(19) LE GOUVERNEMENT
DU GRAND-DUCHÉ DE LUXEMBOURG
Ministère de l'Économie

(11) N° de publication : **LU508574**

(12) **BREVET D'INVENTION** **B1**

(21) N° de dépôt: LU508574

(51) Int. Cl.:
E04B 1/00, E04C 3/00, E04B 2/56

(22) Date de dépôt: 16/10/2024

(30) Priorité:

(43) Date de mise à disposition du public: 23/04/2025

(47) Date de délivrance: 23/04/2025

(73) Titulaire(s):
SANDA UNIVERSITY – Shanghai (China)

(72) Inventeur(s):
JIAO Yu Feng – China

(74) Mandataire(s):
Patent42 SA – 4081 Esch-sur-Alzette (Luxembourg)

(54) **A prestressed joint connection of the prefabricated recoverable functional steel frame-support system.**

(57) The prefabricated recoverable functionality steel frame-bracing system with prestressed joint connections includes prefabricated joint I, prefabricated joint II, bracing structures, floor slabs; prefabricated joint I is a prestressed column-to-column splice joint, located at the inflection point of the column; it consists of a prestressed tie rod support plate, stiffener plate, semi-welded lug plate, web splice plate, prestressed tie rod; prefabricated joint II is a prestressed beam-to-beam splice joint, including a cantilever beam flange plate, an intermediate beam flange plate, post-tensioned prestressed tendons; the bracing structure is arranged in pairs between two adjacent steel beams, with each pair consisting of a bracing rod, bracing rod sleeve, lower-end connector, upper-end connector; the floor slabs include three types of prefabricated concrete floor slabs: Type I, Type II, and Type III; this invention adopts a new type of prestressed steel beam and column splice joint, improving the assembly rate of the structure.

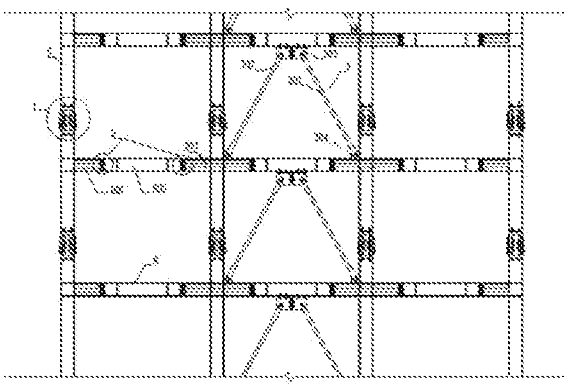

Fig.1

DESCRIPTION

A PRESTRESSED JOINT CONNECTION OF THE PREFABRICATED RECOVERABLE FUNCTIONAL STEEL FRAME-SUPPORT SYSTEM

TECHNICAL FIELD

This invention belongs to the field of structural engineering, specifically relating to a prestressed joint connection for a prefabricated steel frame-support system with recoverable functionality. It utilizes a novel connection joint for prestressed steel beams and columns, which can be used in a new type of prefabricated structure that is operational after simple repairs following an earthquake.

BACKGROUND

In January 2013, the State Council issued the “Green Building Action Plan,” which proposed promoting industrialization in construction and developing a complete, series, and standardized prefabricated structural system that is green, environmentally friendly, energy-efficient, and reusable. In February 2016, the “Several Opinions of the Central Committee of the Communist Party of China and the State Council on Further Strengthening Urban Planning and Construction Management” aimed to ensure that the proportion of prefabricated buildings in new constructions would reach 30% within about ten years. Since the Wenchuan earthquake, domestic experts have suggested that public buildings, such as schools and hospitals, should enhance their seismic resistance requirements and adopt steel structures. Given their regular layout, modular design, and suitability for prefabricated steel frame structures, this approach can improve industrial production efficiency to meet the urgent need for rapid reconstruction after disasters.

Compared to other building materials and structural systems, steel structures are the most suitable type for achieving design standardization, factory production of components, and assembly construction.

However, research on prefabricated steel frame structures in China, especially multi-story prefabricated steel structures, is still in its infancy. In prefabricated steel structure systems, the beam-to-beam and column-to-column connection methods are key factors determining the efficiency of assembly. Existing connection methods mainly include welding of H-beams, bolt connections, or mixed bolt-weld connections. For welding, field operation efficiency is low, and the quality of welding is difficult to guarantee. Bolt connections require a significant amount at the flanges and webs, and when the project volume is large, the labor and material costs do not reflect the advantages of steel structures. Therefore, using traditional connection forms in prefabricated structural systems cannot meet the needs for efficient industrial installation, resulting in excessive steel consumption, which contradicts the national advocacy for green building concepts. Thus, innovation in prefabricated steel structure systems is the development direction for the coming years.

SUMMARY

The purpose of the present invention is to provide a prestressed node-connected, resilient steel frame-support system, which uses new prestressed steel beams and steel columns to connect nodes, improve the assembly rate of the structure, achieve rapid construction, and enable rapid repair and reconstruction after an earthquake.

In order to solve the above technical problems, the technical solution adopted by the present invention is:

A prestressed joint connection of the prefabricated recoverable functional steel frame-support system includes prefabricated Joint I (1), prefabricated Joint II (2), support structure (3), and floor slab (4): prefabricated Joint I (1) is a prefabricated prestressed column-to-column joint that connects two adjacent steel columns (5) above and below; prefabricated Joint II (2) is a prefabricated prestressed beam-to-beam joint that connects the cantilever beam segment (601) and the intermediate beam segment (602) to form the steel beam (6); the floor slab (4) includes three types of precast concrete slabs: type I slab (401), type II slab (402), and type III slab (403); the characteristics are as follows: prefabricated joint I (1) is located at the inflection point of the column and includes a prestressed tie rod support plate (101), stiffening plate (102), half-welded ear plate (103), web splice plate (104), and prestressed tie rod (106); at the connection point of the two steel columns (5), web splice plates (104) are arranged at the front and back web positions; a prestressed tie rod support plate (101) is welded to each of the two steel columns (5), with a stiffening plate (102) set on one side of the prestressed tie rod support plate (101); the two ends of the prestressed tie rod (106) are fixed to the prestressed tie rod support plate (101) to apply pre-tension, connecting the two steel columns (5); the two ends of the half-welded ear plate (103) are connected to the flanges on the same side of the two steel columns (5), with one end welded to the flange on one steel column (5) and the other end fixed to the flange on the other steel column (5) using bolts; prefabricated joint II (2) includes the cantilever beam segment flange plate (201), intermediate beam segment flange plate (202), and post-tensioned prestressed cable (203); one end of the cantilever beam segment (601) is welded to the steel column (5), while the other end is fitted with the cantilever beam segment flange plate (201); the two ends of the intermediate beam segment (602) are each fitted with the intermediate beam segment flange plate (202); the cantilever beam segment flange plate (201) and the intermediate beam segment flange plate (202) have corresponding reserved holes that are connected by bolts; one end of the post-tensioned prestressed cable (203) sequentially passes through the reserved holes on the cantilever beam segment flange plate (201) and the intermediate beam segment flange plate (202); the other end passes through the flange of the steel column (5) or penetrates through the steel column (5) and then sequentially through the reserved holes on the cantilever beam segment flange plate (201) and the intermediate beam segment flange plate (202) of prefabricated joint II (2) on the other side of the steel column (5); pre-tension is applied to both ends of the post-tensioned prestressed cable (203), connecting the cantilever beam segment (601) and the intermediate beam segment (602); the support structure (3) is arranged in pairs between the upper and lower adjacent steel beams (6); each pair of support structures (3) includes a support rod (301), support rod sleeve (302), upper end connector (303), and lower end connector (304); the upper end connector (303) is fixed to the intermediate beam segment (602) of the upper steel beam (6), and the lower end connector (304) is fixed to the beam-column joint of the lower steel beam (6); after the support rod sleeves (302) are installed at both ends of the support rod (301), they are respectively connected to the upper end connector (301) and the lower end connector (302) to form diagonal supports; after an earthquake, rapid repair and reconstruction can be achieved by re-tensioning the post-tensioned prestressed cable (203) and replacing the supports.

Preferably, the type i slab (401), type ii slab (402), and type iii slab (403) are each provided with anchor bolt holes to allow the connection anchor bolts (404) to fix them to the steel beam (6).

Preferably, the plate surface of the lower connecting piece (304) is welded perpendicularly to the flanges of the steel beam (6) and steel column (5) at the beam-column joint.

Preferably, at the upper connecting piece (303) is composed of an l-shaped support piece (303-1) and a vertical connecting plate (303-2);after two l-shaped support pieces (303-1) are fixedly connected, the vertical connecting plate (303-2) is welded to each l-shaped support piece (303-1), and a connection hole for the support rod sleeve (302) is provided on the vertical connecting plate (303-2); the l-shaped support piece (303-1) is made of angle steel or two steel plates welded vertically, with holes opened at the tips and backs of the angle steel or on the two steel plates.

Preferably, profiled steel plates (406) are welded at the ends of both sides of the floor slab (4), and in adjacent floor slabs (4), one slab’s (4) profiled steel plates (406) on both sides form a closing structure (407), while the other slab’s (4) profiled steel plates (406) on both sides form an opening structure (408) that cooperates with the closing structure (407);the two slabs (4) interlock and engage with each other through the closing structure (407) fitting into the opening structure (408).

Preferably, the bolts of the connecting web splicing plate (104) are friction-type high-strength bolts (105) for web shear resistance.

The prestressed joint connection for a prefabricated steel frame-support system proposed in this invention represents a novel structural system within prefabricated steel frame structures. After adopting the aforementioned technical solutions, this invention offers the following beneficial effects:

1. Clear Force Mechanism: In prefabricated node I, the force mechanism is well-defined. After applying prestress to the prestressed rod, it generates a clamping effect on the milled end face of the flange, resulting in a pre-pressure. When prestress is applied to the prestressed rod, it creates localized compressive stress around the bolt holes on the prestressed rod support plate. Consequently, the stiffening plate welded to the bottom of the prestressed rod support plate can prevent buckling deformation of the support plate. The entire node structure can form a collective load transfer path, maintaining good integrity and minimal deformation, thereby ensuring the continuity of the column's flexural stiffness. The use of semi-welded ear plates at the joints can mitigate the uncontrollability of onsite welding quality while fully utilizing the reinforcing effect of the ear plates.

2. Simplified Connection Method: In prefabricated node II, the combination of the post-tensioned prestressed cable and the flange plate connection method simplifies the node structure, making it easier to position and adjust during installation, thus saving assembly time. This also overcomes the shortcomings of ordinary nodes that consume on-site labor, reducing construction costs and shortening the construction period, aligning with the trend of industrialized building development. The advantage becomes even more evident when a large number of nodes are constructed simultaneously.

3. Restorability After Earthquakes: The prefabricated steel frame-support system proposed in this invention can restore the structure to its original position after a significant earthquake by re-tensioning the post-tensioned prestressed cables and replacing supports. Even after the structure experiences plastic deformation due to seismic activity, this new system allows for rapid repairs and restoration to its original position, facilitating quick reconstruction after earthquakes.

4. Classification of Prefabricated Concrete Slabs: The prefabricated concrete slabs are categorized into three types, allowing the selection of the appropriate slab according to their respective installation positions. First, the slab's openings are aligned with the top of the steel column, then lowered onto the supporting beam. After aligning the reserved holes on the beam flange and the slab, anchor bolts are installed. Next, the profiled steel plates at the slab edges are connected and secured with anchor bolts. This installation method significantly speeds up the process, forming a complete prefabricated system with the steel frame and greatly reducing installation time.

5. Enhanced Seismic Performance: The invention utilizes high-ductility metal rods as support components, which, along with the post-tensioned prestressed cables, constitute the energy-dissipating elements of the prefabricated system, effectively improving the overall seismic performance of the prefabricated steel frame.

6. High Efficiency in Assembly: All components of this invention are processed in the factory, resulting in high efficiency during on-site hoisting and assembly. The reasonable design of the joints and systems greatly enhances the overall assembly rate of the structure.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1 is a schematic diagram of the structure of the present invention;

Figure 2 is an assembly diagram of three types of floor slabs;

Figure 3 is a schematic diagram of the structure of assembled node I;

Figure 4 is a structural disassembly diagram of assembled node I at the side column of the steel frame;

Figure 5 is a structural disassembly diagram of assembled node I at the middle column of the steel frame;

Figure 6 is a schematic diagram of the structure and assembly of assembled node II;

Figure 7 is a structural disassembly diagram of the upper part of the supporting structure;

Figure 8 is a three-dimensional diagram of the connection of type I plate;

Figure 9 is a three-dimensional diagram of the connection of type II plate;

LU508574

Figure 10 is a three-dimensional diagram of the connection of type III plate;

Figure 11 is a schematic diagram of the connection between floor slabs and beams;

Figure 12 is a schematic diagram of the connection between floor slabs;

wherein, 1. Prefabricated Node Ⅰ; 101: Prestressed Rod Support Plate ; 102: Stiffening Plate; 103: Semi-Welded Ear Plate; 104: Web Splicing Plate; 05: High-Strength Shear Bolt for Web; 106: Prestressed Rod; 107: Column Stiffening Plate; 2. Prefabricated Node II; 201: Flange Plate of Cantilever Beam Section; 202: Flange Plate of Intermediate Beam Section; 203: Post-Tensioned Prestressed Cable; 3. Support Structure; 301: Support Rod; 302: Support Rod Sleeve; 303: Upper Connection Component; 303-1: L-Shaped Support Component; 303-2: Vertical Connection Plate; 304: Lower Connection Component; 4. Floor Slab; 401: Type I Slab; 402: Type II Slab; 403: Type III Slab; 404: Connecting Anchor Bolt; 405: Reinforcement for Prefabricated Concrete Slab; 406: Profiled Steel Plate; 407: Closure Structure; 408: Opening Structure; 5. Steel Column; 501: Upper Steel Column; 502: Lower Steel Column; 6. Steel Beam; 601: Cantilever Beam Section; 602: Intermediate Beam Section; 603: Beam Stiffening Rib

DETAILED DESCRIPTION OF THE INVENTION

The technical solution of the present invention is further described below through specific implementation modes in conjunction with the accompanying drawings.

The steel columns (5) and steel beams (6) used in this invention’s steel frame are both I-beams.

As shown in Figures 1 and 2, the prestressed node connection for the prefabricated functional recovery steel frame-support system consists of Prefabricated Node I (1), Prefabricated Node II (2), Support Structure (3), and Floor Slabs (4). The floor slabs (4) include three types of prefabricated concrete slabs: Type I (401), Type II (402), and Type III (403).

As shown in Figures 3, 4, and 5, Prefabricated Node I (1) is a prefabricated prestressed column-to-column splicing node that connects two adjacent steel columns (5) and is located at the point of inflection of the columns, approximately at 1/3 to 1/4 of the floor height.

It includes a Prestressed Rod Support Plate (101), Stiffening Plate (102), Semi-Welded Ear Plate (103), Web Splicing Plate (104), and Prestressed Rod (106). At the connection of the two steel columns (5), web splicing plates (104) are set at the front and back of the web at the joint, which are connected by high-strength shear bolts (105). The shear bolts (105) are friction-type.

At a certain distance from the splicing point on each of the two steel columns (5), Prestressed Rod Support Plates (101) and Stiffening Plates (102) are symmetrically arranged. The two Prestressed Rod Support Plates (101) have reserved holes and are connected by the Prestressed Rod (106), to which pre-tension is applied, thereby connecting the two steel columns (5). The two ends of the Semi-Welded Ear Plate (103) are respectively connected to the flanges on the same side of the two steel columns (5). One end of the Semi-Welded Ear Plate (103) is welded to the flange on the side of the upper steel column (501), and the other end is connected to the flange on the same side of the lower steel column (502) using high-strength bolts, thus completing the splicing of the steel column segments. As shown in Figure 4, Stiffening Plates (107) are welded onto the steel columns (5) at the beam-column connection.

As shown in Figure 6, Prefabricated Node II (2) is a prefabricated prestressed beam-to-beam splicing node. The frame steel beam (6) is divided into two cantilever beam sections (601) and one intermediate beam section (602) by two Prefabricated Nodes II (2), where the intermediate beam section (602) serves as the joint for installing the support structure (3). Prefabricated Node II (2) connects the cantilever beam section (601) and the intermediate beam section (602), including the Cantilever Beam Section Flange Plate (201), Intermediate Beam Section Flange Plate (202), and Post-Tensioned Prestressed Cable (203). One end of the cantilever beam section (601) is welded to the steel column (5), and the other end is fitted with the Cantilever Beam Section Flange Plate (201). Both ends of the intermediate beam section (602) are each fitted with the Intermediate Beam Section Flange Plate (202), and corresponding reserved holes are provided on both the Cantilever Beam Section Flange Plate (201) and Intermediate Beam Section Flange Plate (202), which are connected by high-strength bolts.

Depending on the location of Prefabricated Node II (2) in the entire steel frame, the Post-Tensioned Prestressed Cable (203) can be arranged in two ways as follows:

1. When Prefabricated Node II (2) is located at the edge of the entire steel frame, meaning the beam-column connection is in a T-shaped configuration, one end of the Post-Tensioned Prestressed Cable (203) passes sequentially through the reserved holes in the Cantilever Beam Section Flange Plate (201) and Intermediate Beam Section Flange Plate (202), and the other end is fixed to the flange of the steel column (5). Pre-tension is applied at both ends of the Post-Tensioned Prestressed Cable (203), connecting the cantilever beam section (601) and intermediate beam section (602).

2. When Prefabricated Node II (2) is located within the entire steel frame, meaning that the beam-column connection forms a cross shape, one end of the Post-Tensioned Prestressed Cable (203) passes sequentially through the reserved holes in the Cantilever Beam Section Flange Plate (201) and the Intermediate Beam Section Flange Plate (202). The other end passes through the steel column (5) and then through the reserved holes in the Cantilever Beam Section Flange Plate (201) and Intermediate Beam Section Flange Plate (202) of the other side of Prefabricated Node II (2). Pre-tension is applied at both ends of the Post-Tensioned Prestressed Cable (203), connecting the cantilever beam section (601) and the intermediate beam section (602) to complete the splicing and installation of the entire steel beam segment.

As shown in Figure 7, the support structure (3) is positioned in the middle of the entire frame structure. It is not necessary to set up a support structure for every segment and is arranged in pairs. Each pair of support structures (3) includes a Support Rod (301), Support Rod Sleeve (302), Upper End Connector (303), and Lower End Connector (304). The Upper End Connector (303) is fixed to the Intermediate Beam Section (602) of the upper steel beam (6) by bolts, while the Lower End Connector (304) is fixed at the beam-column joint of the lower steel beam (6). The two ends of the Support Rod (301) are fitted with Support Rod Sleeves (302) and connect to the Lower End Connector (304) and Upper End Connector (303) respectively, forming a diagonal brace.

The plate surface of the Lower End Connector (304) is welded perpendicularly to the flanges of the steel column (5) and steel beam (6) at the beam-column joint.

The Upper End Connector (303) consists of an L-shaped Support Member (303-1) and a Vertical Connector Plate (303-2). The L-shaped Support Member (303-1) consists of two components fixed together with bolts. A Vertical Connector Plate (303-2) is welded to each L-shaped Support Member (303-1), and the Vertical Connector Plate (303-2) has connection holes for the Support Rod Sleeve (302).

The L-shaped Support Member (303-1) can be made of angle steel or consist of two vertically welded steel plates, with holes provided on the tips and backs of the angle steel or on the two steel plates. The Support Rod (301) can be a metal screw designed to have a high energy dissipation capacity. The end of the Support Rod (301) is processed into a threaded section, with an effective length of more than 45 mm. The two ends of the Support Rod (301) are equipped with Support Rod Sleeves (302), which also have threads inside, connecting correspondingly with the threads on the ends of the Support Rod (301).

The floor slabs (4) are made of precast concrete and are categorized into three types based on their relative positions to the steel columns (5): Type I Slabs (401), Type II Slabs (402), and Type III Slabs (403). The Type I Slabs (401) extend around the central column on each side by half a span, featuring a square or rectangular cutout in the middle. The dimensions of the cutout are generally matched to the height and width of the cross-section of the steel column (5), allowing for the column (5) to pass through, as shown in Figure 8. The Type II Slabs (402) are arranged along the edge columns, as depicted in Figure 9. The Type III Slabs (403) surround the corner columns, illustrated in Figure 10. The distribution of these three types of floor slabs (4) is shown in Figure 2.

As shown in Figure 11, all three types of floor slabs (4) have reserved openings, with a spacing of 300 mm between the holes and a depth approximately equal to the length of the connection anchor bolts (404). The floor slabs (4) connect to the flanges of the steel beams (6) via the connection anchor bolts (404). In Figure 12, corrugated steel plates (406) are bolted to the ends of both the upper and lower surfaces of the precast concrete floor slabs.

Among the adjacent precast concrete floor slabs, one slab’s corrugated steel plate (406) forms a closure structure (407), while another slab’s corrugated steel plate (406) creates an opening structure (408) that matches the closure structure (407). The closure structure (407) fits into the opening structure (408), allowing the two precast concrete floor slabs to interlock.

The structural features of the present invention are further described below through a specific installation method.

The assembly method of the prestressed node-connected assembled recoverable functional steel frame-support system comprises the following steps:

I. Installation of Frame Columns at the Construction Site (Construction of Assembly Node I1):

First, align the upper and lower steel columns (5). Next, install the web splice plates (4) at the web location. The high-strength bolts (105) for shear resistance at this location should be tightened according to standard bolt requirements. Then, longitudinally insert the prestressed tie rods (106) and tension them. After the tensioning is complete, apply pre-tensioning to the high-strength bolts (105) at the web location. Once this is finished, install and fully tighten the bolts at the semi-welded ear plates (103). During node installation, ensure the column flanges are aligned without any offset. When applying pre-tension to the prestressed tie rod (106), it is recommended to use two methods: hydraulic tensioning and torque method. Both methods apply pre-tension by compressing the prestressed tie rod support plates (101) through the prestressed tie rod (106).

II. Installation of Frame Beams at the Construction Site (Construction of Assembly Node II2):

Since the steel columns (5) on this level have been installed, the position of the cantilever beam section (601) is now fixed. Lift the middle beam section (602) to the designed elevation to connect with the cantilever beam section (601). After aligning the cantilever beam flange plate (201) and the middle beam flange plate (202), insert the bolts and perform general tightening.

Next, one end of the post-tensioned prestressed cable (203) passes through the inside flange of the steel column (5), while the other end goes through the remaining reserved holes on the cantilever beam flange plate (201) and the middle beam flange plate (202). The installation method for the assembly node II2 at the intersection of the middle frame beam and column is consistent with that of the edge frame. After installing the steel column (5), connect the middle beam section (602) to the cantilever beam section (601), aligning the cantilever beam flange plate (201) and the middle beam flange plate (202) before inserting the bolts. One end of the post-tensioned prestressed cable (203) passes through the left flange plates (201) and (202) of the middle frame beam and column, while the other end passes through the right flange plates (201) and (202). Holes are provided on both sides of the column flange at the connection of the middle frame beam and column, allowing the post-tensioned prestressed cable (203) to pass through the column flange. Finally, apply pre-tensioning simultaneously to both ends of the post-tensioned prestressed cable (203) to connect the cantilever beam section (601) and the middle beam section (602) on both sides of the middle frame beam and column connection, completing the assembly of the entire steel beam section.

III. Installation of Floor Slabs (4) When No Support Structure (3) is Required:

Install the floor slabs (4) according to their respective positions. Lower the precast concrete floor slabs from the top of the installed steel columns (5) onto the steel beams (6), aligning the reserved holes on the precast concrete floor slabs with those on the flange of the steel beams (6). Insert the connection anchor bolts (404) to connect them. Simultaneously, interlock the closure structure (407) of one floor slab (4) with the opening structure (408) of the adjacent slab securely.

IV. Installation of Floor Slabs (4) When Support Structure (3) is Required:

In cases where the installation of the support structure (3) is necessary, first install the support structure (3) before proceeding with the installation of the floor slabs (4), following the method described in step III. During the installation of the support structure (3), align and tighten the threads and screws of the support rods (301) and the support rod sleeves (302).

Subsequently, connect the support rod sleeves (302) to the vertical connection plate (303-2) of the upper connection member (303) and the connection plate of the lower connection member (304) using bolts. The connection of the L-shaped support member (303-1) to the middle beam section (602) and between the L-shaped support members (303-1) relies on high-strength bolts for rapid installation.

CLAIMS

1. A prestressed joint connection of the prefabricated recoverable functional steel frame-support system includes prefabricated Joint I (1), prefabricated Joint II (2), support structure (3), and floor slab (4): prefabricated Joint I (1) is a prefabricated prestressed column-to-column joint that connects two adjacent steel columns (5) above and below; prefabricated Joint II (2) is a prefabricated prestressed beam-to-beam joint that connects the cantilever beam segment (601) and the intermediate beam segment (602) to form the steel beam (6); the floor slab (4) includes three types of precast concrete slabs: type I slab (401), type II slab (402), and type III slab (403); the characteristics are as follows: prefabricated joint I (1) is located at the inflection point of the column and includes a prestressed tie rod support plate (101), stiffening plate (102), half-welded ear plate (103), web splice plate (104), and prestressed tie rod (106); at the connection point of the two steel columns (5), web splice plates (104) are arranged at the front and back web positions; a prestressed tie rod support plate (101) is welded to each of the two steel columns (5), with a stiffening plate (102) set on one side of the prestressed tie rod support plate (101); the two ends of the prestressed tie rod (106) are fixed to the prestressed tie rod support plate (101) to apply pre-tension, connecting the two steel columns (5); the two ends of the half-welded ear plate (103) are connected to the flanges on the same side of the two steel columns (5), with one end welded to the flange on one steel column (5) and the other end fixed to the flange on the other steel column (5) using bolts; prefabricated joint II (2) includes the cantilever beam segment flange plate (201), intermediate beam segment flange plate (202), and post-tensioned prestressed cable (203); one end of the cantilever beam segment (601) is welded to the steel column (5), while the other end is fitted with the cantilever beam segment flange plate (201); the two ends of the intermediate beam segment (602) are each fitted with the intermediate beam segment flange plate (202); the cantilever beam segment flange plate (201) and the intermediate beam segment flange plate (202) have corresponding reserved holes that are connected by bolts; one end of the post-tensioned prestressed cable (203) sequentially passes through the reserved holes on the cantilever beam segment flange

plate (201) and the intermediate beam segment flange plate (202); the other end passes through the flange of the steel column (5) or penetrates through the steel column (5) and then sequentially through the reserved holes on the cantilever beam segment flange plate (201) and the intermediate beam segment flange plate (202) of prefabricated joint II (2) on the other side of the steel column (5); pre-tension is applied to both ends of the post-tensioned prestressed cable (203), connecting the cantilever beam segment (601) and the intermediate beam segment (602); the support structure (3) is arranged in pairs between the upper and lower adjacent steel beams (6); each pair of support structures (3) includes a support rod (301), support rod sleeve (302), upper end connector (303), and lower end connector (304); the upper end connector (303) is fixed to the intermediate beam segment (602) of the upper steel beam (6), and the lower end connector (304) is fixed to the beam-column joint of the lower steel beam (6); after the support rod sleeves (302) are installed at both ends of the support rod (301), they are respectively connected to the upper end connector (301) and the lower end connector (302) to form diagonal supports; after an earthquake, rapid repair and reconstruction can be achieved by re-tensioning the post-tensioned prestressed cable (203) and replacing the supports.

2. The prefabricated recoverable functional steel frame-support system according to claim 1, characterized in that the type i slab (401), type ii slab (402), and type iii slab (403) are each provided with anchor bolt holes to allow the connection anchor bolts (404) to fix them to the steel beam (6).

3. The prefabricated recoverable functional steel frame-support system according to claim 1, characterized in that the plate surface of the lower connecting piece (304) is welded perpendicularly to the flanges of the steel beam (6) and steel column (5) at the beam-column joint.

4. The prefabricated recoverable functional steel frame-support system according to claim 1, characterized in that the upper connecting piece (303) is composed of an l-shaped support piece (303-1) and a vertical connecting plate (303-2);after two l-shaped support pieces (303-1) are fixedly connected, the vertical connecting plate (303-2) is welded to each l-shaped support piece (303-1), and a connection hole for the support rod sleeve (302) is provided on the vertical connecting plate (303-2); the l-shaped support piece (303-1) is made of angle steel or two steel plates welded vertically, with holes opened at the tips and backs of the angle steel or on the two steel plates.

5. The prefabricated recoverable functional steel frame-support system according to claim 1, characterized in that profiled steel plates (406) are welded at the ends of both sides of the floor slab (4), and in adjacent floor slabs (4), one slab’s (4) profiled steel plates (406) on both sides form a closing structure (407), while the other slab’s (4) profiled steel plates (406) on both sides form an opening structure (408) that cooperates with the closing structure (407);the two slabs (4) interlock and engage with each other through the closing structure (407) fitting into the opening structure (408).

6. The prefabricated recoverable functional steel frame-support system according to claim 1, characterized in that the bolts of the connecting web splicing plate (104) are friction-type high-strength bolts (105) for web shear resistance.

REVENDICATIONS

1. Un assemblage de joint précontraint du système de support de cadre en acier fonctionnel récupérable préfabriqué comprend un joint préfabriqué I (1), un joint préfabriqué II (2), une structure de support (3) et une dalle de plancher (4) : le joint préfabriqué I (1) est un joint préfabriqué précontraint colonne à colonne qui relie deux colonnes en acier adjacentes (5) au-dessus et au-dessous ; le joint préfabriqué II (2) est un joint préfabriqué précontraint poutre à poutre qui relie le segment de poutre en porte-à-faux (601) et le segment de poutre intermédiaire (602) pour former la poutre en acier (6) ; la dalle de plancher (4) comprend trois types de dalles en béton préfabriquées : dalle de type I (401), dalle de type II (402) et dalle de type III (403) ; les caractéristiques sont les suivantes : le joint préfabriqué I (1) est situé au point d'inflexion de la colonne et comprend une plaque de support de tirant précontraint (101), une plaque de raidissement (102), une plaque d'oreille semi-soudée (103), une plaque d'épissure d'âme (104) et un tirant précontraint (106) ; au point de connexion des deux colonnes en acier (5), des plaques d'épissure d'âme (104) sont disposées aux positions d'âme avant et arrière ; une plaque de support de tirant précontraint (101) est soudée à chacune des deux colonnes en acier (5), avec une plaque de raidissement (102) placée sur un côté de la plaque de support de tirant précontraint (101) ; les deux extrémités du tirant précontraint (106) sont fixées à la plaque de support de tirant précontraint (101) pour appliquer une prétension, reliant les deux colonnes en acier (5) ; les deux extrémités de la plaque d'oreille semi-soudée (103) sont reliées aux brides du même côté des deux colonnes en acier (5), avec une extrémité soudée à la bride d'une colonne en acier (5) et l'autre extrémité fixée à la bride de l'autre colonne en acier (5) à l'aide de boulons ; le joint préfabriqué II (2) comprend la plaque de bride du segment de poutre en porte-à-faux (201), une plaque de bride de segment de poutre intermédiaire (202) et un câble précontraint post-tendu (203) ; une extrémité du segment de poutre en porte-à-faux (601) est soudée à la colonne en acier (5), tandis que l'autre extrémité est équipée de la plaque de bride de segment de poutre en porte-à-faux (201) ; les deux extrémités du segment de poutre intermédiaire (602) sont chacune équipées de la plaque de bride de segment de poutre intermédiaire (202) ; la plaque de bride de

segment de poutre en porte-à-faux (201) et la plaque de bride de segment de poutre intermédiaire (202) ont des trous réservés correspondants qui sont reliés par des boulons ; une extrémité du câble précontraint post-tendu (203) passe séquentiellement à travers les trous réservés sur la plaque de bride de segment de poutre en porte-à-faux (201) et la plaque de bride de segment de poutre intermédiaire (202) ; l'autre extrémité traverse la bride de la colonne d'acier (5) ou pénètre à travers la colonne d'acier (5) puis séquentiellement à travers les trous réservés sur la plaque de bride de segment de poutre en porte-à-faux (201) et la plaque de bride de segment de poutre intermédiaire (202) du joint préfabriqué II (2) de l'autre côté de la colonne d'acier (5) ; une prétension est appliquée aux deux extrémités du câble précontraint post-tendu (203), reliant le segment de poutre en porte-à-faux (601) et le segment de poutre intermédiaire (602) ; la structure de support (3) est disposée par paires entre les poutres d'acier adjacentes supérieure et inférieure (6) ; chaque paire de structures de support (3) comprend une tige de support (301), un manchon de tige de support (302), un connecteur d'extrémité supérieure (303) et un connecteur d'extrémité inférieure (304) ; le connecteur d'extrémité supérieure (303) est fixé au segment de poutre intermédiaire (602) de la poutre d'acier supérieure (6), et le connecteur d'extrémité inférieure (304) est fixé au joint poutre-colonne de la poutre d'acier inférieure (6) ; après que les manchons de tige de support (302) sont installés aux deux extrémités de la tige de support (301), ils sont respectivement connectés au connecteur d'extrémité supérieure (301) et au connecteur d'extrémité inférieure (302) pour former des supports diagonaux ; après un tremblement de terre, une réparation et une reconstruction rapides peuvent être obtenues en retendant le câble précontraint post-tendu (203) et en remplaçant les supports.

2. Système de support à ossature en acier fonctionnelle préfabriquée récupérable selon la revendication 1, caractérisé en ce que la dalle de type i (401), la dalle de type ii (402) et la dalle de type iii (403) sont chacune pourvues de trous de boulons d'ancrage pour permettre aux boulons d'ancrage de connexion (404) de les fixer à la poutre en acier (6).

3. Système de support à ossature en acier fonctionnelle préfabriquée récupérable selon la revendication 1, caractérisé en ce que la surface de la plaque de la pièce de connexion inférieure (304) est soudée perpendiculairement aux ailes de la poutre en acier (6) et de la colonne en acier (5) au niveau de la jonction poutre-colonne.

4. Système de support à ossature en acier fonctionnelle préfabriquée récupérable selon la revendication 1, caractérisé en ce que la pièce de liaison supérieure (303) est composée d'une pièce de support en L (303-1) et d'une plaque de liaison verticale (303-2) ; après que deux pièces de support en L (303-1) sont reliées de manière fixe, la plaque de liaison verticale (303-2) est soudée à chaque pièce de support en L (303-1), et un trou de connexion pour le manchon de tige de support (302) est prévu sur la plaque de liaison verticale (303-2) ; la pièce de support en L (303-1) est constituée d'acier d'angle ou de deux plaques d'acier soudées verticalement, avec des trous ouverts aux extrémités et aux dos de l'acier d'angle ou sur les deux plaques d'acier.

5. Système de support à ossature fonctionnelle préfabriquée récupérable en acier selon la revendication 1, caractérisé en ce que des plaques d'acier profilées (406) sont soudées aux extrémités des deux côtés de la dalle de plancher (4), et dans les dalles de plancher adjacentes (4), les plaques d'acier profilées (406) d'une dalle (4) des deux côtés forment une structure de fermeture (407), tandis que les plaques d'acier profilées (406) de l'autre dalle (4) des deux côtés forment une structure d'ouverture (408) qui coopère avec la structure de fermeture (407) ; les deux dalles (4) s'emboîtent et s'engagent l'une dans l'autre par l'intermédiaire de la structure de fermeture (407) s'insérant dans la structure d'ouverture (408).

6. Système de support à ossature fonctionnelle préfabriquée récupérable en acier selon la revendication 1, caractérisé en ce que les boulons de la plaque de jonction d'âme (104) sont des boulons à haute résistance de type à friction (105) pour la résistance au cisaillement de l'âme.

FIGURES

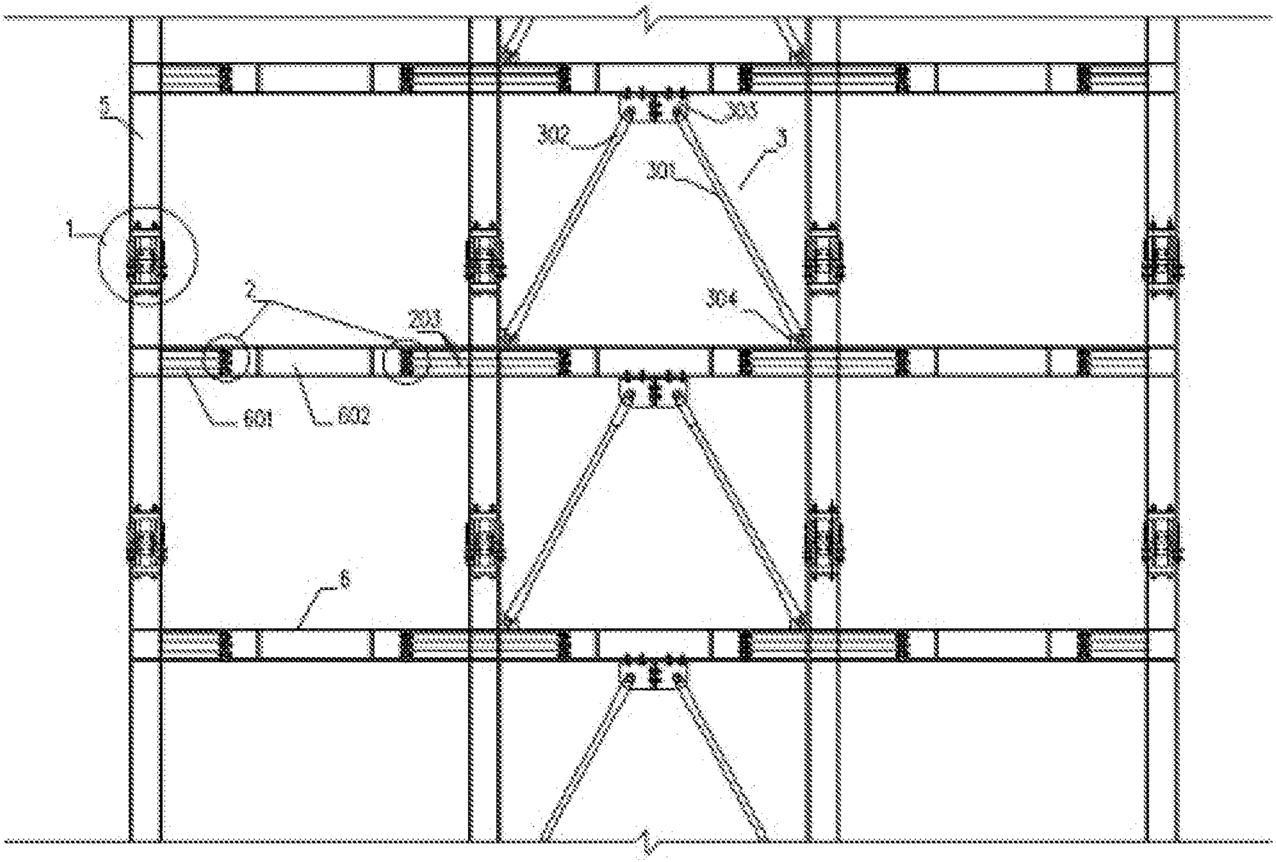

Fig.1

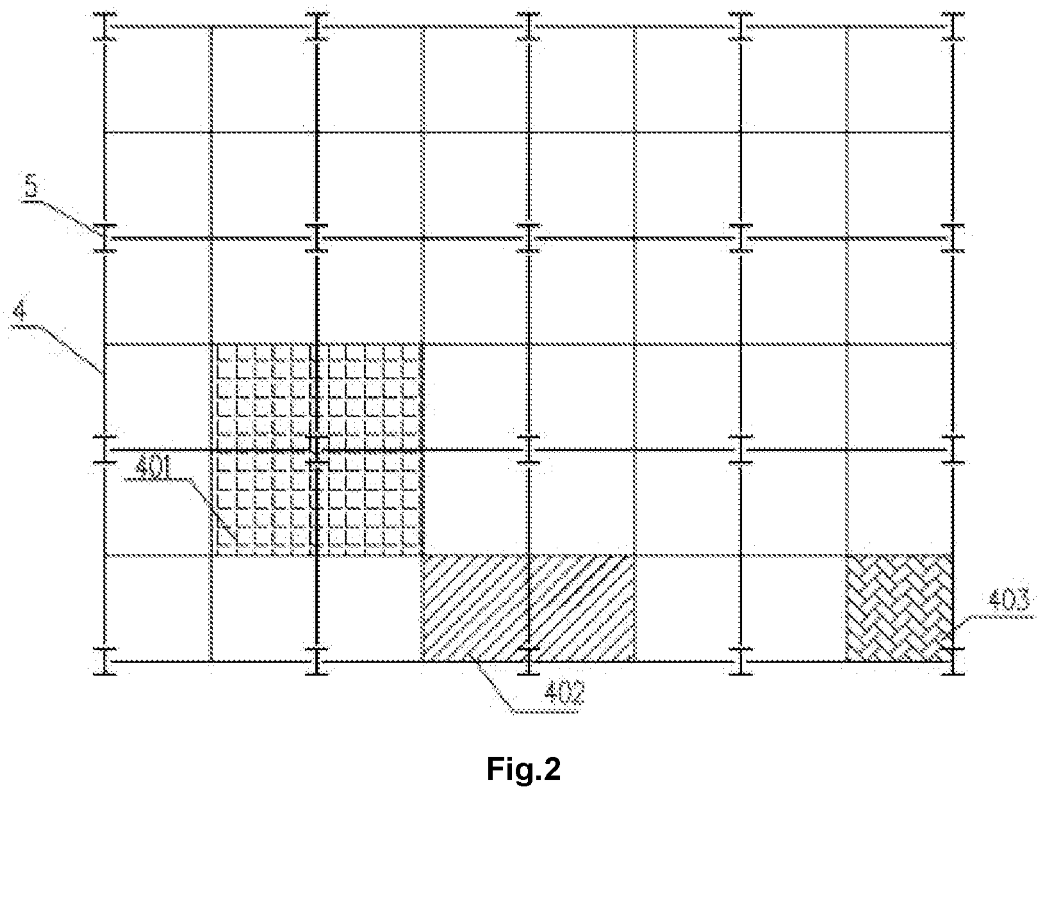

Fig.2

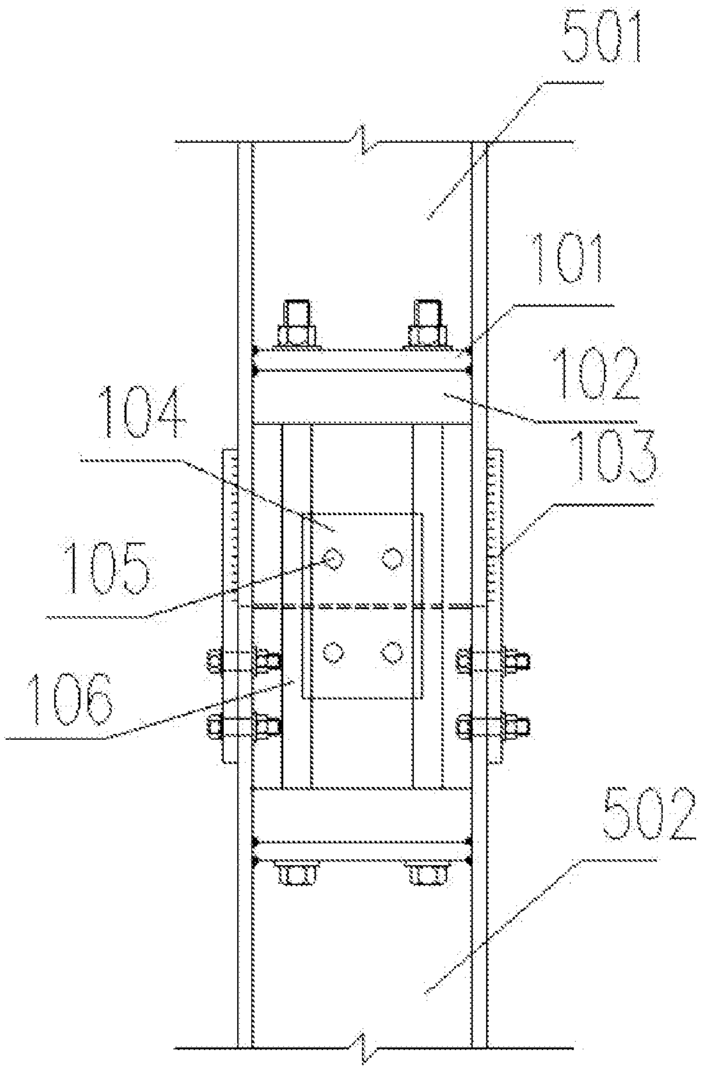

Fig.3

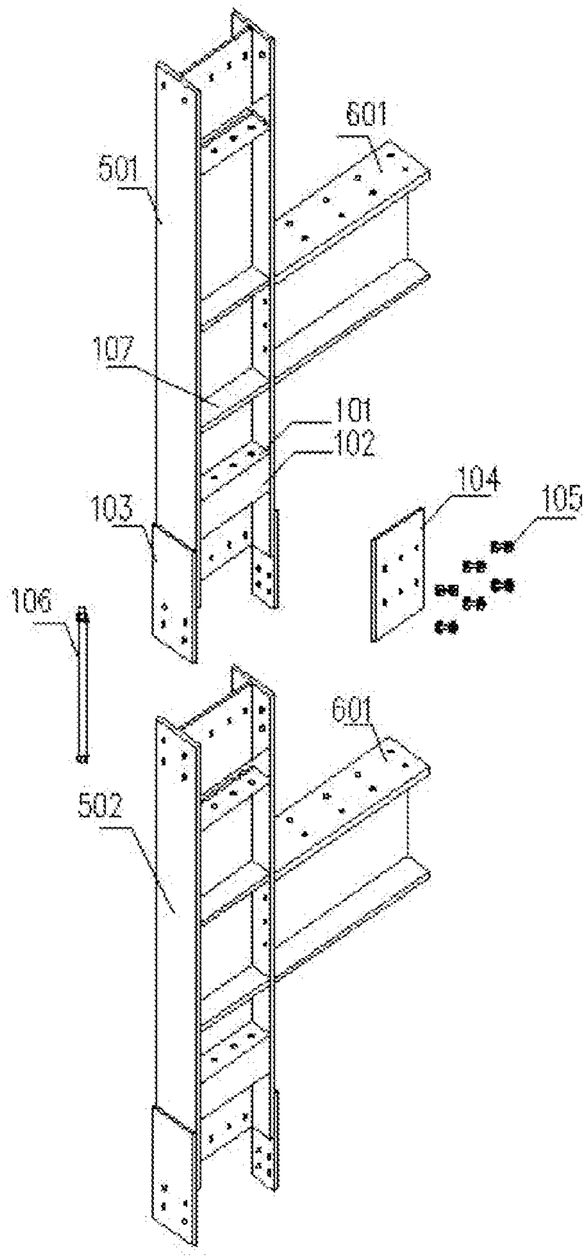

Fig.4

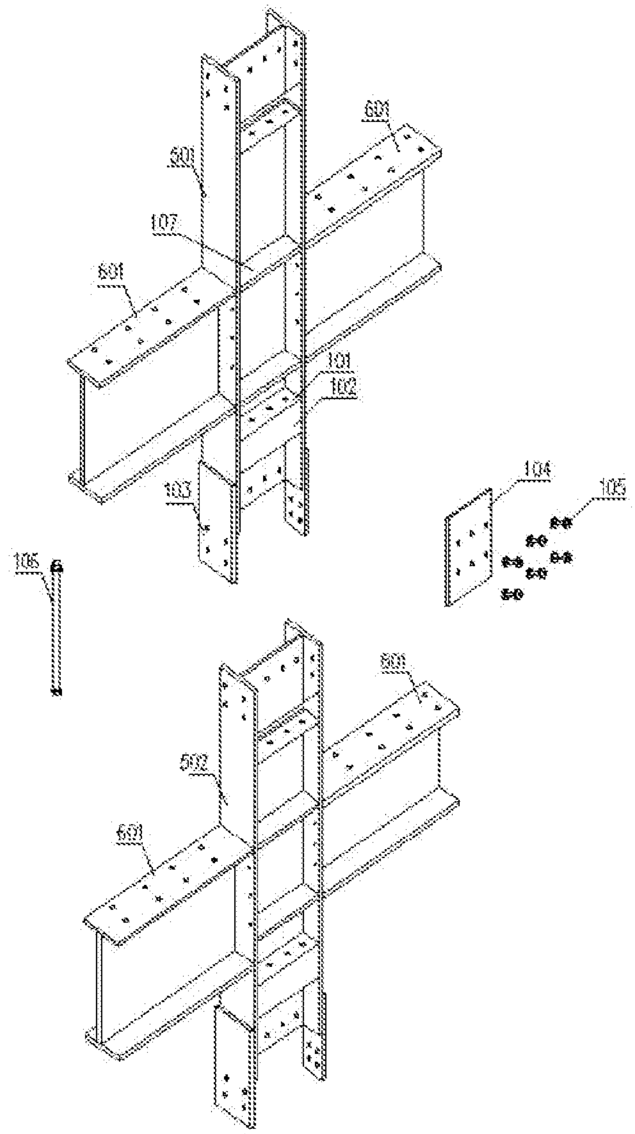
601
501
107
601
101
102
103
104
105
106
601
502
601

Fig.5

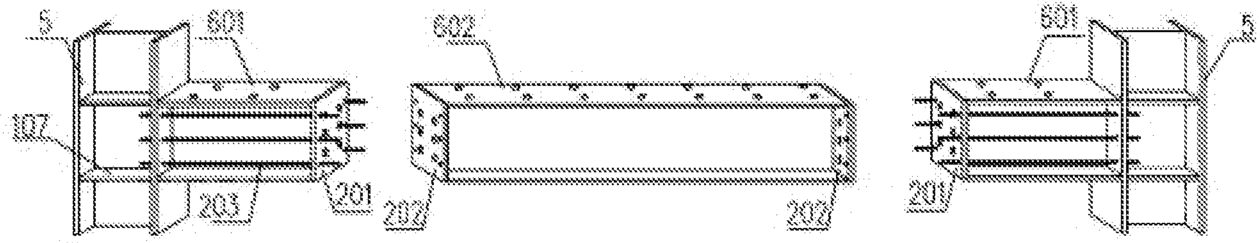
5
601
107
203
201
602
202
202
601
5
201

Fig.6

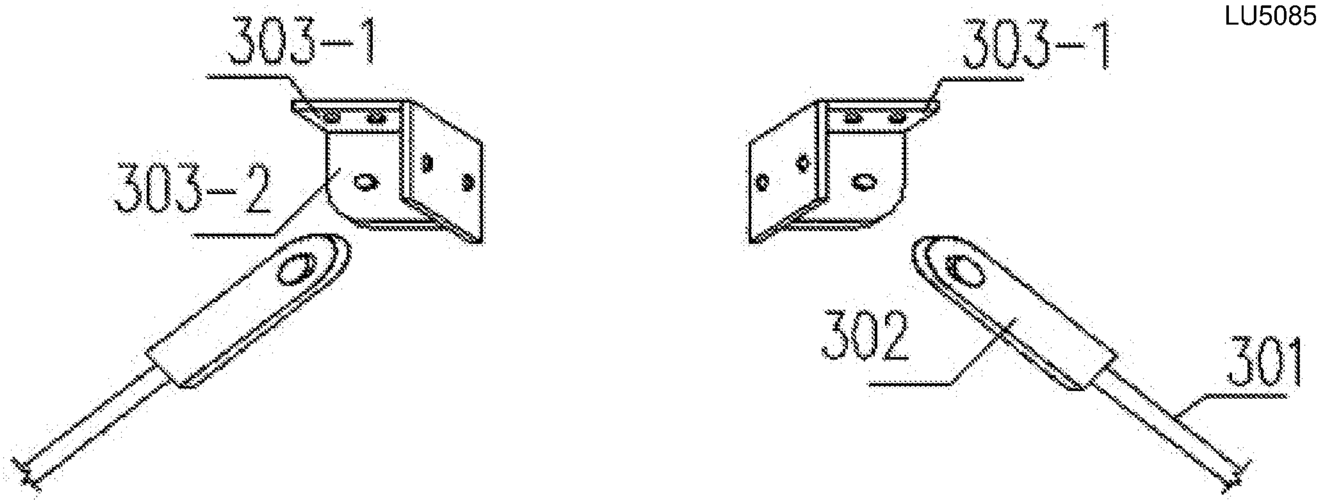

Fig.7

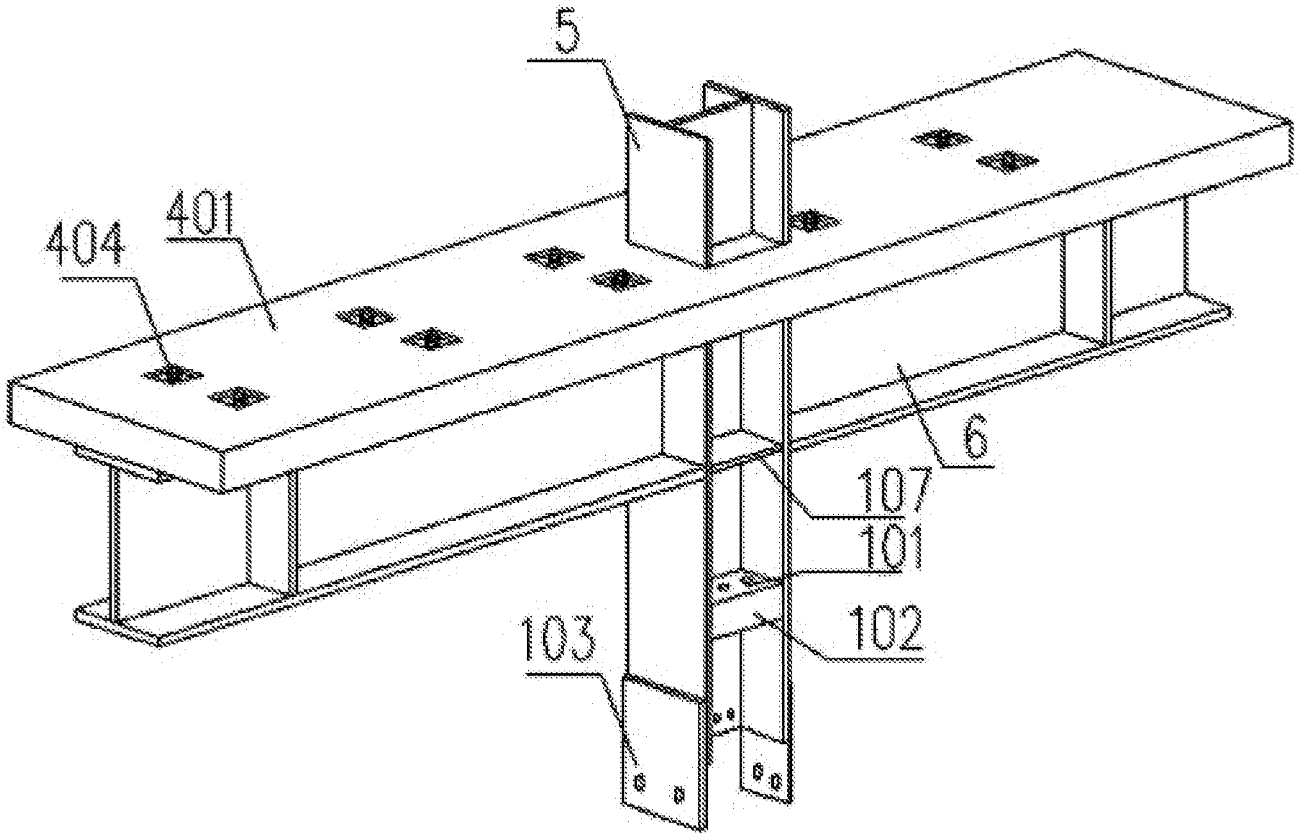

Fig.8

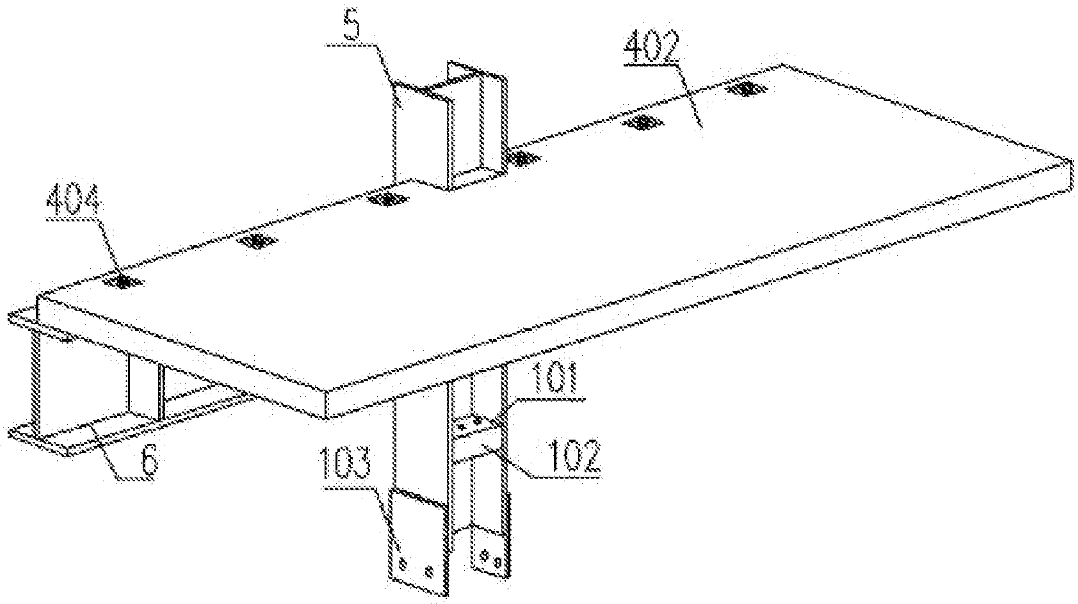

Fig.9

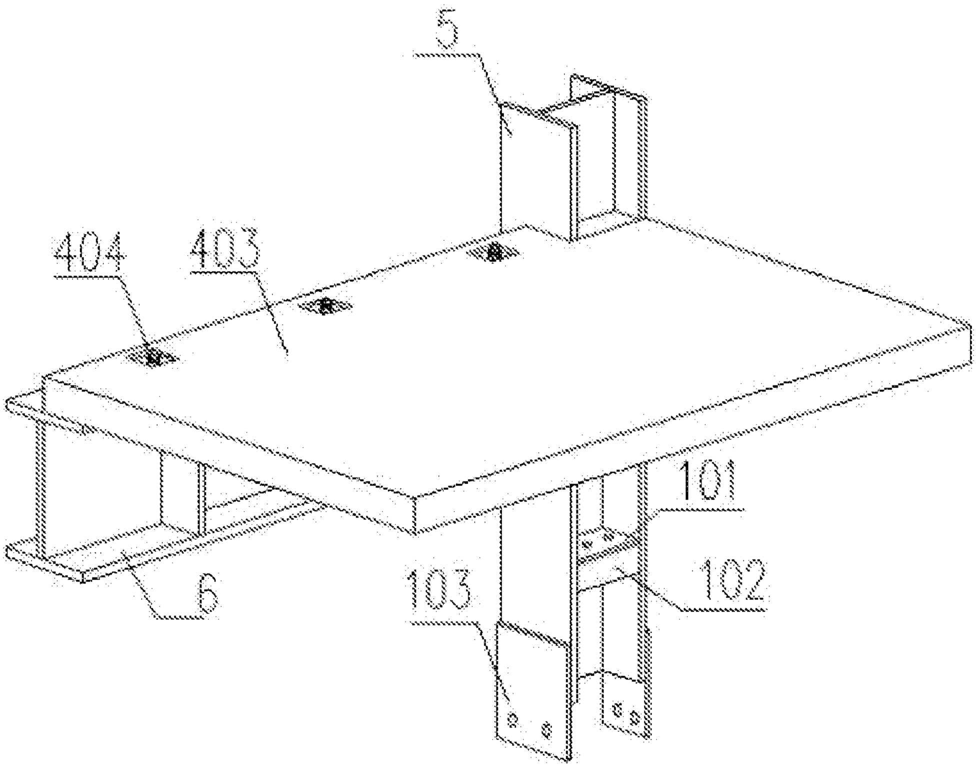

Fig.10

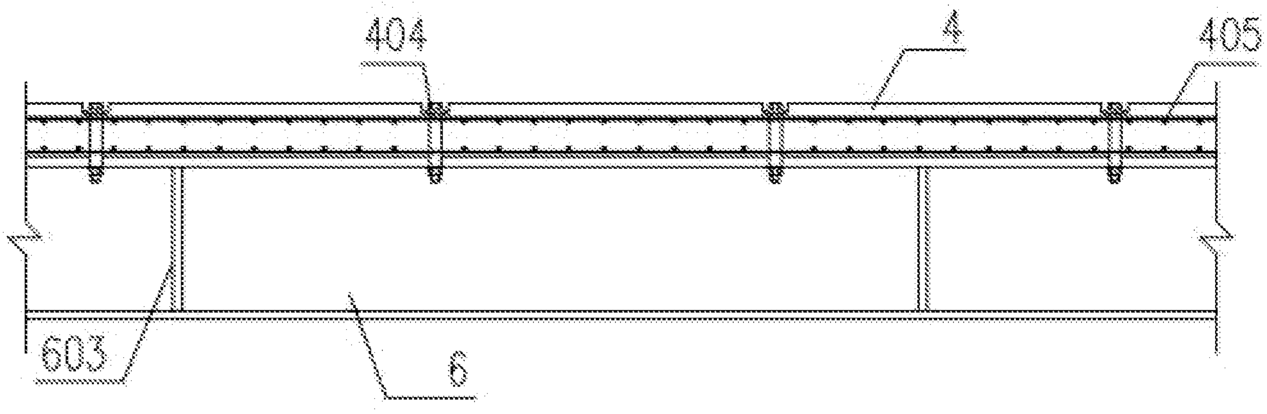

Fig.11

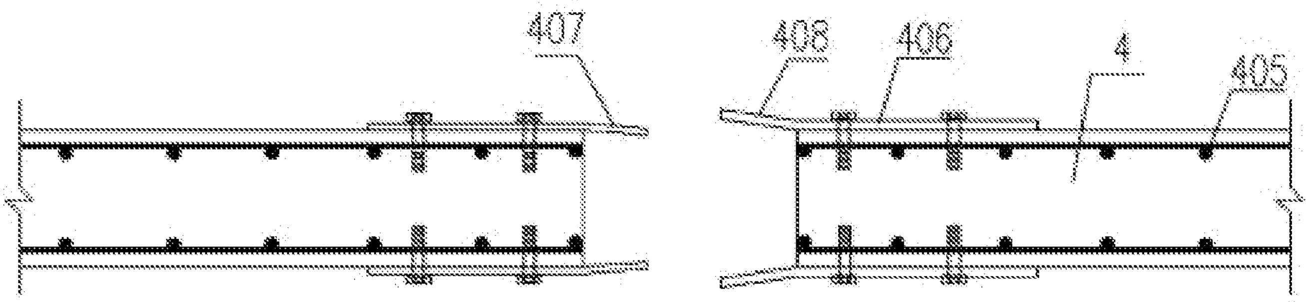

Fig.12