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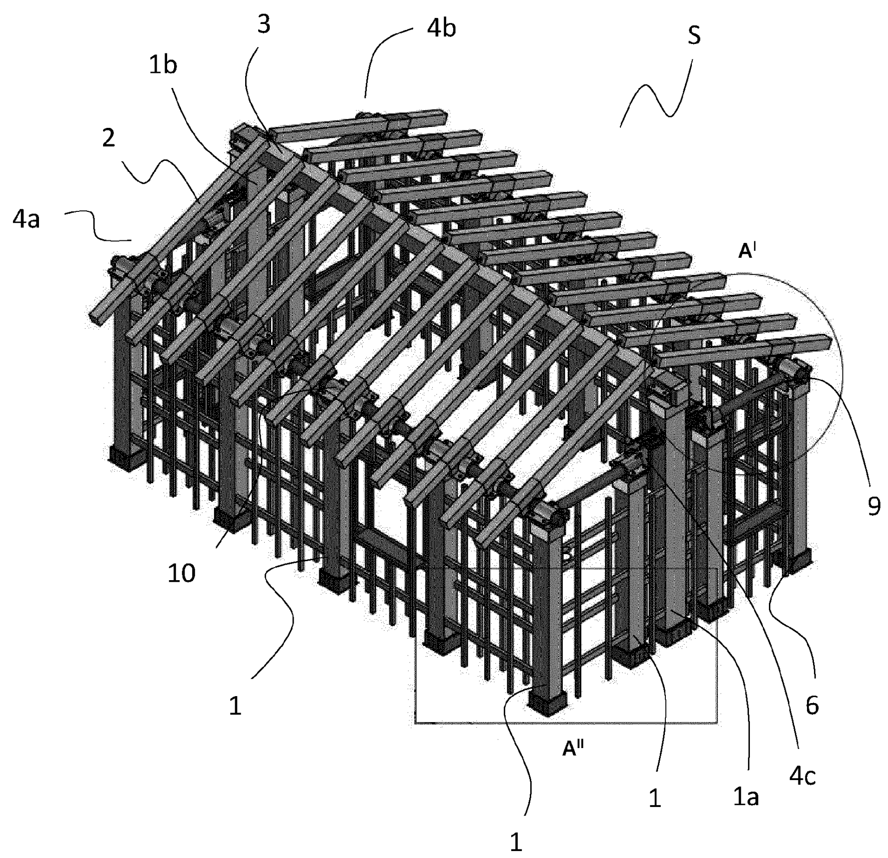
(54) **MODULAR STRUCTURE FOR HOUSES**

(57) Modular structure for houses, with wooden load-bearing elements and shock-absorbing structures, with the function of lowering the risk of collapse of the structure itself if subject to an earthquake.

FIG. 1



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Description

TECHNICAL FIELD

[0001] The present invention refers to the building sector, more particularly it relates to a structure for houses with wooden load-bearing elements and shock-absorbing structures which in the event of an earthquake reduce the risk of collapse of the structure itself.

STATE OF THE ART

[0002] It is known that there are wooden structures, used in the building sector, to make the construction, as a whole, more elastic in the event of an earthquake event.

[0003] The design and sizing of these wooden structures take place according to the seismic zone in which they are to be installed.

[0004] Said known wooden structures comprise components which rest on each other or which are connected to each other by means of rigid joint connections joined with screws, such as Parker screws.

[0005] The criticality of having rested components is that these, if subject to an earthquake, can move, therefore losing their placement with the danger that, once the earthquake is over, they will not be able to return to the starting position, thus increasing the risk of collapse of the structure.

[0006] The criticality instead of having wooden structures with elements connected by rigid joints is that the latter must be reviewed individually and constantly to verify their correct functioning, entailing high construction management costs.

PURPOSE AND SYNTHETIC DESCRIPTION OF THE INVENTION

[0007] The purpose of the present invention is to devise a modular structure for houses, with load-bearing elements in wood and shock-absorbing structures, having the function of lowering the risk of collapse of the structure itself if subject to an earthquake. A further purpose of the present invention is to provide the structure with shock-absorbing structures configured to oppose the rigid movements of the structure and oppose the relative displacements of the components of the structure.

[0008] The purposes of the present invention are achieved by means of a modular structure for houses with one or more floors comprising a plurality of wooden pillars defining a load-bearing structure, a plurality of joists configured to define the roof, at least one ridge beam carried by at least a first and a second main pillar, said structure characterized in that between the top of the pillars and the joists there are interposed a third and fourth rigid structure arranged on opposite sides with respect to the first and second main pillar, each of the third and fourth structures being simultaneously connected to the pillars and joists and comprising a plurality of tubulars, preferably metal, e.g. of iron or construction steel, connected to each other and tie rods configured to connect the third and fourth structure by crossing at least one of the first and second main pillars, and a first and a second elastic unit arranged at opposite sides of said at least one of between first and second main pillars are interposed between said at least one between the first and second main pillars and the third and fourth structure for tensioning the tie rods. Said first and second elastic groups have the function of opposing the rigid movement of the third and fourth structure and opposing the relative displacement of the first and second main pillar with respect to the ridge beam, at the same time absorbing the oscillations due to an earthquake through the elastic units.

[0009] In fact, a structure made in this way by means of the third and fourth rigid structures, the first and second elastic units and the tie rods is able to move in the plane without breaking, absorbing and counteracting a seismic shock at the same time. Furthermore, the weight of the structure and the roof is carried on the third and fourth rigid structure and the ridge beam with the relative pillars have a degree of freedom in the direction of the joists. The latter are locked to the third and fourth structure.

[0010] According to an embodiment, each pillar is inserted in a shock-absorbing structure comprising a "cup" structure configured to be anchored to the foundation and a perforated cerclage contacting the base of the pillar itself. A series of elastic springs is interposed between the cup structure and the cerclage. The base of the pillars by means of the elastic springs is able to move dissipating part of the seismic force at the base, dampening the development of the same in elevation on the floors.

[0011] According to an embodiment, the joists, respectively on the right and on the left with respect to the ridge beam, are connected by means of elastic springs. The springs allow the joists to be held together so that they do not move out of phase with respect to each other. The springs oppose a displacement of the heads of the joists along the ridge of the roof in the event of a seismic event.

[0012] According to one embodiment, the joists are inserted slidingly inside box-shaped sleeves connected to the tubulars by means of the rotational joints. In this way, in the event of a seismic event, the joists are simply placed on the ridge beam and are able to move smoothly inside the sleeves without breaking. According to a preferred embodiment, the tie rods are inserted inside prestressed springs that extend from the main pillars and up to contact L-shaped perforated plates, said springs being tightened to the plates by means of nuts. The prestress given to the springs is such that they can stretch out in the event of a seismic event, making sure that the main pillars remain centered.

[0013] According to an embodiment, the tubulars of the third and rigid structure are connected to each other by means of rotational joints placed in correspondence with each joist and each pillar. The tubulars, being simply resting on the ridge beam, in the event of a seismic event, are able to move rotationally within the joint, preventing them from breaking.

[0014] According to one embodiment, the rotational joints are only rigidly connected to the top of the pillars by means of a lockable taper. The tapering allows a rigid connection with the head of the pillar, implying that the joist can have greater freedom of movement only in correspondence with the ridge of the roof of the structure.

[0015] According to an embodiment, a rubber layer is interposed between the cup structure and the foundation and between the rotational joint and the metal tube. The rubber layer has the function of keeping the elastic springs in position as a structural deformation would lead to a movement of the screws inside the seats causing their deformation. According to an embodiment, the third and fourth rigid structures, the cup structure and the cerclage constitute a flexible metal cage for the modular structure. Said cage is capable of oscillating the structure as a whole in a uniform manner.

[0016] According to an embodiment, the walls of said structure are made with a mixture comprising natural hydraulic lime NHL, perlite, sand and polymer flakes. This mixture allows to obtain an extremely light, flexible and highly insulating wall.

BRIEF DESCRIPTION OF THE FIGURES

[0017] The present invention, together with its purposes and advantages, will be most evident from the following detailed description of preferred forms of embodiment, given by way of illustration and example, but not limitation, with reference to the attached drawing plates, also given by way of example only, in which:

- **FIG. 1:** is an axonometric view of a structural diagram of a modular structure for houses according to the present invention;
- **FIG. 2:** is an axonometric view of the detail A^{I} of FIG. 1;
- **FIG. 3:** is an axonometric view of detail A^{II} of FIG. 1;
- **FIG. 4:** is a front view of the structural diagram of FIG.1;
- **FIG. 5:** is an axonometric view of the first floor of a structural diagram of a modular structure for two-storey houses;
- **FIG. 6:** is an axonometric view of detail A^{III} of FIG. 5;
- **FIG. 7:** is an axonometric view of a structural diagram of a modular structure for two-storey houses;
- **FIG. 8:** is an axonometric view of the detail A^{IV} of FIG. 7;
- **FIG. 9:** is an axonometric view of the detail A^{V} of FIG. 7;
- **FIG. 10:** is an axonometric view of the particular A^{VI} of FIG. 7.

DETAILED DESCRIPTION OF THE INVENTION

[0018] As can be seen in Fig. 1, the structure S comprises a plurality of pillars 1 defining the load bearing structure, a ridge beam 3 carried by at least a first 1a and a second main pillar 1b, a plurality of joists 2 resting on one side on the ridge beam 3 and on the other on a third 4a and fourth rigid structure 4b arranged on opposite sides with respect to the ridge beam 3.

[0019] On opposite sides of said first 1a and second main pillar 1b and interposed between the first 1a and the second main pillar 1b and the third 4a and the fourth 4b structure for tensioning the tie rods, a first 4a' and a second 4b' elastic unit are arranged comprising a series of elastic springs 11.

[0020] The load-bearing structure comprising the plurality of wooden pillars 1 confers stability to the structure over the entire perimeter. Each of said pillars 1 at the base is inserted in a shock-absorbing structure comprising a "cup"-shaped structure 5 made of metal material intended to be anchored to the foundation and a metallic and perforated cerclage 6 contacting the base of the pillar 1 itself.

[0021] Said metal cerclage 6 is contained within said cup-shaped structure 5 and between the two there is a free space. In the holes of the cerclage 6 elastic springs are screwed which extend perpendicularly between the wood of the pillar 1 until they contact the cup-shaped structure 5, in this way the elastic springs occupy the free space described above. A rubber layer 7 with a thickness of at least 1 cm is interposed between the first metal structure 5 and the reinforced concrete of the foundation. This layer is configured to cushion the displacement movement due to a seismic shock, allowing a torsional deformation of the structure during the shock and, at least theoretically, a return to its normal position after the shock. Also the elastic spring, in analogy with the function of the rubber layer, is able to cushion and counteract the displacement movement of the structure, bringing it back, at least theoretically, to its normal position when the shock is over. More generally, the elastic elements accumulate a part of the kinetic energy of the structure during an earthquake and oppose excessive movements of the structure.

[0022] The rubber layer 7 also allows the elastic springs to be kept, simultaneously inserted in the wood of the pillar 1 and in the metal of the first cup-shaped structure 5, in the original assembly position. In fact, the rubber layer 7 plays an important role during the seismic shock since, if it were not there, the structural flexural deformation would entail a movement of the screws inside the seats causing their deformation without the ability to return to their initial shape.

[0023] Also in Fig. 1 it is visible that the pillars 1, at their top, are held together by means of a third 4a and fourth structure 4b, both comprising at least one tubular element 9. Said tubular elements 9 are preferably made of metallic material and are connected to the pillar by means of a taper 13 which is welded to the top of the pillar 1 to increase sealing safety. The number of metal tubulars 9 in both directions in plan will correspond to the center distances between the pillars 1. In the specific case of Fig. 1 in the direction parallel to the ridge beam 3, the pillars 1 are five and therefore the metal tubulars 9 are four, while in the direction perpendicular to the ridge beam 3, not considering the first 1a and the second 1b main pillar, the center distances between the pillars 1 are two and therefore there are also two metal tubular 9, the latter two metal tubular 9 being perpendicular to the first four. Furthermore, considering that the structure is symmetrical with respect to an axis passing through the ridge beam 3, the third structure 4a as well as the fourth structure 4b, with respect to this axis, assumes a "C" shape.

[0024] Each metal tubular 9 in correspondence of each joist 2 and of each pillar 1 is closed inside a rotational joint 10 provided with a first 10a and a second part 10a' symmetrical and bolted together and with a rubber damping layer 7 between the joint 10 itself and the metal tubular 9. The metal rotational joints, in the direction perpendicular to the ridge beam 3, are welded with a perforated L-shaped plate 4c in turn rigidly connected on the head of the pillars 1 respectively right and left to the pillars main 1a and 1b. On the L-shaped plate 4c there are screwed overhangs tie rods 4d which cross the main pillars 1a and 1b to end in a second perforated L-shaped plate 4c. In the direction perpendicular to the ridge beam 3 and protruding in the right and left portion of the main pillars 1a and 1b there are prestressed springs 11, one for each tie rod 4d, which are tightened on the L-shaped plate by means of nuts 12. In particular, each tie rod comprises at least one threaded end portion and a corresponding nut is screwed onto this threaded portion by applying a preload to the springs 11. The tie rods 4d and the prestressed springs 11 have the function in the structure of absorbing the relative displacements between the main pillars 1a and 1b and the rigid structures 4a, 4b, trying to keep them centered in their position and opposing excessive movements.

[0025] The ridge beam 3, in the direction in which the roof joists 2 extend and in correspondence with each joist 2, is equipped with elastic springs 8 which, along a longitudinal direction of the joists, are screwed onto them (figure 8). In the event of a shock, the joists 2 could move and contact the elastic springs 8 of the ridge beam 3, the springs 8 being able to oppose the bending movement due to the seismic event. According to the illustrated embodiment, abutment elements are present on the ridge beam, e.g. L-shaped brackets 15 to define a constraint on the displacement of the heads of the joists 2 along the ridge beam.

[0026] The ridge beam 3 is directly connected only with the main pillars 1a and 1b while it is disconnected with the joists 2. Therefore, the ridge beam 3 is partially disconnected from the rest of the structure.

[0027] The structure as a whole responds to the earthquake following the same movement but in different conditions. Since the ridge beam 3 is partially disconnected from the rest of the structure, it implies that its center of gravity will have less stresses and more dampened and lighter than the center of gravity of the structure of the pillars 1 connected by means of the tubulars 9.

[0028] The joists 2 that form the roof frame "rest" on the ridge beam 3 and are not fixed with screws or other fastening systems but are only supported and therefore free to flex or move within certain limits. As can be seen in the detail of FIG. 8, the absorption of energy due to a seismic shock is guaranteed by the union of the joists 2, on the right and on the left with respect to the ridge beam 3, by means of the elastic spring 8 which allows the bending of the 2 joists without breaks.

[0029] The walls that are delineated in the center distance between the pillars 1 are also load-bearing as being the pillars 1 connected to each other at the top by means of the third 4a and fourth structure 4b, the walls will also be connected to each other. Furthermore, since the pillars 1 are inserted in the cup-shaped structure 5 and in the cerclage 6, this entails the delineation of a structural iron cage. Thanks to the rubber layers, this cage is fully flexible, allowing a minimum of oscillation in the event of a seismic event, dissipating a portion of energy due to the shock.

[0030] This cage allows the structure to rest on an extremely resistant but flexible structure in the event of an earthquake.

[0031] The internal and external walls will be built with mineralized wood panels of the "CELENIT" type. These panels will preferably have a size of approximately 200 cm in length, 60 cm in height and 30 cm in depth. Said panels are fixed, e.g. screwed, to the pillars 1 which have surface recesses to allow the passage of corrugated pipes and piping. In addition, rigid rubber inserts are provided between the panel and the pillar to allow the insertion of the conglomerate on all 4 sides of the supporting pillars. In this way the conglomerate encapsulates and protects the wood, as thanks to the absence of oxygen and humidity, the wood will not be able to undergo rotting phenomena. To further avoid these phenomena of the wood, vapor barrier sheets can be inserted between the external formwork of the external wall and the conglomerate to prevent moisture from coming into contact with the conglomerate.

[0032] The panels then form a fixed formwork where inside will be first run the corrugated pipes and piping for the "electrical/water" systems, and later inserted a mixture consisting of: natural hydraulic lime NHL, perlite, sand and polymer flakes.

[0033] This mixture is then combined with water thus forming a semi-aqueous mixture to be inserted inside the walls thus forming a real insulating wall that is extremely light, flexible and highly insulating.

[0034] The water in the mixture evaporates in about 48 hours and the conglomerate is compacted becoming dry. Then the walls are completely closed. The finished outer wall will have a thickness of about 43 CM.

[0035] The internal walls will have a thickness of about 20 CM. The thermal and acoustic characteristics of the walls described here exceed the required standards, with a thermal displacement of about 20 hours and an acoustic that manages to reduce about 40 decibels between the outside and inside of the house.

[0036] The mixture of the above materials is also included as insulation for the roof and for flat slabs.

[0037] In the detail of FIG. 2 shows in greater detail a portion of the fourth rigid structure 4b comprising a plurality of metal tubulars 9 joined together by joints 10. Each joint 10 is formed by a first part 10a and a second part 10a' having a semicircular shape and joined together them by means of a bolted connection. The joints 10 are also welded to tightenable tapers 13 placed at the top of the pillars 1. The joists 2 are inserted slidingly, during assembly, in box-shaped sleeves 4e connected to the tubulars 9 by means of the joints 10. In the event of a seismic shock, since the joists 2 in correspondence with the ridge beam 3 are connected by means of the spring 8, said spring 8 is able to compress and flex, counteracting the seismic shock, influencing the sliding movement of the joist 2 inside the box-shaped sleeve 4e.

[0038] Figure 4 shows a front view of the structural diagram of a modular structure for houses according to the present invention.

[0039] In greater detail in FIG. 7 it is visible that the joints 4b are placed in correspondence with each joist 2 and each pillar 1.

[0040] In FIGS. 5 and 6 is shown the first floor of a modular structure for two-storey houses and a detail of the latter, in which the warping of the joists 2 that will form the floor slab is visible.

[0041] FIG. 7 shows a two-storey modular structure according to the present invention while in Figures 8 and 9 the details A^{IV} and A^{V} of FIG. 7.

[0042] From the above description the person skilled in the art is able to realize the object of the present invention without introducing further construction details.

Claims

1. Modular structure for houses (S) with at least one floor comprising a plurality of wooden pillars (1) defining a load-bearing structure, a plurality of joists (2) configured to define the roof, at least one ridge beam (3) carried by at least a first (1a) and a second (1b) main pillar, said structure **characterized in that** between the top of the pillars (1) and the joists (2) are interposed a third (4a) and fourth (4b) rigid structure arranged on opposite sides with respect to the first (1a) and second (1b) main pillar, each of the third (4a) and fourth (4b) structure being simultaneously connected to the pillars (1) and the joists (2) and comprising a plurality of tubular elements (9) rigidly connected to each other and tie rods (4d) configured to connect the third (4a) and fourth (4b) structure disposed through at least one between the first (1a) and the second (1b) main pillar, and a first (4a',11) and a second (4b',11) elastic unit arranged at opposite sides of said at least one between first (1a) and second (1b) main pillar and preloaded between said at least one between the first (1a) and the second (1b) main pillar and the third (4a) and fourth (4b) structure for tensioning the tie rods (4d).

2. Modular structure (S) according to claim 1, **characterized in that** each pillar (1) is inserted in a shock-absorbing structure comprising a cup-shaped structure (5) configured to be anchored to the foundation and a perforated cerclage (6) contacting the base of the pillar (1) and wherein a plurality of elastic springs (8) are transversely interposed between the cup-shaped structure (5) and the cerclage (6).

3. Modular structure according to one of claims 1 or 2, **characterized in that** the tubular elements (9) of the third (4a) and fourth (4b) rigid structure are connected to each other by means of rotational joints (10).

4. Modular structure according to claim 3, **characterized in that** the joists (2) are slidingly inserted inside the box-shaped sleeves (4e) connected to the tubular elements (9) by means of the rotational joints (10).

5. Modular structure according to any one of the preceding claims, **characterized in that** at least one right joist and at least one left joist (2), with respect to the ridge beam (3), are connected by means of elastic springs (8).

6. Modular structure according to claim 1, **characterized in that** L-shaped perforated plates (4c) are provided at the ends of the third and fourth structure (4a, 4b) and arranged on opposite side parts of the main pillar, said elastic units (4a', 4b', 11) being preloaded by means of nuts (12) which can be screwed against respective perforated plates (4c) and coupled to threaded end portions of the tie rods.

7. Modular structure according to claim 1, **characterized in that** the rotational joints are rigidly connected to the top of the pillars by means of a tapered clamp.

8. Modular structure according to the preceding claims **characterized in that** a rubber layer is interposed between the cup-shaped structure (5) and the foundation and between the rotational joint (10) and the metal tubular element (9).

9. Modular structure according to the preceding claims **characterized by** comprising a structural iron cage including the third 4a and fourth structure 4b and the cup-shaped structure 5 and the cerclage 6.

10. Modular structure according to the preceding claims **characterized in that** the walls of said structure are made with a mixture comprising natural hydraulic

lime NHL, perlite, sand and polymer flakes.

FIG. 1

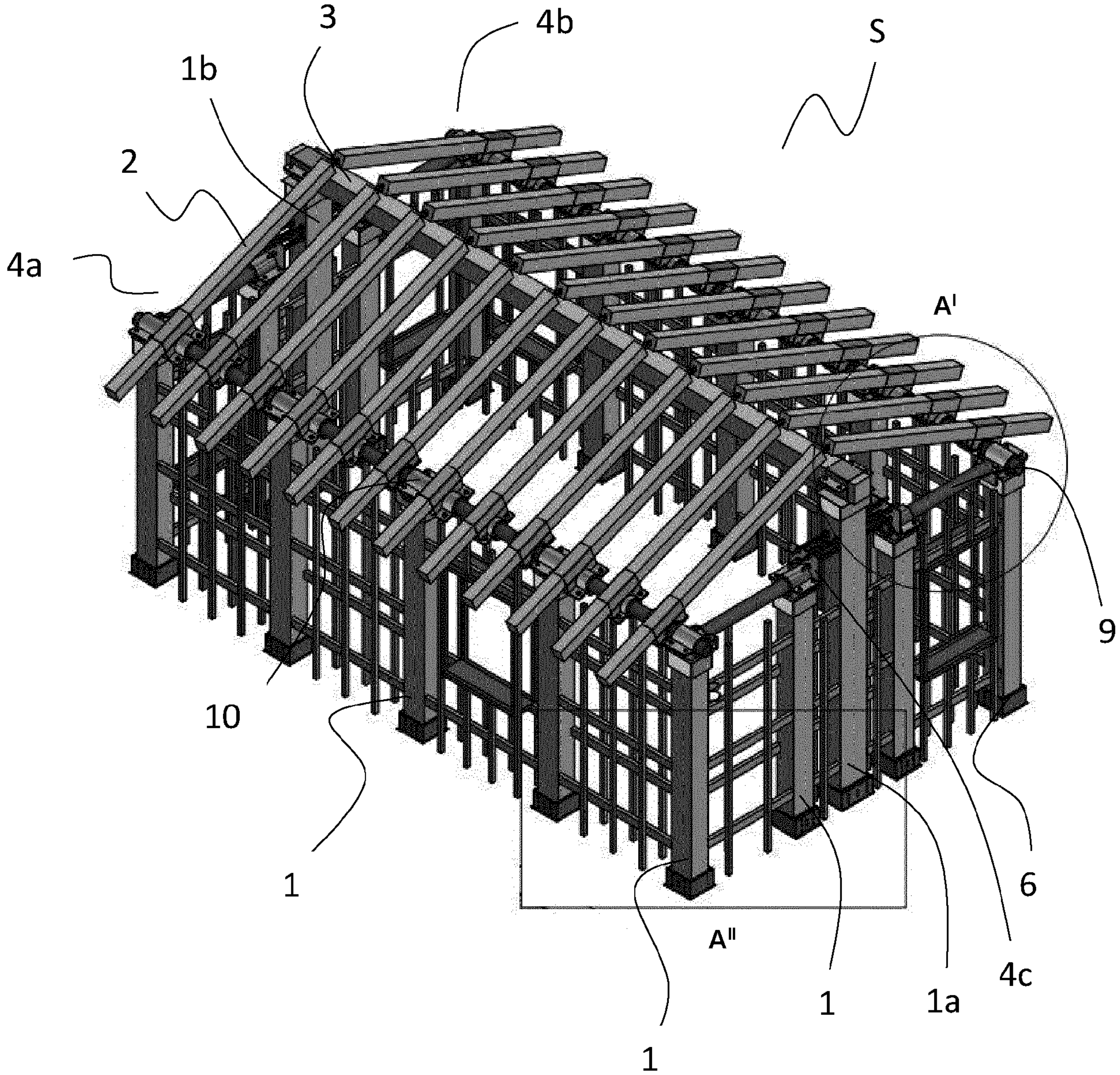


FIG. 2

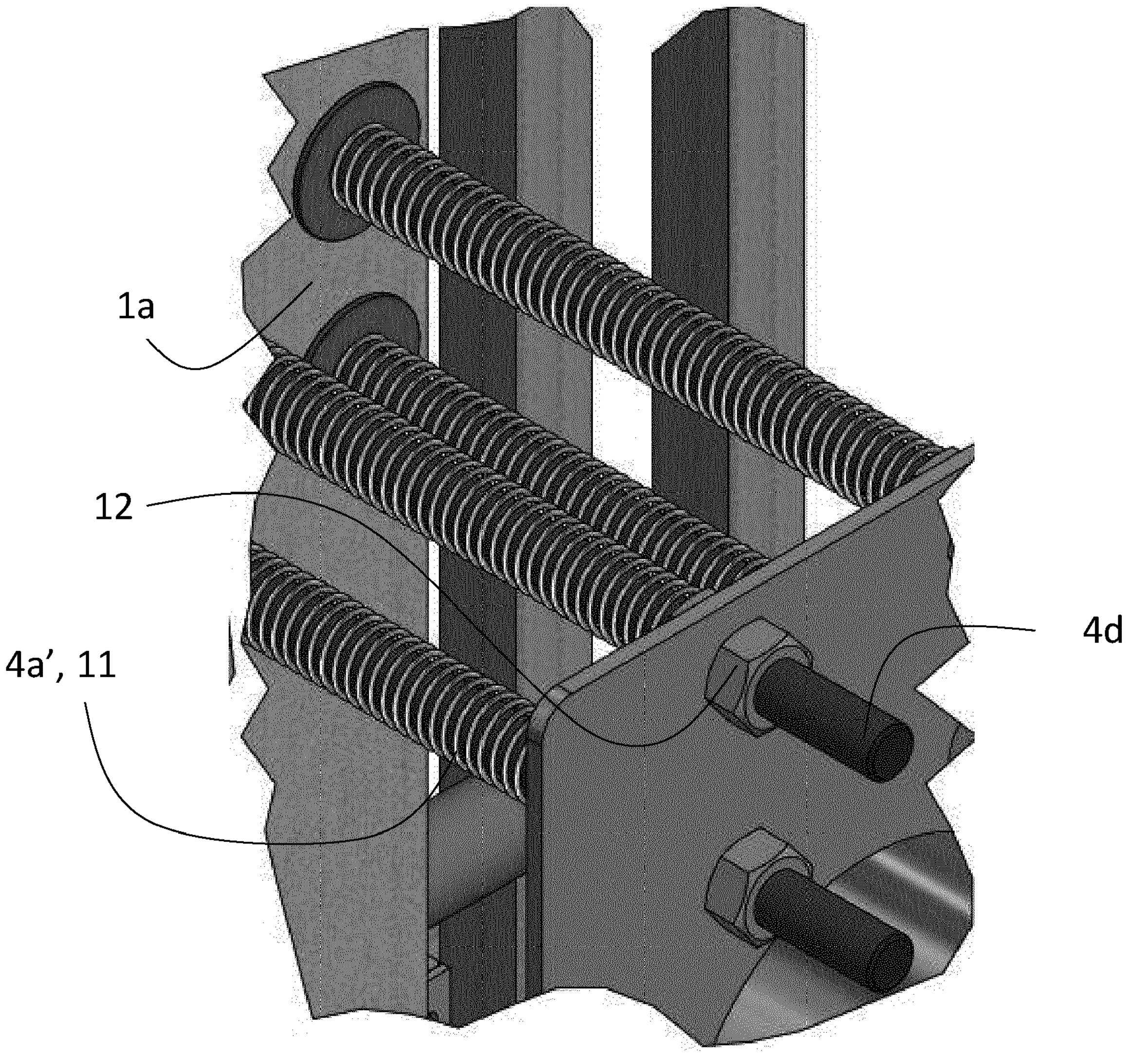


FIG. 3

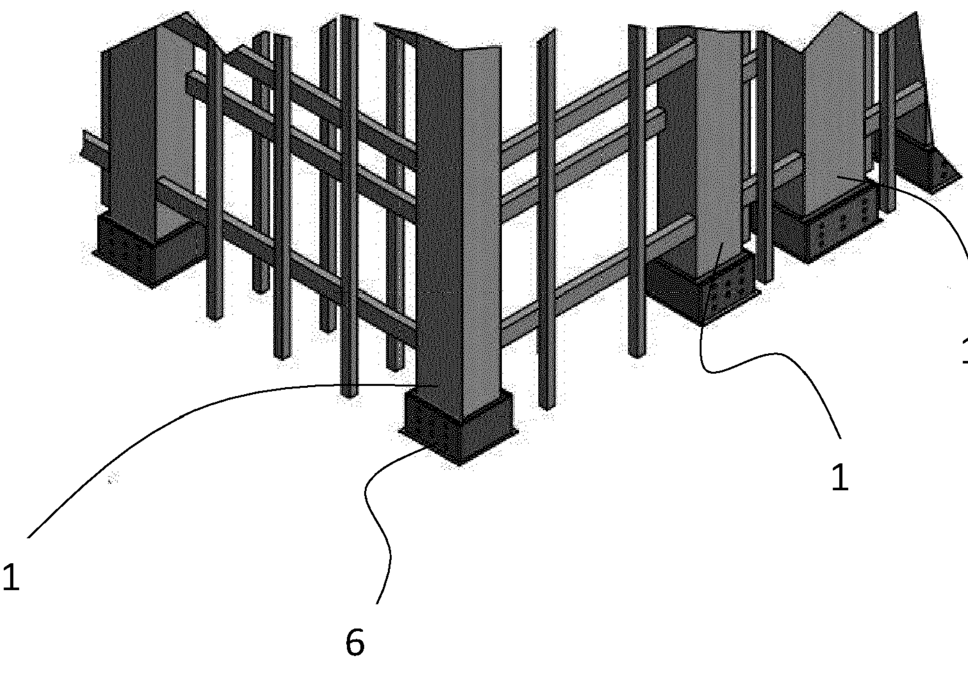


FIG. 4

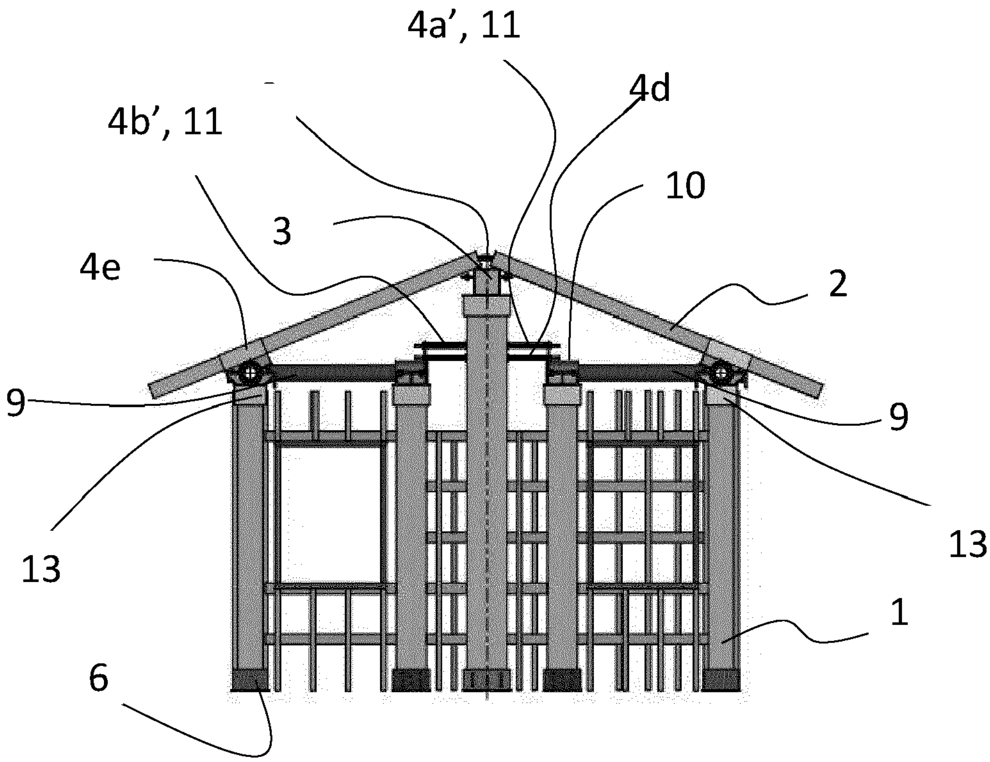


FIG. 5

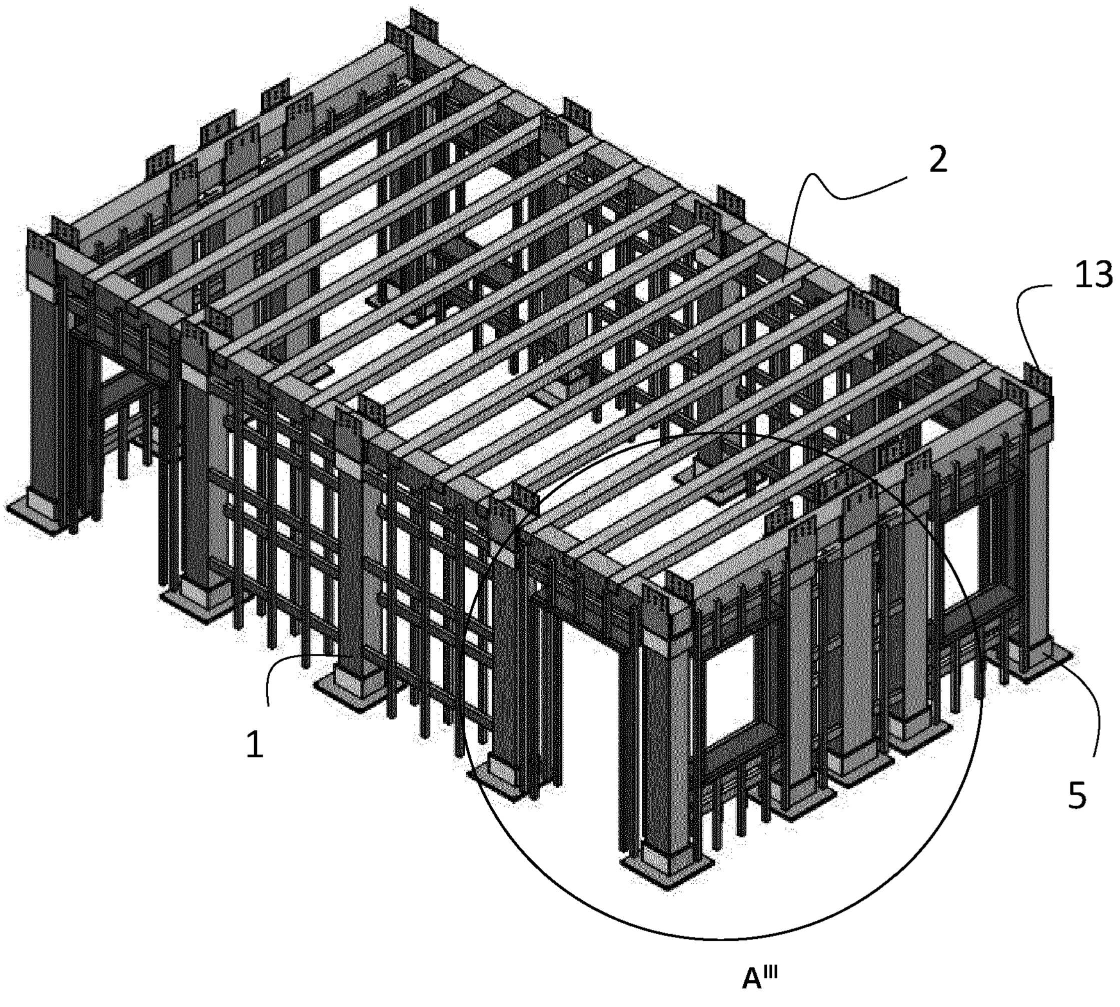


FIG. 6

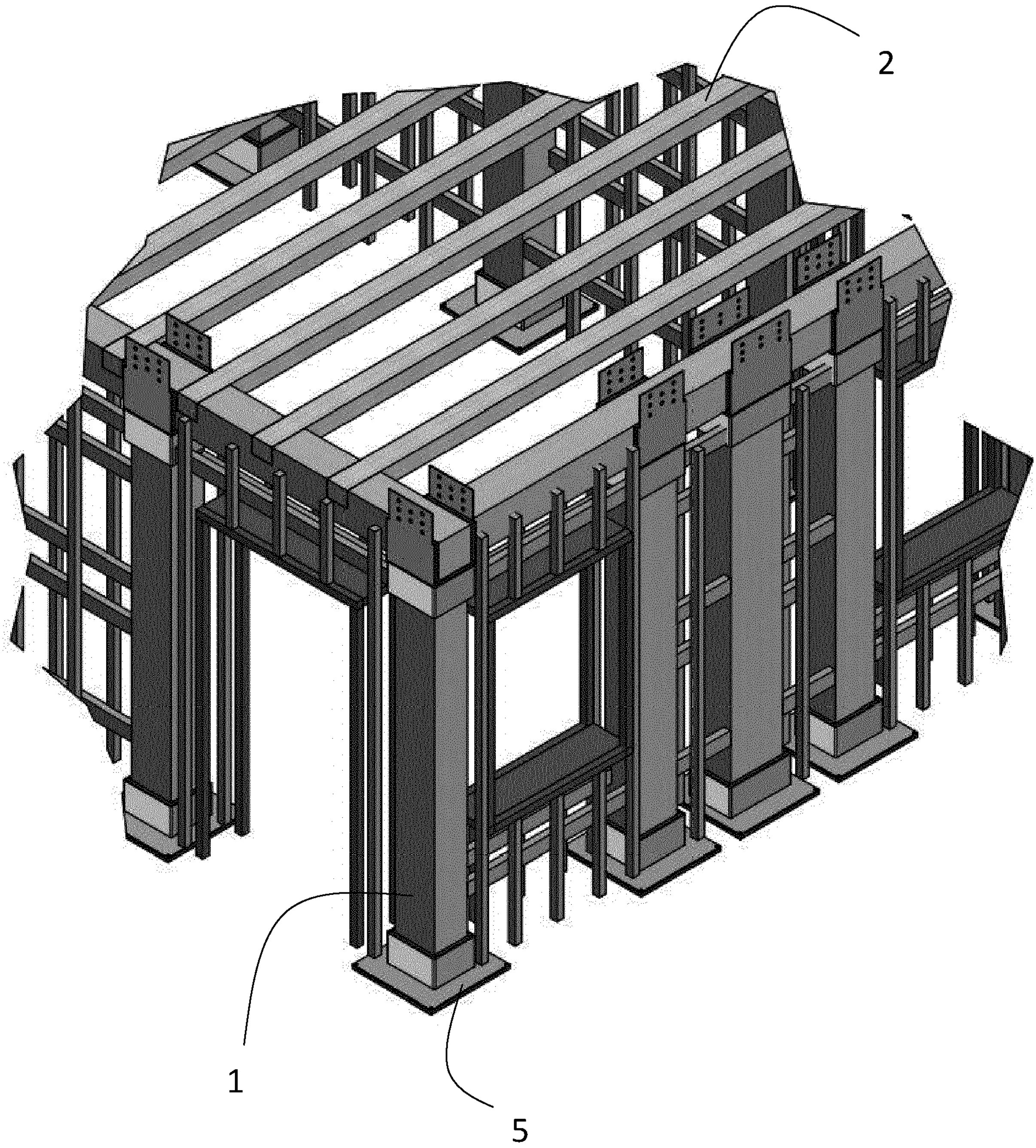


FIG. 7

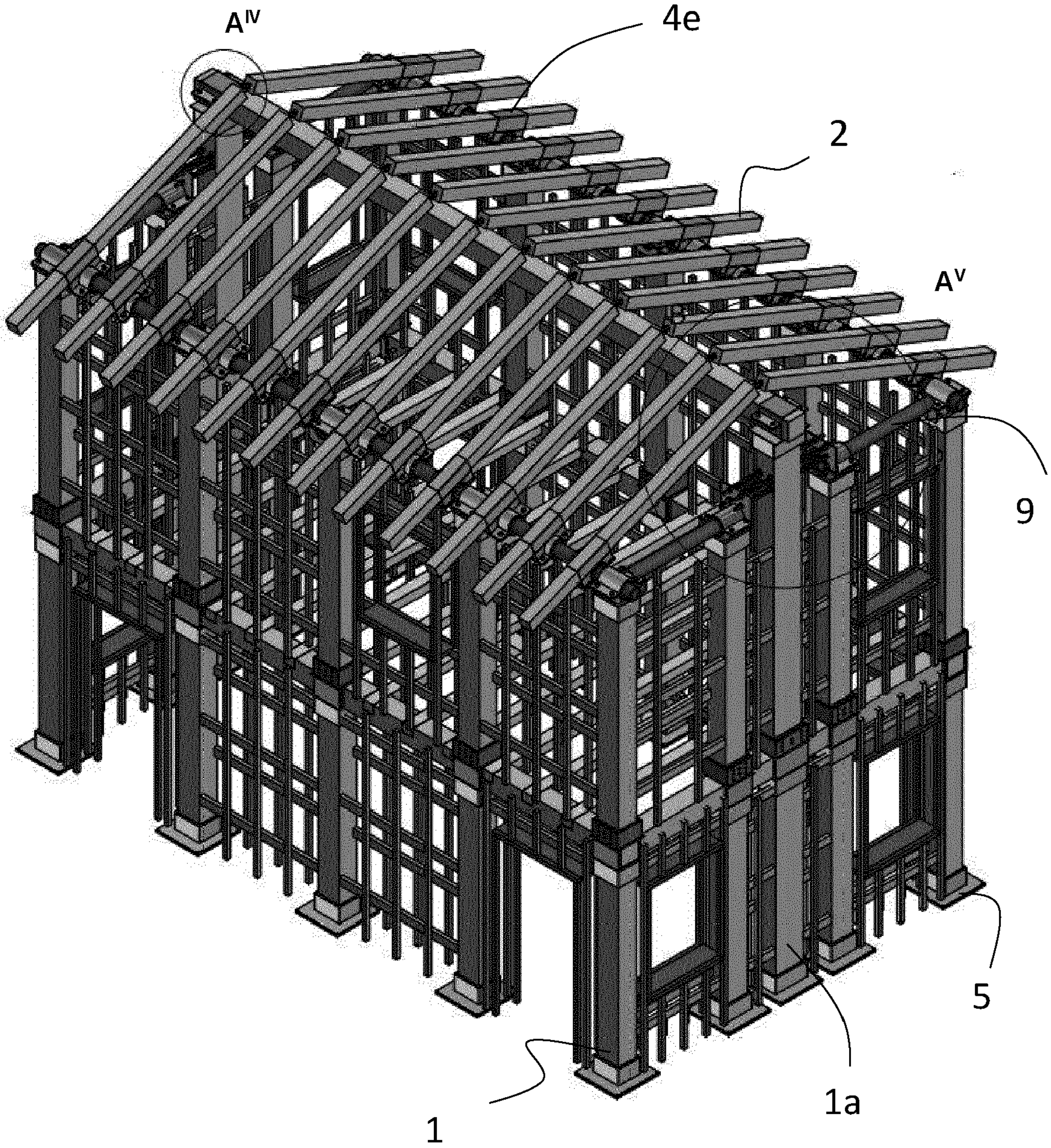


FIG. 8

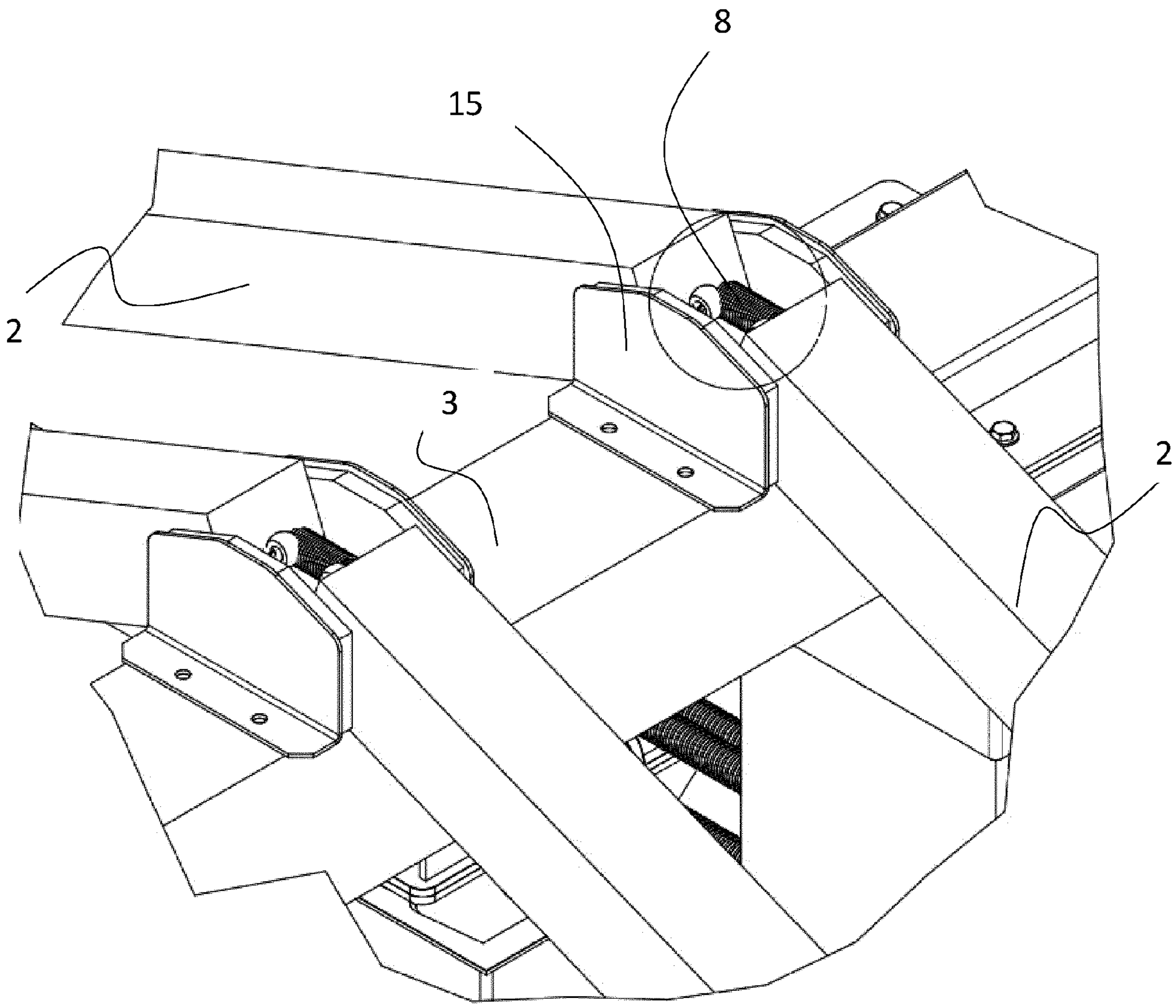


FIG. 9

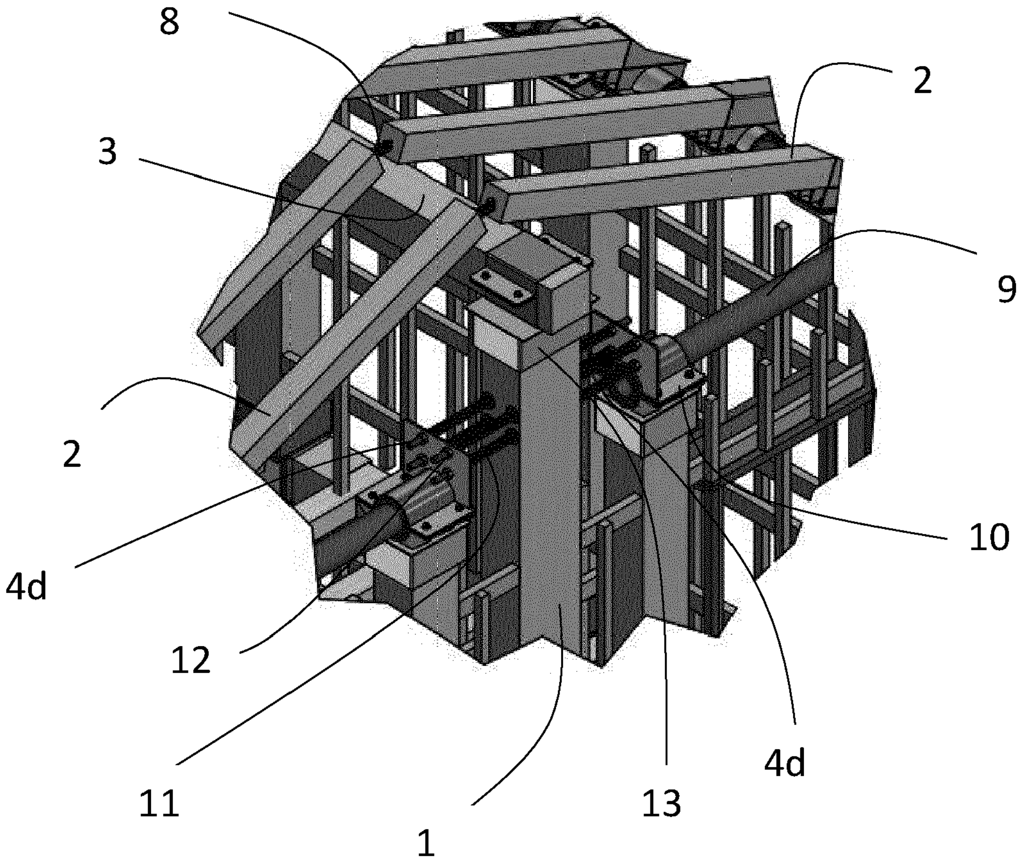
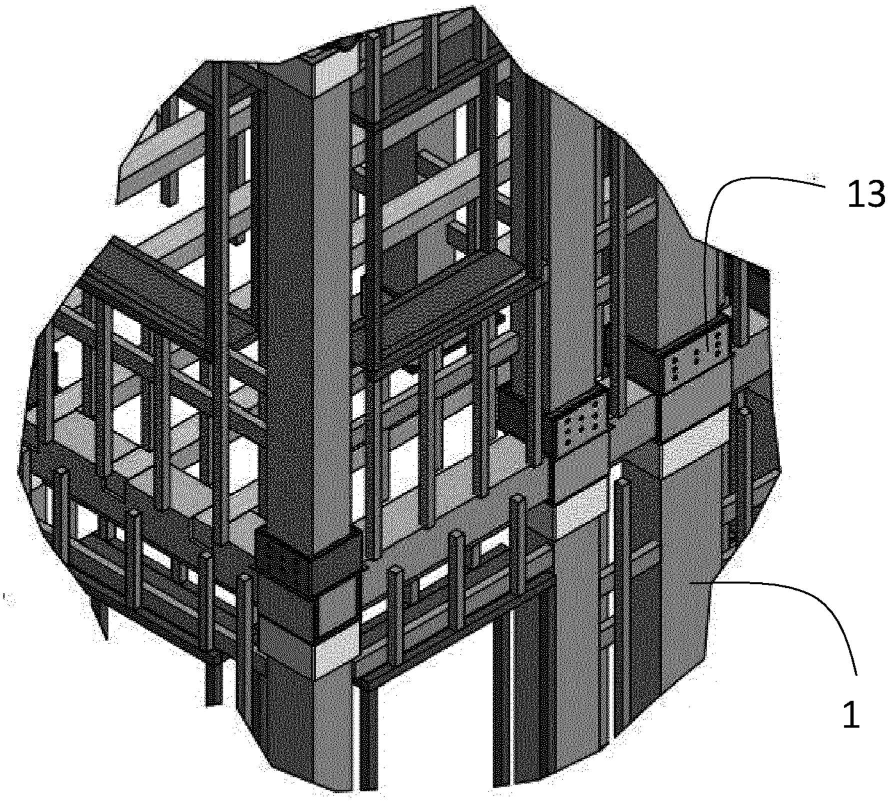


FIG. 10



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EUROPEAN SEARCH REPORT

Application Number
EP 22 20 2703

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 1 979 039 A (JOHNSON ANNIE V) 30 October 1934 (1934-10-30) * page 1, line 1 - page 2, line 105; figures 1-4 *	1-10	INV. E04B1/18 E04B1/26 E04H9/02
A	NL 2 010 981 C2 (HAREN VICTOR) 17 December 2014 (2014-12-17) * page 1, line 7 - page 7, line 26; figure 1 *	1-10	
A	CN 212 453 276 U (HUANG YING) 2 February 2021 (2021-02-02) * the whole document *	1-10	
A	CN 212 613 073 U (UNIV XIAN ARCHITECTUR & TECH) 26 February 2021 (2021-02-26) * paragraph [0001] - paragraph [0082]; figures 1-9 *	1-10	

TECHNICAL FIELDS SEARCHED (IPC)

E04B
E04H

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	10 January 2023	Dieterle, Sibille

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 22 20 2703

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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10-01-2023

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NL 2010981	C2	17-12-2014	NONE	
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82