A building structure that is a one-piece extruded building that can simultaneously build inner and outer walls, roof, reinforcement and optionally even floors. Said structure is made up as a composite of an inner and outer encapsulating building material that provides structural strength, plus an inner core material composed of a highly expanding closed cell foam material for insulation. The building material is polymer based, but can also be a polymer-concrete, wherein traditional fibers are minimized and substituted for other aggregates. The polymer in the encapsulating material can have the catalyst encapsulated and premixed into a slurry form activated at the injection point by mechanically rupturing the capsule, or can be mixed and added at the injection point with a specially designed metering injectors. All corners and joints allow the encapsulating building material to join between inner/outer walls forming columns and evenly spaced beams or studs made from the same encapsulating building material. This system of construction can reduce the construction time to a matter of hours what would normally take days, weeks, or months according to the structure and is built by pumps while allowing for mass production and sizeable cost reductions.
FIG. 4C
DYNAMIC FLEXIBLE EXTRUDING BUILDING METHOD AND APPARATUS AND CONSTRUCTION MATERIAL USED THEREWITH

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a method and apparatus for building structures including residential and commercial structures using a dynamic flexible extrusion process and associated apparatus.

[0003] More particularly, the present invention relates to a dynamic extrusion process by which interior, exterior, bearing and non-bearing walls, floors and/or ceiling are constructed in one extrusion process using curable materials pumped into a mold designed for a desired extruded configuration or shape or extrude profile, where the model can follow a pre-determined course or a course varied on-the-fly. The invention also relates to a moving mold apparatus that permits an entire structure to be constructed onsite.

[0004] 2. Description of the Related Art

[0005] Recent disasters particularly in third world countries has prompted us to consider alternative and unconventional means of fabricating homes in a fast, expedient and cost effective manner. There are many different construction methods and materials that are in use around the world today. Every construction method has advantages and disadvantages. Even with new methods and very creative materials that have been used in construction for thousands of years in some cases, labor, time and cost makes home ownership unreachable for a majority.

[0006] Thus, there is a need in the art for a dynamic building method and apparatus for forming using curable polymeric materials, which allows the construction of relatively low cost housing.

SUMMARY OF THE INVENTION

[0007] The present invention provides affordable, low-cost houses, particularly for third world country constructions to make home ownership a realistic prospect, using a technology that allows complete structures to be built on site in a matter of hours or days rather than weeks or months.

[0008] The present invention provides a method including injecting a curable, filled polymeric material having an optional foam core, where the foam has an expansion factor of up to 50:1 directly into a mold to form structural elements or foam filled structural elements, where the materials are relatively inexpensive and can be handled using standard pumps and extrusion apparatuses, reducing construction costs by more than 50%.

[0009] The present invention also provides a method to build more complex structure such as community buildings or commercial buildings, where the method allows the simultaneous construction of inner and outer walls, roofs, reinforcing webs/beam and insulation. The method also allows for the formation of a smooth pleasing marble-like surface that requires no additional finish. Thus, an entire structure can be prepared in a single extrusion pass. Because the molds can be constructed to generate any shape including curved shapes such as a circular shape or semi-circular shapes by extruding along a curved pathway, unique buildings can be constructed. The method can also be used to generate clear or translucent section by injecting clear or translucent thermosetting polymers into the molds without the aggregate.

[0010] The present invention provides extruded building constructs comprising curable compositions that are primarily of petrochemical origin and possess cure rates that can be adjusted to achieve a desired construction rate. The compositions include a blend of polymers, a blend of various grades of sands or other fillers, a minor or limited amount of dry cement, fibers and/or small amounts of clay (preferably 2 to 3% by weight) or sand residuals. The compositions are a cost effective, alternative construction medium. The extruded constructs can also include a foam composition injected into interior hollow spaces or void volumes in structural elements such as walls, floors, roofs, etc. formed of the filled compositions to generate composite constructs having a desired stiffness and/or strength and/or a given insulation rating without significant weight increase. The structure extruded by this invention can have straight and/or curvilinear structural elements including, without limitation, walls (interior or exterior), ceilings, floors, steps, stairs, roofs, windows, door ways, door and window jams, skylights, or the like, where combinations of these structural elements can define rooms, porches, entry ways, seats, steps, or the like.

[0011] Because the constructs of this invention are prepared using filled polymeric compositions and/or composites, the constructs can better withstand hurricane force winds, are not as prone to rot, rust, mildew, or deterioration, are not as prone to burn like wood, and are affected to a lesser extent by flooding, earthquakes or other natural disasters. The constructs of the present invention are also relatively maintenance free. These combined characteristics should result in reduction in construction cost, maintenance costs and possibly insurance costs.

[0012] The present invention also provides an extruding apparatus that is transportable and easily assembled with reduced numbers of personnel, preferably the assembly can be handled by only two operators. The extruding apparatus of this invention is designed to follow a predetermined pathway or a dynamically changing pathway depending on the desired result. The ability of the apparatus to follow predetermined paths or dynamically changing paths, complex or simple, allows the construction of buildings or constructs having variable shaped and/or compound curved portions, which can further enhance the structural integrity of the resulting structure. The extrusion apparatus of this invention allows the construction of continuous single piece floors, walls, ceilings and/or roof. Although the apparatus of this invention can be used to generate the foundation, conventional slab type foundations can also be used if desired, provided that the convention slab include a plurality, preferably a relatively large plurality of anchoring members built into the slab at spaced apart intervals along the extrusion path. These anchoring members spaced along the extrusion path will act to anchor the extruded portion of the building to the convention slab part of the building. The conventional slab can also, and preferably does also, include various pumping and/or electrical facilities, which are positions so that they will be accessible after the extrusion of the remainder of the construct or building. Thus, the present
invention also provides composite building constructs where a portion of the construct is conventional and a second portion is made by the extrusion apparatus of this invention with proper anchoring of the extruded portion into the conventional portion.

[0013] The apparatus of this invention includes movable molds that are designed to form the desired construct shape through vertical, horizontal or mixed mode movement as the curable composition is being pumped into the molds. Movement is controlled at a rate to insure that the composition has cured sufficiently so that the curing composition has sufficient structural integrity to withstand the load of the composition as it is extruded on top of the curing composition for vertical moving molds or has sufficient structural integrity to reduce or eliminate sagging for horizontally moving molds. For molds that move in both the horizontal and vertical direction simultaneously, then the mold moves at a rate sufficiently slow to allow the curing composition to cure to a sufficient structural integrity to maintain its shape and accommodate the additional load of newly extruded portions. The molds can be stopped at any desired time or periodically so insure that curing is either complete or sufficiently complete to support the load of additional extruded parts. Additionally, support structures can follow the mold to increase structural conformity until the structure is fully cured.

[0014] The present invention provides an extrusion system including a mold including an injector manifold having a plurality of injectors evenly spaced along a length of the mold, a plurality of flexible skirts, a plurality of guide posts and a plurality of rigid W-shaped followers or mold guides designed to movably engage and follow the guide posts.

[0015] The present invention also provides an extrusion apparatus including conventional concrete pumps, mixing hoppers and hoses. The compositions used in this invention is made of material that are generally locally available and the petrochemical materials are generally delivered to the site in tanker trucks or rail cars. Because the molds are reusable, the extrusion system of this invention lends itself to mass production.

[0016] The present invention provides an extrusion method where void spaces are created so that an insulating foam can be injected into the void spaces during the curing process, in so doing the construct becomes one integral piece. Either by mechanical means or by preprogrammed automation, the extrusion apparatus can close off mold sections during the fluid injection process so that doorways, windows, and/or skylights can be built into the constructs at desired locations and heights. The extrusion apparatus also permits variable changes in the extruding faces so that thicknesses can be varied to accommodate in changes of slope, curvature and/or size in the structure.

[0017] This invention provides a building structure comprising a one-piece extruded seamless molded structure including a geometrically shape having a variable cross section, where the structure including floors, roofs, walls and reinforcement and some or all of the floors, roofs and/or walls comprise to outer layers comprising a cured, filled polymeric material and a foam core.

[0018] All of the building structure of this invention are designed to pass or exceed local building code regulations and laws related to residential and/or commercial buildings in accordance to the application.

[0019] The building material used in this invention can include fire retardants in either the structural materials, the foam material or both. The fire retardants suitable for use in this invention include brominated polystyrene or any other commercially available fire retardant.

[0020] Inner and outer wall materials are designed to have a thickness required to support the desired structure; the thickness of the structural wall sections will generally range between a quarter of an inch to four or more inches in thickness depending on the size of the structure and reinforcement required.

[0021] The inner and outer wall and/or roof layers will preferably include a reinforcing web at equally spaced intervals along the wall, where the webs the interval spacing and web thickness is sufficient impart a desired degree of reinforcement to the structure.

[0022] This building method is not restricted to a construct including two exterior layer compose of the filled polymeric composition and a foam core with equidistant reinforcing stud-like webs bridging between the exterior layers, but can be used to extrude single-layered wall, double-layered constructs without a foam core, or multi-layered constructs with or without foam cores in all void spaces. cored wall/roof.

[0023] When a larger project requiring more than two structural layers or skins is needed, the mold can be rotated by 90° and/or 45° while allowing the equidistant reinforcing web to be in a horizontal plane if the previous reinforcing web was in the vertical plane or as required by the type of reinforcement for the structure selected.

[0024] When the selected geometry of the extruded mold does not allow mold rotation by 90° or any other angle, then straight or curved reinforcing beams that conform to the geometric shape being extruded can be added as required and at desired angles to achieve a desired level of structural reinforcement. The beams can have the geometric cross section of an I-beam, a square, a rectangle, an oval, a circle, a triangle, a trapezoid or a variable combination shape in accordance to the architectural design pursued. The beam in can single or multiple-skin, have internal voids, have reinforcement webs, be gas filled, or foam cored in accordance to the structural requirements or application sought. The stud-like reinforcement webs or internal beams can be spaced closer together or increased in thickness where required, or if it is a small structure of limited support, be excluded all together after the addition of the inner foam core.

[0025] The structures including roof, walls, and floor having stud-like reinforcement webs or beams, the webs or beams can be built independent of the structure, continuously as a solid forming a single skin and/or simultaneous with the injection of the foam core within two or more skins or optionally externally foam sprayed if single skin.

[0026] For structures having no abutting edges, the structures can include a reinforcement beam wherever there is a directional change in the wall or the existence of a floor member for added support.

[0027] For structure including windows, doors, and/or skylights, the inner and outer wall layers can be joined together around the foam core to create a reinforced frame
around the windows, doors, and/or skylights. The walls and roof can be discontinuous with an overhang of variable length or can be continuous and curved forming a unitized structure with a flat, angled or dome shaped roof, wherein the outer geometric shape of the structure can be square, circular, oval or a combination. The floor members made using the extrusion apparatus of this invention can be a solid continuous piece with external or internal reinforcement beams or can incorporate rebar, a steel or synthetic mesh, or any other conventional reinforcement technique known in the art. Floors of this invention can incorporate foam core areas for insulation and/or lightening of floor members. If the later structure/foam hybrid approach is used, a series of pertinent reinforcing webs or beams will be integrated to conform to the required support in accordance to local building codes.

[0028] For structure of this invention incorporating conventional slabs or foundations, the convention slabs or foundations will anchoring members imbedded within the slab or foundation and protruding above the surface of the slab or foundation; the walls built over the anchoring members will encapsulate same by allowing inner/outer walls to bridge initially over the rebar till completely covered with the building material, therein after initiating the wall separations to allow space for the core material. The anchoring members can be located in a groove which follows the contour of all wall section to be extruded to increase wall anchoring. The groove can also include spaces into which the extrudate can flow to further increase structural anchoring.

[0029] The core material used can be of a variety of foam materials, but with preference be a polyurethane closed cell material or PVC foam, due to insulating and watertight qualities.

[0030] The foam core material can have a chemical added will further increase the structural stability by introducing it into the two-part injection stream that upon curing can crystallize to form an internal structure within the foam.

[0031] The foam core material wherein an open mesh of varied thickness and rigidity is put in place prior to foaming process wherein after curing becomes an integral part of the foam core while increasing the rigidity of same.

[0032] The structural composition that forms the exterior walls, roof and floors composed of ingredients comprising: a binding agent that can be a polymer, a cement-polymer, or a concrete-polymer hybrid. The structural composition can also include additives that such as: vinyl ester resins, latex resin, acrylic resin, or calcium aluminates; that control the characteristics of the concrete. The structural composition can comprise a polymer based material that can contain: a rigid unsaturated thermosetting polymers, epoxy resins, or transparent castable acrylic resins and additives like adipic acid or diethylene glycol to add flexibility and styrene for greater flow characteristics. The structural composition can also include dry Portland cement is added as an aggregate into the unsaturated thermosetting polyester/epoxy resin, therein forming a polymer-cement. The structural composition can also include aggregates and fillers are added, such as: silica sand fine grade in the range of 250 micron to about 25% of composition, medium grade in the range of 500 micron to about 30%, coarse grade in the range of 1000 micron to about 25%, or any combination thereof. The structural composition can include, depending on cost and the availability, recycled plastics; these can be ground and substitute as much as 50% of the fine/medium/coarse silica sand, for environmental or land fill reduction purposes. The structural composition can also include barium sulfate or other inexpensive filler materials that will not weaken the structural integrity when cured, that have inert characteristics and do not slow down the curing process can be used in a range of 10 to 15%. The structural composition can also include fibers are added for the structural integrity of the material, such as: fiberglass, polypropylene, polyester, nylon, dynel, flex, cotton, or a similar fibrous material and/or metal wire up to about 5%. The structural composition can also include a catalyst such as an amonatory or titanium based catalyst or peroxide catalyst optionally solvents such as methyl ethyl ketone can be added used in the prescribed amount or similar to trigger the curing process. The structural composition can also include a pigment is added in the desired color and shade and dispersed through out the encapsulating building material.

[0033] The extruded material will have a smooth, hard and durable surface that is mildew free and washable. Small specs of the silica sand will be randomly visible close to the surface of the pigmented material that gives it a marble-like finish and texture that requires no additional treatment, painting or maintenance.

[0034] The catalyst used to cure the extrudate can be micro-encapsulated, where the capsules can be ruptured by mechanical means and in this form be totally and homogeneously dispersed into the structural composition. Rupture of the encapsulated catalyst can occur at the injection nozzle when pumped into the mold to initiate the curing process or these capsules can be ruptured by ultrasonic or other mechanical means after injection.

[0035] The catalyst can also be separately containizeed from the polymer slurry and added via a metered mixing nozzle at the mold injection point. When separate catalyst injection is used, the flow of the material is measured by a rotary wheel turned by the flowing slurry in the hose that is geared to a slow moving pump proportionally injecting the catalyst just before entering into the mold. The injection points are distributes to inner, middle and outer parts of the mold to increase catalyst dispersion and improve curing of the structural composition. Moreover, when using separate catalyst injection, it is preferable to include a static mixer to help disperse the catalyst into the composition at each catalyst injection point. The mixers are removable for cleaning. The static mixers preferably include flat edged propellers that fit into the pipe internal diameter allowing an intermittent rotating and counter rotating motion of the slurry to make a homogeneous mixture with the catalyst prior to mold entry.

[0036] The apparatus and methods of this invention can be used to construct houses, warehouses, tanks, containers, refrigerated structures, parabolic dishes, planetariums, pontoons and other structures that can take advantage of the curved seamless construction, cost reduction, structural characteristics, speed and insulation of the building method.

[0037] When the structure is built with a foam core, as a composite, with an adequate reinforcement web, it can be built not only hurricane proof, but flood proof, termite proof, rot proof, be fire resistant, and with the appropriate inhibitors mildew and bug proof.
The proposed building material can be completely void of all aggregate materials and fibers for transparency or translucency and have the geometry and structural reinforcement described in the previous claims. Thickness and webs of the building material will be compensated for when aggregates and fibers are devoid from the material for transparency or translucency purposes in order to achieve the required structural reinforcements. When the transparent/translucent building material is used, no foam core will be injected in double or multiple-skin structure. Insulation of the transparent/translucent building material can be achieved by the following procedures: the void between the skins can be partially vacuumed; the void between the skins can be gas-filled with a thermal insulator; and/or the void between the skins can be liquid or gel filled with a material with a glycol-coolant type material.

When the structure is built as a single skin, whether transparent/translucent or with the above described aggregates, it can still have a reinforcement web simultaneously extruded internally, externally or both to give it sufficient rigidity for extended spans. If the translucent building material has simply air entrapped within the skins, care will be taken that it is properly dry to avoid internal condensation.

A translucent colored pigment can be added to the material for shading, UV ray reduction, setting the mood or decor of the structure. A photosensitive material can be added outer skin of the transparent material such as silver chloride or silver bromide crystals that darken the skin when exposed to direct sunlight. When a liquid or gel is used to fill a void between two or skins, photosensitive material can be added to the fluid. The translucent/clear material will thus be able to be configured into green houses, solar rooms, pool covered rooms, stadium domes, entire building outer walls, following a flat face or variable self-supporting geometric shapes.

The above building materials can be built in a combination of aggregate composite reinforced material as well as with translucent/clear sections in a variety of geometric shapes and compound curves in accordance to the architectural theme sought. When the combination of composite and translucent/clear sections as in the previous claim, the translucent/clear sections will serve as skylights, windows, storefronts, exhibition windows, to the extent that the entire structure can be completely translucent/transparent, or totally covered with the aggregate pigmented material in varied colors added as the extrusion proceeds in accordance to the theme pursued.

The present invention provides a mold extrusion apparatus comprising a skirt made of Teflon or Polyethylene of a height and predetermined shape that retains the injected building material long enough to permit it to solidify before exiting the mold, while new material is pumped slowly behind it in a continuous manner; injection nozzles selected are determined the type of catalyst injection mood, if it is micro-encapsulated and premixed into the slurry a mechanical rupturing procedure such as an ultrasonic nozzle for a sonic sensitive capsule, the second procedure is when the catalyst is separate and added through a metered nozzle dependent on hose flow quantity which controls the catalyst injection pump and delivered to a static mixer; static mixer is used when catalyst is added separately at the injection point, as defined above; guide-path beams preformed to the predetermined mold shape and pathway; a hose array has a main hose delivering building material to a distribution manifold into a series of smaller hoses which are equidistant and pressure sensitive to the guide-path followed by the mold; two or three main hoses with their respective manifold and small hose may be used for controlled sequential building of parts of the structure; a concrete pump equipment used according to job as requirement; a rotating mixer used according to capacity required. The extrusion skirts can be straight or curved and have the ability to flex and form compound curves. The skirts can be of variable shape, having the ability to operate not only in the horizontal position but also in the vertical position and anywhere in between in accordance to the construction design. Two or more extrusion skirts can be operated in two or more directions such as in the vertical direction and horizontal direction leave their respective geometric signatures, simultaneously or sequentially in such a manner that neither interferes in their respective pathways.

When the mold is following a horizontal pathway or any direction other than vertical, due to gravitational forces a braking system will be used to main a positive and perpendicular to pathway back pressure on the mold to maintain a full-fill condition before the gradual advancement of the mold by way of pressure gauges on the tops of the mold which activates forward motion when pressure is maintained in programmed range.

The mold extrusion apparatus can include non-stick extrusion surfaces, which allow resin and combination slurry to slide while curing into the variable cross-sectional shape of the mold. The mold extrusion apparatus is able to create fixed to variable void to allow the injection of foam material immediately upon curing to create a composite structure. The mold extrusion apparatus permits insulation and outer wall/roof material to come together equidistantly to form rigid columns, studs and beams of any size to the required structural engineering specifications to conform with local building codes in accordance to the intended use of the structure. The mold extrusion apparatus can follow a predetermined pathway in a preformed guide-path that mechanically controls the extrusion advancement or by electronic motors that can be speeded up or slowed down, while at the same time the hydraulic pressure of the pumped material can push forward the mold in a vertical horizontal or any pre-selected angle. The mold extrusion apparatus can be automated so that all the features of the structure can be preprogrammed such as: injection rates, over pressure sensors that switch injectors off when a section of the mold is full, directional changes at predetermined distances. The mold extrusion apparatus can include sections of the extruded mold can be turned off or on while allowing inner and outer wall material to intersect at predetermined distances such as in doorways, windows, skylights, or other. The means by which these openings are created can be by mechanical means or by preprogrammed automation.

To allow the proper distribution of the encapsulating building material several main hoses coming from the pump will control the sequential building of sections of the building in complex structures, a simple structure will require a single hose. The main hoses distribute the pumped material into smaller sectional hoses that are of equal length from distributor of the main hose, since the material will migrate to the point of least resistance such as when fol-
lowing a guided compound curve, the area requiring the greatest advance will fill generously because it is less restricted while the latter will fill slowly.

[0046] In order to secure a homogenous and smooth surface the material will be pumped continuously without interruption until completion of the structure, certain sections can be sped up or slowed down to impede sectional mold interference with one another. For sections of the construction that require a receding or lengthening of the mold, no webbing or beams will be placed in this area and a sliding Teflon or Polyethylene end-piece with the matching cross-section of the mold will be able to slide inward or outward perpendicularly or in a variable angle wherein outer rollers assist in maintaining the sectional shape while following a defined pathway and easing in the movement of the end-piece.

DESCRIPTION OF THE DRAWINGS

[0047] The invention can be better understood with reference to the following detailed description together with the appended illustrative drawings in which like elements are numbered the same:

[0048] FIG. 1A depicts an embodiment of a Low-income Housing Unit of this invention;
[0049] FIG. 1B depicts an embodiment of a first floor plan of the unit of the FIG. 1A;
[0050] FIG. 1C depicts an embodiment of the unit of the Figure 1A having a partial second floor plan;
[0051] Figure 1D depicts another embodiment of a first floor plan of the unit of the FIG. 1A;
[0052] FIG. 2A depicts an embodiment of a mold of this invention for extruding the floor plan of Figure 1B;
[0053] FIG. 2B depicts an embodiment of guide posts for use in the mold of FIG. 2A;
[0054] FIG. 3A depicts a top view of an embodiment of a mold of this invention;
[0055] FIG. 3B depicts an end view of the mold of FIG. 3A;
[0056] FIG. 3B depicts a top view of another embodiment of mold of this invention;
[0057] FIG. 3C depicts an end view of the mold of FIG. 3B;
[0058] FIGS. 4A and B depict another embodiment of a follower assembly of this invention;
[0059] FIGS. 4C depict another embodiment of a follower assembly of this invention;
[0060] FIG. 5A depicts a top view of an embodiment of a mold of this invention for producing a composite wall with web reinforcement;
[0061] FIG. 5B depicts an end view of the mold of FIG. 5A;
[0062] FIGS. 6A-C depict an embodiment of a mold end for increasing and decreasing a cross-sectional profile of an extruded structure;
[0063] FIG. 6D-F depicts an embodiment of a telescoping mold end of this invention for increasing and decreasing a cross-sectional profile of an extruded structure;
[0064] FIG. 7A depicts a top view of a cross-section of an extruded structure for the floor plan to FIG. 11D showing the composite wall construction with spaced webs;
[0065] FIG. 7B depicts an expanded view of the wall section of FIG. 7A showing a web;
[0066] FIG. 7C depicts a conventional slab having anchoring members for anchoring the extruded walls of FIG. 7A;
[0067] FIG. 7D depicts an expanded front cross-sectional view of the anchoring members of FIG. 7C;
[0068] FIG. 7E depicts an expanded side cross-sectional view of the anchoring member of FIG. 7C;
[0069] FIGS. 8A-E depicts an embodiment of a mold of this invention having a section designed for forming an opening in the continuous extrudate and its use in making an opening;
[0070] FIG. 8F-I depicts another embodiment of a mold of this invention having a section designed for forming an opening in the continuous extrudate and its use in making an opening;
[0071] FIG. 9A-D depicts embodiments of more traditional rectangular buildings that can be extruded using the extrusion apparatus of this invention;
[0072] FIG. 10A-D depicts embodiments of varied mold layouts for extruding constructs for this invention;
[0073] FIG. 11 depicts an open seating stand which can be extruded using a mold of this invention that pivots about a central axis; and
[0074] FIG. 12 depicts a stadium which can be extruded using a mold of this invention that pivots about a central axis.

DETAILED DESCRIPTION OF THE INVENTION

[0075] The inventor has found that complete structures, residential or commercial, can be built in place in a short time frame, hours or days, using a curable polymer-based composition extruded from a moving mold apparatus and/or system capable of producing a part or an entire structure as the mold moves along a predetermined or dynamically changing path. The inventor has found a moving mold, extrusion apparatus and/or system can produce simple and complex configuration such as compound curves taking advantage of the high strength inherent in the curable polymer-based composition to deliver more rigid structures that require less reinforcement. The inventor has also found that by injecting a foam into void spaces created curing the extrusion process, walls, roof and even the floors to form insulating composite structures, which deliver improved strength, insulation and reduce the overall material structural requirements. The inventor has also found that the present system can potentially reduce the amount of wasted materials needing disposal at landfills, because the cured polymer-based compositions can be ground and recycled. Using the extrusion system of this invention, the inventor believes
that a reduction in construction costs of up to fifty percent (50%) are achievable, while at the same time increasing livable space by at least twenty five percent (25%). The present invention can be used to produce walls, ceilings, roofs and/or floors with or without an insulation rating of 30R or higher. The insulation is achieved when the walls, ceilings, roofs and/or floors include approximately four inches or more for larger structures of closed cell foam core.

[0076] In one preferred embodiment of a residential building constructed using the extrusion system of this invention, the building incorporates innovative architecture having integrated low self-Page opening vents and a central vaulted air pathway creating a passive cooling system. Integral indoor/outdoor areas with ceiling having openings further enhance the lighting and livability, creating an indoor atrium for the low-income home that transforms it into a moderately luxurious house without the added cost.

[0077] The present extrusion system results in cost savings through a reduction in labor. The present extrusion system require mainly pumps for pumping the material into the moving mold assembly of this extrusion system. Further savings are achieved in transportation where bulk material is used such as a bulk foam having an expansion coefficient of up to 50:1. Thus, rather than transporting 50 units of pre-made foam material such as in prefabricated materials, just one unit of the foam forming material need be transported. Since the foam material remains in a liquid state until it is injected into the moving molds of this invention, a large quantity of the unset foam can be transported on a tanker truck for the mass production of several dwellings at a time.

[0078] A significant degree of automation can increase the productivity and precision of this extrusion method. Useful automation that can be incorporated into the extrusion system of this invention includes pressure sensing devices, proximity sensors, and metering devices that can be tied into a programmed field computer. The moving mold apparatuses of this invention are light and assembly and re-assembly is simple enough to be handled by a two-man team. After mold assembly, hoses are attached to the reservoirs containing the structural composite building material and to the reservoirs containing the foam precursor and to the mold injector system. Once everything is in place, an entire building such as a low-income home can be extruded in a matter of hours. Upon completing one building, structure or construct, the entire extrusion system can be disassembled and transported to another location and the process repeated one or more times a day.

[0079] A structure made using the extrusion system of this invention and the polymeric building materials of this invention are expected to result in structures having a third the weight of structure made of conventional building materials, because the entire structure is lighter than traditional structures especially the foam filled structures. Additional cost savings can be achieved, by using locally available sand and/or filler materials and/or fibers. Other materials are petrochemical in origin and can be purchased in bulk liquid form, which can be loaded into tank trucks and transported to the job site.

[0080] By substituting a fast curing petrochemical based resin building composition for concrete, buildings can be built rapidly with thinner walls and when combined with the compound curves, rigid self supporting walls that do not require a core material can be constructed.

[0081] By micro encapsulating the catalysts used in the curable polymer-based system, the onset of cure can be delayed until needed, such as when entering the mold or after being in the mold for a given period of time. Because the catalyst is not released until the capsules rupture, the capsules can be ruptured either using an ultrasonic nozzle, ultrasonic vibrators or other mechanical means that can rupture a micro capsule, depending on the selected capsule characteristics. Alternately, the catalyst can be maintained separately from the slurry and added at the mold injection point via a metering and mixing device. The metering device can be controlled by a system of paddle wheels that rotate to quantify the amount of slurry flowing through the device; the wheels are attached to an external shaft that proportionally rotates a small injection pump containing the catalyst. The metered catalyst is injected downstream from the slurry injectors through small tubes pointing in the direction of slurry flow. Preferably, the catalyst injectors are located in an outer, middle and/or center section of the mold, while the slurry is being pumped into the mold at its top. Preferably, immediately after the catalyst injectors, the mold would include a static mixer having fixed blades in a rotating and counter rotating direction so that the catalyst can be homogeneously dispersion into the polymeric composition at the points of injection point. The mixers are detachable and replaceable should gelling occur within the static mixer so that the mixers can be periodically cleaned, purged with air or solvent or replace.

[0082] The filled, polymer-based building material used in this invention has better tensile strength, better compressive strength and superior flex fatigue properties than Portland cement, an industry standard. In fact, the filled, polymer-based composition, after curing, can have as much as five times greater tensile strength, bonding strength and compressive strength than Portland cement. Thus, in practice a fifth of the equivalent material is required to approximate the values of an equivalent cement structure without the additional load. Flexure is not readily attainable using cement, but is significant in the building material of this invention. The shear strength of this material is at least fifty times that of Portland cement; this feature can be further enhanced by the extruding wall segments having compound curves. When walls are constructed having two layers of filled polymer-based material sandwiching a foam core to form a composite having a foam core interior approximately four times thicker than the two filled polymer layers having a stiffness as much as thirty-seven times greater than a single skin only, the strength is ten times stronger than a single skin only, with an overall increase in weight of about six percent. These properties allow constructs using the foam filled wall construction of this invention to easily achieve laboratory verification that the structure is substantially hurricane proof. Thus, buildings made using the extrusion system of this invention and the foam filled composite walls of this invention become a viable alternative in areas where a hurricane threat is possible. Moreover, by incorporating complex curved walls, wind resistance can be reduced by as much as 50%.

[0083] The compositions used to make all exterior surfaces are substantially water resistant or waterproof, because nothing in the composition is prone to rot, deteriorate, or corrode, except possibly for urethane foam used in the interior of walls. Thus, water damage due to flooding or heavy rains should be negligible. Termites and/or fungus do
not affect the compositions and the surface is highly washable. When this polymer material is used to construct the floor, the floor can be a colored as desired using pigments and/or patterned as desired to produce a substantially waterproof floor. Plexiglas sliding doors, sealed wiring and outlets can be used to further resist flood damage. Even if the structure components such as floors, walls or ceilings are cracked by flood debris, the inside closed cell foam will reduce the migration or seeping of water through the remainder of the structure.

[0084] Fire hazards are diminished using the materials of this invention, because the composition are difficult to burn. Moreover, the structural material (the filled polymer composition) and/or the foam can include fire retardants that impede them from burning. If a fire does occur, it could cause localized melting or partial melting of the material and the core, which can be repaired without too much difficulty.

[0085] Because of the flexure modulus of the structural building material of this invention that can be as high as 4,000 psi, the resulting structure becomes much less susceptible to damage from earthquakes and may in fact be substantially earthquake proof. The foam core of the composite walls of this invention acts as an absorbent, when the walls are exposed to shock wave in tectonic shifts, increasing the structures resistance to earth movement. Cyclic vibration is also mitigated, avoiding the crack propagation that would be expected in concrete structures. These characteristics of the buildings or structures made using the extrusion system and compositions of this invention should result in reduced insurance premiums.

[0086] The proposed extrusion device includes a closed top having injector ports therethrough, an an opened bottom and a plurality of skirts defining the final shape of the extrudate. The area into which the filled polymer composition is pumped is preferably made of or coated with a non-sticking skirt material, such as Teflon, polyethylene, polypropylene or similar materials or mixtures or combinations thereof having adequate thickness to provide rigidity or thin enough to allow the mold to moderately flex when the mold assembly is following a curved pathway. The skirts can be constructed of any material that provides for sufficient flex of the skirts so that the mold assembly can generate walls and/or ceiling having complex horizontal and/or vertical curved surfaces. When a thin skirt material is used, skirt support structures such as support rings can be added in the mid and/or lower sections of the mold assembly to support the skirt. The support structures are preferably attached to tracking assemblies such as rollers secured to the guide posts. The support structures are designed to maintain a skirt separation at a substantially constant amount so that the extrudate has a substantially constant cross-section regardless of the path being followed. When windows or doors are to be formed during the extrusion process, the mold assembly includes segments which can be manually or automatically opened or closed to start or stop material being pumped into desired mold sections. Preferably, the mold assembly is segmented so that reinforcing webs can be simultaneously extruded as the mold assembly progress along its path. Additionally, it is preferred that windows and doors be formed between webs to increase structural stability around the windows and doors and so that the webs form the door/window jams. Alternatively, the composition being pumped into a given section can be changed from the structural composition to a clear composition such as polycarbonate or the like forming windows in situ by substitution of the filled composition with an aggregate-free composition.

[0087] The molds used to make one the preferred low-income house structures of this invention has a degree of design complexity that requires a sequential mold building technique. When there are sections that require the mold to lengthen or shorten during extrusion such as extruding a pyramidal roof where the extrudate has a continually reducing cross-sectional area, one end of the mold is designed to slide either perpendicularly or in a variable angle. This section of the mold will be void of internal webs that interfere with the pathway of this sliding cross-section. Alternatively, the external beams can be added where deemed necessary. Rollers and guides on the exterior of this sliding section will assist in the movement of this section while holding it in the desired positions. This moveable piece will be made of the same material either Teflon or Polyethylene but thicker to increase its rigidity.

[0088] The extrusion apparatus of this invention is generally of a relatively short height. For normal type buildings, the apparatus generally is three feet or less in height with one foot being a practical minimum. For very large structure, extrusion apparatus having a larger height is contemplated. The extrusion system of this invention is designed to allow the filled, curable polymer-based composition to enter the top of the mold via evenly spaced injection nozzles or injectors. The injection system allows the composition to settle evenly to the bottom of the mold. In one preferred embodiment, the outer skirt are a few inches longer than the inner skirts, when double or multiple skirts molds are used, to allow the composition to be embed anchoring structure protruding from the foundation such as rebar loop, staples or pins protruding from the concrete of a conventional foundation cemented protruding rebar to initially anchor the walls. A soft pliable sealing material can be attached to the ends of the skirts to form a leak proof seal between the foundation and the outer skirts to keep the building material from seeping out while in the liquid phase. After the first few inches of material begins to set, the material will be confined into the region between an inner and an outer skirt creating a thin first wall and second wall separated by a 2” to 8” into which foam can be injected to form a foam filled wall, ceiling or floor structure or a thin single skin that increases in height the mold is advance along the path defined by the guide post and as more material is added.

[0089] The building composition of this invention is continuous injected or pumped into the mold at a rate sufficient to produce an upward or forward direction hydrostatic force to help advance the mold along the defined path. Depending on the weight of the mold, this forward motion can be assisted by mechanical or electrical motors activated by pressure sensors that work within a preset range on the top of the molds. The anticipated cure time of the composition is generally in the range between 10 and 15 minutes, once the composition has been injected into the mold and exposed to the catalyst either through individual metering and mixing of the catalyst in composition or by rupturing the capsules of an encapsulated catalyst. The mold is designed to hold the composition in a constant shape within the mold long enough to allow the building composition to cure to the point that it can holds its shape when exiting the mold. Because
the mold is slowly, but continuously moving as new material is injected into the mold, the skirts will also be in constant motion further reducing the prospect of composition sticking to the skirt surfaces; while at the same time, the skirts create an exterior surface which can be pigmented and is slightly textured due to the aggregate. Additionally, small amount of an oil such as vegetable oils or the like can be added to the composition to further reduce molding sticking. The degree of texturing will depend on the relative dimension of the aggregate or fillers used in the composition. Small vibrators positioned in the extruding apparatus can also assist composition settling and reduce mold sticking.

[0090] Although our primary goal of the extrusion apparatus of this invention is the construction of low-income housing, this system has a variety of other residential applications as well as recreational, commercial, industrial and marine applications as well. Due to the ability of this invention to form large reinforced compound curves structures, the invention can be used to construct domes in stadiums, planetariums, parabolic dishes, walls and chemical tanks, pontoons and barges, floating bridges, yachts and ships, refrigerated structures, free form buildings in a variety of geometric shapes or the like. Docks and pilings can be constructed using the present invention to produce relatively non-corrosive structures due to the nature the structural materials used.

[0091] The molds are not restricted to following a vertical path, but can be operated to follow a horizontal path or a compound path include vertical and horizontal components. Some designs may require a combination of vertical and horizontal extruding molds that can slowing change direction forming a variable angle creating unique shapes. When the mold operates in a direction other than the vertical direction, a braking system is generally required to hold a continuous uniform pressure over the entire liquid material being injected into the mold. The braking system is typically activated by pressure sensitive controls in the highest position of the mold or is activated manually. To keep the catalyzed material from flowing back into their holes, back pressure valve are generally needed in molds following a non-vertical path.

[0092] An exciting breakthrough of this invention is the use of the above technology to create an onsite extruded polymer glass that may hereinafter be dubbed as “synthetic glass.” Synthetic glass is achievable by stopping the injection of the filled composition and injection a transparent thermosetting resin, which can be epoxy, acrylic, carbonate or a similar polymeric material. Besides forming a completely transparent extrudate, colored extrudates and well as translucent extrudates can be formed using pigments to reduce light or color the light. Moreover, UV blockers can be added to reduce or block UV rays. Non-translucent pigments can be added that allow brightness to penetrate according to a color theme, or simply white overhead to minimize lighting needs. By adding silver chloride or silver bromide crystals to the extrudate preferably in the exterior skin, the extrudate will become photosensitive, darkening when exposed to direct sunlight and lightening when not exposed to direct sunlight.

[0093] The synthetic glass can be built in the above extruding manner, while compensating for the required thickness for a given rigidity. The structural webs or beams can be extruded in the same manner and made of the same material having a straight or curved profile. The extruded synthetic glass can be single or multiple skinned or panel as described above for making the composite wall construct with a hollow or foamed filled interior. Of course, for transparency, these constructs would not be foam filled. The proposed synthetic glass can be structurally very strong and used for completely transparent buildings; although the primary focus is windows or skylights formed as the filled composition walls and roofs are made. Used in this combined manner a synthesis of emerging modern structures unbound by geometric restrictions is now a reality.

[0094] When the synthetic glass is used in a single skin extrusion format, external and internal reinforcing webs can be used. Multiple skins with their respective webbing is preferred when large expanses of this synthetic glass is required such as in stadium dome or spherical buildings. Whenever a large symmetrical shape is extruded in a curved vertical direction, a horizontal extrusion mold following the same geometric shape can be built on top/under allowing extruded beams/webss to crisscross for even stronger structures. In many cases structures with this geometric shape needs the mold to be simply rotated 90° and build over/under.

[0095] Insulating/soundproofing properties of a translucent nature can be added to these double or multiple skin constructs. This can be achieved by pulling a moderate vacuum in void spaces, by filling the void spaces with an insulating gas, or filling the void spaces with a liquid such as water, oil, or the like or a gel or the like. Dyes can be added to the gas, liquid or gel to match a mood, architectural effects or shading. Moreover, UV absorbers or blocks can be added as well. A viscous fluid or gel containing silver chloride or silver bromide crystals or similar be in suspension can be added for photosynthesis.

[0096] Many traditionally buildings with concrete flooring can be faced with this synthetic glass. The example for simplicity could be in the vertical/horizontal plane not only flat surfaces but can now include curved synthetic glass in sections that follow the floor contours. It is now possible for traditionally built concrete floor buildings that have edges with free-form curves to have glass that follows not only in a vertical plane but also in a horizontal plane or any angle in between. These curves can have pathways that steadily increasing/decreasing in compound curvatures or change directions and take on up to now unimaginable shapes, that are not only functional but have a true artistic/sculptural inspiration for the architects of the new millennium. Practical mold vertical extrusion profiles can be made to rotate into/out of a circular pathway of a small or large radius and build for example a small stadium, amphitheater, church, restaurant, convention center, social building. The profile of said building can have a grade that includes extruded step/seats with back supports, stage, railings, building supports, extruded in one single concentric pass. The design can be such that is saucer shaped while leaving a circular opening on the roof which can be covered/uncovered with synthetic curved glass depending on the intended use. The design can be a complete closed circle or partially open with a different pattern that includes flat or semi-circular stage area, that can also be attached to a conventional building.
Rebar Replacement Materials

[0097] Structural chemical reinforcing material can be added into the polyester/sand slurry while mixing. As previously described, the metered catalyst is added at the mold injection point, or micro-encapsulated into the slurry and ruptured by mechanical means such as an ultrasonic nozzle at the mold injection point. The heat generated by the catalyst process triggers the crystallization of the chemical structural reinforcing material throughout, acting as a liquid rebar that is not localized but dispersed, creating a continuous strand, double bond structure within the building material. Several materials considered vary in ratios of 1% to 20% of the polyester resin portion depending on structural requirements, these are listed, but not limited to, as follows: Benzene diethylene; Methyl Methacrylene; Ethyl Methacrylene; or the like; or mixture or combinations thereof.

[0098] Should structural strength of the construction material become a secondary objective a homogeneously mixed volume enhancing foam material based on a two component system, but not limited to, shall be used wherein one of the components shall be micro-encapsulated and ruptured by the injector.

[0099] A short vortex mixer ensures that the dispersed ruptured foam component comes in contact with the other component to initiate expansion. Foams generally require that they be preheated, but the heat of catalysis causes an adequate expansion sought based on the premixed volume. The foam allows the selected layer to be thicker, and of a predetermined thickness, acting as a continuous beam to separate outer layers that have structural additives. The selected foam additive can be a variety of foams, of an open or closed cell variety, giving the target layer selective characteristics, be these porosity, shock absorbency, sound controlling, thermal or vibration mitigating.

Multi-stage Expandable Molds

[0100] A full size mold of the selected shapes, structure, sculpture or casing is built, wherein the internal surface is of a non-sticking material such as, but not limited to: Teflon, polyethylene, polypropylene, wax, or similar that can be glued, spayed or applied by hand to a supporting structure that retains the target shape; where required additional non-stick agents are added to materials. The mold is designed to be able to shift from a primary, to a secondary, to a tertiary position, or as required, wherein various different types of materials can be injected in each stage, while retaining the initial shape of the mold.

[0101] This apparatus can be used to generate only an external surface, wherein a foam or shaping material is injected initially and outer layers of varied thickness are added, or have an inner and outer moveable surfaces, that an also have additional secondary mold components, such as for example exterior walls and interior walls or extensions.

[0102] A subset mold can insert a component in a given layer; subsequent materials layering can be turn on/off in the insert section, such as, a window, porthole, reinforcement rib or subassembly. Internal or external mold surfaces can be exchanged/substituted at any given moment, that have a variety of surface signatures to create: brick, tile/roof, wood, stucco, granular/smooth, or other pattern simulation, with the corresponding pigmentation or additives.

[0103] The molds are designed to have the capability or gradually flexing in each position increasing greater/lesser as required, with self-supporting reinforcement that hinges on the designed axis to permit such flexing.

[0104] Certain joints may be flat or curved along the expansion route of the mold and can have impervious hermetic seals along said pathway to keep the selected injection material from seeping from mold. Prior to any selected stage of injection, selected joints can be opened to introduce wiring, optics, antennas, ducts/vents, piping, electronics, mechanical devices, coils, or whatever device is needed for the intended application of the mold, thus embedding it into said layer. These molds permit multiple layering of materials that can be structural, insulating, supporting, multiple skinned, shock absorbent, thermal, load distributing, radiant, flowing, cellular, spongy, ornamental, or as required by the application sought.

[0105] Where flexibility is required, an elastic foam matrix can be injected into the first stage with subsequent blastomeric encapsulating compounds, which can be of a rubber or polymer base, woven layers of material can also be added for more strength. Prior to pumping a slurry of material into a void created by the expanding of the mold, fibrous strands of un-impregnated material such as fiber-glass, carbon fiber, Kevlar, Dynel, polypropylene, nylon, cotton, or other, can be blown/vacuumed into the openings; the fibrous strands is then be embedded or encapsulated by the slurry when the slurry is pumped into the openings.

[0106] The internal or external mold surface or both, can be moved to allow hand or machine placement of a variety of woven cut materials similar to above, but can also be pre-impregnated and activated by catalyzed heat, sprayed with an adhesive and of an open weave to conform to compound curves, where surfaces are reactivated prior to injection of material slurries. Other pulverized/granulated inorganic materials can be added to the polymer/cement slurry such as: ceramics, metals, carbon, ores, clays, barites, cements, chemicals, or minerals, recycled plastics/foams, grounded rubber/tires, to enhance the characteristics sought in the project. Ground recycled organic materials can also be added, such wood or vegetable fibers, sugar cane stalk, cotton seeds, shells, or other agricultural byproducts that might otherwise be burned or en up in a landfill.

[0107] The intended applications, although not limited to are: civil construction, such as housing, commercial buildings, domes, storage, refrigeration; boat and yacht construction, sectional parts and components, aircraft fuselages, automobile bodies, truck bodies, hybrid vehicles, casings, containers, beams/columns, statues, sculptures, ornamentals, shafts, piping, tunnels, other.

[0108] These molds are designed to be stationary or mobile to permit onsite construction, to reduce transportation cost of raw materials, particularly if some of these are foam based, to eliminate large prefab transports. Injection points on the above multi-stage mold can be dispersed throughout mold, but depending on characteristics of the injection material such as density, expandability and such, can be made to fill starting at all injection points simultaneously, at selected injection points, or from the bottom of the mold upward. Metering injectors can be used at the mold injection point to add catalysts, or if micro-encapsulated catalyst is premixed into the slurry, the reactor are of a type...
that rupture the capsules at the mold injection point, depending on the capsule characteristic selected. Non-return valves can be used at injector locations, the top section of the mold preferably includes adequate vents to eliminate air pockets with localized sensors to detect full condition, thus stopping the pumping process. The injectors can be traditional pump type injectors or screw extruders for injecting very viscous materials into a mold. In the case of very viscous material, the catalyst capsules can be ruptured by using sonic horns inserted into the extruder nozzles to rupture the catalyst capsules. The structural compositions useful in the inventions are generally filled and fluid enough to be pumped into molds without the need of extruders. Generally, the composition includes at least 50 wt. % fillers, preferably at least 60 wt. % fillers and particularly at least 70 wt. % fillers and 10 to 15 wt. % polymer. The polymers used in the composition is preferably polyester and the catalysis are generally standard catalyst used for polymerizing and cross-linking polyesters such catalysts include anthony compounds, titanium compounds, mixed anthony and titanium compounds or catalysts described in U.S. Pat. Nos. 6,265,526; 5,780,575; 5,750,635; 5,714,570; 5,596,049; 5,428,126; 5,190,457; 5,114,739; and 4,876,296, incorporated herein by reference.  

0109 The molds can include vibrators to assist in the homogenous fill of same, to mitigate bubble/air entrainment and proper distribution of material. The apparatus also have the capability to pump several materials for any given layer, of any given thickness, curing waiting periods, object extraction, and conveyors can be preprogrammed and automated for series production cycles. 

0110 Material reservoir level detectors can stop production should an low-level situation present itself, to avoid an incomplete production cycle. 

0111 Automation is generally preferred in the molding apparatus of this invention, where a computer or digital processing unit can be used to select the sequence, material and quantity to be pumped into the selected voids, what injection nozzles to use, pattern of injection, vibration on/off status, and stage the next position of the mold cycle. Sensors will be introduced into molding apparatus to detect expected fill condition, or abnormal operation, wherein computer can perform corrective measures or shut down production, while signaling operator of malfunction. Operationally, technicians can ensure that the molding apparatus is hooked up to the various selected building materials, ensuring that hoppers are full, and routine maintenance operations are followed. 

0112 In residential application, the molding apparatus will be used in the first stage, by the injection of foam, becoming the core of the structure, which can be, but not limited to, polyurethane closed cell foam. The second stage would move the mold outward on both surfaces a partial inch encapsulating the foam with the pigmented polymer slurry. 

Pneumatic Post-Tensional Reinforcement (PPTTR) 

0113 As part of the described extrusion process, be it continuous or discontinuous, triangulation reinforcement can be included as part of the building process where increased structural strength is required. The vertical triangular truss/beams can be post-injected with foam, vacuumed, or filled with liquids/coolants to create additional structural post-tensional strength, insulation, vibration dampening or sound controlling characteristics. 

0114 The injection of compressed gas/air into triangular, rectangular, hexagonal, pentagonal, circular, waved and similar reinforcing shapes placed in series, sandwiched between inner/outer walls or roof/floor whether in a vertical, horizontal or angular plane, continuous or discontinuous shall be called Pneumatic Post-Tensional Reinforcement (PPTTR). 

0115 PPTTR can be multi-layered for added compounding strength, while at the same time reducing weight and materials requirements; it can be flat or follow compound curvature in accordance to design parameters. PPTTR is used with structural building materials, with transparent or translucent thermosetting polymers that when used in combination with compound curves it can cover large expanses, such as a domes, bridges, or tunnels for example. 

0116 The use of the sectional slip molds can allow the construction of manageable sub-assemblies and adapted to a prefabrication process for transportation and erection by cranes; pieces can be glued or spliced together with hermetic seals with subsequent PPTTR added. Selected reinforcement triangles/ribs be used for other functions, such as: wiring trunks, water/sewage, ventilation, communication, thermal or fluid transfer. 

Multi-Level Structural Reinforcement 

0117 Extruded continuous thin-walled profiles enables the creation of integrated three level structural reinforcement reducing the materials requirements and weight/cost of a structure, can be used as single reinforcement or combined all together, for buildings, sub sea vessels/storage, ships/barges, containers, motor vehicles, aircraft, utility trunks, highways, multiple pipelines, other, these are: Micro-reinforcement (primary level); Modular-reinforcement (intermediate level); and Macro-reinforcement (top level). 

0118 Micro-reinforcement or primary level is intended for the continuous/discontinuous supporting walls/hulls, floor/roof, of the building/vessel, consisting of a continuous truss of varied symmetric geometric shapes extruded perpendicular to the plane of the wall/roof sandwiched between an inner and outer layer of flat or curvilinear surfaces. This first level of structural reinforcement can be multi-layered, or varied thickness with selected voids/layers can be additionally reinforced by PPTTR, foam-filled, ballasted or injected with fibrous structural slurry, such as in a keel or areas where greater strength is required. 

0119 The modular or intermediate level of structural reinforcement consists of varied interconnecting structures which follow varied geometric shapes along the axis of extrusion, be it hexagonal, pentagonal, circular, or other, or same or increasing/decreasing sizes; the inside walls of the module follow a particular geometry that contributes to the rigidity/strength of the module. The walled interior spaces of the module are used for pumping fluids, storage, office space, other, or sealed for hermetic/structural reinforcement, depending on application. At predetermined extruded intervals a reinforcement partition can be injected wherein the mold opens pathways perpendicular to extrusion plane that close for a programmed amount of time to allow the slurry material to initially harden and open to become slip molds.
like the rest of the apparatus. The mold injection process can be interrupted to allow a measured gap before continuing the extrusion; this gap allows the insertion of prefabricated panel/divider/partition, where needed or for building floors at programmed intervals.

[0120] Macro-reinforcement uses the varied interconnected geometric modules to contribute to the ultimate strength of the entire structure/vessel. Wherever the modules become separated, webs of beams/columns are extended in these areas to maintain the unit integrity and interconnectivity, particularly in earthquake or cyclic movements in accordance to intended use.

Modular High-Rise Extrusion

[0121] One or a series of slip molds or modular slip molds of fixed or variable geometry shall be used to extrude in a vertical fixed direction, constant angular, or continuously varying direction. These slip molds can be symmetrical or asymmetrical in shape depending on the architectural theme, with the ability of adding or subtracting modular sections as the extrusion progresses. The modular extrusion apparatus provides a continuous self-supporting interconnected wall structure that can vary in thickness in accordance to the structural requirements; the variability of said thickness shall be internal, external or both, particularly at lower levels that require additional reinforcement, thinner as it progresses upward.

[0122] Extruded pattern can incorporate at any part of the mold, continuous or discontinuous thin-walled triangulation to form columnar-trussed beams instead of simple single/multiple skinned surfaces. Layers of materials can be flat, irregular, waved, or a combination thereof to form internal corrugated/voided spaces at any given layer. The use of the modular slip mold concept makes these sectional molds more manageable in size and allows the interconnectivity of continuous geometric shapes that can be interlocking, enhancing its resistance to seismic activity.

[0123] Continuous vertical interconnected shapes can be hexagonal, pentagonal, circular, but not limited to these shapes; they can be of similar size, larger or smaller, such that by turning off any of these modules, they can create internal voids that transform these into internal atriums of varied expanses. The molds can also have internal structures that are extruded simultaneously, becoming internal self-supporting continuous or discontinuous walls, in accordance to the need, not only to speed up the construction process to structurally enhance the overall strength of the high-rise under construction.

[0124] A combination of voids/stud/columns can be extruded, while studded sections can have a pump on/off status to create vertical openings. Upper ridge or top edge of the extrusion at stud/column location can be turned off sequentially creating waved, sloped or irregular terminations.

[0125] With the synthetic glass that can be transparent or translucent previously described, the slurry material can be substituted at any predetermined wall sections and programmed to be continuous or alternating to form the external windows/skylights of said building.

[0126] Similarly, the substitute material can be such that it can be easily removed for door opening and such, where needed; these are designed into the molding apparatus with the respective parallel pumping mechanism of target materials.

[0127] Certain continuously extruded spaces are smaller in size serving as spaces that not only add to the structural integrity but also serve as trunks for wiring, ventilation, elevator or other functions. The molds can be controlled by electronic circuitry, digital processing units or the like programmed to allow the flow of the construction slurry into interconnected beams at given vertical intervals, thus forming the bases upon which prefabricated floor modules shall be inserted. These interconnected beams become part of the entire modular mold, being used discontinuously at set floor intervals, but to allow a slip status, the mold can include a timed self-opening bottom that allow adequate curing time for the bottom of these beams to catalyze and become self-supporting before initiating slip status.

[0128] Once the floor/beam interval is completed, the continuous wall sections of the mold is cut off the feed into the channeled beams, and the cycle is repeated at every floor interval. As the vertical extrusion progresses, the immediately completed beam section shall have the prefabricated finished out floor sections inserted as the construction progresses upward, to avoid exposing the construction workers to falls exceeding one partial story at a time.

[0129] The completed floor can be finished out, with electrical, air conditioning, telephone and furnishings and be ready for immediate occupancy, as this modularity concept also applies in the vertical direction. The vertical progression of the construction can be on a as needed floor basis, or complete build-out concept as the molds can continue in place and construction proceeds by way of pumping the construction material, but cannot exceed the planned overall height/structural design load of the completed project. Booster pumps are added as the building construction progresses upward, with respective parallel pumping systems/substations of slurry/synthetic glass/removable materials.

Large Scale Lateral Extrusion

[0130] For building large scaled thin-walled extrusion projects such as stadiums, arenas, markets and such, modular rectangular/square structures of adequate stable widths can be piggy backed and clamped together to support large profile molds and material distribution hoses. These modular structures can follow straight, oval, circular, irregular, or combined pathways in accordance to the architectural design extrusion sought. The lateral extrusion profile mold are closed off at initial starting point and pumped materials are allowed to catalyze/harden before lateral movement initiates; this movement transform mold into an open ended slip mold which is timed to move slightly forward only after the adequate amount of minutes have elapsed and after a total fill condition is detected.

[0131] Computers that are fed sensor/timed conditions that activate motors/pumps to inch the entire structure forward, program mold movements, following tracked pathways.

[0132] Since the cured extrusion must be self-supporting, engineering studies based on material strength determines continuous thin-walled triangular support beam/column
trussed webs required for the intended application particularly in horizontal or sloped expanses, with properly spaced walls that become part of the support system.

[0133] The support web trusses, continuous or discontinuous, can be filled with compressed air/gases, foams, liquids and coolants to create additional post-tensioned strength in structures, provide added insulation, vibration dampening and sound proofing characteristics; as previously described as Pneumatic Post-Tensional Reinforcement.

[0134] For stadium type applications, it is possible to integrate seats and back supports as part of the extrusion/support structure. The extruding apparatus can be controlled such that at a given section the polymeric/element slurry can be stopped by a pump stoppage/closing gateway to create open areas, doorways where needed. At external walls/roof, structural building materials can be substituted on the fly, or programmed for replacement by clear/translucent thermosetting polymers to create window/skylights. The intended mode of operation is a continuous uninterrupted construction by a never ending supply of cement/truck to maintain a one piece structure; upon completion of the intended pathway, only a gap large enough to retrieve the mold remains, and a conventional fill mold is used to close the remaining gap. Selected voids of the triangular support structure can be post-filled with foam to enhance the structural support, or provide additional insulating/sound proofing properties to the building/structure.

Continuous Linear Lateral Extrusion

[0135] The lateral extrusion technology can also be continuous following a linear or semi-linear pathway using the above-described technology in any scale, permitting the construction of pipelines, aqueducts, sewer and electrical/utility/communication trunks. By integrating the PPTTR system to the process, additional rigidity and self-supporting capability can be incorporated such as at crossings or under high transit areas. Multi-layered PPTTR also permits the construction of floating/suspended bridges or structures. Tunnel extrusions can follow a large rotary drill that due to minimized catalyzed and increased strength provide greater safety.

[0136] When a flexible extrusion collapsible/expandable mold is used in combination with multilayer PPTTR lighter applications in shipbuilding, pontoons, barges, storage facilities, be it floating or submerged is possible. The PPTTR not only provides added buoyancy, but also becomes a primary external hull, required for the transport of hazardous fuels/chemicals.

[0137] The use of the proposed polymer construction materials, adds the ability of the proposed vessels to be resistant to corrosion, acids, weather, cyclic conditions. With the addition of closed cell foams into the skins/voids, added thermal, sound proofing, strength is achieved, with high R insulation values for housing/refrigeration applications. Continuous impervious reinforced flat surfaces can have applications for highways, walkways, ramps, corridors and shuttle driveways.

[0138] Combined piping/utility trunks that incorporate water, sewer, gas, electrical, communication can be simultaneously extruded as a stronger multifunction unit significantly reducing time, cost, planning. Above highways can be combined with the utility trunks and proportionally be expanded per lane; underlying utility trunk would require a larger single trench that can be extruded with the highway as a unit and topped off with an asphalt/cement finish.

Pneumatic Elevators and Shuttles

[0139] The ability of the continuous smooth precision extrusion process allows us to create extrusions of a variety of geometric shapes; with this capability the apparatus of this invention can create smooth elevator and shuttle shafts with tracks to allow the mobility of passengers in the vertical, horizontal or combined plane thereof. These shuttles can have redundant backup seals on both ends, with the ability of moving in either direction, a minimum of at least three geometrically spaced tracks and wheels can keep it centered and symmetrical to the shaft at all times without putting undue stress on said seals. These seals shall have at least a triple redundancy with sensor capable of detecting air movement between them in a fail situation, thus the shuttle would be sent back to the home position for maintenance or repair.

[0140] The home position would be isolated from vacuum/compression sides of the shaft and permit the retrieval of the entire apparatus for complete checkout or rollers, sensors, seals and ancillary safety devices. The wheels mounted on the shuttle can have regenerative DC current, motor/generator and braking capability, which can be powered by a mounted battery pack for emergency operation. All of the tracks will have electrical power capability, which will be a secondary means of providing power to the shuttle.

[0141] Should a fissure develop on the shaft surface due to an earthquake or force of nature, the shuttle are equipped to bypass air via a throttled valve to allow the shuttle to gently move downward, or activate its’ emergency power pack to move upward.

[0142] All doors can have a double seal mechanism to ensure a hermetic seal to permit the continued operation of the shuttle; these can also have imbedded sensors that detect any airflow between seals and remotely signal the maintenance crew for minor leaks, or shut down the operation for major leaks.

[0143] The shuttles are void of all cables, weights, and motors that operate traditional elevators and are powered pneumatically by a reversible compression/vacuum operation depending on the selected direction of transportation. Booster pumps/compressors shall be placed on both sides of the shaft to assist in peak weight operating conditions, while permitting the rotation of these devices based on operational hours.

[0144] Independent generators can automatically kick in if pressure falls short of minimum programmed pressure of the compression side when the elevator is summoned; this mode can automatically summon the maintenance crew of functional irregularity. Oxygen sensors will be mounted to monitor the breathing conditions of the shuttle and have the ability to trickle additional air from the compressed side of the shuttle with a mounted fan and an internal over pressurization relief valve on the vacuum side to ensure comfort and safety of the passengers.

[0145] Suitable curable polymeric buildings materials can include, without limitation, any thermally curing polymeric system including thermosetting polymeric systems as well as epoxy resin systems.
Such systems include those systems disclosed in U.S. Pat. Nos. 5,921,046, 6,034,155, or 6,048,593, incorporated herein by reference. Preferring curable polymeric systems include epoxy resins and their cure systems available from Everest Coatings Incorporated of Spring, Tex. The curable polymer compositions of this invention can include a blend of at least three thermosetting resins, and at least one thermoplastic resin. Preferably, the major component by weight of the resin blend (as opposed to the entire polymer concrete composition) is a rigid thermoset unsaturated polyester resin, whereas the minor components preferably include a flexible thermoset unsaturated polyester resin, a thermoset vinyl ester resin (preferably, a modified epoxy vinyl ester resin), and a thermoplastic resin (preferably, a thermoplastic polyester-polyurethane hybrid resin). By using a major amount of a rigid unsaturated polyester resin, as opposed to the vinyl ester resin, costs can be reduced. Also corrosion resistance is reduced, although the level of corrosion resistance is sufficient for the compositions to be used in wastewater structures. Significantly, by using a major amount of a rigid unsaturated polyester resin, as opposed to the vinyl ester resin, strength is not sacrificed.

Suitable foam filling material include, without limitation, any polymeric system that is capable of forming closed foam in situ including polyurethanes such as those available from General Electric, Dow Chemical company or other polymeric foam forming materials well known in the art.

Suitable equipment for injecting the curable polymeric material used for making the webbing or beams include, without limitation, any equipment capable of pumping the material into a mold of the present invention under controlled conditions such as equipment available from Everest Coatings Incorporated of Spring, Tex, Gusmer of Lakewood, N.J. or similar suppliers. Suitable equipment for injection the foam into open structures in the beams or webbing include, without limitation, any equipment capable of pumping the foam precursors into the open structures such as equipment available from Polythane Systems Inc. of Spring, Tex.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring now to FIG. 1A, a preferred embodiment of a residential structure generally 100 prepared by the method of this invention is shown. The structure 100 is a synthesis of geometric shapes that are combined to make a comfortable highly insulated house. The structure 100 includes a plurality of curved column sections 102 having an opened roof section 104, lower self-opening vents 106 placed about a distance d (generally d is about a foot) above the ground, a pyramid shaped roof 110 and a foundation or floor 112. The foundation or floor 112, which can be conventional or an extrudate of this invention, is designed to extend past the structural element of the columns 102 and roof 110. However, it should be recognized by an ordinary artisan that the foundation or floor 112 can be designed to have a contour that is coincident with the contour on any or all structural element of the structure 100.

The roof opened sections 104 of the curved column sections 102 are designed to support air circulation within the structure 100 to form a passive ventilation system. The passive ventilation system is particularly well-suited for hot or tropical climates. Thus, as heated air rises through the structure 100 and out of the open roof sections 104, cooler air enters the structure through the vents 106 and a temperature differential between a lower part 114 of the structure 100 and an upper part 116 of the structure 100 promotes this flow to provide passive cooling. Additionally, if the column walls 118 and roof are composed of the composite or foam filled extrudates of this invention, the structural components of the structure 100 can have an 30R insulation factor that will help to maintain a tolerable ambient temperature without air conditioning, which is generally not available in third world countries.

The inward curvature of the open curved columns 102 are designed to allow plenty of light to enter an interior (see FIGS. 1B and C) of the structure 100 without being overwhelmed or constantly exposed to direct sunlight. The compound curves of the columns 102 further enhance the structural rigidity and/or stability of the structure 100, while forming four cornerstones thereof. The central pyramid shaped roof 110 is positioned a sufficient distance above the interior rooms of the structure 100 to increase the separation between the roof 110 and the inner habitat regions of the structure to enhance passive cooling and ventilation. Having the roof 110 a sufficient distance above the habitat regions of the structure also provides the structure 100 with an expansive cathedral ceiling. The roof 110 can also include upper self-opening vents 120 positioned close to a top 122 of a point 124 of the roof 110. A central reversible fan can be installed in the interior of the structure near the top of the ceiling to draw in cooler air or push down warmer air according to the season or the desire of the occupants.

The structure 100 can also include curved roof opening covers 126. The covers 126 are preferably designed to be opened and closed allowing air flow therethrough. Because the roof openings 104 are symmetrically situated about the point 124 of the roof 110, the openings 104 can channel air into the dwelling 100 regardless of wind direction. When the covers 126 are retracted, the openings 104 create an indoor atrium feeling to the dwelling 100. The covers 126 are designed to pivot about pivot points 128 on shafts (not shown) extending into the roof at the pivot points 128 so that the covers 126 can open by sliding into an interior 130 of an upper interior section 132 of the columns. The covers 126 engaged the roof 100 in arcuate grooves 134 which act as a seal against water or rain entering the structure 100 when the covers 126 are shut. The grooves 134 can include a seal such as a rubber shelf or any other mechanical sealing device. A top edge 136 of each column 102 includes a lip with a seal which prevents water or rain from entering the structure 100 when the covers 126 are shut as is well-known in the art. The mechanical apparatus used to open and close the covers 126 can be of any conventional structure including motorized or manually drive mechanisms such as gears designed to engage the shaft located at the pivot points 128, which provide the mechanical means to open and close the covers 126 by rotating them about the pivot points 128. Alternatively, the covers 126 can rotate in the other direction so that they open into the open atrium space of the structure 100.

The structure 100 can be made tall enough to accommodate a single floor or a multi-floor structure. The structure 100 can also be constructed with windows in the columns 102 and/or sky lights in the roof 110. Additionally,
the interior living space can be subject to considerable layout flexibility and changeability. The structure 100 also includes roof dwelling areas 138. These areas 138 can be closed to form rooms or opened to form porch areas 140. The porch areas 140 can include a single support post 142 or a plurality of posts 144 to create an opened air enclosure with no egress or ingress.

[0154] Referring now to Figure 1B, an embodiment of a floor plan 150 of a first floor of the structure 100 of Figure 1A is shown, which is designed to be large enough that it is not confining and reasonable in size to developed nation standards. The plan 150 includes eight (8) rooms: a master bedroom 151, a master bathroom 152, a living room 153, a kitchen 154, a second bathroom 155, two small bedrooms 156 and 157, and an interior room 158. The plan 150 also includes an enclosed porch 159, an open porch 160, main entrance 161 and a back entrance 162 having a curved hallway 171. Each room 151-158 are shown with accompanying furniture 163 and fixtures 164.

[0155] The interior rooms 151-158 include interior walls 165 and door ways 166. Of course, open of ordinary skill in the art should recognize that the interior space of the structure 100 is amenable to many different floor plans and interior configuration.

[0156] Modern features have been added to the kitchen taking advantage of the circular form. As can be seen despite the unusual futuristic circular shapes, there is a balance of straight lines with integrated traditionally shaped furniture. The plan meets the typical home requirements: three bedrooms 151, 157 and 158 and two bathrooms 152 and 155. The plan 150 also provides an inner dining room atrium 158 having a vaulted ceiling. The master bath 152 is shown subdivided into two areas 167 and 168 to maximize utility and a bathtub 169, not usually present or required in underdeveloped countries. The added wash/utility area 170 and porches 159 and 160 provide a much-needed luxury not usually available in low-income homes. The plan 150 also includes closets 172.

[0157] Referring now to FIG. 1C, an embodiment of a floor plan 175 including a partial second floor 176 with the first floor plan of FIG. 1B of the structure 100 of FIG. 1 is shown. When the structure 100 includes a partial or complete second floor, the plan 150 is modified to include a stair case 177. The second floor plan 175 includes a curved ramp 178 uniting a bedroom 179 and a multi-purpose room 180.

[0158] As can be seen from the one and two floor plans of FIGS. 1B and C, a family dwelling can be produced using the extension apparatus and building materials of this invention that approaches middle-income housing standards in developing countries. Moreover, because the buildings of this invention are constructed with electric and plumbing, a hot water heater, an air conditioning, or modern conveniences can be added. Furthermore, the building of this invention can be upscaled through the addition of modern ceramic tiles, a small fountain in the atrium area, or the like to produce a very appealing livable space within the same structure. To fulfill the passive cooling requirements, outer floor vents are included. Moreover, the floors used to produce the second story are designed so that they can be easily removed, thus allowing the living space to be adjusted as the family grows or shrinks, without the pressure of buying a new house.

[0159] Referring now to FIG. 1D, another embodiment of a floor plan 185 of a first floor of the structure 100 of FIG. 1A is shown, where the structure has been rotated 90° in a counterclockwise direction. Additionally, the kitchen 154 is shown with a more conventional arrangement of the appliances against a straight interior wall 186. The plan 185 also includes optional corner windows 187 to make the structure more symmetrical. In addition, the plan 185 includes a moderate-income typical two-car garage 188 and a driveway 189. In low-income housing situations in developing countries, lots are very small and generally do not include space for garages. If the family even has one vehicle, which is parked on the street, this is usually a luxury since public transportation is the norm. Included in this plan 185 is a distribution of a small lot displaying a moderate-income typical two-car garage as would be seen in a developed country. The viewer can appreciate the relatively small, square footprint of the structure 100, and how the lot can be scaled down to accommodate third world country standards.

[0160] Referring now to FIG. 2A, a top view of a preferred embodiment of a mold assembly 200 of this invention for producing the structure 100 of Figures 1A-C is shown. The mold assembly 200 includes four arcuate sections 202, which are designed to form the interior and exterior walls of the columns 104 of FIG. 1A. Each section 202 includes an exterior part 204 and an interior part 206. The mold assembly 200 also includes interior arcuate sections 208 designed to produce a single layered wall and one interior section 210 designed to produce a double-skinned wall or composite wall construct of this invention. The mold assembly 200 also includes non-curved exterior wall section 212 and interior wall sections 213. The mold parts 214 shown in dotted lines represent part of the mold into which the curable composition is not injected in the first part of the construction to provide doorways or not at all depending on the configuration desired for the final extruded structure. The mold assembly 200 can be a continuous mold or preferably is made of interlocking mold portions, where the portions can be coextensive with the above identified sections. Moreover, the mold assembly 200 is designed to create the floor plan 150 or 175.

[0161] The mold assembly 200 also includes a set of four guide posts emplacements 216, 218, 220, and 222 associated with the sections 202. The emplacements 216 are located at a interior location 224 of the arcuate mold sections 202. The emplacements 218 are located at a first exterior location 226 opposite the location 224. The emplacements 220 and 222 are located at a second and third exterior locations 228 and 230, respectively, which are opposite each other, but rotated 90° relative to the locations 224 or 226. The mold assembly 200 also includes a set of guide posts emplacements 232 centered within the corners 234. The emplacements are designed to receive the guide posts which define the path that each mold section with traverse. Although the mold assembly can be a unitary structure, such structure present a transportation problem. Preferably, the mold assembly comprises section that can be easily assembled and disassembled. The mold sections interlock using any conventional connecting mechanisms such as tongue and groove with pins, tongue and groove with spring loaded pins or any other method known in the art. Thus, the mold section can be made in convenient section sizes are between about 2 feet and about 12 feet section and preferably between about 4
feet and about 8 feet. Of course, shorter and longer sections are also useable especially when short or very long molds or mold parts are needed.

[0162] All the walls in this structure are simultaneously built to speed up the construction process; the internal walls are built up to at least eight feet and stopped while the external walls continue on a gradually curving pathway that becomes an integral roof. Beyond the eight-foot interior wall height, the external walls are built in a sequential manner to impede any of the sliding ends of the mold from interfering with other sliding ends of the mold as they travel their respective paths, because the moderate complexity of the design requires that portions of the molds collapse during extrusion. Thus there are three main building sequences that are controlled by three main hoses that have equidistant smaller hose distributions. The three main hoses have valves that can slow down the pump rates on any of these, and proportionally speed up the others. The several smaller distribution hoses equally disperse the building material and depending on the guidepost curvature force more material into one side or the other within the mold in a dynamically balanced fashion.

[0163] Referring now to FIG. 2B, a preferred embodiment of the posts 250, 252 and 254 which are used to construct the structure of FIG. 1A. The post 250 is designed to be inserted into the post emplacements 216 and includes a substantially straight portion 256 and a curved portion 258. The post 252 includes a substantially straight portion 260, a curved portion 262 a second substantially straight portion 264 and is designed to be inserted into emplacement 220,222 and 232. The second substantially straight portion 264 is designed to form the pyramidal roof of Figure 1A. The post 254 includes a substantially straight portion 266 and a curved portion 268 and is designed to be inserted into the emplacements 218.

[0164] The posts 250-254 are typical pathway beams or guide posts that would be used for building the columns of Figure 1A. The four beams or posts are positioned around the mold 90° around the circles including the arcuate mold sections 202. The bends in these posts correspond to the proportional perpendicularity of the mold while following the guideposts, such that the innermost beam possesses the smallest curvature, the mid beams have half, and the outer have the greatest. These bends will be offset and compensated for the spacing required by the rollers and mold width. Additional guideposts with their proportional bends will be placed on the inner four corners of the roof, making it necessary to use at least 20 guideposts for this particular design. The moderate complexity of this design is intentional in order to create the special features of this low-income home. The guidepost emplacements include appropriate bases having placement holders that align the posts with the slab geometry; this will assist in the rapid erection and assembly of the molding apparatus.

[0165] According to the selected design and mold geometry, the mold guidepost can be as few as two. For example if a quarter circle vertical configured mold following a circular pathway, the guidepost placed on the ground would be circular in shape matching the quarter circle diameter, while the top would be a rigid post matching the height of the quarter circle. The post would have a support roller that permitted the mold to pivot on the centerline of this post. A variation of this configuration would be to elongate the pathway such that the building would be longer along one axis, and circular on both ends. This same pathway can be modified so that the resulting structure has vertical walls, a moderately sloped roof with a couple of feet overhang. A similar pathway configuration can be designed to minimize the end curvatures such that the building has a rectangular shape with moderately curved edges.

[0166] Referring now to FIG. 3A, a top view of a preferred embodiment of a mold assembly of this invention, generally 300, for producing a double straight composite wall construct of this invention is shown to include inner flexible skirts 302, outer flexible skirts 304, a plurality of guide posts 318, an injection manifold 320, a plurality of rigid W-shaped guide members 370 and a plurality of guide posts 319. Looking at FIG. 3B, the inner skirts 302 extends from the manifold 320 to a position 306 above a lower end 308 of the mold 300; while the outer skirts 304 extend to the lower end 308 of the mold 300. The outer skirts 304 also include rubber feet 310 which are designed to make a better seal with a floor or foundation and are designed to compress when the mould assembly 300 is placed on a surface. Because the inner skirts 302 do not extend to the end 306 of the mold 300, a space 312 is produced which is designed to be totally filled by the curable composition. This space 312 is designed to anchor the extruded constructs to anchoring members (not shown here) extending into the space 312 from the foundation or floor as shown and described in FIG. 7 and its accompanying written description.

[0167] The injection manifold 320 includes a central mold guide 321, two injection blocks 322, two outer mold guides 323 and 324 and a plurality of guide post followers 325. The inner skirts 302 are affixed at their upper ends 314 to sides 326 of the central mold guide 321 and to inner sides 327 of the injection blocks 322; while the outer skirts 304 are affixed at their upper ends 316 to inner sides 328 of the outer mold guides 323 and 324 and the outer sides 329 of the injection blocks 322. Each injector blocks 322 include a non-stick layer 330 at its lower end 331. Alternatively, the entire injection blocks 324 can be made of a non-stick polymeric material such as Teflon, polyethylene and/or polypropylene. Looking at FIGS. 3C and D, an alternate embodiment of the manifold 320 includes unitary construction 332 having a plurality of downward extending segments 333 forming a plurality of skirt receiving slots 334.

[0168] The followers 325 are rigidly connected to the manifold 320 and include a first roller mount 335 affixed to outer guide 323 and the having a first roller 336 for movably contacting an inside wall 337 of the guide posts 318 and a second roller mount 338 having a second roller 340 for movably contacting an outer wall 341 of the guide posts 318 and rigidly connected to the first mount 355 by a U-shaped arm 342.

[0169] Looking at FIG. 3C, the rigid W-shaped guide members 370 which are designed to fit into slots 371 in the central mold guide 321. The W-shaped guide member 370 includes a top 372, two outer legs 373 and 374 and an inner leg 375. The outer leg 374 includes a spacer 376 located at a position 377 near the lower end 308 of the mold assembly 300. The spacer 376A is designed to contact an outer surface 378 of the skirt 304 to ensure that a gap 379 between the
inner and outer skirts 302 and 304 remains substantially constant during extrusion. The inner leg 375 includes two spacers 376A located at its end 380, which is substantially coincident with the ends of the inner skirts 302. The spacers 376A are designed to extend along the entire mold to prevent the composition being pumped into the mold from entering interior spaces 391 and preferably includes a non-stick coating on their under side. The outer leg 373 also includes a spacer 376C located at the position 377. It will be noted that the spacers are designed to operate collectively to ensure that the gaps 379 remain constant. Of course, the mold assembly 300 can include additional spacers 376 spaced at intervals along the length of the mold assembly to further ensure that the gap 379 remains substantially constant throughout the mold assembly 300. The spacers 376A and 376C preferably extend along the entire mold, but unlike the spacers 376B it can be discontinuous.

[0170] The outer leg 373 also includes a guide post follower 381 associated with its end 382. Like the followers 325, the follower 381 include a first roller mount 383 affixed to outer guide 323 and the having a first roller 384 for movably contacting the inside wall 337 of the guide posts 318 and a second roller mount 386 having a second roller 388 for movably contacting the outer wall 341 of the guide posts 318 and rigidly connected to the first mount 385 by a U-shaped arm 390.

[0171] Referring now FIGS. 4A and 4B, an alternate guide post follower design 400 is shown.

[0172] Looking at FIG. 4A, the follower 400 includes a roller mount 402 mounting a first roller 404 adapted to engage an outer surface 406 of the guide post 408 and a second roller 410 adapted to engage an inner surface 412 of the guide post 408. Looking at FIG. 4B, the mount 402 is adapted to be inserted into and follow a groove 414 and the guide post 408. The mount 402 is designed to be inserted into the groove 414 through a end 416 of the guide post 408 having an enlarged groove opening 418 for making mount insertion easier.

[0173] This exhibit demonstrates how a slot can be cut into one side of a square, circular or however shaped guideposts. Internal and external rollers stabilize mold in the axially while the slot stabilizes it laterally. In some instances the roller can be geared and attached to a slow moving variable speed DC motor to assist the upward-forward movement of the mold. Said motor can have an internal brake that only allows movement when the motor is operating. A variable speed motor is only required when the mold pathway changes direction, wherein the innermost most is slowed down, while the outermost is sped up to maintain perpendicularity of the mold/guidepost at all times. Conventional AC motors can be used if they are tied in to pressure sensitive devices on the tops of each mold. When the pressure drops outside of a predetermined range the motor stops and when the pressure exceeds the determined range, the motor engages moves the mold forward. Each guidepost will have a cutoff relay at the end of each track in any motorized version. There are designs that require molds to work only in the vertical direction; in this case, no motors are required to assist/brake the mold.

[0174] Referring now to FIGS. 4C, another guide post follower design 440 is shown to include a four roller follower configuration. The follower 440 includes a frame 442 shown connected to the outer mold guide 323. The frame 442 includes four roller 444 mounted therein and configured to rollingly engage one of the side 446 of the guide post 408. The frame 442 also includes a top removable member 448 for assembling and reassembling the mold assembly 300.

[0175] A variation from the previous slotted guidepost internal roller configuration would to place all rollers outside of said guidepost. By adding to additional concentric rollers it is possible to maintain stability in all directions on the plane of the mold. This eliminates the necessity of placing a slot on the guidepost particularly if more rigidity is required on it. For most projects of moderate size, a thin walled 6’’ square guidepost will be used. These will make them easy enough to handle, but larger projects may require greater strength, so they will be adjusted accordingly. The slotted guidepost configuration will allow a variety of cross-sections, depending on material availability. It is necessary to point out that guideposts with a moderate curvature may require two or more sets of rollers to assist in flexing the mold along the pathway.

[0176] Referring now FIGS. 5A, a top view of a preferred embodiment of a mold of this invention, generally 500, for producing a composite wall construct of this invention is shown to include flexible outer skirts 502 and an injection manifold 504. The injection manifold 504 includes spaced injectors 506 and a plurality of rectangular section 508 surrounded by flexible rectangular shell, inner skirts 510 and a plurality of W-member slots 512. As the curable composite is injected through the injectors 506 into the mold, the composition forms wall members and reinforcing webs, simultaneously. Looking at FIG. 5B, a cross-sectional profile of the manifold 504, which includes downward extending segments 514 and skirt receiving slots 516.

[0177] The molds for FIG. 3 and 5 are designed so that the outer skirts extend beyond the internal skirt. It is intended that the bottom section of this mold be filled first by the catalyzed fluid to encapsulate the protruding rebar. After this section is filled the building material progresses slowly up the sides forming the two skins of the wall until it is full. By the time the mold is full, at least 15 or more minutes have elapsed and lower material has been kept to the material of the top that is in the fluid phase is now beginning to slowly hydrostatically push the mold upward/forward while the hardened shape of the bottom of the building material exits the mold. New building material is continuously added into the mold slowly extruding a wall or surface. The foam core material is injected afterward where the building material has hardened to the point that is able to withstand the internal expanding forces of the rising foam.

[0178] Small vibrators can be added that will assist in the proper distribution of the building material while at the same time keeping the mold from sticking while it is continuously advancing. Thinners such as styrene will keep the slurry from becoming too viscous to properly be distributed in the mold. To further assist in the distribution of the slurry several equidistant injectors will be distributed throughout the mold. This slurry will not have any aggregate material exceeding ½ of an inch and only a limited amount of short fibers that are easily pumped with an appropriately sized cement pump.

[0179] This slurry can be maintained in a liquid phase until curing is required, because either the catalyst is encaps...
ulated or separated from the slurry. Ultrasonic nozzles for sonic sensitive capsules that retain the catalyst are required to rupture the capsules upon entry into the mold or at some time after slurry injection. Other types of capsules can be used, but a matching system for mechanically rupturing the capsules is required. Alternatively each individual hose will have to be measured for the amount of flowing material, and a mechanical means for proportionally adding the catalyst will be needed. It will be required to separate the proportionally injected catalyst into a wide cross-section of the slurry before it reaches a static mixer to complete the dispersion. Said mixer will create enough turbulence to reach homogenization, and can be discarded upon the job completion.

[0180] As discussed in the previous sections, a system of internal webs or reinforcement beams is required in some structures. A detail on the proposed low-income house shows how these internal webs are placed on this vertical extrusion mold. A three quarter inch mold gap will be used in this design, wherein the polymer based building material is injected into it. As previously described, the mold is preferably filled very slowly and continuously into a top closed open-ended extrusion mold. The molds of this invention are preferably about two feet tall, and retains the curable composition long enough to allow the composition in the lower part of the mold to set before the composition exits the mold. Since material is continually being injected in the top of the mold as the cured material exits the mold, the newly injected material forces the mold along its path. In the design of FIG. 1, the tops of the walls enter into a moderate curve transforming it into the roof of the structure.

[0181] Referring now to FIGS. 6A-C, a sequences of views of a preferred mold 600 for moving the injection zones in or out. The mold 600 includes to cutoff blocks 602, which extend the entire height of the mold and are generally coated with a non-stick coating or made of a non-stick material. The cutoff blocks 602 can be independently or preferably concerted, as shown here, by connecting the blocks together using a connecting handle grip 604. As shown in the FIG. 6A, the blocks 602 start out at a mold end 606. The blocks 602 and grip 604 are then moved to a mold position 608 as shown in FIG. 6B. The blocks 602 and grip 604 are then moved to a new position 610 as shown in FIG. 6C. Of course, if the sequence is reversed, then molded section increases instead of decreases. As the blocks slid past an injector, the injector is either turned on or off depending on whether the mold is contracting or expanding.

[0182] Referring now to FIGS. 6D-E, a sequences of views of another preferred mold 650 for moving the injection zones in or out. The mold 650 includes to telescoping end 652. As the end 652 is pushed in, the shirts 654 slide past each other in interior sections of the 656 of the mold guides 658. Again, the sequence goes from fully extended to first position 660 and then a second position 662 as shown in the Figures. Again, if the sequence is reversed, then the mold expands instead of contracts. The telescoping end can include injectors or not.

[0183] Referring now to Figures 7A&B, a preferred web reinforced, foam filled wall configuration 700 for the structure 100 of Figure 1D is shown to include outer wall layers 702, inner wall layers 704, webs 706 and foam cores 708.

[0184] Referring now to FIGS. 7C-E, a preferred anchoring configuration 750 for a conventional foundation 752 to support the molding of the structure 100 of Figure 1D. At regular intervals 754, rebar anchors 756 having one end 758 embedded in the conventional slab 752 and another end 760 protruding above a top surface 762 of the slab 752. Looking at FIG. 7D, the anchors 756 are shown to be C-shaped 764 with an open part 766 of the C 764 embedded in the slab 752, while a closed end 768 of the C 764 protrudes above the surface 712 of the slab 752. Looking at FIG. 7E, shows the anchors 756 set in a groove 770 in the slab 752 and embedded in a wall 772 of this invention using the molds of FIGS. 3 and 5.

[0185] In this detail we show how the walls are anchored the foundation slab. Staple shaped rebar is imbedded into the concrete slab and made to protrude a few inches. The mold is placed over the rebar and the building material is allowed to cure while totally encapsulating it. To assist in the rapid placement of the rebar prior to pouring the concrete floor and the respective plumbing and conduit, templates will assist in the correct placement of the them.

[0186] Referring now to FIGS. 8A-E, a preferred embodiment of a mold assembly 800 is shown to include removable sections 802 into which cutoff blocks 804 can be inserted to form an opening in the extruded structure such as a window or other opening in the structure. Looking a FIG. 8A, the sections 802 include at least one injector 806 (shown here with two injections 806). When an opening is needed in a structure being extruded, slurry flow to the injectors 806 is stopped, the sections 802 are removed and the blocks 804 are inserted as shown in FIGS. 8B-8C. The blocks 804 are U-shaped having a base 808 and legs 810 having lips 812 where the lips are designed to rest on a top 814 of the mold 800. The base 808 of the blocks 804 is preferably coated with a non-stick coating or made of non-stick composition such as a Teflon, polyethylene, polypropylene or the like. The base 808 is designed to from a smooth bottom edge in the opening. The blocks 804, therefore, should have sufficient weight to form a smooth edge.

[0187] Once a desired opening height is achieved, the blocks 804 are removed and a flat plate 816 is inserted into each section opening 818 and then the sections 802 are placed on top of the plate 816 as the mold moves upward as shown in FIG. 8D. Slurry flow is then restarted into the injectors 806 and extrude 820 is injected on top of the plate 816 and a top edge 822 of an opening 824 is formed as shown in FIG. 8E.

[0188] The blocks 804 have a depth 826 designed to ensure that the slurry cures sufficiently to form a sharp edged opening. This may require the extrusion process to be slowed. Of course, by increasing the depth of the blocks 804, the process can be operated at its normal speed (a speed sufficient to ensure that the extrude exiting the mold has sufficient structural integrity to maintain its extruded profile. For doorway formation, the block depth 816 is the same dimension as the height of the mold.

[0189] Referring now to FIGS. 8F-I, another preferred embodiment of a mold assembly 850 designed to stop slurry flow to a mold section 852 to form an opening is shown. The mold section 852 includes removable mold members 854 having rams 856 and injector ports 858. The rams 856 can be manually operated or is preferably hydraulically operated and remote controlled. When an opening is needed in a structure being extruded, slurry flow to the ports 858 is
stopped, the ports 858 are sealed at their lower ends 860 by blades 862 and the rams 856 are deployed at the same rate as the mold is moving. The distal end 864 of the rams 856 comprises a releasably attached plate 866, preferably coated with a non-stick coating. A lower end 868 of the plate 866 is designed to form a smooth bottom edge of the opening. As described above, when the opening is complete, the ram is retracted leaving the plate 866 behind as shown in FIG. 81.

[0190] Although two mechanisms for forming openings (door ways, windows and the like) are shown, many other techniques known in the art can be used to segment the extrusion apparatus so that openings can be formed during the extrusion process. It should be noted that the mold is moving slow enough so that the extrudate as it exits the bottom of the mold has cured sufficiently to have adequate structure stability to maintain its shape during the remainder of the extrusion process.

[0191] Referring now to FIGS. 9A-D, four designs 900, 920, 940, and 960 of more traditionally shaped dwelling structures that can be extruded using the extrusion system of this invention are shown. The design 900 includes rectangular walls 902 and a tradition triangular shaped roof 904. The design 920 includes rectangular walls 922 and a flat roof 924. The design 940 includes rectangular walls 942 and a convex shaped roof 944. The design 960 includes rectangular walls 962 and a triangular shaped roof 964 having a domed skylight 966.

[0192] Very traditional roofs and housing can be built using this building method, when such is the case, a combination of vertical and horizontal extrusions molds will be used. This configuration allows the building of the typical square edges found in every home. When using this strategy, the mold following this pathway will have the moderately sloping roof shaped into it, while the end sections vertically extruded. Flat roofs are possible using the above molding technique by making the mold with a 0 pitched roof. A circular, oval or elongated domed roof can easily be built by this molding technique, in accordance the design sought. When built with the proposed synthetic glass, it can be translucent or opaque by a white pigment that allows light to enter, but restricts sunlight.

[0193] Now it is also possible to achieve a combination roofs as illustrated, in a single mold passage. Of course, the molds and methods of this invention can be used to extrude any dwelling configuration with a minimal amount of mold restructuring.

[0194] Conventional buildings with concrete floors can be completely faced with synthetic glass.

[0195] This exhibit shows some illustrations of a variation of floor contours. This technique will use a horizontal extruding mold that places rolling guide-paths surfaces on the edges of each of the floors in the building. Since the mold is allowed to flex while holding a constant cross-sections, a bowed in/out effect can be built into the building. The mold following the horizontal pathway can go in a straight line or follow free-form edges as seen in this illustration. The synthetic glass can be single, double or multiple skin, with internal and/or external reinforcing beams/panels. Translucent insulation can be added in liquid form between the skins, or pigmented into the polymers. Photosynthetic qualities can also be included into the polymer/fluid as described in the previous sections.

[0196] Referring now to FIGS. 10A-D, four mold designs of this invention, 1000, 1020, 1040, 1060 are shown. Depending on the guide posts used in association with these mold design, the final construct can be a rectangular with straight walls, inwardly curved wall, outwardly curved walls, inward sloping walls, outwardly sloping walls or mixtures or combination thereof. The guide posts can also provide for roof construction by forming a pyramid roof or by stopping extrusion on two opposing walls, forming a V-shaped roof. Here are illustrations of a variety of molded shapes that are achievable with the use of this technology. These can be of solid cored structural material or built in synthetic glass or a combination thereof. It is thus possible to build from simple cylindrical shapes to spheres and rings.

[0197] Referring now to FIG. 11, an example of an extruded structure 1100 representing a stand with seating steps. The stand 1100 includes a base 1102, a plurality of stair step seats 1104 and a roof 1106. The structure 1100 can be extruded using a mold having a cross-section identical to the extruded structure, where the mold pivots about a central axis 1108 of the structure 1100. Because the extrusion would occur parallel to the ground 1110 upon which the structure 1100 will rest, the molds can either be of a greater height to insure that the extrudate is fully cured before exiting the mold or the mold assembly can include support structures following the mold designed to support the newly extruded extrudate until full curing is achieved. Of course, because the interior of the structure can be substantially hollow, traditional structure braces can be used to increase structural stability.

[0198] Referring now to FIG. 12, an extruded profile 1200 can be build with pertinent structural reinforcements 1202, seats 1204, stage 1206 and other elements following any required radius, where the extrusion apparatus is designed to extrude the profile 1200 by pivoting about a central axis 1208. The top of the dome can be open, or have a curved synthetic glass dome added for air conditioning purposes. These structures can be varied in shape and size according the use intended. Some of these uses can be: sports arenas, amphitheaters, convention centers, social clubs, churches, training centers, restaurants, etc.

**EXAMPLES**

[0199] A series of extruded samples of compositions of this invention were made. The composition comprised 25wt. % fine silica sand, 25wt. % medium size silica sand, 20wt. % coarse silica sand, 5wt. % fiber glass, 5wt. % pigments and catalyst and 20wt. % polyester resin. The pigments used form white or dark colored materials.

[0200] The polymer compositions of the present invention generally will have the following properties: about 13,000 to about 17,000 pounds per square inch (psi) compressive strength using ASTM C-39 or ASTM C-579 and about 15,000 to about 20,000 psi using ASTM D-695 (standard Portland cement concrete exhibits only about 3,000 psi compressive strength using ASTM C-39); about 1500to about 2000psi tensile strength using ASTM D-6380 or ASTM C-307; standard Portland cement concrete exhibits only about 370 psi tensile strength using ASTM C-307); about 4000to about 6000psi shear strength using ASTM D-732; (standard Portland cement concrete exhibits only about 110psi shear strength using ASTM D-732); about
4000 psi flexure strength using ASTM C-947 and flexure (modulus of rupture or MOR) of about 2740 psi using ASTM C-78; a bond strength of about 1200 to about 2000 psi using ASTM C-882 (standard Portland cement concrete exhibits only about 370 psi bond strength using ASTM C-882); and a cold joint bond strength of about 9500 psi (compression load) using a ASTM C

[0201] All references cited herein are incorporated by reference. While this invention has been described fully and completely, it should be understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically described. Although the invention has been disclosed with reference to its preferred embodiments, from reading this description those of skill in the art may appreciate changes and modification that may be made which do not depart from the scope and spirit of the invention as described above and claimed hereafter.

We claim:
1. A method for forming a structure comprising the steps of:
   - movably connecting a mold system to a guide frame including at least one inlet and at least one outlet;
   - injecting a curable polymeric material into the at least one inlet;
   - moving the mold system along the guide frame at a rate sufficient for the polymeric material to cure sufficiently to maintain its shape as defined by the mold system to form an extruded structure including structural elements.
2. The method of claim 1, further comprising the step of erecting the guide frame including a plurality of guide members defining a path.
3. The method of claim 1, where in the mold system comprises a plurality of mold sections, where each mold section defines an extrudate profile and includes a closed end having at least one inlet and an open end defining a part of the at least one outlet.
4. The method of claim 1, further comprising the step of periodically interrupting the injection of the curable polymeric material to form opennings in the extruded structure.
5. The method of claim 1, wherein the polymeric material comprises at least one thermal setting resin.
6. The method of claim 1, wherein the polymeric material comprises at least one thermal setting resin and at least one filler.
7. The method of claim 1, wherein the polymeric material comprises at least one thermal setting resin, at least one filler, and at least one reinforcing fiber.
8. The method of claim 1, wherein the polymeric material comprises at least one thermal setting resin, at least one filler, at least one reinforcing fiber and at least one catalyst.
9. The method of claim 3, further comprising the step of:
   - movably connecting at least one mold section to the repositioned guide;
   - injecting the polymeric material into the mold section;
   - moving the mold section to form an inner or outer element of the structure.
10. The method of claim 1, wherein the structure comprises straight structural elements.
11. The method of claim 1, wherein the structure comprises straight and/or arcuate or curvilinear structural elements.
12. An apparatus for forming an extruded structure comprising:
   - a guide frame including a plurality of posts defining a path; and
   - a mold system movably connected to the guide frame, where the mold system comprises an open end defining an extrudate profile and a closed end having at least one inlet connected to a source of a curable polymeric material,
   - where the mold system being movable along the path to extrude the curable polymeric material out of the open end to form the extrudate profile.
13. The apparatus of claim 12, where in the mold system comprises a plurality of mold sections, where each mold section includes a closed end having at least one inlet and an open end defining a part of the extrudate profile.
14. The apparatus of claim 12, wherein the mold system moves vertically to extrude a wall and horizontally to extrude a ceiling of the structure.
15. The apparatus of claim 12, wherein the mold system moves horizontally to form a floor.
16. The apparatus of claim 12, wherein the structure is residential structure.
17. The apparatus of claim 12, wherein the structure is commercial structure.
18. An extruded structure comprising:
   - continuous members comprising a curable polymeric material where the members are extruded in place.
19. The structure of claim 18, wherein the members include opennings therein.
20. The structure of claim 18, wherein the openings are filled with a closed cell foam.