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METHOD OF FABRICATING STRUCTURES

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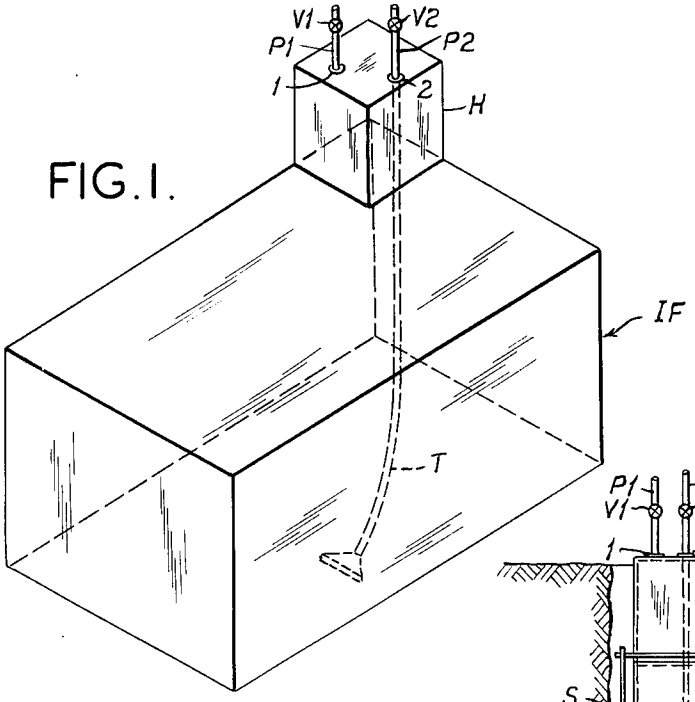


FIG. 1.

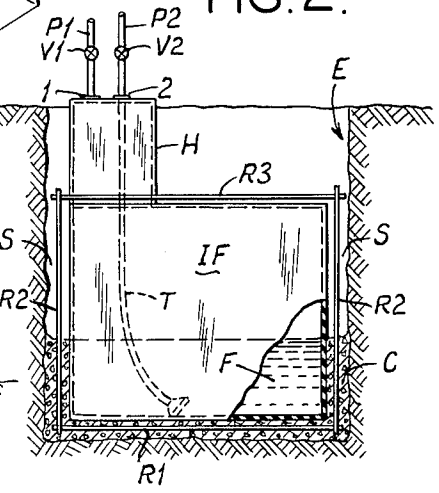


FIG. 2.

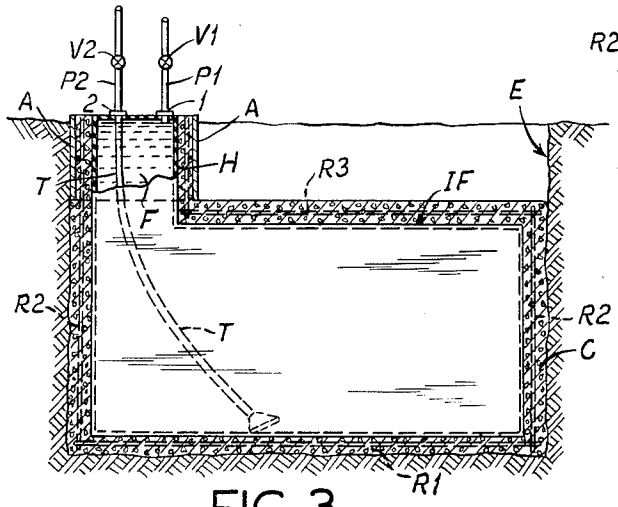


FIG. 3.

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METHOD OF FABRICATING STRUCTURES

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This invention relates to methods of fabricating structures of hardenable plastic material, and more particularly to methods for fabricating structures of this type without the use of rigid interior forms.

Among the several objects of the invention may be noted the provision of methods of fabricating structures, both subterranean and above-grade, which effect a great saving in time and cost over conventional processes; the provision of methods of the type described that may be used in conveniently constructing underground buildings, chambers, swimming pools and above-grade structures; the provision of such methods which are useful in fabricating monolithic structures which may include floors and flat roofs, both with and without reinforcement; the provision of methods of fabricating structures of concrete and the like in which the interior form is nonrigid and may be easily removed after setting of the concrete and reused repeatedly; and the provision of such methods in which structures can be fabricated with a large variety of interior shapes and contours. Other objects and features will be in part apparent and in part pointed out hereinafter.

The invention accordingly comprises the methods hereinafter described, the scope of the invention being indicated in the following claims.

In the accompanying drawings in which one of various possible embodiments of the invention is illustrated,

FIG. 1 is an isometric view of an exemplary collapsible flexible interior form used in one embodiment of this invention;

FIG. 2 is a lateral cross section of the form of FIG. 1 and an excavation illustrating one step in fabricating a structure in accordance with this invention; and

FIG. 3 is a longitudinal cross section of a structure fabricated in accordance with this invention illustrating a final step of this method.

Corresponding reference characters indicate corresponding parts throughout the several views of the drawings.

Conventional methods for fabricating concrete structures involve the erection of both rigid exterior and interior forms to provide wall interspaces into which the wet concrete mix is poured and set. Although in some instances the use of exterior forms can be partially or entirely avoided, considerable time and expense are involved in constructing rigid interior forms and in removing or stripping them from the hardened or set concrete. Also proposed has been a method for fabricating above-grade structures in which inflated pneumatic forms of limited configurations and sizes have been utilized as interior forms and concrete has been sprayed layerwise on the outside thereof. However, this system also has a number of disadvantages including the design and fabrication of an inflatable form with sufficient strength to withstand the stresses inherently applied in supporting the weight of the sprayed-on concrete, any reinforcement members, etc., and maintaining the shape of the interior against substantial deformation and distortion during the fabrication of the structure. Moreover, substantial pneumatic pressure must be applied and maintained inside the form in such a method, and it is apparent that any flat-roofed structure would be impractical to fabricate with such a method.

In accordance with the present invention a method is provided which avoids the disadvantages of these prior

methods and permits the use of expandible nonrigid flexible forms which can be made from very light, relatively weak material, and in which flat-roofed structures can be conveniently fabricated. Moreover, the method of this invention may be utilized to fabricate both above- and below-grade structures of many different interior and exterior configurations and shapes, and the interior flexible forms may be conveniently removed and reused.

Referring now more particularly to the drawings, a collapsible form of flexible substantially inelastic material is generally indicated at reference character IF. This form is preferably made of a relatively thin (i.e., in the order of several mils or thousandths of an inch in thickness) single-ply film of a synthetic resin such as vinyl or polyethylene materials, although it may be made of multi-ply construction, e.g., a fabric layer sandwiched between rubberized surface layers, etc. As illustrated, the IF is a right-angle parallelepiped, which may be formed by folding and/or cutting and sealing flat sheets of the flexible inelastic material to make the final form (when expanded) of a size and configuration having exterior surface dimensions and shape which correspond to the interior of the desired structure to be fabricated. It will be noted that this form can be made to be of nondevelopable shape in whole or in part such as by molding the flexible inelastic material rather than simply fabricating it from flat sheets.

Form IF also includes a generally cubical bulkhead or head H extending or projecting outwardly from the top surface portion of form IF. Form IF is provided with two ports 1 and 2, shown in the head portion H of form IF. Port 1 is selectively connected to a vent or any conventional source of pressurized air (such as a compressor, not shown) by means of a pipe P1 having a valve V1. Port 2 is connected by means of a pipe P2 and a valve V2 to a reversible pump (not shown) for pumping a flowable filler material selectively into or out of the interior of form IF. The flowable filler material may be any fluid material such as for example drilling mud (a suspension of clays and a finely divided dense component, such as barite, etc., in water) which has a specific gravity or density substantially identical to that of the particular mix of concrete or other hardenable plastic material used in fabricating the structures herein.

In carrying out an exemplary method of the present invention, a surrounding rigid enclosure, such as an excavation E, is first dug or formed so as to have interior surfaces, conforming to the size and shape of the exterior of the desired structure, which in this instance would be a storm or fallout shelter, or basement recreation room. Assuming the desired structure is to have a floor and be monolithic, wet concrete mix C is first poured on the bottom of excavation E and suitable reinforcement members R1, such as steel mesh and/or rods, are laid in the mix C as it is poured. After any leveling of the floor surface and while mix C is still not hardened, form IF, usually in a collapsed or semicollapsed condition, is placed on the floored enclosure E with its bottom surface resting on the floor. Form IF is then expanded, preferably by pumping air through P1 into the interior of IF until this form has assumed its distended configuration, as shown in the drawings and in which the exterior surfaces thereof define a size and shape corresponding substantially to those of the interior of the desired structure. It will be noted that an internal pressure only slightly in excess of atmospheric pressure need be applied internally to expand form IF, which is positioned in the enclosure E so that interspaces S between the side surfaces of IF and the excavation correspond to the thickness of the walls of the desired structure. Assuming wall reinforcement is desired, wall reinforcing mesh and/or rods R2 are po-

sitioned in interspaces S and wet concrete C is introduced into interspaces S. Concurrently or simultaneously with the introduction of mix C into the interspaces, flowable filler material F, such as drilling mud, with a density adjusted to equal the density of mix C, is flowed through tube T which is connected to port 2 and pipe P2. The relative flow rates of mix C and filler F are controlled to maintain the levels of mix C and filler F equal as the former rises in the interspaces S and the latter rises in the interior of form IF, thereby maintaining substantially equal hydrostatic pressures on each side of the walls of form IF. Thus, any tendency is avoided for the form IF to distort or change its shape in any way as pouring progresses and no substantial differential pressure exists between opposite sides of the membrane walls of form IF. Valve V1, which may be manually operated or an automatic type valve to release or vent the air pressure from within the form IF when it tends to rise above the slight positive differential necessary to hold form IF distended, functions to gradually and controllably release air as it is displaced by the rising incoming filler material F in form IF. Valve V2 is utilized to control the flow rate of filler F.

Assuming a roofed structure is desired, the flow of mix C into enclosure E is continued after the level of filler F rises to the top of form IF. The rise of filler F up the neck of head H is controlled to be equal to the rise of mix C above the top of form IF and reinforcements R3. The incompressibility of the filler F continues to sustain the roof portion without substantial deformation of the top of form IF.

Assuming an extension of the scuttle or access hole is desired, rigid forms A of wood panels or the like are positioned about the head H as indicated in FIG. 3 and the level of filler F is increased concurrently with the rise of mix C around head H of form IF.

After the concrete mix C has hardened and set, filler material F is removed from the interior of IF by pumping in a reverse direction through T and P2. When empty, or substantially so, form IF can be conveniently removed by collapsing it, such as by applying a slight negative internal pressure, and reused repeatedly to fabricate additional structures of the same size and shape. The resulting structure, as it was made with substantially continuous pouring, is monolithic.

It will be noted, as indicated previously, that concrete structures having a variety of interior configurations can be formed, such as swimming pools with slanting bottoms, and structures of irregular, curved or so-called free-form shapes. Also, if no bottom is desired, or it is preferred to form the bottom or floor after the walls of the structure have been constructed, the form IF is merely directly positioned on the bottom of the rigid enclosure. Moreover, if above-grade structures are to be fabricated, enclosure E would be formed partially or entirely of rigid exterior panels or forms in the conventional fashion. Reinforcing members such as R1–R3 are, of course, optional, although their use is indicated if the dimensions of any unsupported span in the completed structure are great enough so that good engineering practice dictates such reinforcement. It will be understood that any hardenable plastic material is useful as the equivalent of conventional concrete mixes, such as for example light-weight aggregates (using perlite, etc.), plasters, or synthetic resin-filler mixtures. In each instance, it will be understood that the specific gravity or density of the filler material F is adjusted or mixed so as to match that of the hardenable plastic material. Drilling mud, which is a material having an easily adjusted density (e.g., its composition can be simply varied to produce densities in the order of 100–150 lbs./ft.^{3} which matches the densities of typical concrete mixes), is a widely obtainable, inexpensive and easily handleable, flowable filler material, although many other materials are equivalent for this purpose.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As various changes could be made in the above methods without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. The method of fabricating structures without the use of rigid interior forms comprising placing a collapsible form of flexible substantially inelastic material in a surrounding rigid enclosure having interior surfaces conforming to the size and shape of the exterior of the desired structure, said form adapted when expanded to assume a size and shape corresponding substantially to the interior of the desired structure, expanding said form and positioning it in said enclosure whereby the interspaces between the exterior surfaces of said form and the interior surfaces of said enclosure correspond to the thickness of the walls of the desired structure, simultaneously flowing a hardenable plastic material into said interspaces while flowing a flowable filler material having a density substantially equal to that of said plastic material into the interior of said form, controlling the relative flow rates of said plastic and filler materials so that the levels of said materials are maintained substantially equal as said interspaces are filled thereby to maintain substantially equal hydrostatic pressures on the inner and outer surfaces of said form, and removing said filler material from said form and said collapsible form from the interior of the thus formed structure after said plastic material has hardened.

2. The method of claim 1 in which the structure to be fabricated has a roof and an access hole, which further includes providing said form with an outwardly projecting head of flexible substantially inelastic material adapted when expanded to extend above the top surfaces of said form a distance at least equal to the thickness of said roof and to have an exterior shape and size corresponding to the cross section of said access hole, and continuing to flow said plastic material over the top of said form while continuing to maintain substantially equal the levels of the plastic material and filler material as the levels of these materials rise above the top of the form, the incompressibility of said filler material within said form supporting the plastic material above said form, whereby after hardening of said plastic material the desired structure is monolithic.

3. The method of claim 1 in which the structure to be fabricated has a floor of said hardenable plastic material, which further includes the initial step of pouring the floor of said plastic hardenable material, and, before said plastic material hardens, performing the balance of said steps whereby a monolithic structure is thereby formed.

4. The method of claim 2 in which the structure to be fabricated has a floor of said hardenable plastic material, which further includes the initial step of pouring the floor of said plastic hardenable material, and, before said plastic material hardens, performing the balance of said steps whereby a monolithic structure is thereby formed.

5. The method of claim 1 in which the structure to be formed is subterranean and said rigid enclosure is constituted at least in substantial part by the walls of an excavation.

6. The method of fabricating concrete structures without the use of rigid interior forms comprising pouring a floor of wet concrete mix at the bottom of a surrounding rigid enclosure having interior surfaces conforming to the size and shape of the exterior of the desired structure, placing an inflatable collapsible form of flexible substantially inelastic material in said enclosure, said form adapted upon inflation to assume a size and shape corresponding substantially to the interior of the desired

structure, inflating said form and positioning it in said enclosure whereby the interspaces between the exterior surfaces of said form and the interior side surfaces of said enclosure correspond to the thickness of the side walls of the desired structure, simultaneously flowing additional wet concrete mix into said interspaces while flowing a drilling mud having a density substantially equal to that of the concrete mix into the interior of said form, controlling the relative flow rates of said concrete mix and said drilling mud so that the levels of these materials are maintained substantially equal as said interspaces are filled and equal hydrostatic pressures are maintained against the inner and outer surfaces of said form, removing said drilling mud from said form, and collapsing and

removing said flexible form after the concrete mix has set.

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