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METHOD OF REINFORCING A REINFORCED CONCRETE COMPONENT

The invention relates to a method of producing an individual reinforcement of a future reinforced concrete component made of prefabricated reinforcement elements.

Usually, a structural engineer plans a reinforcement plan for a reinforced concrete component, optimally steel quantity-optimized and product-neutral, often already electronically in 3D with the help of a round steel module within a CAD program. This reinforcement plan is used to create the reinforcements of a reinforced concrete component on site or in the precast factory and then produce the reinforced concrete component. Such a reinforcement plan contains the position and amount of the reinforcing steel bars to be laid in the upper and lower planar basic reinforcement as well as the further reinforcement elements arranged in between such as spacers, hooks, bent bars, cages and the like. Such a reinforcement plan already available in 3D electronically is often converted to 2D plans and used printed on paper.

The reinforcement plan is implemented in practice on the site substantially by manually laying the individual cut and bent reinforcing steel bars, which have to be connected to one another by hand using binding wire. This procedure is cumbersome and means considerable working time is required and is uneconomical and especially prone to errors, especially with a growing shortage of labor. It should therefore be sought in principle to use standardized reinforcement elements to implement the reinforcement plan, for example in the form of concrete reinforcement mats, welded wire meshes, mesh cages, amongst others, which can be prefabricated and stored and thus quickly used on the construction site.

The brochure "Informationsbroschüre BAMTEC", Stahlpartner, 13. July 2017, pages 1-12, (URL: https://stahlpartner.com/wp-content/uploads/2017/07/Bamtec_Informationsbroschuere.pdf)

describes a method of producing an individual planar reinforcement element of a reinforced concrete component.

The applicant is also familiar with individualized reinforcement elements in the form of uniaxial, roll-out reinforcement steel bar meshes, in which a plurality of parallel reinforcing steel bars are connected to one another at several points over their length by means of statically non-acting straps, and produced, transported and moved into the resulting component rolled up into a roll, where they just have to be unrolled.

A disadvantage of this procedure is that individual conditions of the individual construction site cannot be sufficiently recorded and therefore manual binding of steel bars is often still necessary.

It is therefore an object of the invention to avoid this disadvantage.

This object is achieved with a method of producing a planar individual reinforcement of a reinforced concrete component made of predominantly prefabricated planar reinforcement elements, which method has at least the following steps: - reading in a first reinforcement plan of the future reinforced concrete component based on reinforcing steel bars having a planar basic reinforcement; - converting the planar basic reinforcement into a modified planar basic reinforcement, which has reinforcing steel bars that are not limited in length in such a way that no overlapping of bars results within the planar basic reinforcement; - calculating a plurality of individual planar reinforcement elements from the modified planar basic reinforcement and the further reinforcement elements of the first reinforcement plan, also by changing the individual reinforcing steel bars in terms of their number, shape, length, diameter, position, steel grade as well as with specification of a laying order for the creation of an individual reinforcement plan; as well as - modification of at least one planar reinforcement element compared to the modified planar basic reinforcement with regard to the

presence, arrangement, length and diameter of at least one reinforcing steel bar with the addition of sacrificial or additional material.

The conversion according to the invention is carried out firstly via the stage of a computational determination of a modified basic reinforcement of the component, in which the reinforcing steel bars provided by the designer are converted into bars that extend continuously from one side of the future component to the opposite side. The modified basic reinforcement of the respective reinforcement layers of the future reinforced concrete component thus has parallel reinforcing steel bars of any length without overlaps. The reinforcing steel bars can therefore also be selected to be any length according to the invention, regardless of the actual possibility of obtaining such extremely long bars. The further reinforcement parts of the first reinforcement plan between the two basic reinforcements are initially not modified in this case. In a further step, a plurality of individual reinforcement elements are calculated from this modified basic reinforcement and the further reinforcement parts of the first reinforcement plan. The reinforcing steel bars intended therefor may also differ according to the invention in terms of number, shape, length, diameter, position, steel quality from those of the first reinforcement plan in that a laying order is specified or additional or other welding points are provided. Likewise, they may include the further reinforcement parts if doing so also makes installation easier and quicker.

The method according to the invention increases the ease of installation of the reinforcement with great advantage at the expense of a higher material input. This is done in particular by the method determining structurally undisturbed areas that are easy to reinforce and providing these areas with reinforcement elements that can be installed easily, quickly and as straight-forwardly as possible, which are extended into the disturbed areas with, if necessary, additional, further reinforcement elements, increasing the

material input. It is highly advantageous that this method can be used in particular with so-called BIM (building information modelling) components, i.e. with those that digitally map a building or its parts. This applies especially when an IFC format is used. In other words, according to the invention, a design-optimized reinforcement solution is created from a quantity-optimized reinforcement solution with computational effort. The design-optimized reinforcement solution is realized in particular in reinforcement bodies produced individually for the construction site.

The method according to the invention can include the following further steps, wherein all steps of the method are preferably carried out with computer assistance, where reasonably possible:

- minimizing the number of reinforcement elements of the individual reinforcement plan;
- fixing an individual reinforcement element in terms of type and arrangement of the reinforcing steel bars in the individual reinforcement plan;
- generating a machine data set for producing at least one calculated individual reinforcement element;
- transferring the machine data set to a production machine and producing at least one individual reinforcement element;
- producing the individual reinforcement on-site on a construction site.

The last three steps are not an essential part of the method. Highly advantageously, individual reinforcing steel bars no longer have to be laid by hand and connected to each other with binding wire; rather, according to the invention, prefabricated reinforcement elements can be used predominantly or exclusively, which respectively replace a plurality of the original individual reinforcing steel bars and which are calculated individually for each construction site. This significantly reduces the work time required to produce the reinforcement on site. The likelihood of installation errors is also highly advantageously minimized due to the significantly smaller number of parts to be installed and connected. Due to the minimization provided

according to the method, the individual reinforcement elements are optimized in their size and shape such that so few of them as possible are required. This further minimizes the work time required to connect the elements.

The method preferably also carries out a collision check of the bars so that changes in terms of number, shape, length, position and laying order cannot lead to problems.

The method selects the type of reinforcement elements to be produced or used from the uniaxial reinforcement meshes, in particular the roll-out uniaxial reinforcement steel bar meshes, the biaxial reinforcement meshes, the edge cages, the connection cages, the welded reinforcing cages and the individual reinforcing steel bars. The use of panel reinforcements is thus also possible. These are static reinforcement solutions consisting of a plurality of different bars in terms of diameter, length, distance combined in a plate-like concrete casing. In addition, spacers and other additional reinforcements positioned between the two basic reinforcement layers can be integrated, but this is not compulsory. In the case of uniaxial reinforcement meshes, each of the upper and lower basic reinforcement has two layers of meshes, which are oriented orthogonally to one another. Biaxial or drawing mats are used if they can be used advantageously at the respective construction site. Edge and connection cages are used to connect the individual reinforcement elements or to connect panel reinforcements and wall reinforcements, which enable a considerable amount of time to be saved compared to laying and bending individual connecting steel bars. These cages are, however, not standardized according to the invention, but rather calculated and produced individually for each construction site, and optimally meet the local connection and edge conditions. Additional reinforcements are, according to the invention, in particular spacers but also non-modifiable, steel-optimized reinforcing steel bars of the original calculation.

The method according to the invention solves the issue of overlapping and impacts as described below through modifications.

These modifications include such with regard to presence, arrangement, length and diameter of at least one reinforcing steel bar, in particular with the addition of sacrificial or supplementary material. The modified basic reinforcement for producing the individual reinforcement elements is modified here, according to the invention, in particular by extending at least one reinforcing steel bar compared to the original reinforcement plan with the addition of sacrificial or purely structural supplementary material. Sacrificial material here relates to a supplementary material not provided in the calculations of the original reinforcement plan. However, such an addition of sacrificial material, which in principle increases costs and should therefore be avoided, has particular advantages in areas where the load is not predominantly static, where welding is not permitted and therefore ends of reinforcing steel bars cannot be connected with straps. An extension of reinforcing steel bars is also provided according to the invention to be able to connect reinforcement meshes with edge or connection cages or to guide a reinforcing steel bar up to the next assembly belt or to the next assembly bar in order to enable attachment to at least two mounting elements without additional individual connecting steel bars being required. Such reinforcement elements also have an extension which must ensure sufficient overlap of a reinforcement joint after an obstacle to be overcome. Alternatively such an extended reinforcement element is one that is the extension itself, i.e. two individual reinforcement elements such as uniaxial roll mats that cannot be unrolled together because they are separated by an obstacle, to be connected to each other by overlapping. Although the extension of reinforcement steel bars according to the invention beyond the originally calculated amount required for the structure is more expensive, the resulting simpler and quicker installation means that a significant

amount of time is saved when constructing the reinforcement. This is particularly advantageous as staffing costs make up a large proportion of the total costs of reinforcement construction.

According to the invention, it is envisaged to provide overlaps at adjacent joints of the reinforcement elements with the help of extended reinforcing steel bars of a reinforcement element. According to the invention, it is therefore possible to offset the reinforcing steel bars of a reinforcement element relative to those of the two adjacent reinforcement elements and thus deviate the position of these offset reinforcement elements relative to the calculated modified basic reinforcement. They are offset here in particular by the diameter of a reinforcing steel bar, whereby two adjacent meshes (reinforcement elements) can be laid to overlap without the reinforcing steel bars coming to rest on each other. In this connection, it is also in accordance with the invention when producing reinforcement elements in the form of uniaxial, rollable reinforcement meshes to move the strip or strips lying in the subsequent overlap region as mounting elements of the bars of a mesh along the longitudinal axis of the reinforcing steel bars such that a height collision is avoided and the level of the reinforcement layer is maintained. The modifications also include an automatic displacement of reinforcing steel bars due to machine specifications in the production process, for example a minimum distance of the reinforcing steel bars due to the production plant.

As well as the modification, there is also the additional calculation and creation of overlapping reinforcement elements, in particular in the form of correspondingly axially short overlapping meshes from parallel reinforcing steel bars, which are designed to be connected to mounting elements and are respectively placed to be overlapping between adjacent abutting reinforcement meshes. Mounting elements are statically non-acting straps in the case of uniaxial reinforcement meshes, and statically acting or non-

acting mounting bars in the case of uniaxial or biaxial meshes.

According to the invention, two or more reinforcement elements can also be produced and transported connected to one another by means of continuous mounting elements, which are only separated during installation on site at in particular correspondingly marked areas by cutting through the mounting elements.

In particular in the case of reinforcement elements that form the upper layer of a basic reinforcement, the method according to the invention envisages moving reinforcing steel bars and/or adding additional reinforcing steel bars, possibly by reduction of the diameters of the reinforcing steel bars in question, if they are otherwise too far apart for a worker to walk safely, for example when concreting the reinforced concrete component. In this embodiment too, the basic principle of the invention is applied to simplify and accelerate the installation of the reinforcement elements using additional materials by producing an installation-optimized design from a quantity-optimized design. This preferably occurs electronically.

In one embodiment of the method according to the invention, it is envisaged that extended reinforcing steel bars in the area of the sacrificial material are connected to a mounting element, which is possibly also extended, such as a strap or bar. If original ends of the extended reinforcing steel bars are found in areas where welding is not allowed, it is impossible to weld on the connecting mounting straps in the area concerned. Accordingly, the ends of the reinforcing steel bars would end up disadvantageously unconnected and loose. Extending the reinforcing steel bars by a purely structural and statistically insignificant length enables welding in this area and thus the attachment of mounting elements connecting the reinforcing steel bars to each other. This results in position stabilization of the reinforcing steel bars.

In a further development of the method, it is envisaged to produce additional reinforcing bars for edge regions of the reinforcement steel bar meshes in the reinforcement, in which the reinforcing steel bars were shortened. In other words, when there are recesses in edge regions of the reinforcement meshes, reinforcing steel bars cut from the recess are reinforced at their ends adjacent to the recess by additional calculated reinforcing steel bars. This ensures compressive and tensile forces are transferred between the reinforcing steel bars with a shorter length and the reinforcing steel bars in the area of the recesses without this hindering or preventing the reinforcement mesh from being simply unrolled or laid out beyond the recess. This again means significant time savings in construction, which in terms of process optimization outweighs the fact that additional material is used.

The individual reinforcement elements are also calculated with recesses according to the invention, wherein additional individual reinforcing steel bars are inserted by computer for the ions omitted in the area of the recess. These are extended if required in order to be attached to two mounting elements. Recesses may be necessary because of holes or indentations or wall connections projecting vertically into the reinforcement layer or the like. At these points, only the mounting straps are rolled out; the additional reinforcing steel bars provided according to the invention then ensure that forces are transmitted around these obstacles. The additional materials required are outweighed in turn by considerable time savings in construction.

The method according to the invention also envisages calculating the length of the reinforcing steel bars such that reinforcement meshes and edge cages can be connected by reinforcing steel bars of the reinforcement mesh overlapping into the edge cages. In this way, reinforcement meshes and edge cages can be connected to one another without having to use additional reinforcing steel bars.

When computationally creating the reinforcement elements from the basic reinforcement, individual additional bars are also possible according to the invention for reinforcement elements and are not or cannot be integrated therein. In this way, prefabrication of the reinforcement elements can also occur if a reinforcing steel bar cannot be integrated into a prefabricated reinforcement element for production or technical reasons associated with reinforcement. The manual addition of the corresponding reinforcing steel bar still ensures the reinforcement required from a structural point of view.

The method according to the invention also envisages that individual reinforcement elements are fixed in type, shape, position or design in their production from the modified basic reinforcement. The actual conditions on the construction site are sometimes different than previously calculated. The resulting need to modify parts of the reinforcement occurs by renewed production of the reinforcement elements from the modified basic reinforcement and the further reinforcements of the first reinforcement plan, wherein the fixed reinforcement elements can, however, no longer be modified. This highly advantageously prevents modifications in a larger quantity of reinforcement elements due to a local change only.

One embodiment of the invention is outlined below using several figures, wherein in the figures:

Fig. 1: shows in detail in three partial figures a), b) and c) a schematic reinforcement plan before and after application of the method according to the invention and

Fig. 2a-d: shows in detail details of redesigned individual reinforcement elements.

Fig. 1 schematically shows in three partial figures a reinforcement plan for a component before and after application of the method according to the invention.

Partial figure a) shows the original, preferably quantity-optimized and product-neutral reinforcement plan of an

outlined reinforced concrete structure 1 coming from the structural engineer, which reinforced concrete structure 1 is based on reinforcing steel bars 3 and has a whole row of overlaps 6. These are arranged arbitrarily as a function of the length of the underlying reinforcing steel bars 2 used. Spacers and other parts of the reinforcement lying below or above the drawing plane are not shown. A layer of the planar basic reinforcement alone is shown, which is often modified to a greater extent by the method according to the invention than the mentioned, non-illustrated parts of the reinforcement.

Partial figure b) represents the modified basic reinforcement produced computationally from the original first reinforcement plan in the first step of the method according to the invention, in which reinforcing steel bars 3 with unlimited lengths are used computationally such that a completely overlap-free modified basic reinforcement is calculated.

Partial figure c) schematically shows a plurality of reinforcement elements calculated individually for each construction site and produced from the modified basic reinforcement via the method and according to the invention, in this case two reinforcement elements 4, 4'. According to the invention, this achieves simpler installation at the cost of a greater amount of material. Of course, considerably more than the two illustrated reinforcement elements 4, 4' are actually calculated.

The reinforcement elements 4, 4' calculated in this way respectively have reinforcing steel bars 3 arranged at certain distances and linked by mounting elements 5. In order to achieve a sufficient static effect despite separation, supplementary material 7 in the form of extensions of the reinforcing steel bars 3 was inserted into end regions of a further reinforcement element 4' adjoining the reinforcement element 4, resulting in overlaps 6 of the reinforcing steel bars of the two reinforcement elements 4, 4'. The mounting straps 5 secure a stable distance of the reinforcing steel

bars 3 of the reinforcement elements 4, 4' and at the same time prevent spread of ends of reinforcing steel bars 3, which would cause undesirable lateral or vertical forces. It can also be seen that the strap 5' of the first reinforcement element 4 was displaced away from the end region along the longitudinal axis of the reinforcing steel bars 3 so that there is no vertical stacking of the two elements 4, 4'. In the example shown, the laying order is thus also set as initially the element 4' has to be unrolled, followed by element 4 in overlapping order. It can also be seen that the reinforcing steel bars 3 of the element 4 in comparison to those of the element 4' were displaced by a bar diameter so that no collision situation arises. The method according to the invention automatically carries out such a procedure. It can also be seen that in addition the reinforcing steel bars 3 of the element 4 were extended to produce an overlap 6. This overlap was not present in the original reinforcing plan in accordance with partial figure a); instead of a continuous, ordered joint, there were a plurality of "wildly" distributed joints.

Fig. 2 shows in detailed figures 2a) to 2d) details of redesigned individual reinforcement elements. The redesign occurs in particular such that undisturbed special areas are identified from the modified basic reinforcement 2 and appropriate reinforcement elements are produced for these, which can be unrolled or laid without disturbance and which are supplemented with additionally produced and specially laid reinforcements in the structurally disturbed areas.

Fig. 2a schematically shows an exemplary reinforcement plan produced with the method according to the invention for a reinforced concrete component 1. The reinforcement was implemented based on a reinforcement element 4 in the form of a uniaxial reinforcement mesh, which has reinforcing steel bars 3 spaced apart which are linked to one another by mounting straps 5. A disturbance 9 is taken into account such that a strap 5' was displaced from an original relative position illustrated with dashed lines to the position

illustrated with solid lines in order to shorten the free ends 3' of the reinforcing steel bars 3 and thus guarantee installation. The top two reinforcing steel bars 3 were also shortened to leave out an area disturbed by the area 9 and maintain the ability to unroll.

Fig. 2b schematically shows a further reinforcement element 4 with mounting bars 5 and reinforcing steel bars 3. The otherwise free ends 10 of shorter bars 3 are extended by the supplementary material 7 in order to be attached to the next mounting bar 5 and thus to at least two mounting elements 5.

Fig. 2c shows part of a prefabricated, roll-out reinforcement element 4. The reinforcement element 4 is provided for installation in areas in which welding is not allowed due to not exclusively static load, or in which a welded reinforcing steel bar 3 can no longer be effectively evaluated from the welding point for the structure analysis. A weld line 11 intersects the reinforcing steel bars 3, which therefore end there according to the modified basic reinforcement. In order to keep these free ends 10 layable, a supplementary material 7 illustrated with dashed lines is added in order to enable welding to the closest mounting strap 5. This welding is, however, not statically relevant as the statically acting areas, illustrated with solid lines, of the bars 3 are not affected. The mounting element 5 was therefore likewise extended into this area.

Fig. 2d schematically illustrates a section of a prefabricated reinforcement element 4, which has a recess 12, for example a ceiling hole, within the surface it spans. In order to be able to lay the reinforcement element 4 over this disturbance, the reinforcing bars 3 are shortened in its area. According to the invention, supplementary material 7 in the form of additional reinforcing steel bars 3' has been added to transfer forces in the region of the recess 12 and additionally extended for attachment to the mounting straps 5. Thus, according to the invention, a reinforcement based on a prefabricated reinforcement element 4 is in turn made possible by adding supplementary material 7.

A reinforcement element, in which the diameter of reinforcing steel bars was reduced and its distance decreased is not shown, nor is one, in which the diameter of reinforcing steel bars was increased and the distance of the reinforcing steel bars was increased. Such adjustments are also according to the invention, as is an adjustment of the steel quality.

REFERENCE LIST

- 1 reinforced concrete component
- 2 modified basic reinforcement
- 3 reinforcing steel bar
- 3' additional reinforcing steel bar
- 4 reinforcement element
- 4' further reinforcement element
- 5 mounting element (mounting strap)
- 6 overlap
- 7 supplementary material
- 8 periphery
- 9 recess
- 10 free end
- 11 weld line
- 12 recess

P A T E N T K R A V

1. Fremgangsmåde til fremstilling af en individuel fladformet armering til et stålarmet betonelement (1) ud fra overvejende præfabrikerede fladformede armeringselementer (4), omfattende mindst følgende trin:

- 5 - Indlæsning af et første armeringsplan for det fremtidige stålarmerede betonelement (1) baseret på armeringsstålstænger (3), omfattende en fladformet basisarmering;
- Omregning af den fladformede basisarmering til en modificeret fladformet basisarmering (2), som omfatter armeringsstålstænger med ubegrænset længde, på en sådan måde, at der ikke forekommer overlap af stænger inden for den fladformede basisarmering;
- 10 - Beregning af en mængde individuelle fladformede armeringselementer (4) ud fra den modificerede fladformede basisarmering (2) og de øvrige armeringselementer i det første armeringsplan – herunder med ændringer af de enkelte armeringsstålstænger (3) med hensyn til antal, form, længde, diameter, placering, stål kvalitet samt under angivelse
- 15 af en lægningssekvens til oprettelse af et individuel armeringsplan; og
- Ændring af mindst et fladt armeringselement (4) i forhold til den modificerede flade grundarmering med hensyn til tilstedeværelse, placering, længde og diameter af mindst en armeringstålstang (3) med tilføjelse af offer- eller ekstramateriale (7).
- 20 2. Fremgangsmåde ifølge krav 1, yderligere omfattende et eller flere af følgende trin:
- Minimering af antallet af fladformede armeringselementer (4) i det individuelle armeringsplan;
- Fastlæggelse af et individuelt fladformet armeringselement (4) med hensyn til type
- 25 og placering af armeringsstålstænger (3) i det individuelle armeringsplan;
- Generering af et maskindatasæt til fremstilling af mindst ét beregnet individuelt fladformet armeringselement (4);
- Overførsel af maskindatasættet til en produktionsmaskine samt fremstilling af mindst ét individuelt fladformet armeringselement (4);
- 30 - Fremstilling af den individuelle fladformede armering på stedet ved en byggeplads.

3. Fremgangsmåde ifølge krav 1 eller 2, hvor de individuelle fladformede armeringselementer (4) er valgt blandt enaksede armeringsmåtter, især udtrækkelige enaksede armeringsstålstangsmåtter og enkelte armeringsstålstænger.

5 4. Fremgangsmåde ifølge et hvilket som helst af de foregående krav, hvor placeringen af et montageelement (5) tilhørende det fladformede armeringselement (4) ændres inden for det fladformede armeringselement (4).

10 5. Fremgangsmåde ifølge et hvilket som helst af de foregående krav, hvor indlæsning af det første armeringsplan sker elektronisk, hvor denne især er en mængdeoptimeret og produktneutral første armeringsplan.

15 6. Fremgangsmåde ifølge et hvilket som helst af de foregående krav, hvor der inden for et udtrækkeligt fladformet armeringselement er foreset udsparinger (12), hvorved der i randområderne, som støder op til udsparingerne (12), beregningsmæssigt indsættes yderligere armeringsstålstænger (3').

20 7. Fremgangsmåde ifølge et hvilket som helst af de foregående krav, hvor armeringsmåtter og randkurve forbindes under montering på en sådan måde, at armeringsstålstænger (3) fra armeringsmåtterne rager ind i randkurvene.

 8. Fremgangsmåde ifølge et hvilket som helst af de foregående krav, hvor montageelementer (5) fra armeringsmåtterne adskilles ved montering på markerede punkter.

25 9. Fremgangsmåde ifølge et af de foregående krav, hvor tillægsstænger tilføjes til stænger i den fladformede basisarmering (2), som ikke kan integreres i præfabrikerede fladformede armeringselementer (4).

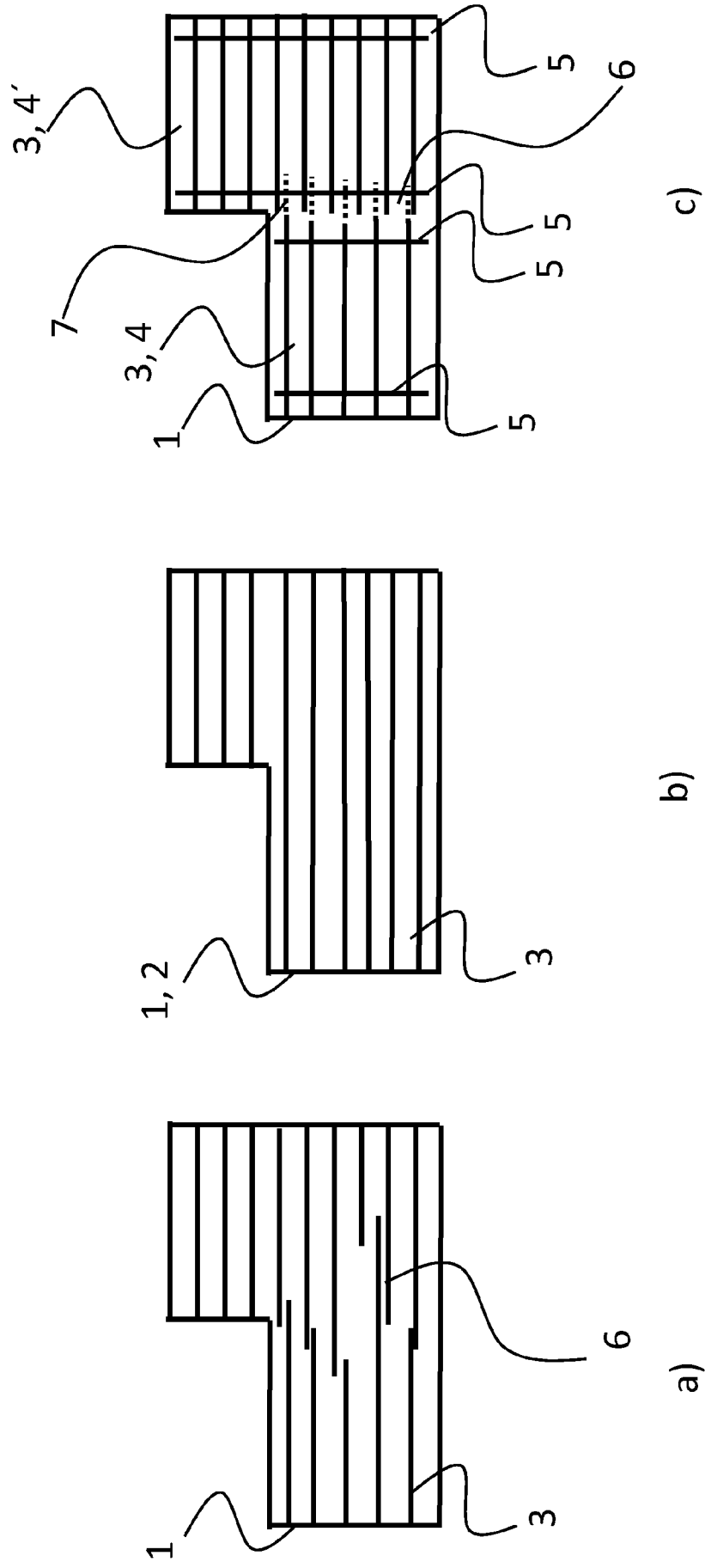


Fig. 1

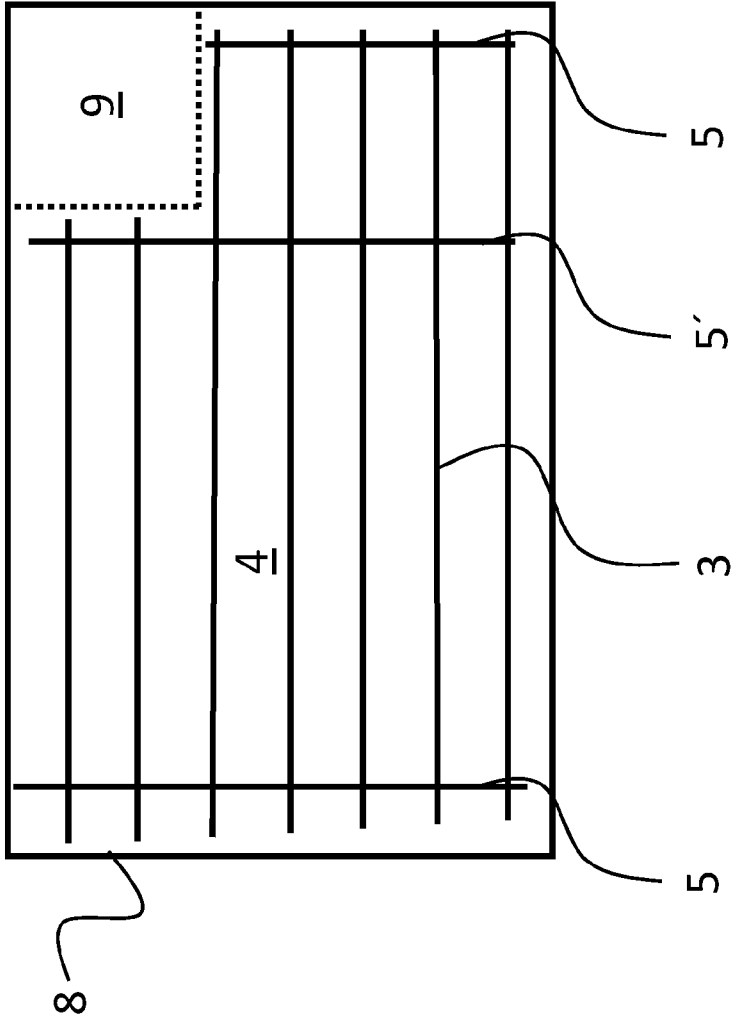


Fig. 2a

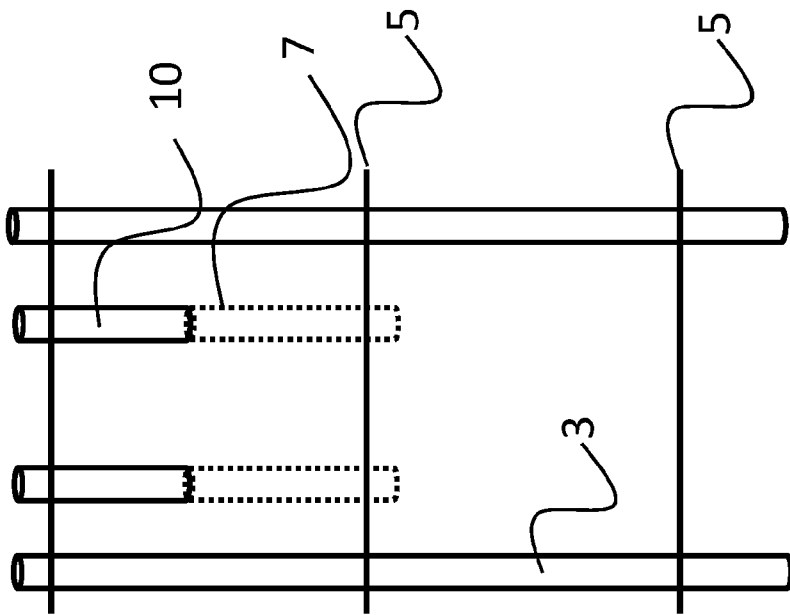


Fig. 2b

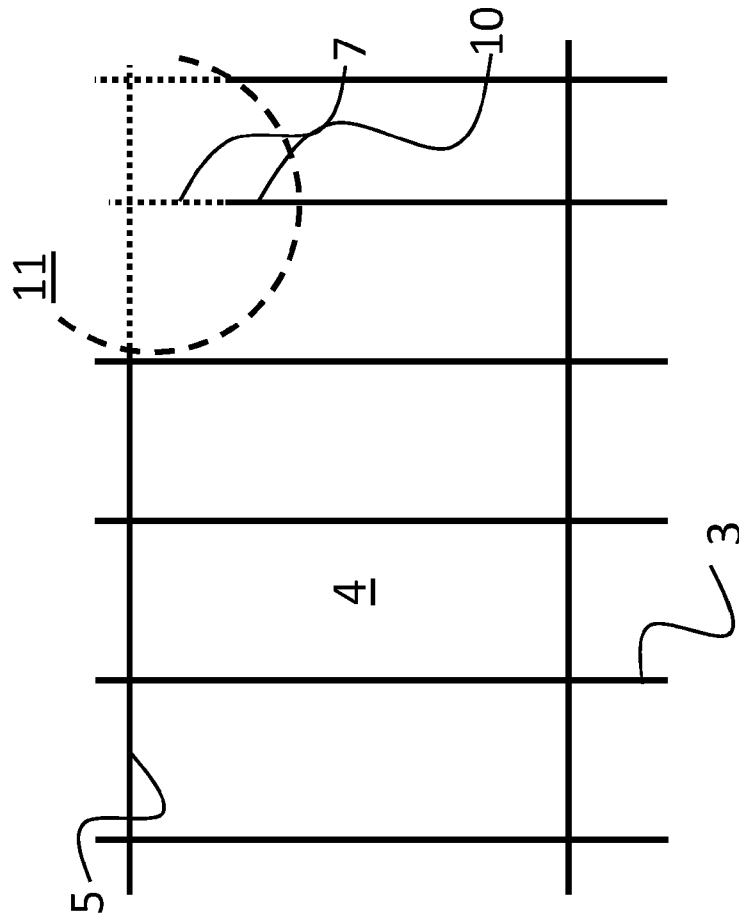


Fig. 2c

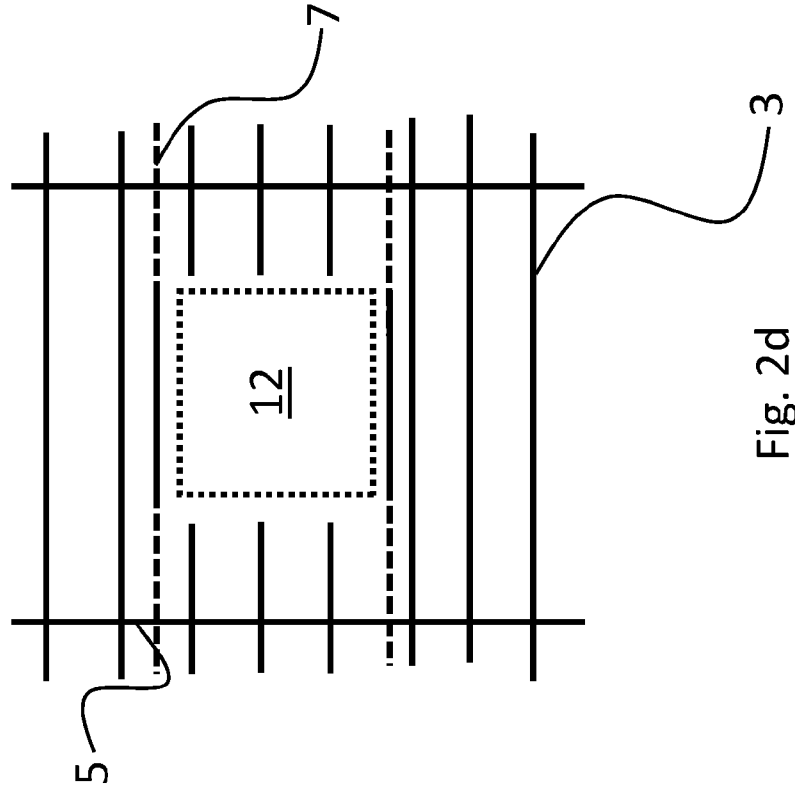


Fig. 2d