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(54) CONCRETE FLOOR AND CEILING SYSTEM WITHOUT STEEL REINFORCING

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(52) **U.S. Cl.**

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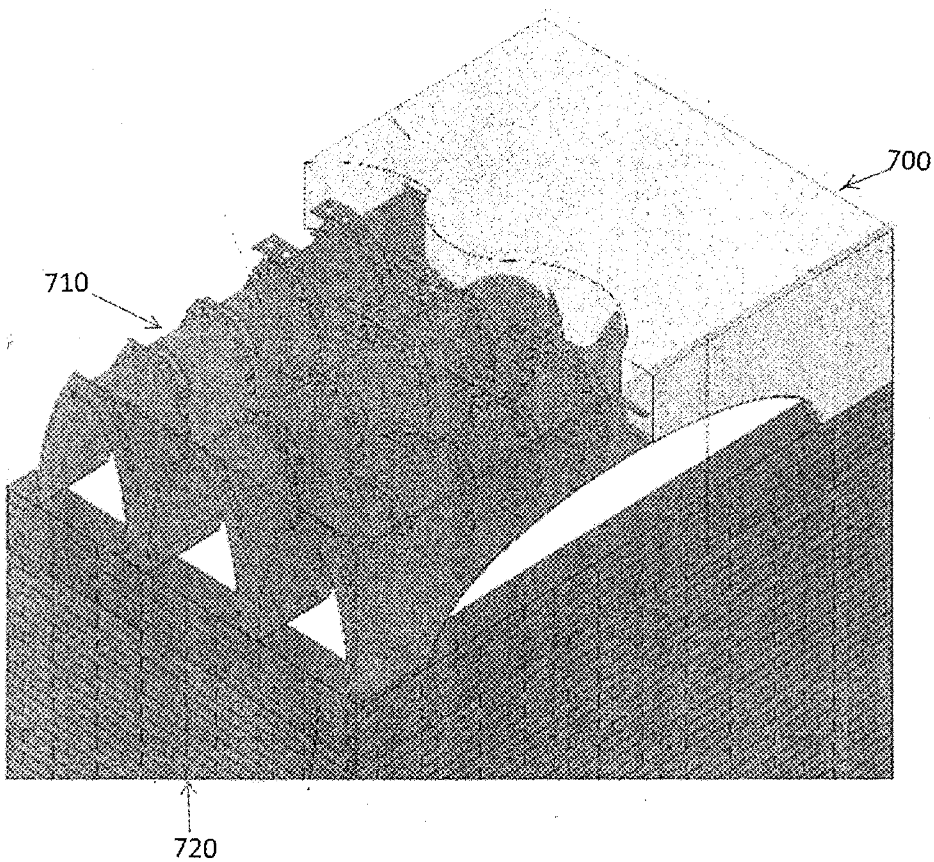
(57) **ABSTRACT**

A building component system including a rigid plastic form having an arched shape in each of two perpendicular vertical planes and having a plurality of protrusions configured to engage concrete poured on top of the rigid plastic form. The system also includes concrete poured on top of the form and cured to bind to the form at least at the plurality of protrusions, thereby forming an arched ceiling for a first story of a building and a flat roof or flat floor for a second story of a building.



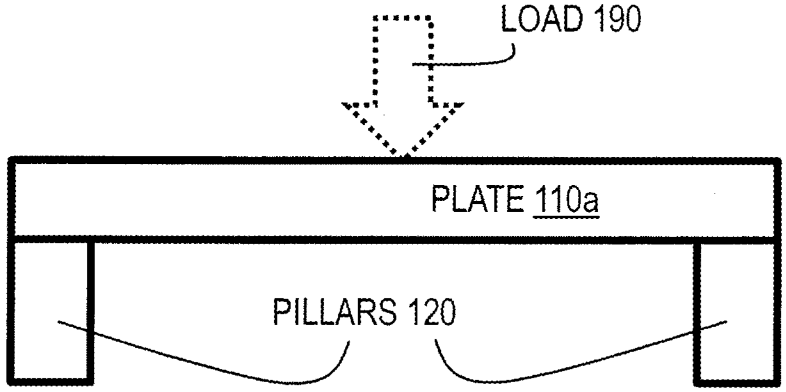

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PLATE 110a
PILLARS 120

FIG. 1A

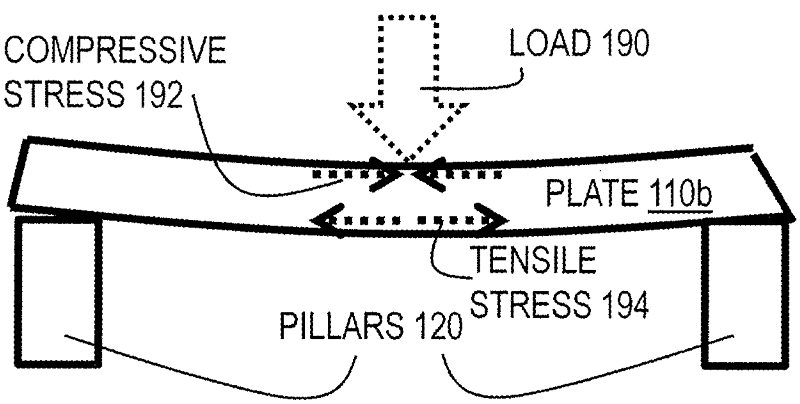
COMPRESSIVE
STRESS 192
LOAD 190
PLATE 110b
TENSILE
STRESS 194
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FIG. 1B

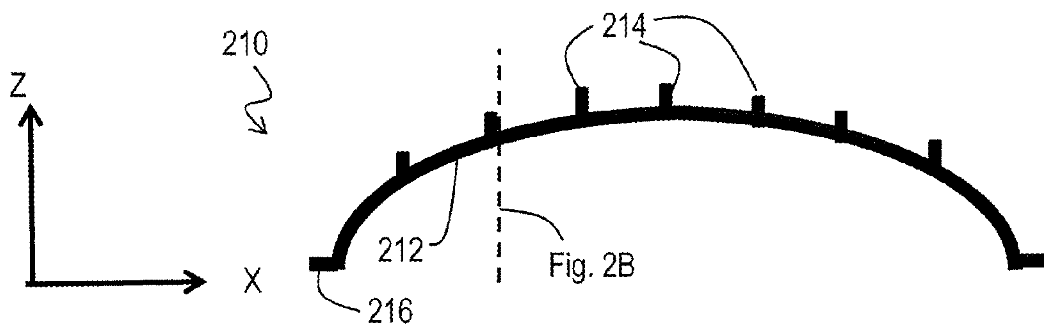

FIG. 2A

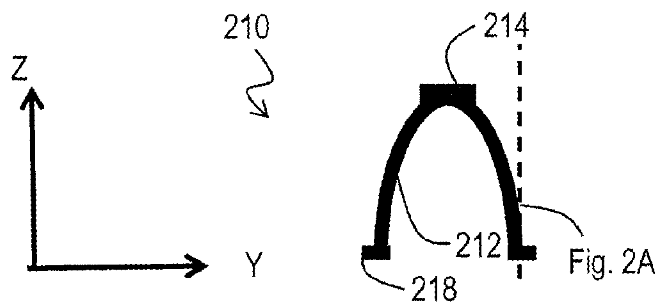

FIG. 2B

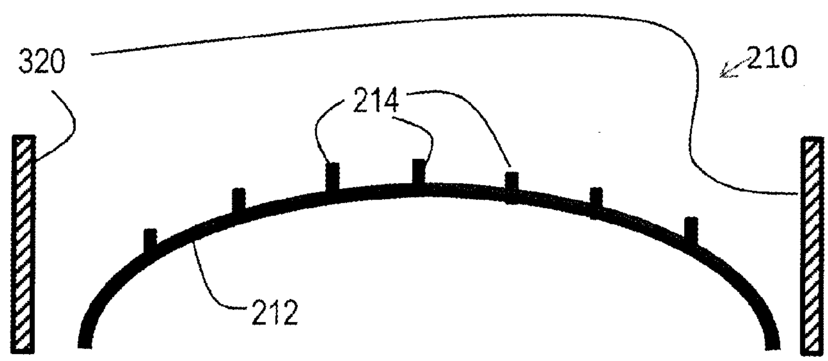

FIG. 3A

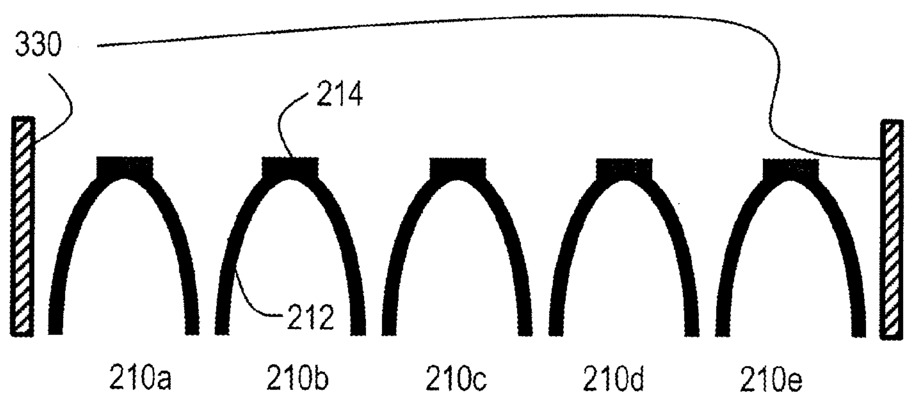

FIG. 3B

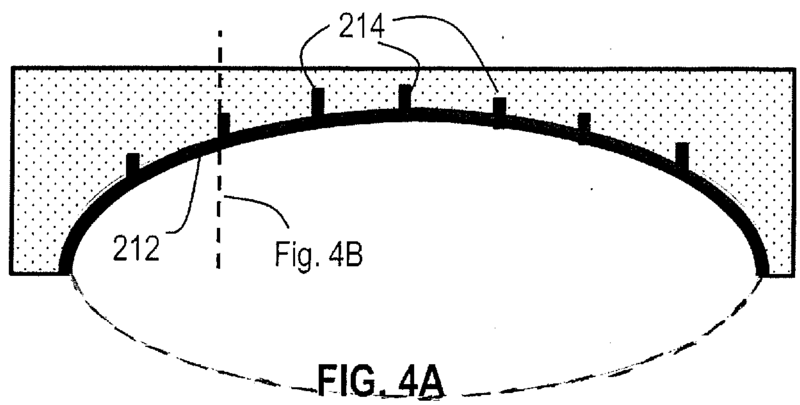

FIG. 4A

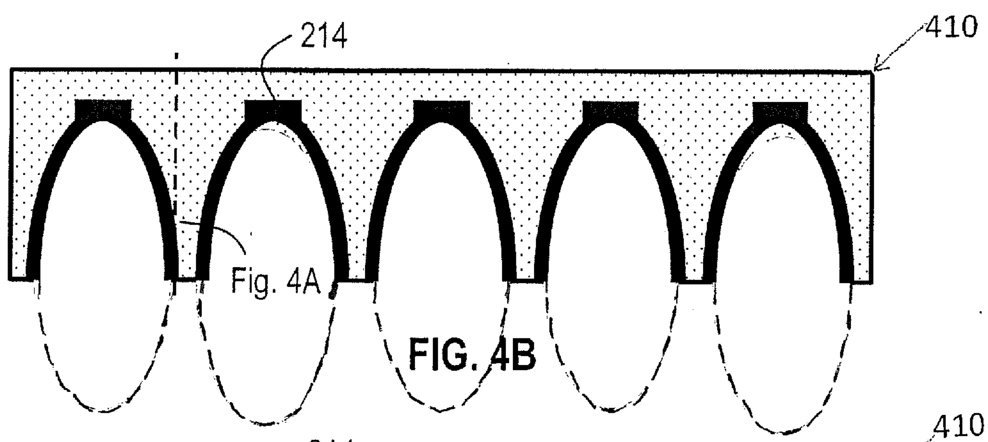

FIG. 4B

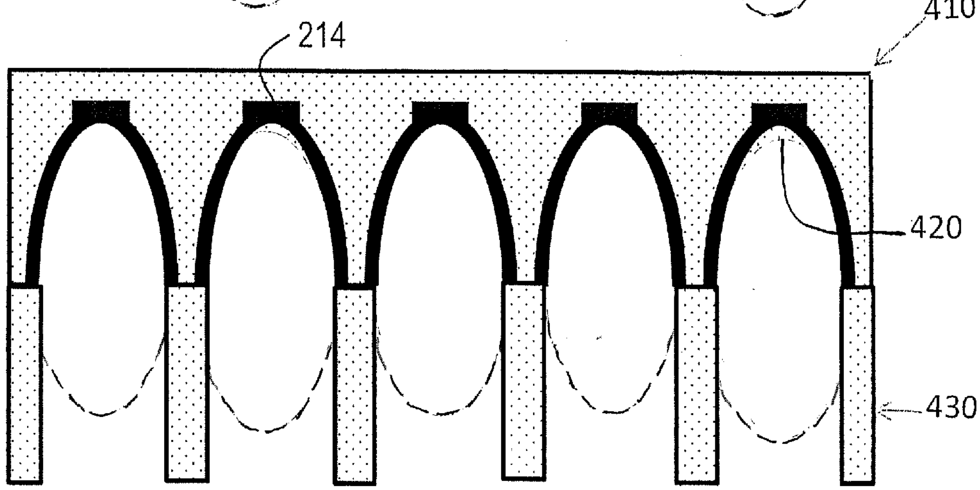

FIG. 4C

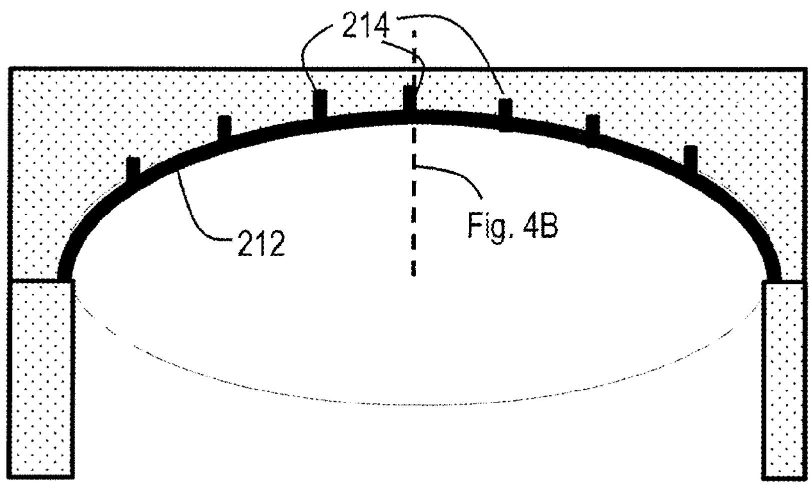

FIG. 4D

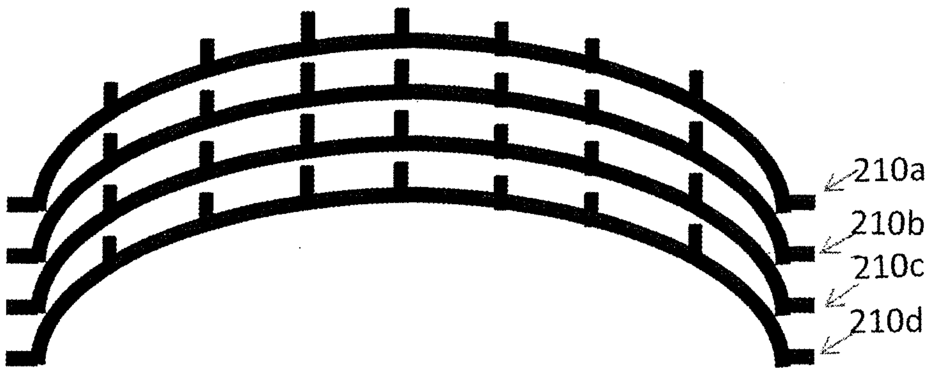

FIG. 5A

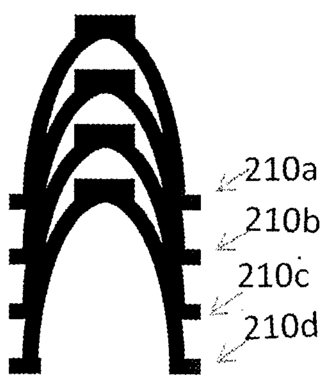

FIG. 5B

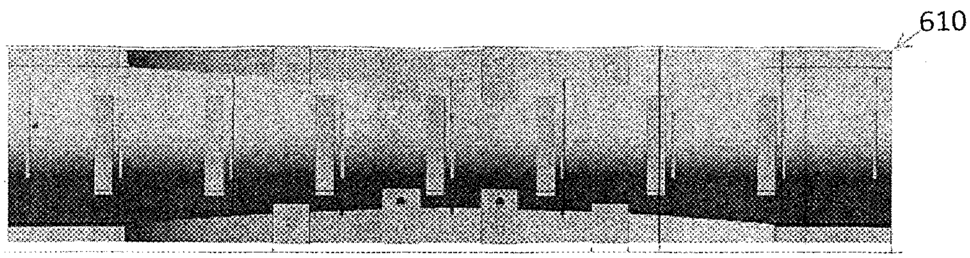

FIG. 6A

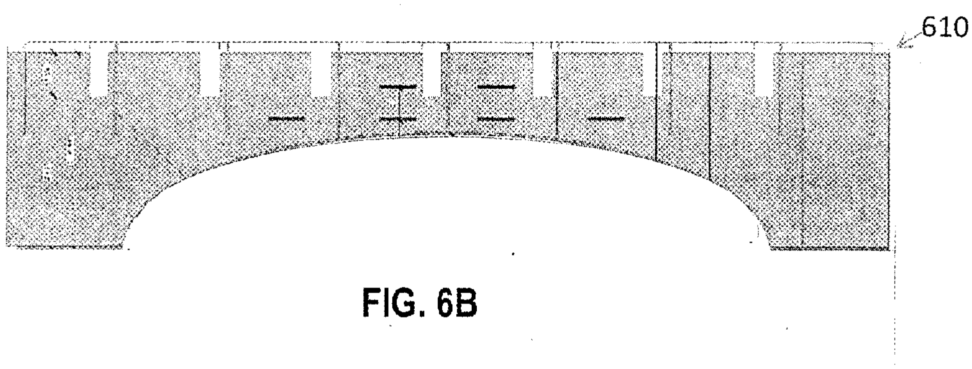

FIG. 6B

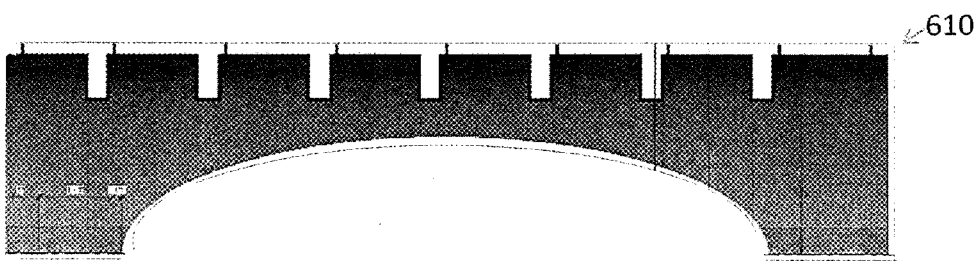

FIG. 6C

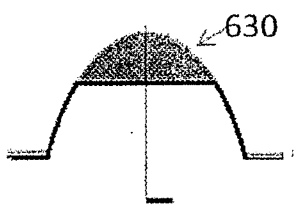

FIG. 6D

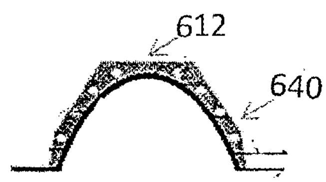

FIG. 6E

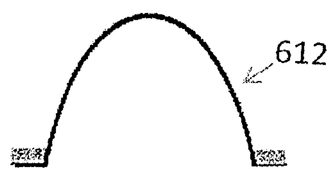

FIG. 6F

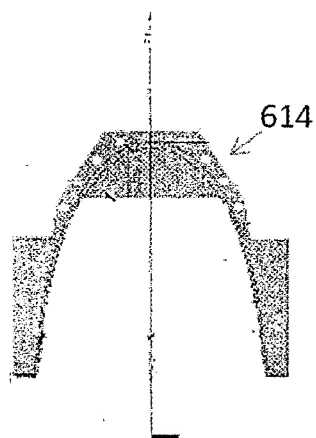

FIG. 6G

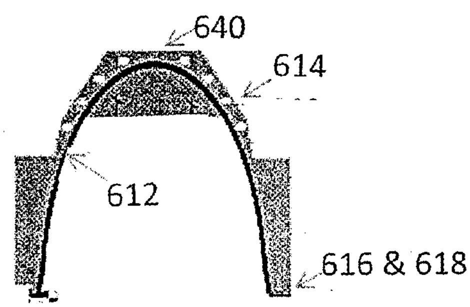

FIG. 6H

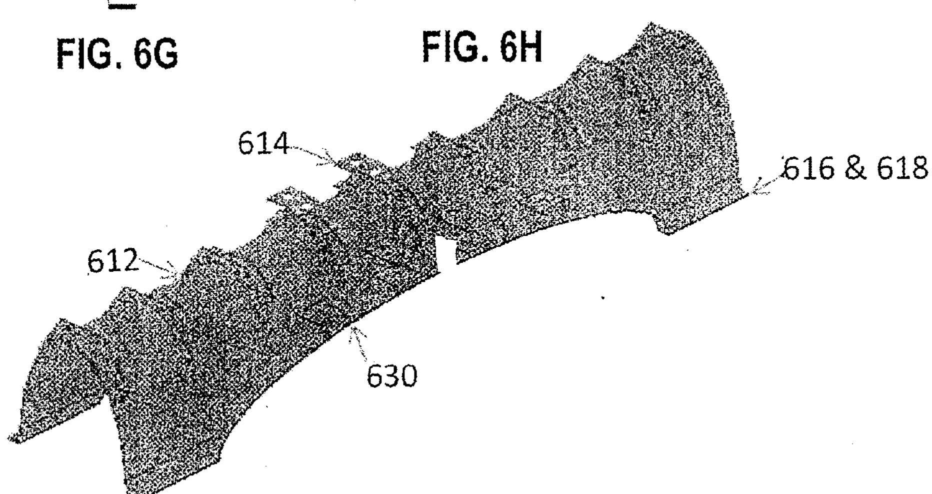

FIG. 6I

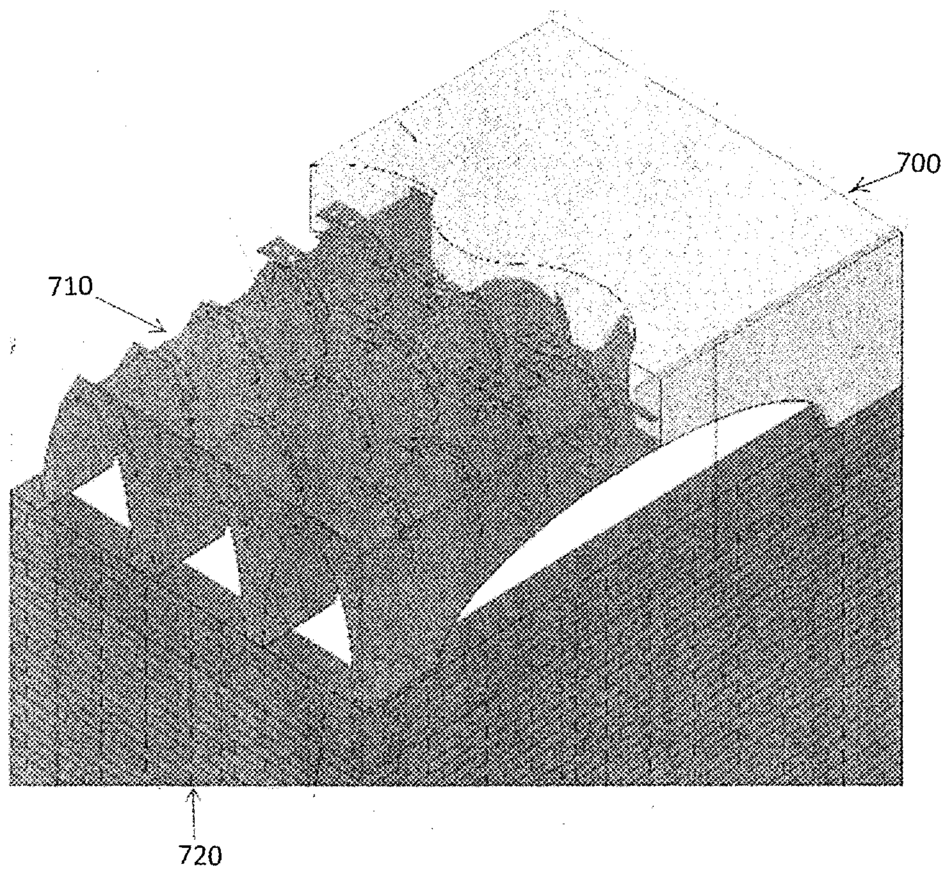

FIG. 7

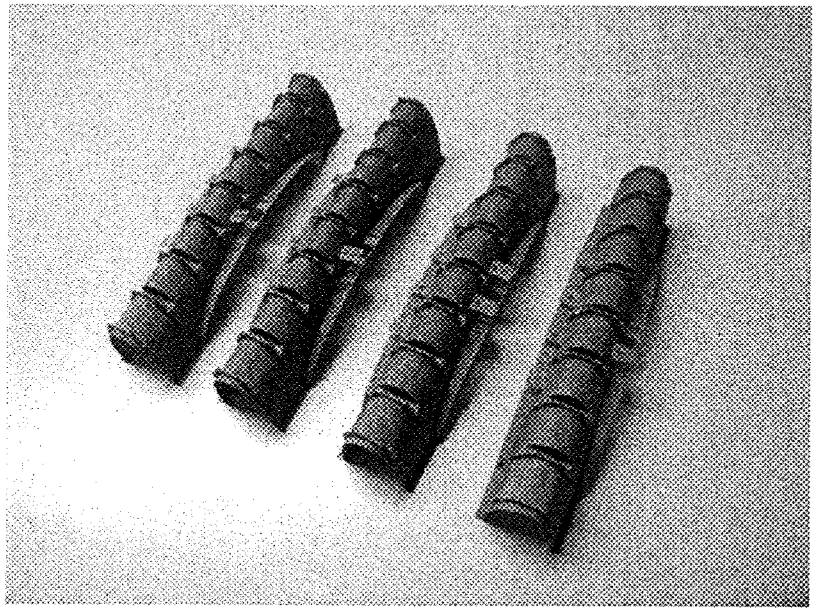

FIG. 8A

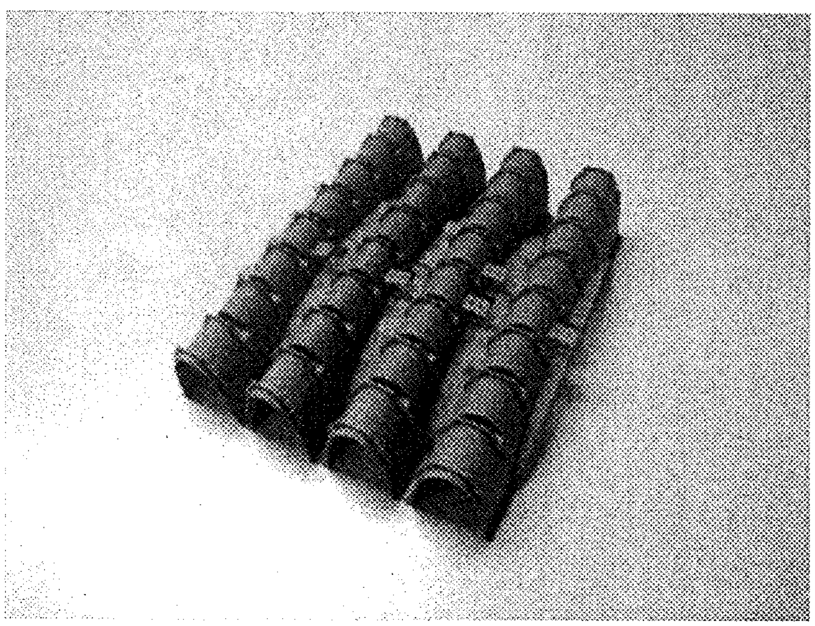

FIG. 8B

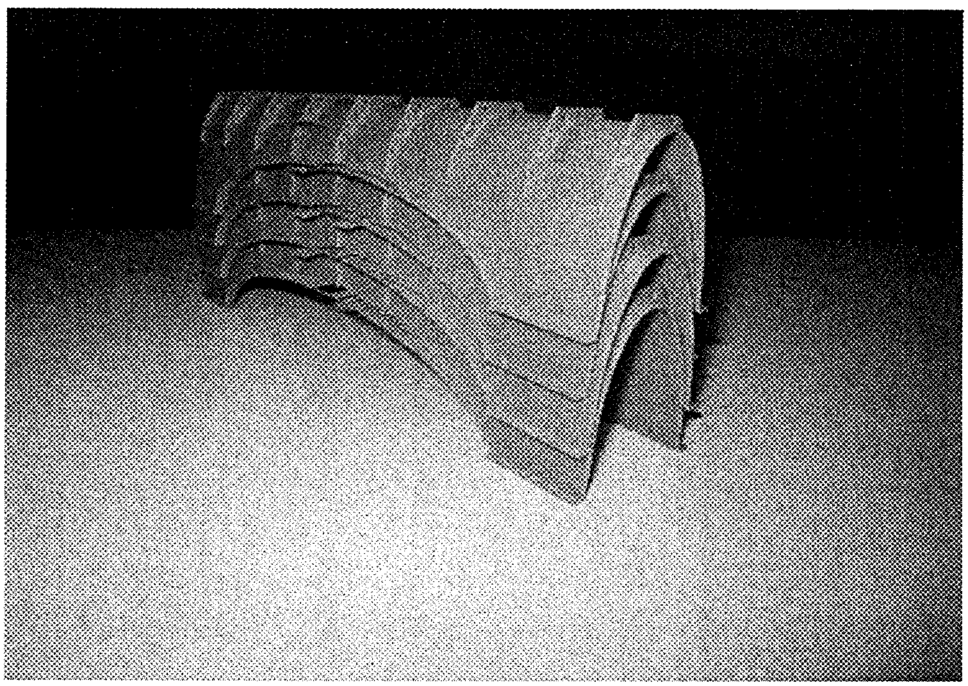

FIG. 8C

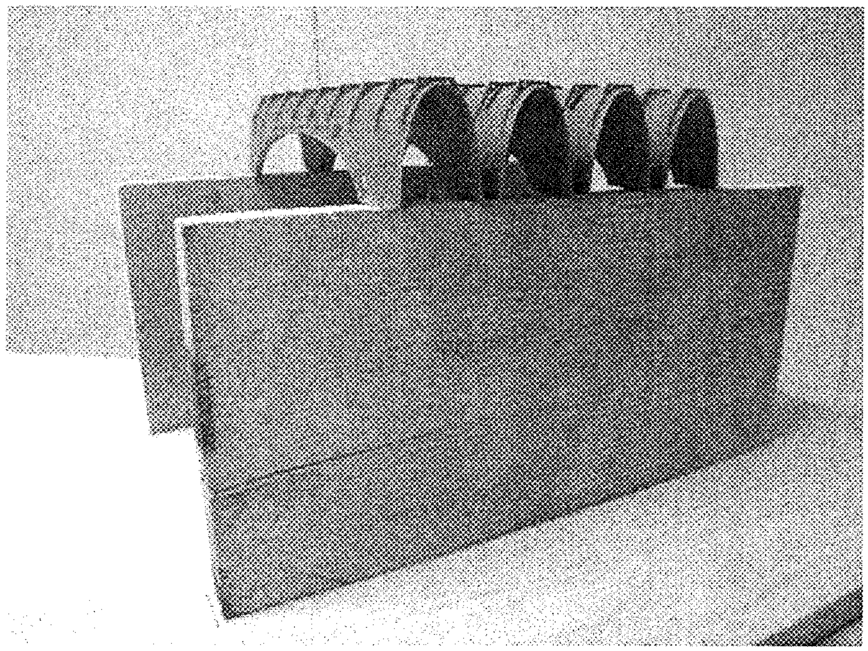

FIG. 9A

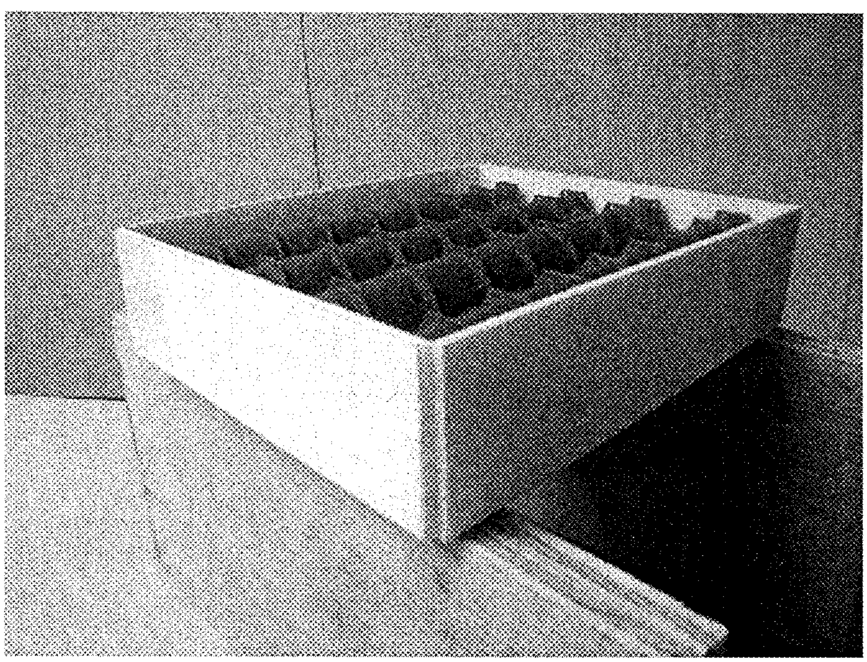

FIG. 9B

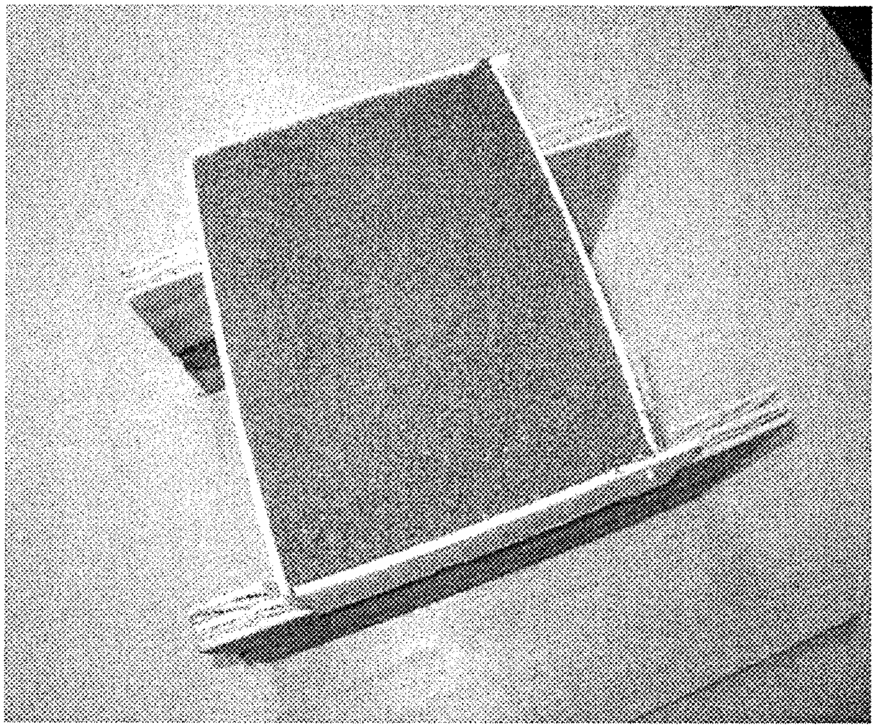

FIG. 9C

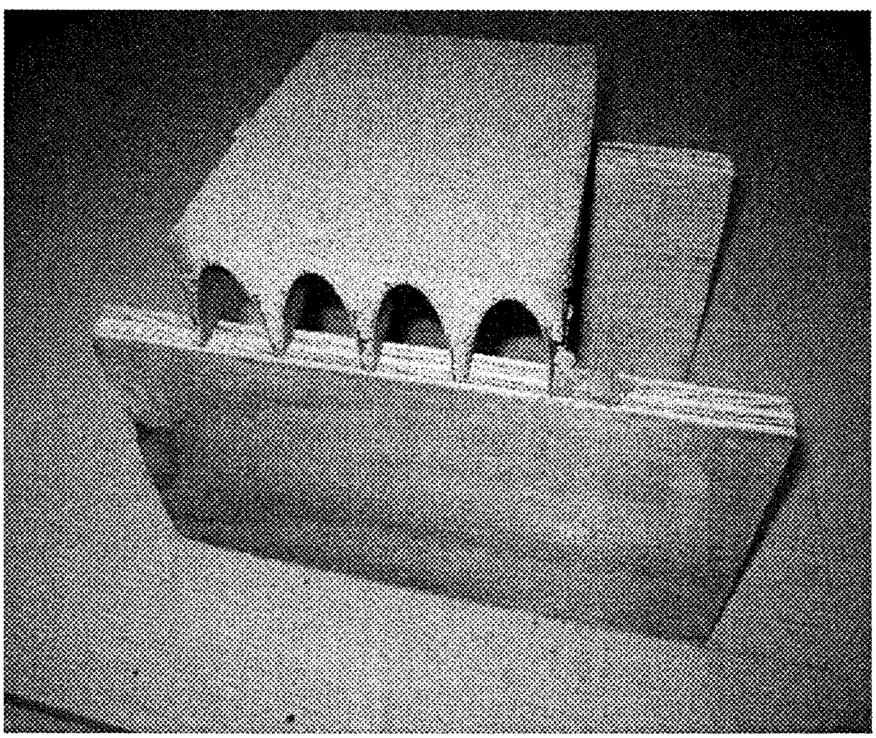

FIG. 9D

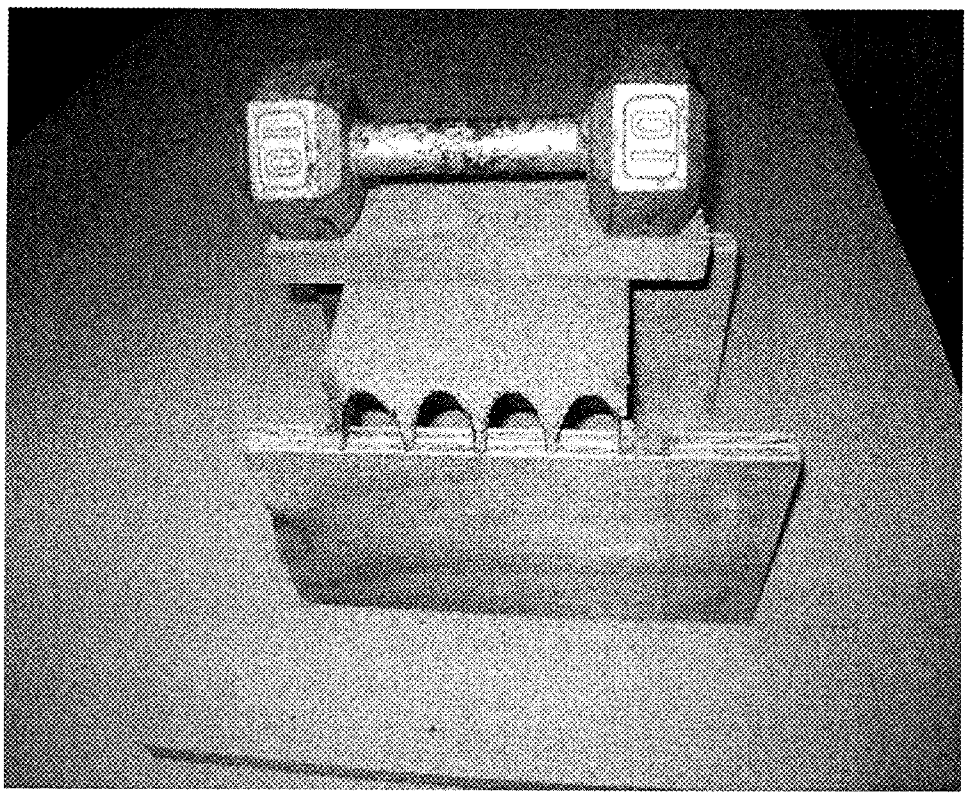

FIG. 10A

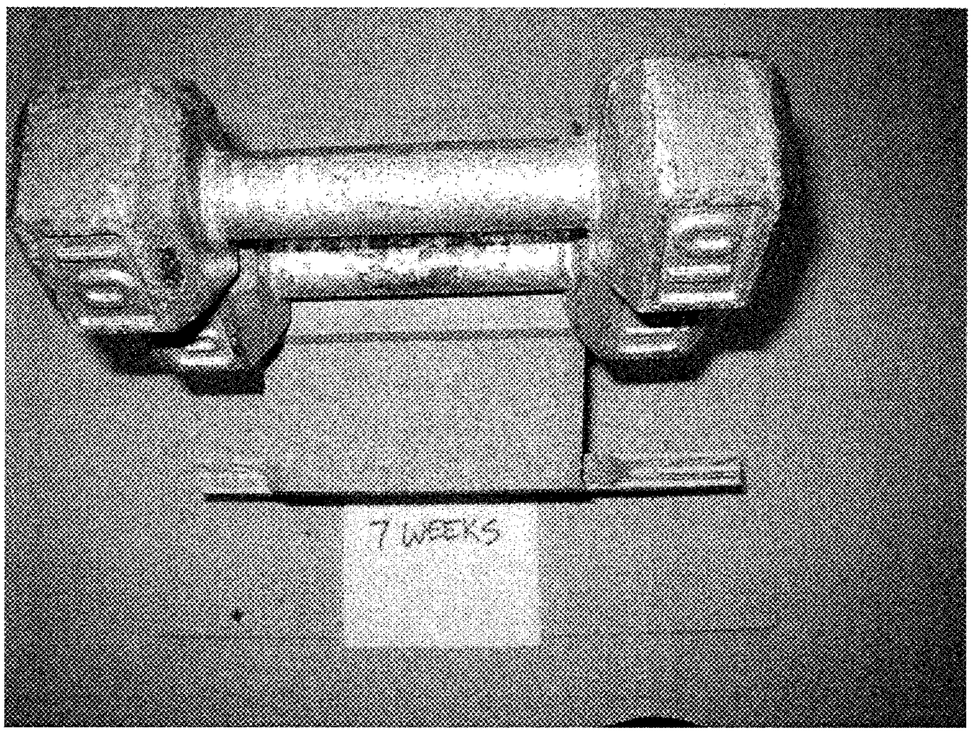

FIG. 10B

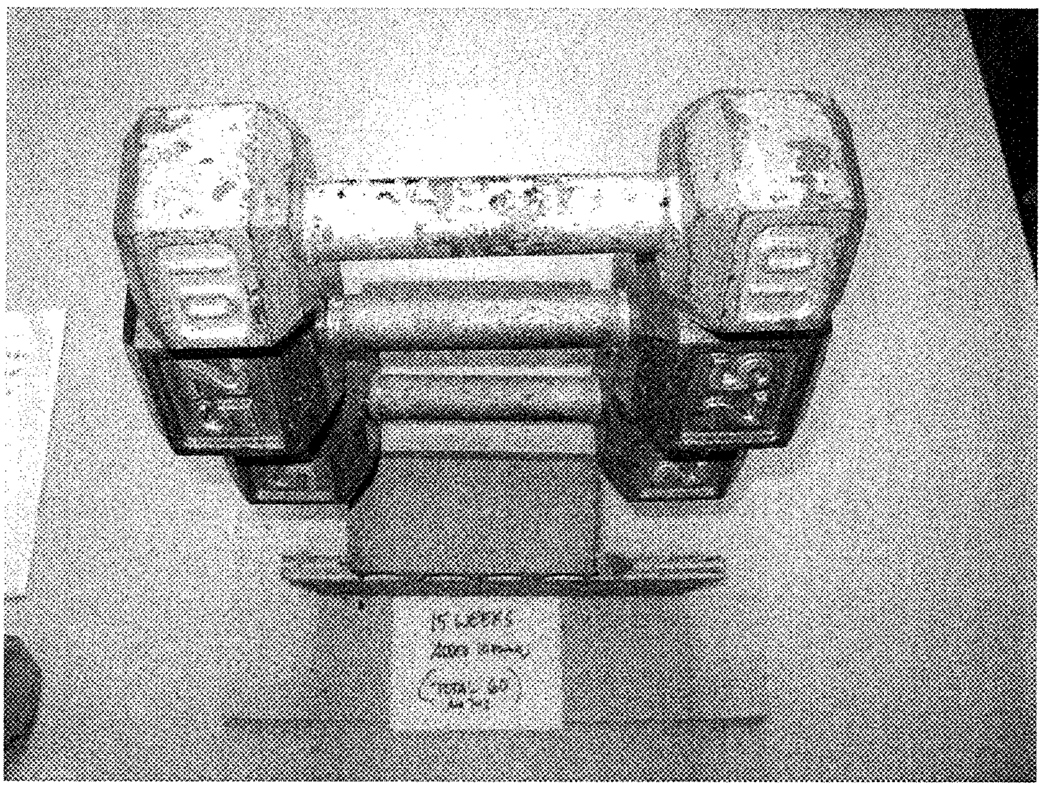

FIG. 10C

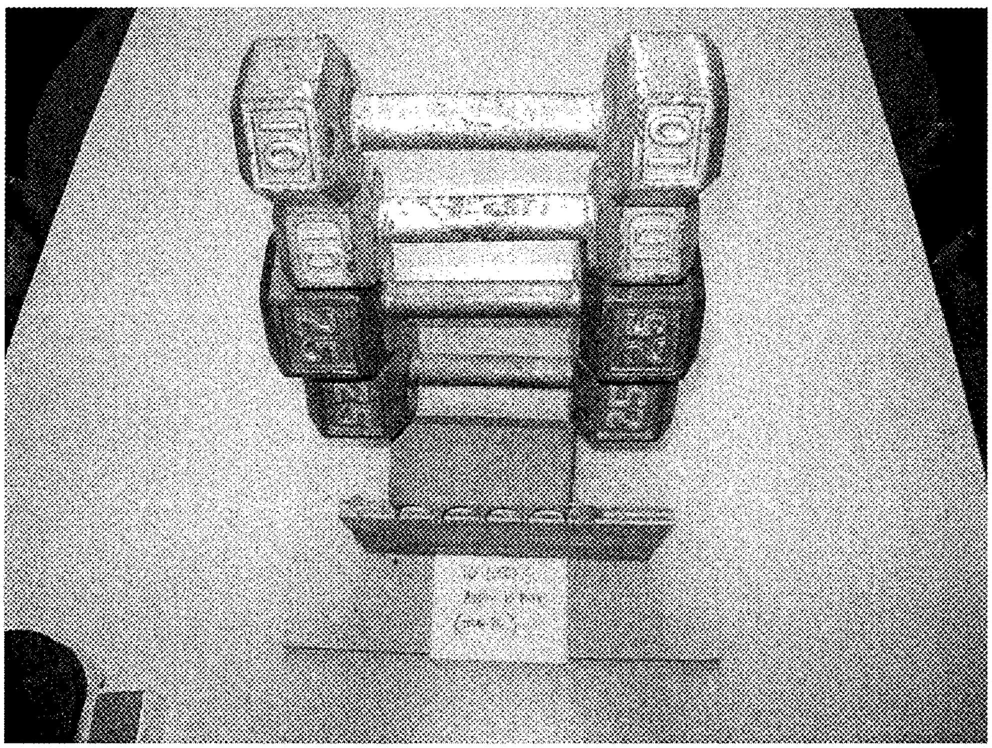

FIG. 10D

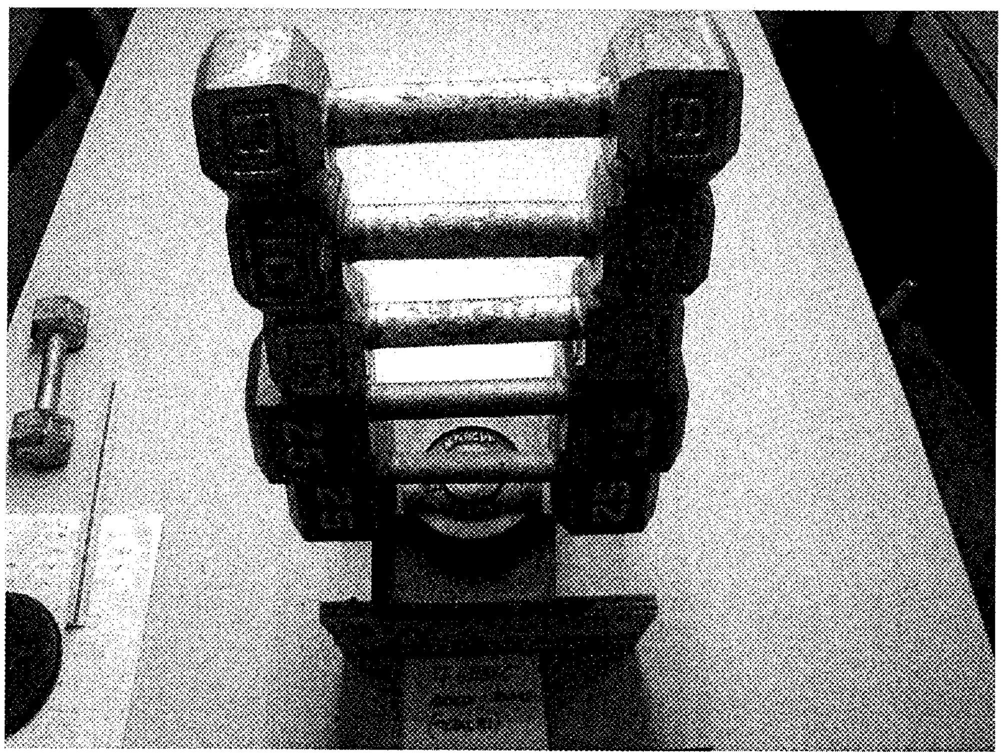

FIG. 10E

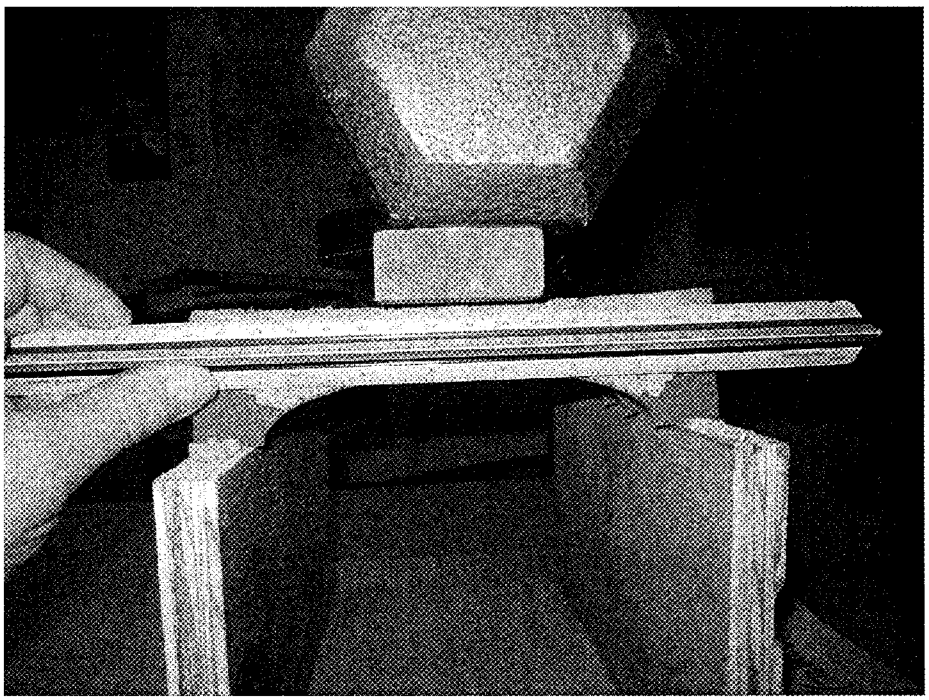

FIG. 10F

CONCRETE FLOOR AND CEILING SYSTEM WITHOUT STEEL REINFORCING

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims benefit of Provisional Application. No. 62/340,042, filed May 23, 2016, the entire contents of which are hereby incorporated by reference as if fully set forth herein, under 35 U.S.C. §119(e).

BACKGROUND

[0002] Concrete construction has brought many advantages to the construction industry since being reintroduced to the world in the late 19th century. Poured concrete was used in ancient Rome, famously for the dome of the Pantheon, but the recipe was lost for millennia. Concrete (composed of Portland Cement, sand, aggregate and water) offers many advantages to other types of framing, including, among others, that: 1) it is composed of basic and easily transported materials; 2) it is malleable when first mixed so it can assume many shapes; 3) it has great compressive strength; and, 4) it is resistant to fire.

[0003] However, concrete is poor in its tensile strength. For this reason, it is paired with steel often in the form of re-bar (reinforcing bars) and/or wire mesh. Such pairing is labor intensive regarding transport and placement. Concrete also requires a labor intensive complex formwork to be placed so that the final structure can assume an irregular shape; and, after the concrete is set, the forms must be removed. While modern reusable form systems have reduced the cost of material, the labor costs remain high.

SUMMARY OF THE INVENTION

[0004] Techniques are provided for a consumable formwork that is incorporated into the final structure and provides sufficient tensile strength that steel reinforcing can be omitted.

[0005] In a first set of embodiments, a building component system includes a rigid plastic form having an arched shape in each of two perpendicular vertical planes and having a plurality of protrusions configured to engage concrete poured on top of the rigid plastic form. The system also includes concrete poured on top of the form and cured to bind to the form at least at the plurality of protrusions, thereby forming an arched ceiling for a first story of a building and a flat roof or flat floor for a second story of a building.

[0006] In some embodiments of the first set, when the form is placed on a flat surface, a space below the form is sufficient for use as a residence for humans or animals or equipment or some combination.

[0007] In some embodiments of the first set, the concrete is not reinforced with steel.

[0008] In some embodiments of the first set, the system includes two or more temporary vertical forms disposed outside the rigid plastic form for providing an outer perimeter of the building component, wherein the temporary vertical forms are removed after the concrete is poured and cured.

[0009] In some embodiments of the first set, a plurality of the rigid plastic forms stack efficiently for transportation of the plurality of rigid plastic forms.

[0010] In some embodiments of the first set, the system includes a mold configured to fabricate the rigid plastic form by injection molding.

[0011] In a second set of embodiments, a method includes placing a rigid plastic form having an arched shape in each of two perpendicular vertical planes and having a plurality of protrusions configured to engage concrete poured on top of the rigid plastic form, and placing two or more simple vertical forms outside the rigid plastic form for providing an outer perimeter of a building component. The method includes pouring and curing concrete on top of the form to bind to the form at least at the plurality of protrusions. The method also includes after the concrete cures, removing the two or more simple vertical forms, thereby forming an arched ceiling for a first story of a building and a flat roof or flat floor for a second story of a building.

[0012] Still other aspects, features, and advantages are readily apparent from the following detailed description, simply by illustrating a number of particular embodiments and implementations, including the best mode contemplated for carrying out the invention. Other embodiments are also capable of other and different features and advantages, and its several details can be modified in various obvious respects, all without departing from the spirit and scope of the invention. Accordingly, the drawings and description are to be regarded as illustrative in nature, and not as restrictive.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Embodiments are illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings in which like reference numerals refer to similar elements and in which:

[0014] FIG. **1**A and FIG. **1**B are block diagrams that illustrate example compression and tensile forces on a concrete slab that are to be modified according to an embodiment;

[0015] FIG. **2**A and FIG. **2**B are block diagrams that illustrate an example consumable form that mitigates the need for steel reinforcing, according to an embodiment;

[0016] FIG. **3**A and FIG. **3**B are block diagrams that illustrate example use of multiple consumable forms that mitigates the need for steel reinforcing to frame a structure, according to an embodiment;

[0017] FIG. **4**A and FIG. **4**B are block diagrams that illustrate an example structure resulting from use of multiple consumable forms that mitigates the need for steel reinforcing, according to an embodiment;

[0018] FIG. **4**C and FIG. **4**D are block diagrams that illustrate an example structure resulting from use of multiple consumable forms and pillars, according to an embodiment;

[0019] FIG. **5**A and FIG. **5**B are block diagrams that illustrate example stacking of multiple consumable forms that mitigates the need for steel reinforcing, according to an embodiment;

[0020] FIG. **6**A and FIG. **6**C and FIG. **6**H and FIG. **6**I are perspective drawings that depict an example plastic form for forming a chamber of intersecting arches from above, from the side, from the front, and obliquely, respectively, according to an embodiment;

[0021] FIG. **6**B is perspective drawing that depicts an inside half view of the same example plastic, according to an embodiment;

[0022] FIG. **6**D through FIG. **6**G are cross sectional drawings that depict the same example plastic form at different longitudinal positions, according to an embodiment;

[0023] FIG. **7** is perspective drawing that depicts pouring cement onto multiple forms of the type depicted in FIG. **6**A through FIG. **6**I, according to an embodiment;

[0024] FIG. **8**A is a photograph that depicts an example set of four plastic forms scaled down to a length of about one foot and a width of about 3 inches, according to an embodiment;

[0025] FIG. **8**B is a photograph that depicts the example set of four plastic forms from FIG. **8**A, set adjacent to each other for framing a concrete structure of one square foot, according to an embodiment;

[0026] FIG. **8**C is a photograph that depicts the example set of four plastic forms from FIG. **8**A stacked for transport, according to an embodiment;

[0027] FIG. **9**A is a photograph that depicts the example set of four plastic forms from FIG. **8**A, set adjacent to each other for framing a concrete structure on a wall of plywood planks, according to an embodiment;

[0028] FIG. **9**B is a photograph that depicts the example set of four plastic forms from FIG. **8**A, set adjacent to each other for framing a concrete structure on a wall of plywood planks with simple side framing, according to an embodiment;

[0029] FIG. **9**C is a photograph that depicts the example framing of FIG. **9**B after pouring concrete, according to an embodiment;

[0030] FIG. **9**D is a photograph that depicts an example structure incorporating the example plastic forms of FIG. **9**A, according to an embodiment;

[0031] FIG. **10**A is a photograph that depicts the example structure of FIG. **9**D externally loaded with a bending stress of 10 pounds, according to an embodiment;

[0032] FIG. **10**B is a photograph that depicts the example structure of FIG. **9**D externally loaded with a bending stress of 20 pounds and then maintained for 7 weeks, according to an embodiment;

[0033] FIG. **10**C is a photograph that depicts the example structure of FIG. **9**D externally loaded with a bending stress of 50 pounds through 15 weeks after adding another 10 pounds for a total of 60 pounds, according to an embodiment;

[0034] FIG. **10**D is a photograph that depicts the example structure of FIG. **9**D externally loaded with a bending stress of 60 pounds through 16 weeks after adding another 10 pounds for a total of 70 pounds, according to an embodiment;

[0035] FIG. **10**E is a photograph that depicts the example structure of FIG. **9**D externally loaded with a bending stress of 70 pounds through 17 weeks after adding another 11 pounds (an 8 pound barbell and a 3 pound disk) for a total of 81 pounds, according to an embodiment; and

[0036] FIG. **10**F is a photograph that depicts a side view of the example structure of FIG. **9**D with 81 pounds per square foot at 17 weeks, according to an embodiment.

DETAILED DESCRIPTION

[0037] A method and apparatus are described for consumable formwork for concrete structures without steel reinforcing. In the following description, for the purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the present invention. It will be apparent, however, to one skilled in the art that the present invention may be practiced without these specific details. In other instances, well-known structures and devices are shown in block diagram form in order to avoid unnecessarily obscuring the present invention.

[0038] Notwithstanding that the numerical ranges and parameters setting forth the broad scope are approximations, the numerical values set forth in specific non-limiting examples are reported as precisely as possible. Any numerical value, however, inherently contains certain errors necessarily resulting from the standard deviation found in their respective testing measurements at the time of this writing. Furthermore, unless otherwise clear from the context, a numerical value presented herein has an implied precision given by the least significant digit. Thus a value 1.1 implies a value from 1.05 to 1.15. The term "about" is used to indicate a broader range centered on the given value, and unless otherwise clear from the context implies a broader range around the least significant digit, such as "about 1.1" implies a range from 1.0 to 1.2. If the least significant digit is unclear, then the term "about" implies a factor of two, e.g., "about X" implies a value in the range from 0.5X to 2X, for example, about 100 implies a value in a range from 50 to 200. Moreover, all ranges disclosed herein are to be understood to encompass any and all sub-ranges subsumed therein. For example, a range of "less than 10" can include any and all sub-ranges between (and including) the minimum value of zero and the maximum value of 10, that is, any and all sub-ranges having a minimum value of equal to or greater than zero and a maximum value of equal to or less than 10, e.g., **1** to **4**.

[0039] Some embodiments of the invention are described below in the context of a particular shape for stackable forms. However, the invention is not limited to this context. In other embodiments the forms do not stack but are fabricated in place using one or more molds and a supply of a suitable plastic material with an injection molding process, or using a 3D printer and a supply of a suitable plastic material.

[0040] As used herein the term "plastic," when used as a noun, refers to a material consisting of any of a wide range of synthetic or semi-synthetic organic compounds that are malleable and can be molded into solid objects. Plastics are typically organic polymers of high molecular mass, but they often contain other substances. They are usually synthetic, most commonly derived from petrochemicals, but many are made from renewable materials such as polylactic acid from corn or cellulosics from cotton linters. Plasticity is the general property of all materials that are able to irreversibly deform without breaking, but this occurs to such a degree with this class of moldable polymers that their name is an emphasis on this ability. Due to their relatively low cost, ease of manufacture, versatility, and imperviousness to water, plastics are used in an enormous and expanding range of products.

Overview of Forms

[0041] FIG. **1**A and FIG. **1**B are block diagrams that illustrate example compression and tensile forces on a concrete slab that are to be modified according to an embodiment of the present invention. Compression forces act to compress a material by pushing molecules together, while tensile forces act to pull molecules apart by pulling on a material in opposite directions causing the material to stretch. The force is usually expressed as a stress, which is a force per unit area. Both compressive stress and tensile stress come to bear when a bending force or stress is applied to a structure, as indicated in FIG. **1**A and FIG. **1**B. FIG. **1**A depicts a plate **110***a* suspended on two pillars **120** subjected to a bending force, called load **190**, caused by the weight of the plate **110***a* or some additional objects placed on the plate **110***a*, or some combination. In response, as depicted in FIG. **1**B, the plate **110***b* tends to bend into a configuration in which the material close to the bending force is subject to a compressive stress **192** and the material opposite the bending force is subject to a tensile stress **194**.

[0042] As stated above concrete is a common building material. While concrete is resistant to failure due to compressive stress **192**, it is subject to failure due to tensile stress **194**. Tensile strength is a measure of the ability of a material to withstand a tensile stress, expressed as the greatest tensile stress that the material can stand without breaking. For this reason a concrete plate is constructed with steel bars, called reinforcement bars (or "rebar"), because steel has a higher tensile strength than concrete. However, steel is expensive and heavy to move. As a consequence, steel rebar is not readily available in many disadvantaged areas where housing and other buildings are needed.

[0043] Plastic is a lighter and less expensive material than steel, and thus plastic is more readily available in disadvantaged areas than steel. In addition, plastic has superior tensile strength compared to concrete. Furthermore, the malleable properties of plastic also are advantageous for generating forms of arbitrary shape. Thus, it is advantageous to use plastic for both purposes simultaneously, e.g., to provide forms for shaping concrete and to stay in place to provide tensile strength for the resulting concrete structure. To provide tensile strength for the resulting structure, features are added to the plastic forms to engage the concrete; and, thus, work with the concrete to resist various loads that impart a tensile stress. Furthermore, plastic is superior to fiberglass suggested in the prior art, because the tensile strength of plastic is much greater (about 16 times greater) than the tensile strength of fiberglass that has a tensile strength only slightly greater (less than a factor of two greater) than concrete. Table 1 summarizes tensile strength and other properties of these materials.

TABLE 1

Properties of various materials.

MATERIAL	COMPRESSIVE STRENGTH psi	TENISLE STRENGTH psi	MODULUS OF ELASTICITY psi	DENSITY pcf
Concrete	4,000	500	3,600,000	150
Steel	36,000	70,000	29,000,000	483
Fiberglass (70% Egb)	135	805	1,200,000	112
Plastic (nylon 6)	12,000	13,000	1,800,000	83

[0044] In some embodiments, the plastic forms are shaped to provide sufficient height and width for the resulting structure that the resulting structure can be used as a supported ceiling for a first story and a floor for the story above. Thus modular buildings can be rapidly constructed with one or a few different plastic forms and concrete without steel reinforcing, e.g., without steel rebar. In many embodiments, the formwork's geometry uses parabolas and arches to push the concrete to almost pure compression, especially as the bending load moves from the center toward the edges. In some embodiments, the forms are also shaped to efficiently stack, which is an advantage in the transport of multiple such forms. In some embodiments, the forms are fabricated on site, and the forms need not be designed to stack efficiently.

[0045] Thus the embodiments described herein is distinguished over the fiberglass forms described in prior U.S. Pat. No. 8,991,137 by using plastic of greater tensile strength or providing greater vertical extent of the arches so that the concrete is working more in compression and less reliant on the tensile strength of the form, or both. In some embodiments, the vertical extent is sufficient that the space below the form is suitable for housing humans or animals or equipment without the use of additional walls or pillars.

[0046] FIG. **2**A and FIG. **2**B are block diagrams that illustrate an example consumable form **210** that mitigates the need for steel reinforcing, according to an embodiment of the present invention. This example embodiment also stacks sufficiently well to allow many such forms to be transported together on a flatbed truck or rail car or cargo hold of ship or aircraft or other vehicle. In this illustration, Z refers to the vertical direction, while X and Y refer to perpendicular horizontal directions. In the illustrated embodiment, the form has a curved plate **212** that is arched over a long distance in the X-Z plane and arched over a shorter distance in the perpendicular Y-Z plane. In addition, the framework has an articulated surface with protuberances **214**, such as flanges, which increase surface friction and allow the concrete to grab, and transfer tensile stresses to, and otherwise interact with the form **210**. In some embodiments, at different cross sections, the form does not reach the ground so as to provide opening between chambers generated by the form, as shown in more detail for the example embodiment with reference to FIG. **6**A and following. The cross sections depicted were selected to show that the form reaches the ground to form at least four legs to support the form and the resulting structure. In some embodiments, only three legs are used; and, in other embodiments, more than four legs are formed. In some embodiments, the form **210** also includes components **216** and **218** that serve as spacers to control the separation between adjacent forms when placed at a construction site in the X and Y directions, respectively.

Overview of Method of Use

[0047] FIG. **3**A and FIG. **3**B are block diagrams that illustrate example use of multiple consumable forms that mitigates the need for steel reinforcing to frame a structure, according to an embodiment. As depicted, a single form **210** is placed in the X direction between two simple vertical forms **320** in the Y-Z plane. In other embodiments, more forms are placed in the X-direction. Multiple forms **210***a*, **210***b*, **210***c*, **210***d* and **210***e* are placed in the Y direction between two simple vertical forms **330** in the X-Z plane. In other embodiments, fewer or more forms are placed in the Y direction. In some embodiments, the spacing between adjacent forms is varied or subject to the discretion of the builder. In some embodiments, the forms are spaced at least a distance apart determined by any spacers **216**, **218** present on the forms. The forms are then filled with concrete to a level above the highest portion of the forms and protuberances **214**. In some embodiments, the forms **210***a* through **210***e* are each shored up with one or more supports until the concrete cures into a solid form.

[0048] FIG. **4**A and FIG. **4**B are block diagrams that illustrate an example structure resulting from use of multiple consumable forms that mitigates the need for steel reinforcing, according to an embodiment. In the X-Z plane the structure forms a chamber that has an arched ceiling that is high enough to serve its purpose, e.g., greater than or equal to the height of the persons or animals or equipment or provisions to be housed in the structure. In the Y-Z plane the structure has multiple arched entrances to the interior chamber or chambers. The top of the structure provides a flat floor **410** for the next story. Where both the X-Z form and the Y-Z form touch the ground, a leg is formed that stands on the ground and supports the vaulted ceiling **420** and flat floor **410** with pure compressive stress well supported by the concrete. A second story can then be formed by repeating the process depicted in FIG. **3**A and FIG. **3**B on top of the structure depicted in FIG. **4**A and FIG. **4**B.

[0049] FIG. **4**C and FIG. **4**D are block diagrams that illustrate an example structure resulting from use of multiple consumable forms and pillars **430**, according to an embodiment. In this embodiment, pillars are formed using conventional or simple forms, or preformed pillars are erected and the forms are placed on top of the pillars. FIG. **4**C shows the relationship of legs to pillars in the Y-Z plane; (the pillars are shown in black and occur only at the ends of the form) and, FIG. **4**C shows the relationship of legs to pillars in the X-Z plane. After concrete is poured and cured, the structure sits atop pillars; one pillar supporting each leg.

[0050] FIG. **5**A and FIG. **5**B are block diagrams that illustrate example stacking of multiple consumable forms **210** *a-d* that mitigates the need for steel reinforcing, according to an embodiment. Such stacking is advantageous for the transport of multiple forms to a building site on truck, train, boat or aircraft.

Experimental Embodiment

[0051] According to an example experimental embodiment, a scale model was constructed to test the strength of the resulting structure. It is desirable in building application that a floor be able to withstand a bending load of 30 pounds per square foot (psf, 1 psf=47.8803 newtons per square meter) for the life of the building for most residential and light commercial applications. The experimental embodiment presented here demonstrates that this embodiment would allow for quick and less expensive means to build flat floors and/or roofs that are capable of holding 30 pounds per square foot of live load or more.

[0052] To test the ideas, we had 1/24 scale models of the form made in plastic (nylon 6) on a 3D printer. A structure was assembled as it would be in the field by pouring concrete on the form. This gave a platform of 8"×6" which is one third of a square foot (48 square inches is one third of 144 square inches equal to one square foot). Considering what is happening on the molecular level, the 1/24 scale would seem an insignificant magnitude difference—particularly since both the model and the full scale version would ultimate act monolithically. After 28 days of curing time the structure was loaded with 10 pounds 7 ounces which is the equivalent of over 31 psf. After a week, the load has held without cracking or failure. After carrying the load for 4 weeks, the load was increased repeatedly until failure.

[0053] FIG. **6**A and FIG. **6**C and FIG. **6**H and FIG. **6**I are perspective drawings that depict an example plastic form **610** for forming a chamber of intersecting arches from above, from the side, from the front, and obliquely, respectively, according to an embodiment. FIG. **6**B is perspective drawing that depicts an inside half view of the same example plastic, according to an embodiment. This design for the form provides for substantial intrusions of concrete between horizontally displaced portions of the frame to more fully engage the tensile strength of the form with the tensile stresses on the structure.

[0054] FIG. **6**D through FIG. **6**G are cross sectional drawings that depict the same example plastic form at different longitudinal positions, according to an embodiment. At different longitudinal positions, the form descend less far from the top and includes a shelf that holds cement above the form and covers the distance to the next adjacent form. FIG. **6**D shows a solid section **630** that represents the dips in the form that allow the substantial intrusion of concrete below the top profile of the form. FIG. **6**E shows a flange with holes **640** to engage the concrete and help transfer tensile stresses from the concrete to the form. FIG. **6**D through **6**I also show curved arch plates **612**, protuberances **614** and spacer components **616**, **618** from different perspectives.

[0055] FIG. **7** is a perspective drawing that depicts pouring cement **700** onto multiple forms **710** of the type depicted in FIG. **6**A through FIG. **6**I, according to an embodiment. The forms are set above walls **720** to form a vaulted ceiling for a rectangular room and a floor for the story above.

[0056] FIG. **8**A is a photograph that depicts an example set of four plastic forms scaled down to a length of about one foot and a width of about 3 inches, according to an embodiment. FIG. **8**B is a photograph that depicts the example set of four plastic forms from FIG. **8**A, set adjacent to each other for framing a concrete structure of one square foot, according to an embodiment. FIG. **8**C is a photograph that depicts the example set of four plastic forms from FIG. **8**A stacked for transport, according to an embodiment.

[0057] FIG. **9**A is a photograph that depicts the example set of four plastic forms from FIG. **8**A, set adjacent to each other for framing a concrete structure on a wall of plywood planks, according to an embodiment. FIG. **9**B is a photograph that depicts the example set of four plastic forms from FIG. **8**A, set adjacent to each other for framing a concrete structure on a wall of plywood planks with simple side framing, according to an embodiment. FIG. **9**C is a photograph that depicts the example framing of FIG. **9**B after pouring concrete, according to an embodiment. FIG. **9**D is a photograph that depicts an example structure incorporating the example plastic forms of FIG. **9**A, according to an embodiment. This structure provides a vaulted ceiling for the room between the two plywood planks and a floor for a story above.

[0058] FIG. **10**A is a photograph that depicts the example structure of FIG. **9**D externally loaded with a bending stress of 10 pounds plus 7 ounces of a two by four, according to an embodiment. FIG. **10**B is a photograph that depicts the example structure of FIG. **9**D externally loaded with a bending stress of 20 pounds and then maintained for 7 weeks, according to an embodiment. No failure by the structure is indicated, suggesting that the tensile strength provided by the plastic frame suffices for a sustained external load of 3×20=60 pounds per square foot.

[0059] FIG. **10**C is a photograph that depicts the example structure of FIG. **9**D externally loaded with a bending stress of 50 pounds through 15 weeks after adding another 10 pounds for a total of 60 pounds, according to an embodiment. No failure by the structure is indicated, suggesting that the tensile strength provided by the plastic frame suffices for a sustained external load of at least 50×3=150 pounds per square foot and a temporary load of 3×60=180 pounds per square foot.

[0060] FIG. **10**D is a photograph that depicts the example structure of FIG. **9**D externally loaded with a bending stress of 60 pounds through 16 weeks after adding another 10 pounds for a total of 70 pounds, according to an embodiment. No failure by the structure is indicated, suggesting that the tensile strength provided by the plastic frame suffices for a sustained external load of at least 3×60=180 pounds per square foot and a temporary load of 3×70=210 pounds per square foot.

[0061] FIG. **10**E is a photograph that depicts the example structure of FIG. **9**D externally loaded with a bending stress of 70 pounds through 17 weeks after adding another 11 pounds (an 8 pound barbell and a 3 pound disk) for a total of 81 pounds, according to an embodiment. No failure by the structure is indicated, suggesting that the tensile strength provided by the plastic frame suffices for a sustained external load of at least 3×70=210 pounds per square foot and a temporary load of 3×81=243 pounds per square foot.

[0062] FIG. **10**F is a photograph that depicts a side view of the example structure of FIG. **9**D with 81 pounds at 17 weeks, according to an embodiment. A straight edge shows that there is very slight bending, as evident from the center of the structure being slightly closer to the straight edge than the legs of the structure.

[0063] After additional weight was added, the structure failed. The forms and concrete held 70 pounds securely with slight deformation. When the load was increased to 81 pounds, the form and concrete only held for a couple of hours before it collapsed. Support at 70 pounds translates to a load of 210 psf (10,054 n/m2); failure was at 81 pounds which translates to a load of 243 psf (11,635 n/m2).

Alternative, Enhancements and Modifications

[0064] In the foregoing specification, the invention has been described with reference to specific embodiments thereof. It will, however, be evident that various modifications and changes may be made thereto without departing from the broader spirit and scope of the invention. The specification and drawings are, accordingly, to be regarded in an illustrative rather than a restrictive sense. Throughout this specification and the claims, unless the context requires otherwise, the word "comprise" and its variations, such as "comprises" and "comprising," will be understood to imply the inclusion of a stated item, element or step or group of items, elements or steps but not the exclusion of any other item, element or step or group of items, elements or steps. Furthermore, the indefinite article "a" or "an" is meant to indicate one or more of the item, element or step modified by the article.

What is claimed is:

1. A building component system comprising:

a rigid plastic form having an arched shape in each of two perpendicular vertical planes and having a plurality of protrusions configured to engage concrete poured on top of the rigid plastic form; and

concrete poured on top of the form and cured to bind to the form at least at the plurality of protrusions, thereby forming an arched ceiling for a first story of a building and a flat roof or flat floor for a second story of a building, wherein the form is not removed and stays in place after the concrete cures.

2. The system of claim **1** wherein, when the form is placed on a flat surface, a space below the form is sufficient for use as a residence for humans or animals or equipment or some combination.

3. The system of claim **1** wherein the concrete is not reinforced with steel.

4. The system of claim **1** further comprising two or more temporary vertical forms disposed outside the rigid plastic form for providing an outer perimeter of the building component, wherein the temporary vertical forms are removed after the concrete is poured and cured.

5. The system of claim **1** wherein a plurality of the rigid plastic forms stack efficiently for transportation of the plurality of rigid plastic forms.

6. The system of claim **1** further comprising a mold configured to fabricate the rigid plastic form by injection molding.

7. The system of claim **1** wherein the arches are parabola shaped and designed to push the concrete to pure compression.

8. The system of claim **1** wherein the arches provide a great vertical extent so that the concrete is working more in compression and less reliant on the tensile strength of the form.

9. A method comprising:

placing a rigid plastic form having an arched shape in each of two perpendicular vertical planes and having a plurality of protrusions configured to engage concrete poured on top of the rigid plastic form;

placing two or more simple vertical forms outside the rigid plastic form for providing an outer perimeter of a building component;

pouring and curing concrete on top of the form to bind to the form at least at the plurality of protrusions; and

after the concrete cures removing the two or more simple vertical forms, thereby forming an arched ceiling for a first story of a building and a flat roof or flat floor for a second story of a building.

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