete wall forms which are formed by the temporary interconnection of a plurality of architectural forms. The arrangement defines the upstanding exterior and interior walls of the house, with spaced wall forms being interconnected by a plurality of wall ties. Since the wall forms are formed by interconnecting a plurality of relative small architectural forms, it is readily apparent that heavy construction equipment is not required to reach this stage in the method of the present invention, nor is it required in order to complete the masonry building structure. In addition, the use of the pin and wedge arrangements illustrated in FIGS. 3A and 3B, as well as the quick clamp device of FIG. 3I greatly facilitates the erection of the wall forms, as well as facilitating the removal of the wall forms upon completion of the formation of the walls.

Moist or uncured concrete is poured in the space defined between the spaced groups of concrete wall forms 60 and 62, and allowed to cure. The concrete may be poured to a height level with the upper edge of the wall forms, in which case a flat roof would subsequently be constructed or alternatively, the uncured concrete may be poured and finished with its upper surface inclined from one end of the house to the other, in which case an inclined roof structure may then be constructed. After the monolithic concrete walls have been poured, the architectural forms are removed, and the wall ties 74 may also be removed, with the resulting holes left by the wall ties being filled with a suitable caulking compound. FIG. 3K illustrates an alternate form of wall tie wherein the tie 144 is tapered both in width and along its length thereby enabling its easy removal from the cured concrete wall. It should be understood that certain of the wall ties may be maintained in place and employed during the construction of the roof structure during the final step of the method of the present invention. Also, the wall ties may be constructed to include lines of weakened areas so that those portions of the tie extending beyond the resulting wall may be readily snapped off, thereby leaving the bulk of the tie within the wall for structural purposes.

In order to complete the construction of a monolithic masonry house, the step of forming a concrete roof on the masonry structure mentioned hereinabove will now be described in detail, with particular reference to FIG. 6. First a temporary arrangement of shoring members is constructed within the enclosure defined by the exterior walls. This may be accomplished through the use of a plurality of props 150, one of

which is shown in detail in FIG. 6A. Prop 150 is of the variable length type, and its upper end is suitably configured to accept a prop head 152, shown in detail in FIG. 6B.

5 The upper end of the prop head 152 includes a U-shaped member having a pair of aligned holes 152', and a pivot top 154 (see FIG. 6C) is pivotally connected, by a suitable pin means, to the upper end of the prop head 152. Pivot top 154 comprises a generally elongated channel-shaped member designed to accommodate an elongated structural beam member 156. As shown in FIG. 6, a plurality of props 150 are aligned along two walls of the structure, with the two aligned arrangements of props accommodating two parallel structural beam members 156. Extending between and transverse to the longitudinal axes of the generally parallel structural beam members 156 are a plurality of telescoping support beams 160. As shown in detail in FIG. 6D, each telescoping beam 160 includes on the opposite ends thereof flanges 162 adapted to rest on the respective beams 156, 156. The combination of the props 150, the structural beam members 156, and the arrangement of telescoping beams 160 provides a temporary structure for supporting a plurality of interconnected architectural forms 10. The latter are shown in FIG. 6 as being of the smooth type, whereby the interior surface of the resulting roof will be smooth.

In order to extend the roof structure beyond the perimeter of the house as defined by the exterior walls, resort is made to overhanging braces of the types illustrated in FIGS. 6E and 6F. The overhang brace illustrated in FIG. 6E is of the variable angle type, and is generally designated by numeral 170, and includes a support leg 172 which includes apertures for connection to wall ties projecting from the wall portion of the masonry wall. Secured to the upper end of the support leg 172 is a fixed arm 174, having pivotally connected at its outer end thereof, a second arm 176. Arm 176 may be inclined relative to fixed arm 174 by means of a threaded screw arrangement 178, whereby the variable angle overhang brace 170 may be adjusted to any desired pitch of the roof.

FIG. 6F illustrates a second form of overhang brace which is of the fixed type, and is designated by numeral 180. Fixed overhang brace 180 comprises a support leg 182, to which is fixed an arm 184 disposed at a right angle to the leg 182, and an angle support leg 186. As shown in FIG. 6, in the construction of a house according to the method of the present invention wherein an inclined or pitched roof is provided, overhang braces 180 of the fixed type illustrated in FIG. 6F would be used along the sides or gable ends, as shown on the left side of the house, while variable angle overhang braces 170 would be

employed along the pitched surfaces of the roof, as shown on the front end of the roof.

The edge of the roof form is defined by means of a continuous upstanding member 200 supported by roof edge supports illustrated in FIGS. 6G and 6H. The roof edge supports are secured to the flanges of the architectural forms disposed about the periphery of the roof form. Roof edge support 190 illustrated in FIG. 6G provides an arrangement wherein the upstanding member 200 of the roof form is mounted flush with the edge of the architectural roof form, whereas roof edge support bracket 192 illustrated in FIG. 6H includes a stepped portion, which enables the upstanding member 200 to be stepped in with respect to the edge of the roof form.

As is clearly shown in FIG. 6, where an inclined or pitched roof is desired, the roof form is supported by the temporary arrangement of shoring members within the enclosure, and by the various overhang braces in a manner whereby a portion of the upstanding wall projects into the plane of the architectural roof forms and thus defines a portion of the lower surface of the roof form. By this arrangement, after the uncured concrete is poured to form the roof structure, a monolithic connection between the walls and the roof of the resulting house is achieved. After the roof form has been completed, uncured concrete is poured into the confines of the roof form and allowed to cure. The temporary arrangement of shoring members is then removed, thereby completing construction of the house according to the method of the present invention.

FIGS. 7-9 illustrate a method for constructing a two-storey house. The steps involved in forming the foundation or floor and the walls, as well as the roof as described with reference to FIGS. 1-6 are identical, except that, as shown in FIG. 7 the uppermost architectural wall form 10 is left in place and is employed during the formation of the second floor as the continuous upstanding member defining the outer peripheral edge thereof. After the upper floor has cured, the wall forms for forming the second storey of the building structure are assembled, as shown in FIG. 8. It is suggested that a bracing member 202 be provided at this time preparatory to the formation of the walls of the second storey. Also, to facilitate construction, resort is made to the scaffold brackets 130 of the type illustrated in FIG. 3J for enabling the workmen to assemble the temporary wall forms for the second storey. After the concrete for the walls of the second storey has been poured and cured, the roof is constructed in a generally similar manner to that illustrated with reference to FIG. 6. This is shown in FIG. 9, with FIG. 9A illustrating

in detail the variable angle overhang brace 170 used for supporting the roof form.

Accordingly, the present invention provides a method for making a commercially acceptable built-in-place building structure of concrete. The method of the present invention produces a finished result on both surfaces of the wall. This is due to the pattern which is an integral part of the architectural form. This feature is important as no further finishing is required on the wall surface. This is necessary to the overall economy of cast-in-place concrete structures. The architectural forms employed in the present method go together like a giant constructional toy set, with a simple pin and wedge fastener. This results in very significant savings in labour costs. There is no other forming system which can produce an architectural result in concrete at anything approaching the speed of the method of the present invention. The present method is so simple that unskilled men can accomplish the same results as skilled brick layers and other craftsmen. Since the architectural forms are made of light-weight material, large enough sections can be handled by one man to be very efficient and rapid, and no expensive machinery is required. The method of the present invention is completely designed to produce a cast-in-place house or other structures.

An architectural result in the concrete is absolutely essential to an acceptable cast-in-place concrete house. In many areas of the world, special climatic conditions require special techniques and methods of construction. Therefore people have rejected the cast-in-place concrete house, not only for an attractive appearance, but because they consider concrete to be cold, or that it retains heat, etc. The method of the present invention has taken this into consideration and it has solved these problems. One innovative method of providing comfort and insulated properties to the concrete, is by incorporating special chemicals in the concrete which produce dead air spaces which provides insulation properties. In addition, the method of the present invention may be employed for the construction of multi-storey buildings, and allows for adaptability to any plan, dimension, and architectural style design. While the invention has been described in connection with several preferred procedures, it will be understood that it is not intended to limit the invention to those procedures. On the contrary, it is intended to cover all alternatives, modifications and equivalents as may be included within the spirit and scope of the invention as defined by the appended claims.

#### WHAT WE CLAIM IS:—

1. A method of making a cast-in-place concrete structure comprising the separate and sequential steps or:—

- (a) levelling the ground area on which the concrete structure is to be constructed and forming a foundation form by temporarily interconnecting a plurality of architectural forms to define the area of the foundation; 70
  - (b) forming the foundation and floor of the concrete structure by pouring uncured concrete into the confines of said foundation form and allowing said concrete to cure; 75
  - (c) removing said foundation form; 75
  - (d) forming on the foundation an arrangement of pairs of opposed spaced concrete wall forms by temporarily interconnecting a plurality of architectural forms, said pairs of concrete wall forms being interconnected by a plurality of upper and lower wall form ties, said arrangement of wall forms defining the upstanding exterior and interior walls of the said concrete structure; 80
  - (e) forming the upstanding exterior and interior walls of the concrete structure by pouring uncured concrete into the space defined between said pairs of opposed concrete wall forms, and allowing said concrete to cure; 85
  - (f) removing said concrete wall forms; 90
  - (g) removing said lower wall form ties and leaving the upper wall form ties for subsequently supporting brackets for a roof form; 95
  - (h) constructing the roof form of the concrete structure by, 95
    - (i) providing a temporary arrangement of shoring members within the enclosure defined by said exterior walls; 100
    - (ii) securing outwardly overhanging brackets to said upper wall form ties externally of the exterior walls in order to provide a temporary support for the roof form; and 105
    - (iii) forming the roof form by temporarily inter-connecting a plurality of architectural forms, and supporting said roof form on said arrangement of shoring members and said brackets, with the peripheral edge of said roof form being defined by a continuous upstanding member; 110
  - (i) forming the roof of the concrete structure by pouring uncured concrete into the confines of said roof form and allowing said concrete to cure; and 115
  - (j) removing said temporary arrangement of shoring members, brackets, upper wall form ties, and said roof form, leaving the roof supported on the upstanding walls. 120
2. A method of making a cast-in-place concrete structure according to Claim 1 wherein the step of forming the upstanding exterior and interior walls of the concrete structure includes placing and curing uncured concrete in the space between the pairs of opposed concrete forms with the upper surface of the uncured concrete at an inclined angle from one end of the structure 125 130



\* C L M S \*

in detail the variable angle overhang brace 170 used for supporting the roof form.

Accordingly, the present invention provides a method for making a commercially acceptable built-in-place building structure of concrete. The method of the present invention produces a finished result on both surfaces of the wall. This is due to the pattern which is an integral part of the architectural form. This feature is important as no further finishing is required on the wall surface. This is necessary to the overall economy of cast-in-place concrete structures. The architectural forms employed in the present method go together like a giant constructional toy set, with a simple pin and wedge fastener. This results in very significant savings in labour costs. There is no other forming system which can produce an architectural result in concrete at anything approaching the speed of the method of the present invention. The present method is so simple that unskilled men can accomplish the same results as skilled brick layers and other craftsmen. Since the architectural forms are made of light-weight material, large enough sections can be handled by one man to be very efficient and rapid, and no expensive machinery is required. The method of the present invention is completely designed to produce a cast-in-place house or other structures.

An architectural result in the concrete is absolutely essential to an acceptable cast-in-place concrete house. In many areas of the world, special climatic conditions require special techniques and methods of construction. Therefore people have rejected the cast-in-place concrete house, not only for an attractive appearance, but because they consider concrete to be cold, or that it retains heat, etc. The method of the present invention has taken this into consideration and it has solved these problems. One innovative method of providing comfort and insulated properties to the concrete, is by incorporating special chemicals in the concrete which produce dead air spaces which provides insulation properties. In addition, the method of the present invention may be employed for the construction of multi-storey buildings, and allows for adaptability to any plan, dimension, and architectural style design. While the invention has been described in connection with several preferred procedures, it will be understood that it is not intended to limit the invention to those procedures. On the contrary, it is intended to cover all alternatives, modifications and equivalents as may be included within the spirit and scope of the invention as defined by the appended claims.

#### WHAT WE CLAIM IS:—

1. A method of making a cast-in-place concrete structure comprising the separate and sequential steps or:—

- (a) levelling the ground area on which the concrete structure is to be constructed and forming a foundation form by temporarily interconnecting a plurality of architectural forms to define the area of the foundation;
  - (b) forming the foundation and floor of the concrete structure by pouring uncured concrete into the confines of said foundation form and allowing said concrete to cure;
  - (c) removing said foundation form;
  - (d) forming on the foundation an arrangement of pairs of opposed spaced concrete wall forms by temporarily interconnecting a plurality of architectural forms, said pairs of concrete wall forms being interconnected by a plurality of upper and lower wall form ties, said arrangement of wall forms defining the upstanding exterior and interior walls of the said concrete structure;
  - (e) forming the upstanding exterior and interior walls of the concrete structure by pouring uncured concrete into the space defined between said pairs of opposed concrete wall forms, and allowing said concrete to cure;
  - (f) removing said concrete wall forms;
  - (g) removing said lower wall form ties and leaving the upper wall form ties for subsequently supporting brackets for a roof form;
  - (h) constructing the roof form of the concrete structure by,
    - (i) providing a temporary arrangement of shoring members within the enclosure defined by said exterior walls;
    - (ii) securing outwardly overhanging brackets to said upper wall form ties externally of the exterior walls in order to provide a temporary support for the roof form; and
    - (iii) forming the roof form by temporarily inter-connecting a plurality of architectural forms, and supporting said roof form on said arrangement of shoring members and said brackets, with the peripheral edge of said roof form being defined by a continuous upstanding member;
  - (i) forming the roof of the concrete structure by pouring uncured concrete into the confines of said roof form and allowing said concrete to cure; and
  - (j) removing said temporary arrangement of shoring members, brackets, upper wall form ties, and said roof form, leaving the roof supported on the upstanding walls.
2. A method of making a cast-in-place concrete structure according to Claim 1 wherein the step of forming the upstanding exterior and interior walls of the concrete structure includes placing and curing uncured concrete in the space between the pairs of opposed concrete forms with the upper surface of the uncured concrete at an inclined angle from one end of the structure



to the opposite end thereof in order to enable the roof to be formed at a desired pitch.

3. A method of making a cast-in-place concrete structure according to Claim 1 or 2 wherein the roof form is supported on said arrangement of shoring members and said overhang brackets with said upstanding walls projecting into the plane of said roof form so as to define a portion of the lower surface of said roof form, whereby the roof and the walls form a monolithic structure after curing of the concrete.

4. A method of making a cast-in-place concrete structure according to any one of the preceding Claims wherein the step of forming a continuous arrangement of pairs of opposed concrete wall forms comprises constructing the wall forms to include openings for receiving the frames of doors and windows in the concrete structure, with the periphery of said openings being closed by cooperation of the wall forms and the window and door frames, said window and door frames being temporarily secured to the wall forms by waler brackets.

5. A method of making a cast-in-place concrete structure according to any one of the preceding Claims, including the additional step of securing straightening members to the concrete wall forms prior to the pouring of moist concrete material therein.

6. A method of making a multi-storey cast-in-place concrete structure comprising the separate and sequential steps of:—

(a) levelling the ground area on which the concrete structure is to be constructed and forming a foundation form by temporarily interconnecting a plurality of architectural forms to define the area of the foundation;

(b) forming the foundation and floor by pouring uncured concrete into the confines of said foundation form and allowing said concrete to cure;

(c) removing said foundation form;

(d) forming on the foundation a first continuous arrangement of pairs of opposed spaced concrete wall forms by temporarily interconnecting a plurality of architectural forms, said first concrete wall forms being interconnected by a plurality of upper and lower wall form ties and defining the upstanding exterior and interior walls of the first storey of said concrete structure;

(e) forming the upstanding exterior and interior walls of the first storey of the concrete structure by pouring uncured concrete into the space defined between said first concrete wall forms, and allowing said concrete to cure;

(f) removing said first concrete wall forms except for maintaining a series of architectural forms connected to said upper wall form ties externally of the exterior walls

of the first storey to define the peripheral edge of the first floor;

(g) constructing the first floor form of the concrete structure by,

(i) providing a temporary arrangement of shoring members within the enclosure defined by the first storey exterior walls; and

(ii) forming a floor form by temporarily interconnecting a plurality of architectural forms, and supporting said floor form on said arrangement of shoring members;

(h) forming the first floor by pouring uncured concrete into the confines of said floor form and allowing said concrete to cure;

(i) removing said temporary arrangement of shoring members and said floor form, along with the series of architectural forms defining the peripheral edge of said first floor leaving the first floor supported on the first storey walls;

(j) forming a second continuous arrangement of pairs of opposed spaced concrete wall forms, said second arrangement of wall forms being mounted on said first floor, said second concrete wall forms being interconnected by a plurality of upper and lower wall form ties, and defining the upstanding exterior and interior walls of the second storey of said concrete structure;

(k) forming the walls of the second storey of the structure by pouring uncured concrete into the space defined between said second concrete wall forms and allowing said concrete to cure;

(l) removing said second concrete wall forms;

(m) removing the lower wall form ties in the walls of the second storey and leaving the upper wall form ties for subsequently supporting brackets for the roof form;

(n) constructing the roof form of the two-storey concrete structure by,

(i) providing a temporary arrangement of shoring members within the enclosure defined by the exterior walls of the second storey, and supported on said first floor;

(ii) securing overhang brackets to the upper wall form ties externally of the exterior walls of said second storey in order to provide a temporary support for a roof form to enable the latter to extend beyond the peripheral edges of said upstanding exterior walls of said second storey; and

(iii) forming a roof form by temporarily interconnecting a plurality of architectural forms, and supporting said roof form on said arrangement of shoring members and said overhang brackets, with the peripheral edge of said roof form being defined by



- a continuous upstanding member;  
(o) forming the roof of the multi-storey concrete structure by pouring uncured concrete into the confines of said roof form and allowing said concrete to cure; and  
(p) removing the temporary arrangement of the shoring members, the upper wall form ties, the overhang brackets, and said roof form, so as to leave the roof supported by said upstanding walls of the second storey.  
7. A method of making a cast-in-place concrete structure according to Claim 6 wherein the roof form is supported on said arrangement of shoring members and said overhang brackets with said upstanding walls of the second storey projecting into the plane of said roof form so as to define a portion of the lower surface of said roof form, whereby the roof and the walls form a monolithic structure after curing of the concrete.  
8. A method of making a cast-in-place concrete structure according to Claim 6 or 7, wherein in the steps of forming the continuous arrangement of the pairs of opposed concrete wall forms for the first and second

storey walls, openings are left for receiving the frames of doors and windows in the concrete structure, with the periphery of said openings being closed by cooperation of the wall forms, and the window and door frames, said window and door frames being temporarily secured to the wall forms by waler brackets.

9. A method of making a multi-storey cast-in-place concrete structure according to any one of Claims 6 to 8, comprising the further steps of repeating steps (f) to (k) prior to carrying out steps (l) to (p), in order to form additional storeys for the concrete structure.

10. A method of making a cast-in-place concrete structure, substantially as hereinbefore described with reference to the accompanying drawings.

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