ABSTRACT

Disclosed is an environmentally friendly system to manufacture composite cementitious building panels and to assemble them into completely finished structures. The present invention is an economical building system that provides greater protection from various environmental hazards while requiring less maintenance, energy consumption and upkeep than the currently available systems.
FIG. 1
COMPOSITE STRUCTURAL PANELS AND THEIR DESIGN, MATERIALS, MANUFACTURING, HANDLING, ASSEMBLY AND ERECTION METHODS USED FOR CONSTRUCTING HOMES AND COMMERCIAL STRUCTURES

[0001] This application claims priority to U.S. Provisional Application 60/981,770 filed 22 Oct. 2007, the entire disclosure of which is incorporated by reference.

TECHNICAL FIELD AND BACKGROUND

[0002] The present invention relates to a composite panel building and fencing systems. More specifically a system is disclosed that provides building panels in a controlled factory environment and including the assembly methods and equipment to erect and connect panels at the construction site to complete buildings and fences. The cementitious composite panels include necessary assembly and handling attachments and necessary internal plumbing, HVAC ducting, conduit, wiring and so forth.

[0003] In total, in the present invention the composite panel building and fencing system includes all of the necessary manufacturing methods and equipment to build panels in a controlled factory environment and includes the assembly methods and equipment to erect and connect panels at the construction site to complete buildings and fences. The cementitious composite panels include necessary assembly and handling attachments and necessary internal plumbing, HVAC ducting, conduit, wiring and so forth.

[0004] An important attribute, of wall panels for buildings, is that the structural materials utilized produce panels that permit nailing, sawing, and drilling and screw retention properties similar to hard wood, unlike the properties of conventional hard and brittle concrete. This attribute facilitates easy and secure mounting of cabinets or other wall-mounted accessories at any position on the wall at the job site and permits easy mounting of pictures, mirrors, shelves and like items by the home owners.

[0005] The wall and roof panel’s fenestrations are sized to fit standard flanged windows and standard skylights with no need for custom fitting and trimming. Special finishing frames or bezels may also be furnished to complete the window or skylight installations and match the particular decorative pattern selected for the structure. Likewise, the fenestrations for doors are sized to facilitate mounting of standard pre-hung doors. These features reduce the installation time and costs for installing doors and windows while providing improved appearance, fit and finish and reduce air infiltration and improve thermal efficiency.

[0006] An auxiliary part of the building system is the availability of repair kits that supply special materials for repairing panels that have been damaged by vandalism, accident or natural disasters. The supplies provided include the materials, reinforcing tape, coloring agents, patterns and the instructions that are required for panel repairs.

[0007] Material efficiency in the panels is provided by design where the materials and components are arranged to maximize the panel’s thermal resistance, thermal mass and structural strength properties on a per-unit cost basis. A unique and important energy conservation feature is provided by design of the insulating panels so they completely cover all structural elements. This eliminates any uninsulated paths between the outside and inside surfaces of the structure, that is, thermal short circuit paths are eliminated. This helps maintain the highest possible energy efficiency.

[0008] In combination, these features insure the building’s energy efficiency, strength, load carrying ability and resistance to environmental damage. The consistency and quality of the composite panel system are assured and costs are controlled by building the panels on automated tools and equipment in a manufacturing environment and by using modern purchasing and quality control procedures and documentation.

[0009] Computer controlled drawings and lists of panels, including self-supporting and water resistant roof panels, are scheduled and molded according to the requirements of each building design. The necessary construction equipment and methods may be provided, along with the panels, as a complete construction system.

[0010] The builder is provided all components required for producing all interior and exterior walls, floors, ceilings and roofs. Special tools and equipment are available if required by the builder. Buildings are created by erecting and interconnecting the appropriate panels onto a prepared foundation, installing doors and windows and completing the plumbing and wiring and installing the HVAC, cabinetry, appliances, fittings, fixtures and trim. These measures assure that the building can be completed in the shortest possible time and help to control construction cost and quality.

[0011] The interconnected panels produce buildings that are attractive, strong, energy efficient and low maintenance and that are fire, moisture, insect and mold resistant. They are designed to support all normal loads and offer improved survivability from assaults and overloads from earthquake, high winds, snows and floods.

[0012] Current state of the art for constructing dwellings and small buildings consists primarily in the use of wood or masonry for structural members. The structures are predominantly fabricated and/or assembled at the building site. This method of building can be wasteful in the use of materials and labor and often produces buildings of uncertain quality and with expensive delays in construction due to variations in materials, labor skills, weather and the tools and equipment that are available in various locales. The structures that are produced by these traditional methods and materials are excessively vulnerable to damage from wind, flood, earthquake and various biological and environmental hazards such as mold, termites and fire. And, when finally placed into service, they often require an inordinate amount of care and maintenance.

[0013] Traditional building methods and materials have been modified to produce improved buildings by increasing their quality and resistance to environmental hazards. However, such improvements are generally accomplished through the use of more labor and premium or extra materials. This results in increased cost of production. Cost problems are further exacerbated when increases in labor and material costs cannot be, at least partially, offset by other material and productivity cost reductions. Further costs are often incurred due to the delays caused by weather, late material deliveries and labor problems. The conclusion is that buildings produced by simple improvements in traditional materials and methods will remain excessively variable in quality and expensive to build, operate and maintain and vulnerable to fire, wind, flood, termites and so forth. These structures will
not be as safe and secure as they could be and they will often be of lower quality and of uncertain reliability with respect to environmental hazards.

[0014] There have been some successful building improvements compared to the typical traditional “stick built” methods of construction. This is particularly true in the development and application of new materials and construction methods; as has been the case in commercial construction. These improvements include the use of prefabricated steel structures and tilt-up concrete panels. Commercial steel buildings are now being produced that are attractive and low cost; however, there is still some resistance to their use in various markets, including the residential market segment.

[0015] Concrete is recognized as the world’s single most utilized building material, particularly for larger structures. Tilt-up concrete wall panels are now rather widely accepted in the commercial market. In this construction method, concrete wall panels are molded at the building site, often complete with decorative finish. The panels are tilted up and joined to form complete walls. This type of construction has materially reduced construction time. Buildings produced from built-on-site tilt-up concrete panels, however, are subject to the problems related to weather and labor and to material variations from area to area. These commercial buildings typically utilize conventional roofing in their construction because many improvements, such as steel shingles, are not suitable for their roofs. The use of conventional roofing materials and methods leaves this high cost and high maintenance portion of the building untouched by improvements comparable to those for walls. Beyond these considerations, tilt-up construction still needs a significant amount of development in order to be acceptable for residential applications. Simply stated, the tilt-up panel method of construction has not demonstrated capability to produce attractive, secure and cost-competitive residential and light commercial structures.

[0016] While concrete is certainly a leading building material, it has traditionally not been accepted for building homes in many US residential markets. However, Insulated Concrete Forms (ICF) has demonstrated some success in residential construction. In that building method, concrete forms are constructed on site from thermal insulating material, typically expanded polystyrene foam sheets, into which concrete is pumped or poured to form walls. The insulating forms remain in place as part of the wall. The walls must be finished at the building site by applying the desired interior and exterior finishes, paneling, siding and so forth that are required for protection and decoration. This construction method replaces the wood framing components in outside structural walls with concrete. But, wood components are typically retained for internal walls, ceilings and roofs. The overall appearance of homes constructed using ICF, when completed, is quite conventional. This is believed to aid in consumer acceptance of this use of concrete.

[0017] One performance advantage of ICF concrete walls, compared to conventional construction using mostly wooden components, is the improvement they provide in helping to maintain a comfortable interior environment. Comfort is improved by virtue of the wall’s thermal mass or energy storage ability and in the reduction in transmission of outside noise. The energy storage reduces the homes’ overall energy input requirement and increases the occupants’ sense of comfort as well. Even despite its advantages, ICF still suffers from the variations in cost and quality caused by building on-site and from continuing to use conventional roofing materials and construction methods and in the use of conventional interior walls and partitions and conventional exterior and interior finishing. These shortcomings limit the quality and durability of ICF structures and their resistance to damage from storms and fire.

[0018] The present invention relates to improvements in the art of constructing nearly all components for residential and commercial buildings, as well as structures such as fences, walls, safe rooms, kiosks, storage sheds and so forth from cementitious materials. The improvements relate to the advantages of using composite panels for building a structure and from the custom manufacturing methods and equipment that are used to produce the panels.

[0019] The present invention includes product design, specialized materials and formulations, manufacturing process and controls, methods and equipment used in factory facilities to produce panels. Handling and erection methods used for loading, shipping, delivering, erecting and assembling the panels to produce complete structures are included. These factors reduce construction time and cost and increase product quality, reliability and durability.

[0020] Panel production utilizes special and unique process controls, tools and equipment. The panels’ design includes custom materials and formulations and methods that improve their performance, quality, reliability and consistency.

[0021] Composite cementitious panels are used for interior and exterior walls and for floors, ceilings and roofs of residential and commercial buildings. See FIGS. 1 and 2 which show where the panels are used in a typical residential building. Several cementitious material formulations are tailored to the specific requirements of each type of panel application. For example, a light weight cellular concrete is used for walls where loads are modest and factors such as nailability are important. A high flexural strength concrete is used for floors, ceilings and roofs where long unsupported spans are important.

[0022] These variations in formulations are chosen to match panels’ physical performance to individual application requirements and to reduce overall product cost. They may include the use of standard commercial Portland cement or they may use a special custom fast setting cement to provide high early strength to allow removal of molds in four hours or less. Early strength is a vital factor in increasing equipment utilization, product production rate and to lowering product costs.

[0023] The structures, produced from the assembly of these panels, are erected very quickly, are attractive and strong, durable and energy efficient. This construction method is much less dependent on large numbers of skilled tradesmen. And, because all walls, floors, ceilings, roofs and so forth are produced from cementitious materials, the structures have greater resistance to damage from natural catastrophes and biological and environmental hazards than conventional construction.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] The objects, features, and advantages of the present invention will be apparent from the following detailed description of the preferred embodiment of the invention with references to the following drawings.

[0025] FIG. 1 is a drawing of a flat roof design of one embodiment of the present invention.

[0026] FIG. 2 is a drawing of a pitched roof design of one embodiment of the present invention.
FIG. 3 is a drawing of a roof panel and parapet connection of one embodiment of the present invention.

FIG. 3a is a drawing of an enlarged view of the parapet and roof connection of one embodiment of the present invention.

FIG. 4 is a drawing of a wall to foundation or wall connection of one embodiment of the present invention.

FIG. 4a is a drawing of an enlarged view of a roof and wall connection of one embodiment of the present invention.

FIG. 4b is a drawing of an enlarged view of a wall foundation connection of one embodiment of the present invention.

FIG. 5 is a drawing of a foundation or wall connection to a roof of one embodiment of the present invention.

FIG. 5a is a drawing of enlarged view of a roof wall connection of one embodiment of the present invention.

FIG. 5b is a drawing of an enlarged view of a wall foundation connection of one embodiment of the present invention.

FIG. 6 is a drawing of an electrical wireway of one embodiment of the present invention.

FIG. 7 is a drawing of a wall panel cross section of one embodiment of the present invention.

FIG. 8 is a drawing of a cast panel in a floor application of one embodiment of the present invention.

FIG. 9a is a drawing of a fence of one embodiment of the present invention.

FIG. 9b is a drawing of a fence of one embodiment of the present invention.

FIG. 9c is a drawing of a fence of one embodiment of the present invention.

FIG. 9d is a drawing of a fence of one embodiment of the present invention.

FIG. 10a is a drawing of a fence of one embodiment of the present invention.

FIG. 10b is a drawing of a fence of one embodiment of the present invention.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

Various aspects of the illustrative embodiments will be described using terms commonly employed by those skilled in the art to convey the substance of their work to others skilled in the art. However, it will be apparent to those skilled in the art that the present invention may be practiced with only some of the described aspects. For purposes of explanation, specific numbers, materials and configurations are set forth in order to provide a thorough understanding of the illustrative embodiments. However, it will be apparent to one skilled in the art that the present invention may be practiced without the specific details. In other instances, well-known features are omitted or simplified in order not to obscure the illustrative embodiments.

Various operations will be described as multiple discrete operations, in turn, in a manner that is most helpful in understanding the present invention, however, the order of description should not be construed as to imply that these operations are necessarily order dependent. In particular, these operations need not be performed in the order of presentation.

The phrase “in one embodiment” is used repeatedly. The phrase generally does not refer to the same embodiment, however, it may. The terms “comprising”, “having” and “including” are synonymous, unless the context dictates otherwise.

Referring to FIGS. 1 and 2, as in one embodiment is a flat roof section 10 and as in one embodiment is a pitched roof section 11. Roof panels 12 are designed as an inverted “F” beam 13. This type of section provides the required strength, uses less material and increases the panels’ thermal mass. Since unreinforced concrete beams may collapse catastrophically when grossly overloaded, roof panels 12 are reinforced with steel and fiber 14 to increase strength and to provide safety by holding a panel together in the unlikely event of a gross overload. The roof panels are joined to each other and to wall panels 20 using through bolts or rods and or concrete screws or bolts. See FIGS. 4a and 5a which show typical roof panel attachment details. The wall panels 20 are designed to span the joints between roof panels when assembled to insure that the roof panels cannot separate. The roof panels are generally molded complete with all required reinforcement, penetrations, ducts, piping, conduit and so forth.

The structural members are covered with one or more layers of thermal insulation 22. The thermal insulation 22 may be one, or a combination, of materials. The materials include conventional fiberglass and prefabricated or foamed in place foam insulation. The roof is covered with any of several water resistant decorative materials 24 that may be finished, similar to the wall panels, with various patterns, textures and colors to simulate shingles, shakes, tile or other roofing treatments. Successful simulations of conventional roof appearances are achieved through the use of durable coloring, shading and texturing materials and formulations. Special application and finish methods are necessary, along with coloring and highlighting, to achieve the desired effects. These special requirements make factory finishing the preferred method for producing the decorative panels used to cover roofs after erection, however, roof covers may be finished on-site if desired. Decorative covers for flat roofs and balconies may be surfaced with tough, reinforced elastomeric coating with special textures for safety and durability if they are to be subjected to regular foot traffic.

As in the case of the exterior wall panels, the roof’s decorative panels may be attached to individual roof panels in the factory, or they may be made large enough to cover multiple structural panels after they are erected. The roof’s decorative panels are attached using adhesives or mechanical fasteners, or a combination thereof, as designs dictate. The roof panels’ decorative layers may be mechanically joined, caulked or taped and coated at joints and penetrations after erection and installation of all penetrations. It then becomes a complete, continuous surface to minimize the possibility of leaks.

Description of Wall Panels and Interconnections

The exterior wall panels 20 are comprised of reinforced cementitious structural, insulating 22 and decorative elements 30. The structural bodies are laminated with the thermal insulating and decorative elements to form composite structural panels that are assembled into walls for homes, commercial buildings, fences and similar structures. The structural portion of exterior and interior walls and partitions is comprised of a precast cementitious main body reinforced with rebar, welded wire mesh and/or plastic or glass fiber to meet strength and safety requirements and codes.
The main body is molded complete with all necessary internal fiber and steel reinforcements and includes the fenestrations for doors, windows, vents, piping, electrical conduit, switch and receptacle boxes and so forth as applicable. See FIGS. 6 and 7.

Typical thermal insulation materials used on exterior panels include one or more layers of extruded or expanded closed or open cell thermoplastic or thermoset foams such as phenolic, PVC, polyurethane, polystyrene, polyisocyanurate and others. The insulation may be used in sheet form or foamed in place. If insulating materials are vulnerable to some particular hazards, they may be treated to improve their resistance to conditions or alternate materials used, if economically justified.

A decorative and protective exterior finish is laminated, in one or more layers, onto a substrate comprised of thermal insulating material that has necessary structural properties. The decorative finish, or layers, are applied to the substrate and may be any of several select composite materials to match the requirements of particular patterns, finishes and costs. Finished substrates are attached to the main body of the wall, either in the factory or on site as required, using adhesives or mechanical fasteners, or a combination thereof. Finish materials are preferably applied to the substrate while arranged horizontally but it may, in some cases, be applied to a vertical substrate. Suitable application methods for finish materials include casting, slip forming, pouring, troweling and spraying. Suitable finishing methods include casting, brushing, striking, stamping and rolling depending on particular textures, finishes and patterns. Common patterns and finishes include various types of siding and wood grain as well as brick, tile, stone, slate, shakes and stucco. The patterns are tinted, dyed or painted on the substrate to insures consistent control of the color and texture of the finishes. Tints and dyes may be integral with the finish materials or they may be applied to the surface or a combination of both techniques may be used to achieve desired effects.

Interior wall panels are generally composed of a single body but they may have finishes similar to exterior walls or have interior cavities to reduce weight and the amount of materials used in addition to reducing sound transmission. The interior wall and partition panels include piping, electrical conduit, switch and receptacle boxes, and so forth along with fenestrations as required by the design.

Referring to FIGS. 3 and 3a, as in one embodiment parapet walls 40 are attached to roof panels 12 with concrete screws or bolts 42. Referring to FIGS. 4, 4a and 4b, as in one embodiment wall panels 20 may be uniquely attached and secured by means of vertical through-rods or rebar 50. These rods 50 are anchored into the foundation 52 and to roof or ceiling panels 12. Referring to FIGS. 5, 5a and 5b, as in one embodiment wall panels 20 may be secured by concrete screws or bolts 56 to the foundation 50 and roof or ceiling panels 12. The foundation or floor panels 50 and individual ceiling or roof panels 12 are designed to span the joint between wall panels. When assembled, the wall attachments prevent separation of wall panels. See FIG. 7 which shows typical wall panel sections.

Description of Floor and Ceiling Panels and Interconnections

Floor and ceiling panels are similar to roof panels but may be flat slab, “T” beam, inverted “T” beam or box beam, depending on application. Floor beams may be finished with patterned or textured coatings or with traditional floor coverings such as wood, tile, carpet and others. Ceiling panels are finished similar to the interior wall surfaces. See FIG. 8 for typical floor and ceiling panel construction. In FIG. 8 shown is a floor panel 80.

The main body of the wall panel, roof panel and foundation panel is molded complete with all necessary internal fiber and steel reinforcements and includes the fenestrations for doors, windows, vents, piping, electrical conduit, switch and receptacle boxes and so forth as applicable. In FIG. 6 shown are electrical wireways 70. In FIG. 7 is a cross section of the wall panel 20 shown are electrical wireways 70 and plumbing vent 72.

The panels are joined to each other and to foundation and wall panels. Wall panels are designed to span joints between floor and ceiling panels when assembled so that these attachments prevent panel separation. See FIG. 4a and FIG. 5a which show one type of panel to panel connections. Wall panels may be attached to the foundation and to the roof or ceiling and to floor panels with continuous rods or rebar that pass vertically completely through the wall panel as shown in FIG. 4b or by shorter embedded “J” bolts or rods 60 as shown in FIG. 5b. The continuous rods or rebar are anchored into the foundation and grouted or cemented into the appropriate wall cavities. These steel rods pass through the roof, ceiling or floor panels and are attached there using flat, force distribution, washers and high strength unidirectional push-on fasteners. This configuration is designed to provide maximum strength and rigidity of the assembled structure while providing thermal expansion capability under relatively constant tension. Alternatively, the panels may be attached to foundation and roof panels using thread cutting concrete bolts or anchor bolts and brackets.

Materials for Cementitious Panels

Conventional concrete consists of Portland cement, water and coarse and fine aggregates. Aggregates are typically gravel or stone and sand but they may include other materials such as concrete waste and various types of cinders, slag, pumice, plastics and cellulose, vermiculite, zeolite, expanded clay and so forth. The use of waste and recycled materials is encouraged wherever they can be economically utilized because of the important positive effects on the environment.

Such concrete has various shortcomings in properties with respect to use in the production of the described panels. The shortcomings include excessive setting time, limited strength, brittleness, high density and unattractive appearance. The products utilized in making the referenced panels necessarily have more complex material requirements. In addition to the basic ingredients, various materials are added to:

1. Reduce setting time and density (reduced density improves nailability)
2. Increase strength and toughness
3. Increase the range of usable textures and finishes
4. Improve colorability and appearance

The additives include custom fast setting cement and other pozzolans, foaming agents, plasticizers, water reducers, modifiers, fiber, manufactured and natural sands, light weight aggregates, accelerators, retarders and modifiers. Other special materials are used in coloring and finishing of the panels. These include primers, modifiers, sealers, granules, textures and powdered and liquid dyes, tints and colors.
While, with a few exceptions, these are commercial materials, the special formulations and blending yield properties specific to application requirements.

Formulations of Products

[0066] The compressive and flexural strength of these mixtures must meet all applicable building codes and practices for concrete construction. Also, where applicable, a few percent (3 to 5%) air entrainment is specified to improve freeze-thaw and weathering resistance.

[0067] The minimum number of basic structural panel formulations is two. There is a minimum of three basic formulations required for finish panels. Other structural and finish formulations are available for special purposes.

[0068] The structural formulations include:

[0069] 1. High strength, high density, fast setting cement, sand, gravel, fiber and plasticizer and water reducer mix. This mix is used for roof, ceiling and floor panels. These panels require high flexural strength.

[0070] 2. A cellular, light weight, fast setting cement, sand, fiber, plasticizer and water reducer mix. This mix is used for most wall and partition panels that require nailability and moderate compressive and flexural strength.

[0071] The formulations for decorative finishes include various amounts of cement, sand, light weight aggregate and or foam, fiber and modifier. The decorative mixes vary in material content dependent on the application. For example, a mix formulated for floor finishing must be waterproof, strong, hard and durable to support mopping, scrubbing and continuous occupant traffic and wear. A mix formulated for finishing exterior walls must be formulated to survive temperature cycling, water, ultraviolet radiation and associated weathering. The mix for interior wall and ceiling panel finishing must be capable of good coverage in thin applications and have capabilities to be made smooth for wallpaper or to be smooth or textured with good retention of water or oil based paints.

Control of Formulations for Products

[0072] Manufacturing of the formulations is controlled by computer based mix design documents and programs that specify and control the amounts and dispensing of each constituent material and the specific mixing order, equipment used and mixing time. Curing conditions and curing time are specified for the mixes along with required test sampling frequency and the sample testing requirements. These documents and programs are used to control and confirm production of uniform products that meet performance requirements.

[0073] The single most important manufacturing consideration in panel production is the time required between pouring and safely removing the panels from the mold. This minimum curing time largely determines the manufacturing throughput and the product’s cost. Therefore, it is vital to minimize this time. To increase throughput, and reduce costs for a single shift operation, it is necessary to use a mix that develops sufficient panel strength to permit removal from the molds and for handling and storage in four hours or less. This cure time permits multiple panels to be produced per eight hour shift from each mold. During this time, the panels should reach about half of their full strength in order to be safely handled. This rate of curing is difficult, and often impossible, to achieve with conventional cement, even using accelerators.

It is best achieved by use of the proprietary fast-setting cement that has been developed. This cement dramatically reduces setting time and provides superior physical properties. Fiber and steel reinforcements may be utilized along with special modifiers to further increase strength.

Composite Panel Fences (Wall)

[0074] Shown in FIG. 9a to 9f and FIGS. 10a to 10b. This portion of the invention applies to the design, construction and assembly of fences and retaining walls, consisting of steel reinforced, concrete panels located and supported by steel reinforced concrete pylons. The pylons 90 are set on, and rigidly attached to, steel reinforced concrete bases that are pre-poured into excavations at the building site. Bases 92 may be poured only under pylon locations or they may be poured as a continuous footer where required. See FIGS. 9a to 9d. The assembled fence forms a type of construction that is suitable for a wide range of soil conditions and terrain features. See FIGS. 10a and 10b.

[0075] Panels and pylons are precast, finished, stamped, tinted or stained in a controlled factory environment and delivered to the job site ready to erect. This assures uniform high quality of the fence’s appearance, strength, function, fit and finish. The pylons and panels may include integrated cores and/or conduit, electrical boxes and so forth to reduce weight and to facilitate wiring for electrical lighting, automated gate power, controls and so forth.

[0076] The fence panels 94 and pylons can be supplied in a multitude of colors, patterns and finishes directly from the factory and ready to install on the pre-poured bases. Panels are available in various stone, brick and stucco patterns and with finishes that are resistant to rain and flooding, sunlight, freezing and thawing. They may also include an optional anti-graffiti coating that is an effective means for facilitating safe removal of graffiti from the concrete surfaces. Molded decorative concrete caps 96 are also available as an option for the tops of pylons and panels.

[0077] The fence consists of three main concrete elements. They are:

1. Fence panel
2. Vertical pylon
3. Pylon base

Fence Panel

[0081] The fence panel is a rectangular concrete body of typical dimensions:

[0082] 1. Length variable between nominal limits of 10-feet to 24-feet
[0083] 2. Height variable between nominal limits of 32-inches to 8-ft
[0084] 3. Thickness variable between nominal limits of 3-inches to 13-Inches.

[0085] Fence panels may be constructed either as a solid section or as a laminate of two or more sections. The panels may include decorative reveals on one or both sides to contain and highlight the finished and textured area(s).

[0086] The advantages of constructing panels as solid sections are principally in simplifying the molding processes. Panels constructed this way are finished on at least one side after molding. Panels assembled from multiple layers or laminates permit more of the finish patterns and texturing to be accomplished as part of molding process. Since finishing is often a very significant part of the cost of production, lami-
nated panels can offer opportunities for cost reduction depending on the finish treatment required.

All fence panels are made with multiple layers of welded steel wire and/or rebar and fiber reinforcement. The steel reinforcement is located beneath, and parallel to the fence panels' main surfaces on each side of the panel. Fiber reinforcement is uniformly distributed throughout the panel. This arrangement protects the steel from moisture and corrosion while improving the panels' strength and resistance to side forces from either direction.

Fence Pylon

The pylon is a concrete pillar or post with dimensions sufficient to receive and secure the ends of fence panels and to support part or all of the shear and overturning forces imposed on the fence. See FIG. 10. The pylons have decorative and patterned areas and reveals similar to fence panels.

Pylons are reinforced with multiple full length steel rebar. The number of rebar required depends on the application and local codes. The rebar are embedded and cast into the pylon's base, extended through, and grouted to the pylon. The pylons have one or more vertical slots into which the ends of fence panels are inserted for location and support.

Pylon Base

The pylon base is a steel reinforced, concrete body or footing cast into an excavation at the erection site. See FIG. 10. Rebars are cast into the base for attaching and securing the pylon to the base. They are located so as to support a pylon and one or more fence panels. Dimensions for bases are designed to match the load bearing properties of the soil. It also ballasts and supports the loads impressed on the panels by soil, winds and so forth. The base is designed to extend below the maximum frost depth to insure the fence's long term stability.

Fence Design and Manufacturing

All fence elements, with the exception of pylon bases, are precast in an enclosed factory environment to permit close control of the variables affecting panel and pylon dimensions, quality, strength and appearance. The concrete mixtures used for casting all structural fence elements are high strength, high density, fast setting cement, sand, gravel, fiber and plasticizer and water reducer mix. Panels require durability and high flexural strength. The formulations for decorative finishes include various amounts of cement, sand, light weight aggregate and or foam, fiber and modifier. The decorative mixes vary in material content dependent on the application. See the table below for an example of typical design requirements for a fence:

<table>
<thead>
<tr>
<th>Ground</th>
<th>5-in</th>
<th>90 mph</th>
<th>C (0.3 g)</th>
<th>Negligible</th>
<th>10-In</th>
<th>Negligible</th>
<th>Negligible</th>
<th>25°F</th>
<th>No</th>
<th>Some areas</th>
<th>71 days</th>
<th>61°F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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cess control are vital to the product’s performance, cost and market acceptance of cementitious panels.

Experience has shown that control of the amounts of materials used in concrete mixes is most precisely and reliably handled by dispensing the materials by weight. The weights of materials dispensed must still be adjusted for variations in the material properties such as the free moisture content in aggregates. Other material properties that can affect mixes that must be independently checked include:

1. Particle size distribution (fineness modulus)
2. Particle shape, roughness and chemistry of aggregates
3. Material cleanliness (amount and type of contamination)
4. Material composition (chemistry) of pozzolans and cements
5. Type and fineness of the cement
6. Temperature of the materials during mixing and curing

Industrial standard tests exist for determining material variables. After the material variables are determined, it is still necessary to control the weight of materials used in the mix. This requires highly precise weighing and dispensing equipment. This type of equipment has only recently been adopted by significant numbers of concrete producers; however, even those who use weighing equipment typically do not weigh all materials, particularly their liquid materials. Liquids are usually metered with equipment that is not temperature compensated and which can introduce even more significant errors when air is entrained in the fluid.

The weighing and dispensing system included in this invention has usable operating weight measurement capability, for all materials, of better than 1% accuracy. The system incorporates precision load cells and electronic circuitry along with custom software for weight measurement and fast, electro-pneumatic actuators for dispensing. The overall process is described below.

Solid materials, such as cement and aggregates, are delivered from bulk storage to hoppers by augers or conveyors. They are dispensed from the storage hopper, according to the formulation requirements, by weight into the mixer, directly or by conveyor. The weighing and dispensing processes utilize electronic control hardware and software.

Fluids are delivered from bulk storage by pumps to containers from which they are also dispensed by weight into the mixer, according to the formulation requirements, using electronic control hardware and software.

The order and manner in which the materials are introduced into the mixer is also automatically controlled. After materials are added, they are mixed for a specified time period, or number of mixer revolutions, under automatic control. During mixing, the moisture content and temperature of the mix is monitored along with the input torque or power to the mixer. These parameter measurements provide detailed information about the condition of the mix and permit fine adjustments, if required, to assure consistency in the properties of the cementitious products.

After the materials are mixed, the mixer’s contents are pumped or otherwise conveyed to molding tables. Molding tables are large, rigid, smooth surfaced tables onto which panel molds or forms may be placed and secured. The molding tables may be made fixed or tiltable. Tiltable tables are often used to facilitate the removal, orienting and handling of panels after molding. The panels normally do not require external heating when quick setting cement is used; however, if the desired temperature is not maintained by the reaction of cement, it is necessary to add a source of heat during curing. Heat can provide faster reaction (hydration) of the cement. After molding, the panels may be humidified and heated by fog, steam or other moisture and heating mechanisms to maintain the humidity and temperature desired during curing.

Unique adjustable molds or forms are used on the tables to facilitate making various shapes and sizes of panels while minimizing the number of molds and the amount of hardware required. The molds are quickly setup, and prepared with all the necessary reinforcement and fenestration sub-assemblies, piping, conduit, electrical boxes and so forth installed, prior to pouring each panel. During pouring of the panels, concrete test specimens are taken at specified intervals and cured according to standards. They are later tested at specific time intervals to document the strength of each batch of material used in panels.

After pouring, the panels are finished on their exposed surfaces, manually or automatically, as product volume and cost dictate. Note that the surfaces of the panel that are in contact with the table or mold have a smooth finish that normally requires only minor touchup. After finishing, the panels are covered to retain heat and moisture and allowed to cure for approximately four hours. They are then moved to a curing storage area, where they are covered and/or otherwise subjected to a controlled temperature and humidity environment during their extended curing time.

Other custom manufacturing and assembly equipment includes lifting and handling frames and gear that are used in production. Special support battens or frames may be required to support panels that have major fenestrations and also to separate, secure and protect panels during shipment. Large decorative panels, that cover multiple structural panels, are especially vulnerable and require support for handling and transportation. Other accessories are used to facilitate lifting, turning and positioning panels during special assembly problems such as positioning a panel under an overhanging obstruction.

Adjustable supports are used to hold wall and roof panels erect or in position until they are secured. Wall braces are configured to hold edges of adjacent wall panels in alignment during assembly. Adjustable roof jacks are used to position ceiling and roof panels until they can be secured. Large manual or powered clamps may be used to pull abutting panels together.

While the present invention has been related in terms of the foregoing embodiments, those skilled in the art will recognize that the invention is not limited to the embodiments described. The present invention can be practiced with modification and alteration within the spirit and scope of the appended claims. Thus, the description is to be regarded as illustrative instead of restrictive on the present invention.

What is claimed is:

1. A roof panel comprising:
   a selected one of a flat roof section and pitched roof section,
   the roof panels are designed as an inverted “T” beam,
   roof panels are reinforced with steel and fiber to increase strength and to provide safety by holding the roof panel together, the roof panels are joined to each other and to wall panels using through bolts or rods and/or concrete screws or bolts, the wall panels are designed to span the joints between roof panels when assembled to ensure that the roof panels cannot separate, the roof panels are
generally molded complete with all required reinforcement, penetrations, ducts, piping and conduit.

2. A wall panel comprising:

   a wall section, the wall panels are designed as a selected one of a solid and hollow cored section, wall panels are reinforced with steel and fiber to increase strength and to provide safety by holding the wall panel together, the wall panels are joined to each other and to wall panels using a selected one of through bolts, rods, concrete screws, and concrete bolts and any combination of through bolts, rods, concrete screws, and concrete bolts, the selected one of roof and ceiling and floor panels are designed to span the joints between wall panels when assembled to insure that the wall panels cannot separate,

the wall panels are generally molded complete with all required reinforcement, penetrations, ducts, piping and conduit.

3. A fence panel comprising:

   a fence section, the fence panels are designed as a selected one of a single solid section and a laminated double section and that facilitates production of surface patterns and relief and that have a selected one of solid and hollow panel, fence panels are reinforced with steel and fiber to increase strength and to provide safety by holding the fence panel together, the fence panels are joined to each other at pylons, the fence panels are designed to span from one pylon to another pylon.

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