

SYSTEM AND METHOD FOR ATTACHING A WALL TO A BUILDING STRUCTURE

This application claims priority to U.S. Patent Application No. 12/659,886 filed March 24, 2010, the entire contents of which are incorporated herein by reference.

BACKGROUND

[0001] Field of the Disclosure

[0002] The present disclosure relates to attachment members made from sheet materials for connecting walls to building structures, building structures made using such attachment members, and an attachment member forming system for fabricating attachment members to connect walls to building structures.

[0003] Background Information

[0004] Conventional methods are known in the art for erecting building structures made of sheet material building panels, *e.g.*, galvanized steel sheet metal. The roof of such building structures can be formed from interconnected arched building panels attached side-by-side and the end walls of the building structures can be formed from substantially flat building panels or other suitable materials. The panels are interconnected by placing them adjacent one another and forming a sealed joint where the edges of the panels overlap. As a result, the length of the building increases with the number of interconnected panels forming the roof and the width of each panel. The width of the building, on the other hand, is a function of the length of each panel. Thus, the overall size of the building is dependent upon the dimensions of each panel and the total number thereof.

[0005] In conventional building structures, the end walls are typically connected to a single arched building panel at the outermost edge of the roof. However, the present inventors have observed that attaching the end walls to the outer edge of a single building panel in this manner forms a structurally weak joint that may not be suitable for certain building structures. In particular, the present inventors have observed that this type of joint may be subject to buckling in some areas and that such buckled areas can significantly reduce the strength of the joint and the structural integrity of the building structure. For example, as the size of each panel forming the roof increases, so does its weight. Because weight is a gravitational force, which imparts a moment upon structures, as the width and length of each panel increases, the panel is subject to greater moments that can cause failure of this joint.

SUMMARY

[0006] According to an exemplary aspect, a system for forming an attachment member for connecting a wall to a curved roof of a building structure is described. The system includes a support structure and a cutting assembly supported by the support structure configured to receive sheet material wherein a plane of the sheet material is oriented in a substantially vertical orientation, the cutting assembly including a slit to cut the sheet material along a feed direction of the sheet material into first and second portions of sheet material, the slit having guides to support the first and second portions of sheet material in the substantially vertical orientation, the guides directing the first portion of sheet material in a first direction and directing the second portion of sheet material in a second direction different from the first direction. The system also includes a forming assembly supported by the support structure. The forming assembly is configured to receive sheet material from the cutting assembly and includes a frame, and multiple rollers supported by the frame, the multiple rollers arranged to impact the first portion of sheet material and change a cross-sectional shape of the first portion of sheet material as the first portion of sheet material passes along the multiple rollers in the feed direction to form an attachment member, the attachment member having a plurality of segments in cross section in a plane perpendicular to the feed direction including a first flat segment in cross section and a second segment extending perpendicularly in cross section from the first segment.

[0007] According to another aspect, an attachment member formed from sheet material is described. The attachment member is configured to connect a wall to a curved roof of a building structure, the curved roof being formed from a plurality of curved building panels, the attachment member being curved in a longitudinal direction and having a shape in cross section in a plane perpendicular to the longitudinal direction. The attachment member includes a first segment having a flat center portion and a pair of walls extending perpendicular to the center portion in cross section, the pair of walls defining a recess oriented in a direction perpendicular to the center portion, wherein the recess is adapted to accommodate a portion of a wall of a building structure. The attachment member further includes a second segment extending from one of the walls of the first segment, the second segment being oriented in a same plane as the flat center portion of the first segment in cross section, the second segment including a longitudinal rib, the longitudinal rib protruding in cross section from the second segment, the longitudinal rib being adapted to mate with a rib of a curved building panel.

[0008] According to another aspect, a building structure is described. The building structure comprises a curved roof formed from a plurality of interconnected building panels, each building panel extending in a longitudinal direction and having a shape in cross section in a plane perpendicular to the longitudinal direction, wherein each building panel includes a central portion having a rib in cross section. The building structure also includes a wall. And further, the building structure includes an attachment member formed from sheet material attaching the wall to the curved roof. The attachment member comprises a first segment having a flat center portion and a pair of walls extending perpendicular to the center portion in cross section, the pair of walls defining a recess oriented in a direction perpendicular to the center portion, wherein the recess is adapted to accommodate a portion of a wall of a building structure; a second segment extending from one of the walls of the first segment, the second segment being oriented in a same plane as the flat center portion of the first segment in cross section, the second segment including a longitudinal rib, the longitudinal rib protruding in cross section from the second segment, the longitudinal rib being adapted to mate with a rib of a curved building panel; and wherein the flat center portion of the first segment is connected to a first building panel of the curved roof, and the longitudinal rib of the second segment is connected to a rib of a second building panel of the curved roof.

[0009] According to yet another aspect, a method of forming an attachment member for connecting a wall to a building structure is described. The method comprises cutting sheet material from a source of sheet material in a feed direction into first and second portions of sheet material, a plane of the sheet material being oriented in a vertical orientation; supporting the first and second portions of sheet material in the vertical orientation with guides such that the first portion of sheet material is directed in a first direction and the second portion of sheet material is directed in a second direction different from the first direction; translating the first portion of sheet material through multiple rollers, the multiple rollers arranged to impact the first portion of sheet material as the first portion passes along the multiple rollers in a feed direction to form an attachment member, the attachment member having a plurality of segments in cross section in a plane perpendicular to the feed direction including a first flat segment in cross section and a second segment extending perpendicularly in cross section from the first segment; and crimping the second segment of the attachment member to impart a longitudinal curve to the attachment member along a length of the attachment member.

[0010] According to still another aspect, a system for forming an attachment member for connecting a wall to a curved roof of a building structure is described. The system includes a

support structure and a cutting assembly supported by the support structure configured to receive sheet material, the cutting assembly including a slitter to cut the sheet material along a feed direction of the sheet material into first and second portions of sheet material, the slitter having guides to support the first and second portions of sheet material, the guides directing the first portion of sheet material in a first direction and directing the second portion of sheet material in a second direction different from the first direction. The system further includes a forming assembly supported by the support structure that is configured to receive sheet material from the cutting assembly. The forming assembly includes a frame, and multiple rollers supported by the frame, the multiple rollers arranged to impact the first portion of sheet material and change a cross-sectional shape of the first portion of sheet material as the first portion of sheet material passes along the multiple rollers in the feed direction to form an attachment member, the attachment member having a plurality of segments in cross section in a plane perpendicular to the feed direction including a first flat segment in cross section and a second segment extending perpendicularly in cross section from the first segment. The forming assembly is configured to form an attachment member including: a first segment having a flat center portion and a pair of walls extending perpendicular to the center portion in cross section, the pair of walls defining a recess oriented in a direction perpendicular to the center portion, wherein the recess is adapted to accommodate a portion of a wall of a building structure; and a second segment extending from one of the walls of the first segment, the second segment being oriented in a same plane as the flat center portion of the first segment in cross section, the second segment including a longitudinal rib, the longitudinal rib protruding in cross section from the second segment, the longitudinal rib being adapted to mate with a rib of a curved building panel.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] These and other featured aspects and advantage for the present disclosure will become better understood with regard to the following description, appended claims, and accompanying drawings.

[0012] FIG. 1 illustrates an exemplary gable style building that can be formed using building panels according to an exemplary aspect.

[0013] FIG. 2 illustrates an exemplary circular or arch style building that can be formed using building panels according to an exemplary aspect.

[0014] FIG. 3 illustrates an exemplary double radius or two radius style buildings that can be formed using building panels according to an exemplary aspect.

[0015] FIG. 4 illustrates a conventional method of attaching a curved roof building to a substantially planar wall.

[0016] FIG. 5 illustrates an exemplary cross-sectional shape of a building panel that is straight along its length prior to being curved longitudinally according to an exemplary aspect.

[0017] FIG. 6a illustrates an exemplary cross-sectional shape of exemplary building panel having a longitudinal curve along its length according to an exemplary aspect.

[0018] FIG. 6b illustrates another exemplary cross-sectional shape of an exemplary building panel having a longitudinal curve along its length according to an exemplary aspect.

[0019] FIG. 6c illustrates another exemplary cross-sectional shape of an exemplary building panel having a longitudinal curve along its length according to an exemplary aspect.

[0020] FIGs. 7a – 7c illustrate an exemplary attachment member connected to an exemplary curved building panel according to exemplary aspects.

[0021] FIGs. 8a – 8c illustrate exemplary attachment isometric views of attachment members according to exemplary aspects.

[0022] FIGs. 9a -9c illustrate exemplary cross-sectional shape of attachment members according to exemplary aspects.

[0023] FIGs. 10a - 10b illustrate exemplary attachment members according to exemplary aspects.

[0024] FIG. 11 illustrates a side view of an exemplary panel curving system according to an exemplary aspect.

[0025] FIGs. 12a – 12c illustrate an exemplary coil holder in a system for forming an attachment member according to an exemplary aspect.

[0026] FIG. 13 illustrate an exemplary drive unit of a system for forming and attachment member according to an exemplary aspect.

[0027] FIG. 14 illustrates an exemplary sharing assembly of a system for forming an attachment member according to an exemplary aspect.

[0028] FIGs. 15a - 15b illustrate exemplary views of a sharing assembly in a system for forming an attachment member according to exemplary aspects.

[0029] FIGs. 15c - 15d illustrate a close up view of an exemplary splitting assembly in a system for forming an attachment member according to an exemplary aspect.

[0030] FIG. 16a illustrates an isometric view of an exemplary forming assembly in a system for forming an attachment member according to an exemplary aspect.

[0031] FIGs. 16b – 16o illustrate front and rear views of an exemplary forming assembly configured to produce varying cross-sectional shapes of attachment members according to an exemplary aspect.

[0032] FIG. 17 illustrates an isometric view of an exemplary curving assembly in a system for forming an attachment member according to an exemplary aspect.

[0033] FIG. 18 illustrates an exemplary controller in a system for forming an attachment member according to an exemplary aspect.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0034] Building structures manufactured using building panels formed from sheet material can be constructed in a variety of configurations. For example, FIGs. 1-3 illustrate exemplary shapes of buildings that can be manufactured using building panels and attachment members as described herein. These exemplary building shapes include gable style buildings; an example of which is shown in FIG. 1; circular style buildings, an example of which is shown in FIG. 2; and double radius or two radius style buildings an example of which is shown in the example of FIG. 3. In the exemplary buildings illustrated in FIGs. 1-3, longitudinally curved building panels are used to form the roof sections and substantially straight building panels or other materials are used to construct the flat wall sections. Other shapes can also be fabricated such as lean to buildings, which are taller at one side than another side and other variations using combinations of building panels having longitudinally curved portions of various radii and building panels having straight portions.

[0035] FIG. 4 illustrates a conventional method of attaching a curved roof building structure to an end wall. In FIG. 4, an edge panel 2, shown as an L shaped metal component, is attached to an edge portion of a roof panel 1 to form a joint. The short leg of the edge panel 2 is bolted to a lip on the top outermost edge of the roof panel 1, and the long leg of the edge panel 2 extends downward proximate the edge of the roof panel 1. An elbow shaped panel 3 extends over the short leg of the edge panel 2 and is bolted to the edge panel 2, and the remainder extends over a top portion of the end wall panel 5. Typically, a wooden beam 4 is placed between the underside of the panel 3 and the top portion of the end wall panel 5.

[0036] However, the present inventors have noted that the configuration of conventional attachment members, *i.e.*, attachment members attached to the outermost edge of a curved building panel, has disadvantages. For example, the conventional structure lacks stability due

to the fact that it is attached to the edge of the building panel and can be subject to torsion that can cause buckling or failure. As shown in FIG. 4, the open space between the edge panel 2 and the roof panel 1 provides an unsupported area that may be particularly susceptible to these stresses.

[0037] Exemplary building panels and attachment members described herein may be formed from sheet material, such as, for example, structural steel sheet material ranging from about 0.035 inches to about 0.080 inches in thickness. These building panels and attachment members can be formed from other sheet materials as well, such as other types of steel, galvalume, zincalume, aluminum, or other building material that is suitable for construction. The thickness of the building panels and attachment members may generally range from about 0.035 inches to about 0.080 inches in thickness ($\pm 10\%$), depending on the type of sheet material used. Of course, the building panels and attachment members may be formed using other thicknesses and using other sheet building materials so long as the sheet materials possess suitable engineering properties of strength, toughness, workability, etc. It should also be noted that the building panels and the attachment members need not be made of the same material.

[0038] Exemplary building panels that may be used with exemplary attachment members as described herein will now be described with reference to FIGs. 5, 6a and 6b. As illustrated in FIG. 5, the exemplary building panel 10 includes a curved center portion through 30, a curved side portion 36 and 38, extending from the curved center portion 30 in cross-section, and a pair of connecting portions 32 and 34, extending from the side portions 36 and 38 respectively, in cross-section. The overall outline of the curved center portion 30 is illustrated by the curved dotted line C. Connecting portion 32 may include a hook portion 32a as illustrated in FIG. 5; but in general, any suitable configuration may be used for the connecting portion 32. Similarly, connecting portion 34 may include a hem portion 34a, the hook portion 32a and the hem portion 34a being complementary in shape for joining the building panel to adjacent building panels. However any suitable complementary shape may be used for the connecting portion 34 that permits connecting portion 34 to be joined to connecting portion 32.

[0039] As shown in FIG. 5, the building panel also includes a plurality of segments 12, 14, 16, 18, 20, 22, 24, 26 and 28. These segments extend in the longitudinal direction L along the length of the building panel 10. These segments may also be referred to as longitudinal deformation, longitudinal ribs, stiffening ribs and the like and serve to strengthen the building panel 10 against buckling and bending under loads. In this example, segments

22, 24, 26 and 28 extend outwardly in cross-section and segments 12, 14, 16, 18 and 20 extend inwardly in cross-section. For reference purposes, inward as used herein means closer to a geometric center of the cross-section of a building panel and outward means further from the geometric center of the cross-section of a building panel. As shown in FIG. 5, adjacent segments extend in opposing directions. For example, segment 12 extends inwardly whereas in adjacent segment 22 extends outwardly. In the example of FIG. 5, the depth of a given segment relative to the adjacent segment is a depth d . The depths of a segment of the building panel may all be the same as illustrated in the example of FIG. 5; or the depths of the segment may differ from one another.

[0040] The exemplary building panel 10 illustrated in FIG. 5 includes five inwardly extending segments 12, 14, 16, 18, 20 and four outwardly segments 22, 24, 26 and 28 but other numbers of outwardly extending segments and inwardly extending segments may be used. For example, the number of outwardly extending segments could be greater or less than the number of inwardly extending segments. Various sizes and number combination of segments may be used depending upon the cross-sectional shape desired and the building panel.

[0041] FIG. 6a is a cross-sectional view of another exemplary building panel that may be used with certain exemplary embodiment described herein. The exemplary building panel 39 includes a central portion 40, and two inclined sidewall portions 44, 45 extending from opposite ends of the central portion 40. The central portion 40 is straight and in order to increase that portion's stiffness it may include a longitudinal rib 43. Assuming the central portion includes a notched stiffener or longitudinal rib, the central portion 30 would be separated into two sub-central portions 41, 42. Although such a feature is not shown, the inclined sidewall portion 44, 45 may also include notches to stiffen those portions of the building pane. Continuing through FIG. 6a, the building panel 39 further includes two wing portions 46, 47 extending from the inclined sidewall portion 44, 45 respectively; the wing portions 46, 47 are substantially parallel to the straight central portion 40 and may include notch stiffeners 50, 51. A hem portion 48, extends from one wing portion 46, and a complementary hook portion 49 extends from the other wing portion 47.

[0042] FIG. 6b is a cross-sectional view of another exemplary building panel that may be used with certain exemplary embodiment described herein. The exemplary building panel 55 comprises a curved central portion 56 from the ends of which extend a pair of outwardly diverging inclined sidewall portions 57, 58. The panel 55 also comprises two wing portions 59, 60, which extend from the outer end of inclined sidewall portion 57, 58 respectively. It

may also be preferable to include notches 61, 62 within the wing portion 59, 60 to increase the stiffness of those portions. Similarly, although they are not illustrated in FIG. 6b, it may be preferable to include a notch stiffener within each of the inclined sidewall portion. Continuing to refer to FIG. 6b, at the end of one wing portion 59 is the hem portion 53 and at the end of the other wing portion 60, is the complementary hook portion 54 capable of receiving the hem portion 53.

[0043] FIG. 6c is a cross-sectional view of another exemplary building panel that may be used with certain exemplary embodiment described herein. The exemplary building panel 63 has a convex base 64 in cross section, a pair of spaced upright side portions 65 and 66 projecting upwardly from the opposite marginal edges of and in a direction transverse to the convex base 64, an upper inturned flange portion 67 projecting inwardly from the upper marginal edge of and in a direction transverse to the side portion 65. An upper outturned flange portion 68 projects outwardly from an upper marginal edge of and in a direction transverse to the side portion 66 and has a downturned terminal portion 66a at the outer marginal edge thereof. The inturned flange portion 67, has a terminal section 67a bent toward the side portion 65 to provide a reverse bend or fold and a double thickness. The outturned flange portion 68 is bent downwardly to provide a straight, downturned terminal portion 68a providing an inverted, generally U-shaped connecting channel with a bottom opening. The bottom opening formed by the outturned flange portion 68 is of greater width than the inturned flange portion 66 so that it will receive the inturned flange portion of the next adjacent panel directly through the bottom opening to facilitate assembly of the panels. The base 64 and the side portions 65, 66 may include corrugations therein to improve the structural integrity of the panel 63.

[0044] FIG. 7a illustrates the building panel of FIG. 5 connected to an exemplary attachment member and the attachment member connected to an end wall in accordance with certain exemplary embodiments. FIG. 7a shows a curved roof 70 comprised of multiple curved building panels. The curved building panels include a first roof panel 72 connected to a second roof panel 74. As shown, the connecting portion 32 of the first roof panel 72 is connected to the connecting portion 34 of the second roof panel 74 in a longitudinal direction. Mated to the bottom of the two building panels of the curved roof 70 is an attachment member 76. The attachment member 76 includes a first portion 78 connected to the bottom portions of the roof building panels 72, 74 and having an L-shape in cross section. The attachment member 76 also includes a second portion 80 nested into the bottom of the first portion 78 and also having a L-shape in cross-section.

[0045] Nested between the perpendicular walls of the first portion 78 and the second portion 80 is a sealing element 82 (*e.g.*, neoprene, or any other suitable material such as rubber, plastics and other polymer and/or foam materials as will be appreciated by one of ordinary skill in the art). The sealing element 82 seals the top portion of the end wall 84 to provide a moisture barrier between the outside and inside of the building structure. The end wall 84 of a building structure in accordance with exemplary embodiments is typically substantially planar in shape and may be composed of interconnected building panels made from sheet material, concrete cinderblocks, wood, or any other suitable building material as would be known to one of ordinary skill in the art. FIG. 7b illustrates the curved roof 70, mated to the attachment member 76 and including a sealing element 82, but without the end wall 84. FIG. 7c illustrates the curved roof 70, connected to the attachment member 76 but without the sealing element 82 or the end wall 84.

[0046] Advantageously, exemplary building structures manufactured using attachment members as described in exemplary embodiments herein may not suffer from the weakness of conventional techniques of attaching end walls to the roof because they may be attached to the bottom portion of two building panels. This configuration can provide additional rigidity and strength to the joint because it provides a triangle-shaped support structure in cross section between the roof and the end wall that is more resistant to stresses and bending moments. For example, as shown in FIG. 7a, the apex of the triangle is the seam between the building panels 72, 24, the upper walls are the inner walls of the building panels 72, 74, and the base is formed by the attachment member 76.

[0047] In addition, attaching the end walls between the bottom portion of two building panels allows advantageous configurations that were not readily achievable with conventional techniques. For example, since the end wall in exemplary embodiments of the present disclosure does not need to be attached to the edge of a roof panel, the end wall can be inset from the edge of the curved roof by any desired distance. The end wall can be inset by the width of one or two building panels to form an eave, or inset by a greater distance to provide an open yet covered area (*e.g.*, a shelter or sun shade area). Moreover, walls can also be attached interior to the building structure, allowing contractors to construct buildings with internal partitions.

[0048] FIG. 8a illustrates an isometric view of an exemplary attachment member. The exemplary attachment member 76 has a longitudinal direction L as shown in FIG. 8a, and a cross section in a plane perpendicular to the longitudinal direction L. The attachment member 76 typically is curved in the longitudinal direction L to match a longitudinal curve in

building panels forming the roof of a building structure, so that it can closely mate with these building panels.

[0049] The exemplary attachment member 76 is formed from two portions: the first portion 78 having an L-shape in cross section and a second portion 80 also having an L-shape in cross section. The first portion 78 includes a channel wall 92 at one end and a longitudinal rib 96 at the other end (shown as an arcuate portion). Similarly, the second portion 80 includes the channel wall 90, at one end and a longitudinal rib 98 at the other end. When the second portion 80 is mated to the first portion 78, the attachment member 76 has a first segment that forms a channel for accommodating an end wall and a second segment including a longitudinal rib for mating with the rib of a first curved building panel of the roof.

[0050] The first segment of the exemplary attachment member 76 is formed from three components: (i) the flat center portion 93 (*i.e.*, the portion of the first portion 78 extending past the wall of the second portion 80), (ii) the perpendicular channel wall 90 of the second portion 80, and (iii) the perpendicular channel wall 92 of the first portion 78, which together define a recess 94 oriented in a direction perpendicular to the center portion 93. The recess 94 is designed to accommodate the upper portion of an end wall 84 and may include the sealing member 82 as illustrated in FIG. 7a. The top of the flat center portion 93 vertically supports and may be attached to the bottom of a second curved building panel of the roof that is adjacent to the first panel, for example, by way of bolts, screws, rivets, or other suitable means. The second segment of the exemplary attachment member 76 extends from the first segment starting at the wall 90 of the second portion 80 and is oriented in the same plane as the flat center portion 93 of the first segment. The second segment includes longitudinal ribs 96, 98 at the end of the first and second portions 78, 80, which are designed to accommodate the longitudinal rib portions 16 of the building panel shown in FIG. 5 or the longitudinal rib section 43 of the building panel shown in FIG. 6a. These ribs 96, 98 may be affixed to the longitudinal rib of a building panel by any suitable means; for example, a rivet, bolt, screw, weld or any other suitable means. The dimensions of the recess 94 may vary to accommodate various sizes of end wall portions in certain exemplary embodiments. For example, FIG. 8b illustrate an exemplary attachment member with a slightly narrower recess portion 94 in cross section, and FIG. 8c illustrates an exemplary attachment member with an even more narrow recess 94 in cross section.

[0051] FIG. 9a illustrates a cross-section of the exemplary attachment member 76 shown in FIGs. 8a – 8c. In cross-section, the exemplary attachment member 76 includes the first portion 78 and second portion 80. The first portion 78 includes at one end a perpendicular

channel wall 90 and at the other end a longitudinal rib designed to mate with the longitudinal rib portion of a building panel forming a curved roof. The second portion 80 includes at one end, a perpendicular channel wall 90 and at the other end, a longitudinal rib 98. When the first portion 78 and the second portion 80 are mated together they form a recess 94 designed to accommodate the upper portion of an end wall. The attachment member 76 may be attached to a curved building panel, for example, using bolts, rivets, screws, welds, any combination thereof, or any other suitable means.

[0052] FIG. 9b illustrates an attachment member 100 in accordance with another exemplary embodiment. The attachment member 100 includes a first portion 102 having an L-shape in cross-section and a second portion 104 having a C-shape in cross-section. The first portion 102 has at one end a perpendicular channel wall 103 and at the other end a longitudinal rib 112 designed to accommodate the longitudinal rib of a curved building panel. The second portion 104 is the channel segment of the attachment member that includes two perpendicular channel walls, 106 and 108, which form a recess 110 designed to accommodate the upper portion of an end wall. This segment may also include a sealing element to seal the upper portion of the end wall. The C-shaped second portion 104 nests into the L-shaped first portion 102, and may be attached to a curved building panel, for example by means of a bolt, rivet, screw, weld or any other suitable means.

[0053] FIG. 9c illustrate an attachment member in accordance with yet another exemplary embodiment. The attachment member 120 is composed of a single sheet and both ends of the attachment member include longitudinal ribs 128, 130, designed to mate with longitudinal rib portions of curved building panels that form a curved roof. The center segment of the attachment member 120 includes two perpendicular channel walls 122 and 124 that define a recess 126. The recess 126 can accommodate the upper portion of an end wall and may also include a sealing element to seal the upper portion of the end wall.

[0054] FIGs. 10a and 10b illustrate an attachment member in accordance with another exemplary embodiment. FIG. 10a illustrates an isometric view of an attachment member 114 having a C-shape in cross-section, attached to a curved building panel 72 and having a sealing member 115 inserted therein. FIG. 10b illustrates a close-up isometric view of attachment member 114. The attachment member 114 includes perpendicular channel walls 116, 117 that define a recess 118, the recess being designed to accommodate the upper portion of an end wall.

[0055] FIG. 11 illustrates an exemplary attachment member forming system 150. The system 150 includes a support structure 152, shown in this example as a mobile trailer

platform, which can be towed behind a truck so that the system 150 can be easily transported to a job site. Supported by the support structure 152, is a coil holder 154 for supporting a coil of sheet material, *e.g.*, steel sheet material. Shown supported on the coil holder is a coil of sheet material 155. Also supported on the support structure 152 and proximate coil holder 154 is a drive unit 156. The drive unit 156 comprises opposing drive rollers having faces with rubber or other suitable material for grabbing the sheet material and driving it through the system 150. The drive unit 156 may include a hydraulic motor or electric motor for driving the drive rollers, or the drive unit 156 may be pneumatically or manually operated, and is designed to feed sheet material from the coil holder 154 to the subsequent components of the system 150.

[0056] As illustrated, the components of the exemplary system 150 preferably support the sheet material in a substantially vertical orientation when in use (wherein substantially vertical is defined herein as any orientation within a few degrees, *e.g.*, $1^{\circ} - 2^{\circ}$ or less, of an orientation parallel to the axis of gravitational force after the support structure 152 has been leveled) and translate the sheet material in a feed direction F. Advantageously, arranging the components to work the sheet material in a vertical orientation may allow the components to take up less space than a horizontal arrangement, thereby facilitating transportation of all the components on a single trailer. However, it is explicitly contemplated that embodiments of the present disclosure also can include one or more components configured in a horizontal arrangement. For example, in such embodiments the coil holder 154 could have a horizontal axis of rotation and feed sheet material to a horizontally oriented drive unit 156, which would then feed horizontally oriented sheet material to the subsequent components of the system 150.

[0057] Proximate the drive unit 156 and supported on the support structure 152 is a cutting assembly that includes a shearing assembly 158 and a slitting assembly 160. The cutting assembly cuts the sheet material to a shape (typically rectangular with longer dimensions along the feed direction F) and size suitable for forming the desired attachment members in accordance with exemplary embodiments. The shearing assembly 158 cuts the sheet material in a direction perpendicular to the feed direction F, *i.e.*, a vertical direction as shown in FIG. 11. The exemplary slitting assembly 160 cuts the sheet material along its length (*i.e.*, in the feed direction F) into two portions: an upper portion that is scrap sheet material and a lower portion that is used to form the attachment member. The slitting assembly 160 includes guides that direct the upper portion of the sheet material in a first direction (*i.e.*, out of the plane of the feed direction F) for collection by workers, and the

lower portion in a second direction different from the first direction (*e.g.*, along the feed direction F) to a forming assembly 162.

[0058] The forming assembly 162 includes multiple hydraulically actuated rollers designed to form the sheet material into the desired cross-sectional shape (*e.g.*, a C-shape or L-shape in cross-section). However, it should be noted that they could be driven in any suitable manner such as, for example, electrically, manually or pneumatically. Once the attachment member has been formed to have the desired cross-sectional shape, it can then be fed back through the curving assembly 164, which includes crimping rollers for imparting a longitudinal curve to the attachment member. The rear of the curving assembly 164 includes guides to direct sheet material from the cutting assembly to the forming assembly 162 and the exemplary curving assembly 164 is mounted on a track so that it can be moved on the support structure perpendicular to the feed direction F. Advantageously, this configuration provides the capability for stowing the curving assembly inside a trailer to facilitate transportation, and for extending the curving assembly to provide a track from the cutting assembly to the forming assembly 162.

[0059] The support structure 152 also includes a controller 166 that may be, for example, a programmable logic controller (PLC) or a microprocessor based controller used for controlling the operations of the components of the attachment member forming system 150. In addition, a power supply, for example, a diesel generator 168, can also be provided on the support structure 152 to power the various functions of the system 150. In addition, in exemplary embodiments a building panel forming machine may also be included on the support structure 152. For example, a building panel forming machine as described in U.S. Patent Nos. 5,249,445 or 5,359,871 or in US Patent Application Publication No. 2003/0000156 could be supported on a portion of the support structure 152 that is not occupied by the attachment member forming system 150.

[0060] The individual components of an exemplary system for forming an attachment member for connecting an end wall to a curved roof of a building structure will now be described with reference to specific figures.

[0061] FIG. 12a illustrates an exemplary coil holder 154 (also referred to herein as a decoiler) in accordance with exemplary embodiments. As shown in FIG. 12a, the decoiler 154 comprises a frame 169 (*e.g.*, a horizontal metal platform) and multiple support roller assemblies 170 supported by the frame 169, each support roller assembly 170 comprising a conical support roller 171, an outer support member 178, and an inner support member 173. The inner and outer support members 173 and 178 support each of the support rollers 171 via

suitable bearings. In the example of FIG. 12a, there are four support roller assemblies 171, one of which is hidden from view. The decoiler 154 also includes a central rotatable spindle 172, which serves to maintain a coil of sheet material centered on the decoiler 154. FIG. 12b illustrates the decoiler 154 with a coil of sheet material 155 positioned thereon, wherein it is seen that the coil of sheet material 155 has an outer surface, a hollow core, and an inner surface within the hollow core.

[0062] As shown by comparing FIGS. 12a and 12b, the rotatable spindle 172 is positioned to coincide with the bottom opening of a hollow core of the coil 155 of sheet material. Also shown in FIGs. 12a and 12b, the dotted line “B” designates the rotation axis of the rotatable spindle 172, which coincides with the cylindrical axis of the coil 155. The rotation axis “B” of the spindle 172 is oriented perpendicularly to a horizontal plane associated with the frame 169 (*e.g.*, a plane of a supporting platform such as shown in the example of FIGs. 12a and 12b). The rotation axis B is oriented substantially vertically along the Z direction when the decoiler is in use. As referred to herein “substantially vertical” means that the rotation axis B of the decoiler is within a few degrees (*e.g.*, 1-2 degrees or less) of a gravitational force direction. In other words, when the support frame 169 is horizontally oriented to within a few degrees of “level” (*e.g.*, 1-2 degrees or less), the rotation axis B will be oriented substantially vertically.

[0063] Referring again to the example of FIG. 12a, the rotatable spindle 172 may comprise a rotating platform 175 (*e.g.*, a disk of metal plate), a set of radial members 174a and 174b supported by the rotating platform 175, a vertical shaft 176 (and associated housing and bearings), and a cap 177 that secures and/or guides the radial members 174a, 174b. The rotatable spindle 172 may comprise an adjustable mechanism wherein some radial members 174b are movable inward and outward in radial directions perpendicular to the rotation axis B via scissors mechanisms, while other radial members 174a have fixed positions. A suitable scissors mechanism can be provided, for example, by connecting a lower linkage of the scissors mechanism to a vertical sleeve that slides up and down an outer surface of the central rotating shaft of the spindle 172 such that when the sleeve is pushed upward (*e.g.*, via hydraulics), the upper and lower scissors linkages are brought closer together, thereby moving the radial members 174b radially outward, and vice versa. Of course, the positions of the radial members 174b could also be controlled via a scissors mechanism driven by a hand-crank instead of hydraulics as will be appreciated by those skilled in the art.

[0064] The radial members 174a, 174b preferably are shaped to have sloped upper edges as shown in FIG. 12a such that when a coil of sheet material 155 is positioned onto the

decoiler (*e.g.*, lowered onto the decoiler 154 via straps held from a hoist or forklift) the sloped edges of the radial members 174a, 174b serve to guide the coil 155 to an approximately centered position. Then, radial members 174b (whose positions are adjustable) may be moved outward in a cooperative manner so as to contact the inner surface of the coil 155 to push the coil 155 into a centered position such that the cylindrical axis of the coil coincides with the rotation axis B of the rotatable spindle 172. When a coil of sheet material 155 has been consumed, the radial members 174b can be retracted radially inward.

[0065] FIG. 12c illustrates a side cross-sectional view of a support roller assembly 170 comprising an inner support member 173 and an outer support member 178 that support the support rollers 171 via suitable bearings. As illustrated in FIG. 12c, the conical support rollers 106 each have a conical shape with a wide end and a narrow end, wherein each of the conical support rollers 106 has a respective axis of rotation C. The conical support rollers 171 are oriented such that their respective rotational axes C are directed radially toward the rotation axis B of the rotatable spindle, *i.e.*, toward, a center of the coil 155, and oriented at an angle θ upward relative to a horizontal direction that is perpendicular to the axis of rotation B of the rotatable spindle, so that the portions of the conical support rollers 171 that contact the bottom of the coil 155 are arranged substantially horizontally. This orientation of the conical support rollers 171 permits the flat bottom of the coil 155 to be supported along the length of each support rollers 171. Each support roller assembly 170 may also include a side roller 179 whose axis of rotation is oriented parallel to axis of rotation B supported by outer support member 178, wherein the side roller 179 can provide lateral support to prevent the coil of sheet material 155 from shifting radially outward past an outer edge of the support roller 171.

[0066] The dimensions of the conical support members 171 can be selected based upon the expected sizes of coils of sheet material anticipated. A typical coil 155 may have, for example, an inner diameter of about 24 inches, an outer diameter of about 40 inches, and a height of about 36 inches. Generally, the length of each conical support roller 171 should be at least as large as the difference between the inner and outer radii of the coil 155, *i.e.*, the length of each conical support roller 171 should be at least as large as the radial width of the sheet material coiled on the coil 155. To accommodate typical sized coils of sheet material, the conical support rollers 106 can be about 12.3 inches long with a narrow-end diameter of about 2.25 inches and a wide-end diameter of about 5.3 inches. The narrow end of the support roller 171 can be positioned at a distance of about 9 inches from the rotation axis B of the rotatable spindle 172 (*i.e.*, from the cylindrical axis of the coil 155), and the wide end of

the support roller 171 can be positioned at a distance of about 12.3 inches from the rotation axis B. The wide-end and narrow-end diameters of the conical support rollers 171 should be chosen according to the relationship $R1/R2 = A1/A2$, where $A1$ is a diameter of the roller 171 near its narrow end, $A2$ is a diameter of the roller 171 near its wide end, $R1$ is a distance from the rotation axis B to a contact point on the roller 171 at diameter $A1$, and $R2$ is a distance from the rotation axis B to a contact point on the roller 171 at diameter $A2$, such as shown in FIG. 12c. Choosing the support roller dimensions according to satisfy this relationship ensures that at any given distance from the rotation axis B, the linear speed of the sheet material riding on the support roller 171 matches the linear speed of the surface of the support roller 171 at that point. Thus, $R1$ and $R2$ can be chosen to accommodate the expected sizes of coils, $A1$ can be selected to a desired value (e.g., large enough for desired structural strength such as, e.g., 2.25 inches, 2.5 inches, 3 inches, etc.), and $A2$ can then be calculated based on $R1$, $R2$ and $A1$. As seen from FIG. 12c, the angle θ can be given by $\sin\theta = A1/(2 \cdot R1) = A2/(2 \cdot R2)$. Suitable dimensions for support rollers to accommodate other coil sizes can be selected by those skilled in the art in light of the explanation above.

[0067] Choices for the materials used in fabricating various components of the decoiler 154 and the other devices described herein can be made based upon the expected size and weight of the coils and sheet material to be accommodated. For example, as noted above, a typical coil for use in metal building fabrication may have an inner diameter of, for example, about 20 inches (*i.e.*, the diameter of the hollow core is about 20 inches), an outer diameter of about 40 inches, and a height of about 36 inches. The weight of such coils may range from about 6000 to 9000 pounds typically, for example. The materials used for fabricating various components according to the present disclosure should be chosen to accommodate the weight of the coils and sheet material being used. For example, frame pieces may be made from stainless steel or aluminum-alloy plates, *e.g.*, 0.5-0.75 inches in thickness, support rollers made be made from stainless steel or polyurethane, connecting rods and shafts may be made from stainless steel or hardened steel, bearings and gears may be made from hardened steel, etc.

[0068] The coil holder 154 may include a tensioning mechanism for opposing a rotation of the rotating member so as to permit tensioning of the sheet material as it is fed from the coil. For example, the tensioning mechanism may be provided by a rotating disk attached to the rotating member that rotates with the rotating member, against which a brake shoe or other device may be pressed so as to provided a controllable frictional force against the disk.. The coil holder 154 may also include a radially adjustable clamping mechanism (*e.g.*, a

vertically oriented roller) that can be moved radially inward and outward and positioned against the outermost sheet of the coil 176 to prevent the coil from unwinding when its holding strap is released. The coil holder 154 may also include a drive mechanism to drive a pair of the support rollers 171 to rotate the coil, *e.g.*, to facilitate feeding sheet material from the coil 155 into the drive unit 156. In addition, the coil holder 154 may be arranged on an adjustable platform that can be attached to a side of the support structure 152 so as to reposition the coil holder 154 (*e.g.*, rotate the vertical rotation axis by about 90 degrees) to put it in a non-use position when the overall system 150 is being transported. An exemplary decoiling system that can be used for the coil holder 154 is disclosed in U.S. Patent Application No. _____ (Attorney Docket No. 011925-0084-999) entitled "Vertical Sheet Metal Decoiling Systems and Methods" filed even date herewith, the entire contents of which are incorporated herein by reference.

[0069] FIG. 13 illustrates an exemplary drive unit 156 in accordance with exemplary embodiments. The drive unit 156 includes a frame 180 that supports the components of the drive unit therein. Attached to the frame 180 is a pair of inlet guide rollers 182 that support inserted sheet material in a vertical orientation. The inserted sheet material translates through the drive unit 156 in the feed direction, which in FIG. 13 is from right to left. The sheet material passes between rollers 188, 190 in the feed direction. Rollers 190 are fixed to the frame 180 and rollers 188 are attached to a shaft 186, that is driven by a gear 192. The gear 192 is driven by drive gear 194, which is mated to the hydraulic assembly 184 to drive the rotation of the rollers 188 and translate the feed material in the feed direction through the drive unit 156.

[0070] In addition to sheet material supplied from the exemplary coil holder 154, the drive unit 156 may also receive and translate scrap sheet metal that may be available at the job site. For example, if suitable sheet material has been previously slit as described with reference to the exemplary slitting assembly 160 below, there may be sufficient scrap sheet material to produce additional attachment members. This scrap sheet material can be fed into the drive unit 156 by hand or by any other suitable mechanism.

[0071] FIG. 14, 15a, 15b, 15c, and 15d illustrate exemplary embodiments of the cutting assembly. The cutting assembly includes a shearing assembly 158 illustrated in FIG. 14. The shearing assembly 158 includes a frame 200 adapted to be supported on the support structure 152. Attached to the frame are vertical guide members 202 that guide sheet material as it translates through the shearing assembly 158 in the feed direction, which in FIG. 14 is from right to left. Also attached to the frame are guiding rollers 204 that horizontally support the

sheet material as it passes through the shearing assembly 158 in the feed direction. Attached within the frame is a cutting blade 206 (*e.g.*, a guillotine type blade) that is used to cut the sheet material along a vertical axis, *i.e.*, in a plane perpendicular to the feed direction F. The cutting blade 206 is driven by hydraulic pistons 208, which are mounted on the frame 200, to cut through the sheet material.

[0072] FIGs. 15a and 15b illustrate an exemplary front view and side view, respectively, of a slitting assembly 160 in accordance with exemplary embodiments. The slitting assembly 160 includes a frame 210 that supports the components of the slitting assembly therein. Sheet material passes into the slitting assembly 160 through inlet guide rollers 224 that support the sheet material in a substantially vertical orientation. After the sheet material passes through the inlet guide rollers 224, it is then slit into two portions, an upper portion and a lower portion, lengthwise along the feed direction. In the exemplary embodiment, the upper portion is scrap metal translated out of the plane of the feed direction for collection, and the lower portion is translated in the feed direction toward the forming assembly 162 to be formed into an attachment member. Of course, the destinations and use of the portions of sheet material have been described for exemplary purposes only and could readily be reversed.

[0073] FIGs. 15c and 15d illustrate close-up views of the slitting members 226 and the proximate sheet material supporting components. As shown, the slitting members 226 include a pair of cutting wheels 232, 236 that are vertically offset, and a stripper wheel 234 supported opposite the cutting wheel 232 and mounted on a shaft below the cutting wheel 236 that prevents sheet material from adhering to the cutting wheel 236 during the slitting process. The cutting wheel 232 is mounted on a shaft above a horizontal guide roller 222. In operation, the sheet material is translated between the hydraulically driven cutting wheels 232, 236, which causes the sheet material to be slit lengthwise. The cutting wheels 232, 236 are rotationally driven by a hydraulic motor of the hydraulic assembly 228, which is mounted to the frame 210. Providing support to and driving the sheet material as it passes through the slitting members 226 is an assortment of horizontal guide rollers 222 supported by supporting members 238 (*e.g.*, square brackets, bars, or other supports). While described as hydraulically driven, it should be noted that the slitting members 226 could be driven in any suitable manner such as, for example, electrically, manually or pneumatically.

[0074] The present inventors have found that it is desirable to support the upper portion of the sheet material closely after slitting it (*i.e.*, cutting it into upper and lower portions in the feed direction), to prevent the upper portion from bending downward under gravitational force against the lower portion, and to prevent binding of the slitting assembly 160. This also

prevents damage to the slitting members 226 that could be caused by the binding of the sheet material in the slitting assembly 160. Accordingly, exemplary embodiments of the present disclosure include vertical rollers 230 (*e.g.*, rollers with a v-shaped or u-shaped recesses) that support the sheet material vertically shortly after it is slit by the slitting members 226. These vertical rollers 230 keep the upper portion (*i.e.*, the scrap metal) of the sheet material from falling down and interfering with the lower portion of the sheet material. The vertical guide rollers 230 are supported by supporting members 238 and attached to an adjustable pedestal 216, which is movably mounted to the frame 210. The adjustable pedestal 216 is mounted on a track and can be moved up or down by handwheel 218 via a set of linkages. This adjustability allows the slitting assembly 160 to cut varying cross sectional widths of sheet material suitable for varying sizes of attachment members.

[0075] As can be seen, the upper portion of sheet material passes along a different path than the lower portion of sheet material. The lower portion passes along fixed guiding members 212 and vertical guiding rollers 214, which are both fixedly mounted to the frame 210. The lower portion is also supported by vertical guide rollers 231 (*e.g.*, rollers with a v-shaped or u-shaped recesses) at the upper end. Similar to the vertical guide rollers 230, the vertical guide rollers 231 are also mounted to the adjustable pedestal 216 to accommodate varying cross sectional widths of sheet material suitable for varying sizes of attachment members.

[0076] FIG. 16a to 16o illustrate an exemplary forming assembly 162 for imparting a desired cross sectional shape to the sheet material in order to fabricate attachment members. FIG. 16a illustrates an exemplary configuration of rollers suitable to form L-shaped portions of sheet material. In FIG. 16a, flat sheet material oriented in a vertical direction Z enters on the right side of the forming assembly 162, translates through a series of rollers in the feed direction F, and exits on the left side of the forming assembly with an L-shapes cross section imparted thereto. The forming assembly 162 has a frame 240 that supports the components of the forming assembly therein. Starting from the right side of FIG. 16a, an inlet guide assembly 241 is attached to the frame 240, the inlet guide assembly including fixed members and vertically oriented rollers that support the sheet material as it enters the forming assembly in a vertical orientation. The inlet guide assembly 241 includes a set of upper vertical guide rollers 243 (*e.g.*, with v-shaped or u-shaped recesses therein) that are adjustable to accommodate various cross sectional widths of sheet material.

[0077] After the sheet material passes the inlet guide assembly 241 in the feed direction F, it passes between a first pair of shafts: a front shaft 246, and a rear shaft 247. The front

shaft 246, and rear shaft 247 are attached to the frame 240 via bearings that allow the shafts to rotate. A concave roller 248 is at the upper end of the front shaft 246, and a complementary convex roller 249 is at the upper end of the rear shaft 247; both rollers being supported in position by an adjustable platform 263. When sheet material passes between the concave roller 248 and the convex roller 249, these rollers impact the sheet material and form a longitudinal rib therein. Also, attached to the bottom end of the front shaft 246 is a conical roller 250 having an angle approximately 15° from vertical; and attached to the bottom of the rear shaft 247 is a complementary conical roller 251. When the sheet material passes between these conical rollers 250, 251, these rollers impact the sheet material and begin to bend the sheet material to provide a first bend to ultimately obtain a cross sectional L shape.

[0078] Next the sheet material passes between a second pair of shafts: front shaft 252 and a rear shaft 253. The front shaft 252 extends vertically from the base of the frame 240 to approximately the center of the frame, and is supported by adjustable platform 267. Attached to the upper portion of the front shaft 252 is an upper conical roller 254 having an angle approximately 45° from vertical. The upper conical roller 254 may be removed and replaced with a cylindrical roller 258 as explained further below to form the sheet material into different shapes. Attached to the middle portion of the rear shaft 253, and also supported by adjustable platform 267 is a complementary conical roller 255, also removable, designed to mate with the upper conical roller 254.

[0079] As illustrated in FIGs. 16b, 16c, 16f, 16g, 16l, and 16m, the conical rollers 254, 255, which are removable, are used when the forming assembly 162 is configured to produce C-shaped portions of sheet material in cross section. When the sheet material passes between these conical rollers 254, 255, these rollers impact the sheet material and bend the upper portion of the sheet material to obtain a cross sectional C shape.

[0080] The upper conical roller 254 may be loosened and removed via the adjustment mechanism 260 (e.g., a frictional locking mechanism), which uses a hand-crank mechanism. The upper conical roller 254 may be replaced with a cylindrical roller 258. The replacement cylindrical roller 258 is used when the forming assembly is configured to produce L-shaped portions of sheet material in cross section. As such, when the upper conical roller 254 is replaced with the cylindrical roller 258, the rollers 255, 258 impart no cross section shape to the sheet material and instead act merely as horizontal guides that serve to translate sheet material through the forming assembly. Attached to the bottom end of the front shaft 252 is a conical roller 256 having an angle approximately 30° from vertical; and attached to the bottom of the rear shaft 253 is a complementary conical roller 257. When the sheet material

passes between these conical rollers 256, 257, these rollers impact the sheet material and further bend the sheet material to obtain more of a cross sectional L shape. In other words, as described further below, the conical roller 254 is used when the forming assembly 162 is used to create a C-shaped member from the sheet material (e.g., a C-shaped member with two 90 degree bends), and the cylindrical roller 258 is used when the forming assembly 162 is used to create an L-shaped member from the sheet material.

[0081] After the sheet material passes between the second pair of shafts 252, 253 in the feed direction F, it passes between a third pair of shafts: a front shaft 268, and a rear shaft 269. The front shaft 268, and rear shaft 269 are attached to the frame 240 via bearings that allow the shafts to rotate. A concave roller 270 is at the upper end of the front shaft 268, and a complementary convex roller 271 is at the upper end of the rear shaft 269, both rollers being supported in position by the adjustable platform 263. When sheet material passes between the concave roller 270 and the convex roller 271, these rollers further impact the sheet material to further form the longitudinal rib therein. Also, attached to the bottom end of the front shaft 268 is a conical roller 272 having an angle approximately 45° from vertical; and attached to the bottom of the rear shaft 269 is a complementary conical roller 273. When the sheet material passes between these conical rollers 272, 273, these rollers impact the sheet material and further bend the sheet material to obtain more of a cross sectional L shape.

[0082] Next the sheet material passes between a fourth pair of shafts: front shaft 274 and a rear shaft 275. The front shaft 274 extends vertically from the base of the frame 240 to approximately the center of the frame, and is supported by adjustable platform 267. Attached to the upper portion of the front shaft 274 is an upper conical roller 276 having an angle approximately 75° from vertical. The upper conical roller 276 may be removed and replaced with a cylindrical roller 280 as explained further below to form the sheet material into different shapes. Attached to the middle portion of the rear shaft 275, and also supported by adjustable platform 267 is a complementary conical roller 277 designed to mate with the upper conical roller 276.

[0083] As illustrated in FIGs. 16b, 16c, 16f, 16g, 16l, and 16m, the conical rollers 276, 277 are used when the forming assembly 162 is configured to produce C-shaped portions of sheet material in cross section. When the sheet material passes between these conical rollers 276, 277, these rollers impact the sheet material and further bend the upper portion of the sheet material to obtain a cross sectional C shape.

[0084] The upper conical roller 276 may be loosened and removed via the adjustment mechanism 261 (e.g., a frictional locking mechanism), which uses a hand-crank mechanism.

The upper conical roller 276 may be replaced with a cylindrical roller 280. The replacement cylindrical roller 280 is used when the forming assembly is configured to produce L-shaped portions of sheet material in cross section. As such, when the upper conical roller 276 is replaced with the cylindrical roller 280, the rollers 277, 280 impart no cross section shape to the sheet material and instead act merely as horizontal guides that serve to translate sheet material through the forming assembly. Attached to the bottom end of the front shaft 274 is a conical roller 278 having an angle approximately 60° from vertical; and attached to the bottom of the rear shaft 275 is a complementary conical roller 279. When the sheet material passes between these conical rollers 278, 279, these rollers impact the sheet material and further bend the sheet material to obtain more of a cross sectional L shape.

[0085] After the sheet material passes between the fourth pair of shafts 274, 275 in the feed direction F, it passes between a fifth pair of shafts: a front shaft 283, and a rear shaft 289. The front shaft 283, and rear shaft 289 are attached to the frame 240 via bearings that allow the shafts to rotate. A concave roller 285 is at the upper end of the front shaft 283, and a complementary convex roller 286 is at the upper end of the rear shaft 289, both rollers being supported in position by the adjustable platform 263. When sheet material passes between the concave roller 285 and the convex roller 286, these rollers further impact the sheet material to further form the longitudinal rib therein. Also, attached to the bottom end of the front shaft 283 is a conical roller 287 having an angle approximately 75° from vertical; and attached to the bottom of the rear shaft 289 is a complementary conical roller 288. When the sheet material passes between these conical rollers 287, 288, these rollers impact the sheet material and further bend the sheet material to obtain more of a cross sectional L shape.

[0086] Finally, the sheet material passes between a sixth pair of shafts: a front shaft 286, and a rear shaft 290. The front shaft 286, and rear shaft 290 are attached to the frame 240 via bearings that allow the shafts to rotate. A concave roller 291 is at the upper end of the front shaft 286, and a complementary convex roller 292 is at the upper end of the rear shaft 290, both rollers being supported in position by the adjustable platform 263. When sheet material passes between the concave roller 286 and the convex roller 292, these rollers further impact the sheet material to further form the longitudinal rib therein. Also, attached to the bottom end of the front shaft 286 is a cylindrical roller 293; and attached to the bottom of the rear shaft 290 is a complementary cylindrical roller 294. When the sheet material passes between these cylindrical rollers 293, 294, these rollers impact the sheet material and complete bending the sheet material into the desired a cross sectional L shape.

[0087] Furthermore, attached to approximately the middle of the front shaft 286 is a cylindrical roller 259; and attached to approximately the middle of the rear shaft 290 is a complementary cylindrical roller 265. As illustrated in FIGs. 16b, 16c, 16f, 16g, 16l, and 16m, these rollers are used when the forming assembly 162 is configured to produce C-shaped portions of sheet material in cross section. These cylindrical rollers 259, 265 are affixed in tracks on the shafts 286, 290 by screws so that they may be adjusted up or down on the shafts to produce varying sizes of C-shaped portions. When the upper portion of the sheet material passes between these cylindrical rollers 259, 265, these rollers impact the sheet material and complete bending the upper portion of the sheet material into the desired a cross sectional C shape. Thus depending upon which combinations of rollers are used as explained above, the sheet material may be formed into different shapes, e.g., L-shaped members or C-shaped members (e.g., the C-shaped members having two 90 degree bends..

[0088] As discussed above, the conical rollers 254, 255, 276, 277 are supported on the adjustable platform 267, which is adjustable vertically via the adjustment mechanism 282 that includes a socket configured to receive a hand-crank attached via a set of linkages to move the adjustable platform 267 up and down within the frame. This feature allows the forming assembly 162 to accommodate a variety of sizes of attachment members.

[0089] In addition, the rollers 248, 249, 270, 271, 285, 286, 291, 292 are supported by an adjustable platform 263 that can be adjusted vertically by way of an adjustment mechanism 262. This adjustment mechanism 262 includes a socket configured to receive a hand-crank attached via a set of linkages to move the adjustable platform 267 up and down within the frame 240.

[0090] At the outlet of the forming assembly 162 is a set of guide rollers, a lower guide roller 264, which is fixed to the frame, and a set of upper guide rollers 266 that are adjustable and/or removable from the frame to accommodate various sizes of attachment members after they have received the desired cross sectional shape.

[0091] In the illustrated exemplary embodiment, the shafts and rollers in the forming assembly 162 are driven by a hydraulic motor. However, it should be noted that they could be driven in any suitable manner such as, for example, electrically, manually or pneumatically. Hydraulic assembly 244 is coupled to a drive gear 295, which is in turn engaged with the gears attached to the shafts at the top portion of the frame. As illustrated, the large gears 242 are attached to the top of the rear shafts 247, 253, 269, 275, 289, 290. These large gears 242 are in turn coupled to each other by way of coupling gears 296. Furthermore, the large gears 242 engage with and drive small gears 297 that are attached to

the front shafts 246, 268, 283, 286. As can be seen, the front shafts 252, 274 do not extend fully to the top of the frame 240. Accordingly, the rear shafts 253, 257, which do extend fully from the top to the bottom of the frame, have gears attached to the bottom that engage with small gears 298 attached to the bottom portion of front shafts 252, 274. The small gears 298 drive these front shafts.

[0092] Referring now to FIGs. 16b to 16o, various configurations an exemplary forming assembly 162 are shown configured to provide varying sizes of C-shaped and L-shaped attachment members.

[0093] FIG. 16b and 16c illustrate a front and rear view respectively of a forming assembly 162 configured to provide a C-shaped attachment member in cross section. As can be seen, the sheet material enters the right side of FIG. 16b and is substantially planar at that point. As the sheet material passes between the rollers configured to impart the cross sectional C-shape, it exits the right side having the desired cross-sectional shape. FIG. 16d and 16e illustrate a front and rear view respectively of a forming assembly 162 configured to provide a L-shaped attachment member in cross section. FIG. 16f and 16g illustrate a front and rear view respectively of a forming assembly 162 configured to provide a C-shaped attachment member in cross section. FIG. 16h and 16i illustrate a front and rear view respectively of a forming assembly 162 configured to provide a L-shaped attachment member in cross section. FIG. 16j and 16k illustrate a front and rear view respectively of a forming assembly 162 configured to provide a L-shaped attachment member in cross section. FIG. 16l and 16m illustrate a front and rear view respectively of a forming assembly 162 configured to provide a C-shaped attachment member in cross section. FIG. 16n and 16o illustrate a front and rear view respectively of a forming assembly 162 configured to provide a L-shaped attachment member in cross section.

[0094] FIG. 17 illustrates an exemplary curving assembly 164. The exemplary curving assembly 164 includes a base 300 mounted in a track 302 that allows the curving assembly 164 to be moved in and out from the support structure 152. The curving assembly 164 includes a frame 304 that supports the components therein. Attached to the frame 304 is a lower crimping assembly 316 which drives a pair of crimping rollers: a lower crimping roller 312 and an upper crimping roller 314 that are designed to crimp a portion of sheet material that passes between them. Each of the crimping rollers 312 and 314 includes a plurality of crimping blades separated by spaces therebetween. A blade of one crimping roller is positioned opposite a space between blades of the opposing crimping roller to crimp the material passing therebetween to thereby impart a longitudinal curve or arch to the

attachment member. The spacing between lower crimping roller 312 and upper crimping roller 314 is adjustable by way of handwheel 320 attached through linkages to the lower crimping assembly 316. This adjustment allows the crimps imparted to the sheet material to be adjusted so that the longitudinal curve of the attachment member can varied to match the longitudinal curve of curved building panels forming the roof of a building structure.

[0095] The curving assembly 164 also includes an upper crimping assembly 318 attached to a pair of crimping rollers 330, 332, which also have an adjustable offset to provide different longitudinal curves to an attachment member. The spacing between the crimping rollers 330, 332 is adjusted by way of handwheel 322 that is linked via a gear assembly to the upper crimping assembly 318. By having both an upper crimping assembly 318 and a lower crimping assembly 316, the curving assembly can crimp both opposing sides of a C-shaped attachment member to provide the longitudinal curve.

[0096] In addition, the spacing between the lower crimping assembly 316 and the upper crimping assembly 318 can be adjusted by way of handwheel 324. This adjustment allows the curving assembly 164 to accommodate various sizes of attachment members. It should be noted that to accommodate attachment members having an L-shape in cross section, the upper crimping assembly 318 can be moved sufficiently up into the housing 304 to avoid impacting any portion of the attachment member as it translates through the curving assembly. The lower crimping assembly 316 then crimps one side of the L-shaped attachment member to provide the longitudinal curve. The crimping rollers 312, 314, 330, 332 can be driven by a hydraulic motor 328, which imparts driving force to these rollers. The hydraulic assembly 328 is controlled by controller 326 (e.g., a PLC) to provide an on-off capability.

[0097] Also attached to the base 300 of the curving assembly 164 is a guide assembly 306 having an upper portion and a lower portion, where the upper portion directs scrap metal outward so that it can be collected by workers, and the lower portion directing sections of sheet material to be formed into attachment members to the forming assembly 162. The upper portion of the guide assembly comprises an upper guide 308 (e.g., curved brackets with a space therebetween through which the sheet material can pass) that is curved to direct the scrap metal outward, which is attached to shafts 336 that allow the upper guide 308 to be adjusted vertically to accommodate varying sizes of scrap metal. Similarly, the lower portion of the guide assembly 306 comprises lower guides 310 (e.g., straight brackets with a space therebetween through which the sheet material can pass) mounted on shafts 334 that allow

these lower guides to be adjusted up and down to accommodate varying sizes of sheet material suitable to be formed into attachment members.

[0098] FIG. 18 illustrates an exemplary control panel 166 that allows operators to control various features of the attachment member forming system 150. The controller 166 may be driven via a simple PLC, or by a more complicated microprocessor based controller as would be known to one of ordinary skill in the art. The controls include a power switch 340 for turning on and off the system 150. The controls also include a run button 344 that causes the system 150 to translate sheet material in the feed direction through the system, and a halt button 342 that stops the translation of sheet material. Also included is a jog switch 348 that allows an attachment member translating through the system to be moved in short bursts forward and backward, and a shear button 346 that powers the shear assembly 158 to cause it to cut sheet material in a direction perpendicular to the feed direction. The control panel further includes a numeric keypad 350 for entering data (*e.g.*, controlling the length of panels) into the controller and a display 352 for rendering information for an operator of the controller. Further included on the controller 166 are various other controls including: a selector switch 354 for selecting between an attachment member forming system and a building panel forming system (for exemplary embodiments that include both an attachment member forming system and a building panel forming system on the same support structure), an eject button 356 to eject material from the attachment member forming system after it has been sheared, a hydraulic stop 358, an emergency stop 360, an ignition switch 362, an engine start 364, a high speed/low speed selector for a diesel generator 366, a low voltage pilot light 368 and a diesel generator instrument panel 370 that provides indications of various parameters of the diesel generator including fuel, pressure, temperature, and voltage.

[0099] While the present invention has been described in terms of exemplary embodiments, it will be understood by those skilled in the art that various modifications can be made thereto without departing from the scope of the invention as set forth in the claims.

What is claimed is:

1. A system for forming an attachment member for connecting a wall to a curved roof of a building structure, the system comprising:

- a. a support structure;
- b. a cutting assembly supported by the support structure configured to receive sheet material wherein a plane of the sheet material is oriented in a substantially vertical orientation, the cutting assembly including a slitter to cut the sheet material along a feed direction of the sheet material into first and second portions of sheet material, the slitter having guides to support the first and second portions of sheet material in the substantially vertical orientation, the guides directing the first portion of sheet material in a first direction and directing the second portion of sheet material in a second direction different from the first direction; and
- c. a forming assembly supported by the support structure, the forming assembly being configured to receive sheet material from the cutting assembly and comprising:
 - i. a frame, and
 - ii. multiple rollers supported by the frame, the multiple rollers arranged to impact the first portion of sheet material and change a cross-sectional shape of the first portion of sheet material as the first portion of sheet material passes along the multiple rollers in the feed direction to form an attachment member, the attachment member having a plurality of segments in cross section in a plane perpendicular to the feed direction including a first flat segment in cross section and a second segment extending perpendicularly in cross section from the first segment.

2. The system of claim 1 further comprising:

- d. a curving assembly supported on the support structure for curving the attachment member, the curving assembly comprising:
 - a first pair of crimping rollers offset from one another and located within the curving assembly configured to receive the attachment member such that when the attachment member enters the curving assembly the second segment of the attachment member passes between said crimping rollers,

wherein the first pair of crimping rollers is configured to crimp the second segment of the attachment member to impart a longitudinal curve to the attachment member along a length of the attachment member.

3. The system of claim 1, wherein the system is configured to form the attachment member such that the attachment member comprises:

a. a first segment having a flat center portion and a pair of walls extending perpendicular to the center portion in cross section, the pair of walls defining a recess oriented in a direction perpendicular to the center portion, wherein the recess is adapted to accommodate a portion of a wall of a building structure;

b. a second segment extending from one of the walls of the first segment, the second segment being oriented in a same plane as the flat center portion of the first segment in cross section, the second segment including a longitudinal rib, the longitudinal rib protruding in cross section from the second segment, the longitudinal rib being adapted to mate with a rib of a curved building panel.

4. The system of claim 1 wherein the multiple rollers comprises:

a. an upper set of rollers attached to an adjustable platform mounted on a shaft; and

b. a lower set of rollers;

c. wherein a distance between the upper set of rollers and the lower set of rollers is adjustable such that attachment members of different sizes can be accommodated.

5. The system of claim 1 further comprising a building panel forming apparatus supported on the support structure.

6. The system of claim 1 further comprising a decoiler supported by the support structure configured to feed sheet material to the cutting assembly, wherein the decoiler is oriented vertically such that a rotation axis of the decoiler is parallel to a vertical direction.

7. The system of claim 6 further comprising a drive unit supported on the support structure proximate the decoiler and the cutting assembly, the drive unit configured to feed the sheet material from the decoiler to the cutting assembly.

8. The system of claim 1 wherein the curving assembly further comprises a second pair of crimping rollers offset from one another and offset from the first pair of crimping rollers, wherein a distance between the first pair of crimping rollers and the second pair of crimping rollers is adjustable to accommodate different sizes of attachment members.

9. The system of claim 1 wherein at least one of the rollers of the forming assembly is removable to form the attachment member into either an L-shape or C-shape in cross section.

10. The system of claim 1 wherein the curving assembly is mounted on a movable platform supported on the support structure and located between the cutting assembly and the forming assembly.

11. An attachment member formed from sheet material configured to connect a wall to a curved roof of a building structure, the curved roof being formed from a plurality of curved building panels, the attachment member being curved in a longitudinal direction and having a shape in cross section in a plane perpendicular to the longitudinal direction, the attachment member comprising:

a. a first segment having a flat center portion and a pair of walls extending perpendicular to the center portion in cross section, the pair of walls defining a recess oriented in a direction perpendicular to the center portion, wherein the recess is adapted to accommodate a portion of a wall of a building structure; and

b. a second segment extending from one of the walls of the first segment, the second segment being oriented in a same plane as the flat center portion of the first segment in cross section, the second segment including a longitudinal rib, the longitudinal rib protruding in cross section from the second segment, the longitudinal rib being adapted to mate with a rib of a curved building panel.

12. The attachment member of claim 11 wherein the central portion of the curved building panel includes a rib in cross section, and wherein the longitudinal rib of the attachment member is adapted to mate with the rib of the building panel.

13. The attachment member of claim 11 wherein the attachment member is formed from two portions of sheet material.

14. The attachment member of claim 13, wherein the attachment member comprises:
- a. a first L-shaped portion in cross section, the first L-shaped member forming one of the walls of the first segment; and
 - b. a second L-shaped portion in cross section forming the other wall of the first segment;
 - c. wherein the first L-shaped portion is mated to the second L-shaped portion to form the first segment of the attachment member.
15. The attachment member of claim 13, wherein the attachment member comprises:
- a. an L-shaped portion in cross section; and
 - b. a C-shaped portion in cross section;
 - c. wherein the C-shaped portion is nested into the L-shaped portion to form the first segment of the attachment member.
16. The attachment member of claim 11 wherein the attachment member is formed from a single portion of sheet material.
17. The attachment member of claim 16 wherein the attachment member further comprises:
- a. a third segment extending from a wall opposite the second segment, the third segment being oriented in a same plane as the flat center portion of the first segment in cross section, the third segment including a second longitudinal rib; and
 - b. the second longitudinal rib protruding in cross section from the third segment, the second longitudinal rib being adapted to mate with a rib of another curved building panel.
18. The attachment member of claim 11 wherein the sheet material comprises sheet metal having a thickness between about 0.035 inches and about 0.060 inches.
19. A building structure comprising:
- a. a curved roof formed from a plurality of interconnected building panels, each building panel extending in a longitudinal direction and having a shape in cross

section in a plane perpendicular to the longitudinal direction, wherein each building panel includes a central portion having a rib in cross section;

b. a wall; and

c. an attachment member formed from sheet material attaching the wall to the curved roof, the attachment member comprising:

i. a first segment having a flat center portion and a pair of walls extending perpendicular to the center portion in cross section, the pair of walls defining a recess oriented in a direction perpendicular to the center portion, wherein the recess is adapted to accommodate a portion of a wall of a building structure;

ii. a second segment extending from one of the walls of the first segment, the second segment being oriented in a same plane as the flat center portion of the first segment in cross section, the second segment including a longitudinal rib, the longitudinal rib protruding in cross section from the second segment, the longitudinal rib being adapted to mate with a rib of a curved building panel; and

iii. wherein the flat center portion of the first segment is connected to a first building panel of the curved roof, and the longitudinal rib of the second segment is connected to a rib of a second building panel of the curved roof.

20. The building structure of claim 19 wherein the wall is an exterior wall of the building structure.

21. The building structure of claim 19 wherein the wall is inset from an edge of the curved roof by greater than the width of one of the interconnected building panels to provide an open yet covered area.

22. The building structure of claim 19 wherein the wall is an interior wall of the building structure.

23. The building structure of claim 19 wherein the wall is formed from a set of interconnected building panels.

24. The building structure of claim 19 wherein the wall is formed from a set of concrete blocks.

25. A method of forming an attachment member for connecting a wall to a building structure, the method comprising:
- a. cutting sheet material from a source of sheet material in a feed direction into first and second portions of sheet material, wherein a plane of the sheet material is oriented in a substantially vertical orientation;
 - b. supporting the first and second portions of sheet material in the vertical orientation with guides such that the first portion of sheet material is directed in a first direction and the second portion of sheet material is directed in a second direction different from the first direction;
 - c. translating the first portion of sheet material through multiple rollers, the multiple rollers arranged to impact the first portion of sheet material as the first portion passes along the multiple rollers in a feed direction to form an attachment member, the attachment member having a plurality of segments in cross section in a plane perpendicular to the feed direction including a first flat segment in cross section and a second segment extending perpendicularly in cross section from the first segment; and
 - d. crimping the second segment of the attachment member to impart a longitudinal curve to the attachment member along a length of the attachment member.
26. The method of claim 25 wherein the attachment member comprises:
- a. a first segment having a flat center portion and a pair of walls extending perpendicular to the center portion in cross section, the pair of walls defining a recess oriented in a direction perpendicular to the center portion, wherein the recess is adapted to accommodate a portion of a wall of a building structure; and
 - b. a second segment extending from one of the walls of the first segment, the second segment being oriented in a same plane as the flat center portion of the first segment in cross section, the second segment including a longitudinal rib, the longitudinal rib protruding in cross section from the second segment, the longitudinal rib being adapted to mate with a rib of a curved building panel.
27. The method of claim 25 further comprising the steps of:
- a. attaching a first segment of the attachment member to a first building panel of a curved roof;

b. attaching a second segment of the attachment member to a second building panel of the curved roof, wherein the second building panel is adjacent the first building panel; and

c. attaching the attachment member to a portion of a wall of a building structure.

28. A system for forming an attachment member for connecting a wall to a curved roof of a building structure, the system comprising:

a. a support structure;

b. a cutting assembly supported by the support structure configured to receive sheet material, the cutting assembly including a slitter to cut the sheet material along a feed direction of the sheet material into first and second portions of sheet material, the slitter having guides to support the first and second portions of sheet material, the guides directing the first portion of sheet material in a first direction and directing the second portion of sheet material in a second direction different from the first direction; and

c. a forming assembly supported by the support structure, the forming assembly being configured to receive sheet material from the cutting assembly and comprising:

i. a frame, and

ii. multiple rollers supported by the frame, the multiple rollers arranged to impact the first portion of sheet material and change a cross-sectional shape of the first portion of sheet material as the first portion of sheet material passes along the multiple rollers in the feed direction to form an attachment member, the attachment member having a plurality of segments in cross section in a plane perpendicular to the feed direction including a first flat segment in cross section and a second segment extending perpendicularly in cross section from the first segment;

wherein the forming assembly is configured to form the attachment member such that the attachment member comprises:

a first segment having a flat center portion and a pair of walls extending perpendicular to the center portion in cross section, the pair of walls defining a recess oriented in a direction perpendicular to the center portion, wherein the recess is adapted to accommodate a portion of a wall of a building structure;

a second segment extending from one of the walls of the first segment, the second segment being oriented in a same plane as the flat center portion of the first

segment in cross section, the second segment including a longitudinal rib, the longitudinal rib protruding in cross section from the second segment, the longitudinal rib being adapted to mate with a rib of a curved building panel.