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[Continued on next page]

(54) Title: INNOVATION FOR SHEAR REINFORCEMENT OF COUPLING BEAMS OF COUPLED SHEAR WALLS

(57) Abstract: The invention relates to the innovations for the crosswise reinforcements to serve as the main load-bearing system on the coupling beams of coupled shear walls, vertical reinforcements, horizontal reinforcements, connecting parts and joining parts.

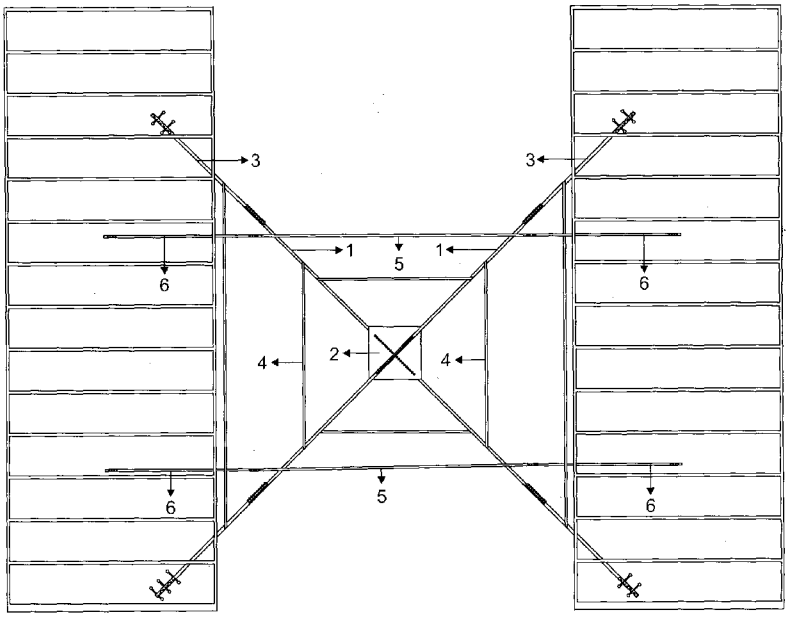

FIGURE 3

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Declarations under Rule 4.17:

— *as to the identity of the inventor (Rule 4.17(i))*

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— *with international search report (Art. 21(3))*

DESCRIPTION

INNOVATION FOR SHEAR REINFORCEMENT OF COUPLING BEAMS OF COUPLED SHEAR WALLS

TECHNICAL FIELD

Invention relates to innovation done in structural walls with coupling beam, diagonal reinforcement that will work as main load-bearing system ,vertical reinforcement, horizontal reinforcement, splices, connection region and joining points.

PRIOR ART

In load-bearing systems in which structural walls are used; because the hollows those left for functional reasons like door, window and installation passage, structural walls with coupling beams occur. This type of wall systems are called as coupled shear wall system or structural walls with coupling beams. Not only position but also number and size of hollows along the wall affect the behavior of building and the distribution of its internal force on coupling beams and structural walls. In case of being the openings that left on the structural walls relatively smaller than the size of wall, the affect of openings is ignored and the system is accepted as structural walls without openings. But in the situation that the openings are visibly bigger, by considering the affect of the hollows, the system is designed as a structural wall with coupling beams. In this type of buildings location of openings should de designed by considering its affects to the building behavior. When the structural walls with coupling beam and coupling beams are designed properly they can behave sufficiently ductile.

In buildings, the structural walls and structural walls with coupling beams are frequently encountered. The shear walls and coupled shear walls of which stiffness is higher than columns are preferred to respond horizontal force like earthquake and wind force. The structural walls with coupling beams occur when openings are left for doors, windows and corridors. This type of systems are called structural walls with coupling beams, also can be considered as a special version of structural wall systems. In condition of designing and building

coupling beams of structural walls with coupling beams which are found in multistory reinforced concrete buildings, as they'll show ductile behaviors it behaves more ductile then the structural walls without openings.

With the affect of horizontal force which affect to the structural walls with coupling beams; axial force, shearing force and bending moments are occurred on structural walls on the other hand on coupling beams shearing force and bending moments are occurred. Overturning moment which occurred in the system because of the horizontal forces that affect the structural walls with coupling beam systems is carried by two different forces. These are: bending moments which occurred on structural walls in system and reaction moments which are formed by couple of opposite marked axial and equal value force on structural walls. Magnitude of axial force on wall couples, depend on the ability of transferring the shearing force that occurs on coupling beams to the structural walls without loss of capacity. When the stiffness of coupling beams get higher the mutual work of walls will surface more efficiently on the other hand because of shearing force on the bounding beams, the normal force on the walls increase. With the increasing stiffness of coupling beams the bending moments decreases, the shearing force of coupling beams increases.

The main aim of coupling beams is to provide the transfer of the shearing force which is formed by horizontal force that affect the system. Coupling beams exposed to reversed cyclic force that change its direction especially by the affect of earthquake. On structural walls with coupling beams the earthquake damage occur primarily on coupling beams. The experimental searches on the structural walls with coupling beams, has presented conventional beam details have negative efficient on system behaviors. The coupling beam with short spans which is equipped by classical simple reinforcements and stirrups become lack of power because of the failure of the coupling beams due to diagonal tension before reaching the bending capacity. The coupling beam with short spans which is equipped by classical simple reinforcements and stirrups even if the shearing force capacity is kept high by increasing the proportion of shear reinforcement and regulating the stirrups properly it doesn't indicate the intended structural behaviors by the reason of

adherence declination on both sides and sudden consuming power of shearing force on the edge profile.

On coupled shear wall systems, coupling beams and structural walls are aimed to work together. Special shearing reinforcement to be inserted on the coupling beam in the event that both equitation's given below according to Turkish Earthquake Regulations (ABYYHY 2007) shall be determined by the methods whose validity was proved with experiments or crosswise reinforcements shall be used to meet shearing force on the coupling beam and bending moment it created.

$$\ell_n \leq 3 \times h_k$$

$$V_d > 1.5 \times b_w \times d \times f_{ctd}$$

In the formula above;

ℓ_n : Clear length between the wall surfaces of the coupling beams,

h_k : height of coupling beam,

b_w: thicknesses of coupling beam,

d : useful height of coupling beam,

f_{ctd}: design tensile strength of the concrete.

Total reinforcement area in each crosswise reinforcement cluster shall be determined with equitation below in Turkish Earthquake Code Regulations (ABYYHY 2007).

$$A_{sd} = V_d / (2 \times f_{yd} \times \sin\gamma)$$

In this equitation;

A_{sd} : Total area of each of the crosswise reinforcement cluster in the coupling beam,

V_d : Design force caused from vertical load and earthquake load which is multiplied by design coefficients.

f_{yd} : design yield strength of longitudinal reinforcement,

γ : The angle which crosswise reinforcement cluster made with the horizontal one.

There shall be four reinforcements at least in the crosswise reinforcements clusters with intended use in Turkish Earthquake Regulations in order to meet the shearing force and bending moment formed by the shearing force and these reinforcements shall be extended one and half time as the clamping in length at least towards the parts of structural wall. Reinforcement clusters shall be wrapped by special earthquake stirrups and the diameter of stirrups shall not be smaller than 8 mm, the distance between each stirrups shall not be more than 8 times of the diameters of the crosswise reinforcement and 100 mm. In addition to crosswise reinforcements, minimum amount of stirrup intended and horizontal reinforcement shall be put into the coupling beam.

According to European Earthquake Code Regulations (Eurosode8 2004) it is required to apply the reinforcements along both diagonals of the coupling beam to meet the seismic impacts in the event that both equations given below under the principles stated below.

$$l < 3 \times h$$

$$V_{Ed} > b_w \times d \times f_{ctd}$$

Within the formula above;

l : clear span remaining between the surfaces of the shear walls of coupled shear wall systems,

h : height of coupling beam,

V_{Ed} : design shear force in the coupling beam,

b_w : width of coupling beam,

d : useful height of the coupling beam,

f_{ctd} : Design tensile strength of the concrete.

a) according to Eurocode8, 2004, equation below should be satisfied in crosswise reinforcement of coupling beams.

$$V_{Ed} = 2 \times A_{si} \times f_{yd} \times \sin\alpha$$

In the formula above;

V_{Ed} : design shear force in the coupling beam,

A_{si} : total area of the reinforcements in the each diagonal direction in the coupling beam,

f_{yd} : yield strength of the longitudinal reinforcement,

α : The angle which crosswise reinforcement cluster made with the horizontal one.

b) It should be reinforced like column element in way that width of diagonal shall be $0.5 \times b_w$ at least.

c) Stirrups should be used to prevent buckling of the longitudinal reinforcements in this cross wise elements reinforced like column.

d) Vertical and horizontal reinforcements should be placed into both surfaces of coupling beam and meet minimum conditions specified in European Earthquake Regulation (Eurocode8 2004)

It is required to construct the crosswise reinforcements wrapped with dense stirrups intended in the Regulations interpenetrating in the middle of coupling beam and mount in a way that it shall enter into the structural wall splices where dense reinforcements are contained as clamping length. It is impossible to construct the crosswise reinforcements wrapped with dense stirrups interpenetrating in the middle of coupling beam extending as the length of clamping to the dense reinforced structural wall splice. Density of the reinforcement in the structural wall splices and crosswise reinforcements in the coupling beam; this causes serious problems during the phase of preparation of the reinforcements, interpenetrating, placement and mounting, causes the crosswise reinforcements are different from the one intended in the project and renders the construction impossible in many cases.

It is required to construct structural wall splices wrapped with dense stirrups where the dense vertical reinforcements are contained during the first phase in building coupled structural wall due to construction technique and later to construct the crosswise reinforcements wrapped with dense stirrups, embed in and mount the structural wall splices and structural body. These kind of cross wise reinforcements could not find a wide application opportunity because there is no possibility of practical and applicable mounting in site conditions as

construction of the crosswise reinforcements interpenetrating with dense stirrups and instead mounting is almost impossible.

Due to dense of reinforcement practically and difficulty of mounting, cross wise reinforcements intended in regulations can not be applied. Therefore, different coupling beam reinforcements were offered in literature. As the coupling beam in literature; H profile was placed into the coupling beam horizontally and embedded in the structural walls, a kind of composite beam. Here H profile is mounted to the bond beam horizontally in one piece. Steel plates are joined to H profile by welding in order to delay buckling and corrugation of H profile located in the coupling beam. Mounting and embedding problems are also encountered in this steel H profile produced in one piece.

This was offered as coupling beam to the literature before in prefabricated (precast) beams. Coupling beams and reinforcements are prepared as precast, that is the coupling beam is brought to the site as the concrete was casted. Embedding reinforcements are extended from coupling beam reinforcements. Precast beams are prepared under the factory conditions and brought to the site, mounting reinforcements are inserted and placed into the structural walls and later structural concrete is casted and monolithic system is sought to be formed. In this case, mounting problems are encountered during the placement of the reinforcements detached from the prefabricated coupling beams.

A monolithic crosswise reinforcement was formed as coupling beam reinforcement before in literature, welding of H profiles cross wisely and experimented. Cutting chocks were welded to H profile splices in order to increase the length of embedding at the part remaining within the structural wall. It is almost impossible to mount H profiles welded to each other to the coupling beam and into the wall in monolithic way.

BRIEF SUMMARY OF THE INVENTION

The invention relates to the innovations for crosswise reinforcement which are to serve as the main load-bearing system on coupling beams of

coupled structural walls, vertical reinforcements, horizontal reinforcements, connection parts, joining parts and connection regions.

Coupling beam reinforcements offered to the literature before are constructed in monolithic way. This can not be applied practically as embedment and mounting of the crosswise reinforcements constructed as a whole into the structural walls with dense reinforcement are very difficult and laborious. Therefore, structural steel elements made of fragmental system with this proposal (L profiles, U profiles, I profiles, T profiles, H profiles, box profiles and pipe profile sor L, U, I, T, H, box and pipe profile plates) are used and a new reinforcement type (cross wise reinforcements) is offered to the literature. Each of the fragmental system can be produced in factory or site. If crosswise coupling beam reinforcements are fragmental, mounting becomes easier. Structural steel elements remaining within the coupling beam and structural steel elements remaining inside the structural wall shall be produced fragmentally and mounted onsite. Thus, cross wise reinforced coupling beams can be applied practically and constructed.

DESCRIPTION OF THE REFERENCE NUMERALS

Drawing 1. Cross wise Reinforcements Intended to Use in Turkish Earthquake Regulation to Meet Shearing Force and Bending Moment formed by This Force on the Coupling Beam (ABYYHY 2007)

Drawing 2. Diagonally Reinforced Coupling Beams (Eurocode8, 2004)

Drawing 3. Mounted Image from Coupling Beams of Coupled Shear Walls

Drawing 4. A Detail Outlook

Drawing 5. B Detail Outlook

Drawing 6. C Detail Outlook

Equivalents of the number of the parts indicated in the figures are given below.

1. Cross Bar
2. Connecting Plate
3. Anchor Handle
4. Vertical Handle

5. Horizontal Handle
6. Horizontal Anchor Handle

DETAILED DESCRIPTION OF THE INVENTION

The invention is characterized in that it consists of cross wise handle (1), connecting plate (2), anchor handle (3), vertical handle (4), horizontal handle (5), horizontal anchor handle (6) parts.

In the known technique, four reinforcements are required in cross wise reinforcement cluster and these reinforcements should be extended one and half times as clamping length towards the parts of the shear wall. Reinforcement clusters should be wrapped with special earthquake stirrups. There are splices of the wall of structural walls on the right and left surface of the coupling beam. Dense vertical reinforcements on the structural wall splices are wrapped with frequent interval stirrups. This becomes almost impossible to mount the cross wise reinforcements by embedding the cross wise reinforcement clusters wrapped with stirrups to the structural walls with dense reinforcement rate.

As a result of my studies in order to minimize the negative effects of the forces on the coupling beams exposed by the coupled structural walls due to horizontal forces such as seismic effects and wind effects and additionally vertical loads, ground effect, temperature changes and such loads; it was put forward to hold together structural steel elements as cross reinforcements (L profiles, U profiles, I profiles, T profiles, H profiles, H profiles, box profiles and pipe profile, L, U, I, T, H box and pipe profile plates) with structural steel elements designed as vertical and horizontal reinforcement and new reinforcements which provides opportunity to join the system with connecting elements such as screwed, bolted, high resistant bolted, riveted, smart secrewed, welded etc. among structural steel elements.

Two cross bars (1) at least are connected to rectangular, square, eclipse or circle shaped connecting plate with bolt, screw, smart screw, welding and similar connecting elements.

Structural steel elements which consist of cross bars (1), connecting plate (2), anchor handle (3), vertical handle (4), horizontal handle (5) and horizontal anchor handle (6) parts can be produced from L,U,I,H,T, box and pipe profile or L, U, I, H, T, box and pipe profile twist plate.

The invention is formed by mounting cross bars (1) which consists of L, U, H, T, I, box, pipe profile steel elements on one connecting plate (2) at least and connecting horizontal handle (5) and vertical handles (4) between the cross bars (1) with the mounting elements such as screw, smart screw, bolt, high resistant bolt, rivet, welding etc. after the connection of these cross bars (1) to four anchor handles.

Connecting plate (2) may be in convenient width, height and thickness, square, rectangular, oval and circle shaped in a way that it shall meet the incoming loads. Appropriate hole sor channels are left in order to connect the coupling beam cross wise reinforcements to the connecting plate (2). One or two of the cross wise reinforcements may be connected to the connecting plate by welding depending the ease of mounting. Coupling beam crosswise handles (1) are prepared from L, U, I, H, T, box, pipe profile or twist plate in accordance with the length of the beam. Vertical handle (4) and horizontal handle (5) consist of structural steel elements in appropriate sizes in order to prevent buckling of coupling beam reinforcements, make more stable and meet some of the inner forces. Prepared structural steel elements are placed in length, width and thickness appropriate for the project and in appropriate intervals and frequency. Suitable hole sor channels are left in order to ensure connection of vertical handle (4) and horizontal handles (5) with the crosswise handles (1). Anchor handles (3) are built from the structural steel elements in the length to provide sufficient anchor remaining within the wall. Vertical handles (4) and horizontal handles (5) are connected to anchor handles (3) through appropriate holes and channels in the number, frequency appropriate for the project.

Application of the invention; anchor handles (3) and horizontal anchor handles (6) are placed while preparing structural wall reinforcements (fixed, may be connected to wall reinforcements). Connection of crosswise handles (1) to anchor handles (3) with appropriate number of connecting elements (screw,

bolt, high resistant bolt, rivet, smart screw and welding etc.) and its sustainability. This is connected to connecting plate (2) with crosswise handle (1) connecting elements in number appropriate for the project. Vertical handle (4) and horizontal handle (5) are connected to cross bars (1) and anchor handles (3) with connecting elements through the appropriate hole and channels. Anchor handle is connected to all or several of the horizontal handles (5) joined between the cross bars (1) in a way that it shall enter inside the wall in order to increase embedment feature of the system in the number and feature appropriate for the project. Sequence of the structural steel elements to be joined according to ease of mounting.

A Standard shall be created with vertical handle (4), horizontal handle (5) and cross bars (1) to be formed using structural steel elements in coupling beams and much more secure, economic structures may be built for people living in the building resistant to the forces exposed due to the loads on the building or seismic forces.

In the event that reinforcements of coupling beams with the system described in our invention on the coupling beams of the coupled shear walls, more economic, more quickly constructed and more secure industrial structure systems can be created. Today coupling beams are constructed by passing crosswise reinforcements, formed like a column by wrapping dense stirrups, through the dense vertical reinforcements in the structural wall splices and embedding to the structural wall. Serious problems are encountered during the stages of construction of the crosswise reinforcements built like a column wrapped with frequent intervals, during the stages of reinforcement placement, concreting and pressing. Secure, industrial buildings shall be constructed minimizing the costs, without any difficulty of mounting, construction, without any density of reinforcement on the coupling beams formed using cross bars (1), connecting plate (2), anchor handles (3), vertical handles (4), horizontal handles (5) and horizontal anchor handles made of structural steel elements in our invention. Moreover, problems faced during the stages of reinforcement preparation, reinforcement placement, concreting and pressing because resistance to horizontal and vertical forces.

Workmanship costs and time loss is one of the serious problems economically and industrially as construction and placement of the crosswise reinforcements wrapped with stirrups specified in the regulations in construction of coupling beams of coupled shear walls. Industrial crosswise reinforcements in compliance with standards prevent workmanship and time loss as horizontal and vertical reinforcements become possible with our invention.

CLAIMS

1. Shear reinforcement system of coupling beams of coupled shear wall characterized in that it consists of two cross bars (1) at least, one connecting plate (2) at least, a vertical handle (4) at least, a horizontal handle (5) at least and a horizontal anchor handle (6) at least.
2. Crosswise handle according to claim 1; characterized in that it can be mounted in two pieces on the connecting plate (2).
3. Connecting plate (2) according to claim 2 characterized in that; it is the part combining cross bars (1) and maintaining sustainability.
4. Vertical handle (4) according to claim 1 characterized in that; it is the part placed between the cross bars (1) on the vertical axis.
5. Vertical handle (4) according to claim 1 characterized in that; it is the part meeting some part of inner forces coming to the coupling beams and decreasing the twisting length of cross bars (1).
6. Horizontal handle according to claim 1 characterized in that; it is the part placed between cross bars (1) on horizontal axis.
7. Horizontal handle according to claim 1 characterized in that; it is the part meeting some part of inner forces coming to the coupling beams and decreasing the buckling length of cross bars (1).
8. Anchor handle (3) according to claim 1 characterized in that it is the part ensuring continuality between the structural wall and cross bars (1).
9. Horizontal anchor handle (6) according to claim 1 characterized in that; it is the part ensuring continuality between the structural handle and horizontal handle (5).

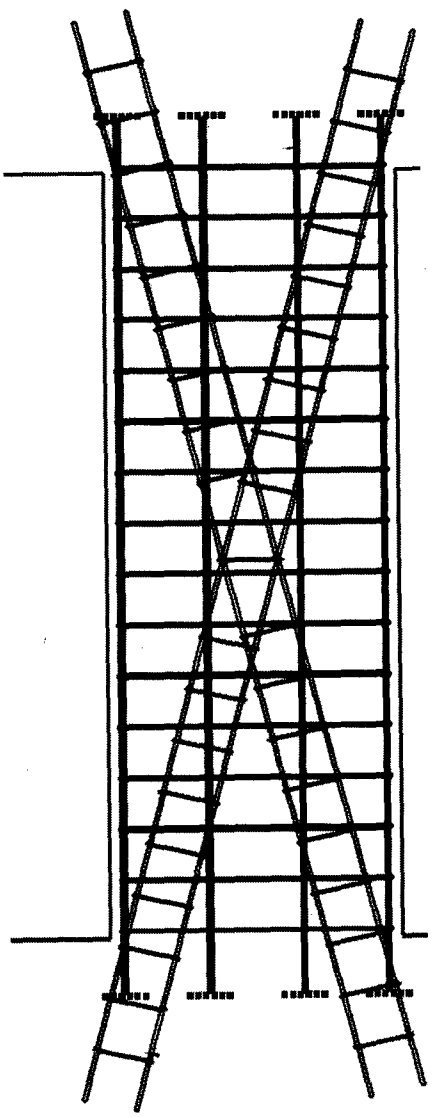

FIGURE 1

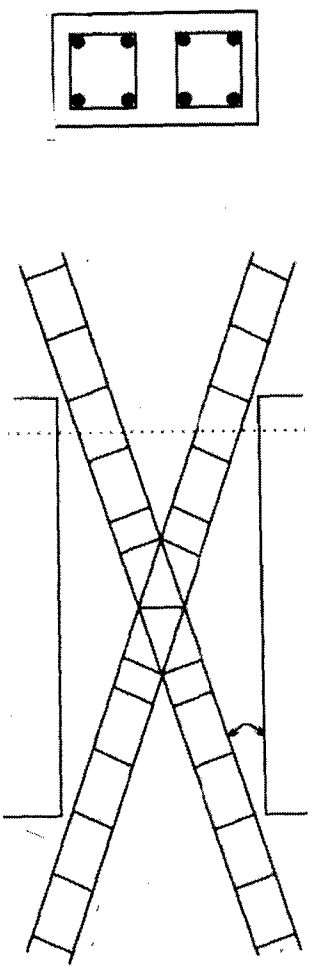

FIGURE 2

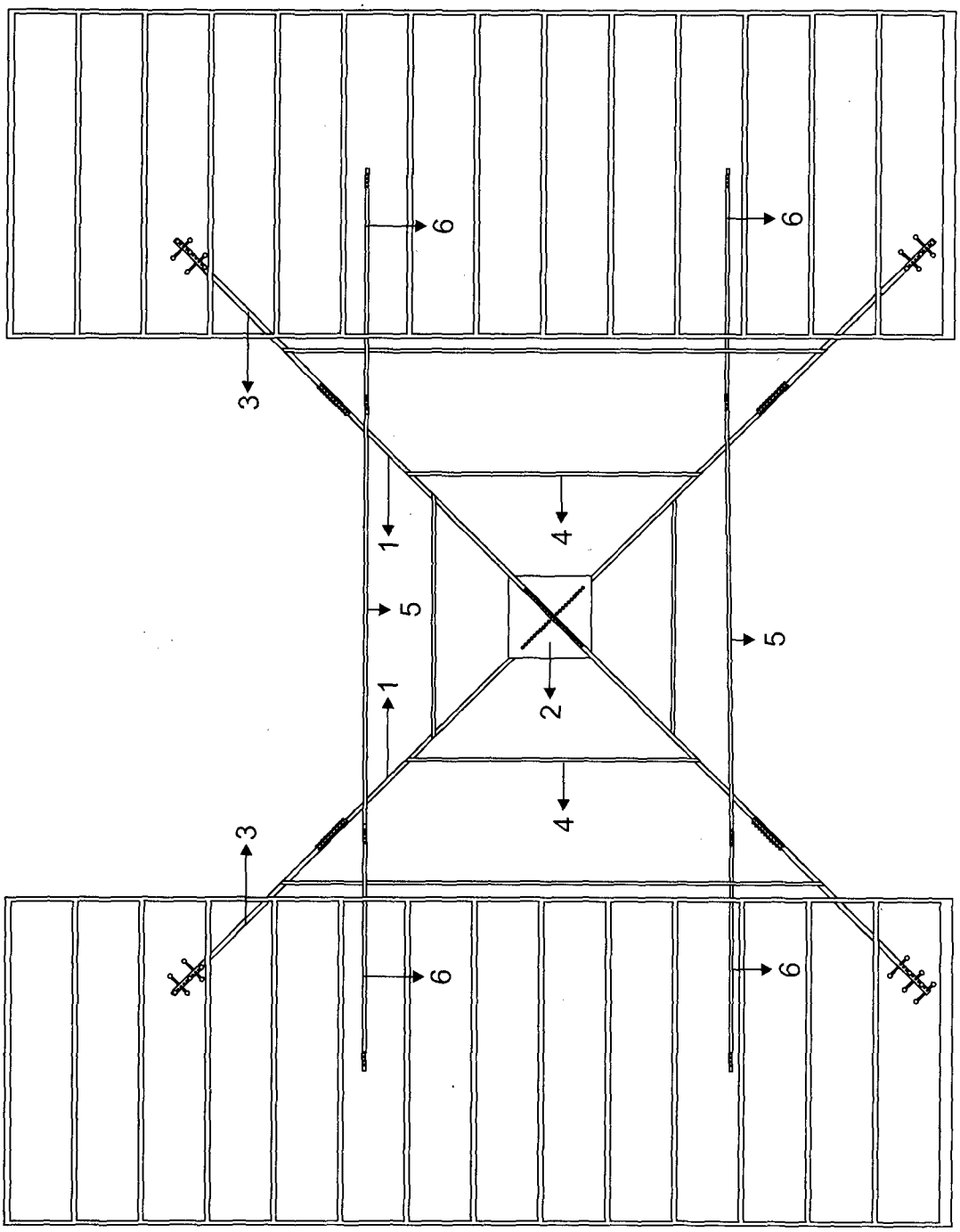

FIGURE 3

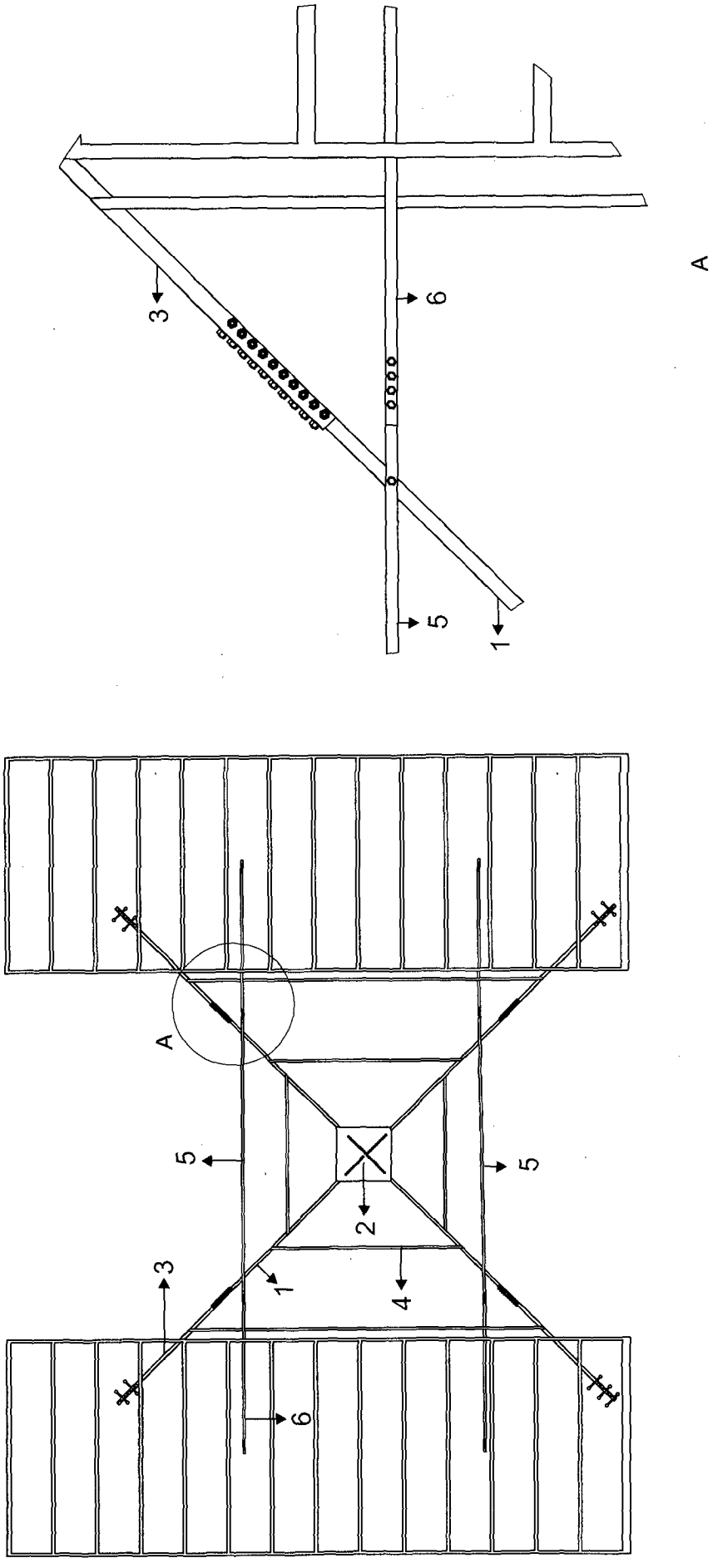

FIGURE 4

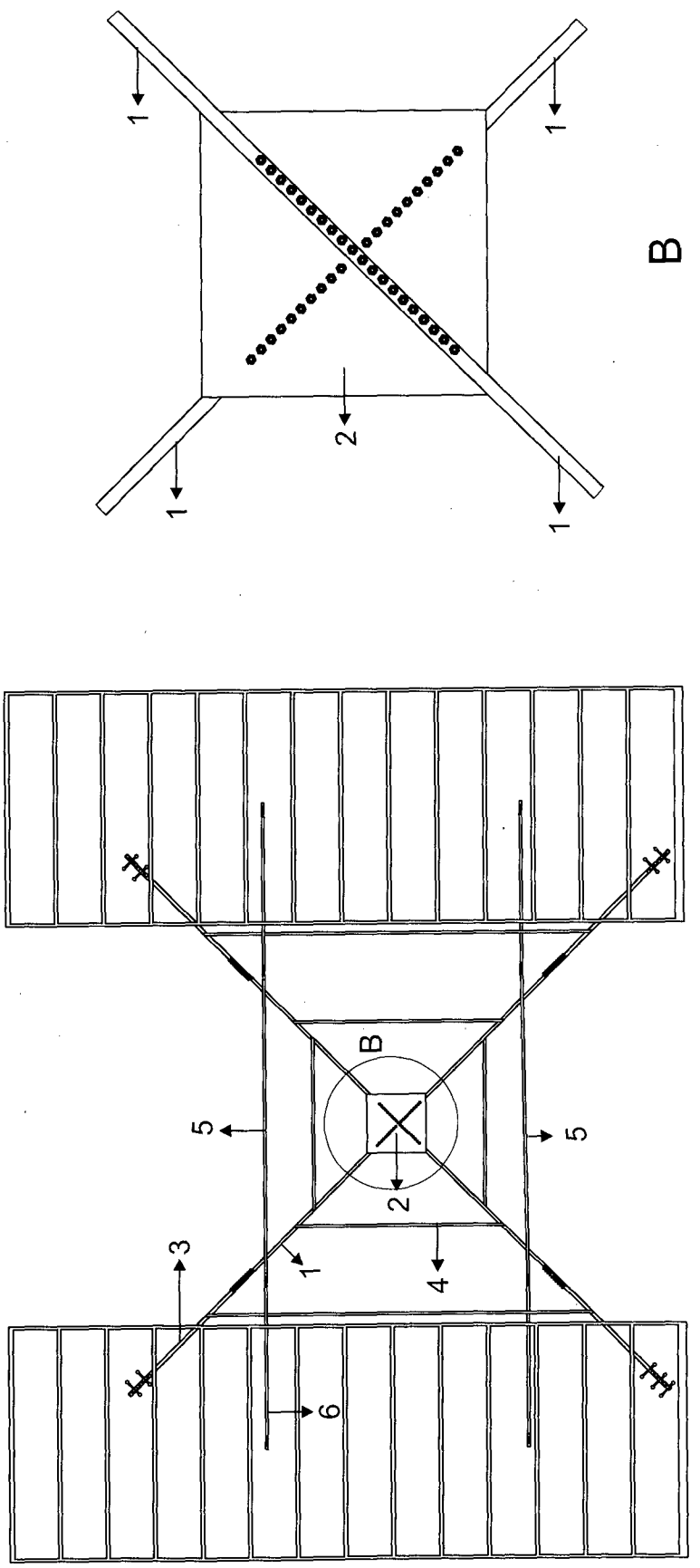

FIGURE 5

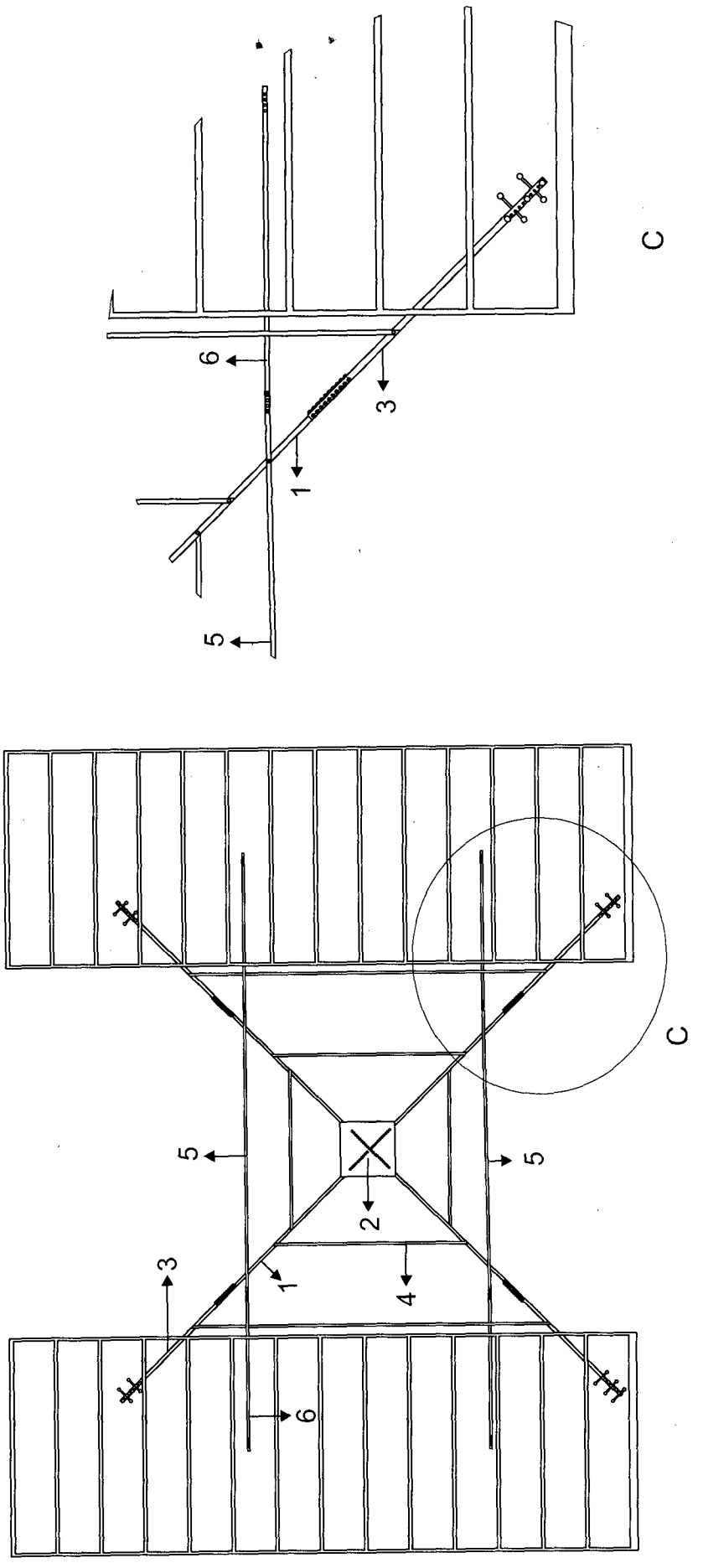

FIGURE 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/TR2014/000061

A. CLASSIFICATION OF SUBJECT MATTER
INV. E04C5/06 E04H9/02 E04B1/34 E04C5/04
ADD.

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)
E04C E04B E04H

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 201 343 782 Y (BEIJNG UNIVERSITY OF TECHNOLOGY) 11 November 2009 (2009-11-11) figures 1-3	1-9
A	US 3 512 329 A (F. DE BARBUAT) 19 May 1970 (1970-05-19) figures	1
A	US 7 934 347 B2 (BRIENEN) 3 May 2011 (2011-05-03) abstract; figures	1

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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Date of the actual completion of the international search	Date of mailing of the international search report
27 June 2014	04/07/2014

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Righetti, Roberto

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/TR2014/000061

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
CN 201343782 Y	11-11-2009	NONE	
US 3512329 A	19-05-1970	CH 459523 A	15-07-1968
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		GB 1189082 A	22-04-1970
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US 7934347 B2	03-05-2011	NONE	