ABSTRACT OF THE DISCLOSURE

A prefabricated building structure consists of at least a pair of sections formed of steel beams aligned horizontally and vertically, and arranged in a three-dimensional, closed, rectangular pattern by welded, moment resisting joints, in the manner of a plurality of Vierendeel trusses. Each section is enclosed by flooring, roofing, or curtain wall paneling on all sides except those which will abut the other sections. Each section has cable engaging means attached to it, which form its upper surface so that the units may be fabricated at a factory site and transported to a building site or a truck or the like. The framing arrangement allows the sections to be lifted off the truck by means of cranes which attach to the cable engaging means, without any substantial deformation of the building structure. The sections are joined together on their open sides and drawn together with bolting systems.

This invention relates to a building formed of a number of sections which are prefabricated at a place removed from the site of the building and are then simply joined at the building site to form a complete structural unit.

In order to achieve the economies of quantity production by specialized laborers using specialized equipment there has been a trend toward the prefabrication of components or sections of buildings at a "factory" location and then the assembly of these components or sections at the actual building site to form the finished structure. The degree of prefabrication of these structures varies from the simple forming of roof trusses at an off-site location to the complete erection of the building at the factory location and its subsequent transfer to the building site. The present invention relates to a structure which is close to the latter situation in broad concept and contemplates a building wherein the activity at the actual site simply comprises the joining together of a number of completely finished units.

While the present invention may involve structures formed by the joinder of any number of prefabricated units, the preferred embodiment of the invention, which will be subsequently described in detail, employs only two of the prefabricated sections. The novelty of the present invention particularly lies in the form of the prefabricated units which allows them to be constructed at a factory site, easily transported to the building site and then quickly joined together, with a minimum of lifting and handling to form a building having a high degree of structural integrity.

The problems associated with prefabricating a relatively large structure at a factory site and then transporting it to a building site are similar to those encountered in the prefabrication of existing buildings from one site to another. The prefabricated sections must be sufficiently rigid so that when lifted by applying forces to a plurality of points or areas the structure will not deform sufficiently to damage the structural components or disturb their relation to one another. Additionally, sections should be as light in weight as possible and should be easily lifted, preferably from the top.

The preferred embodiment of the invention achieves these objects in a highly economical manner by employing prefabricated sections built about a frame which takes the form of a Vierendeel truss. This form of truss or girder consists of an open web array of horizontal and vertical members, but no diagonal members, with the horizontal and vertical members joined to one another with rigid, moment resisting joints. The framing members are joined together in a rectangular pattern which is inherently stable but which allows the members to be moved in groups. Thus, the use of prefabricated units is facilitated. Additionally, sections should be as light in weight as possible and should be easily lifted, preferably from the top.

The use of a frame construction on the principles of a Vierendeel truss provides several important advantages to the structure. First, the structure may be transported by lifting it at a number of spaced apart points of the upper horizontal beams of the frame. The vertical members transmit these upward forces to the lower members with a minimum of lifting forces and the moment resisting welded joints absorb these moments. The frame structure may be formed of any number of rectangular groupings and still be lifted at not more than four spaced points on the upper beams. This allows the formation of prefabricated structures of any length or width, limited only by the ease of transportation of a large section. Another advantage of this particular type of framing lies in the fact that normal rectangular wall, window, or door panels may be disposed within the rectangular frame sections.

In the preferred embodiment the Vierendeel frame is formed into a rectangular unit closed on five of its sides by panels, windows, and doors, and open on one vertical side. The open side may have a plurality of vertical beams disposed between the end beams and these beams are preferably placed in a symmetrical relation between the ends so that a pair of identical building units may be joined together by locking their open sides into abutting relationship so that the interior beams line up with one another. Each of the rectangular units has legs extending from the corner of one of its horizontal surfaces so as to raise the structure above the ground. A pair of units is locked together by means of eye plates which are aligned in the vertical direction and extend outwardly from the sides of a pair of columns forming the sides of the open end of the frame. A bolt passed through the eyes of two abutting units not only blocks the units together but insures exact alignment of the entire structure. An elastic compression tape is disposed along one of the outer beam and column faces and is compressed against the face of the adjoining, to form an air tight seal between the units.

In order to avoid the use of complicated lifting frames, it is preferable that not more than four lifting points be associated with each structure. Accordingly, the preferred embodiment employs lifting hooks which are made integral with the horizontal beams at the top of each unit. Four of these hooks are used with each unit, two being disposed along each of the opposed beams.

The preferred embodiment also employs a unique system for joining the panel elements within the frame members of the Vierendeel truss and for providing for flooring and ceiling construction. It is therefore seen to be a primary object of the present invention to provide a building structure made of at least two prefabricated structures which are formed in the shape of rectangular units constructed with Vierendeel trusses having welded, moment resisting joints, each being closed on all sides except one and wherein means are provided for locking a pair of the units together on their
open sides to form a completely enclosed building structure.

Another object is to provide such a structure wherein the lifting hooks are fixed to the top of the horizontal beams which support the roof of the structure so that the structure may be lifted by a crane without the use of a lifting frame.

Another object is to provide such a structure wherein the lower beams of the truss have downwardly extending legs members from lifting hooks at the four corners to raise the floor level above the ground surface so that no preparation need be made to the site surface before the building is placed on site.

Other objects, advantages, and applications of the present invention will be made apparent by the following detailed description of a preferred embodiment of the invention. The description makes reference to the accompanying drawings in which:

FIGURE 1 is a perspective view of a completed structure, formed of two sections, representing the preferred embodiment of the invention, with sections of the wall, ceiling, and floor broken away to disclose the method of construction;

FIGURE 2 is a perspective view of a completed steel frame used in connection with each of the sections of the preferred embodiment; and

FIGURE 3 is a perspective view of a section of the framing member showing the method of joining the two prefabricated units to one another and the method of fixing panel elements within the recangles of the Vierendeel frame.

Referring to the drawings, each of the sections which are joined to form the structure of the preferred embodiment is formed about a frame generally indicated at 11, fabricated from elongated rectangular steel tubes. The tubes consist of longitudinal lower beam members 10 and transverse lower beam members 12, longitudinal upper beam members 14 and transverse beam members 16, and vertical columns 18. The corners of the rectangular array formed by the lower beams 10 and 12 are joined to the corners of the complimentary upper rectangular array formed by the beams 14 and 16 by the column members 18. The resulting structure may be viewed as consisting of three cubes, generally indicated at 20, 22 and 24, the adjacent cubes each sharing one surface with one another. The length of the longitudinal members between a pair of transverse members may not be the same as the length of the transverse members. That is, the units 20, 22 and 24 may not be regular cubes but may have the width which is different than their length.

The arrays could be formed with a greater or lesser number of cubes and cubes could be added along the width of the structure to form various arrays as required by the structure. The joints between the beams and the columns are made by welding. The nature of the welded joint is such as to join those beams and columns which meet at a joint into a unitary structure, able to absorb the moments which are imposed on any of its members, during normal use, without causing a sufficient distortion of the frame to damage the panels which may be supported on the frame.

Each of the columns 18 extends beyond the surface of its joint with the lower beams 10 and 12 by a few inches so as to form an extending leg 26. Flat steel pads are welded to the bottom sides of each of these legs and provide a bearing surface for the building site. The legs add to raise the lower surface of the structure above the surface of the building site so that the site need not be prepared for the structure in any special manner, other than providing a generally level and compacted surface for the pads 28 to rest on.

The frame structure disclosed in FIGURE 2, is completed by the provision of four lifting hooks 30 spaced points on the upper surfaces of the two longitudinal top beams 14. The lifting hooks take the form of iron rods bent into an inverted U-shape with outwardly extending flanges at the extremes of the legs. These flanges are then welded to the selected points on the top surfaces of the beam 14. The placement of the lifting hooks is spaced on the beams 14 so that one half the length of the beam 14 extends between them and one quarter of the length is disposed between each hook and the beam 14. Holes may be provided in the structure is evenly imposed on lifting cables and the angled force of the cable is resolved into pure lifting forces and stresses in the direction of the beams 14 and 16 which are absorbed within the top frame. The use of the Vierendeel truss frame makes it possible to limit the number of lift points to four, or even three. The use of more lift points would require the provision of a complicated lifting frame to equalize the load on all of the cables. The Vierendeel truss allows a section to cantilever beyond the ends of the supports and thus provides for the most economical lifting operation.

A variety of members such as wall panels 40, windows 42, and doors 44, may be provided in the sides of the structure by means of a retaining system which is detailed in FIGURE 3. The wall panels 40 may have an outer aluminum skin 43 which is filled with a suitable insulation 46 such as foam plastic. Each panel is individually attached to one of the surfaces of the framing tubes such as the column 18 by means of T-shaped extrusions generally indicated at 48. The extrusions each have cross members 50 with a pair of keyways on their inner faces which retain gaskets 53. One of these gaskets abuts a surface of the wall panel 40 and the other gasket abuts the contiguous surface of one of the framing members. The T member 48 has an upright member 54 which extends between the abutting faces of the panel and the tube member. The upright member has a central slot 56 which is formed with a line of thread-like serrations. One of the T members 48 is placed on each side of each edge of the panel. In order to lock the system together, a bolt 60 is passed through a hole formed in one of the cross members of the T and its threaded end is passed into the slot 56 in the opposite member and is threaded therein so as to draw the system together. Windows and doors may be retained in a similar manner.

The flooring 70 and the ceiling 72 of each unit is formed about wood framing 76 which is attached to the interior sides of the beams and columns which are formed into a rectangular array. Panels of suitable surfacing material are placed over and under the wooden framing and an insulation 78 is arranged within the interstices.

Each of the two sections which are joined to form a finished unit such as shown in FIGURE 1, is enclosed completely on its top and bottom and on all of its sides except one. In the preferred embodiment one of the long sides of each of the sections is left free of side panel members. When assembling the two units, these two exposed faces are brought into alignment with one another and a compressive tape member 90 is disposed between the opposed faces of the beams and column members.

Each of the column members at the two extreme ends of the open faces are equipped with eye plates 92 at their upper and lower sides. Each of the plates has a central hole formed therein and the two structures are drawn together by passing bolts 94 through the holes and fixing them with nuts.

It is therefore seen that the present invention provides a building structure which may be almost completely finished in a factory and then easily moved to a site and assembled with another identical unit in order to form a prefabricated structure.

Having thus described our invention, we claim:

1. A pair of rectangular structures having side, top and bottom framing consisting of elongated steel beams ar-
ranged in closed, rectangular, three-dimensional trusses consisting of vertical and horizontal members welded at their joints to form rigid, moment-resisting joints, each of said rectangular structures consisting of a number of rectangular cubes stacked end to end, cable engaging members attached in pairs on one surface of each rectangular structure, with each member of the pair being spaced and disposed intermediate the ends of the rectangular structure, the spacing between the members of each pair being substantially twice the spacing between each member and the closest end of said rectangular structure, panel means enclosing five sides of each structure, leaving open a side on a surface perpendicular to that to which the engaging means are attached, and means for joining the pair of structures with their unpaneled faces abutting one another so as to form a single unitary structure with all sides enclosed; whereby said pair of structures may be transported to a site and moved into position with respect to one another by lifting them from the transport means by cables attached to the cable engaging means without substantial deformation of the structures.

2. The structure of claim 1 wherein the surface of each structure, opposite to that which supports the cable engaging members, has legs extending normally to the surface, away from the structure, so as to support the structure with its lower surface above an existing terrain.

3. The structure of claim 1 wherein means for joining the two structures together to form a single unit consists of eye plates extending from the columns which frame the outer edges of the unpaneled side of each structure, disposed so that the eye plates on the two structures abut one another, and bolts, operative to pass through the eye plates and draw the structures together.

References Cited

UNITED STATES PATENTS
1,853,803 4/1932 Dreisel 52—584 X
1,907,119 5/1933 Reynolds 52—79
2,795,014 6/1957 Kelly 52—79
3,082,848 3/1963 Keller 52—417
3,103,709 9/1963 Bolt 52—79 X
3,162,863 12/1964 Wokas 52—79 X

RAYMOND D. KRAUS, Primary Examiner
BOBBY R. GAY, Assistant Examiner
U.S. Cl X.R.

52—79, 584