(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 792 845 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
22.10.2014 Bulletin 2014/43

(51) Int Cl.:
E21D 11/08 *(2006.01)*

(21) Application number: **14163683.7**

(22) Date of filing: **07.04.2014**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(30) Priority: **08.04.2013 IT RM20130207**

(71) Applicant: **RECC - Rebar and Concrete Composites S.R.L.**
84012 Angri (SA) (IT)

(72) Inventor: **VAGO, Giuseppe**
84012 Angri (SA) (IT)

(74) Representative: **Fiammenghi, Eva et al**
Fiammenghi - Fiammenghi
Via Quattro Fontane, 31
00184 Roma (IT)

(54) **Reinforcement net for ashlars in the construction of galleries**

(57) Ashlar (1) for galleries, comprising the matrix (2) made of concrete; the three-dimensional reinforcement (3), inside said ashlar (1) and made of metallic and/or polymer and/or composite material, characterized in that it internally comprises at least one curved, rigid and two-dimensional net (4), made of composite material and adapted to reinforce the front face (5) of the ashlar (1).

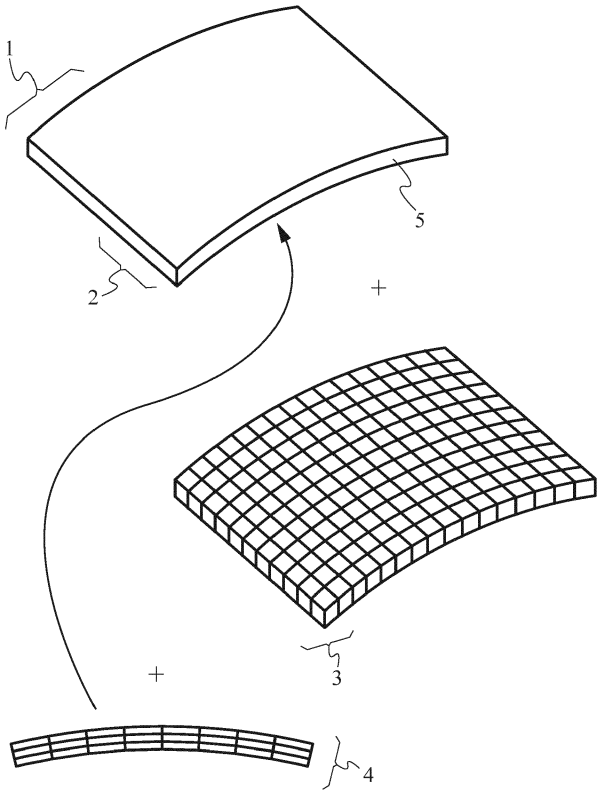

Fig. 1

EP 2 792 845 A1

Description

Field of the art

[0001] The present invention refers to the field of prefabricated structures made of concrete for the construction of galleries. More in detail, the present invention refers to the application of a new structural component, made of composite material, to be applied to the front face of the prefabricated ashlar for galleries, adapted to prevent cracking of the concrete during the advancing of the TBM. The present invention also refers to the product resulting from such application, i.e. to ashlars with a reinforcement, for the front face of the ashlar, made of composite material.

State of the art

[0002] The use of composite materials in many different fields has been known for many years, in particular in all those fields of application where it is necessary to meet low weight and high mechanical performance requirements. One example is given by the widespread use of composite materials in the automobile, naval and aeronautical field, for obtaining components such as: body panels, fuselage boats, wing structures, motor parts, and for obtaining many other components, also in fields such as sports, medicine and piping plant design.

[0003] One of the most widespread composite materials is fiberglass which, due to its excellent properties of lightness, solidity and stress resistance, has been applied in a great number of fields since the 1950s. In addition, given its considerable structural stability, and its chemical - physical properties, resulting from the combination of its constituent substances, fiberglass demonstrates considerable chemical inertia that has contributed to its application also in environments that generally promote corrosion when in contact with structures having substantially metallic character. For example, fiberglass is widely used for obtaining pipes in marine environments. The effects of the interaction between the surrounding environment and a use material are of undoubted relevance for the selection of a material in some applications - even if more importance is often given to the mechanical properties that the used material must possess in order to accomplish a specific function. In the excavation of galleries, for example, the walls made of concrete, obtained with the technique that uses the Tunnel Boring Machine (acronym TBM), are made in an automatic manner, by using previously-fabricated arch segments made of reinforced concrete, which are then positioned and forced by the TBM in a manner so as to obtain complete covering rings. Said arch segments, commonly known as "ashlars", are generally made of concrete and reinforced with a metallic reinforcement, thus obtaining a piece made of reinforced concrete.

[0004] In the lifetime of the ashlar, the most critical phase, in which the ashlar is most stressed, is that of the TBM advancement. In this phase of the excavation, the head of the TBM must be abutted by means of the thrust jacks against the front face of the ashlars, in a manner so as to obtain the necessary reaction to the advancing stresses. At this particular moment, the front face of the ashlar is subjected to concentrated and poorly distributed stresses, exerted by the jacks of the TBM, which must exert force on the ashlar in order to obtain the necessary opposition to the advancement. Such operation is hard to control, also due to the difficult working conditions in galleries, such that, during this operation, the ashlar is very often severely damaged, cracked and/or chipped/broken.

[0005] In order to prevent all these drawbacks, it would be necessary to increase the reinforcement of the ashlar, usually made of metal, in proximity to the thrust zone by positioning it as close as possible to the surface of the ashlar, nearly eliminating the concrete cover.

[0006] This cannot be actuated with a steel reinforcement, for example, since the lack or reduction of such concrete cover would in short time lead to the deterioration of the reinforcement itself due to the corrosion thereof. The oxidation of the metallic reinforcement, in addition to causing a decrease of strength thereof, with the swelling thereof would also cause the breakage and ejection of concrete pieces.

[0007] For such purpose, the present invention described in detail hereinbelow proposes as solution to the aforesaid problems the use - in addition to the conventional three-dimensional reinforcement inside the ashlar - of a further structural component, hereinbelow indicated as "curved and rigid net", made of composite material and already two-dimensionally curved. Such net is to be applied inside the ashlar, in accordance with the front face of said ashlar. Said rigid net, already curved in accordance with the radius of the gallery, due to its chemical - physical and mechanical properties allows reinforcing the front wall of the ashlar, both in the presence of a minimal concrete cover and in the absence of said concrete cover. Substantially, this result is obtained due to the good chemical inertia of said net, such to ensure that it is not subject to oxidative processes and the consequent problems connected therewith.

Description of the invention

[0008] The present industrial invention patent application describes a new ashlar type for galleries, which is characterized in that it internally comprises a further reinforcement component, in addition to the conventional reinforcement inside the ashlar. Said additional component is made of composite material and is represented by a rigid net structure, already curved in the two-dimensional plane, made of composite material and preferably of fiberglass. Said rigid and curved net is also represented by a monolithic structure or, alternatively, by a plurality of bars that are already curved, suitably assembled together in order to give rise to said rigid and curved net.

[0009] An important aspect of the present description is also given by the fact that the curved net in question, due to its constituent materials, is not corroded by the potentially-aggressive external environment, even when positioned very close to the external surface of the front face of the ashlar.

[0010] **The present invention therefore intends to describe and claim:** ashlars comprising, in addition to the internal reinforcement, at least one curved and rigid net, made of composite material, to be applied inside the ashlar in proximity to the front face of said ashlar; said curved and rigid net; as well as the use of said curved and rigid net for the surface reinforcement of said ashlars.

[0011] More in detail, the ashlars, object of the present description, comprise a matrix made of concrete, reinforced with: a three-dimensional reinforcement, made of metallic or composite material; and with a further reinforcement element, represented by at least one two-dimensional curved and rigid net made of composite material and preferably of fiberglass. Said net is suitable for fulfilling the role of surface reinforcement structure of the front face of the ashlars, during the TBM advancing operations.

[0012] Still more in detail, said rigid and curved net is represented by a monolithic or assembled structure, adapted to ensure the necessary resistance to the thrust of the jacks during the positioning of the ashlar and during the advancing of the TBM. In addition, all the curved or straight sections identifiable in the net in question - both in the case of sections of a monolithic structure and in the case in which said net results from the assembly of a plurality of curved bars - have in the many different embodiments of the invention a cross section defined by any one closed curve or polygonal form, but preferably have a cross section with circular profile. Said sections of curved or straight bars also have a resistant section comprised between 12 mm^2 and 200 mm^2.

[0013] The fiberglass used for obtaining the described net is not the only composite material employable for the purpose of the invention. In particular, said rigid and curved net can comprise, as structural material, a composite material comprising carbon fibers, and/or aramid fibers and/or basalt fibers and/or the like.

[0014] A further aspect characterizing the present invention is given by the fact that the rigid and curved net is applied *in situ* during the production of the ashlar. More in detail, the rigid and curved net is correctly arranged inside the ashlar in a manner so as to be configured parallel to the surface of the internal reinforcement close to the external face of the ashlar that one intends to reinforce. This condition is obtainable due to the mold used for obtaining the ashlar, and more in detail due to the lateral walls of said mold. Still more in detail, the rigid and curved net, at the time of its positioning in the ashlar, is initially situated affixed on the lateral surface of the formwork, near the surface of the ashlar to be reinforced. The curved and rigid net is also stably positioned due to common pins or hooks integrated with the lateral surface of the formwork, on which said net is laid. The rotary movement of the lateral surface of the mold allows conducting the net into the desired position, i.e. parallel to the reinforcement surface close to the front face of the ashlar being produced. The subsequent casting of the concrete, hardening of the latter and removal from the mold ensure that the present curved and rigid net remains in the pre-established position. In particular, for the applications of interest for the invention, said curved and rigid net is positioned inside the ashlar in a manner so as to lie at least 0.1 cm from the front face of said ashlar. In addition, said rigid and curved net does not contact the reinforcement surface, to which it is parallel.

Brief description of the drawings

[0015]

FIGURE 1 shows an exploded view of the ashlar 1, object of the present industrial invention patent application. Figure 1 shows that said ashlar 1 comprises: the matrix 2 made of concrete, the three-dimensional reinforcement 3 inside the ashlar 1, and the rigid, curved and two-dimensional net 4, to be applied inside said ashlar 1 parallel to the front face 5 of said ashlar 1, in a manner so as to protect and reinforce said face 5, the latter usually being subjected to strong thrusts during the TBM installation and advancing processes.

FIGURE 2 shows a front and detailed view of the curved, rigid and two-dimensional net 4, object of the present invention. More in detail, the figure under examination shows that the single curved or straight sections 7, identifiable on said net 4, have a cross section defined by any one closed curve or polygonal form.

FIGURE 3 shows a front and detailed view of the rigid, curved and two-dimensional net 4, according to a particular embodiment of the invention. More in detail, the figure shows the case in which said net 4 results from the assembly of a plurality of bars, already curved, made in composite material and preferably made of fiberglass. Still more in detail, figure 3 shows that the curved net 4 is obtained from the assembly of longitudinal curved bars 6 and transverse straight bars 6', joined together, by way of a non-limiting example by means of binding (Fig. 3 (a)) or by means of gluing (Fig. 3 (b)).

FIGURE 4 shows a front and detailed view of the curved and rigid net 4 in a particular embodiment of the present invention.

[0016] More in detail, figure 4 (a) shows that on said rigid and curved net 4, the single identifiable sections 7 have variable center distances. This result is obtainable

both in the case in which the net 4 is obtained from the assembly of bars 6 and 6' variously spaced from each other, and in the case in which the net 4 represents a monolithic structure obtainable with a mold from the predefined profile. Figures 4 (b) and 4 (c) instead intend to emphasize that the sections 7 identifiable on the net 4 and made of composite material can have improved adherence, respectively obtainable with sand filler 8 or with reliefs 9.

Description of the preferred embodiments

[0017] In all embodiments of the invention, object of the present industrial invention patent application, the ashlar 1 comprises a matrix 2, typically made of concrete, a three-dimensional internal reinforcement 3 adapted to reinforce the entire ashlar, and is characterized in that it comprises, always internally, at least one rigid, curved and two-dimensional net 4, placed parallel to the front face of said ashlar 1, i.e. parallel to the front face 5 of the ashlar 1, which is generally subjected to the thrusts of the jacks of the machinery used for installing said ashlars, and for advancing the TBM during the construction of tunnels such as road and train galleries. Said ashlars 1 are also characterized in that said curved and rigid net 4 is made of composite material, and preferably of fiberglass.

[0018] Said curved and rigid net 4, also object of the present invention, is further represented in one of its embodiments by a monolithic structure, i.e. constituted by a single piece of composite material, or alternatively by the assembly of bars, made of composite material, suitably assembled together. More in detail, in the latter case, the net 4 results, from the assembly of longitudinal curved bars 6 and transverse straight bars 6', joined together with mechanisms of known type, for example for binding, using common straps, or by means of gluing. In addition, in the case in which the curved net 4 is obtained by joining a plurality of curved bars 6 and straight bars 6', the bars can be variously spaced from each other, in a manner so as to be able to identify sections 7 of various length. The same result can also be obtained in the case of sections of monolithic net 4. In this case, the mold used for obtaining said monolithic structure will have the profile adapted for obtaining the predefined monolithic net 4. The curved 6 and straight 6' bars used, and in any case the sections 7 identifiable in said net 4, have a cross section defined by any one closed curve or polygonal form and preferably a cross section defined by a circular profile. Said sections 7 also have a resistant section comprised between 12 mm^2 and 200 mm^2.

[0019] The fiberglass used for obtaining said curved, rigid and two-dimensional net 4 is not necessarily the only material employable for the role that said net 4 must accomplish. By way of a non-limiting example, composite materials can indeed be used comprising carbon fibers and/or basalt fibers and/or aramid fibers and/or doped composite materials with the purpose of obtain improved adherence, for example by means of sand filler 8 and/or by means of reliefs 9, obtained during the production process without any removal of resistant material.

[0020] As mentioned above, a further characterizing aspect of the present invention is given by the fact that the curved and rigid net 4 is inserted inside the ashlar 1 during the production of said ashlar, due to the employed mold. More in detail, said net 4 is carried, with a rotary movement, from the lateral surface of the formwork, on which it is initially affixed, into a parallel orientation with respect to the reinforcement surface close to the front face 5 to be protected of the ashlar 1, as well as parallel to said front face 5, which will be formed once the concrete subsequently poured on the reinforcement 3 has hardened.

[0021] Said curved, rigid and two-dimensional net 4 is also placed inside the ashlar 1, in a manner so as to lie at least 0.1 cm from the front face 5 of said ashlar 1, and preferably from 0.1 cm to 6 cm from such face. In addition, said curved net 4 is arranged inside the ashlar in a manner such that it is not in contact with the reinforcement 3 inside the ashlar 1. More in detail, said curved net 4 lies at least 0.1 cm from the reinforcement surface 3 close to the front face 5 of the ashlar.

[0022] The ashlars 1, object of the present invention, further internally comprise a strengthening reinforcement 3 which is typically made of metallic material, but which can alternatively be made of composite material.

[0023] The claimed curved and rigid net 4 must instead be made of composite material and preferably of fiberglass, in order to exploit the substantial chemical inertia of said materials against corrosive agents, or in any case against oxidizing agents, to which the metallic structures conventionally used for reinforcing the ashlars in galleries are usually subjected.

Claims

1. Ashlar (1) for galleries, comprising the matrix (2) made of concrete; the three-dimensional reinforcement (3), inside said ashlar (1) and made of metallic and/or polymer and/or composite material, **characterized in that** it internally comprises at least one rigid, curved and two-dimensional net (4), made of composite material and adapted to reinforce the front face (5) of the ashlar (1).

2. Ashlar (1) for galleries according to the preceding claim, **characterized in that** the rigid, curved and two-dimensional net (4) is arranged, inside said ashlar (1), with curvature analogous to the curvature of the ashlar (1), and parallel to the front face (5) of said ashlar (1) and lies at least 0.1 cm from said face (5), preferably 0.1 cm to 6.0 cm from said face (5).

3. Ashlar (1) for galleries according to the preceding claim, **characterized in that** the rigid, curved and

two-dimensional net (4) is arranged parallel with respect to the surface of the reinforcement (3) close to said face (5) and lies at least 0.1 cm from said surface of the reinforcement (3).

4. Ashlar (1) for galleries according to the preceding claim, **characterized in that** the rigid, curved and two-dimensional net (4) is represented by sections having variously profiled cross section, said net (4) being defined by a plurality of sections (7) having a cross section defined by any one closed curve or polygonal form.

5. Ashlar (1) for galleries according to the preceding claim, **characterized in that** said sections (7) have a resistant section comprised between 12 mm^2 and 200 mm^2.

6. Ashlar (1) for galleries according to the preceding claim, **characterized in that** the rigid, curved and two-dimensional net (4) is obtained from the assembly of longitudinal bars (6), already curved and made of composite material, and straight transverse bars (6') made of composite material.

7. Ashlar (1) for galleries according to the preceding claim, **characterized in that** the assembly of the curved longitudinal bars (6) and straight transverse bars (6') occurs by means of gluing or by means of binding.

8. Ashlar (1) for galleries according to claims 1 to 5, **characterized in that** the rigid, curved and two-dimensional net (4) is represented by a monolithic composite structure.

9. Ashlar (1) for galleries according to any one of the preceding claims, **characterized in that** the rigid, curved and two-dimensional net (4) is made of fiberglass.

10. The rigid, curved and two-dimensional net (4), **characterized in that** it has the characteristics of the net (4) comprised in the ashlars (1) according to any one of the preceding claims, and **in that** it is inserted inside the ashlar (1) at the time of production of said ashlar (1) due to the rotary movement of the lateral surface of the formwork on which said net (4) is initially placed.

11. Use of the rigid, curved and two-dimensional net(s) (4) according to the preceding claim for the reinforcement of the front face (5) of the ashlars during the installation thereof in the construction of galleries.

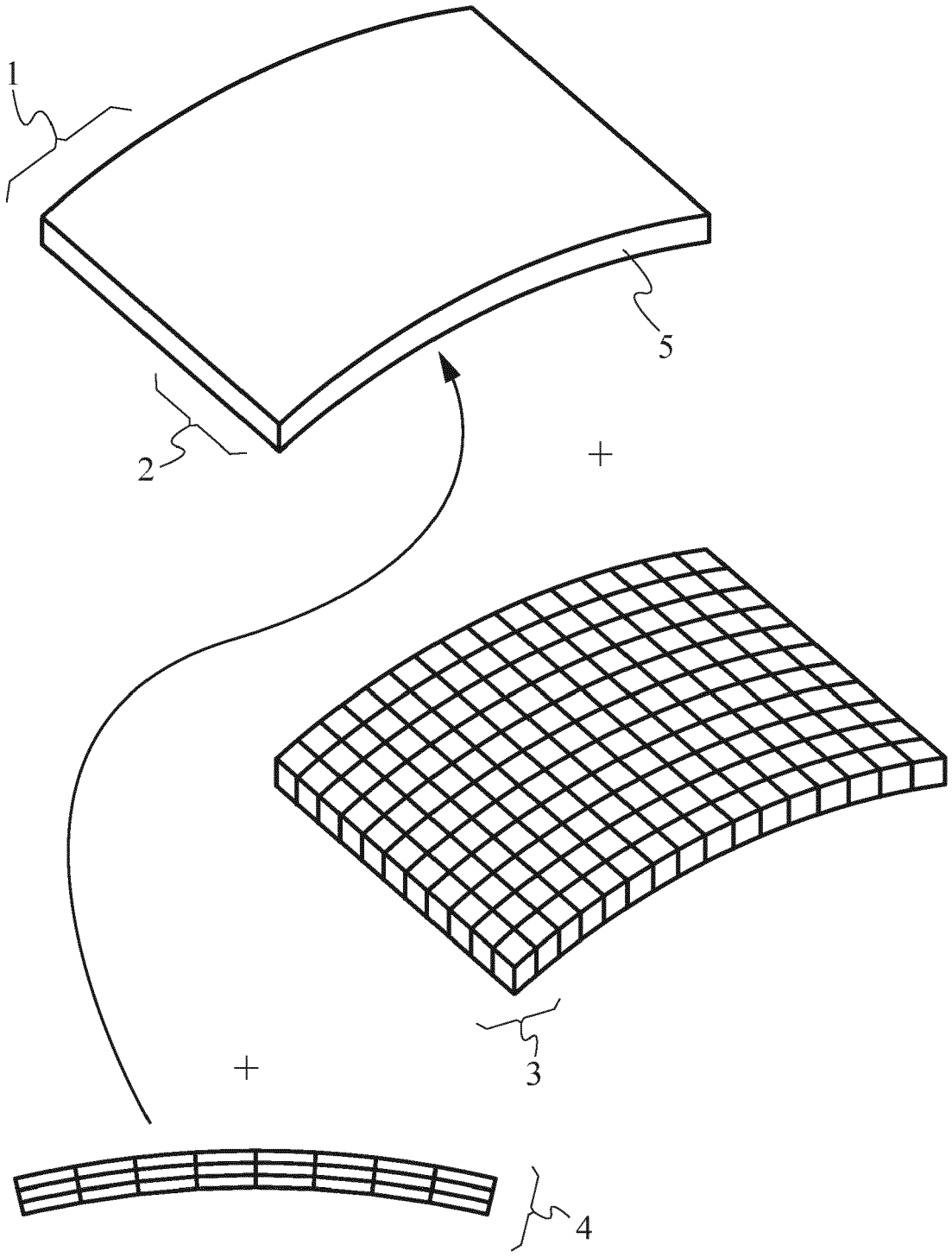

Fig. 1

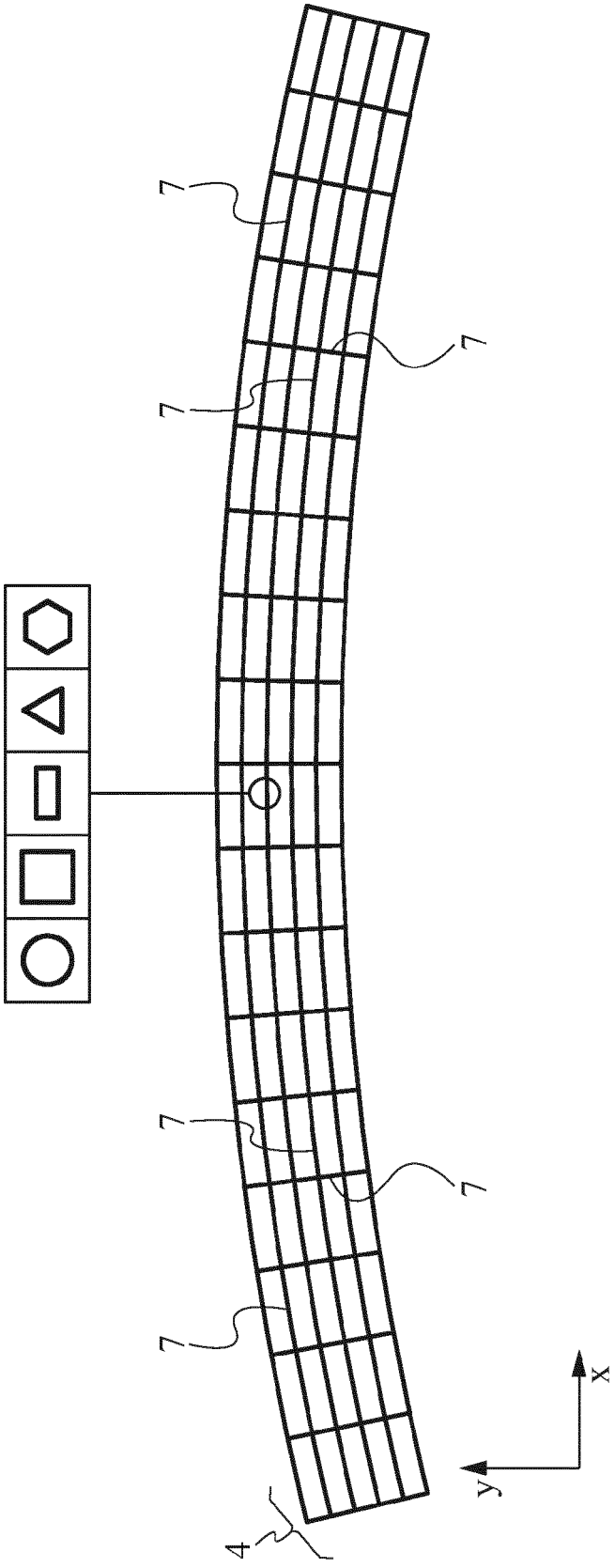

Fig. 2

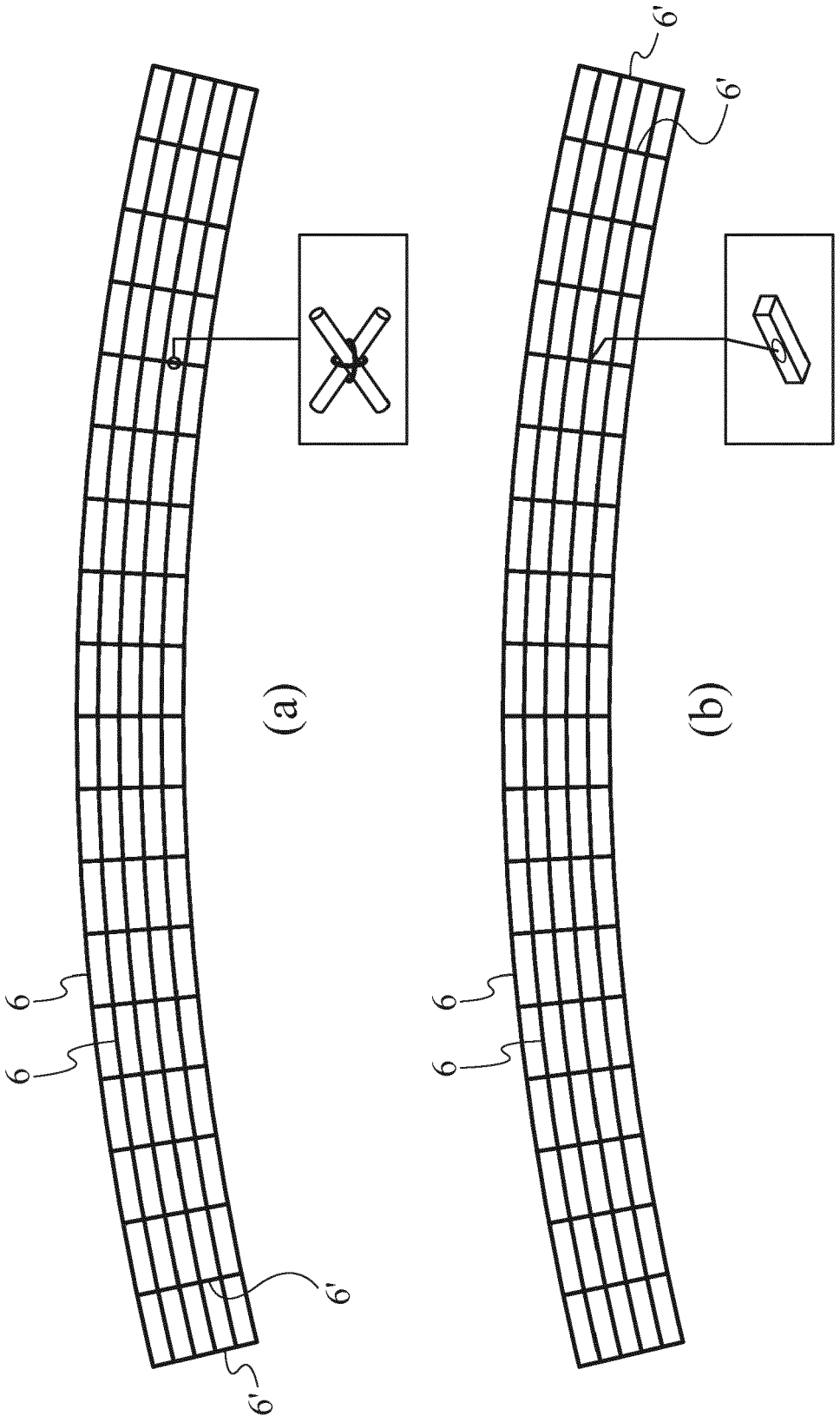

Fig. 3

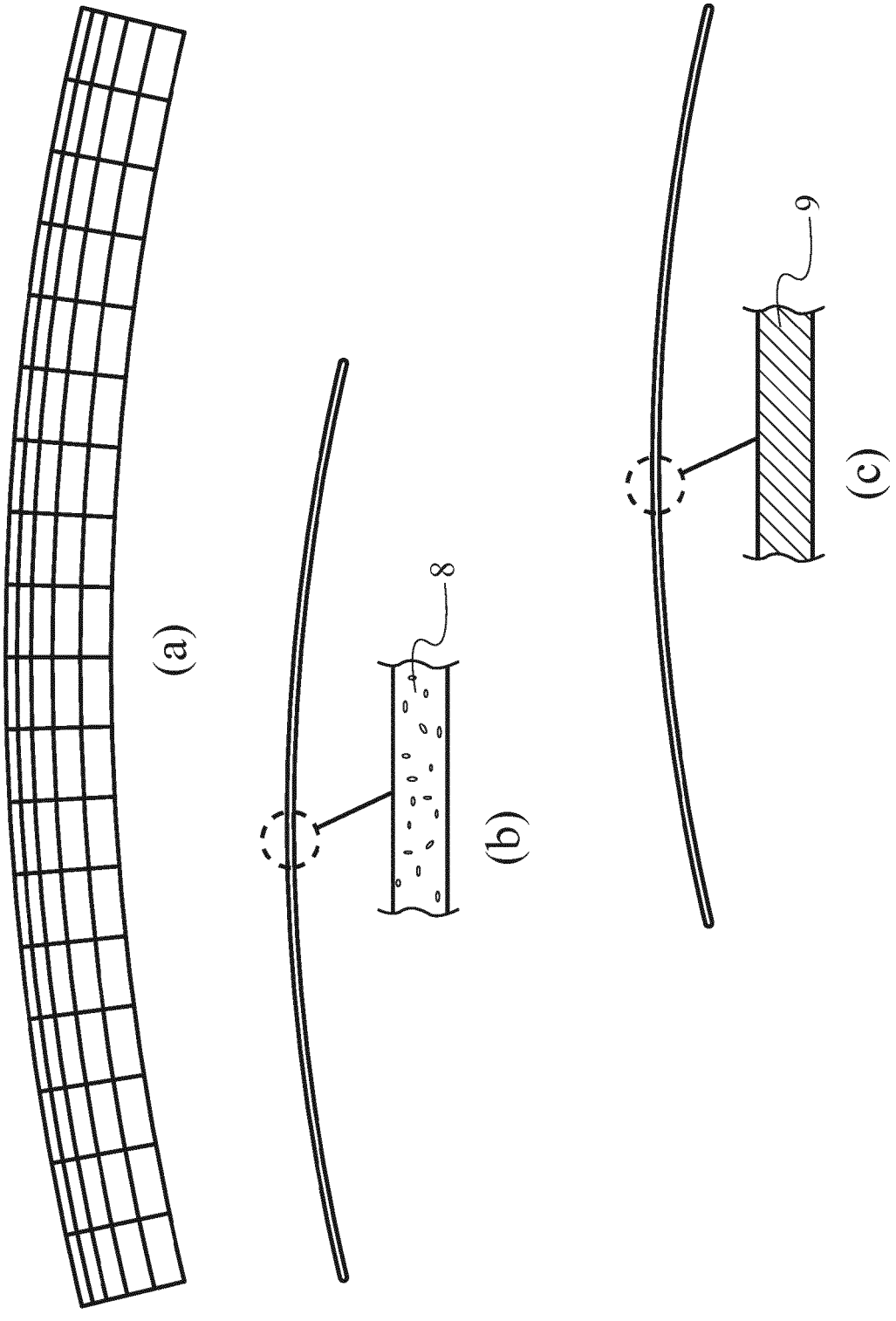

Fig. 4

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 14 16 3683

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	JP 2008 150814 A (MAEDA CONSTRUCTION; NIPPON STEEL MATERIALS CO LTD; SHIMIZU CONSTRUCTIO) 3 July 2008 (2008-07-03) * abstract *	1-11	INV. E21D11/08
X	JP 2001 262983 A (OHBAYASHI CORP; ISHIKAWAJIMA KENZAI KOGYO KK) 26 September 2001 (2001-09-26) * abstract *	10,11	
A	JP 2011 202492 A (NIPPON STEEL MATERIALS CO LTD; FUJIMI KOKEN KK; GEOSTR CORP) 13 October 2011 (2011-10-13) * abstract *	1-11	
A	JP 2003 056294 A (KINKI CONCRETE INDUSTRY CO LTD; KANSAI ELECTRIC POWER CO) 26 February 2003 (2003-02-26) * abstract *	1-11	
A	JP 2007 321518 A (TAISEI CORP) 13 December 2007 (2007-12-13) * abstract *	1-11	TECHNICAL FIELDS SEARCHED (IPC) E21D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	8 September 2014	Garrido Garcia, M

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 14 16 3683

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

08-09-2014

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2008150814 A	03-07-2008	JP 5162125 B2	13-03-2013
		JP 2008150814 A	03-07-2008
JP 2001262983 A	26-09-2001	NONE	
JP 2011202492 A	13-10-2011	NONE	
JP 2003056294 A	26-02-2003	NONE	
JP 2007321518 A	13-12-2007	JP 4795852 B2	19-10-2011
		JP 2007321518 A	13-12-2007

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82