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(54) **Title:** HSS CONNECTOR WITH SWAGED INTERFACE

(57) **Abstract:** A connector for a structural column includes a male element of a first column segment. The male element includes a male outer surface and a plurality of first fastener apertures. The connector also includes a female element of a second column segment. The female element includes a female inner surface and a plurality of second fastener apertures. At least one of the female element and the male element is swaged such that the female inner surface of the female element is sized to receive the male outer surface of the male element such that each of the first fastener apertures aligns with a corresponding one of the second fastener apertures. The connector further includes a plurality of fasteners configured to be received in the aligned pairs of first and second fastener apertures

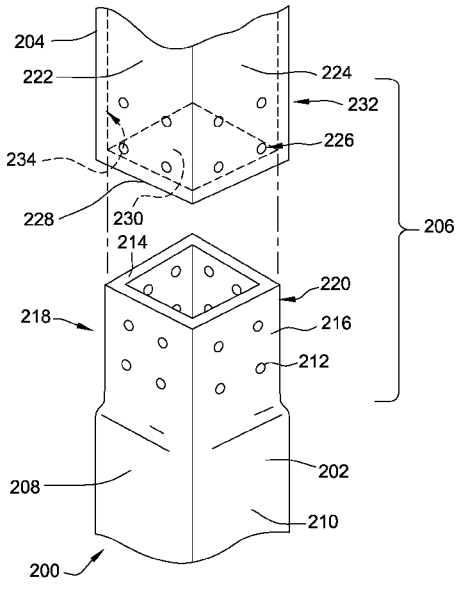

FIG. 2

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HSS CONNECTOR WITH SWAGED INTERFACE

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of, and priority to, U.S. Provisional Pat. App. Ser. No. 62/375,759 filed October 28, 2016, the contents of which are hereby incorporated by reference in their entirety.

BACKGROUND

[0002] The field of the disclosure relates generally to connectors with swaged interfaces and, more particularly, to a connector with a swaged interface for joining together tubular support members in a building frame.

[0003] Many known building structures have a frame that includes a plurality of beams and a plurality of columns. When erecting a taller (e.g., multistory) building, it can be difficult to transport full-length columns to the building site, and it is common to instead transport each column in segments that are ultimately welded together at the building site. However, it can be time consuming and costly to weld column segments together at a building site.

BRIEF DESCRIPTION

[0004] In one aspect, a connector for a structural column is provided. The connector includes a male element of a first column segment. The male element includes a male outer surface and a plurality of first fastener apertures. The connector also includes a female element of a second column segment. The female element includes a female inner surface and a plurality of second fastener apertures. At least one of the female element and the male element is swaged such that the female inner surface of the female element is sized to receive the male outer surface of the male element such that each of the first fastener apertures aligns with a corresponding one of the second fastener apertures. The connector further includes a plurality of fasteners configured to be received in the aligned pairs of first and second fastener apertures.

[0005] In another aspect, a method of assembling a column for a frame of a building is provided. The method includes positioning a second column segment with

respect to a first column segment. The first column segment includes a male element including a male outer surface and a plurality of first fastener apertures. The second column segment includes a female inner surface and a plurality of second fastener apertures. At least one of the female element and the male element is swaged such that the female inner surface of the female element receives the male outer surface of the male element such that each of the first fastener apertures aligns with a corresponding one of the second fastener apertures. The method also includes coupling the second column segment to the first column segment via a plurality of fasteners received in the aligned pairs of first and second fastener apertures to form the assembled column.

[0006] In another aspect, a column for a moment-resisting frame is provided. The column includes a first hollow structural section (HSS) column segment and a second HSS column segment. The column also includes a connector that includes an integrally formed male element of the first HSS column segment. The male element includes a male outer surface and a plurality of first fastener apertures. The connector also includes an integrally formed female element of the second HSS column segment. The female element includes a female inner surface and a plurality of second fastener apertures. At least one of the female element and the male element is swaged such that the female inner surface of the female element receives the male outer surface of the male element such that each of the first fastener apertures is aligned with a corresponding one of the second fastener apertures. The connector further includes a plurality of fasteners received in the aligned pairs of first and second fastener apertures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Figure 1 is a schematic illustration of a site at which an exemplary building frame is being erected;

[0008] Figure 2 is an exploded view of an exemplary column for use in the frame shown in Figure 1; and

[0009] Figure 3 is a perspective view of the exemplary column shown in Figure 2 after assembly.

DETAILED DESCRIPTION

[0010] The following detailed description illustrates connectors with swaged interfaces and methods of assembling the same by way of example and not by way of limitation. The description should enable one of ordinary skill in the art to make and use the connectors, and the description describes several embodiments of the connectors, including what is presently believed to be the best modes of making and using the connectors. An exemplary connector with a swaged interface is described herein as being used to couple together support members in a building frame. However, it is contemplated that a connector with a swaged interface has general application to a broad range of systems in a variety of fields other than frames of buildings.

[0011] Figure 1 is a schematic illustration of a site 100 at which an exemplary building frame 102 is being erected. In the exemplary embodiment, building frame 102 is a moment-resisting frame (e.g., a special moment frame or an intermediate moment frame) that includes a plurality of columns 104 and a plurality of beams 106. In some embodiments, columns 104 and beams 106 are made of structural steel. In other embodiments, columns 104 and beams 106 may be made of any suitable material that facilitates enabling frame 102 to function as described herein. In the exemplary embodiment, at least one column 104 of frame 102 has a first column segment 108 and a second column segment 110 that are coupled together by a connector 112 that includes a swaged interface. More specifically, first column segment 108 has a first end 114 and a second end 116, and second column segment 110 has a first end 118 and a second end 120. Connector 112 having a swaged interface is defined at first end 114 of first column segment 108 and at second end 120 of second column segment 110, such that at least one column 104 of frame 102 is assembled onsite by coupling its associated first column segment 108 to its associated second column segment 110 at first end 114 and second end 120, respectively, using connector 112. Although first column segment 108 is illustrated as being coupled to a foundation 122 in the exemplary embodiment, first column segment 108 may not be coupled to foundation 122 in other embodiments (i.e., first column segment 108 may have any suitable position within frame 102, including a position that is elevated above foundation 122). Moreover, although second column segment 110 is illustrated as being lifted onto first column segment 108 using a crane 124 in the exemplary

embodiment, second column segment 110 may be positioned with respect to first column segment 108 using any suitable method.

[0012] Figure 2 is an exploded view of an exemplary embodiment of column 104, designated as column 200, for use in frame 102. Column 200 includes a first column segment 202, a second column segment 204, and a moment-resisting swaged connector 206 for coupling first column segment 202 to second column segment 204. In the exemplary embodiment, each of first column segment 202 and second column segment 204 is a hollow structural section (HSS). Alternatively, in some embodiments, first column segment 202 and/or second column segment 204 may be any suitable tubular column segment (e.g., at least one of first column segment 202 and second column segment 204 may not be a hollow structural section (HSS)). Moreover, in other embodiments, segments 202 and 204 may not be column segments, but may instead be another suitable type of tubular support member that is coupleable using connector 206 as described herein.

[0013] In the exemplary embodiment, first column segment 202 has a pair of opposing male side walls 208 and a pair of opposing male end walls 210, each of which has at least one first fastener aperture 212. Male side walls 208 and male end walls 210 collectively define a male end surface 214 generally perpendicular to side walls 208 and 210, and a male outer surface 216. A male element 218 of first column segment 202 adjacent male end surface 214 partially defines connector 206. Male outer surface 216 has a substantially rectangular cross-section along male element 218 (i.e., male outer surface 216 has four first outer corners 220 along male element 218, each male outer corner 220 being defined at the junction of a male side wall 208 and a male end wall 210). Likewise, in the exemplary embodiment, second column segment 204 has a pair of opposing female side walls 222 and a pair of opposing female end walls 224, each of which has at least one second fastener aperture 226. Female side walls 222 and female end walls 224 collectively define a female end surface 228 generally perpendicular to side walls 222 and 224, and a female inner surface 230. A female element 232 of second column segment 204 adjacent female end surface 228 partially defines connector 206. Female inner surface 230 has a substantially rectangular cross-section along female element 232 (i.e., female inner surface 230 has four second inner corners 234 along female element 232, each female inner corner 234 being defined at the junction of a female side wall 222 and a female end wall 224).

[0014] In the exemplary embodiment, male outer surface 216 of male element 218 is sized and shaped to be received within female inner surface 230 of female element 232, such that male outer surface 216 interfaces with female inner surface 230 adjacent female end surface 228. Moreover, male element 218 is receivable within female element 232 such that first fastener apertures 212 are aligned with second fastener apertures 226. In some embodiments, male outer surface 216 and female inner surface 230 are dimensioned to yield an interference fit. In other embodiments, male outer surface 216 and female inner surface 230 are dimensioned to yield a clearance fit.

[0015] Although surfaces 216 and 230 of male and female elements 218 and 232, respectively, have cross-sections that are substantially rectangular and of substantially interfacing peripheries in the exemplary embodiment, in alternative embodiments, surfaces 216 and 230 have any suitable cross-sections that enable connector 206 to function as described herein. For example, at least one of surfaces 216 and 230 has a substantially circular cross-section. For another example, surfaces 216 and 230 have cross-sections that include other than substantially interfacing peripheries.

[0016] In the exemplary embodiment, at least one of male element 218 and female element 232 are formed using a swaging process. For example, male and/or female elements 218 and 232 are swaged using at least one of a cold-worked swaging process and a hot-working process. In one embodiment, male element 218 and/or female element 232 are formed via a tube swaging process. In another embodiment, male element 218 and female element 232 are formed using a rotary swagger. In some embodiments, male element 218 and/or female element 232 are swaged about an internal mandrel. In one embodiment, a mandrel with a selected surface finish is used to form female inner surface 230 and/or male outer surface 216 so that a coefficient of friction between female element 232 and male element 218 is increased when the elements are joined. In other embodiments, male element 218 and female element 232 are formed using any suitable swaging process that enables connector 206 to function as described herein.

[0017] In some embodiments, at least one of male element 218 and female element 232 are integrally formed with thickened walls relative to a main body of the respective column segment 202 and 204, for example to facilitate resistance to cracking at the bolt hole locations. In some such embodiments, at least one of male and female

elements 218 and 232 are formed in a swaging process that results in a thickened element wall section relative to other portions of the respective column segments 202 and 204. Additionally or alternatively, at least one of male and female elements 218 and 232 are formed in any suitable process that results in a thickened element wall section. In an embodiment, the wall thickness of each of the male and female elements is increased in an amount that does not exceed twice a thickness of the parent wall thickness.

[0018] In the exemplary embodiment, male and female elements 218 and 232 are of substantially the same wall thickness. In other suitable embodiments, male and female elements 218 and 232 have any suitable wall thickness that enables connector 206 to function as described herein.

[0019] In the exemplary embodiment, female element 232 has an external cross-section that is substantially identical to an external cross-section of a main body of first column segment 202 (i.e., the portion of first column segment 202 below male element 218, with respect to the orientation shown in Figure 2), such that after male element 218 is received within female element 232 to at least partially couple connector 206, the resulting joined column 200 has a substantially uniform outer cross-section. In alternative embodiments, the external cross-section of female element 232 has any suitable size relative to the external cross-section of the portion of first column segment 202 below male element 218.

[0020] In the exemplary embodiment, male element 218 and female element 232 of connector 206 are substantially the same length. In other suitable embodiments, male element 218 and female element 232 have any suitable length that facilitates their use as described herein.

[0021] Figure 3 is a perspective view of column 200 after assembly. In the exemplary embodiment, after male element 218 is received within female element 232, a plurality of fasteners 316 (e.g., bolts) is inserted through aligned pairs of first and second fastener apertures 212 and 226 to securely couple male element 218 to female element 232. In other embodiments, male element 218 and female element 232 are securely coupled in any suitable fashion that enables column 200 to function as described herein.

[0022] To assemble column 200 onsite when erecting frame 102, first column segment 202 is coupled to a suitable base structure (e.g., foundation 122 or another support member of frame 102). Second column segment 204 is then lowered into position to form connector 206 using crane 124 such that male element 218 is inserted into female element 232 such that female element 232 of second column segment 204 is seated on top male element 218 of first column segment 202. More specifically, male element 218 is inserted into second column segment 204 such that each male side wall 208 is oriented substantially parallel with a female side wall 222 of second column segment 204 in spaced relation thereto, and such that each male end wall 210 of first column segment 202 is oriented substantially parallel with a female end wall 224 of second column segment 204 in spaced relation thereto. Thus, each first fastener aperture 212 of its associated male side wall 208, and each first fastener aperture 212 of its associated male end wall 210, is aligned with the second fastener aperture 226 of its associated female side wall 222 and the second fastener aperture 226 of its associated female end wall 224, respectively.

[0023] With second column segment 204 seated on first column segment 202 the plurality of fasteners 316 (e.g., bolts such as, for example, blind bolts) are then inserted into female fastener apertures 226 of female element 232 to engage male element 218 via male fastener apertures 212. Upon tightening fasteners 316, male element 218 is prevented from moving relative to female element 232, and axial movement of first column segment 202 relative to second column segment 204 is also prevented. In some embodiments, no welding is required to complete the secure coupling of column 200 at connector 206.

[0024] The methods and systems described herein facilitate erecting a moment-resisting frame at a building site. More specifically, the methods and systems facilitate coupling HSS column segments together onsite using a connector with a swaged interface that is integral to the HSS column segments. The methods and systems thereby facilitate eliminating the time that would otherwise be required to weld column segments to one another and/or to the connector. As such, the methods and systems facilitate transporting longer columns to a building site in segments and assembling the columns at the building site by coupling the associated column segments together using a moment-resisting connector that is strictly mechanical in nature. As such, the methods and systems

facilitate reducing the time and cost associated with erecting a multistory, moment-resisting frame at a building site.

[0025] Exemplary embodiments of connectors and methods of assembling the same are described above in detail. The methods and systems described herein are not limited to the specific embodiments described herein, but rather, components of the methods and systems may be utilized independently and separately from other components described herein. For example, the methods and systems described herein may have other applications not limited to practice with frames of buildings, as described herein. Rather, the methods and systems described herein can be implemented and utilized in connection with various other industries.

[0026] While the invention has been described in terms of various specific embodiments, those skilled in the art will recognize that the invention can be practiced with modification within the spirit and scope of the claims.

WHAT IS CLAIMED IS:

1. A connector for a structural column, said connector comprising:

a male element of a first column segment, said male element comprising a male outer surface and a plurality of first fastener apertures;

a female element of a second column segment, said female element comprising a female inner surface and a plurality of second fastener apertures, at least one of said female element and said male element being swaged such that said female inner surface of said female element is sized to receive said male outer surface of said male element such that each of said first fastener apertures aligns with a corresponding one of said second fastener apertures; and

a plurality of fasteners configured to be received in said aligned pairs of first and second fastener apertures.

2. The connector in accordance with Claim 1, wherein said connector is a moment-resisting connector.

3. The connector in accordance with Claim 1, wherein said male element and said female element are substantially rectangular in cross-section.

4. The connector in accordance with Claim 1, wherein said male element and said female element are substantially circular in cross-section.

5. The connector in accordance with Claim 1, wherein said male element and said female element are dimensioned to yield a clearance fit.

6. The connector in accordance with Claim 1, wherein said at least one of said male element and said female element is integrally formed with thickened walls relative to a main body of the respective first and second column segment.

7. A method of assembling a column for a frame of a building, said method comprising:

positioning a second column segment with respect to a first column segment, wherein the first column segment includes a male element including a male outer

surface and a plurality of first fastener apertures, wherein the second column segment includes a female inner surface and a plurality of second fastener apertures, and wherein at least one of the female element and the male element is swaged such that the female inner surface of the female element receives the male outer surface of the male element such that each of the first fastener apertures aligns with a corresponding one of the second fastener apertures; and

coupling the second column segment to the first column segment via a plurality of fasteners received in the aligned pairs of first and second fastener apertures to form the assembled column.

8. The method in accordance with Claim 7, wherein coupling the second column segment to the first column segment via the plurality of fasteners comprises forming a moment-resisting connector.

9. The method in accordance with Claim 7, wherein positioning the second column segment with respect to the first column segment comprises positioning the male element and the female element that are each substantially rectangular in cross-section.

10. The method in accordance with Claim 7, wherein positioning the second column segment with respect to the first column segment comprises positioning the male element and the female element that are each substantially circular in cross-section.

11. The method in accordance with Claim 7, wherein positioning the second column segment with respect to the first column segment comprises receiving the male element within the female element in a clearance fit.

12. The method in accordance with Claim 7, wherein positioning the second column segment with respect to the first column segment comprises positioning the at least one of the male element and the female element having integrally formed thickened walls relative to a main body of the respective first and second column segment.

13. A column for a moment-resisting frame, said column comprising:

a first hollow structural section (HSS) column segment;

a second HSS column segment; and

a connector comprising:

an integrally formed male element of said first HSS column segment, said male element comprising a male outer surface and a plurality of first fastener apertures;

an integrally formed female element of said second HSS column segment, said female element comprising a female inner surface and a plurality of second fastener apertures, at least one of said female element and said male element being swaged such that said female inner surface of said female element receives said male outer surface of said male element such that each of said first fastener apertures is aligned with a corresponding one of said second fastener apertures; and

a plurality of fasteners received in said aligned pairs of first and second fastener apertures.

14. The column in accordance with Claim 13, wherein said connector is a moment-resisting connector.

15. The column in accordance with Claim 13, wherein said male element and said female element are substantially rectangular in cross-section.

16. The column in accordance with Claim 13, wherein said male element and said female element are substantially circular in cross-section.

17. The column in accordance with Claim 13, wherein said male element and said female element are dimensioned to yield a clearance fit.

18. The column in accordance with Claim 13, wherein said at least one of said male element and said female element is integrally formed with thickened walls relative to a main body of the respective said first and second HSS column segment.

19. The column in accordance with Claim 13, wherein said female element has an external cross-section that is substantially identical to an external cross-section of a main body of said first HSS column segment.

20. The column in accordance with Claim 13, wherein said first HSS column segment and said second HSS column segment are coupled at said connector without welding.

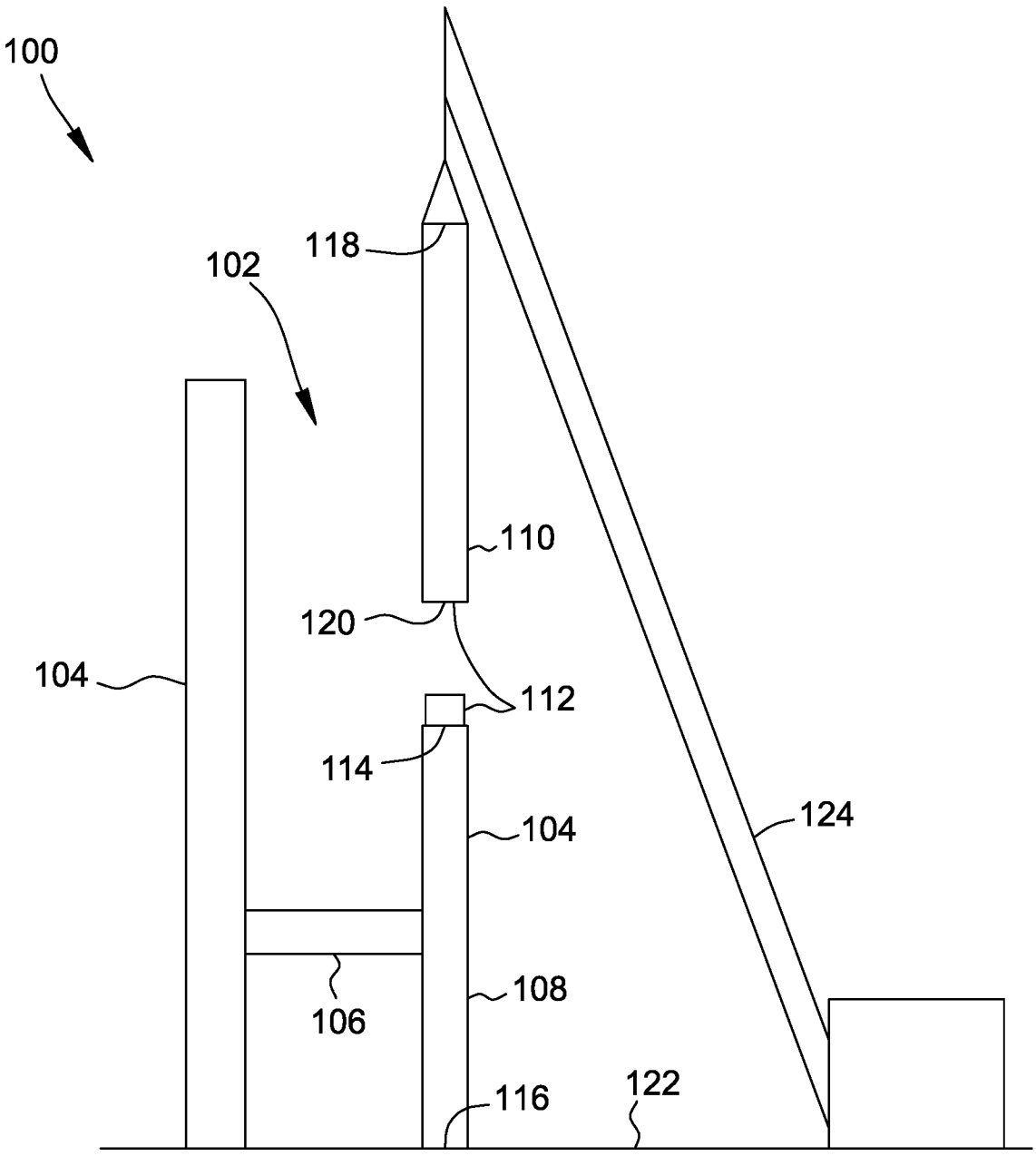

FIG. 1

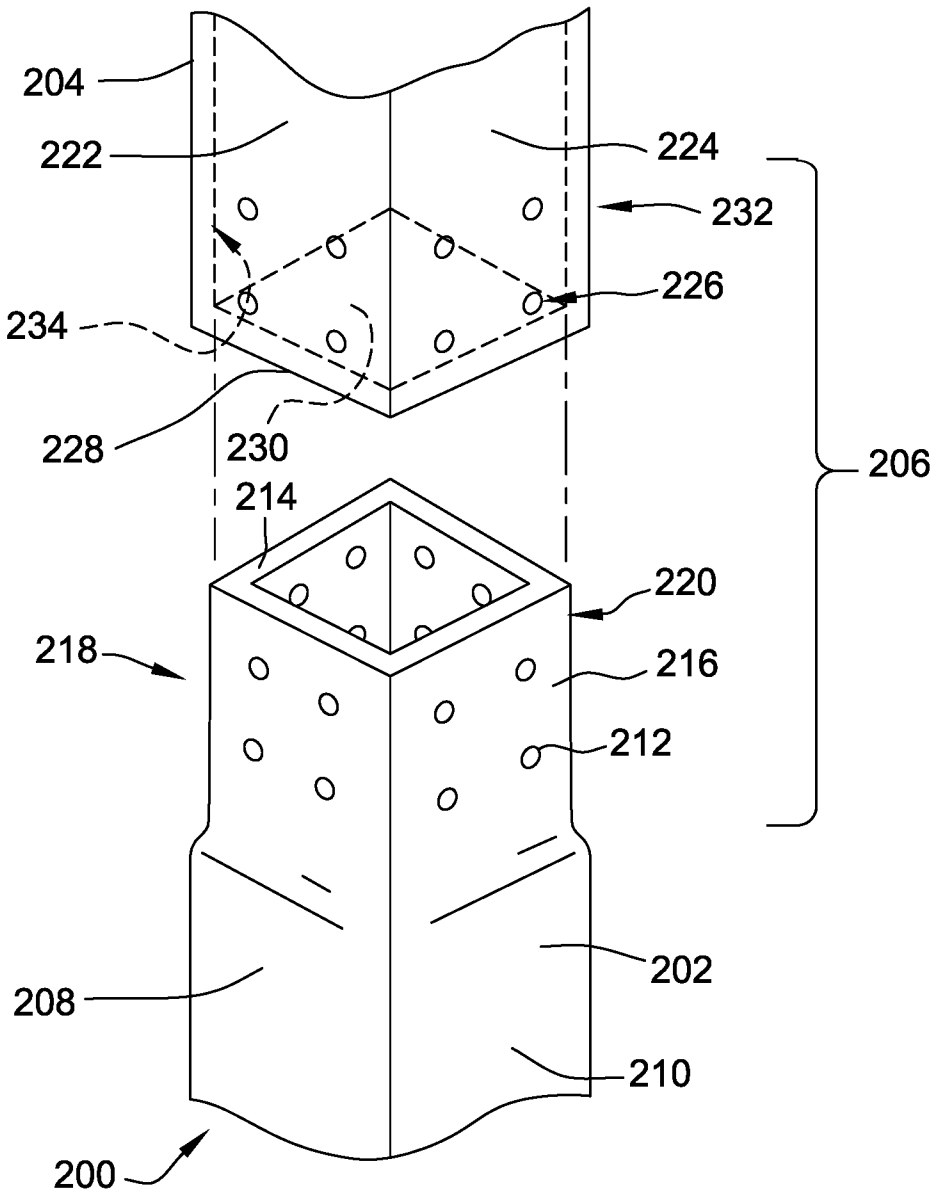
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FIG. 2

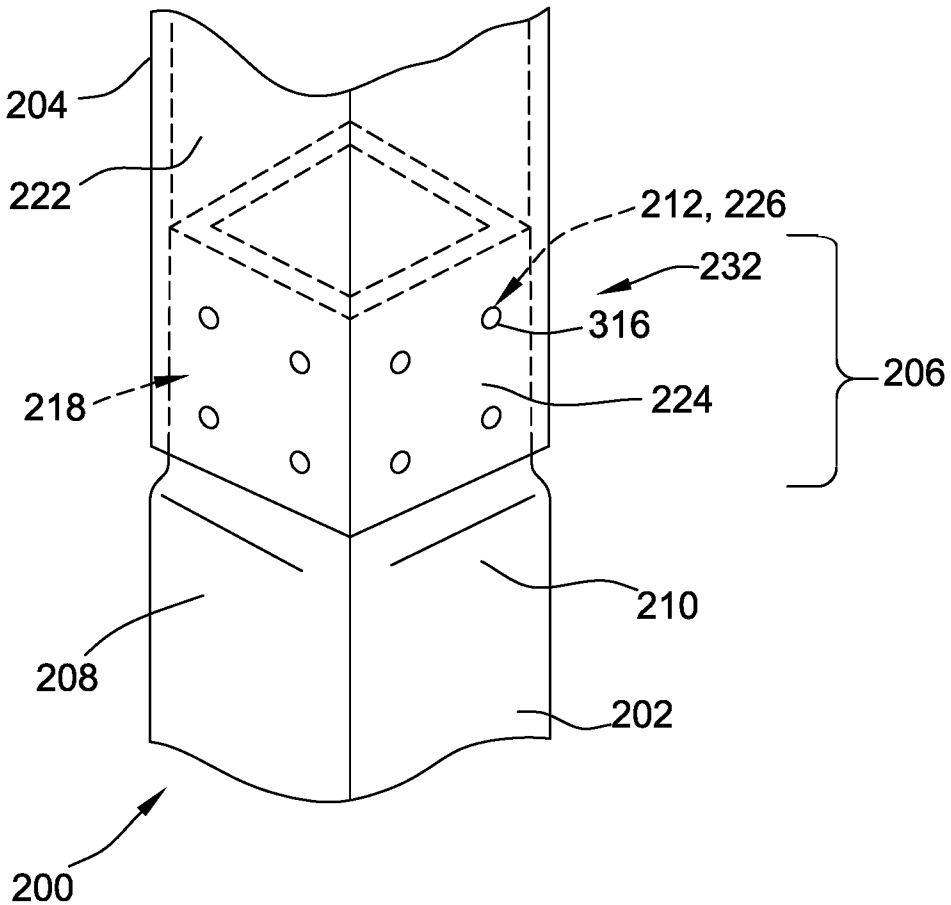

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US17/47337

A. CLASSIFICATION OF SUBJECT MATTER
IPC - E04B1/24, E04C3/02, 3/04, 3/30, 3/32, 3/36, F16B7/18 (2017.01)
CPC - E04B1/185, E04B1/2403, E04B1/5831, E04B1/585, E04C3/005, F24J2/5258, F24J2/5205, F24J2/5233, F24J2/5239, F24J2/5249, F24J2/525

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
See Search History document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2003/0177735 A1 (SEEBA, G et al.) 25 September 2003, Fig. 1, 6, 7, para. [0034]-[0042], [0048], [0049]	1-20
A	JPH-0978692 A (US KOGYO KK) 25 March 1997, entire document	1-20
A	US 2007/0209314 A1 (VAUGHN, W) 13 September 2007, entire document	1-20
A	US 2007/0261356 A1 (VAUGHN, W) 15 November 2007, entire document	1-20
A	US 2013/0239516 A1 (WILLIAM B. VAUGHN) 19 September 2013, entire document	1-20

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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Date of the actual completion of the international search	Date of mailing of the international search report
05 October 2017 (05.10.2017)	27 OCT 2017
Name and mailing address of the ISA/ Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Shane Thomas PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

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