Disclosed herein is a modular building structure. The structure includes a modular building roof structure comprising the roof structure which includes a plurality of truss structures each having a top and a bottom and a pair of deck layers attached to and for transversely spanning the tops of the truss structures. The roof structure also includes an acoustical ceiling suspended along the bottoms of the truss structures. The building structure also includes a modular building floor structure which comprises a deck structure including an upper deck pan and a lower deck pan disposed opposite and adjacent each other to create a plurality of spaced apart support channels. In a preferred embodiment, the deck structure is oriented transverse to the support beams. The floor structure further includes a plurality of support beams for supporting the deck structure. Significantly, the deck and the acoustical ceiling define a return air plenum that provides for proper venting, distribution and circulation of air, including introduction of fresh air, throughout the modular structure. Advantageously, no separate ductwork or duct system is required with the use of the air plenum. Preferably, the structure is substantially non-combustible and mold-resistant.
MODULAR BUILDING STRUCTURE

BACKGROUND OF THE INVENTION

[0001] This invention relates generally to modular building systems, and more particularly to modular building roof and floor structures.

[0002] Modularly constructed building structures are advantageous in that they provide shelter from the elements in which a variety of activities can be housed, and are relatively easily transported from one locale to another. Moreover, such structures can typically be assembled in stackable sections, or sections placed side-by-side (i.e., the sections are positioned adjacent each other), right on site after being transported. Modular building structures can be used for production of single and multi-unit or multi-family homes, as well as apartments, condominiums, classrooms, general offices, medical facilities, commercial buildings and the like.

[0003] Many modular building structures are custom designed. However, building structures can also be designed according to standard or pre-fabricated building templates as well. Today’s modular building structures are computer-engineered to meet national building codes. They can be precisely engineered for increased structural durability. High quality can be maintained by inspection during construction process. In one construction example, a modular building structure is delivered to a desired site, after which individual modular structures or “modules” are assembled into an overall modular building structure.

[0004] In general, the metrics of building construction costs break out on a per square foot basis. It is a continuous goal to reduce the construction costs of the modular structures. To this end, it would be desirable to provide a modular building structure that, while meeting all applicable building codes and other standards, is simpler to construct than known modular building structures. For example, a building structure comprising fewer pieces, parts or other components in its construction is desirable. Similarly, material selection for each modular building structures is key, in that the material type and placement can result in a building structure of having a greater useful life and durability.

[0005] It would also be desirable to use stronger and more durable modules or substructures in making the overall modular building structure. This can lead to a decrease in the number of supports or braces in a given area, thereby reducing modular building structure costs on a square foot basis. Advantageously, the mating of various components can provide increased strength, which, in conjunction with the reduction in the number of support structures, reduces overall modular weight, in addition to construction and transportation costs.

[0006] Further, in the modular building structure industry, there are increasing requirements aimed at improving the structure resistance to mold and combustion. Accordingly, it would be desirable to provide a modular building structure that increases the use of stainless steel materials in order to achieve these desired ends.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Embodiments of the invention are disclosed with reference to the accompanying drawings and are for illustrative purposes only. The invention is not limited in its application to the details of construction or the arrangement of the components illustrated in the drawings. The invention is capable of other embodiments or of being practiced or carried out in other various ways. Like reference numerals are used to indicate like components.

[0012] FIG. 1 is a perspective view of a group of modular building structures according to one aspect of the present invention;

[0013] FIG. 2 is a top plan view of a plurality of modular building structures;

[0014] FIG. 3A is a cut-away partial perspective view of the modular building structure taken along line 3A-3A of FIG. 1;

[0015] FIG. 3B is an alternative embodiment of the perspective view of the modular building structure of FIG. 3A showing the use of an I-beam dual deck pan floor construction;

[0016] FIG. 3C is a is an alternative embodiment of the perspective view of the modular building structure of FIG.
3A showing the use of an I-beam dual deck pan floor construction in addition to a dual deck pan roof construction;

[0017] FIG. 4 is a cross-sectional view of the modular building structure taken along line 4-4 of FIG. 1;

[0018] FIG. 5 is a cross-sectional view taken along line 5-5 of FIG. 4;

[0019] FIG. 6 is an enlarged sectional view taken along line 6-6 of FIG. 4 showing a portion of the modular building roof structure;

[0020] FIG. 7 is an enlarged sectional view taken along line 7-7 of FIG. 4 showing a portion of the modular building floor structure;

[0021] FIG. 8 is an enlarged cross-sectional view taken along line 8-8 of FIG. 4 showing a portion of the modular building roof structure with a return air plenum according to one aspect of the present invention;

[0022] FIG. 9A is an enlarged cross-sectional view taken along line 9A-9A of FIG. 7 showing the pair of deck pans according to one aspect of the present invention;

[0023] FIG. 9B is an alternative embodiment of the pair of deck pans shown in a spaced apart arrangement; and

DETAILED DESCRIPTION OF THE INVENTION

[0024] Referring to FIG. 1, a perspective view of a group of modular building structures 10 are shown. The group includes any number (as indicated by the hashed lines) of individual structures 12a-d, such as modular structure 12b, which can be aligned or positioned in a repeatable fashion as shown according to the space requirements for the particular application. In the embodiment shown, the modular units include roof structures 18 having a pitch with an apex along centerline 21. In select applications, the roof structures 18 can be constructed in a flattened manner to the extent that modular units can be stacked to facilitate transportation of multiple units to specific locations. In general, if stacking of the modular structures is desired, as is contemplated in multi-story applications of the present invention, the roof structure pitch is typically reduced or eliminated altogether. Applications for modular building structures such as that shown in FIG. 1 include office, educational, health or medical, laboratory space, residential, and light manufacturing, among others. In a typical construction, each modular building unit can include such features as doors 14 and windows 16, replicating features found in permanent building structures. Each individual structure or module 12a-d has in and of itself the requisite elements to resist the lateral loads due to winds and earthquake conditions. Advantageously, the lateral loads resistance or lateral load bearing characteristics are also additive. That is, when the structures are placed next to one another side to side, the lateral load resistance is additive. Therefore, providing one structure with a lateral load resistance level next to another structure with a lateral load resistance, an additive effect of \( x + y \) total lateral load resistance will be achieved. The combined structure will be able to withstand the combined individual additive lateral loads. When a plurality of the modular buildings are placed laterally together to create a modular building group having a total lateral load bearing character-

istic, the total lateral load bearing characteristic is additive from the individual modular building lateral load bearing characteristics.

[0025] FIG. 2 is a top plan view of a plurality 20 of modular building structures 22a-e. In structure 22d, a portion of the modular building structure interior 24 is shown along with several interior elements 26 (e.g., a sink, a toilet, a door, etc.). In the embodiment shown, the modular structures are shown positioned in side-by-side or adjacent fashion, however, it is contemplated that the modular units can be arranged or positioned in ways that can vary to convenience. In addition, the modular units are scalable, both in size and number, depending on the application at hand.

[0026] FIG. 3A is a cut-away partial perspective view of modular building structure 10 taken along line 3A-3A of FIG. 1. In FIG. 3A, various components and layers are illustrated in cutaway fashion to facilitate understanding of the invention. FIG. 4 is a cross-sectional view of the modular building structure 10 taken along line 4-4 of FIG. 1.

[0027] Referring to FIGS. 3A and 4, modular building structure 10 includes a modular building roof structure 32 and a modular building floor structure 34. The modular building roof structure 32 includes a plurality of longitudinal, open web trusses 36. Each of the plurality of trusses 36 has a first end 38 (FIG. 3A) and a second end 40 opposite the first end. Tubular columns 42 may be positioned at the first and second ends 38, 40 of the trusses 36 for supporting the trusses. The ends 38, 40 of the trusses 36 may also be supported by a two-dimensional frame in order to reduce the number of columns required. Each truss or truss structure 36 includes longitudinally disposed supporting beams 46 and 48 connected in overlapped or “sandwiched” fashion using tension and compression members 50. The beams 46 and 48 are, in the embodiment shown, comprised of individual support beam members 46a,b and 48a,b. A deck 52 is attached to and spans the tops 35 of the truss structures 36. In one embodiment, the deck is roll-formed and can be made of steel. A suspended acoustical ceiling 54, which may be of a ceiling tile variety, can be suspended along the bottom 39 of the trusses and in this fashion be combined with the modular roof structure 32.

[0028] Significantly, the deck 52 and the suspended acoustical ceiling define a return air plenum space 56. The return air plenum space 56, in combination with any physical vents, provides for proper venting, distribution and circulation of air; including introduction of fresh air, throughout the modular structure. As a result of the present structural arrangement, no separate ductwork or duct system is required, which provides savings in the manufacture, both in terms of material and labor costs, of the modular building structure of the present invention. Preferably, at least one of the plurality of longitudinal, open web trusses, the plurality of tubular columns, and the roll-formed deck can be constructed of steel, and in a preferred embodiment, the deck 52 is substantially covered with a mold-resistant foam insulation material 57. Accordingly, the modular building roof structure 32 can be described as substantially non-combustible and substantially mold-resistant.

[0029] The modular building structure 10 further includes a modular building floor structure 34 which is joined or connected to the roof structure 32 as shown via columns 42.
The floor structure 34 includes a single layer deck structure 58. A plurality of longitudinal main support beams 60, also called “Z purlins”, are connected to the deck pans and are oriented transverse to the length of the floor structure. Advantageously, the present invention provides for the ability of the support beams to be positioned in spaced apart fashion, typically about 12 to 14 feet apart over the entire length of the modular building unit. End support beams or “I-beams” 62 are utilized at the outer region of the floor structure. In one embodiment, a decking surface 64, typically of a plywood, cement board, poured concrete or combination type, can be connected to, positioned or laid over, or otherwise formed over, the pair of deck pans. As an additional feature, wheels 66 can be provided to improve the mobility of the modular unit.

[0030] FIG. 3B is an embodiment of the perspective view of the modular building structure 10 of FIG. 3A showing an improvement through the use of an I-beam dual deck pan floor construction 61 for use in the overall floor structure 34. The Z purlins of FIG. 3A are replaced here on each edge with an I beam 63 that runs the length of the building 10. Although not shown, the opposite edge would mirror the edge shown to complete the floor structure. Advantageously, the result is the use of fewer heavy metal construction components. Specifically, the plurality of transverse Z-purlins are replaced by only two I beams that run the length of module 10. The benefits conferred by I-beams 63 include: reduction of construction costs of module 10, reduced overall weight, and reduced material (which reduced material transport costs), among others. A pair of deck pans 65 is utilized in order increase strength. The pair are oriented to be transverse to the length of the I-beams such that the ribs of the pair run the width of module 10. It is the increased strength of the transverse deck pan pair 65 that helps permit the use of the longitudinal I beams 63, and at longer intervals between beams, to reduce the number of support beams required overall. The traverse dual decking 65 and the lengthwise I-beams 63 together make up the I-beam dual deck pan floor construction 61 for use in the overall floor structure 34.

[0031] FIG. 3C is a is an alternative embodiment of the perspective view of the modular building structure of FIG. 3B showing an improvement of the I-beam dual deck pan floor construction 61 in addition to a dual deck pan roof construction 71. By “dual deck pan roof construction” it is meant that the roof construction comprises two main trusses 73, 75 along with a pair of deck pans 77, 79. Again, the dual pans provide additional structural support when compared to a single deck panel arrangement. The increased strength permits the weight of the roof to be supported by fewer trusses, as shown, trusses 73, 75, without deleterious effects such as buckling or significant bending. The benefits conferred by the roof structure shown include: reduction of construction costs, reduced overall weight, and reduced material (which reduce material transportation costs), among others.

[0032] FIG. 6 is an enlarged sectional view taken along line 6-6 of FIG. 4 showing a portion of the modular building roof structure 32. Support members 46b and 48b are connected via tension and compression members 50. Decking 52 is attached at its lower surface 68 to the top of truss 36, and specifically as shown to member 46b. 1.5” deck is one material that is suitable for use in the present invention. Acoustical ceiling 54, which is typically made of an insulation material, is attached at its upper surface 70 to decking 52 through the use of suspension wires. The roof structure and ceiling create combination 37. Decking 52 and ceiling 54 create return air plenum 56. Again, as a result of the present structural arrangement, no separate return air ductwork or duct system is required, the modular building structure of the present invention can be constructed for less money with fewer materials and with a less complicated air distribution system. Truss 36 is supported at its end by column 42. Various supports 72 include, as shown, 2x2 or 2x4 wood supports members. A roofing material 74 (e.g., 0.060 in. EPDM) can be laid or applied to the upper surface of the foam insulation 57. The roofing material can be secured, for example, by trim 76. Supports 72 are connected and secured to the truss 36 via a track 78, such as a “C” track, and covered by the roofing material 74. Other paneling 80 and trim elements 82 can be added to complete the exterior of the roof structure as desired.

[0033] FIG. 8 is an enlarged cross-sectional view taken along line 8-8 of FIG. 4 showing a portion of modular building roof structure 32 with plenum 56. Space or plenum 56 runs, in a preferred embodiment, substantially the entire length of the modular building roof structure. Again, in a known fashion, the plenum is defined by the deck 52 at its upper boundary and the ceiling insulation material 54 on its lower boundary, as well as, by thermal insulation material 76 on its ends. The deck and ceiling are connected by truss 36.

[0034] Referring to FIG. 5, a cross-sectional view taken along line 5-5 of FIG. 4, is shown. As can be seen, a portion of the modular building structure is shown, illustrating several basic structural members. These members include tubular members 42, “C” beams 44, which, in conjunction with stud members 45 serve to provide the requisite support for the trusses and connects the roof structure with the floor structure of the modular building unit. Also, these members eliminate the need for intermediate support or support members within the overall modular building structure. Exterior panels 47 are also included to protect the exterior surface of the modular building structure.

[0035] FIG. 7 is an enlarged sectional view taken along line 7-7 of FIG. 4 showing a portion of the modular building floor structure 34. Support beams, such as I-beam 62 and Z-purlins 60 which are shown in exemplary fashion, are used to support the deck pan 58 (with I-beams being used in transverse fashion when supporting dual layer deck pans). Again, foam insulation 82, paneling 84 and trim 86 are used to provide protection and buttress the support beams. Stud 88, preferably made of steel, provides the support necessary for the dual pans 58 to withstand the stresses imposed thereon. A steel strap 89 is shown for use in supporting insulation (not shown) which can be inserted or placed in space 93 located above the strap. The strap runs through center punches 91a-b (also called eyelets) in I-beam 62 and Z-beam 60.

[0036] FIG. 9A is an enlarged cross-sectional view taken along line 9A-9A of FIG. 7 showing deck structure pair 65 of deck pans. In one embodiment, 1.5” deck is one material that is suitable for use in the present invention, although other materials are possible and contemplated. More specifically, an upper deck pan 90 and a lower deck pan 92 are positioned in opposing adjacent fashion to create the deck support. The positioning of the pans 90, 92 create support
channels 94, spaced apart by regions 96 in which the pans contact or substantially contact each other. One manner of accomplishing this arrangement is to take a first rolled, corrugated deck pan, and position it in opposing fashion with a similar, if not identical, second deck pan. The arrangement illustrated promotes maximum strength and rigidity for the modular floor structure, while minimizing the need for additional or unnecessary floor structure support members. Additionally, bending or other deflection of the floor structure is also minimized. As a result, the deck structure is capable of supporting a greater load than each of one of the pair of deck pans individually. Also, the deck structure has a combined deflection level that is less than an individual deflection level for each of the deck pans individually for a given load. Advantageously, the strengthening can be accomplished using materials, such as those described herein, that are common in the modular building industry. Moreover, it is contemplated to add or insert materials into channels 94, with the insertion of said additional materials adding to the strength of the deck structure pair 58.

3. The combination of claim 1 wherein the pair of deck layers is roll-formed.

4. The combination of claim 1 wherein the pair of deck layers is corrugated.

5. The combination of claim 1 wherein the pair of deck layers is constructed of steel.

6. The combination of claim 1 wherein the modular building roof structure is at least one of substantially non-combustible and substantially mold-resistant.

7. The combination of claim 1 further wherein at least one of the plurality of longitudinal, open web trusses, the plurality of tubular columns, and the roll-formed deck comprise steel.

8. A modular building floor structure comprising:

a deck structure including an upper deck pan and a lower deck pan disposed opposite and adjacent to each other to create a plurality of spaced apart support channels; and

a plurality of support beams for supporting the deck structure;

wherein the deck structure is oriented transverse to the support beams.

9. The modular building floor structure of claim 8 further comprising a decking surface laid over the pair of deck pans.

10. The modular building floor structure of claim 9 wherein the decking surface includes plywood and wherein the plywood is supported at least in part by the support channels.

11. The modular building floor structure of claim 8 wherein the decking surface includes cement board and wherein the cement board is supported at least in part by the spaced apart support channels.

12. The modular building floor structure of claim 8 wherein the decking surface includes poured concrete and wherein the concrete is supported at least in part by the support channels.

13. The modular building floor structure of claim 8 wherein at least one of the upper and lower deck pans is corrugated.

14. The modular building floor structure of claim 8 wherein the deck structure is capable of supporting a greater load than each of one of the pair of deck pans individually.

15. The modular building floor structure of claim 8 wherein the deck structure has a combined deflection level that is less than an individual deflection level for each of the deck pans individually for a given load.

16. The modular building floor structure of claim 8 wherein the support members comprise at least one I-beam.

17. The modular building floor structure of claim 16 wherein the support members comprise two I-beams.

18. The modular building floor structure of claim 8 wherein the plurality of main support beams are spaced apart in intervals that are in a range of about 12 to about 14 feet.

19. A modular building structure comprising:

a modular building roof structure in combination with a suspended acoustical ceiling system, the combination comprising:

a plurality of truss structures each having a top and a bottom;
a pair of deck layers attached to and for transversely spanning the tops of the truss structures; and
an acoustical ceiling suspended along the bottoms of the truss structures; and
a modular building floor structure comprising:
a deck structure including an upper deck pan and a lower deck pan disposed opposite and adjacent each other to create a plurality of spaced apart support channels; and
a plurality of support beams for supporting the deck structure;
wherein the deck and the acoustical ceiling define a return air plenum; and
wherein the deck structure is oriented transverse to the support beams.

The modular building structure of claim 19 wherein the upper deck pan and the lower deck pan are separated to create a plurality of deck gaps, and further including a plurality of spacers inserted into the plurality of deck gaps.

The modular building structure of claim 19 further including inserting support materials into the plurality of spaced apart support channels for increasing the support strength of the deck structure.

The modular building structure of claim 19 wherein each modular building has a lateral load bearing characteristic, and that when a plurality of the modular buildings are placed laterally together to create a modular building group having a total lateral load bearing characteristic, the total lateral load bearing characteristic is additive from the individual modular building lateral load bearing characteristics.

The modular building structure of claim 19 wherein the pair of deck layers are separated to create a plurality of deck gaps, and further including a plurality of spacers inserted into the plurality of deck gaps.

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