MODULAR ROOF CONSTRUCTION UNIT AND METHOD OF MAKING SAME

Maurice W. Goodwill, 1126 17th St. S., Fargo, N. Dak. 58102, and Leslie W. Haug, 1011 180th St. S.W., Grand Forks, N. Dak. 58201
Filed Jan. 14, 1963, Ser. No. 251,394
12 Claims. (CI. 72—297)

This invention relates to modular roof construction units. More particularly, it relates to a novel modular roof construction unit and a method of manufacturing the same.

It is a general object of our invention to provide a novel and improved modular roof construction unit of simple and inexpensive construction and improved function.

Another object is to provide a novel method of manufacturing a modular roof construction unit which is simple and inexpensive in construction and manufacture.

Another object is to provide a novel and improved modular roof construction unit and method of making the same in which the unit is simple and inexpensive to manufacture, assemble, and utilize and has increased strength.

Another object is to provide a novel and improved modular roof construction unit and method of making the same in which the in the building resulting therefrom is fireproof, rodent and bird proof, and requires no cross ties within the interior thereof.

Another object is to provide a novel method of manufacturing a modular roof construction unit which requires a minimum of time, labor, and materials and provides a unit of improved building characteristics.

These and other objects and advantages of this invention will more fully appear from the following description, made in connection with the accompanying drawings, wherein like reference characters refer to the same or similar parts throughout the several views, and in which:

FIG. 1 is a perspective view of an elongated hollow rib member formed in the first step of our novel method.

FIG. 2 is a side elevational view of the same on a reduced scale, after the final step is completed.

FIG. 3 is a vertical sectional view taken through a portion of the roof of the building constructed through the use of our novel modular roof construction unit.

FIG. 4 is a diagrammatic rear elevational view of a machine utilized in practicing our method of manufacturing the novel modular roof construction unit.

FIG. 5 is a diagrammatic side elevational view of the same machine with the die thereof retracted to starting position and with a hollow rib member positioned thereon in preparation for practicing the final step of our novel method, and

FIG. 6 is a diagrammatic side elevational view of the same machine showing the die in its position at the end of the performance of the final step of our novel method.

In practicing our invention we utilize flat rectangular sheets of zinc coated rolled steel, generally referred to as "galvanized iron." From such elongated sheets (not shown) we form an elongated hollow rib member 7 which is best shown in FIG. 1, through stamping the same or die-forming the same in manners well known in the art. Each of these elongated hollow ribs 7, when formed, includes a flat horizontal crest portion 8 and a pair of side walls 9 and 10 which extend downwardly and outwardly from opposite sides of the elongated crest portion 8. The lower areas of each of the side walls has a longitudinally extending flange such as 11 and 12 which extends laterally outwardly from the lower areas of its supporting side wall 9 or 10, as the case may be. Reference to FIGS. 1 and 3 shows that the flange member 11 has a horizontally extending portion 11a and a downwardly extending portion 11b. Similarly, the flange 12 has a horizontally extending portion 12a and a downwardly extending portion 12b. It will be noted that the rib member 7 is upstanding and hollow.

The next step in the invention is to place the rib member 7 in the machine which has been indicated generally by the numeral 13. This machine 13, as shown, is comprised of a pair of laterally spaced A-frames 14 and 15 which have their apaxes fixedly connected to a base member 16. Brace members 17 and 18 support the A-frames 14 and 15, respectively, as best shown in FIGS. 4—6.

A rigid shaft 19 extends transversely of the machine between the base legs of the two A-frames 14 and 15 at the rear of the machine and pivotally mounts a hydraulic cylinder and piston assembly 20 about in a vertical plane. The piston rod 21 of the assembly 20 extends forwardly and carries a suitable clamping device 22 which is constructed to engage and grip the flanges 11 and 12 and the crest portion 8 of the rib member 7. This gripping device 22 is preferably of a hydraulic or pneumatic type to facilitate the gripping action but, of course, any suitable means for clamping and holding the one end portion of the rib member 7 as shown in FIG. 5, may be utilized.

The forward end of the cylinder and piston assembly 20 is connected by a hydraulic line 23 to a pressure tank 24. A valve member 25 is interposed in the conduit 23 and a branch line 26 extends to a reservoir (not shown).

A valve 27 is interposed within the line 26 as best shown in FIG. 5. The pressure tank 24, as diagrammatically illustrated in FIG. 5, has a supply of hydraulic fluid 28 therein and carries a head of nitrogen 29 above the hydraulic fluid 28. A pressure gauge 30 is carried at the upper end of the tank 24 and this end of the tank is also connected by a gas line 51 to a high pressure nitrogen tank 32 from which the supply of nitrogen is obtained. A valve member 33 is interposed within the gas line 31 as illustrated in FIG. 5.

The rear end of the cylinder and piston assembly 20 is connected in fluid communication with a hydraulic line 34 which extends to a pump (not shown) to provide for hydraulic fluid to be pumped upwardly into the rear end of the cylinder when desired. A valve 35 is interposed within this line. A branch line 36 is connected to the line 45 between the valve 35 and the cylinder and piston assembly 20 as shown in FIG. 5 and this line extends to a reservoir (not shown). A valve member 37 is interposed within the line 36.

Extending between the two A-frames 14 and 15 at the forward corner thereof is a shaft 38 which pivotally mounts a die member 39. This member 39 has an upstanding rib 40 carried at its upper surface and, as clearly shown in FIGS. 5 and 6, this rib member is convexly shaped. As illustrated in FIG. 6 the rib member 40 is substantially identical in cross-sectional shape to the cross-sectional shape of the interior of the hollow rib member 7 so that the rib member 7 may be brought downwardly around the upstanding rib 40 of the member 39. It will be appreciated, of course, that the rib member 40 is disposed directly below the hollow rib member 7 which is positioned in the machine as shown with its hollow interior facing downwardly in position to receive the upstanding rib member 40 thereon.

The forward end of the die member 39 carries a clamp member 41. This clamp may be similar in construction to the clamp 22 but its construction is not critical so long as it is adapted to engage and firmly hold the end portion of the hollow upstanding rib member 7 as shown. The rear end portion of the member 39 is pivotally connected by a pin 42 in driven relation to a piston rod 43 which is a part of a cylinder and piston assembly 44. The cylinder
and piston assembly 44 is pivotally mounted upon the base member 16 as best shown in FIG. 4 for swinging movement in a vertical plane rearwardly and forwardly as required when the piston rod 43 is extended. The length of the die element 39 is slightly less than the length of the rib member 7 so that when the piston rod 43 is extended as a result of the introduction of hydraulic fluid into the assembly 44, the rear end of the die element 39 will move into close proximity with the clamping element 22 as illustrated in FIG. 3.

In forming the irregularly shaped modular roof construction shown in FIG. 2 from the elongated upstanding hollow rib member 7 which extends in a horizontal plane, the rib member 7 is mounted upon the machine 13 as shown in FIG. 5. To accomplish this, the valve 37 is closed and the valve 35 is opened so that pump (not shown) may force hydraulic fluid into the rear end of the piston and cylinder assembly 20 to force the piston rod 21 and the clamp element 22 sufficiently far forward so that the clamp element 22 may engage the rear end of the hollow rib member 7. It will be understood, of course, that pump 34 to which piston rod 43 will be connected as shown in FIG. 5 and that the forward end of the rib member 7 will have been fixedly secured in the clamp 41, as shown in that figure. When the clamp member has been moved forwardly sufficiently as described, it is operated to fixedly engage the rear end of the rib member 7. In forming, the valve 35 is closed and the reservoir valve 37 is opened to permit the fluid to flow from behind the piston to the reservoir. The hydraulic fluid pressure transmitted through the line 23 to a position ahead of the piston and urged by the head of pressure of nitrogen causes the grip member 22 to be urged rearwardly and impose longitudinal tension upon the hollow rib member 7 across its entire length. Since the pressure exerted by the head of nitrogen gas in the tank 24 was overcome by the pump, there is a sufficient head to immediately move the piston rod 21 rearwardly upon the opening of the valve 37.

The pressure within the tank 24 is then adjusted by manipulation of the valve 33 so as to apply tension upon the rib member 7 of approximately 80–90 percent of the yield strength of the rib member 7. We prefer to apply longitudinal tension equal to approximately 80 percent of the yield strength of the rib member and, of course, care is taken to avoid at any time ever exceeding the ultimate strength of that member. In order to determine the pressure to be utilized to provide this desired tension, we utilize the yield point provided by the manufacturer of the metal from which the rib member 7 is made and multiply the same by the thickness of the sheet from which the member 7 was made and its cross-sectional length. We then take 80 percent of this figure and divide it by the effective area of the piston of the assembly 20 to arrive at the approximate pressure which should be utilized in the tank 24 to cause the clamp 22 to exert a longitudinal stress approximately 80 percent of the yield strength of the rib 7. For example, when utilizing a sheet having a cross-sectional length of 21.5 inches and a thickness of 0.036 inch and having a yield point of approximately 30,000 p.s.i., upon multiplication of these figures and taking 80 percent thereof we arrive at a figure of approximately 18,630. Division of this figure by the effective area of piston of approximately 40 square inches, we arrive at the desired pressure of approximately 465 p.s.i. Consequently, we utilize a pressure of 465 p.s.i. or slightly thereabove to apply a longitudinal stress to the rib member 7 of approximately 80 percent of its yield strength.

After having imposed a longitudinal stress of approximately 80 percent of the yield strength upon the rib member 7 and while maintaining this stress, we cause the piston member 43 to be gradually extended, thereby causing the die member 39 to rock upon the shaft 38 to the final position shown in FIG. 6. Such rocking movement causes a bending moment to be applied through the rib member. This bending moment may be described as a force directed along rolling opposite points longitudinally of the rib member 7 and being applied from a point between the flanges 11 and 12 of the rib member toward the crest portion 8 of that member. Extension of the piston 43 and rocking of the die member 39 causes the upstanding rib member 40 to move into the interior of the hollow rib member 7 with the upper surface thereof engaging and stretching longitudinally the crest portion 8. It will be noted that the sum member 7 is in swiped around or drawn around the upstanding rib member 40 while the tension of approximately 80 percent of the yield strength is maintained. The rocking movement of the upstanding rib member 40, however, imposes an additional longitudinal stress upon the crest portion 8 and the side walls 9 and 10 of the rib member with the result that the yield strength of the side wall portions 9 and 10 and the crest portion 8 is exceeded and consequently longitudinal stretching of these portions takes place. It will be noted that the maximum stretching takes place in the crest portion 8 of the rib member 7 and that the anklework, etcetera in the side walls 9 and 10 decreases equally and gradually toward the flange members 11 and 12 when the rib member is considered in cross-section. We prefer to avoid longitudinal stretching of the flanges 11 and 12 so as to avoid elongation of the openings 45 which are formed in the horizontal flanges 11 and 12 from the punch member 33 and the formation of a roof when these units are used. Consequently, the stretching of the side walls 9 and 10 is terminated at their lower areas adjacent the point at which the flanges 11 and 12 extend laterally therefrom. The finished modular roof construction unit has been identified by the numeral 46.

In practice, we manufacture the units 46 in lengths of approximately 13 feet and they are fixedly secured to laterally extending flange portions 47 of elongated flanges 48 so as to connect a plurality of such panels. A batten 49 is secured across the flange portions 11 and 12 of the rib member 46 and is secured thereto by bolts 50 and 51 which are passed through the openings 45 and through openings provided in the flanges 47 of the panel 48. It will be understood, of course, that the panels 48 are elongated and somewhat arcuate in shape corresponding to the curvature of the rib members 45 and that a plurality of the ribs 46 connect a plurality of panels 48 in a manner as illustrated in FIG. 3, with one of the rib members 46 extending parallel and between and connecting each of the panels.

When the unit 46 has been completed upon the machine 13 as hereinbefore described, the valve 35 from the pump is opened and the reservoir valve 37 is closed to permit fluid to be pumped into the rear of the cylinder assembly 20 and loosen the gripper 22 as it is moved forwardly. The piston 43 is retracted and the completed roof unit 46 is removed from the grippers. The operation may then be repeated.

It will be noted that the bending moment applied to the rib member 7 results in a yielding of the upper portions of the point of the rib member 7 and the crest of the rib member 7. In other words, the yield strength of the crest portion 8 and the side walls 9 and 10 is exceeded while the yield strength of the flanges 11 and 12 is not attained. By experience we have found that approximately 80 to 90 percent of the yield tension applied to the rib member 7 before the die member 39 is operated will result in the yield strength being exceeded in the crest and side wall portions without exceeding the yield strength of the flanges of the rib member. The introduction of the bending moment is accomplished by rotating the element 39 hydraulically until the entire rib member 7 is curved.

The use of the nitrogen gas over the hydraulic fluid in the pressure tank 24 allows the piston in the cylinder 20 to extend as the die is being rotated. We have found that by utilizing a compressible gas head over the hydra-
lie fluid in the pressure tank, we avoid exceeding the ultimate strength of the side wall and crest portion of the rib member 7 and the yield strength of the flanges.

From the above it can be seen that we have provided a novel method of manufacturing a modular roof construction unit which requires a minimum of time, effort and materials and yet produces such a unit having the required strength and is capable of being readily assembled into a roof or building that is fire proof, rodent and bird proof and requires no tie rods extending across the interior thereof. Thus, it is possible through the use of these modular roof construction units in combination with the panels 40 to construct an entire building of the "light" shape wherein the lower ends of the units abut upon the foundation to provide an all steel building which is particularly ideal for the storing of grain, etc. In so doing, it will be understood, that the construction unit members 46 are connected in end over end overlapping relation to complete the formation of such a building, a sufficient number of members being connected until the desired arc is completed to provide the desired height within the interior of the building.

It will be understood that the cross-sectional shape of the rib 46 of the die member 39 is substantially identical to the cross-sectional shape of the rib member 7, but that the elevation of the rib member 40 is sufficient so that the flange members 11 and 12 of the rib member 7 merely touch the corresponding portions of the die member 39. Also, the ends of the unit 46 are trimmed after the unit has been removed from the machine 13.

It will, of course, be understood that various changes may be made in the form, details, arrangement and proportions of the parts without departing from the scope of this invention which consists of the matter shown and described herein and set forth in the appended claims.

What is claimed is:

1. A method of making a modular roof construction unit consisting in:
(a) first forming a rectangular sheet of metal into a straight elongated hollow upstanding rib member having a flat horizontally and longitudinally extending crest portion and a pair of longitudinally extending side wall portions each of which extends downwardly and outwardly from opposite sides of said crest portion and a pair of longitudinally extending flanges one each of which extends laterally outwardly from the lower area of one of said side wall portions, (b) then tensioning the rib member longitudinally along a flat plane and along its entire length to approximately 80 percent of its yield strength, and
(c) then, while maintaining said tension on said rib member, applying a bending moment of force to said rib member progressively at rolling opposite points along and uniformly throughout its length, (d) the said bending moment of force applied to said crest portion and said side wall portions being from within the hollow rib member and in a direction generally from a point between the flanges towards the crest portion of the rib member and being sufficiently great to tension said portions longitudinally beyond their yield strengths but less than their ultimate strength,
(e) the magnitude of said bending moment of force applied to said crest portion and said side wall portions being greatest at said crest portion and progressively less from said crest portion toward said flanges and thereby causing said rib member to assume a convex shape.

2. A method of making a modular roof construction unit consisting in:
(a) first forming a rectangular sheet of metal into a straight elongated hollow upstanding rib member having a flat horizontally and longitudinally extending crest portion and a pair of longitudinally extending side wall portions each of which extends downwardly and outwardly from opposite sides of the crest portion and a pair of longitudinally extending flanges one each of which extends laterally outwardly from the lower area of one of the side wall portions, (b) then tensioning the rib member longitudinally along a flat plane and along its entire length to approximately 80 percent of its yield strength, and
(c) then, while maintaining said tension on the rib member, further tensioning the side wall and crest portions of the rib member longitudinally and progressively at rolling opposite points along and uniformly throughout the length of the rib member to a unit stress exceeding the yield strength but less than the ultimate strength of the said portions while simultaneously applying at said points a bending moment of force from within the hollow rib member in a direction generally from a point between the flanges to the crest portion of the rib member and sufficiently great to cause the rib member to assume a convex shape,
(d) said further tensioning being applied to the side wall and crest portions in ever decreasing units of stress when considered in cross-section of said rib member from said crest portion toward said flanges.

3. A method of making a modular roof construction unit consisting in:
(a) first forming a rectangular sheet of metal into a straight elongated hollow upstanding rib member having a flat horizontally and longitudinally extending crest portion, a pair of longitudinally extending side walls one each of which extends downwardly and outwardly from opposite sides of the crest portion, and a pair of longitudinally extending flanges one each of which extends laterally outwardly from the lower area of one of the side wall portions, (b) then tensioning the rib member longitudinally along a flat plane and along its entire length to approximately 80 percent of its yield strength, and
(c) then, while maintaining said tension on said rib member, further tensioning said side wall and crest portions of the rib member longitudinally and progressively at rolling opposite points along and uniformly throughout the length of the rib member to a unit stress exceeding the yield strength but less than the ultimate strength of the said portions and thereby stretching said side wall and crest portions longitudinally,
(d) said further tensioning being applied to the side wall and crest portions in ever increasing units of stress, when considered in cross-section of the rib member, from the flanges to the crest portion.

4. A method of making a modular roof construction unit from a straight elongated hollow upstanding rib member having a flat horizontally and longitudinally extending crest portion and a pair of longitudinally extending side wall portions extending downwardly and outwardly from opposite sides of said crest portion and longitudinally extending flanges extending laterally outwardly from lower areas of said side wall portions, said method consisting in:
(a) first tensioning said rib member longitudinally along a flat plane and along its entire length to approximately 80 percent of its yield strength and
(b) then further tensioning said side wall and crest portions of said rib member longitudinally and progressively at rolling opposite points along and throughout their length and along a convex arc to a unit stress exceeding the yield strength but less than the ultimate strength of said portions and thereby stretching said side walls and crest portions longitudinally,
(c) said further tensioning being applied to said side wall and crest portions in ever increasing units of stress, when considered in cross-section of the rib member, from said flanges to said crest portion.
5. A method of making a modular roof construction unit consisting in:

(a) first forming a rectangular sheet of metal into a straight elongated hollow upstanding rib member having a flat horizontally and longitudinally extending crest portion, a pair of longitudinally extending side walls extending downwardly and outwardly from opposite sides of said crest portion, and longitudinally extending flanges extending laterally outwardly from the lower portions of said side walls;

(b) then tensioning said rib member longitudinally along its entire length to approximately 80 percent of its yield strength,

(c) then wrapping said rib member progressively along and throughout its length from one of its end portions to its other end portion, while maintaining said tension thereon, around a rigid elongated continuously convex surface having a cross-sectional shape substantially identical to the cross-sectional shape of said rib member and thereby progressively stretching said side walls and said crest portion uniformly in a longitudinal direction, the extent of stretching considered in cross-section of said rib member said progression being radially outwardly from said flanges to said crest portion.

6. A method of making a modular roof construction unit from a straight elongated hollow upstanding rib member having a flat horizontally and longitudinally extending crest portion and a pair of longitudinally extending side wall portions extending downwardly and outwardly from opposite sides of said crest portion and longitudinally extending flanges extending laterally outwardly from lower areas of said side wall portions, said method consisting in:

(a) first tensioning said rib member longitudinally along its entire length to approximately 80 percent of its yield strength, and

(b) then stretching said side wall and crest portions of said rib member longitudinally and progressively along and throughout their length from one of said rib member end portions to its other end portion, while maintaining said tension thereon, around a rigid elongated convexly curved surface having a cross-sectional shape approximately identical to the cross-sectional shape of said rib member, said stretching when considered in cross-section of said rib member being of an ever increasing extent upwardly from the flanges to the crest portion of the rib member.

7. A method of making a modular roof construction unit from a straight elongated hollow upstanding rib member having a flat horizontally and longitudinally extending crest portion and a pair of longitudinally extending side wall portions extending downwardly and outwardly from opposite sides of said crest portion and longitudinally extending flanges extending laterally outwardly from lower areas of said side wall portions, said method consisting in:

(a) first tensioning said rib member longitudinally along its entire length to approximately 80 percent of its yield strength, and

(b) then stretching the uppermost portions of said rib member longitudinally and progressively along and uniformly throughout its length from one of its end portions to its other end portion, the longitudinal stretching of said uppermost portion of said rib member being of an ever increasing magnitude toward said crest portion when considered cross-sectionally of the rib member.

8. A method of making a modular roof construction unit consisting in:

(a) first die-forming a rectangular sheet of metal into a straight elongated hollow upstanding rib member having a flat horizontally and longitudinally extending crest portion and a pair of longitudinally extend-
11. A method of making a modular roof construction unit from a straight elongated hollow upstanding rib member having a flat horizontally and longitudinally extending crest portion and a pair of longitudinally extending side wall portions extending downwardly and outwardly from opposite sides of said crest portion and longitudinally extending flanges extending laterally outwardly from lower areas of said side wall portions, said method consisting in:
(a) tensionally stretching throughout their entire lengths said crest portion and said side wall portions longitudinally beyond their elastic limits and continuously and progressively along their lengths;
(b) the extent of said stretching when considered cross-sectionally of said member being greatest throughout said crest portion and diminishing gradually and equally from said crest portion through said side wall portions toward said flanges;
(c) the extent of said stretching when considered longitudinally of said members being uniform throughout.

12. A method of making a modular roof construction unit consisting in:
(a) first die-forming a rectangular sheet of metal into a straight elongated hollow upstanding rib member having a flat horizontally and longitudinally extending crest portion and a pair of longitudinally extending side wall portions, one each of which extends downwardly and outwardly from opposite sides of said crest portion and a pair of longitudinally extending flanges one each of which extends first laterally outwardly and then downwardly from the lower area of one of said side wall portions;
(b) then progressively and simultaneously at opposite points along and throughout the length of said rib member tensionally stretching said crest portion and said side wall portions longitudinally beyond their elastic limits;
(c) the extent of said tensional stretching, when considered in cross-section of said rib member, being greatest throughout said crest portion and diminishing gradually and equally from said crest portion through said side wall portions toward said flanges;
(d) the extent of said tensional stretching when considered longitudinally of said member being uniform throughout.

References Cited
UNITED STATES PATENTS
2,292,731 8/1942 Amiot 72—297
2,514,830 7/1950 Bath 72—151
2,536,738 1/1951 Green 72—151
2,810,421 10/1957 Dolney et al. 153—40
2,812,730 11/1957 Herman 50—61
2,816,593 12/1957 Hein et al. 153—40
2,880,780 4/1959 Mackey 72—151
2,887,143 5/1959 Ahonen 72—297
2,933,056 4/1960 Martin 50—61
2,963,067 12/1960 Kelso et al. 72—297

RICHARD J. HERBST, Primary Examiner.
E. J. WITMER, Assistant Examiner.