MODULAR HOUSING SYSTEM

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Appl. No.: 10/970,980
Filed: Oct. 25, 2004

Related U.S. Application Data
Provisional application No. 60/513,222, filed on Oct. 23, 2003.

Publication Classification
Int. Cl.7 E04H 5/00; E04H 1/00

US. Cl. 414/787

ABSTRACT

A modular production system and method for producing wall panels of a modular building. The system includes a worktable, a plurality of telescoping tools mounted over the worktable, an overhead tram disposed adjacent the worktable, and a plurality of material supply bridges movably supported on the overhead tram so as to be movable over the worktable. The method of manufacturing a panel of a modular structure includes moving the first material supply bridge over a worktable to place panels of sheeting on the worktable, and then moving a second material supply bridge over the worktable to place steel members for the construction of a steel frame. A third material supply bridge is then moved over the worktable to apply adhesive on the sheeting in a pattern mirroring the steel frame.
From Table Front, Green Bridge lays Bottom SHEETING toward Rear Panel Reference. Sheeting Materials is 4' - 0" wide and length is equal to Module Panels produced on Workable (CPS) width. All operations directed by Central Computer Controller (CCC).
FIG. 12

Blue Bridge TRANSPORTS Cold Formed Steel Rolled Shapes (CFSRS) of panel length to form Panel Edge Beams (EB). CFSRS clamped together, magnetically attached to face of LETM on each side of Table, and then are raised 12" by TPT for welding clearance. CFSRS are welded to form EB's and IB's.
PROCEDURE 7

ETC's, fasten and secure Pre-Assembled Electrical Power Distribution & Devices installed in Panels on Workable (E.P.H.), PIPING & MECHANICALS to steel frame at TEL locations of PROCEDURE 2.
Green Bridge moves toward Table Front, lays Top SHEETING OSB, V/ROC OR GYP.
SUM. Sheeting material is 4'-0" wide and length is equal to CPS width. Green Bridge
returns to Table Front to park and restock. TILLEN NAILS sheeting to step frame.
MODULAR HOUSING SYSTEM

[0001] This application claims the benefit of U.S. Provisional Application No. 60/513,222, filed Oct. 23, 2003.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a novel system for constructing modular housing structures. In particular, the modular housing system produces light gauge steel modular structures. The system is capable of producing all types of panels including insulated closed panels having installed electrical and mechanical systems.

[0004] 2. Description of Related Art

[0005] The present inventor, with the benefit of 40 years in the design and construction industry, has developed a modular housing system that will provide stronger homes. The system gives full consideration to national building codes, and the underlying principles of safety, comfort, energy savings, and green construction. The housing system will provide the best retirement plan for America’s aging population, a higher quality manufactured home providing the realization of long term homeowner equity.

[0006] The construction of modular building structures, which are fabricated at a housing plant, is limited by applicable laws and regulations. The United States housing industry, which includes HUD-code homes and modular housing, is controlled by laws that limit the dimensions of products that can be shipped over the interstate highways. These limitations include width restrictions to insure vehicular safety, height restrictions to clear overhead obstructions, and length restrictions of the modular unit and transporter.

[0007] Typically manufactured HUD homes and modular homes include three dimensional “boxes or modules” that are shipped over the road, and thus are confronted with the continuing problem of the regulatory shipping limitations. Accordingly, the most economical roof designs have generally been limited to low and medium pitched roofs. Also, the height limitations impose constraints on the design of the building structures, and the building structures have taken on the connotations associated with the homes produced by the earlier mobile home industry. Various solutions have been proposed, such as entirely independent roof sections and saddle roofs that hang over the side of the module. However, shipping independent roof sections substantially increases the construction and transportation costs, and saddle roof designs consume a portion of the over-the-road regulatory width, thereby reducing the allocable width of the module living space. Both of these methods have limitations and increase the cost of equivalent floor area in the building structures. Furthermore, the applicable laws have created several limitations within the modular housing industry such as:

[0008] 1. The dimensional geometry of the shipped product is restricted to widths of 12 feet, 14 feet, and 16 feet (under controlled conditions); heights of 14 feet, which includes either the transporter or wheel and rail assemblies; and lengths of 80 feet.

[0009] 2. The traffic flow patterns within the housing plans are restricted, which causes stairways to the second floor of 12 foot and 14 foot wide modules to be L-shaped with landings and returns. This is necessary to fit the stair within the restricted module widths, which must ultimately terminate near the center of the second floor traffic pattern.

[0010] 3. The lengths of the modules are required to be extended, in the only dimension available, in order to overcome the limitations of the width of the module. This is necessary to encapsulate more floor area. Also, as the lengths of the modules have been extended upward in excess of 70 feet, the modules have been exposed to increased flexure during shipping and handling, resulting in increased damage to both the structure and interior finishes of the module.

[0011] 4. The extended module lengths have created awkward planning constraints that require the main front entrances of the homes to be located near the center of the modules in order to minimize the length of hallways and to improve efficient access to rooms at the ends of the modules.

[0012] 5. The extended module lengths have necessitated that the slope direction of the major roof be 90 degrees with respect to the length of the module in order to remain below the shipping height limitations. By employing multiple roof panels, which are folded during shipping and unfolded and tilted up during the erection process, the housing industry has successfully created techniques that achieve up to 12/12 roof pitches. However, this requires the production of additional multiple panels and substantially increases costs. Furthermore, this process exposes the module to potential weather damage during the erection procedure.

[0013] 6. The total width of one and two story homes is limited to two modules having a combined width of approximately 28 feet. This is necessary in order to avoid the creation of saw-tooth roof configurations, which are created by joining more than two modules. Saw-tooth roof configurations are inconsistent with the aesthetics of traditional home designs. Furthermore, limiting the house width to two module widths, avoids the complicated water drainage problems created by the long valleys of saw-tooth roofs. Some patio homes have been produced in contemporary plans by sliding and offsetting the modules in a direction parallel to their longitudinal dimension, thereby reducing the problems associated with the saw-tooth roofs. However, this has been accomplished by increasing the exterior wall area, which inherently increases the heating and cooling costs.

[0014] The above-discussed limitations have affected not only the housing product itself, but have also imposed restrictions on the sitting of the homes on the lots. The positioning of the front entrances near the center of the modules, as previously explained, has in most designs, required that the lengthened modules be sited parallel to the front lot line. This is necessary to avoid the alternative positioning at 90 degrees to the front lot line, which would place the front entrance adjacent to the side lot line and thereby provide inadequate visibility from the street. Further, the lengthened modules require wider lots, which inherently increases the infrastructure cost of the lots. Also, the present lengthened modules are not compatible with the concept of clustered housing on smaller lots, which is being promoted today in order to reduce housing costs. The clustered housing concept requires housing products that can more effectively utilize the depth of the lots without placing the front entrances adjacent to the side lot lines.

[0015] The HUD-code home and modular housing industries of today have evolved from a combination of the
mobile home industry of the 1950’s and on-site construction. Planning, with the assistance of computers, has enabled module producers to offer a range of customization within the above-described constraints. Although the production of the modular homes occurs in the controlled environment of a plant, the homes are still constructed with conventional materials, in much the same way as in the mobile home industry of the 1950’s and the frame construction of site-built homes.

[0016] The evolution of the modular production process has occurred without recognizing and utilizing the accomplishments and techniques of the automotive industry. A new approach could find new techniques, solve the problems created by the limitations discussed above, and enhance all aspects of the housing products while reducing costs.

[0017] By recognizing and utilizing advances in the automotive industry, the scale of the planning component in the housing industry can be increased from the historic 2x4 wood stud to a functional module. Accordingly, an object of the present invention is to provide a completely new approach to the structure for roofing modules that will overcome most of the previously discussed limitations, and to allow the development of standardized spatial modules of varying functional and utilitarian use, and modules that could be selected and composed by the consumer so as to create unlimited house designs.

[0018] Partial solutions to the above-identified problems were developed by the present inventor in U.S. Pat. No. 6,681,544, which issued on Jan. 27, 2004 and U.S. Pat. No. 6,705,051, which issued on Mar. 16, 2004. Due to the advances disclosed and claimed in these patents it is now possible to realize more efficient modular home designs to fit narrower lots, and higher density land development, thereby lowering street and utility infrastructure costs. Stronger steel homes can resist higher winds, and refrigeration type insulation can greatly reduce energy costs. This accomplishment will allow production builders in the United States to shift from current high cost and time consuming building practices, thereby lowering their costs by converting to industrialized totally mechanized, high quality modular housing.

SUMMARY OF THE INVENTION

[0019] An object of the present invention is to provide a modular housing system that can satisfy the public’s desire for higher pitched roofs, provide historic aesthetics, and convert the industry’s present wood trusses, which wasted volumes of costly space, to usable and accessible attic storage and bedrooms.

[0020] The system employs the present inventor’s flat shipped, panel roof, which is rolled up into place by a crane while setting the modules at the job site, accomplishes this entire transition. Converting the modular roof system from trusses to closed and open flat panel components simplifies the entire modular structure. This enables true industrialization and mass production of every major flat panel component composing a modular house on one CNC (computer numerical control) encoder driven work table, consuming only 3300 square feet of plant floor area. As demonstrated in FIG. 1, the necessary plant size is significantly less in comparison with the typical wood modular plant. In the present invention, the work table is connected to an overhead tram, which transports the finished panels to the assembly table where all the panel components, which compose the module, are assembled.

[0021] The work table is equipped with major telescoping transverse encoder driven tools, and is powered by an overhead tram with three material supply bridges and encoder driven material placement systems (see FIG. 3). The supply bridges are loaded with materials directly from four truck trailers by the plant’s overhead crane system. The materials have been temperature tempered, by over-night storage in the plant for immediate panel production.

[0022] The open panels (OP) and closed panels (CP) when assembled, create housing modules constructed with cold formed steel rolled shapes (CFSRS). The framing for floors, roofs, gables and wall panels, are all produced on the single CNC Encoder Driven Work Table. The closed panel sub-components are assembled into finished housing modules in the plant, and are shipped on boggy wheels and erected by a crane at the building site. The closed panels (CP) include the following materials: steel framing (CFSRS), gypsym panels (GP), oriented strand board (OSB) or Plywood (PLWD), cement bonded particle board (CBP), sanitary piping, water piping, sprinkler piping, heat ducts, ventilation ducts, wiring harnesses and high R-value, foamed insulation. The modular housing system includes a 48’ CNC driven work table and a 120’ overhead tram with three powered material supply bridges. Two tables can be installed in a 38,500 square foot plant (see FIG. 2). With the inventive modular system, in a period of four days, the module interior and exterior can be completely finished, and then assembled on site by a crew of four men to produce a two-story 1800 square foot home having a two-car garage in four days.

Panel Production Center

[0023] The panel production center includes the following four major, control integrated components (see FIGS. 3-4).

[0024] (1) Central Computer Controller

[0025] (2) CNC Driven Work Table “W TAB”

[0026] As shown in FIG. 5, the work table includes two longitudinal 76 foot linear encoder tracks above the top, and ten actuator heads, eight transverse 10 foot linear encoder tracks and actuator heads, and eight vertical encoded actuators, or eight synchronized motor cylinders beneath the table top.

[0027] (3) Three Material Supply Bridges on an Overhead Power Tram (OPT)

[0028] As shown in FIGS. 6-7, three material bridges are provided on an overhead power tram (OPT). The material bridges are color coded for production communication, for example, the three material supply bridges include a Green Bridge for supplying sheeting and transporting the sheeting; a Blue Bridge for supplying steel and transporting the steel; and the Red Bridge for supplying adhesive and insulation.

[0029] (4) Four Major Telescoping Linear Encoded Transverse Tools (TLETT)

[0030] The third component of the panel production system includes routers, material locators, nailers, and diamond saws (see FIG. 8).
The modular housing system also include a panel assembly center comprising a module component assembly table (MAT), which has an assembly encoder lift and a hold hi-bay provided with four hoists and two bridges. The module component assembly table also includes an exterior and interior wall panel lift and position apparatus which has four hoists and two bridges.

The novel modular housing system can be arranged in two forms, i.e., a standard semi-mechanized manual system which is contemplated to be primarily used in under-developed nations in which the cost of labor is low; and an optional totally mechanized system applicable primarily in developed nations in which the labor costs are relatively high.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will now be described by way of example only with reference to the accompanying drawings in which:

FIG. 1 is a schematic top plan view comparing the area of a conventional modular plant with the area of a plant constructed in accordance with the present invention;

FIG. 2 is a schematic top plan view of a plant constructed with two production lines and indicating the potential production capability;

FIG. 3 is an illustration of the four major control integrated functions of the production center of the present invention;

FIG. 4 is a perspective view of the production center and assembly center of the modular housing system;

FIG. 5 is a perspective view of a worktable constructed in accordance with the present invention with material and transverse tool locators;

FIG. 6 is a perspective view showing the three material supply bridges supported on an overhead tram;

FIG. 7 is a perspective view of the three material supply bridges shown in FIG. 6 with the bridges loaded with materials for constructing panels;

FIG. 8 is a perspective view of the worktable and the four major telescoping transverse tools;

FIG. 9 is a schematic illustration of the central computer controller;

FIGS. 10 and 11 are perspective views illustrating production procedures 1 and 2;

FIGS. 12 and 13 are perspective views illustrating production procedure 3;

FIGS. 14 and 15 are perspective views illustrating production procedure 4;

FIGS. 16 and 17 are perspective views illustrating production procedures 5 and 6, respectively;

FIGS. 18 and 19 are perspective views illustrating production procedure 7;

FIGS. 20 and 21 are perspective views illustrating production procedure 8;

FIG. 22 is a perspective view illustrating production procedures 9 and 10;

FIG. 23 is a perspective view illustrating production procedure 11;

FIG. 23A is a perspective view illustrating a wall panel layout for a typical module;

FIG. 24 is a perspective view showing a single rectangular framed panel;

FIG. 25 is a perspective view showing a sheeting layout of a single rectangular framed gable following production procedures 9 and 10;

FIGS. 26, 27 and 28 are perspective views of a telescoping linear encoded diamond saw cutting a steel frame into gable panels in production procedure 11;

FIG. 29 is a perspective view showing the cut gable frame being reinforced with steel angles in production procedure 11;

FIG. 30 is a perspective view showing the application of exterior finish material in production procedure 11;

FIG. 31 is a perspective view showing the roll over of the cut gable frame using a rollover device in production procedure 11;

FIG. 32 is a perspective view showing the process of transporting the gable frame, produced in production procedure 11, to the module assembly table;

FIG. 33 is a perspective view illustrating production procedure 12;

FIG. 34 is a perspective view of the process of dissecting the singular rectangular framed gable and final gable positioning prior to installation;

FIG. 35 is a perspective view illustrating the final folding position of the gable panels prior to roof panel final placement;

FIG. 36 is a perspective view illustrating the process of fastening roof ridge lift hinges to the roof panels;

FIG. 37 is a perspective view illustrating the process of installing roof rollers to slidably attach the roof panels to an attic floor panel;

FIG. 38 is a perspective view illustrating the process of testing the roof panel sub assembly;

FIG. 39 is a perspective view illustrating the process of storing the roof panel sub assembly following completion of the testing shown in FIG. 38;

FIG. 39A is a perspective view of first floor panel, interior, exterior and marriage wall panels in a stacked position on the assembly table;

FIG. 40 is a perspective view of the module assembly table after transporting of the completed panels forming the module envelope;

FIG. 40A shows typical wall panel junctures;

FIG. 41 is a perspective view illustrating lifting procedure 3 at the module assembly table;
FIG. 42 is a perspective view showing the roof panel sub assembly being lowered onto the module's bearing walls to complete the module assembly at the module assembly table;

FIG. 43 is a perspective view showing the completed module assembly being transported by the plant overhead crane system;

FIG. 44 is a schedule of the major procedures performed at the worktable for producing walls and ceilings; and

FIG. 45 is a schedule of the major procedures performed at the worktable for producing floors and roofs.

DETAILED DESCRIPTION OF THE INVENTION

The work table (WTAB), shown in FIG. 5, supports thirteen (13) major production procedures and several minor procedures. The major procedures are performed in a numerical sequence, and the specific procedures that are performed on a particular panel is dependent on the type of panel being produced. Thus, not all of the procedures are necessary for each panel, and depending on the panel, some of the procedures are omitted. See the schedules “System Procedures Walls & Ceilings” and “System Procedures Floors & Roofs” for single family homes. The schedules include 17 panel types which enable the modular housing system to construct homes of all types, and code approved modules for construction of apartments, motels, and commercial structures, one through four stories, which can be increased by creating hybrid panels.

The term “CC” or “CCC” used herein refers to control by the operator at the CNC Central Computer in a glassed booth that is preferably located adjacent to the front of the Work Table (see FIG. 9). The modular housing system requires a 48 foot work table and single framed panel widths of 5’5” through 15’9.5” and panel lengths from 2’ through 48’. Two wall panels can be produced simultaneously in any combination of interior or exterior widths of 79.5”.

Single wall panels, limited by first floor module shipping heights, can be produced at, ceiling heights of 9’5”. Multiple Panels can be produced, the sum of the lengths not to exceed 48’ and sawn to their designed installed lengths by the Diamond Saws (STLEDS). The exterior finishes of Wall Panels & Gable Panels are applied on the Module Component Assembly Table (MAT).

The work table’s eight telescoping pylons tubes (TPT) can be driven horizontally by a transverse mechanical actuator system (MAS) or a linear encoder motor (LEM) beneath the surface of the work table. The synchronized movement of the pylon tubes is normally equal distance from their storage positions toward the center of the work table. The transverse motion is controlled independently for each side of the work table and may be varied to accommodate asymmetric panel configurations. The “CCC” establishes the panel width being produced. This movement carries the reinforced longitudinal linear encoder track with electromagnets (LLETM) and its encoder actuator heads (EAIH) on the telescoping pylon tubes (TPT) in the transverse motion.

The encoder actuator heads (EAIH) are normally parked at the front of the work table and the initial movement to the longitudinal Center, less than ½ of the panel length being fabricated, is controlled by the operator at the CNC Central Computer (CCC). This movement locates the front of the panel to start fabrication and centers the panel on the work table (WTAB), x and y axis. Thereafter the incremental movement is controlled by the operator at the CNC Central Computer (CCC) and the panel computer program, but is activated by the equipment trained controllers (ETC) on the work table operating the supply bridges on the overhead power tram (OPT).

The head of the eight pylons and the linear encoder tracks are raised and lowered by synchronized motor cylinders (SMC), or vertical encoded actuators (VEA), which locate the vertical position of the longitudinal linear encoder track (LLETM), enabling various production functions (see Procedures for Floors & Roofs and Walls & Ceilings, Pylons Vert. Ref.).

The encoder actuator heads (EAIH) positioning, on both the left and right sides of the worktable is controlled by the operator at the CNC central computer (CCC), who locates all of the transverse reference lines about the longitudinal axis of the work table. This is consistent for all work procedures, including the x-axis of the transverse telescoping linear encoder (TTLE), which locates the Y-axis of all openings in the field of panels being produced on the work table.

The computer numerical control (CNC) driven work table (WTAB) is of modular design and can be extended in 15 foot increments to lengthen panels produced and thereby increasing the module length capability of the system.

The base structure of the work table is recessed 72 inches below the plant’s main floor. This maintains the top of the table elevation at 18 inches above the plant floor and conceals the transverse linear encoded motors (TLEM) and the base of the motor cylinders. This further provides access for maintenance and space for dirt and dust collection systems beneath the table. Access to this space is a basement door and steps in the plant floor at the rear of the work table.

Three Powered Supply Bridges on Overhead Power Tram (OPT)

GREEN—Sheathing, BLUE—Steel, RED—Adhesive & Insulation

The Overhead Tram is supported on two rows of 10 inch tubular steel columns; spaced 20 feet on center (see FIGS. 4, 6 and 7). Each row is 13 feet 7 inches from the longitudinal axis of the table. The columns support three 10 inch tubular steel beams parallel to the work table. The tubes are bolted to the head of the columns and separated to receive energy chain systems (ECS) that power and provide encoder control systems to the three supply bridges spanning over the work table (WTAB). Each of the three bridges moves independently and parallel to the longitudinal axis of the table.

The supporting arms of the bridges are each independently supported on an inverted steel angle track mounted on top of the three longitudinal tubular steel beams.

The green sheathing bridge, blue steel bridge, and red adhesive/insulation bridge are designed so that they may
each cross over or under each other in the performance of their independent production procedures without interfering with each other. The bridges may also move to their point of origin for restocking beyond the front of the work table, or to a temporary parking place in preparation of their next scheduled procedure. This allows for the production of multiple panel types, which require alternate procedures, in varying sequence. The three supply bridges, with cross-over or under capability permit thirteen production procedures in any order. Also, hybrid structural panels are constructed of multi-layered structural members and varied sheeting materials as shear layers and bonded by adhesives and pin fastenings.

[0087] The tram extends beyond the rear of the work table to provide temporary parking space for the three supply bridges. The green bridge tram rail continues to the module assembly table (MAI) to enable transport of finished panel components for assembly.

[0088] The front of the work table provides a home base for each of the supply bridges to be loaded by the plant’s overhead crane system (POCS), directly from four loaded trailer trucks positioned in the plant.

[0089] Berths for the four major supply trailers (STIP) are provided to achieve temperature and moisture stability of the materials prior to inclusion in the production procedures (see Procedures for Floors, Roofs, and Walls, Ceilings).

[0090] Each of the bridges are connected by the tram to electric power and control wiring for (1) welding, (2) press joining of metal, and (3) attachment by screw guns and other tools at the point of material placement. Each bridge is equipped with the tools required to complete the installation of the materials being transported. The control wiring allows the integration of optional encoder driven sub-systems, which will increase the speed of material placement and fastening thereby reducing the number of equipment trained controllers (ETC) on line.

[0091] Procedures 1, 9 & 12

[0092] The Green Bridge (Sheeting & Transport) is equipped with standard manual motor and vacuum assisted sheet placement, as shown in FIG. 10, and is also available with an optional encoder driven system, which advances the Green Bridge by incremental sheeting panel widths and an encoder driven slide mechanism, which slides the top sheet from sloping or a flat pallet, which is not shown to its placement parallel or perpendicular to the longitudinal axis on the work table (WTAB). Also, in procedure 9, the top sheet is slid onto the top of the steel frame (see FIG. 22). The Green Bridge in Procedure 12 transports the panel components to the module component assembly table (MAI) (see FIG. 32). The Green Bridge is equipped with encoder vertical adjustment to permit clearance of standard and hybrid panels of varying thickness and the dispensing of sheeting materials for all panel heights.

[0093] Procedures 4 & 7

[0094] The Blue Bridge (steel) is equipped with transverse steel members (standard manual dispensing) hand-held automatic welders, metal press joining equipment, and screw guns. The Blue Bridge is also available with an optional encoder driven system, which advances the Blue Bridge concurrently with the encoder actuator heads (EAH) on the longitudinal encoder track (LEETM) and mechanically dispenses the cold formed steel members (TFM), e.g. floor joists, ceiling joists, roof joists, wall studs, and gable studs, into the locator arm of the encoder actuator heads (EAH) material holder (see FIGS. 14 and 18). Mechanized welders, metal press joining equipment, and screw guns fasten the steel members (TFM) to the panel edge beams, intermediate beams, or wall track, thereby automating the steel member (TFM) fastening.

[0095] Procedures 5 & 8

[0096] The Red Bridge for applying adhesive and insulation is equipped with standard hydraulic controller platforms and manually operated adhesive and insulation placement devices (see FIGS. 16 and 20). It is also available with an optional encoder driven system, which advances the Red Bridge automatically in accordance with steel member (TFM) location data stored at the central computer control (CCC). The hydraulic platforms are fitted with transverse linear encoder driven tracks and encoder actuator heads for transporting and activating the adhesive nozzles and insulation spray heads which are equipped with optical laser depth sensors to apply the insulation materials between and adhesives on top of the framing members.

[0097] Four Major Telescoping Linear Encoded Transverse Tools

[0098] As shown in FIG. 8, the four major telescoping tools include routers, material locators, nailers, and diamond saws. Each of the four major telescoping tools are composed of two structural components with interlocked sliding bearing surfaces, which permits each tool to contract and expand in length to accommodate panel widths controlled by the pylon’s (TPT) positioning of the longitudinal linear encoder track (LEETM) establishing the panel widths. The telescoping feature also allows additional length contraction and expansion of each tool controlled by the independent encoder positioning of the encoder actuator heads (EAH) on each of the longitudinal linear encoder tracks (LEETM), which permits skewing of the tools (e.g. see FIG. 26) to perform angular operations of routing, locating, nailing, and sawing.

[0099] Each of the tool’s two structural components is equipped with parallel encoder locators that drive the power tools the length of the structural component and overlapping each other’s function. To perform a continuous unbroken operation, the encoder actuator heads (EAH) adjust to maintain an uninterrupted function, compensating for the combined thickness of the tool’s two structural components.

[0100] Each of the power tools encoder locators, measure independently from the encoder actuator heads (EAH) on the longitudinal linear encoder tracks (LEETM) toward the center of the work table (WTAB).

[0101] Procedures 2 and 11

[0102] The routers (TTLER) in procedure 2 (see FIG. 10) rout openings in the bottom sheeting, which is installed in procedure 1 work table. The openings include windows, doors, stair openings, mechanical, electrical, plumbing, access panels and other miscellaneous openings.

[0103] As shown in FIG. 23, procedure 11 includes routing openings in the top sheeting which is installed in procedure 9. This procedure is similar to procedure 2.
Procedures 7 and 10

Material locators (TTEL) in procedure 7 locate and display callout for fastening mechanical, electrical, plumbing and other miscellaneous devices on steel framing and aligning with openings routed in procedures 2 and 11.

In procedure 10, following the nailer (TTEL), the transverse telescoping encoder locators (TTEL) mark the location of all interior wall panels on the closed floor panel (CP) sheeting, which was installed in procedure 9.

As shown in FIG. 22, the nailers (TTEL) in procedure 10, which follows procedure 9, locate and nail top sheeting to the steel frame.

Procedure 11G

Diamond saws (STLED) in procedure 11G saw cuts skewed gables and other metal framing as required in the fabrication process (see FIGS. 26, 27 and 28).

Panel Steel Edge Beams (EB) & Intermediate Beams (IB)

Two Blue Bridge welding systems (BWSB) and two welding stations (BWS) are employed in the process of fabricating the edge beams and the intermediate beams (see FIG. 13).

The edge beams and intermediate beams are fabricated of two C-shaped joists (CFSR), welded flange to flange, top and bottom, with the 1 1/4" flange member toward the outside of panel and a 2" flange member toward the inside of panel. This creates a 3 3/8" wide beam and by placing the (CFSR) members to counter align the web openings, and increased beam strength is realized.

Mounted on Blue Bridge are two welding systems (BWBS) and two suspended welding stations (BWS). The Blue Bridge transports the C-shaped cold formed rolled steel members (CFSR), temporarily clamped together and suspended beneath the Blue Bridge, to the work table where they are fastened electro-magnetically to the inner face of each of the longitudinal encoder tracks (LLETM). As shown in FIG. 13, the beam fabrication process takes place on the work table at the beam welding station (BWS).

The pylons (TPT) raise the linear encoder tracks (LLETM) 12" above the work table surface and the beam welding station (BWS), which is suspended beneath the Blue Bridge, is lowered and placed on the linear encoder tracks (LLETM) encoder actuator heads (EAH), which drive and position the beam welding station (BWS) intermittently welding, simultaneously the top and bottom flanges to create the finished end beams (EB) and intermediate beams (IB). When the welding is completed, the beam welding stations (BWS) are retracted to the bottom of the Blue Bridge.

The central computer activates the pylons of the work table to raise the linear encoder tracks (LLETM) and the panel edge beams (EB) to the working height to begin the placement of the transverse framing members (TFM).

The welding of the end beams (EB) and intermediate beams for an entire days panel production can be produced off shift, and temporarily stored at the front of the work table to enhance the daily module output.

Procedures 1 & 9—Green Bridge Sheeting Installation

The green bridge is operable to place the closed panel (CP) bottom and top sheeting materials, i.e. gypsum panels (GP), oriented strand board (OSB) and cement bonded particle board (CPB). In procedures 1 and 9, the pylons on the transverse axis of the worktable locate the inner face of the longitudinal linear encoder tracks (LLETM) at the outside dimension of the steel frame. This prepares the worktable to receive the panels of sheeting. The purchased lengths of sheeting are normally equal to the outside dimension of edge beams of the steel frame (less positioning tolerance), but may be reduced to apply higher compressive bearing materials under increased loading.

Sheeting is received on flat bed trailers, which are parked in the plant. The pallets are composed of 20 to 30 sheets of gypsum or other sheeting materials, 4'-0" wide purchased lengths and of varying thickness (1/16" thru 1/4"). The sheeting materials, in procedure 1 (FIG. 10) with their finish side in the down position and in procedure 9 (FIG. 22) with their finished side in the up position, are lifted by the plant overhead crane using modified pallet lifters and stacked on the live green bridge. The Green Bridge is activated by "controllers" moving from the front to the rear above the worktable. As shown in FIG. 10, the Green Bridge is suspended from the tram rails that extend parallel to the longitudinal axis of the worktable, and is powered by variable speed electric power drives (EPD) on each track of the inner rail of the tram.

The controllers activate vacuum assist slides, shifting the sheeting off and onto the worktable (Procedure 1) or steel framing (Procedure 9), the ends of the sheeting panels are positioned in line with the surface of the longitudinal linear encoder tracks (LLETM) thereby placing the bottom or top sheeting of the closed panel (CP).

Procedure 4—Closed Panel Steel Framing

(Edge Beams, Intermediate Beams, Transverse Framing Members, Blocking)

Single Closed Panel Framing Procedure:

The central computer (CC) activates the pylons (TPT) to raise the pylon heads to the framing height above the worktable (WTAB). This is normally 32 inches above the table top, but can be adjusted to a higher setting within the range of the 47 3/4" stroke of the synchronized motor cylinders (SMCS) or vertical encoded actuators (VEA) depending on the workers’ height to provide a comfortable working range.

As shown in FIG. 14, single panels are framed by two workers, i.e., equipment trained controllers referred to herein as ETC’s. The two ETC’s activate the incremental movement of the encoder actuator heads (EAH) on the HD049 or longitudinal linear encoder tracks (LLETM) locating and supporting transverse framing members (TFM) and blocking until they are screwed in place, to the longitudinal edge beams (EB) and intermediate beams (IB). The edge beams (EB) are magnetically attached and supported by the longitudinal linear encoder tracks (LLETM) on the telescoping pylon tubes (TPT).

Each ETC completes the screw or press metal fastening of the transverse framing member (TFM) on each
side of the panel and the encoder actuator heads (EAH) are activated to the next framing position, to allow for variations in the time required for each ETC to complete work in his area of responsibility. A lockout is required, until the work is completed, by the second ETC.

[0123] There are conditions when the transverse framing members (TFM) do not extend so as to bear on the edge beam (EB) on one side of the panel, but will frame into an intermediate beam (IB) creating panel openings for stairs, HVAC trunk ducts, etc. Temporary supports are placed beneath the intermediate beams (IB) until the framing about the opening is completed.

[0124] This will require the ETC on one side of the worktable to override the lockout to activate the HD049 or encoder actuators heads (EAH) and enable the placement of transverse framing members from his side of the table. A positioning laser located on the HD049 or encoder actuator heads (EAH) is used to position the interior setting of the framing members into the intermediate beam (IB).

[0125] The standard framing system of transverse framing members (TFM) is 24 inches on center, additional framing members are located by the HD049s or the encoder heads (EAH) at different spacing to accommodate various structural conditions and interior panel dissection during the erection procedure of the interior wall panels. Blocking, which is screw attached between the framing members (TFM), is located by the transverse telescoping encoder locators (TTEL) following the encoder actuator heads (EAH).

[0126] The two ETC's work overtop of the transverse framing members (TFM) to screw attach the clip angles to the edge beams (EB). The clip angles are preinstalled on the transverse framing members (TFM) off of the worktable using the press metal joining at each end of the framing member maintaining overall length tolerance.

[0127] Double Closed Panel (2) St'd 7'-9.5"x48'-0" Wall Panels Int. or Ext. Framing Procedure

[0128] Double wall panel fabrication is performed by four workers on the worktable. This includes two ETC's, one adjacent to each of the HD049s or encoder actuator heads (EAH) and two assemblers in the center of the worktable. One worker is located on each side of the four stanchions, which rise from beneath the surface of the worktable, supporting a continuous steel plate parallel to the longitudinal axis of the worktable. The steel plate will support electromagnetic clamps to anchor the top structural tracks, which receive the studs. Stanchions, when activated by central controller (CC), maintain the same height as the telescoping pylon tubes (TPT). The wall panels are fastened by press metal, joining the steel studs to the steel track, with equipment suspended from overhead and supported by the Blue Bridge.

Procedure 7—Mechanical & Electrical Sub Assembly Installation

[0129] (Piping Sub Assemblies (PSA), Duct Sub Assemblies (DSA), Electric Power Harnesses (EPH), and Cable Harnesses (CH))

[0130] FIG. 18 shows the ETC's performing the seventh procedure in which pre-assembled mechanical and electrical power distribution and devices are installed in panels on the worktable. Sanitary piping, water supply piping, sprinkler piping, referred to herein as piping sub assemblies (PSA), are assembled in jigs and air tested, prior to positioning them at the end of the worktable. The piping sub assemblies (PSA) drain in the direction of the longitudinal axis of the flat panels, and longitudinal edge beams (EB) permit front or rear module connections to all utilities.

[0131] Heating and air conditioning ducts and ventilation ducts, referred to herein as duct sub assemblies (DSA) are completed in jigs and air tested, prior to positioning them at the end of the worktable. The duct sub assemblies (DSA) are engineered to distribute main air supply parallel to the longitudinal axis of the flat panels framed with intermediate beams (IB) and sub transverse distribution parallel or through the open webs of the steel joists. Grommets and patented anchoring devices are used to protect electrical and mechanical components.

[0132] Wiring harnesses are assembled on a wiring fixture, including switches, outlets and electrical junction boxes referred to herein as electric power harnesses (EPH). Security cables, network cables, telecom cables referred to herein as cable harnesses (CH) are assembled off of the worktable. The electric power harnesses (EPH) and cable harnesses (CH) are coiled on roll off spools and placed at the end of the worktable.

[0133] Starting at the control end of the worktable the piping sub assemblies (PSA), duct sub assemblies (DSA), electric power harnesses (EPH) and cable harnesses (CH) will be fed through the open webs of the end edge beams (EB). As the ETC's place the transverse framing members (TFM) and screw them into place, the ETC's also place grommets and pull the mechanical and electrical sub assemblies through the open webs of the transverse framing members (TFM). The securing of these assemblies to the framing in their final location is not performed until the frame system is lowered and set in the adhesive on the bottom sheeting material. The material locators (TTEL) mark and call out on the screen instructions relating to the assemblies as they are secured in place by the ETC's.

[0134] Mechanical and electrical sub assemblies are clamped and fastened to the frame. Sub assemblies are installed through the openings previously routed in the bottom panel (GP). Piping is installed to drainage specifications and branch piping is extended in the transverse directions parallel to the transverse framing members (TFM) to the open webs of the edge beams (EB) to serve adjacent modules. Plumbing and duct outlet risers are extended to the bottom level of the next top application of a panel (OSB or GP).

Procedures 5 & 8—Application of Adhesives & Insulation

[0135] Procedure 5: RED BRIDGE applies Urethane Adhesives

[0136] In this procedure, the completed structural frame is lowered by the central controller (CCC). Then the synchronized motor cylinders (SMC) or vertical encoder actuators lower the pylons and steel frame to a height of 1½ inches above the bottom sheeting. As shown in FIG. 16, two suspended work platforms, for supporting two ETC's, are
lowered beneath the bottom of the Red Bridge. The ETC's stand on the platforms and apply the adhesive, with handheld wands, from the Red Bridge. The adhesive beads are applied to the sheeting in a pattern mirroring the frame. Two types of urethane adhesives, a high early strength and a long term high strength, are applied to the sheeting. This provides for early handling of the closed panels (CP). Once the adhesive application is completed, the poylrams are again actuated and powered by the central controller (CCC), imbedding the steel frame into the adhesive on the upper surface of the bottom sheeting.

[0137] Procedure 8—Red Bridge Applies Urethane and Icynene Foam Insulation

[0138] As the red bridge moves from the rear toward the front, the ETC's install the urethane and icynene foam insulation from the suspended platforms (see FIG. 20). The insulation is pumped under pressure from dispensing systems located on the overhead red bridge in order to fill the panel cavities to achieve specified insulation R-Values.

[0139] Procedure 8—Red Bridge Applies Urethane Adhesive

[0140] Also, in the eighth procedure (FIG. 21), heads of long term high strength adhesives are placed on top of the edge beams (EB) and transverse framing members (TFM) from the rear to the front in preparation of procedure 9, i.e. placing the top sheeting (OSB, GP).

Roof Panel Sub Assembly (RPSA)

1 Attic Floor Panel, 4 Gable Panels, 2 Roof Panels

Assembling: the Roof Panel Sub Assembly (RPSA)

[0141] As shown in FIGS. 32 and 33, panels composing the roof panel sub assembly are produced on the worktable (WTAB) in the order of assembly, on the module assembly table (MAT). The attic floor panel is transported by the Green Bridge and centered on the module assembly table (MAT).

[0142] As shown in FIG. 34, a single rectangular framed gable (SRFG) is produced on the worktable (WTAB) and is partially cut by the skewed telescoping linear encoded diamond saws (STLEDs) into the four gable panels (GAP) (see FIGS. 26, 27, 28). The (ETCS) reinforce the cut gable frame with screwed in place steel angles (see FIG. 29). The (SRFG) finish siding material is installed on the worktable (see FIG. 30). The four gable panels remain attached as a single rectangular framed gable (SRFG) to be inverted after Procedure 11G by the roll over (RTPT) on the worktable (see FIG. 31). The gable panels (GAP) will remain attached until they are transported by the Green Bridge to the module assembly table (MAT) and placed on top of the attic floor panel, with the exterior finish side in the down position where they will be dissected to be sandwiched between the roof panels and the attic floor panel (AFP) in their final roof roll-up position. The two ETC's press join additional steel angles to the back of the single rectangular framed gable (SRFG), and cut free the four gable panels (GAP) permitting relocation of the gable panels on the attic floor (FIG. 34), to assume the slide out position during the roll-up roof procedure.

[0143] Two roof panels (ROPA) are produced and transported either as one or, two separately, if the sum of the total length exceeds the work table (WTAB) production capability of 48 feet. The Green Bridge places the roof panels on top of the four gable panels (GAP), and returns to the worktable (WTAB).

[0144] As shown in FIG. 36, roof ridge lift hinges (RRLH) are inserted between the two roof panels, from the top and screwed in place. The hinges provide attachment rings for the hoists to raise the roof during tests on the module assembly table (MAT) and raise the roof during field installation of the module. The hinges are removed after the raised panels are braced and screw attached to the top of the gable tracks and the roof tail joint stops (RTJS) are screw attached to the ends of the attic floor panel (AFP). The hinges are returned to the plant for reuse.

[0145] The two ETC's in FIG. 36 fold down, reversed assembly hinges that are preinstalled on the worktable (WTAB) at the inside of the roof panel rake beam (RP RB). The hinges are screw fastened to the roof panel and fastened at the assembly table at the top of the gable panels (GAP).

[0146] The roof panel sub assembly (RPSA) is raised by four hoists on the encoder lift and hold hi-bay (ELHH). The roof panel sub assembly is lifted to a height of 6 feet, thereby providing the necessary clearance for the ETC's standing under the flat roof panel extension, to insert and snap in place four modular housing roof rollers (RR) at four roof tail joistins (see FIG. 37). The roof rollers connect the roof panels at the juncture of the attic floor panel on each end of the roof panels. The roof rollers are rolled tight to the end of the attic floor panel (AFP), where the anchor plates are screw attached to the end of the attic floor panel (AFP). The roof rollers are discarded in U.S. Pat. No. 6,681,544, which is incorporated by reference herein.

Testing the Roof Panel Sub Assembly (RPSA)

[0147] As shown in FIG. 38, the assembled roof panel sub assembly (RPSA) is lowered to the top of the module assembly table (MAT), and the attic floor is anchored to the module assembly table. Then, as shown in FIG. 39, the encoder lift and hold hi-bay centers a crane bridge and one hoist over the roof ridge lift hinges (RRLH), and lifts the roof sub assembly to roll up the roof and verify dimensional accuracy. Once the test is completed, the attic floor is detached and the roof panel sub assembly (RPSA) is reconnected to four hoists on two crane bridges of the encoder lift and hold hi-bay and hoisted to the overhead storage space and safety blocked by the turn-outs mounted on the four tubular columns.

Module & Wall Panel Assembly

[0148] (First or Second Floor Panel, Interior Walls Panels, Exterior and Marriage Wall Panels) As shown in FIG. 23a, module panels are produced on the worktable (WTAB) and transported to the module assembly table (MAT) by the Green Bridge. The module floor panel is centered on the module assembly table (MAT). The double closed panel (CP) composed of interior wall panels (IWP) are transported second, as a single panel by the Green Bridge. The interior wall panels (IWP) are unloaded in the flat position centered on the middle of the floor panel. The double closed panels (CP), composed of exterior and marriage wall panels
(EMWP) are the last produced on the worktable (WTAB), and are transported by Green Bridge to be positioned on top of the interior wall panels (IWP) and are to be the first erected. The completed panels that have been transported to the module assembly table (MAT) are shown in FIG. 39A & FIG. 40.

[0149] As the double closed panels (CP) are positioned in the flat position, they are dissected longitudinally, forming two linear multi-panels (LMP), composed of one longitudinal exterior wall panel (LEWP) joined at the top and bottom track, to one transverse exterior wall panel (TEWP) and one longitudinal marriage wall panel (LMWP) joined at the top and bottom track, to one transverse exterior wall panel (TTTEWP, see FIG. 39A & FIG. 40).

[0150] **Lifting Procedure 1: Wall Panel Lift and Position (WPLP)** (see FIG. 40)

[0151] The lower crane way with Bridge #1 and #2 and two hoists, lifts the joined longitudinal exterior wall panel (LEWP) and the transverse exterior wall panel (TEWP) to a vertical position and places the bottom (OSB) extension of the longitudinal exterior wall panel (LEWP) over the longitudinal edge of the floor panel to be screwed in place. The joined transverse exterior wall panel (TEWP) is cantilevered beyond the end of the floor panel. The hoist on Bridge #2 is reconnected to the center of the transverse exterior wall panel (TEWP) and the top and bottom plate is cut free, allowing the transverse exterior wall panel (TEWP) to be turned 90 degrees and installed on the transverse end of the floor panel.

[0152] Steel angle plates are screwed in place to complete the 90 degree joint of the longitudinal exterior wall panel (LEWP) and the transverse exterior wall panel (TEWP), thereby permitting the uncoupling of the Bridge #1 from the longitudinal exterior wall panel (LEWP).

[0153] **Lifting Procedure 2 (see FIG. 40)**

[0154] This Procedure is a mirror image of Lifting Procedure 1, and includes substituting a longitudinal marriage wall panel (LMWP) for the longitudinal exterior wall panel (LEWP).

[0155] Lifting procedures 1 and 2 complete the exterior envelope of the module.

[0156] **Lifting Procedure 3**

[0157] The interior wall panels (IWP) are produced as one linear multi-panel (LMP) on the worktable (WTAB). The linear multi-panel (LMP) is composed of a series of short interior wall panels (IWP) joined by a common top and bottom track to be dissected incrementally during erection. The interior wall panels (IWP) are positioned in the linear multi-panel (LMP) in the order of erection within the module envelope. Typical Interior Wall Panel (IWP) panel junctures and connections are illustrated in FIG. 40A.

[0158] As shown in FIG. 41, the lower crane way (WPLP) with Bridge #1 and #2 and two hoists lifts the linear multi-panel (LMP) to a vertical position, stabilizing the top, and lowers the bottom track to temporary support blocks, located between the points of interior wall panels (IWP) dissection. Two ETC’s will handle the dissected interior wall panels (IWP) with manual tools and screw anchor them in place (see FIG. 40A—Typical Panel Junctures).

[0159] During the interior wall panels (IWP) erection, the ETC’s complete the electrical and mechanical connections of the installed systems in the panels during production on the worktable (WTAB).

[0160] **Lifting Procedure 3** completes the interior panel installation and then the panels are screw anchored to the floor.

[0161] **Setting the Roof Panel Sub Assembly (RPSA)**

[0162] As shown in FIG. 42, the roof panel sub assembly (RPSA) is lowered by the four hoists on the encoder lift and hold hi-bay (ELHH) and is supported on temporary blocking on top of the module’s bearing walls. This operation is performed to allow the ETC’s to pull down electrical cables stubbed off in the bottom of the attic floor panel, to connect to junction boxes in the module’s wall panels and also attach HVAC and mechanical connections to the like systems in the module’s wall panels.

[0163] Once this operation is complete, the roof panel sub assembly (RPSA) is raised, the blocks are removed and the roof panel sub assembly (RPSA) is lowered to its final bearing position on the bearing walls. The final structural connections are made by screw fastening steel plates to the attic floor panel and the module’s envelope bearing walls.

[0164] During the entire module assembly, four electrified articulated jib arms extending from the tube columns provide counter-balanced screw guns, press joining tools, steel nibbler cutting, and other miscellaneous tools used in the performance of the work.

[0165] **Installing Module Exterior Finish Material**

[0166] Concurrent with Lifting Procedure 3, the ETC’s perform preliminary work on the exterior wall panels leading to the application of the exterior finishes which will begin at the first module completion station on the final assembly finishing line. Following the installation of the exterior finish material, the plant overhead crane (POCS) transports the assembled module to the final assembly finishing line.

[0167] The preceding description is of a preferred embodiment of the present invention, however, it should be understood that the same is not limited thereto but is susceptible to numerous changes and modifications as will be apparent to one of ordinary skill in the art. Accordingly, the scope of the invention is not to be limited to the details shown and described herein, and is intended to cover all modifications which are encompassed by the scope of the appended claims.

I claim:

**1. A modular production system for producing wall panels of a modular building, the system comprising:**

- a worktable;
- a plurality of telescoping tools mounted over the worktable;
- an overhead tram disposed adjacent the worktable; and
- a plurality of material supply bridges movably supported on the overhead tram so as to be movable over the worktable in a longitudinal direction thereof.
2. The modular production system as claimed in claim 1, further comprising a controller for controlling operation of the worktable and the material supply bridges.

3. The modular production system as claimed in claim 2, wherein the controller comprises a computer.

4. The modular production system as claimed in claim 1, further comprising a module assembly table for receiving, storing and assembling wall panels produced at the worktable.

5. The modular production system as claimed in claim 1, wherein the worktable includes longitudinal encoder tracks supported on a plurality of telescoping pylon tubes for setting the vertical position of the longitudinal encoder tracks.

6. The modular production system as claimed in claim 5, wherein the pylon tubes are movable horizontally toward and away from a central axis of the worktable.

7. The modular production system as claimed in claim 5, wherein each of the longitudinal encoder tracks includes at one encoder actuator head.

8. The modular production system as claimed in claim 1, wherein each of the plurality of material supply bridges is independently movable in the longitudinal direction of the worktable, and the material supply bridges are arranged so that they can cross over or under each other while performing independent production procedures.

9. The modular production system as claimed in claim 1, wherein the plurality of material supply bridges comprises a first supply bridge for supplying sheeting material to the worktable, a second supply bridge for supplying steel members to the worktable, and a third supply bridge for supplying adhesive and insulation to the worktable.

10. The modular production system as claimed in claim 9, wherein the first material supply bridge includes opposing sloping pallets for supporting panel sheets, and a sheet placement device for moving the sheets from the first material supply bridge to the worktable.

11. The modular production system as claimed in claim 9, wherein the second material supply bridge includes welders, metal press joining equipment, and screw driving devices.

12. The modular production system as claimed in claim 1, wherein the third material supply bridge includes an adhesive dispensing device and an insulation spray device.

13. The modular production system as claimed in claim 1, wherein each of the plurality of telescoping tools comprises two structural members having interlocked bearing surfaces to permit the tool to contract and expand in length to accommodate different panel widths.

14. The modular production system as claimed in claim 1, wherein the plurality of telescoping tools comprises a transverse telescoping linear encoded router, a transverse telescoping encoded material locator, a telescoping linear encoded diamond saw, and a transverse telescoping linear encoded nailer.

15. The modular production system as claimed in claim 14, wherein the ends of the telescoping linear encoded diamond saw can be skewed to enable the saw to make cuts at an angle to the longitudinal axis of the worktable.

16. The modular production system as claimed in claim 5, wherein each of the plurality of telescoping tools comprises encoder actuator heads supported on the longitudinal encoder tracks.

17. A method of manufacturing a panel of a modular structure, the method comprising:

moving a first material supply bridge over a worktable in a longitudinal direction of the worktable to place panels of sheeting on the worktable, wherein the first material supply bridge is supported on an overhead power tram; and

moving a second material supply bridge over the worktable in the longitudinal direction of the worktable to place steel members for the construction of a steel frame, wherein the second material bridge is supported on the overhead power tram.

18. The method of manufacturing a panel of a modular structure as claimed in claim 17, further comprising connecting the steel members to form edge beams and intermediate beams of the steel frame.

19. The method of manufacturing a panel of a modular structure as claimed in claim 18, further comprising moving a third material supply bridge over the worktable in a longitudinal direction of the worktable to apply adhesive on the sheeting in a pattern mirroring the steel frame, wherein the third material bridge is supported on the overhead power tram.

20. The method of manufacturing a panel of a modular structure as claimed in claim 19, further comprising lowering the steel frame so as to embed the steel frame in the adhesive on the surface of the sheeting.

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