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(54) **Structural node for steel-concrete composite truss joint**

(57) Apparatus for positioning and constraining metal beams to be used in the mixed steel-concrete structures, comprising constraint means integral with the beam to be constrained, at least an additional reinforcement, connecting means to constrain said constraint means to said additional reinforcement, characterized in that said constraint means and said additional reinforcement are configured so that they are constrained by means of said connecting means.

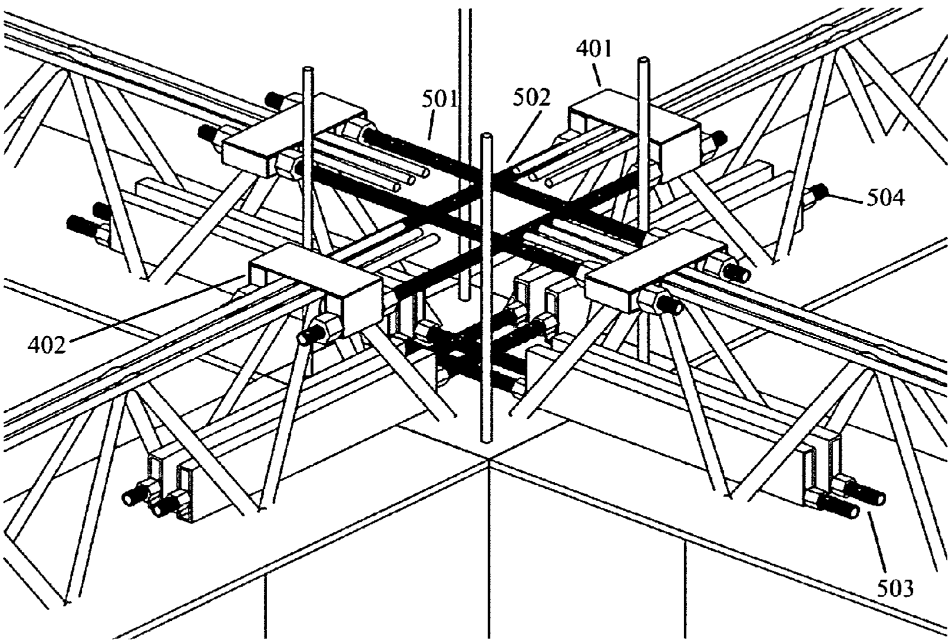

Fig. 7

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Description

[0001] The present patent application relates to a new kind of structural panel point for mixed steel-concrete reticular trusses. At the state of the art there are known some embodiments of panel points for mixed steel-concrete reticular structures, commonly used in the building field for realizing structures in reinforced concrete.

[0002] They are generally structures constituted by one or more prefabricated metal reticular trusses, which are assembled in a concrete casting realized in the building yard. The placement of such structures is provided firstly by the positioning of the prefabricated reticular truss and in the following by the realization of the concrete casting. Therefore, two phases of the useful life of such structures, commonly called phase 1 and phase 2, can be distinguished.

[0003] The phase 1 is the phase in which the resistance is provided totally by the steel lattice, which being self-supporting, has to resist to the floor and completing fluid concrete weight, to the weight of the additional reinforcement prearranged before the casting at the points stressed by negative moments and to accidental loads possible during the phase 1. The steel lattice, being subjected to each above described action, has to remain in an acceptable deformation field, which is expected and calculated in the project phase. In phase 2, instead, the resistance is provided by the structure formed by the steel lattice and by the concrete of the additional casting, which at the end of the curing, has developed the mechanical properties expected in the project phase. Since the additional casting of concrete is made on the entire deck, it is able to make the entire structure integral, thus providing a continuous beam assembly.

[0004] During phase 1, according to constructive systems known at the state of the art and commonly used in the building field, the prefabricated steel lattices coming from the workshops are rested, by means of suitable cranes, on the heads of pillars, thus realizing structures, statically schematizable as beams simply rested on the ends. A schematization of the static model of phase 1 applied to the embodiment of the mixed reticular trusses is shown in figure 1. As it can be noted, the kind of constrain considered at the intersection between beam and pillar is a support (1). On the beam a distributed vertical load (3) acts, which generates a not negligible maximum moment (4) in the middle of the beam between two adjacent supports (1).

[0005] During phase 2, consequently to the concrete curing, the reference static model for calculating stresses and deformations becomes that of a beam fixed to the ends, one schematization of which applied to the embodiment of the mixed reticular trusses known at the state of the art is shown in figure 2, where it can be noted how a support at the intersection between beam and pillar is no more provided, but it is provided a fixed end (2). Obviously, it is needed to provide structural continuity at the constraints, yet in during phase 1. Generally, in fact, on one pillar (21) more beams (11, 12, 13, 14) are rest, which can be arranged according to various directions as it is shown in figure 3. According to what is known at the state of the art, the structural continuity at the constraints is made possible by using bars (31, 31) with better bond coefficient, simply rested on the longitudinal reinforcements (111, 121, 131, 141) of the prefabricated beams (11, 12, 13, 14), resting on the same pillar. Such bars, said also additional bars, are positioned before the casting, and are normally bonded with binding wire to the beams to be bonded. In this way, when the concrete casting comes to curing, the reinforcements guarantee a continuity between the adjacent beams by means of known resistant mechanisms due to the adherence between steel and concrete.

[0006] The embodiments known at the state of the art, commonly used in works in ordinary reinforced concrete have many limits, mainly linked to the uncertainties inherent to the building yard operations. The correct positioning of the bars (31, 32) and the suitable anchorage of the same to the longitudinal reinforcements of the prefabricated beams, which guarantee their position also during the casting, are in fact fundamental requirements for the correct functioning of the structure. The work thus realized has to correspond in fact to the structural model provided in the project phase, according to which the resistance and deformation tests are carried out.

[0007] Yet referring to the uncertainties of the building yard operations, it is needed that the concrete thickness covering the additional reinforcements complies with the minimum dimensions provided by the regulations concerning the adopted calculating models, so that the desired resistant mechanisms can be developed. This implies particular attention during the concrete casting phase.

[0008] Moreover, as it is known, the adherence anchorage needs that a certain length percentage of reinforcement called "anchorage length" to be summed up with the one really resistant, is destined only to guarantee the starting of suitable resistant mechanisms. The calculating modes of the anchorage lengths of the bars with better coefficient bond are defined by the regulations on the basis of a series of project parameters. In the most recently regulations, such for example the New technical regulations on construction (NTC 2008) and the Eurocode 2, the trend is a substantial increase in the anchorage length. From figure 3 it is clear that the additional reinforcements (31, 32) are provided with a non negligible length.

[0009] The construction modes set by the kinds of beams now available on the market impose to calculate the stresses in a differentiated way in phase 1 and phase 2, applying then the principle of effects overlapping, in the hypothesis that the deformation in first and second phase are maintained in the elastic range. In particular, the calculation is carried out considering the metal structure in phase 2, pre-stressed by the loads of phase 1. Therefore, for the Ultimate limit state tests, the effects deriving from the phase 1 are considered as permanent actions (structural) in the load combinations of the phase 2. Such effects refer to the stresses and to the respective deformations. To carry out the calculations according to these hypotheses implies a significant computational load with, in addition, the need for the operators to carry out a double structural test for the two phases, changing each time the structural model and the reference loads.

[0010] In particular in the calculations of the stresses the structural model of the beam with simple supports at the ends in phase 1, shown in figure 1, implies that in the middle of the beam relevant stresses (4) are reached (maximum positive moment), on the basis of which the dimensioning of the lower plate (112, 122) of the prefabricated lattice is carried out. Such lower plate (112, 122) in phase 2, when the beam has the end constraints similar to fixed joints (2), whose rigidity is defined each time, results over-dimensioned.

[0011] Moreover, at the moment, the upper longitudinal reinforcements (111, 121) of the lattice (11, 12), which have to resist to compression during the phase 1, are practically inactive during phase 2 at the critical area of the beam. This means that the upper stringers of the lattice which have to resist to compression in phase 1 and to remain almost inactive to traction in the area interested in phase 2 are not optimally exploited. In synthesis, the current constructive modes force to over-dimensioning the metal reinforcements with respect to the loads to be effectively resisted in working phase.

[0012] Aim of the present invention is therefore to provide a structural steel panel point to be used in realizing mixed steel-concrete reticular structures, which while improving the constrain conditions of the structures in phase 1 allows not to over-dimension the metal reinforcements with respect to the loads to be supported in the working phase. Consequently, there results an important economical advantage, linked to cost reduction for purchasing, working and transporting the metal reinforcements.

[0013] Moreover there result other advantages linked to the elimination of the building yard uncertainties which impose to over-dimension the additional reinforcements, and to less computational load in testing the structure in phase 1 and phase 2.

[0014] These and other advantages will be highlighted in the following detailed description of the present invention, which refers to the appended drawings 1 to 8.

Figure 1 shows a scheme of the static model of the loads acting during the phase 1 on a mixed reticular structure realized according to techniques known at the state of the art.

Figure 2 shows a scheme of the static model of the loads acting during the phase 2 on a mixed reticular structure realized according to techniques known at the state of the art.

Figure 3 shows a structural panel point realized according to embodiments known at the state of the art.

Figure 4 shows a view of a preferred embodiment of the structural steel panel point according to the present invention, in which it is shown the assembly of lower bars.

Figure 5 shows a view of a preferred embodiment of the structural steel panel point according to the present invention, in which it is shown the assembly of upper bars.

Figure 6 shows two constrained beams with the structural panel point according to the present invention.

Figure 7 shows four cross-constrained beams with the structural panel point according to the present invention.

[0015] As yet said, the steel lattice (11, 12, 13, 14) arrive in the building yard according to the current constructive modes. After their positioning on the heads of the pillars (21), first the additional reinforcement (31, 32) are arranged and next the concrete casting is carried out.

[0016] As it is shown in figure 4 and figure 5, on the lattices comprising the steel panel point according to the present invention there are provided sections (40, 41) constrained to the metal lattices (11, 14) at the constraint of the same pillar (21). The sections (40, 41) are preferably in steel, and the constraint of these lattices (11, 14) occurs preferably by welding. In this way, the constraint of the section (40, 41) to the lattice (11, 14) can be carried out in the workshop and not in the building yard. The sections (401, 402, 411, 412) are arranged so that, once the two beams (11, 14) are arranged in their assembly position, through the sections (401, 402, 411, 412) of the two adjacent beams one or more threaded bars (50) can be introduced, which function as additional reinforcements. According to an assembly scheme particularly common in the building field, the threaded bars (50) can be arranged in parallel to the main axis of the lattice (11, 14), as shown in figures 4 and 5.

[0017] The constraint of the beams (11, 14) by using the structural panel point according to the present invention occurs, after the positioning of the same, by introducing the threaded bars (50) inside the sections (401, 402, 411, 412) constrained to the two beams (11, 14) and which are aligned when the same are in assembly position. On each threaded bar (50), before or after introducing the sections therein, a couple of nuts (51) are screwed for each section crossed by the bar (50).

[0018] The dimensions of the sections (401, 402, 411, 412), the nuts (51) and the threaded bars (50) have to be chosen so that the nuts (51) thread on the threaded bars (50) and the free space of the sections (401, 402, 411, 412) is such that the passage of the threaded bar (50) is possible, but not the one of the nut (51) screwed on the same. In this way, as it is shown in figure 6, the nuts (51) constrain the respective position of the threaded bars (50) with respect to the beams (11, 14) and, so, of the same beams the one to the other.

[0019] A feature of the sections (401, 402, 411, 412) is therefore to be hollow metal sections, preferably obtained by extrusion. As it can be noted by the comparison of the elements (401, 402) and (411, 412) in figure 4, their length can be strongly variable, and it can be convenient chosen by the engineer according to the load features of the projected work. Moreover, the shape of the sections can be preferably rectangular or square, as it is shown in figure 4, but other shapes are not excluded from the objects of the present invention, as for example the cylindrical one.

[0020] The unique obligation is that the arrangement of the sections (401, 402, 411, 412) with respect to the beams (11, 14) and their dimension are such that the assembly of the structural panel point is possible according to what above described. Moreover, the use of the threaded bars (50) allows to respect scrupulously the distances between the beams (11, 14) defined in the project phase, in addition to control the stress imposed to the reinforcement and to the structural elements by the constraint. In fact, it is sufficient to tighten the nuts (51) by means of a dynamometric key, in order to comply with the prescriptions about the tightening torque defined in project phase.

[0021] A plurality of sections (40, 41) can be constrained to the metal lattices (11, 14) to realize the structural panel point without departing from the scope of the present invention. According to a preferred embodiment, shown in figure 6, some sections are provided at the upper (111, 141) and lower reinforcements (112, 142) of the metal lattices (11, 14), but this aspect does not limit the possibility to arrange a different number of sections in positions different from what is shown. Similarly, the kind of lattice shown is to be intended only as a way of example and non limiting the aims of the present invention, which can be usefully applied on metal reinforcements of different shape or structure.

[0022] According to a preferred embodiment, shown in figures 4 and 5, the sections (411, 412) arranged at the lower reinforcements (112, 142) of the lattices (11, 14) can be positioned so that they project axially with respect to the same lattices, and they are usefully used as supports for a suitable positioning of the lattices (11, 14) on the heads of the pillar (21).

[0023] The use of the structural panel point according to the present invention allows to solve the limits of the structural panel points known at the state of the art, linked as said to the uncertainties during the phases of placement of the additional reinforcements. In fact, the upper (111, 121, 131, 141) and lower reinforcements (112, 122, 132, 142) of the beams (11, 12, 13, 14) realized to be constrained to the structural panel point according to the present invention are provided with well defined housings, constituted by the sections (401, 402, 411, 412), inside which the additional reinforcements (50), in this case by the threaded bars, are to be introduced and bolted.

[0024] Moreover the provision of the bolts (51), in addition to their possible controlled tightening, guarantees that during the casting phases the position of the beams (11, 12, 13, 14) and of the additional reinforcements (50) remains unchanged thus allowing to reproduce exactly in the building yard the structural model expected in calculating phase.

[0025] Moreover the threaded reinforcements (50) are active along their whole net length, calculated from the first to the last threaded bolt (51) thereon. This aspect allows to adopt shorter reinforcements, which are simply transportable and controllable, in addition to be cheaper with respect to what is known at the state of the art. It is not needed in fact, as occurs according to embodiments known at the state of the art, to over-dimension the length of the additional reinforcements (31, 32) to guarantee the adherence with the concrete.

[0026] Another advantage of the structural panel point according to the present invention is that it allows to use a continuous beam model in the calculating phase since the phase 1. Thanks to the threaded reinforcements (50) placed and bolted immediately after the positioning of the lattices (11, 12, 13, 14) on the pillars (21) and before the positioning of the floors and the concrete casting, it can be used in fact a calculating schematization with more rigid constraints then a simple support at the pillars. This allows to reduce the maximum moment (4) in the middle of the lattices (11, 12, 13, 14) and as a consequence to dimension in a more contained way the reinforcements of the same lattice. At the same time, on the pillar (21) a bending stress is generated which can be simply managed.

[0027] Moreover, as yet said, having since the phase 1 a continuous beam allows to carry out the calculation on a unique structural model with pre-stressed reinforcements, simplifying the calculations and diminishing the computational loads.

[0028] The provision of the reinforcements (40, 41) welded to the upper longitudinal reinforcements (111, 121, 131, 141) of the lattices (11, 12, 13, 14) allows to activate to traction said longitudinal bars, thus allowing the length of the additional reinforcements to be reduced at minimum.

[0029] Moreover, the configuration of the panel point in its different elements, allows to carry out easily the project following the local hierarchy principle of the resistances, allowing to carry out a correct dimensioning of the different elements according to the peculiarities of the structure used each time. Finally, the proposed solution, as it is clear in figure 7, solves the problem of the interaction between the upper (501, 502) and lower bars (503, 504) in case four beams coincide in the panel point. The use of the rectangular sections (401) allows to mount easily the bars of the primary beams (501, 503) and those of the secondary beams (502, 504) at different heights.

[0030] It is clear that what described can be realized with the most convenient material, for example carpentry steel or reinforced concrete steel.

Claims

1. Apparatus for positioning and constraining metal beams to be used in mixed steel-concrete structures, comprising:

- constraint means (401, 402, 411, 412) integral with the beam to be constrained (11, 12, 13, 14),
- at least an additional reinforcement (50, 501, 502, 503, 504)
- connecting means (51) to constrain said constraint means (401, 402, 411, 412) to said additional reinforcement (50, 501, 502, 503, 504)

characterized in that
said constraint means (401, 402, 411, 412) and said additional reinforcement (50, 501, 502, 503, 504) are configured so that they are constrained by means of said connecting means (51).

2. Apparatus for positioning and constraining metal beams to be used in reticular mixed steel-concrete structures according to claim 1, **characterized in that** said constraint means (401, 402, 411, 412) comprise at least a hollow section metal bar, welded to the beam, and positioned so that the axis of the bar is parallel to the axis of the beam.

3. Apparatus for positioning and constraining metal beams to be used in mixed steel-concrete structures according to claim 1 or 2, **characterized in that** said additional reinforcement (50, 501, 502, 503, 504) comprises at least a threaded bar and said connecting means (51) comprise nuts of such dimensions that they can be screwed on said threaded bar.

4. Apparatus for positioning and constraining metal beams to be used in mixed steel-concrete structures according to claim 3, **characterized in that** the dimensions of said threaded bar (50) and said hollow section metal bar (401, 402, 411, 412) are configured such that the threaded bar (50) can pass through the hollow section (401, 402, 411, 412), but the nuts (51) threaded on the threaded bar are greater than the opening of the section (401, 402, 411, 412).

5. Apparatus for positioning and constraining metal beams to be used in mixed steel-concrete structures according to any one of the preceding claims, **characterized in that** said constraint means (401, 402) integral with the beam to be constrained allow said additional reinforcement (50) to be positioned at different heights with respect to the same beam.

6. Metal beam (11, 12, 13, 14) to be used in the reticular mixed steel-concrete structures comprising the apparatus for positioning and constraining the metal beams according to any one of the preceding claims.

7. Metal beam according to claim 6, **characterized in that** the beam is configured such that when said beam (11) in positioned on the same assembly line of a second metal beam (14) according to claim 6, each of said constraint means (401, 411) is positioned so that it can be connected, by means of an additional reinforcement (50) constrained by means of said connecting means (51), to a corresponding constraint means (402, 412) integral with the second beam (14) to be constrained.

8. Metal beam according to claim 6, comprising at least two constraint means (401, 411) integral with the beam, positioned so that the additional reinforcements (50) constrained to said constraint means integral to the beam, are positioned at the upper reinforcements (111) and/or the lower reinforcements (112) of the beam (11).

9. Metal beam according to claim 7, **characterized in that** said constraint means (411) at the lower reinforcements (112) of the beam (11) project axially with respect to the same beam (11).

10. Method for realizing a structural panel point comprising at least two metal beams (11,14) according to any one of claims 5 to 8 to be constrained to a pillar (21), comprising the steps of:

- positioning the beams (11, 14) in their assembly position with respect to the pillar (21), possibly using as support said metal sections (411, 412) projecting from each beam at the lower reinforcements (112, 142),
- introducing one or more threaded bars (50) through each couple of sections (401, 402) (411, 412) which is in corresponding position to the two beams (11, 14) to be connected,
- constraining the threaded bars (50) to the metal sections (401, 402, 411, 412) by means of a couple of nuts (51) threaded on each threaded bar (50) at each section (401, 402, 411, 412),
- possible tightening of said nuts (51) by means of a dynamometric key so to guarantee a controlled traction stretch to the threaded bar.

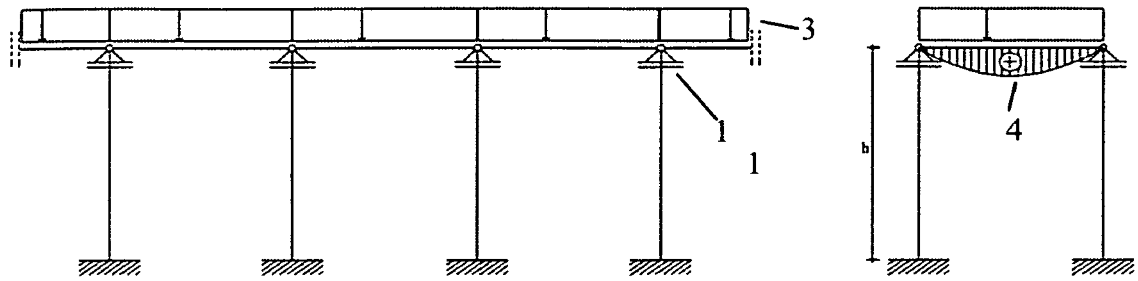

Fig. 1

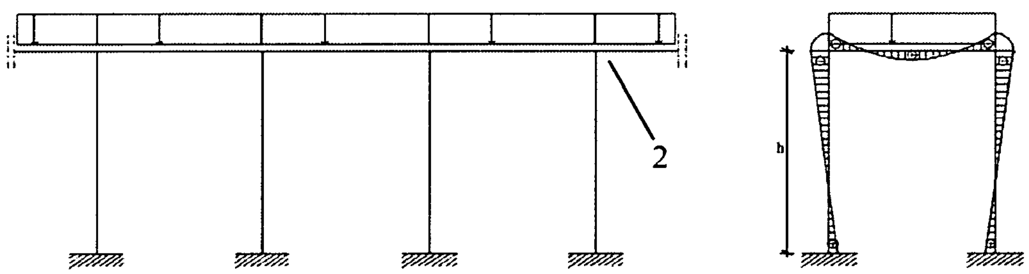

Fig. 2

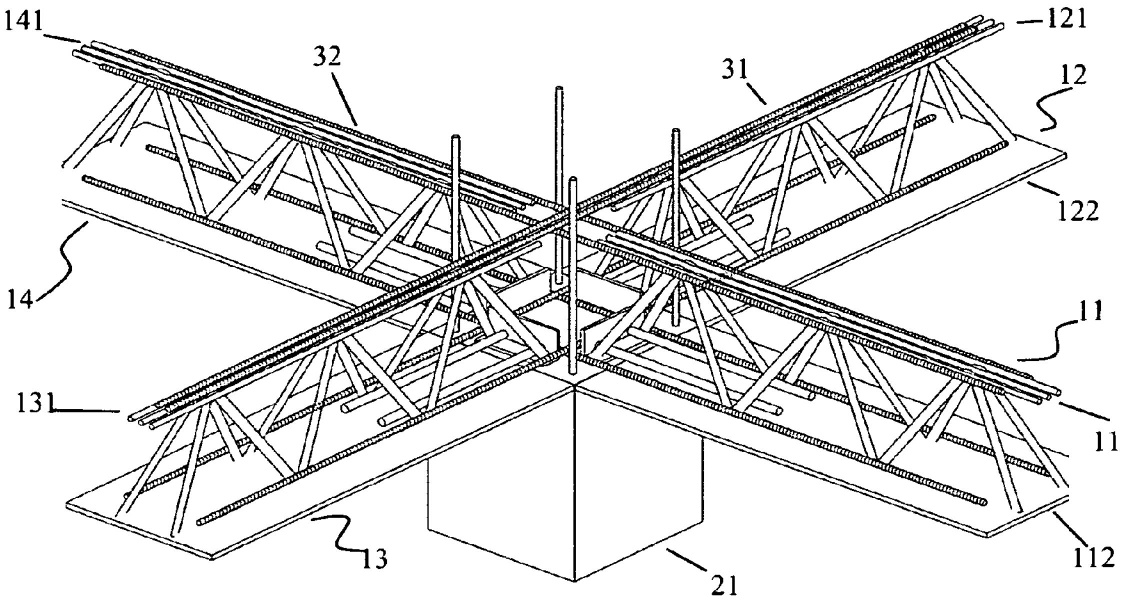
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Fig. 3

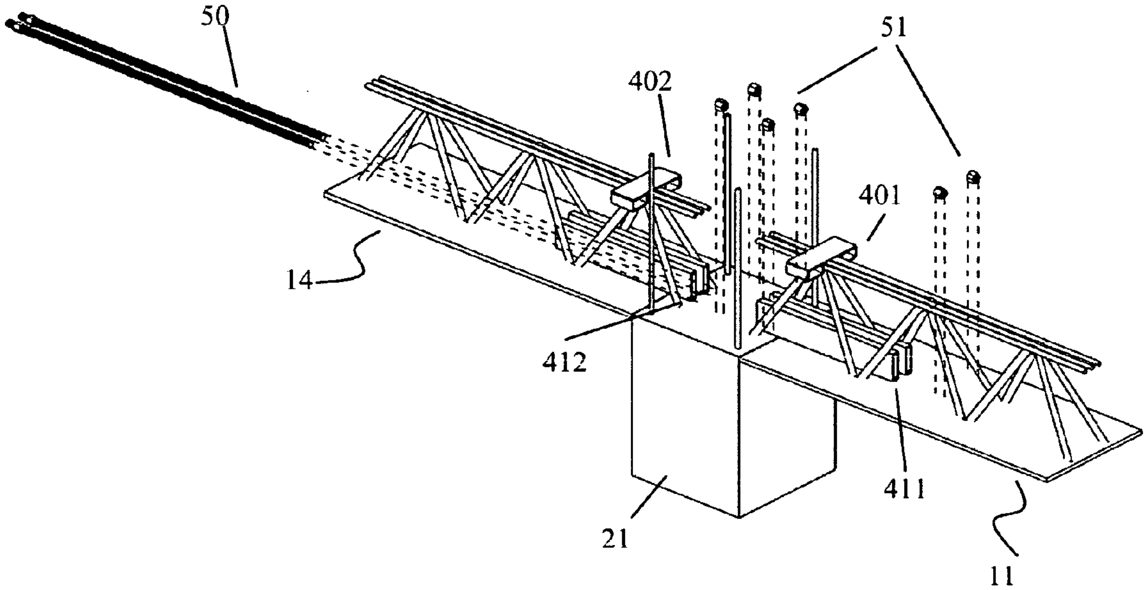
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Fig. 4

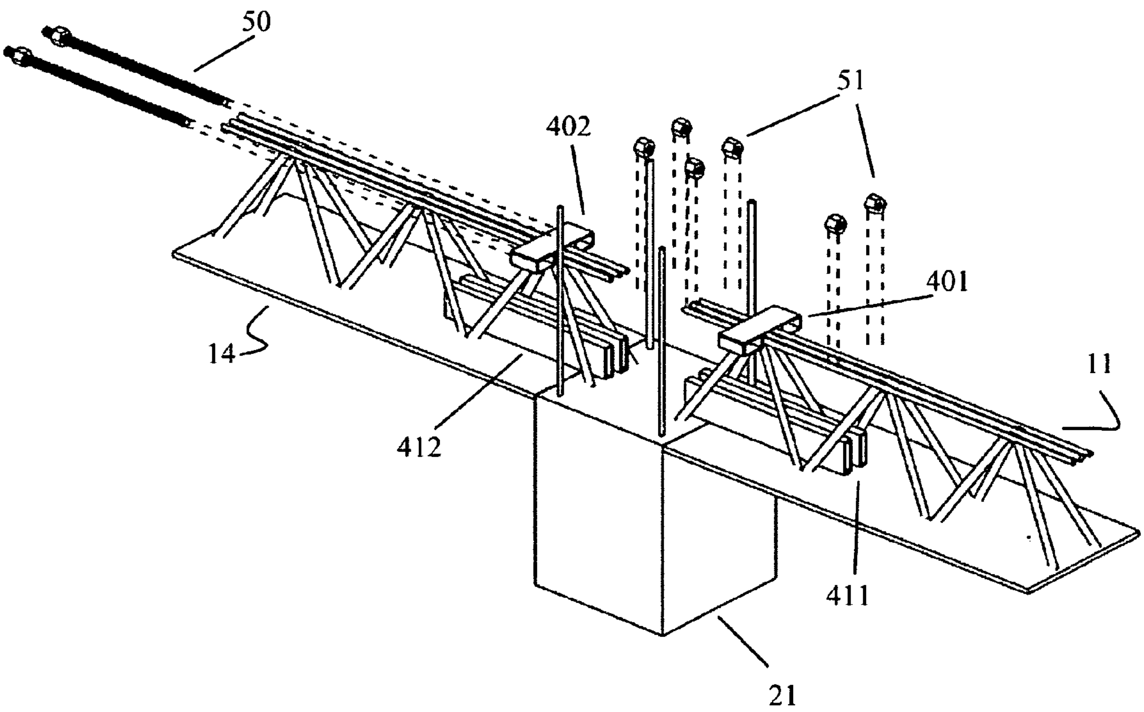

Fig. 5

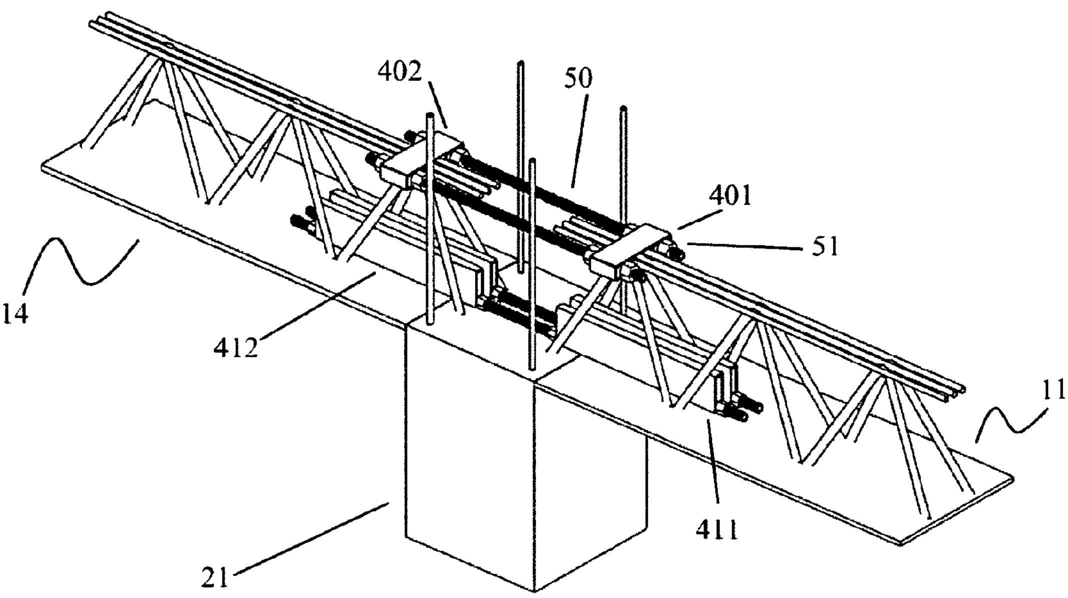

Fig. 6

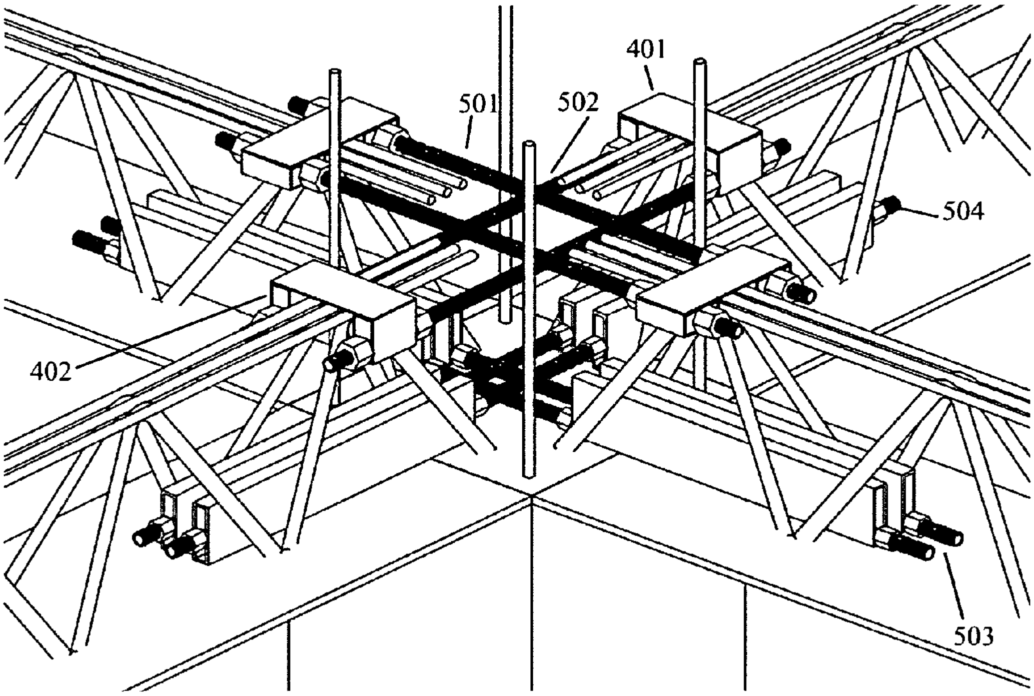

Fig. 7

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EUROPEAN SEARCH REPORT

Application Number
EP 11 42 5262

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E04B
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	28 March 2012	Demeester, Jan

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