

Method and apparatus for precast and framed block element construction

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RELATED APPLICATIONS

- 5 This application is related to U.S. Provisional Patent Application No. 60/417,065 filed October 8, 2002, and claims the benefit of that filing date.

BACKGROUND OF THE INVENTION

1. Field of the Invention

- 10 This invention is related to a building system that consists of pre-cast structural building blocks and precast or framed floor, wall and roof blocks, the combination of those blocks to create structural elements, and methods of manufacturing, assembly, disassembly and reconfiguration of those blocks.

15 2. Description of Related Art

Various types of construction are known in the prior art including wood framed buildings, steel framed buildings, and concrete structures.

- 20 The majority of structural design decisions that are made in conventional practice are driven by cost; there are enormous pressures on structural engineers of most building projects to minimize costs while upholding their first duty to ensure the safety of structures. These pressures tend to minimize the structure in many buildings. This tendency can be unfortunate when a structure is subjected to rare but extreme loads that cannot reasonably be incorporated into statistical load guidance provided by building codes.

Accordingly, engineered structures are typically designed to safely resist code-specified loads without necessarily providing large reserve capacity beyond that achieved by virtue of required safety factors. By building to provide structural capacities that are significantly in excess of those required to resist the minimum loads required by building codes, new opportunities are created in the functionality and versatility of the built structure.

The design of a structure of conventional construction typically seeks to concentrate forces to conserve usable floor space, and relies on secondary lateral systems, such as diagonal braces or shear walls, to stabilize the structure. Benefits can be gained by intentionally distributing structural forces across a wide base that minimizes stresses on the supporting surface.

Conventional construction generally consists either cast-in-place construction with obstructive and costly formwork, or of interconnected stick or panel framing that relies on diagonal bracing or shear walls for lateral stability. Because much of conventional construction is inherently unstable until the construction of structural diaphragms and lateral systems are complete, structural failures during the relatively brief construction period are more common than in completed buildings that stand for years of service.

The lateral bracing and shoring that is typically required for conventional construction creates building site obstructions that contribute to many construction accidents. Because conventional construction commonly involves the field assembly of parts that can be lifted and handled by one or two workers, the construction of exterior walls and roofs generally involves a significant amount of labor far above ground level; this creates the potential for falling hazards that generate the most lethal jobsite injuries. Where conventional construction utilizes large parts, such as with tilt-wall construction,

expensive crane time is typically consumed holding those parts in position while lateral shoring and bracing members and connections are installed; this is required to stabilize the part prior to releasing the hoisting lines. It is desirable to build using a system of independently stable modules that eliminate the need for temporary shoring and bracing,
5 and that allow crane time to be utilized efficiently.

In the field of concrete buildings or concrete framed structures, the structural elements are typically either cast in place on site such as with flat-plate or beam and slab type of applications, prefabricated on-site such as with tilt wall construction, or prefabricated off-site such as with precast concrete planks, tees, and wall blocks. Most
10 significant building structures are built based on a unique design that is the result of the work a team of design professionals; the design of a given building is generally unique to that project. The design of unique projects under ever-increasing time, budget, and liability pressures presents real challenges to design professionals; it also places an enormous burden on the builder that must interpret and build a unique and complex
15 project from what will inevitably prove to be an imperfect set of drawings and specifications. It is highly desirable to introduce a building system that allows design flexibility while offering vast simplifications in both design and construction; this can be accomplished by means of an expanding kit of compatible parts.

The use of on-site casting for concrete cast-in-place structures requires the
20 expense and delay of field-fabricating the forms for pouring concrete. It is desirable to provide concrete structural elements which can be built in stacks or mass-produced by other means either on-site or under factory controlled conditions.

Tilt wall construction provides some advantage in pre-casting wall elements, but has the disadvantage of requiring the advance construction of large areas of grade-

supported slab to serve as a casting surface for the wall blocks. Tilt wall construction also requires the use of temporary shoring during the assembly process to hold walls in place until additional structural elements are attached to the walls. It is desirable to provide pre-cast concrete structural elements that can be assembled into a variety of structural
5 elements and finished buildings without the use of temporary shoring.

Concrete building blocks such as cinder blocks are typically provided in relatively small units that require labor-intensive mortared assembly to form walls and structures. It is desirable to provide larger structural units that can be site cast in stacks or trucked to a job site and assembled together into a wide variety of structural forms without extensive
10 use of mortar or adhesive.

Once conventional construction is complete, the modification or removal of a finished building generally involves destructive demolition. It is common practice in conventional construction to design for a relatively short building life span, and to simply demolish buildings that because of age, location, or poor initial construction have met the
15 end of their useful service lives. This practice results in millions of tons of construction debris being hauled to landfills every year. It is desirable to build using a system that is built of durable but cost-effective construction and which offers ease of modification or removal and reuse without the waste of materials and manpower associated with conventional demolition practices. It is desirable to introduce a building system that
20 enables the wholesale recycling and reuse of entire buildings by use of durably constructed large-scale building blocks.

This invention provides the unexpected benefit of deliberately using a large footprint for structural modules. In typical construction, support elements such as concrete columns or steel beams have relatively small footprints to maximize usable floor

space of a structure. In this invention, blocks and structural modules with large footprints are used. The advantages of this approach include the ability to construct a structural frame from relatively simple planar elements that can be cast on site or efficiently manufactured under controlled conditions and shipped to the site. Much of the assembly
5 can be done at ground level. Structural modules assembled in this manner may be erected quickly and are stable without temporary shoring. The completed frame may be disassembled quickly, and components can be reused. There is less load per area on base elements, so slab or foundation requirements are relaxed. Some applications can be assembled on grade. In many cases, the space inside the structural modules can be
10 accessed and used effectively.

BRIEF SUMMARY OF THE INVENTION

The method and apparatus for construction described herein provides a system of precast reinforced structural building blocks that may be replicated and combined with
15 identical blocks to form a variety of structural elements, and with modified but similar and complimentary blocks to form a complete primary structure. The primary structure can then be enclosed using manufactured blocks or either precast or framed construction to establish perimeter walls and roofs.

In various embodiments of the current invention, precast elements maybe
20 fabricated in an efficient controlled environment such as through stack casting to provide plurality of building elements which maybe configured into a wide variety of desirable structures. The elements that can be created by combining modular blocks include walls, portions of walls, support columns, roof trusses and completed structural frames. These building blocks may be quickly assembled at a construction site and may be supported on

a concrete slab, on discreet foundations, and in some cases directly on grade. By combining individual blocks or combinations of blocks with other combinations of blocks, diverse structural frames and buildings can be quickly designed and assembled. By building using large manufactured blocks with simple bolted or interlocking connections, frames and entire buildings of this construction can also be modified or dismantled without demolition.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

These and other objects and advantages of the present invention are set forth below and further made clear by reference to the drawings, wherein:

FIG. 1A is an elevation view of a single block.

FIG. 1B is an isometric view of the block of FIG. 1A.

FIG. 2A is a perspective view of blocks being lifted by a top edge.

FIG. 2B is a perspective view of blocks being lifted by a first edge chord and assembled on the ground.

FIG. 3A is a front view of various block configurations

FIG. 3B is a cross section view of a rectangular beam

FIG. 3C is a cross section view of a six sided polygonal beam

FIG. 4 is a front view of a variety of block shapes.

FIG. 5A is a front view of biaxial block connection sleeves

FIG. 5B is a perspective view of biaxial block connection sleeves

FIG. 6 is a perspective view of a portion of the block reinforcement

FIG. 7 is a perspective view showing the alignment and connection of blocks with biaxial sleeves.

FIG. 8A is a detailed perspective view of a portion of a form with a sleeve receiver

FIG. 8B is a detailed perspective view of a portion of a form with a sleeve and a sleeve receiver

FIG. 9 is a front view of typical reinforcement for a block.

5 FIG. 10A is a perspective view of a reinforcement cage step in a stack casting sequence

FIG. 10B is a perspective view of a first level form tying step in a stack casting sequence

FIG. 10C is a perspective view of a first level concrete cast step in a stack casting sequence

FIG. 10D is a perspective view of an inverting forms step in a stack casting sequence

10 FIG. 10E is a perspective view of a subsequent level preparation step in a stack casting sequence

FIG. 11 is a perspective view of several block columns attached to a surface with connectors through base sleeves.

FIG. 12 is a perspective view of pairs of blocks forming "L" shaped elements.

15 FIG. 13A is a perspective view of several blocks forming a flat wall.

FIG. 13B is a perspective view of several blocks forming a perimeter wall system of arbitrary layout

FIG. 14 is a perspective view of several blocks forming a pilastered wall.

FIG. 15 is a perspective view of several blocks forming a ribbed wall.

20 FIG. 16 is a perspective view of several blocks forming square and rectangular box columns.

FIG. 17 is a perspective view of box columns supporting steel floor framing blocks.

FIG. 18 is a perspective view of a completed primary structural frame with box columns supporting roof trusses on discrete cap elements

- FIG. 19 is the frame of FIG. 18 carrying light-gage steel secondary framing
- FIG. 20A is a one-story block with cantilever chord extensions at the second level
- FIG. 20B is a two-story block with cantilever chord extensions at the second level
- FIG. 20C is a three-story block with cantilever chord extensions at the second level
- 5 FIG. 20D shows a three-story block with a lateral bay to carry a shed roof and an omitted bottom chord for pedestrian passage
- FIG. 20E is a two-story block with an omitted bottom chord for pedestrian passage
- FIG. 20F is a three-story block with cantilever chord extensions and a sloping top chord for roof block support
- 10 FIG. 20G is a one-story block with a sloping top chord
- FIG. 20H is a one-story block with a stepped, double-sloping top chord
- FIG. 20J is a two-story block with a stepped bottom chord to receive a dropped floor and a sloping top chord for roof block support
- FIG. 21A is a triangular block
- 15 FIG. 21B is a wishbone spacer block for connection of two adjacent blocks into a module
- FIG. 21C is a roof truss block with a segmented arc top chord
- FIG. 21D is a bowstring truss block with a steel tie rod
- FIG. 21E is a perspective view of a corner cap block
- FIG. 21F is a view of the underside of the block shown in 21E
- 20 FIG. 22A is an exploded perspective view of a paired roof truss module
- FIG. 22B is an asymmetric box column
- FIG. 23A is a framed wall block with light gauge metal wall framing
- FIG. 23B is an inside view of the wall block shown in FIG. 23A

FIG. 23C is an exterior view of three varieties of precast wall blocks that depicts a cast pattern that emulates stacked stone

FIG. 23D is an inside view three varieties of precast wall blocks

FIG. 23E is hinged wall blocks

5 FIG. 24A is a view of the interior framework of a framed wall block

FIG. 24B is a view of the framed wall block of FIG. 24A with inner and outer metal skins installed

FIG. 25A is a perspective view of an assembled wall block on open box columns

FIG. 25B is a detailed view of a hanger connection.

10 FIG. 26A is a top view of precast roof blocks

FIG. 26B is an underside view of precast roof blocks

FIG. 27A is a perspective view of steel framing for a framed roof block

FIG. 27B is a perspective view of a framed roof block with metal panels installed

FIG. 27C is a detail view of a bolted connection clip

15 FIG. 27D is an underside view of the completed roof block

FIG. 28 is an assembly of a roof block on an asymmetric column

FIG. 29A is an assembly of two box columns fitted with bolted haunches carrying floor support blocks

FIG. 29B is three winged box columns supporting precast floor blocks

20 FIG. 29C is a top view of two precast floor blocks

FIG. 29D is an underside view of two precast floor blocks

FIG. 30A is an exploded view of a three part precast floor block assembly

FIG. 30B is an underside view of a precast floor block assembly

FIG. 31A is three modules that are used to begin assembly of a structural shell

FIG. 31B is three modules with installed floor blocks

FIG. 31C is three modules with installed wall blocks added to the structural shell

FIG. 31D is a completed structural shell with roof blocks

FIG. 32A is six modules on a slab with an overhang that is used to build a structural shell

5 FIG. 32B is the addition of suspended access floor blocks and paired roof truss modules

FIG. 32C is adding the installed wall blocks, clerestory blocks, wall header blocks, and sliding door blocks

FIG. 32D is the enclosed structural shell completed by the installation of roof blocks

FIG. 33A is twelve box columns sitting on a slab to begin assembly of a structural shell

10 FIG. 33B is a detailed view of bolted haunches

FIG. 33C is a perspective view of box column modules carrying framed floor blocks

FIG. 33D is a primary frame with solid cap blocks carrying tied bowstring trusses

FIG. 33E is a near completed structure after installation of precast wall blocks, metal wall studs, and metal roof deck

15 FIG. 34A is an example of a multi level structural shell with slab, box columns, various winged box columns of various heights

FIG. 34B is an example of a multi level structural shell with the addition of cap blocks, floor modules and a hinged wall block.

FIG. 35A is an example of walk through box columns on a slab with simple box columns
20 at each end

FIG. 35B is the addition of the corner cap elements and cap elements added to the walk through box columns and box columns

FIG. 35C is the addition of wall and low roof blocks to the assembled structure

FIG. 35D is the upper roof consisting of framed roof blocks and clerestory roof blocks

DETAILED DESCRIPTION OF EMBODIMENT – Precast and framed construction blocks

A basic block of one embodiment of the invention is shown in FIG. 1A and FIG. 1B which are an elevation and isometric view of a single block. It is from the geometry of this most basic block of the building system that LadderBlock™ derives its name. The block **10** shown is 5 feet wide, 30 feet tall, and 6 inches thick, with two edge chords **21** and **22**, and three vertical openings **41-43** defined by beam sections **31-34**. This block is referred to as a three-story block in this discussion. In one example, reinforced concrete chord sections of this embodiment are 6" wide by 6" thick, and beam sections are 12" deep by 6" thick. The block overall geometry, dimensions, number of openings, cross-sectional dimensions and reinforcement may each be adjusted within practical limits for a specific application.

The design of this system is intended to allow the rapid replication of identical high-quality building blocks to serve as large-scale building elements that enable rapid but sturdy construction. The control and assurance of quality construction can readily be achieved by the repetitive manufacture of identical parts. Blocks are generally intended to be cast flat and then lifted into position. FIG. 2A is a perspective view of blocks **10** being lifted by a top edge **34**, such as by a crane (not shown). Fig 2B is a perspective view of blocks **10** being lifted by a first edge chord **21**, and then assembled on the ground as illustrated by block **10a** being attached by a edge chord **22** to the first edge chord.

Replication of blocks may be accomplished by stack-casting a series of blocks one on top of another, or by means of a forming system that allows rapid stripping and re-

utilization of forms. Blocks may be site-cast on a previously built concrete floor slab, or they may be precast and shipped to the jobsite on flatbed trailers.

Block geometry

The configuration of a block may be modified in several ways, such that a
5 given block geometry may be manipulated by the design professional as required for a specific use. Blocks are planar elements that generally consist of two or more chords with monolithically cast rigid joints at chord intersections. Chords may or may not be orthogonal to one another, and they may cantilever beyond the shape enclosed by other beams and chords as required to provide extensions for the support of foundation, floor,
10 or roof elements. Cross-sections of block chords may also be thickened and more heavily reinforced where required by structural analysis. In addition, cross-sections of beams and chords may be modified in cross-section to be other than rectangular as shown in FIG. 3B; what is essential to permit stack-casting and stacked shipping is that elements remain planar. If cast in separable forms, for example, it is convenient for beam and chord cross-
15 sections to incorporate a taper from each side toward the centerline of the cross-section to facilitate form stripping, as indicated in the beam cross-section FIG. 3C. The resulting six-sided polygon presents new opportunities for the interlock of supported parts, as depicted in FIG. 3C. Referring again to FIG. 1A and 1B, the geometry in the example embodiment provides three openings through the erected block with a horizontal
20 clearance of 4 feet between parallel chords and a vertical clearance of 8 feet 8 inches between parallel beam elements. These clear openings are constricted by 4 inch chamfers 38 at each corner, and are intended to provide the required headroom and lateral clearance required for a person to pass through the opening with floor framing supported by the beam element below the opening.

In addition to dimensional variability described above, the base block may be modified by the introduction of additional and variously spaced beam elements as illustrated in FIG. 3A which is a front view of various block configurations **10c-10g**. The beams may be used to stiffen the block or to provide additional lines of support for
5 secondary framing where passage through the block is not required. FIG. 3A illustrates variability of block height, block width, the number and location of beams in a block, and in the beam or chord cross sectional shape.

The beams and chords need not be orthogonal. FIG. 4 is a front view of a variety of block shapes. For instance, block **12** includes the addition of sloped diagonal struts **61**.
10 Struts may be steel assemblies that are designed to bolt to cast-in sleeves, or they may be reinforced concrete cast monolithically with the module.

Block **11** illustrates the use of a sloped chords **23** such as may be utilized to build a battered wall, to stiffen a block in response to high lateral forces, or to utilize a block as a long-span horizontal framing member.

15 A sloped chord roof truss **13**, may be formed by assembling two sloped chord blocks **11** with optional diagonal struts **61**, or may be cast as a single unit.

Biaxial block connection sleeves

In one embodiment, the block is designed to incorporate a series of cast-in sleeves that serve a number of functions. In this embodiment, sleeves are shown as 1 ½”
20 diameter steel pipe. Sleeves are intentionally oversized to provide fit-up tolerance. Threaded rod connectors that pass through the 1 ½” diameter sleeves will typically be in the ¾” to 1” diameter range. In this embodiment, pipe sleeve lengths are 6” through chord sections and 12” through beam sections, and pairs of sleeves **101** and **102** are

centered and tack-welded at 90 degrees to one another, as illustrated in FIG. 5A and 5B, to form biaxial modular connection sleeves **100**.

These pairs of connection sleeves are positioned at modular locations within each chord element, typically centered within the reinforcement **120** as shown in FIG. 6.

- 5 Other sleeves such as vertical sleeves **103** for attachment to a foundation, attachment of roofing elements, or attachment of shelving or flooring members are typically also included in the block reinforcement.

In this embodiment, the sleeve pairs are asymmetric and may be rotated 90 degrees from the left edge chord **22** to the right edge chord **21** of the block as shown by
10 pairs of connection sleeves **105** and **106** in FIG. 7. The result of this rotation is that a chord sleeve at any given level will align with its counterpart in a second identical block, but it will also align with a sleeve in the 90 degree opposing face of the other chord of the second identical block. For instance, block **10i** is located between block **10h**, which is rotated 180 degrees with respect to block **10i**, and block **10j** which is rotated 270 degrees
15 with respect to block **10i**. By rotating a block in plan, one can therefore interconnect identical blocks to form a variety of configurations, as described below. In other embodiments, the sleeve pairs are symmetric so that they can be used to form modules such as paired trusses or asymmetric columns as discussed below.

In addition to the interconnection of blocks, sleeves may serve a number of
20 functions both during construction of the block and in the assembled structure. During construction of the block, sleeves serve as internal chairs to hold reinforcing steel in position. Referring now to FIG. 8A and 8B, which are detailed perspective view of a portion of a forming system for this embodiment, form **201** incorporates a sleeve receiver **120** on its inside face that positions sleeve **100** and provides a simple method for tying the

form together during casting. As described below, forms may also incorporate a spaced sleeve receiver that serves to position the form for a subsequent, stack-cast replication of the block.

Sleeves also provide connection points for stripping and lifting the cast block, and
5 for connections to and support of secondary framing in the assembled structure. Sleeves through beam elements provide opportunities for anchor bolt connections to the supporting structure, for the connection of intermediate levels of supported framing, and for the connection of cap elements or roof framing.

10 Where the structural spacing and interconnection of two identical, asymmetrical blocks is desired, as depicted in FIG. 22A and 22B, biaxial connection sleeves are oriented to provide consistent sleeve heights at each side of the spacer block. In cases such as this the orientation of biaxial sleeves is not rotated 90 degrees between sides, but is placed consistently at both edge chords of the spacer block such as 290 in FIG. 22B.

15 Biaxial modular connection sleeves allow the designer near limitless variety in the structural assemblies including wall blocks, box columns, paired blocks, and trusses that may be built into structural modules using repetitive identical elements. Potential configurations may include, but are not limited to, the following structural elements. A single block may be used as a lightly loaded column and/or a pilaster for the lateral support
20 of secondary exterior wall framing as illustrated in FIG. 11. A pair of blocks **10a** and **10b** may be connected at 90 degrees to form an "L" shaped element as illustrated in FIG. 12. A series of blocks **10m-10p** may be interconnected, by rotating alternating blocks by 180 degrees in plan to align modular sleeves, to form a flat wall as illustrated in FIG. 13. A combination of blocks may also be used to construct a perimeter load-bearing wall

system of arbitrary shape as illustrated in FIG. 13B. A similar assembly that also utilizes additional blocks **10q-10r** to form a pilastered wall system as illustrated in FIG. 14. A series of blocks **10s-10v** may be interconnected at 90 degree angles to one another to form a ribbed wall system as illustrated in FIG. 15.

5 A rectangular or square box column **70** may be constructed from blocks **10w-10z** as illustrated in FIG. 16. Square box columns are formed by radial lapping of block edges, and rectangular box columns are formed by paired spacer blocks between outer blocks. Asymmetric blocks may also be used to construct asymmetric column elements **290** as illustrated by FIG. 22B.

10 Biaxial sleeve connectors may be omitted in other embodiments where alternate connection means, such as mechanical interlock, are provided for the combination of blocks into structural modules and completed structures.

Cross-section and Reinforcement Design

Concrete cross-sections, reinforcing steel bar sizes, and tie spacing may be
15 selected by the structural engineer on the basis of anticipated design forces for a given application. A block must be designed to safely resist stripping and handling forces, gravity loads, shears, lateral loads, and forces induced by the interaction of the block with other elements. This system is intended to give the design engineer flexibility in the selection of geometry, cross-sections and reinforcement as required for a specific
20 application.

Construction of Block

In this embodiment, the construction sequence for stack-cast blocks is designed to yield easily and quickly erected structures. As noted above, sleeve assemblies may be pre-cut and tack-welded. Referring now to FIG. 9 which is a front view of typical

reinforcement for a block, reinforcing steel cages **220** are tied into units using deformed bar or wire ties. The ties may be standard cross-ties or they may spiral ties **225** as shown.

FIGs 10A-10E illustrate a stack casting procedure. FIG. 10A is a perspective view of a reinforcement cage step in a stack casting sequence. Reinforcing steel is spaced and
5 held in position by the sleeve assemblies **100**, which are in turn held in position by sleeve receivers **120** mounted on the forms **201**. FIG. 10B is a perspective view of a first level form tying step in a stack casting sequence. After the tied cage **220** is positioned in the form **201** and **202** sleeve receivers **120**, threaded rods **210** are temporarily placed through sleeves and forms, and nuts are tightened on rods to tie the side forms together. FIG.
10 10C is a perspective view of a first level concrete casting step in a stack casting sequence. For the first block **240** in a stack, the form set may be temporarily anchored to a casting slab or surface. Bond between the casting slab concrete and the element is prevented by use of a sheet membrane or common bond-breaker applied to the casting surface. FIG.
15 10D is a perspective view of an inverting forms step in a stack casting sequence. After casting and initial curing of the first block **240**, forms are stripped, and a bond-breaker is applied to the top surface of the cast block. FIG. 10E is a perspective view of a subsequent level preparation step in a stack casting sequence. The forming systems of this embodiment is designed to facilitate stack-casting, and can incorporate extension tabs **208** and spaced sleeve receivers **120** that allow a form section **201**, **202** to be inverted after the
20 first cast and the spaced receiver to be “snapped” onto the cast sleeve in the first block **240**. This positions the sleeve receiver at the correct location to receive the sleeve and reinforcing steel cage for the second block. This system allows multiple blocks to be stack-cast and consistently reproduced, one on top of another, quickly and easily.

Frame Components

The LadderBlock™ Building System derives its name from the most basic block in the building set as shown in FIG. 1. The framing system consists of planar elements that form story-high rigid frames, and may be multi-story with multiple lateral cells as shown in FIGs 20A through 20I.

FIGs 20A through 20I are representative shapes of planar structural blocks. FIG. 20A shows a simple rectangular block such as a one story block **230** which includes a top beam **34** having a cantilevered extension **50** on both sides.

FIG. 20B shows a rectangular block with cantilevered extensions **50** from each side of an intermediate beam **32**.

FIG. 20C shows a taller rectangular three story block **234** with cantilevered extension **50**, these cantilevered extensions typically serve as bearing supports and are designed to occupy recesses in the underside beams of interlocking floor blocks (not shown).

FIG. 20D shows a stepped block **236** which includes a first edge chord **21**, a second edge chord **22**, an intermediate chord **23**, a first top beam **36** between the first edge chord and the intermediate chord, and a second top beam **35** between the second edge chord and the intermediate chord. Typically the second top beam **35** is used to support high roof structural elements. The first top beam **36** is used to support a low sloped roof.

FIG. 20E shows an open rectangular block **238** without a base beam which is omitted to allow pedestrian access without a tripping hazard.

FIG. 20F shows rectangular element **240** which includes a sloped cantilevered extension **52** from top beam **34**. This combination of top beam **34** and extension **52** is used to support a high roof with overhang.

FIG. 20G shows a simple block which includes a sloped top beam **34**. FIG. 20H shows a stepped block **244** with two sloped top beams **35** and **36** and an intermediate beam **23**. This top beam configuration accommodates planar roof blocks of opposing slopes and clerestory windows for natural lighting.

FIG. 20I shows a planar block **246** with a first side edge chord **21**, an offset extension **51**, a top beam extension **52** and an intermediate beam extension **50**. The ends of these extensions are connected by a vertical chord **24**. In some cases the offset extension **51** is above the surface and in some cases it is below the surface. While base beam **31** distributes loads to the supporting foundation, offset extension **51** is intended to cantilever beyond the supporting foundation edge with the top of the lower extension at the same elevation as the top of slab. The first edge chord **21** and the second edge chord **22** may rest on a slab such that the first edge chord overhangs the slab. In other embodiments, the two edge chords may rest on discrete footings.

FIG. 21A shows a basic triangular block **260** having a first edge chord **21**, a top beam **34** and a base beam **31**.

FIG. 21B shows a wishbone spacer **280** having a first flange **281** and a second flange **282**.

FIG. 21C shows a segmented arc roof truss **300** having a first edge chord **301** and a second edge chord **302**, a base beam **311**, and segmented top chords **304**, **305**, **306**, and **307**. In this example the roof truss includes the notches or daps **303** which are typically used to provide a horizontal bearing surface at truss supports. Referring again to FIG.

20F, the first edge chord **21** has an extension **28** which provides the horizontal bearing surface.

FIG. 21D shows a tied bowstring truss **319** with a segmented arch top chord **320**, a steel tie **321**, a bearing seat **324** and a tapered key **322**.

5 FIG. 21E shows a perspective view of a cap element **400**, with side beams **401** and **402**, box column split pockets **403** and **404**, with a cross beam **405**, and a tapered key receiver **406**. FIG. 21F shows a view of the underside of cap element **400**.

FIG. 21G shows a corner cap element **410** incorporating a side beam **401**. The end **413** of a cap element is typically centered over a box column, such that the ends **412** and **413** meet over a corner box column. FIG. 21H shows an underside view of the
10 corner cap element **410**.

FIG. 21I and 21J show top side and underside views of another embodiment cap element **409** that features simple cross beams **405**, split box column pockets **404** and box column pockets **420** that center over a box column, and cantilevered extension **422**.
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DETAILED DESCRIPTION OF EMBODIMENT –Structural Modules

In one embodiment, these structural blocks are typically combined into structural modules such as box column **70** as shown in FIG. 16 and other examples discussed below.

20 FIG. 22A is an exploded perspective view of a paired roof truss module **440** which comprises a pair of segmented arc roof trusses **300** joined by wishbone spacers **280**. In this example the segmented arc roof trusses are held in rigid parallel alignment by the wishbone spacers such that they form a laterally stable structural module that may be preassembled at ground level and hoisted into position as a unit. In this example the

module is assembled by a threaded connectors inserted through beam or chord elements **308** and wishbone spacer flange such as **281**. Other connection schemes may be used.

FIG. 22B shows an asymmetric box column **450** formed by a pair of stepped blocks **246**, a rectangular block **248**, and a rectangular block **290** with bolted edge chord extensions **291** and **292**. The bolted edge chord extensions work in conjunction with edge chord extension **28** of stepped block **246** to form a keyed and bolted bearing seat for paired roof truss module **440**. This mating is shown in perspective in FIG. 28.

One embodiment will employ at least two basic methodologies of combining structural modules to form complete building structures. One method, as depicted in FIGS. 18 and 32B, can be characterized as base modules such as **70** and **450** supporting discrete roof blocks or modules such as **15** or **440**. A second method incorporates cap blocks such as **400** and **409** of FIGs. 21E and 21I spanning between and bearing on base modules to support a series of more closely spaced roof framing blocks, as shown in FIGs. 33D and 35B.

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DETAILED DESCRIPTION OF EMBODIMENT – Wall Blocks

FIG. 23A shows a framed wall block **460** with light gauge metal wall framing, an inside surface **462** and outside surface **461**. Metal wall blocks on both faces of the block provide finished surfaces and stressed skin panel rigidity for handling of the block. In a design environment that generally emphasizes the most efficient use of materials possible, the use of metal panels on both faces of a wall element in an industrial building is non-obvious. The incorporation of the inner skin brings significant benefit by creating a stressed-skin panel that is structurally redundant and is of sufficient durability to resist lifting and handling forces on the block and to carry reactions back to discreet and simple

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connections, thus allowing ease and speed of assembly and disassembly. This feature enables the wholesale recycling of buildings without visits to the landfill, as well as enabling the rapid erection of quality buildings where needed, as in the case of an emergency relief shelter. FIG. 23B shows an inside view of the wall block shown in FIG.

5 23A.

FIG. 23C shows an exterior view of three varieties of precast wall blocks **470**, **471**, and **472**, and depicts a cast pattern that emulates stacked stone. FIG. 23D shows an inside view of the same three blocks. These blocks feature flanges such as **473** to interlock with beam elements of the LadderBlock frame. In another embodiment, keyed
10 interlock connections are omitted in lieu of bolted flange connections through LadderBlock sleeves.

FIG. 23E shows hinged wall blocks **475**. FIG. 24A is a view of the interior framework **465** of another embodiment of a framed wall block **464**. The framework includes bent plate clips **466** which typically engage box column beams. FIG. 24B shows
15 the framed wall block of FIG. 24A with inner and outer metal skins installed.

FIG. 25A is a perspective view of an assembled wall block on open box columns. The wall block **464** may be hung on cross beams **32** of LadderBlock **248** which is part of open box column **451**. FIG. 25B is a detailed view of this hanger connection. Heavy precast wall blocks and framed wall blocks that are restrained against upward movement
20 by roof elements may rely solely on interlock for connectivity to the base structure, but wall blocks that do not meet these criteria must be bolted to the supporting structure to ensure competence under high wind loads.

DETAILED DESCRIPTION OF EMBODIMENT – Roof Blocks

FIG. 26A is a top view of precast roof blocks **480** and **482**. FIG. 26B is an underside view of those same blocks, and shows tapered beam **481** which is upslope of beam **484**. These beams serve to carry joists **483** and bear on LadderBlock module beams at bearing seats **485**. In most applications, the mass and interlock of precast roof blocks offer sufficient connection to the supporting structure such that mechanical connectors may not be required.

FIG. 27A is a perspective view of steel framing **492** for framed roof block **490**. These lighter blocks require bolted connection clips **493** to resist wind uplift pressures; these clips are shown projecting from the underside of the framing in FIG. 27A. FIG. 27B shows a perspective view of framed roof block **490** with metal panels installed. As with framed wall blocks such as **460**, framed roof blocks **490** typically incorporate an inner and outer structural skin to enable lifting and handling of the block. FIG. 27C is a detail view of a bolted connection clip **493**, and FIG. 27D shows an underside view of the completed roof block **490**.

FIG. 28 shows an assembly of a roof block **490** on an asymmetric column **450** as shown in FIG. 22B. The roof block is mounted on top beams **34** of stepped block **246** with bolted connection clips **493**.

DETAILED DESCRIPTION OF EMBODIMENT – Floor Blocks

FIG. 29A shows an assembly of two box columns **70** fitted with bolted haunches **76** carrying floor support blocks **496** which in turn support framed floor blocks **494**. Bolted haunches **76** are shown in detail in FIG. 33B.

FIG. 29B shows three winged box columns **74** each comprised of pair of blocks **232** and a pair of rectangular blocks **10**. The winged box columns are shown supporting

two interlocking interior spans of precast floor block **486** and one precast floor end block **488**. FIG. 29C shows a top view of these two floor blocks and FIG. 29D shows an underside view of the same blocks. The beam configuration on the underside of these precast floor blocks forms receiving pockets **489** for bearing on cantilevered beam extension of blocks **232**.

FIG. 30A is an exploded view of a three part precast floor block assembly consisting of interior block **500**, infill frame **506**, and infill plank **504**. FIG. 30B shows an underside view of this precast assembly installed on stepped blocks **510**.

10 DETAILED DESCRIPTION OF EMBODIMENT – Erection of Modules

Upon completion of casting, blocks are allowed cure until concrete has gained the necessary strength to resist lifting and handling forces. The initial lifting operation must break the suction and/or bond forces on the down-cast face of the element. Stripping forces can represent the most severe loading to which a block will ever be subjected. On blocks that are too slender to strip from upper lifting sleeves (as shown in FIG. 2A) without damage to the element, stripping may be accomplished by using a strong-back (as illustrated in FIG. 2B) that simultaneously lifts from several of the chord sleeves. Once the block is broken loose from its casting surface, typically a casting slab or an underlying stack-cast element, it is lifted into vertical position by crane rigging that utilizes cast-in sleeves as lifting points. Slender blocks may require the use of a strongback during lifting, or they may be interconnected to one or more perpendicular blocks while still laid flat.

A stiffened structure that is formed of interconnected blocks will be more easily erected. The risk of damage due to lifting stresses is reduced and the structural assembly

is more likely to be independently stable without the need of temporary bracing. The weight of the example embodiment is on the order of 3,500 lb, and a four-block box column weighs 7 tons, so that only a light crane is required to lift these elements.

After lifting, the block or assembly is set in its designated position. Referring now
5 to FIG. 11, base connections on a slab **50** may consist of pre-set anchor bolts or drilled
and epoxy or grout-set threaded rods that pass through base sleeves **103** and are tensioned
using nuts in combination with oversized washers or spreader plates. An erected block
that has not been assembled into a structural module can be temporarily braced using
diagonal struts that are perpendicular to the face of the block, by immediate connection to
10 other stable blocks; but the preferred construction method using this system will consist
of the assembly of multiple blocks into independently stable modules prior to lifting.
When they are required, temporary struts may connect using modular sleeves and
temporary anchors to the slab. Final construction will typically employ interconnected
assemblies of perpendicular blocks or lateral bracing via secondary members **52**.
15 Interconnection of blocks is accomplished using washers and nuts in conjunction with
standard length threaded rods that pass through modular connection sleeves. Secondary
elements such as wall girts, roof purlins, or miscellaneous framing may be similarly
connected at modular connection sleeves. In a building that incorporates wall, floor and
roof blocks of this system, girts and purlins are replaced with blocks of construction that
20 are built at ground level, lifted into position with a light crane, and connected to the
structural frame by means of interlocking or simple bolted or interlocking connections.

This system is designed to allow forces to be distributed over a relatively large
area at the base of a structural assembly and to receive forces from multiple sources at the
top of an assembly, such as roof framing and rail beam for bridge crane carried on a

single box-column assembly, while concurrently providing an element with inherent lateral stability and the potential for a flexible range of secondary functionality. For example, blocks may carry intermediate floors or industrial shelves, and closed box-column sections may house storage space, mechanical rooms, restrooms, elevators or
5 other building functions.

Load Bearing Capacity

The LadderBlock building system is designed to allow the economical construction of structures that can safely carry loads that are much greater than most conventional building systems are designed to carry. By building to provide structural
10 capacities that are significantly in excess of those required to resist the minimum loads required by building codes, new opportunities are created in the functionality and versatility of the built structure. Buildings of this construction can generally carry high-load floors, support heavy hinged-panel operable walls, provide support for hoisting systems, and carry future levels of floor structure without modification to the original
15 structure. This reserve structural capacity is achieved economically through the straightforward, repetitive construction at ground level of identical pre-engineered blocks.

Construction Stability and Speed

Although blocks may be combined in a variety of configurations, the basic methodology at play in this building system is the interconnection of manufactured blocks
20 to form independently stable structural modules; these modules generally form three-dimensional multi-sided frames. Precast blocks are generally open frameworks with rigid joints at member intersections. They are made of structural-grade castable material such as concrete and are reinforced, such as by rebar, as indicated by an engineering analysis for a given application. Precast and framed blocks are designed to be easily

interconnected to form independently stable structural modules. This enables the construction of structural modules that can be set in position with a light crane and immediately let go, without the need for installation of temporary lateral bracing prior to releasing the hoist lines, as is necessary with tilt-wall construction. This feature allows
5 expensive crane time to be utilized very efficiently; the crane can continue setting structure if it is not needed to stabilize inherently unstable parts while they are being braced. Once set in position and anchored as required to the supporting structure, independent structural base modules serve to resist both gravity and lateral loads with an open but stable and structurally redundant framework.

10 Construction Safety

Independent base modules are typically interconnected with roof and/or floor construction that generally consists of other pre-assembled modules that are themselves independently stable. The independent modules effectively create large-scale building blocks that may be erected and will stand stable without the need for temporary shoring
15 or bracing, in contrast to conventional construction that relies on diagonal bracing or shear walls for lateral stability. By building with large, independently stable blocks made of interconnected precast parts, construction may progress much more rapidly and safely. By eliminating the need for lateral bracing and shoring, the construction site can be kept clear of obstructions that contribute to many construction accidents. Because

20 LadderBlock parts are built at ground level, and can generally be interconnected into modules at ground level, elevated work and the associated falling hazards are minimized. The structural redundancy provided by building with independently stable blocks should also significantly enhance the performance of the overall building if subjected to a

collapse-initiating overload; redundancy is the best insurance against progressive and total collapse of a building structure.

Distribution of Base Forces

In contrast with conventional construction techniques that concentrate forces to
5 conserve usable floor space, this system intentionally distributes these forces across a wide base that minimizes stresses on the supporting surface. By building this base so wide that the volume enclosed by the structural element is itself usable space, this structural advantage can concurrently offer functional advantages.

The wide distribution of base forces, and the attendant lowering of base pressures,
10 generally allows a LadderBlock structural module to be directly supported on a stiffened slab-on-grade where similar load carrying capacity would normally require special and costly foundations. As a building gets taller, it must resist larger wind pressures and forces that generate shears and overturning moments at the base of the structure. Because these overturning moments are also distributed across a wide base, the tie-down
15 connections required to resist overturning at the base of a LadderBlock structural module may be of lighter and less costly construction than might otherwise be necessary. If the supported structure is of sufficient weight and is not subjected to seismic loads, it may not require tie-downs at all. The selection of LadderBlock components from which to build a structure, the analysis of load paths through that structure, and decisions regarding tie-
20 down requirements are all subject to the required structural engineering analysis of the overall structure for a given application.

The supporting surface to which a structural module is tied down may consist of an underlying layer of structure or a stiffened concrete slab. In light-use, low-rise

construction, the supporting surface may consist of nothing more than a level pad of compacted fill or natural soils that exhibit adequate bearing capacity and stability.

Assemblies of blocks may be utilized for functions beyond that of the primary structural system for a building. Beam elements **75** and **76** between block columns, pairs, or individual blocks may be utilized to support intermediate levels of occupied floor space or large-scale industrial shelf space as illustrated in FIG. 17. The vertical shaft within an appropriately sized box column **70** may be utilized as the framework for an elevator, as multi-level storage closets that can be loaded with a forklift, or as a plenum for mechanical, electrical, or plumbing systems. Additionally, assemblies of blocks can provide the required structural capacity to support bridge cranes, jib hoists, and other lifting devices without the need for additional structure.

DETAILED DESCRIPTION OF EMBODIMENT – Structural frames and shells

FIG. 18 shows a sample of a completed primary structural frame that is built using this system. In that example, a plurality of box columns **70** support roof trusses **15**. Additional elements such as wall blocks and roof blocks may be attached to the structural frame.

FIG. 19 shows the frame of FIG. 18 carrying secondary framing in the form of roof purlins **18** and wall girts **19**, prior to installing remaining minor framing and the exterior skin that completes the building envelope.

FIGS 31A to 31D show a sequence of assembly of an enclosed structural shell. In this example, three modules **520** as shown in FIG. 31A are set on a support surface, such as a compacted fill pad. Each of these modules **520** is comprised of stepped blocks **244** and two rectangular blocks **243** and **245**. The blocks are stable and self supporting when set into position, and are ready to receive floor blocks **494** and **496** as illustrated in FIG.

31B, wall blocks **522**, **524**, and **526** as illustrated in FIG. 31C, and roof blocks **528** and **529** as show in FIG. 31D.

Another example is illustrated in FIGs 32A through 32D. In this example, six modules **450** are set so that they partially overhang a slab **540**. FIG. 32B shows
5 suspended access floor blocks **541** and paired roof truss modules **440** prior to installation of wall and roof blocks. FIG. 32C shows installed wall blocks **542** and **543**, clerestory blocks **544**, wall header blocks **545**, and sliding door blocks **546**. FIG. 32D shows the enclosed structural shell completed by the installation of roof blocks **550**.

FIGs 33A through 33E represent a structural shell of an open industrial building
10 of box columns **70** supporting two upper levels of framed floor blocks **494**, and shows passage floor blocks **495** to receive stair units **497**. FIG. 33A shows the box columns erected, FIG. 33B provides a detail view of bolted haunches, and FIG. 33C shows the box columns **70** carrying framed floor blocks **494**. FIG. 33D shows the primary frame with solid cap blocks **408** carrying tied bowstring trusses **319**. FIG. 33E shows the near
15 completed structure after installation of precast wall blocks **552**, metal wall studs **554**, and metal roof deck **558**.

FIG. 34A and 34B show another example of a multi level structural shell including a slab **540**, box columns **70**, and an assortment of winged box columns of various heights **560**, **562**, and **564**. These box columns support floor modules **486** and
20 **488**, and cap blocks **409**. The box columns also support hinged wall blocks **475**.

FIGs 35A though 35D show another example of a structural shell. In this example box columns **70** and asymmetric walk through box columns **580** are provided. The walk through box columns **580** provide walk up access to the interior of the box column to allow utilization of this space. The cap elements **400** and corner cap elements **410** are

used to support roof trusses such as **319**. The asymmetric box columns **580** support concrete roof blocks **480** and **482** which provide fire resistant structure at low roofs. The upper roof shown in FIG. 35D consists of framed roof blocks **490** and clerestory roof blocks **499**.

Claims

What is claimed is

1. A planar precast construction block for transmitting a load to a support
5 surface, the construction block comprising
a substantially upright first edge chord and a second edge chord
spaced apart from the first edge chord, each edge chord comprising
a first end with a base surface, such that the base surface
transmits a load from the edge chord to the support surface,
10 a second end,
a first surface in the same plane as the first surface of the
other edge chord, a second surface in the same plane as the
second surface of the other edge chord,
at least one surface facing away from the other edge chord,
15 and
at least one surface facing toward the other edge chord;
a top support beam between the second end of the first edge chord
and the second end of the second edge chord, such that the top
support beam may transmit a load to the first edge chord and the
20 second edge chord;
at least one cross beam, such that the cross beam connects a portion
of the first edge chord to the second edge chord; and

at least one block connection means integral to the first edge chord,
such that a second construction block can be attached to the first edge
chord.

5 2. The construction block of claim 1 wherein

a cross beam is a base beam between the first end of the first edge
chord and the first end of the second edge chord, such that the base
beam has a surface in the same plane as the base surfaces of the first
and second edge chords.

10

3. The construction block of claim 2 further comprising

at least one cantilevered beam extension of the base beam, such that
the base beam extends past an edge chord.

15 4. The construction block of claim 2 further comprising

a second cross beam positioned between the base beam and the top
beam; and

a substantially vertical intermediate chord positioned between the
first edge chord and the second edge chord, such that the intermediate
20 chord connects a portion of the second cross beam to a portion of the
base beam.

5. The construction block of claim 1 wherein

the support surface is selected from the group consisting of a slab foundation, a pier, a plurality of piers, a footing, a plurality of footings, a construction block, a structural module, and an on-grade surface.

5

6. The construction block of claim 100 wherein

the top beam has at least one cantilevered beam extension, such that the top beam extends past an edge chord.

10

7. The construction block of claim 1 further comprising

at least two intermediate cross beams positioned between the first and second ends of the first and second edge chords, such that each intermediate cross beam connects a portion of the first edge chord to the second edge chord.

15

8. The construction block of claim 7 wherein

at least one intermediate cross beam has at least one cantilevered beam extension, such that the intermediate cross beam extends past an edge chord.

20

9. The construction block of claim 1 wherein

the second edge chord is parallel to the first edge chord; and

the top support beam is perpendicular to the first edge chord and the second edge chord, such that the construction block is a rectangular construction block.

5 10. The construction block of claim 1 wherein

the connection means is selected from the group consisting of sleeve connectors, keyed connectors, geometric interlocks, and hinged connectors.

10 11. The construction block of claim 1 wherein

the connection means is a biaxial sleeve connector.

12. The construction block of claim 11 further comprising

a first biaxial sleeve connector on the first edge chord; and

15 a second biaxial sleeve connector on the second edge chord.

13. The construction block of claim 12 wherein

the second biaxial sleeve connector is oriented asymmetrically with respect to the first biaxial sleeve connector.

20

14. The construction block of claim 12 wherein

the second biaxial sleeve connector is oriented symmetrically with respect to the first biaxial sleeve connector.

15. The construction block of claim 1 further comprising
at least one planar outward cantilevered extension from the third
surface of an edge chord.
- 5 16. The construction block of claim 15 wherein
the extension is offset from the support surface.
17. The construction block of claim 1 wherein
the first edge chord comprises
- 10 a first outside edge surface facing away from the other edge
chord, and
a second outside edge surface facing away from the other
edge chord.
- 15 18. The construction block of claim 1 wherein
the first edge chord comprises an extension beyond the top beam.
19. The construction block of claim 1 further comprising
at least one diagonal strut positioned between the first edger chord
- 20 and the second edge chord.
20. A precast construction block for transmitting a load to a support surface,
the construction block comprising

a substantially upright first edge chord and a second edge chord spaced apart from the first edge chord, each edge chord comprising

5 a first end with a base surface, such that the base surface transmits a load from the edge chord to the support surface,

a second end,

a first surface in the same plane as the first surface of the other edge chord,

a second surface in the same plane as the second surface of the other edge chord,

10 at least one surface and facing away from the other edge chord, and

at least one surface facing toward the other edge chord;

a substantially vertical intermediate chord positioned between the first edge chord and the second edge chord; the intermediate chord

15 comprising

a first end with a base surface, such that the base surface transmits a load from the intermediate chord to the support surface,

a second end,

20 a first surface in the same plane as the first surfaces of the first and second edge chord;

a first top support beam between the second end of the first edge chord and the second end of the intermediate chord, such that the top

support beam may transmit a load to the first edge chord and the intermediate chord;

a second top support beam between the second end of the second edge chord and the second end of the intermediate chord, such that the top support beam may transmit a load to the second edge chord and the intermediate chord;

a first cross beam, such that the first cross beam connects a portion of the first edge chord to the intermediate chord; and

at least one block connection means integral to the first edge chord such that a second construction block can be attached to the first edge chord.

21. The construction block of claim 20 wherein

the first cross beam and the second cross beam comprise a base beam between the first end of the first edge chord and the first end of the second edge chord, such that the base beam has a surface in the same plane as the base surfaces of the first and second edge chords.

22. The construction block of claim 21 further comprising

at least one cantilevered beam extension of the base beam, such that the base beam extends past an edge chord.

23. The construction block of claim 20 wherein

the support surface is selected from the group consisting of a slab foundation, a pier, a plurality of piers, a footing, a plurality of footings, a construction block, a structural module, and an on-grade surface.

5

24. The construction block of claim 20 wherein

the first top beam has a cantilevered beam extension, such that the first top beam extends past the first edge chord.

10

25. The construction block of claim 20 wherein

the second top beam has a cantilevered beam extension, such that the second top beam extends past the second edge chord.

26. The construction block of claim 20 further comprising

15

a second cross beam, such that the second cross beam connects a portion of the second edge chord to the intermediate chord; and

27. The construction block of claim 20 further comprising

20

at least one intermediate cross beam positioned between the first and second ends of the first edge chord and the intermediate chord, such that the intermediate beam connects a portion of the first edge chord to the intermediate chord.

28. The construction block of claim 27 wherein

the intermediate cross beam has at least one cantilevered beam extension, such that the intermediate beam extends past a edge chord.

29. The construction block of claim 20 wherein

5 the connection means is selected from the group consisting of sleeve connectors, keyed connectors, geometric interlocks, and hinged connectors.

30. The construction block of claim 20 wherein

10 the connection means is a biaxial sleeve connector.

31. The construction block of claim 30 further comprising

a first biaxial sleeve connector on the first edge chord; and
a second biaxial sleeve connector on the second edge chord.

15

32. The construction block of claim 20 further comprising

at least one planar outward cantilevered extension from the third surface of an edge chord.

20 33. The construction block of claim 32 wherein

the extension is offset from the support surface.

34. A connected pair of precast construction blocks, the pair comprising

a first planar precast construction block and a second planar precast construction block, each block comprising

5 a substantially upright first edge chord and a second edge chord spaced apart from the first edge chord, each edge chord comprising

a first surface in the same plane as the first surface of the other edge chord,

a second surface in the same plane as the second surface of the other edge chord,

10 a third surface perpendicular to the first surface and the second surface and facing away from the other edge chord, and

at least one surface facing toward the other edge chord;

15 at least two beams between the first edge chord and the second edge chord;

such that the third surface of the first beam of the first block is attached to the first surface of the second beam of the second block in order to create an L-shaped pair of blocks.

20

35. The connected pair of precast construction blocks of claim 34 wherein the blocks are attached with threaded connectors placed through sleeves of biaxial sleeve connectors.

36. The connected pair of precast construction blocks of claim 34 further comprising

a third planar precast construction block comprising

a substantially upright first edge chord and a second edge

5 chord spaced apart from the first edge chord, each edge chord comprising

a first surface in the same plane as the first surface of the other edge chord,

10 a second surface in the same plane as the second surface of the other edge chord,

a third surface perpendicular to the first surface and the second surface and facing away from the other edge chord, and

15 at least one surface facing toward the other edge chord;

at least two beams between the first edge chord and the second edge chord;

20 such that the second surface of the second beam of the first block is attached to the third surface of the first beam of the third block, thereby forming a ribbed wall section.

37. The connected pair of precast construction blocks of claim 34 further comprising

a third planar precast construction block comprising

a substantially upright first edge chord and a second edge chord spaced apart from the first edge chord, each edge chord comprising

- 5 a first surface in the same plane as the first surface of the other edge chord,
- a second surface in the same plane as the second surface of the other edge chord,
- a third surface perpendicular to the first surface and the second surface and facing away from the other
- 10 edge chord, and
- at least one surface facing toward the other edge chord;
- at least two beams between the first edge chord and the second edge chord;
- 15 such that the third surface of the first beam of the second block is attached to the first surface of the second beam of the third block in order to create an open box column.

38. The connected pair of precast construction blocks of claim 34 further

20 comprising

a fourth planar precast construction block comprising

a substantially upright first edge chord and a second edge chord spaced apart from the first edge chord, each edge chord comprising

- 5 a first surface in the same plane as the first surface of
the other edge chord,
a second surface in the same plane as the second
surface of the other edge chord,
a third surface perpendicular to the first surface and
the second surface and facing away from the other
edge chord, and
at least one surface facing toward the other edge
chord;
- 10 at least two beams between the first edge chord and the
second edge chord;
such that the third surface of the first beam of the third block
is attached to the first surface of the second beam of the fourth
block, and the third surface of the first beam of the fourth
15 block is attached to the first surface of the second beam of the
first block in order to create a square box column.

39. A connected pair of precast construction blocks, the pair comprising
a first planar precast construction block and a second planar precast
20 construction block, each block comprising
a substantially upright first edge chord and a second edge
chord spaced apart from the first edge chord, each edge chord
comprising

- a first surface in the same plane as the first surface of
the other edge chord,
a second surface in the same plane as the second
surface of the other edge chord,
5 a third surface perpendicular to the first surface and
the second surface and facing away from the other
edge chord, and
at least one surface facing toward the other edge
chord;
10 at least two beams between the first edge chord and the
second edge chord;
such that the third surface of the first beam of the first block is
attached to the third surface of the first beam of the second block in
order to create a planar pair of blocks.
15
40. The connected pair of precast construction blocks of claim 39 further
comprising
a third planar precast construction block comprising
a substantially upright first edge chord and a second edge
20 chord spaced apart from the first edge chord, each edge chord
comprising
a first surface in the same plane as the first surface of
the other edge chord,

- 5 a second surface in the same plane as the second surface of the other edge chord,
a third surface perpendicular to the first surface and the second surface and facing away from the other edge chord, and
at least one surface facing toward the other edge chord;
at least two beams between the first edge chord and the second edge chord;
- 10 such that the third surface of the second beam of the first block is attached to the third surface of the second beam of the third block, thereby forming a flat wall section.

41. The flat wall section of claim 40 further comprising

- 15 a fourth planar precast construction block comprising
a substantially upright first edge chord and a second edge chord spaced apart from the first edge chord, each edge chord comprising
a first surface in the same plane as the first surface of
20 the other edge chord,
a second surface in the same plane as the second surface of the other edge chord,

5 a third surface perpendicular to the first surface and
the second surface and facing away from the other
edge chord, and
at least one surface facing toward the other edge
chord;
at least two beams between the first edge chord and the
second edge chord;
such that the third surface of the first beam of the fourth block is
attached to the first surface of the first beam of the first block,
10 thereby forming a pilastered wall section.

42. The connected pair of precast construction blocks of claim 40 further
comprising

15 a plurality of other construction blocks, each block comprising
a substantially upright first edge chord and a second edge
chord spaced apart from the first edge chord, each edge chord
comprising
a first surface in the same plane as the first surface of
the other edge chord,
20 a second surface in the same plane as the second
surface of the other edge chord,
a third surface perpendicular to the first surface and
the second surface and facing away from the other
edge chord, and

at least one surface facing toward the other edge
chord;

at least two beams between the first edge chord and the
second edge chord;

- 5 such that the first block, the second block, the third block, and the
plurality of other construction blocks are each connected to at least
one other block, thereby forming a general perimeter wall.

43. An asymmetric module comprising

- 10 a first planar precast construction block and a second planar precast
construction block, each block comprising

a substantially upright first edge chord and a second edge
chord spaced apart from the first edge chord, each edge chord
comprising

- 15 a first surface in the same plane as the first surface of
the other edge chord,

a second surface in the same plane as the second
surface of the other edge chord,

- 20 a third surface perpendicular to the first surface and
the second surface and facing away from the other
edge chord, and

at least one surface facing toward the other edge
chord,

an substantially vertical intermediate chord, positioned
between the first edge chord and the second edge chord,
at least two beams between the first edge chord and the
intermediate chord, and
5 at least two beams between the second edge chord and the
intermediate chord,
a first connection element between the first edge chord of the first
block and the first edge chord of the first block; and
a second connection element between the second edge chord of the
10 first block and the second edge chord of the first block.

44. The asymmetric module of claim 43 wherein

the first connection element is a precast construction block; and
the second connection element is a a precast construction block.
15

45. An asymmetric roof truss module comprising

a first planar precast construction block and a second planar precast
construction block, each block comprising
a top beam,
20 a base beam, and
a plurality of chords between the top beam and the base beam;
and
a plurality of structural connection elements between the chords of
the first block and the chords of the second block.

46. A building frame comprising

a plurality of independently stable structural modules, each structural module comprising

5 a first planar precast construction block spaced apart from a second planar precast construction block, each block comprising

a substantially upright first edge chord,

a second edge chord spaced apart from the first edge

10 chord,

at least two beams between the first edge chord and the second edge chord;

at least one structural member connecting the first block to the second block; and

15 a plurality of connection members connecting each structural module to at least one other structural module.

47. The building frame of claim 46 wherein

the structural member of at least one structural module is a third

20 block, such that the third block is attached in perpendicular orientation to the first block and to the second block, thereby forming an open-sided box column.

48. The building frame of claim 46 wherein

at least one structural module comprises a third block and a fourth block, such that the third block and the fourth block are attached in perpendicular orientation to the first block and to the second block, thereby forming a box column.

5

49. The building frame of claim 46 wherein

at least one structural module comprises a first block which is skewed with respect to the second block.

10 50. The building frame of claim 46 further comprising

a plurality of structural modules set on a support surface in a radial orientation at least partially circumscribing a center point on the support surface, wherein each structural module comprises

15

a first planar precast construction block spaced apart from a second planar precast construction block, each block comprising

a substantially upright first edge chord,

a second edge chord spaced apart from the first edge chord,

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at least two beams between the first edge chord and the second edge chord,

a first structural member connecting the first block to the second block, and

a second structural member connecting the first block to the second block; such that the first structural member is closer to the center point on the support surface than the second structural member, and the first structural member is narrower than the second structural member.

51. The building frame of claim 46 wherein
at least one structural module comprises a first block attached to the structural member with at least one connector means positioned through aligned sleeves provided in the first block and the structural member.

52. The building frame of claim 51 wherein
the connector means is a biaxial sleeve.

53. The building frame of claim 52 wherein
the connector means is geometric interlock

54. The building frame of claim 46 further comprising
a plurality of wall blocks supported by at least a portion of the modules.

55. The building frame of claim 54 further comprising

a plurality of floor blocks supported by at least a portion of the modules.

56. The building frame of claim 54 wherein

5 at least two of the modules are winged box columns which support floor blocks.

57. The building frame of claim 56 further comprising

10 a plurality of roof support members supported by at least a portion of the modules; and
a plurality of roof blocks supported by the roof support members.

58. A stack cast process for forming reinforced concrete construction blocks, the process comprising

15 pouring a first block flat on an existing casting surface by
placing a release agent on the casting surface,
temporarily securing a mold form on the casting surface, such that
the block is poured in a flat orientation,
positioning reinforcement in the mold form,
20 supplying wet concrete to the form to cast the first block;
partially curing the first block;
removing the mold form from the first block;
pouring a second block on top of the first block by
placing a release agent on the first module,

temporarily securing a mold form on the first block, such that the
second block is poured in a flat orientation,
positioning reinforcement in the mold form,
supplying wet concrete to the form to cast the second block.

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59. The method of claim 58 wherein temporarily securing an open-top
molding form on the casting surface further comprises

temporarily securing a first form member to the casting surface;
positioning a plurality of biaxial connection sleeves in the molding
10 form, such that the sleeves provide passages through the block after
casting;
securing a second form member at a desired distance from the first
form member by
placing a threaded rod through the first form member, through
15 a connection sleeve, and through the second form member, such
that the threaded rod has a first end and a second end,
placing a temporary first restraining means on the threaded rod in
proximity to the first end, and
placing a temporary second restraining means on the threaded rod
20 in proximity to the second end, such that the first and second
restraining means hold the first and second form members against
the connection sleeve.

60. The method of claim 58 wherein positioning reinforcement in the molding form further comprises

5 positioning a plurality of biaxial connection sleeves in the molding form, such that the sleeves provide passages through the block after casting; and
securing reinforcement members to the biaxial connection sleeves.

61. The method of claim 58 further comprising

removing the second form;
10 lifting the second block; and
attaching the second block to the first block while the first block is on the casting surface; and
erecting the connected pair of the first block and the second block.

15 62. The method of claim 61 further comprising

attaching a third block to the first block while the first block is on the casting surface; and
erecting the connected first block, second block, and third block.

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