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# (54) METHOD AND SYSTEM FOR ANCHORING A WATERPROOFING LINER TO CONCRETE CURBS OF A HYDRAULIC STRUCTURE

VERFAHREN UND SYSTEM ZUR VERANKERUNG EINER WASSERDICHTEN VERKLEIDUNG IN BETONBORDEN EINER HYDRAULISCHEN STRUKTUR

PROCÉDÉ ET SYSTÈME POUR ANCRAGE D'UN REVÊTEMENT D'ÉTANCHÉITÉ À DES BORDURES EN BÉTON D'UNE STRUCTURE HYDRAULIQUE

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## Description

### BACKGROUND OF THE INVENTION

**[0001]** The present invention relates to a method, as defined by claim 1, and to a system, as defined by claim 10, suitable for anchoring a waterproofing liner consisting of flexible sheets of synthetic material, to a wall of a hydraulic structure of compacted loose material, for example a dam, or the sides of the embankment of a large basin for containing water or for similar uses, by means of which it is possible to provide a firm anchorage of the waterproofing liner to a laying down surface along continuous anchoring lines, both during the construction of the hydraulic structure, and subsequently, while allowing at the same time a drainage, by gravity, of the water seeped from the body of the hydraulic structure, between the waterproofing liner and the same laying down surface.

### PRIOR ART

**[0002]** Hydraulic structures such as dams in loose material and embankments for large water basins are in general obtained by superimposing a plurality of layers of earth and/or rock, which are compacted until to form an embankment of a desired dimension and shape, provided with longitudinally and vertically extending sloped and/or horizontal surfaces.

Dams and embankments in loose material of hydraulic structures are nevertheless subject to water losses through cracks and fissures, with consequent financial harm, risk of erosion and a possible collapse of the hydraulic structure. To avoid water infiltrations and water losses through the body of a hydraulic structure, use of a waterproofing liner consisting of flexible membranes in synthetic material has been variously proposed, suitable for contact with the ground, for example membranes of PVC or resin-based materials, known as "geomembranes", which are embedded into the mass of loose material of the hydraulic structure, or are mechanically fixed to the water facing wall.

**[0003]** In the past, to anchor waterproofing membranes to walls of hydraulic structures of concrete or masonry material, mechanical anchor systems have been proposed comprising metal sections fixed, by pins, directly to the concrete or masonry wall of the hydraulic structure. Mechanical systems for anchoring waterproofing liners to hydraulic structures are disclosed for example in EP 0 722 016 and US 4 913 583.

**[0004]** To replace known mechanical anchoring systems, and as an alternative to the use of waterproofing membranes directly embedded into the hydraulic structure, US 6.612.779 or corresponding EP 1.137.850 suggests to use a plurality of short anchor strips in synthetic material, which are partially embedded and retained by simple frictional forces in a transition layer of loose material, to which a waterproofing membrane in synthetic material of the same type or compatible with the synthetic material of the anchor strips is subsequently anchored by separately seaming the waterproofing membrane to each anchor strip.

**[0005]** As shown in figures 17 and 19 of US 6.612.779, the single anchor strips are "L" or "C" folded, partially embedding each single anchor strip into the transition layer of loose material spread on a sloped wall of the hydraulic structure facing the water side. The anchor strips are spaced apart from one another and are arranged at different heights so as to form a plurality of variously distributed single anchor points for the waterproofing liner.

**[0006]** As described in US 6.612.779, in alternative to previous solutions, the anchor strips may horizontally extend for part or the entire longitudinal length of body of the hydraulic structure, such a solution provided by separate anchor strips admittedly enables the difficulties and problems to be remedied that are inherent in the known mechanical anchoring systems, but on the other hand the solution has certain drawbacks arising from both the discontinuity of the anchoring points for the waterproofing liner and from the fact that the single anchor strips are simply retained by frictional forces in the layer of material in loose state. As in hydraulic structures of the mentioned type the liner consisting of a flexible waterproofing membrane is normally subject to the action of external forces, for example to a strong suction action exerted by the wind, the speed of which can reach and exceed 150km/h, causing a membrane lifting pressure equal to or greater than 1500 Pa. The waterproofing membrane can be also subjected to the action of water streams or waves; therefore the use of discontinuous anchoring points has often been unsuitable because, by simply fastening the anchor strips between superimposed layers of loose material, entails the risk of the anchoring strips to be unstuck, or tear resistance being exceeded with consequent loosening and/or breakage of the waterproofing membrane. Document US 6.612.779 discloses the features of the preamble of claim 1 and claim 10.

**[0007]** Conversely, the use of continuous and horizontal anchor strips could involve additional problems consisting in the impossibility to drainage the water seeped from the body of the hydraulic structure between the waterproofing liner and the facing surface of the wall of the hydraulic structure; consequently the pressure of the seeped water will cause the bulging of the waterproofing liner, entailing the same risks and drawbacks previously referred to.

### OBJECTS OF THE INVENTION

**[0008]** The main object of the present invention is to provide a method and a system that are suitable for laying down and enabling a firm anchorage of a waterproofing liner, consisting of a flexible membrane of synthetic thermoplastics, to an ample wall surface of a hydraulic structure of compacted loose material, for example to a slant-

ed wall, such as to remedy the drawbacks inherent in previously known anchoring systems, allowing at the same time a discharge by gravity of the water seeped from the body of a hydraulic structure into the space between the waterproofing liner and the water facing surface of the hydraulic structure wall.

In particular, one object of the invention is to provide a method and a system that are suitable for firmly anchoring a waterproofing liner to a wall of a hydraulic structure of compacted loose material, by means of which it is possible to laying down the waterproofing liner both during the construction of the hydraulic structure, and subsequently, performing maintenance and/or repair operations simply, without damaging the entire anchoring system, also allowing interventions under water.

**[0009]** A further object of the invention is to provide a system suitable for anchoring a waterproofing liner to a wall of a hydraulic structure of the referred type, by means of which it is possible to significantly increase the anchorage surface, and consequently reducing the stress concentration and the risks of tearing and breaking the waterproofing liner.

## SHORT DESCRIPTION OF THE INVENTION

**[0010]** These and further objects and advantages of the invention are achievable by a method according to claim 1, and by an anchor system according to claim 10, suitable for anchoring a waterproofing liner of synthetic material to a wall of a hydraulic structure of loose compacted material; for the purposes of the present description, the term "wall" is defined as any sloped and/or horizontal wall of any hydraulic structure of compacted loose material.

**[0011]** According to a first aspect of the invention a method has been provided for anchoring a waterproofing liner to a side wall which extends in a longitudinal direction of a hydraulic structure comprising compacted layers of loose material, according to which the waterproofing liner comprises flexible sheets of synthetic material fastened to the side wall, the method further comprising the steps of:

defining a laying surface of the side wall for laying down the waterproofing liner, providing the laying surface with a plurality of continuous seaming bands for the waterproofing liner, in synthetic material;

fastening the waterproofing liner to the side wall of hydraulic structure by seaming the waterproofing liner to the continuous seaming bands;

characterised by the steps of:

configuring the side wall of the hydraulic structure with a plurality of concrete curbs providing said laying surface;

anchoring the plurality of continuous seaming bands to the concrete curbs by vertically disposing the continuous seaming bands in a traverse direction from an upper to a lower position of the side wall;

laying down the waterproofing liner on the laying surface of the concrete curbs; and

anchoring the waterproofing liner to the concrete curbs by seaming the waterproofing liner to the continuous seaming bands.

**[0012]** According to another aspect of the invention, a method has been provided for anchoring a waterproofing liner of synthetic material, to a wall of a hydraulic structure of loose material, as defined previously, according to which the waterproofing liner is anchored to seaming bands of synthetic material fastened to the wall of the hydraulic structure, comprising the steps of:

providing a plurality of concrete curbs in a longitudinal and/or transverse direction of the wall of the hydraulic structure;

providing a plurality of spaced-apart continuous seaming bands in synthetic material for seaming the waterproofing liner, superimposing the continuous seaming bands to the concrete curbs, in which each continuous seaming band comprises a plurality of axially aligned modular strips each provided with a rear anchor part and a fore seaming part;

progressively forming each continuous seaming band by fastening the rear anchor part of each modular strip to a concrete curb, partially superimposing and seaming the fore part of each modular strip to a contiguous anchor strip previously fixed to a same concrete curb;

laying down and fixing the waterproofing liner, or part thereof, by superimposing the waterproofing liner to the concrete curbs, then seaming the waterproofing liner to said seaming bands along continuous seaming lines.

**[0013]** The concrete curbs can be extruded horizontally partially superimposing the curbs in contact with one another, in a longitudinal direction to the wall of the hydraulic structure; the fastening of each modular strip in a transverse direction to the concrete curbs, can be achieved by locking the rear anchor part of the modular strip between contiguous concrete curbs, in particular between a lower previously extruded curb and a subsequently extruded upper curb in a position above the former one, locking the rear anchor part of each anchor strip to the concrete curb by a layer of compacted loose material, spread behind the curb.

**[0014]** Subsequently, the fore part of each anchor strip is seamed to a contiguous anchor strip previously fastened to a same concrete curb. Apparatuses for extruding concrete curbs are illustrated, for example, in US 4,217,065 and US 6,540,435.

**[0015]** According to another embodiment, each concrete curb comprises a plurality of modular blocks, axially aligned according to the slope of the wall, or more in

general in a direction transverse to the wall of the hydraulic structure; thus each single anchor strips is fastened to each modular block by clamping a rear part of the anchor strip between opposite ends of two contiguous modular blocks, and partially superimposing the fore part of the anchor strip to the fore part of a contiguous anchor strip previously fastened to an underlying modular concrete block, seaming each anchor strip for example close to the rear part of a contiguous anchor strip clamped between a lower modular block and an upper modular block of a same curb.

**[0016]** Preferably, the extrusion or casting of the single modular blocks of the concrete curbs, and formation of continuous seaming bands occur progressively, for example from the bottom to the top of the wall of the hydraulic structure; in this manner it is possible to anchor part of the waterproofing liner during the construction of the hydraulic structure. Although it is possible to use any suitable concrete material for this use, it is preferable to use water permeable porous concrete material because of the lesser rigidity thereof that permits greater flexibility compatible with the typically stiffness of an embankment of compacted loose material.

**[0017]** According to another aspect of the invention, a system has been provided suitable for anchoring a waterproofing liner in synthetic material to a side wall extending in a longitudinal direction of a hydraulic structure in compacted loose material, according to the method of claim 1, in which the waterproofing liner is fastened to continuous seaming bands in synthetic material anchored to the side wall, characterised by comprising:

a plurality of parallely arranged concrete curbs defining a laying surface for the waterproofing liner;
a plurality of continuous seaming bands extending on the concrete curbs from an upper to a lower position of the side wall;
each continuous seaming band comprising a plurality of modular anchor strips arranged in series along the seaming band, each anchor strip comprising a rear anchor portion fastened to a concrete curb, and a fore seaming portion seamed to a continuous anchor strip.

**[0018]** Using continuous seaming bands fastened to concrete curbs, to provide a firm anchorage of a waterproofing liner to a side wall of a hydraulic structure, in which the seaming bands transversely extend from an upper and a lower position of the side wall, permits numerous advantages, in particular:

- makes it possible to maintain the waterproofing liner perfectly stretched against the wall surface to be protected, to withstand to external forces that would tend to damage the same waterproofing liner, providing a suitable spacing between contiguous seaming bands during the designing, according to specific technical requirements and/or conformation of the hydraulic structure, environmental conditions and/or mechanical features of the same waterproofing liner;
- enables the risk of breakage and/or tearing in the waterproofing liner and seaming bands to be reduced, by varying the number and dimensions of the seaming bands, allowing a greater anchoring surface and a greater distribution of the stresses;
- seaming the liner by continuous seaming lines further permits better positioning of the waterproofing liner, enabling the waterproofing liner to be laid down more regularly, minimising the formation of slack zones;
- anchoring the liner by continuous seaming lines along transversely extending seaming bands, enables the protective liner to be laid down gradually, both vertically and horizontally, in several side by side arranged sections, or separate from one another; if the waterproofing liner is laid down by horizontal sections, after the construction and waterproofing of the lower part of the hydraulic structure has finished, it is possible to continue the construction and waterproofing of the upper part providing a secure barrier to water in the case of inundation during construction and hydraulic structure.

**[0019]** Lastly the use of vertically extending continuous seaming bands, crosswise a shaped wall of a hydraulic structure, provide a firm anchorage of the waterproofing liner and an appropriate discharge, by gravity, of the water seeped from the body of the hydraulic structure.

**[0020]** For the purposes of the present description, a "continuous seaming line" is defined as a seaming line that extends substantially for the entire length of each seaming band, between the two ends without any interruption, or with interruptions of comparatively reduced length with respect to the length of the entire seaming band, for example of the order of a few centimetres or tenth of centimetres if this is necessary for specific needs, maintaining all the advantages of the invention.

**[0021]** It is further pointed out that the term "seaming" defines any type of heat seaming, induction seaming or chemical seaming between the protective liner and the seaming bands, according to the chemical and physical features of the synthetic material of the liner and the same seaming bands.

**[0022]** According to a further version of the invention, as previously mentioned, the concrete curbs instead of being continuously extruded in a horizontal direction, superimposed on one another in the longitudinal direction of the slanted wall of the hydraulic structure, the curbs can extend vertically, i.e. in a direction transverse to the wall; in this latter case each curb consists of modular blocks of preset length, obtained for example by casting a concrete consisting of gravel of suitable granulometry mixed with a cement binder, in suitable formworks on the slanted wall of the hydraulic structure, or in suitable trenches.

**[0023]** In all the cases, before the extrusion of a sub-

sequent curb, i.e. before casting a modular block positioned immediately above, thus before the seaming step, each anchor strip can be provisionally fixed to the body of the curb, or to an already cast modular block, by shot nails, ballast, or other types of anchoring system.

**[0024]** The use of concrete curbs extruded directly or cast during work, constitutes a rapid method of both fastening the anchor strips constituting the continuous seaming bands for the waterproofing liner, and for constructing on the water facing side of hydraulic structure a stable surface of porous concrete material having constant water permeability that may be defined during the design step, i.e. such as to enable a discharge of water seeping from the body of the hydraulic structure, making the water flow by gravity to the bottom and conveyed to a drainage system. Similarly, between vertical curbs a layer of porous concrete material can be provided for the purpose referred to above; alternatively, the waterproofing liner could be laid down directly in contact with the ground, providing a waterproofing geomembrane of synthetic material having an antipuncturing layer consisting of a suitable geotextile or technical textile, and adding if necessary a synthetic drainage material such as "geonet" to replace the drainage layer of porous concrete.

**[0025]** As the walls of hydraulic structures can have differently shapes, the curbs can be configured in such a manner as to make the curbs self-locking, preventing them to slide both under the pressure of the water contained in the hydraulic structure, and possible settling of the curbs and/or of the same hydraulic structure.

## SHORT DESCRIPTION OF THE DRAWINGS

**[0026]** These and other features and advantages of the anchoring method and device for protective waterproofing liners of hydraulic structures according to the present invention, will be clearer from the following description of certain preferred embodiments, with reference to the enclosed drawings, in which:

Fig. 1 is a schematic top view of a basin for containing water;

Fig. 2 is an enlarged detail, according to line 2-2 of figure 1, relating to a first embodiment;

Fig. 3 is an enlarged cross sectional view, according to line 3-3 of figure 2;

Fig. 4 is a more enlarged detail of figure 3;

Fig. 5 is an enlarged detail similar to figure 4, according to line 5-5 of figure 2;

Fig. 6 is a view similar to figure 2, which shows the laying down and seaming of a first sheet of the waterproofing liner;

Fig. 7 is a view similar to that of figure 6, which shows the laying down and seaming of a second sheet of the waterproofing liner;

Fig. 8 is an enlarged cross sectional view according to line 8-8 of figure 7;

Fig. 9 is a frontal view similar to figure 2, relating to a second embodiment;

Fig. 10 is an enlarged cross sectional view according to line 10-10 of figure 9;

Fig. 11 is an enlarged cross sectional view according to line 11-11 of figure 9:

Figs 12, 13, 14 and 15 show cross sectional view similar to figure 11, relating to different methods of laying seaming strips for the waterproofing lines, both on flat, horizontal and slanted surfaces.

## DETAILED DESCRIPTION OF THE INVENTION

**[0027]** Figure 1 shows a top view of a hydraulic structure, for example a large hydraulic basin; nevertheless, the method and the system for anchoring a waterproofing liner according to the present invention, are similarly applicable to any type of hydraulic structure, such as dams, artificial basins, canals, or any other possible applications, for example for waterproofing landfill sites and to lay down protective waterproofing liners.

**[0028]** In the embodiment in figure 1 the hydraulic structure 10 comprises an embankment 11 of rectangular shape that bounds a large basin for containing water; the embankment 11 is obtained by superimposing a plurality of compacted layers of earth and/or rock or other suitable loose material. The embankment 11, on the side facing the water, has a sloped inner wall 12 that extends from the top of the embankment 11 downwards to the bottom of the same embankment. To prevent the water in the basin from leaking outside through the same embankment 11, the inner wall 12 has to be protected by a suitable waterproofing liner 13 consisting, for example, of a plurality of flexible sheets of synthetic material, which are elastically stretchable and sealingly seamed together on a laying surface of said side wall. For example, the waterproofing liner 13 can consist of a plurality of sheets of PVC, or another synthetic material such as a "geomembrane", or "geocomposite" provided with a rear protective layer of "geotextile" suitable for a contact with the ground.

**[0029]** As schematically indicated in figure 1, the inner wall 12 of the embankment 11 is protected by a waterproofing liner 13 fastened by seaming, to a plurality of continuous seaming bands 14 of synthetic material, parallely arranged and spaced apart from one another.

**[0030]** The seaming bands 14 extend from top to bottom in a transverse direction to the wall 12, and are anchored to a plurality of concrete curbs 15, preferably of porous concrete material permeable to water, obtained for example by extrusion or casting, which in the embodiment in figure 1 extend parallel to the longitudinal direction of the wall 12.

**[0031]** For the purposes of the present description, porous concrete material is defined as a mass of gravel, sand or other inert material, of suitable granulometry, mixed with a cement binder in correct proportions, so as to enable the drainage through open pores and interstices of the concrete, of the water that has impregnated the body of the hydraulic structure, conveying the seeped

water to the bottom or to a system of discharge conduits.

**[0032]** The method and the system for anchoring a waterproofing liner to a wall of a hydraulic structure according to the invention are particularly suitable for constructing hydraulic works by superimposing compacted layers of earth, rock and other loose material, in which an homogeneous layer of porous concrete may be formed on the side wall facing the interior or water side, defining with the curbs 15 a laying surface for a waterproofing liner; nevertheless, other applications are not excluded.

**[0033]** In the embodiment under consideration, a number of porous concrete curbs 15 are extruded horizontally following longitudinal outline of the wall 12 to be lined; the curbs 15 can be extruded and the embankment 11 can be constructed gradually in successive steps, to form continuous seaming bands 14 progressively during the extrusion of the curbs and formation of the compacted layers of the embankment 11, as explained below.

**[0034]** Still with reference to the embodiment under consideration, and to figures 2, 3 and 4, the hydraulic structure 10 is constructed and the waterproofing liner 13 is anchored to an inner side wall in the following manner: initially, a first base curb 15.1 is formed at the base of the wall 12 of the hydraulic structure 10, by extruding the concrete by a suitable apparatus, for example of the type previously mentioned and normally used for forming road curbs or similar applications.

**[0035]** Once the first base curb 15.1 has been extruded and consolidated, in each of preset positions of the curb 15.1 at which the seaming bands 14 for the protective liner 13 have to form, a first modular anchor strip 14.1, consisting for example of a strip of a preset length of the same synthetic material as the waterproofing liner 13, or of compatible synthetic material, is superimposed and positioned transversely to the curb 15.1, then being folded downwards against the rear side of the curb to which it can be provisionally fastened by shot nails 17 and/or ballast material 18.

**[0036]** After the extrusion of the first base curb 15.1 and the superimposition and fastening to the curb of an appropriate number of anchor strips 14.1 at the zones of the wall 12 in which the seaming bands 14 have to be performed, a first layer 16.1 of loose material is laid down and compacted so as to form the body 10 of the embankment, and at the same time locking a rear anchor portion of each anchor strip 14.1 against the curb 15.1, by the layer 16.1 of compacted loose material; a second curb 15.2 is then extruded, being partially superimposed on the previously extruded base curb 15.1, definitively locking the first set of anchor strips 14.1.

**[0037]** More precisely, as shown in figures 3 and 4 of the embodiment under consideration, the curbs 15 have a wedge-shaped cross section, configured with: a first sloping upper surface 15', having substantially the same slope as the wall 12 of the hydraulic structure; a second upper horizontal surface 15" suitable for constituting a resting zone for the curb 15.2, which is extruded subsequently; and a pinching zone PI, figure 4, for the anchor strips 14.1. Each curb 15 further comprises a side surface 15"" along the rear side, which lies on a vertical or slightly slanted plane, against which the rear anchor portion of each seaming strip 14.1 is firmly locked by a layer of loose material 16.1 during laying and compacting operations; similarly the anchor portion of the remaining anchor strips is locked between the upper flat surface 15" of each curb 15, and the lower flat surface 15'" of a curb 15 immediately positioned above.

**[0038]** As shown in figures 3 and 4, the anchor strips 14.1, 14.n will thus be configured with a first fore seaming portion 14' that is superimposed on the sloped upper surface 15' of a respective curb 15.1, 15.n, and with a rear anchor portion 14" intended for being fastened and locked between the upper horizontal surface 15" of the curb 15.1 in the embodiment in figure 4, and the lower surface 15"' of the curb 15.2, partially superimposed to the preceding curb 15.1. The rear anchor portion 14" of each anchor strip 14.1, 14n, extends with a vertical length 14"', along the rear surface 15"" of the curb 15.1.

**[0039]** Thus, after laying on the curb 15.1 a first set of anchor strips 14.1 at the points in which the seaming bands 14 have to be formed, the single anchor strips 14.1 can be provisionally anchored to the curb 15.1, after a suitable hardening time, for example by shot nails 17, ballast material 18 or other anchor means, maintaining the single anchor strips 14.1 in a stretched condition; a first layer of loose material 16.1 is then laid down and compacted. After the first curb 15.1 is completed, the first anchor strips 14.1 and the first layer of material 16.1 constituting the body of the hydraulic structure 10 are laid down, a second curb 15.2 is extruded being partially superimposed to the preceding curb 15.1; in this manner a firm anchorage of the rear anchor portion 14", 14"', of the first set of anchor strips 14.1 is achieved, the rear anchor portion 14", 14'" being firmly locked between opposite facing surfaces 15" and 15'" of two contiguous curbs 15.1 and 15.2, and by the layer of compacted loose material 16.1.

**[0040]** After the second curb 15.2 has been extruded, one proceeds again to lay a second set of anchor strips 14.2 in a same identical manner and axially aligned to the first set of anchor strips 14.1.

**[0041]** After provisionally fixing the rear anchor portion of the second set of anchor strips 14.2 to the second curb 15.2, the fore seaming portion 14' of each strip of the second set of anchor strips 14.2 is axially laid down and fastened to a respective contiguous anchor strip 14.1 by seaming the fore edge 19 thereof for example to the fore portion 14' of the anchor strip 14.1.

**[0042]** As shown in detail in figure 4, in which the same reference numbers have been used as for the preceding figures to indicate similar or equivalent parts, it is preferable that the seaming of the fore edge 19 of the successive second set of anchor strips 14.2, 14.n to the preceding first set of anchor strips, should be close, or as near as possible to the rear anchor portion 14" of the first set of anchor strips 14.1; then a second layer of loose ma-

terial 16.2 is laid down and compacted on the preceding layer 16.1. The construction by superimposed layers of loose material of the hydraulic structure, the laying, locking and seaming of the sets of modular anchor strips 14.1, 14.n that make up the set of seaming bands 14, can continue in the manner disclosed previously, until the hydraulic structure 10 and the liner 13 are completed. Thus all the anchor strips 14.1-14.n belonging to a same seaming band 14, will be arranged in series in a traverse direction and axially aligned according to the slope of the wall 12, firmly fixed together and to the concrete curbs 15.1-15.n; at this point it will be possible to lay down on the laying surface defined by the curbs, a length of the waterproofing liner 13, compatible with the space between the anchor strips of contiguous seaming bands 14, fastening along continuous seaming lines.

**[0043]** In order to prevent the various curbs 15 to move and accidentally slide along a sloped wall of the hydraulic structure, for example as a result of local settling or for other causes, the curbs 15, as shown in figures 2 and 5, are configured with interlocking elements, for example consisting of triangular elements 20 that extend from the lower surface 15''' of each curb 15, against the rear side 15'''' of a curb 15 immediately downstream; naturally, the interlocking elements between curbs 15 can also be configured and differently arranged from what has been shown.

**[0044]** Still with reference to the embodiment under consideration, after extrusion of the concrete curbs 15, positioning and seaming of the anchor strips 14.1-14.n of the set of seaming bands 14, it is possible to proceed to lay down of the single waterproofing sheets that make up the waterproofing liner 13 on the laying surface defined by the concrete curbs 15, and then seaming the single waterproofing sheets on the anchor strips 14 both with the hydraulic structure completed and during the construction.

**[0045]** The above will now be disclosed in greater detail with reference to figure 2, 6, 7 and 8 of the drawings; figure 2 shows a partial view of the wall 12 of the hydraulic structure 10, on the side facing the water, after the concrete curbs 15 have been extruded and the set of seaming bands 14 have been anchored to the curbs 15 in the manner previously disclosed.

**[0046]** Starting from the condition of figure 2, a first waterproofing sheet 13.1 is laid down seaming the lateral edges to a respective seaming band 14, along a first continuous seaming line 21, as shown in figure 6.

**[0047]** Subsequently, as shown in figure 7, a second waterproofing sheet 13.2 is laid down partially superimposed and seamed to the underlying edge of the preceding waterproofing sheet 13.1, along a second continuous seaming line 22, as shown in the section in figure 8.

**[0048]** Superimposition and sealing seaming of the waterproofing sheets 13 each others and to the seaming bands 14, can be differently achieved. For example, as shown in the cross section of figure 8, the edge of the first waterproofing sheet 13.1 is seamed directly on the seaming band 14 by a continuous seaming 21; otherwise the edge of the second waterproofing sheet 13.2 is partially superimposed on and directly seamed to the edge of the first waterproofing sheet 13.1 by a second continuous seaming 22; it is nevertheless not excluded that the waterproofing sheets 13.1, 13.n can be sealingly connected side by side directly to the various seaming bands 14 without the need to reciprocally superimpose the sheets 13.

**[0049]** If the single waterproofing sheets consists of a simple geomembrane of synthetic resin, for example PVC or another suitable plastic material, the seamings 21 and 22 can be performed with the edges of the waterproofing sheets directly overlapped in contact with one another, and/or in contact with the seaming band 14; if the single waterproofing sheets 13.1, 13.n consist of a geocomposite, i.e. comprise a geomembrane coupled with a geotextile, a band of geotextile must be previously removed along the edges to be seamed. The laying down of the entire waterproofing liner 13 can therefore be gradually performed.

**[0050]** With reference to figures 9, 10 and 11, a second embodiment of the method and system for anchoring waterproofing liners to hydraulic structures in loose material, according to the present invention will now be disclosed.

**[0051]** In the preceding embodiment of figures 1 to 8, the single waterproofing sheets 13.1, 13.n that make up the waterproofing liner 13, are fastened to seaming bands 14 formed progressively from the bottom up, between a lower and an upper edge or position of the wall 12, transversely extending to a plurality of parallely arranged horizontal extruded concrete curbs 15, locking the single anchor strips 14.1-14.n between curbs 15 extruded in a longitudinal direction of the wall 12 of the hydraulic structure 10, as disclosed previously.

**[0052]** Otherwise, in the case of figures 9-11 the anchor strips 14.1, 14.n that form each transverse seaming band 14 are again serially arranged in the sloping direction of the wall, and superimposed to corresponding concrete curbs 23 consisting of modular blocks made by casting a concrete material in apposite formworks, which transversely extend to the sloped wall 12 of the hydraulic structure, always proceeding from bottom to top; also in this case the entire hydraulic structure is gradually constructed, by superimposing compacted layers 16 of loose material, proceeding simultaneously to casting the single modular blocks 23.1-23.n that make up the concrete curbs 23, and laying down to the curbs 23 a set of seaming bands 14, each consisting of a plurality of serially arranged modular anchor strips 14.1, 14.n axially aligned and seamed to one another, suitably fixing the anchor strips 14.1, 14.n to the modular blocks 23 during casting; also in this case it is preferable that the concrete material is of porous type, as previously mentioned.

**[0053]** During laying down of an intermediate layer 24 of porous concrete, or subsequently, by suitable formworks or moulds, the single concrete curbs 23 are formed by a succession of concrete casts relative to a plurality

of axially aligned modular blocks 23.1-23.n, starting from the bottom to the top, in such a manner that the fore end of each modular block 23.1 - 23.n, subsequently cast, comes to rest against the rear end of the previously cast underlying modular block.

**[0054]** After each modular block 23.1, 23.n is cast, a corresponding set of modular anchor strip 14.1, 14.n is laid down by superimposing the fore part 14' thereof longitudinally to the upper surface 23' of a respective modular block 23. As shown in figure 10, the rear anchor part 14" of each anchor strip 14.1, 14.n is folded downwards, against the rear surface of the already cast modular block 23, to which can be provisionally fixed by one or more shot nails 17, or in another manner, extending the rear anchor part 14"', which is locked between the modular block 14.2 and the layer 16 of compacted loose material; then the fore seaming part 14' of each anchor strip 14.2 is seamed to a contiguous preceding anchor strip 14.1 such as the fore part of the strip 14.1 in a stretched condition on the previously cast modular block 23.1. The rear anchor part 14" of each anchor strip 14.1 - 14.n during casting of the immediately following modular block, above the preceding one, is thus firmly locked between opposite facing surfaces of two contiguous modular blocks, and between the modular blocks and the layers of compacted loose material 16; in this manner a plurality of transverse curbs 23, each consisting of a plurality of single modular blocks 23.1-23.n adjacent to and axially aligned one another, are vertically formed in a traverse direction to the longitudinal wall of the hydraulic structure, proceeding to the simultaneous forming and anchoring of the seaming bands 14, and compactation of the layers 15 of loose material; in particular the layers of loose material are compacted before the laying down of the drainage layer in porous concrete, and curbs may be formed for example by filling empty spaces between the porous concrete layers.

**[0055]** Also in this case, after casting of modular curb blocks of a number of curbs, a set of anchor strips are laid down, fixedly seamed and locked by superimposed layers of compacted loose material 16 during the construction of the hydraulic structure, to make possible the laying down of a number of waterproofing sheets, then gradually proceeding to the formation of the waterproofing liner 13.

**[0056]** In all cases continuous seaming bands 14 are formed that vertically extend, transversely to the length of and for the entire height of the wall 12 to be protected of any hydraulic structure, to which waterproofing sheets 14.1-14.n of synthetic material may be to sealingly fastened by continuous seaming lines, until an entire waterproofing liner is formed.

**[0057]** The width of the single seaming bands 14, the space between them and the modular length anchor strips 14.1, 14.n, can be of any value; in general they are defined during the design step, according to specific features or requirements of the hydraulic structure. By way of example, the width of the seaming bands 14 and of the anchor strips can be comprised between 20 and 60 cm; moreover the space between centre lines of the seaming bands 14 can be comprised between 100 and 2000 cm. Equally, the modular length of the anchor strips 14.1, 14.n can be comprised between 130 and 150 cm, according to the slope and/or the height of the wall.

**[0058]** Also the length of the fore seaming part and of the rear anchor part for locking to the curbs 15, or to modular blocks 23 of the anchor strips, can vary each time and can always be defined during the design step. Further, as shown in figure 11, between contiguous curbs 23 intermediate layer 24 of porous concrete can be laid down suitable for defining with the curbs a laying down surface for the waterproofing liner 13, which is permeable to water.

**[0059]** Figures 12, 13, 14 again by way of example, show other possible solutions for fastening the anchor strips to the modular blocks of the concrete curbs 23; while in the preceding cases, the anchor strips 14.1-14.n are locked between facing side surfaces of extruded curbs, or surfaces of contiguous modular blocks, and between the curbs or modular blocks and layers of compacted loose material 16, in the case of figures 12, 13 and 14, as indicated by reference number 14.n, the anchor strips are locked between the modular blocks 23n, the intermediate layers of porous concrete 24 and the compacted layers 16 or the underlying ground. In this case the single anchor strips are partially or totally folded around each modular block 23n, as shown, superimposing on and seaming each end of an anchor strip 14n to the facing ends of contiguous anchor strips.

**[0060]** In particular, in the case of figure 12 an anchor strip 14n is shown that is folded into a "Z" shape; the anchor strip 14n comprises an upper longitudinal wing 14.1n, which defines a seaming part for the waterproofing sheets 13, that extends from an edge of the upper surface of the modular block 23n laterally to the left, outside the block 23n, above the intermediate layer in porous concrete material 24.

**[0061]** The anchor strip 14.n, further comprises an intermediate portion 14.2n folded downwards, clamped between opposite surfaces of the modular block 23n and of the left layer of porous concrete 24, and comprises a lower wing 14.3n between the lower surface of the modular block 23.n, and the bottom layer 16n, in which the intermediate portion 14.2n and the lower wing 14.3n define the part for locking the strip to the modular block 23n.

**[0062]** Further, as previously pointed out, the two ends of each anchor strip 14 protrude for a certain length from the respective ends of the modular block 23, to be seamed to the contiguous anchor strips. Also in this case, the partially superimposed lateral edges of contiguous waterproofing sheets 13.1, 13.2, can be seamed together and to the upper wings 14.1n of continuous anchor strips, as indicated by the reference numbers 21 and 22, defining continuous seaming lines for a waterproofing liner 13.

**[0063]** Figure 13 shows a further solution that is substantially similar to those of figure 12, for which the same

reference numbers have been used to indicate similar or equivalent parts; the solution of figure 13 differs from that of figure 12 inasmuch as the anchor strip 14.n is folded into an upturned omega shape, around a corresponding modular block 23.n, with two side wings 14.1n folded to the exterior with respect to the modular block 23.n. Also in this case the waterproofing sheets 13.1, 13.2 can be sealingly seamed together and to at least one of the side wings 14.1n of the anchor strips, the series succession and connection of which forms a continuous seaming band 14 for the waterproofing liner 13.

**[0064]** Figure 14 shows a variant of the solution of figure 13; in the case of figure 14 the same reference numbers as for figure 13 have been used to indicate similar or equivalent parts. The solution of figure 14 differs from figure 13 inasmuch as each waterproofing sheet 13.1 is seamed in 21 to a respective side wing 14.1n, as shown; further, with reference number 20 a waterproofing band for covering the modular blocks 23n has been indicated. Lastly, it is pointed out that in all cases shown, the single sheets 13.1-13n of waterproofing material can also be fixed locally, in preset positions, by mechanical anchors, for example shot nails, pins or the like.

**[0065]** Figure 15 shows a last solution that is again comparable with the preceding figures 12 and 13; in the case of figure 15, the two side wings 14.1n of the anchor strip 14n have been folded towards the interior, against the upper surface of the modular block 23n, superimposing and seaming them together in 25; in this manner a tubular anchor strip is formed around and along each modular block 23.n, to which the waterproofing sheets 13.1 and 13.2, of the waterproofing liner, can be again seamed in 21 and 22, as shown.

From what has been said and shown it is thus clear that a method and a system for anchoring a waterproofing liner have been provided consisting of a plurality of flexible sheets of synthetic material, which can be sealingly seamed together and to continuous seaming bands of synthetic material, ensuring in this manner a firm anchorage to a plurality of concrete curbs, which are extruded or cast and, which extend longitudinally and/or transversely to a sloped or horizontal wall to be protected of any hydraulic structure made of compacted loose material, or the like.

## Claims

1. A method for anchoring a waterproofing liner (13) to a side wall (12) which extends in a longitudinal direction of a hydraulic structure (10) comprising compacted layers (16) of loose material, according to which the waterproofing liner (13) comprises flexible sheets (13n) of synthetic material fastened to the side wall (12), the method further comprising the steps of:

   defining a laying surface of the side wall (12) for laying down the waterproofing liner (13), providing the laying surface with a plurality of continuous seaming bands (14) for the waterproofing liner (13), in synthetic material;
   fastening the waterproofing liner (13) to the side wall (12) of hydraulic structure (10) by seaming the waterproofing liner (13) to the continuous seaming bands (14);
   **characterised by** the steps of:

      configuring the side wall (12) of the hydraulic structure (10) with a plurality of concrete curbs (15, 23) providing said laying surface for the waterproofing liner (13);
      anchoring the plurality of continuous seaming bands (14) to the concrete curbs (15, 23) by arranging the continuous seaming bands (14) in a traverse direction from an upper to a lower position of the side wall (12);
      laying down the waterproofing liner (13) on the laying surface of the concrete curbs (15, 23); and
      anchoring the waterproofing liner (13) to the concrete curbs (15, 23) by seaming the waterproofing liner (13) to the continuous seaming bands (14).

2. The method for anchoring the waterproofing liner (13) according to claim 1, **characterised in that** each seaming band (14) consists of a plurality of modular anchor strips (14.1 - 14.n) axially aligned, seamed together and fastened to the concrete curbs (15, 23).

3. The method for anchoring the waterproofing liner (13) according to claim 1, **characterised by** the steps of:

   extruding or casting a plurality of concrete curbs (15, 23) in a longitudinal direction to the wall (12) of the hydraulic structure (10);
   providing a plurality of continuous seaming bands (14) for the waterproofing liner (13), transversely extending to the concrete curbs (15), wherein each continuous seaming band (14) comprises a plurality of axially aligned modular anchor strips (14.1 - 14.n), each anchor strip (14.1 - 14.n) comprising a fore seaming part (14') and a rear anchor part (14") for anchor to a concrete curb (15, 23);
   progressively forming each continuous seaming band (14) by fastening the rear anchor part (14") of each anchor band (14.1 - 14.n) to a first concrete curb (15, 23); and
   partially superimposing and seaming the fore seaming part (14') of each anchor strip (14.1-14.n) to the fore seaming part (14') of a

contiguous anchor strip (14.1 - 14.n) previously fastened to a second concrete curb (15, 23) contiguous with the previous one.

**4.** The method for anchoring a waterproofing liner (13) to a wall (12) of a hydraulic structure (10), according to claim 3, **characterised by** the steps of:

superimposing each anchor band strip (14.1-14n) transversely to an extruded curb (15), and folding the rear anchor part (14") of the anchor strip (14.1-14n) against the extruded curb (15); and
locking the folded rear anchor part (14") of each anchor strip (14.1-14n) against the previously extruded curb (15), by a compacted layer (16) of loose material and by a subsequently extruded contiguous concrete curb (15).

**5.** The method for anchoring a waterproofing liner (13) to a wall (12) of a hydraulic structure (10) according to claim 4, **characterised in that** each anchor strip (14.1-14.n) is provisionally fastened to an extruded curb (15) before the extrusion of a next concrete curb (15).

**6.** The method for anchoring a waterproofing liner (13) to a wall (12) of a hydraulic structure (10) according to claim 3, **characterised by** configuring the concrete curbs (15) with opposite shoulder elements (15"", 20).

**7.** The method for anchoring a waterproofing liner (13) to a wall (12) of a hydraulic structure (10) that extends in a longitudinal direction, according to claim 1, **characterised by** :

configuring each concrete curb (23) with a plurality of concrete modular blocks (23n), axially aligned in a transverse direction to the wall (12); and
providing a continuous seaming band (14) longitudinally to each concrete curb (23), consisting of a plurality of modular anchor strips (14.1 - 14.n) each comprising a rear anchor part fastened to a respective modular block (23n) and a fore seaming part seamed to a fore anchor strip (14.1-14.n) contiguous to the preceding one.

**8.** The method for anchoring a waterproofing liner (13) according to any preceding claims, **characterised in that** the concrete curbs (15, 23) for anchoring the waterproofing liner (13), are made of porous concrete.

**9.** The method for anchoring a waterproofing liner (13) according to claim 7 **characterised by** fastening each anchor strip (14.1 - 14.n) by partially or totally winding it to each modular block (23), and configuring each anchor strip (14.1-14.n) with at least one side seaming wing (14.ln) for the waterproofing liner (13).

**10.** A system suitable for anchoring a waterproofing liner (13) in synthetic material to a side wall (12) extending in a longitudinal direction of a hydraulic structure (10) in compacted loose material, according to the method of claim 1, in which the waterproofing liner (13) is fastened to continuous seaming bands (14) in synthetic material anchored to the side wall (12), **characterised by** comprising:

a plurality of parallely arranged concrete curbs (15; 23) defining a laying surface for the waterproofing liner (13);
a plurality of continuous seaming bands (14) transversely extending from an upper to a lower position of the side wall (12);
each continuous seaming band (14) comprising a plurality of modular anchor strips (14.n) arranged in series along the seaming band (14), each anchor strip (14.n) comprising a rear anchor portion fastened to a concrete curb (15, 23), and a fore seaming portion seamed to a continuous anchor strip.

**11.** The system suitable for anchoring the waterproofing liner (13) to the wall (12) of the hydraulic structure (10) according to claim 10, **characterised by** comprising a plurality of extruded concrete curbs (15) that extend, in mutual contact, longitudinally to the wall (12) of the hydraulic structure; and
in that each seaming band (14) comprises a plurality of axially aligned anchor strips (14.1 - 14.n), in which each anchor strip (14.1 - 14.n) is arranged transversely bridging each concrete curb (15).

**12.** The system suitable for anchoring the waterproofing liner (13) to the wall (12) of the hydraulic structure (10), according to claim 10, **characterised in that** each anchor strip (14.1 - 14.n) of a continuous seaming band (14), comprises a fore seaming part (14') superimposed and seamed to a fore seaming part (14") of a contiguous anchor strip (14.1 - 14.n), and a rear anchor part fastened to a concrete curb (15).

**13.** The system for anchoring a waterproofing liner (13) to the wall (12) of the hydraulic structure (10), according to claim 10, **characterised in that** the concrete curbs (15, 23) extend transversely and/or longitudinally to a sloped wall (12) of the hydraulic structure (10).

**14.** The system for anchoring the waterproofing liner (13) to the wall (12) of the hydraulic structure (10) accord-

ing to claim 13, **characterised in that** each concrete curb (23) comprises a plurality of concrete modular blocks (23n), axially aligned in a traverse direction to the wall (12) of the hydraulic structure (10).

**15.** The system suitable for anchoring the waterproofing liner (13) to the wall (12) of the hydraulic structure (10) according to claim 14, **characterised in that** each anchor strip (14.1-14.n) is partially or totally folded around a concrete modular block (23).

**16.** The system suitable for anchoring the waterproofing liner (13) to the wall (12) of the hydraulic structure (10) according to any preceding system claim, **characterised in that** each concrete curb or modular block (15, 23n) consists of a porous concrete.

**17.** The system for anchoring the waterproofing liner (13) to the wall (12) of the hydraulic structure (10), according to any preceding system claim, in which the single concrete curbs (15) comprise modular blocks (23) that transversely extend to the wall (12) of the hydraulic structure (10), **characterised by** comprising a layer (24) of porous concrete between contiguous concrete curbs (23n).

**18.** The system suitable for anchoring the waterproofing liner (13) to the wall (12) of the hydraulic structure (10) according to any one of claims 10 to 17, **characterised by** comprising mechanical members for fastening the waterproofing liner (13) to the concrete curbs (15, 23).

**Patentansprüche**

**1.** Verfahren zur Verankerung einer wasserdichten Auskleidung (13) an einer Seitenwand (12), die sich in einer Längsrichtung einer Hydraulikstruktur (10) erstreckt, die verdichtete Schichten (16) von Schüttgut umfasst, nach dem die wasserdichte Auskleidung (13) flexible Folien (13n) aus synthetischem Material umfasst, die an der Seitenwand (12) befestigt sind, wobei das Verfahren weiter die folgenden Schritte umfasst:

Festlegen einer Verlegefläche der Seitenwand (12) zum Verlegen der wasserdichten Auskleidung (13), wobei die Verlegefläche mit einer Mehrzahl von durchgehenden Falzbändern (14) für die wasserdichte Auskleidung (13) aus synthetischem Material bereitgestellt ist;
Befestigen der wasserdichten Auskleidung (13) an der Seitenwand (12) der Hydraulikstruktur (10) durch Falzen der wasserdichten Auskleidung (13) an den durchgehenden Falzbändern (14);
**gekennzeichnet durch** die Schritte:
des Konfigurierens der Seitenwand (12) der Hydraulikstruktur (10) mit einer Mehrzahl von Betonbordsteinen (15, 23), welche die Verlegefläche für die wasserdichte Auskleidung (13) bereitstellen;
der Verankerung der Mehrzahl von durchgehenden Falzbändern (14) an den Betonbordsteinen (15, 23) durch Anordnen der durchgehenden Falzbänder (14) in einer Querrichtung von einer oberen zu einer unteren Position der Seitenwand (12);
des Verlegens der wasserdichten Auskleidung (13) auf der Verlegefläche der Betonbordsteine (15, 23); und
der Verankerung der wasserdichten Auskleidung (13) an den Betonbordsteinen (15, 23) durch Falzen der wasserdichten Auskleidung (13) an den durchgehenden Falzbändern (14).

**2.** Verfahren zur Verankerung der wasserdichten Auskleidung (13) nach Anspruch 1, **dadurch gekennzeichnet, dass** jedes Falzband (14) aus einer Mehrzahl von modularen Ankerstreifen (14.1-14.n) besteht, die axial ausgerichtet, miteinander verfalzt und an den Betonbordsteinen (15, 23) befestigt sind.

**3.** Verfahren zur Verankerung der wasserdichten Auskleidung (13) nach Anspruch 1, **gekennzeichnet durch** die Schritte:

des Extrudierens oder Gießens einer Mehrzahl von Betonbordsteinen (15, 23) in Längsrichtung zur Wand (12) der Hydraulikstruktur (10);
der Bereitstellung einer Mehrzahl von durchgehenden Falzbändern (14) für die wasserdichte Auskleidung (13), die sich quer zu den Betonbordsteinen (15) erstrecken, wobei jedes durchgehende Falzband (14) eine Mehrzahl von axial ausgerichteten, modularen Ankerstreifen (14.1-14.n) umfasst, wobei jeder Ankerstreifen (14.1-14.n) einen vorderen Falzteil (14') und einen hinteren Ankerteil (14") zur Verankerung an einem Betonbordstein (15, 23) umfasst;
der schrittweisen Bildung jedes durchgehenden Falzbandes (14) durch Befestigen des hinteren Ankerteils (14") jedes Ankerbandes (14.1-14.n) an einem ersten Betonbordstein (15, 23); und
des teilweisen Überlagerns und Falzens des vorderen Falzteils (14') jedes Ankerstreifens (14.1-14.n) zu dem vorderen Falzteil (14') eines durchgehenden Ankerstreifens (14.1-14.n), der zuvor an einem zweiten Betonbordstein (15, 23) befestigt wurde, der mit dem vorherigen angrenzend ist.

**4.** Verfahren zur Verankerung einer wasserdichten Auskleidung (13) an einer Wand (12) einer Hydrau-

likstruktur (10) nach Anspruch 3, **gekennzeichnet durch** die Schritte:

des Überlagerns jedes Ankerbandstreifens (14.1-14n) quer zu einem extrudierten Bordstein (15) und des Faltens des hinteren Ankerteils (14") des Ankerstreifens (14.1-14n) gegen den extrudierten Bordstein (15); und
des Verriegelns des gefalteten hinteren Ankerteils (14") jedes Ankerstreifens (14.1-14n) gegen den zuvor extrudierten Bordstein (15), durch eine verdichtete Schicht (16) aus Schüttgut und durch einen nachfolgend extrudierten angrenzenden Betonbordstein (15).

**5.** Verfahren zur Verankerung einer wasserdichten Auskleidung (13) an einer Wand (12) einer Hydraulikstruktur (10) nach Anspruch 4, **dadurch gekennzeichnet, dass** jeder Ankerstreifen (14.1-14.n) vor der Extrusion eines nächsten Betonbordsteins (15) provisorisch an einem extrudierten Bordstein (15) befestigt wird.

**6.** Verfahren zur Verankerung einer wasserdichten Auskleidung (13) an einer Wand (12) einer Hydraulikstruktur (10) nach Anspruch 3, **gekennzeichnet durch** das Konfigurieren der Betonbordsteine (15) mit gegenüberliegenden Schulterelementen (15"", 20).

**7.** Verfahren zur Verankerung einer wasserdichten Auskleidung (13) an einer Wand (12) einer Hydraulikstruktur (10), die sich in Längsrichtung erstreckt, nach Anspruch 1, **gekennzeichnet durch**:

Konfigurieren jedes Betonbordsteins (23) mit einer Mehrzahl von modularen Betonblöcken (23n), die axial in einer Querrichtung zur Wand (12) ausgerichtet sind; und
Bereitstellen eines durchgehenden Falzbandes (14) längs zu jedem Betonbordstein (23), bestehend aus einer Mehrzahl von modularen Ankerstreifen (14.1-14.n), die jeweils einen hinteren Ankerteil, der an einem entsprechenden modularen Block (23n) befestigt ist, und einen vorderen Falzteil, der an einen vorderen Ankerstreifen (14.1-14.n), der an den vorhergehenden angrenzend ist, gefalzt ist, umfassen.

**8.** Verfahren zur Verankerung einer wasserdichten Auskleidung (13) nach einem der vorstehenden Ansprüche, **dadurch gekennzeichnet, dass** die Betonbordsteine (15, 23) zur Verankerung der wasserdichten Auskleidung (13) aus Porenbeton hergestellt sind.

**9.** Verfahren zur Verankerung einer wasserdichten Auskleidung (13) nach Anspruch 7, **gekennzeichnet durch** die Befestigung jedes Ankerstreifens (14.1-14.n) durch sein teilweises oder vollständiges Aufwickeln auf jeden modularen Block (23) und das Konfigurieren jedes Ankerstreifens (14.1-14.n) mit mindestens einem seitlichen Falzflügel (14.1n) für die wasserdichte Auskleidung (13).

**10.** System, das zur Verankerung einer wasserdichten Auskleidung (13) aus synthetischem Material an einer Seitenwand (12) geeignet ist, die sich in Längsrichtung einer Hydraulikstruktur (10) aus verdichtetem Schüttgut erstreckt, nach dem Verfahren nach Anspruch 1, worin die wasserdichte Auskleidung (13) an durchgehenden Falzbändern (14) aus synthetischem Material befestigt ist, die an der Seitenwand (12) verankert sind, **dadurch gekennzeichnet, dass** es Folgendes umfasst:

eine Mehrzahl von parallel angeordneten Betonbordsteinen (15; 23), die eine Verlegefläche für die wasserdichte Auskleidung (13) definieren;
eine Mehrzahl von durchgehenden Falzbändern (14), die sich quer von einer oberen zu einer unteren Position der Seitenwand (12) erstrecken;
wobei jedes durchgehende Falzband (14) eine Mehrzahl von modularen Ankerstreifen (14.n) umfasst, die in Reihe entlang des Falzbandes (14) angeordnet sind, wobei jeder Ankerstreifen (14.n) einen hinteren Ankerabschnitt umfasst, der an einem Betonbordstein (15, 23) befestigt ist, und einen vorderen Falzabschnitt, der an einen durchgehenden Ankerstreifen gefalzt ist.

**11.** System, das zur Verankerung der wasserdichten Auskleidung (13) an der Wand (12) der Hydraulikstruktur (10) nach Anspruch 10 geeignet ist, **gekennzeichnet durch** das Umfassen einer Mehrzahl von extrudierten Betonbordsteinen (15), die sich in gegenseitigem Kontakt längs zur Wand (12) der Hydraulikstruktur erstrecken; und
worin jedes Falzband (14) eine Mehrzahl von axial ausgerichteten Ankerstreifen (14.1-14.n) umfasst, worin jeder Ankerstreifen (14.1-14.n) quer zu jedem Betonbordstein (15) angeordnet ist.

**12.** System, das zur Verankerung der wasserdichten Auskleidung (13) an der Wand (12) der Hydraulikstruktur (10) nach Anspruch 10 geeignet ist, **dadurch gekennzeichnet, dass** jeder Ankerstreifen (14.1-14.n) eines durchgehenden Falzbandes (14) einen vorderen Falzteil (14') umfasst, der mit einem vorderen Falzteil (14") eines angrenzenden Ankerstreifens (14.1-14.n) überlagert und verfalzt ist, und einen hinteren Ankerteil, der an einem Betonbordstein (15) befestigt ist.

**13.** System zur Verankerung einer wasserdichten Aus-

kleidung (13) an der Wand (12) der Hydraulikstruktur (10) nach Anspruch 10, **dadurch gekennzeichnet, dass** sich die Betonbordsteine (15, 23) quer und/oder längs zu einer schrägen Wand (12) der Hydraulikstruktur (10) erstrecken.

**14.** System zur Verankerung der wasserdichten Auskleidung (13) an der Wand (12) der Hydraulikstruktur (10) nach Anspruch 13, **dadurch gekennzeichnet, dass** jeder Betonbordstein (23) eine Mehrzahl von modularen Betonblöcken (23n) umfasst, die axial in Querrichtung zur Wand (12) der Hydraulikstruktur (10) ausgerichtet sind.

**15.** System, das zur Verankerung der wasserdichten Auskleidung (13) an der Wand (12) der Hydraulikstruktur (10) nach Anspruch 14 geeignet ist, **dadurch gekennzeichnet, dass** jeder Ankerstreifen (14.1-14.n) teilweise oder vollständig um einen modularen Betonblock (23) gefaltet ist.

**16.** System, das zur Verankerung der wasserdichten Auskleidung (13) an der Wand (12) der Hydraulikstruktur (10) nach einem der vorstehenden Systemansprüche geeignet ist, **dadurch gekennzeichnet, dass** jeder Betonbordstein oder modulare Block (15, 23n) aus einem Porenbeton besteht.

**17.** System zur Verankerung der wasserdichten Auskleidung (13) an der Wand (12) der Hydraulikstruktur (10) nach einem der vorstehenden Systemansprüche, worin die einzelnen Betonbordsteine (15) modulare Blöcke (23) umfassen, die sich quer zur Wand (12) der Hydraulikstruktur (10) erstrecken, **gekennzeichnet durch** das Umfassen einer Schicht (24) aus Porenbeton zwischen aneinandergrenzenden Betonbordsteinen (23n).

**18.** System, das zur Verankerung der wasserdichten Auskleidung (13) an der Wand (12) der Hydraulikstruktur (10) nach einem der Ansprüche 10 bis 17 geeignet ist, **gekennzeichnet durch** das Umfassen mechanischer Elemente zur Befestigung der wasserdichten Auskleidung (13) an den Betonbordsteinen (15, 23).

## Revendications

**1.** Procédé d'ancrage d'un chemisage d'étanchéité (13) sur une paroi latérale (12) qui s'étend dans une direction longitudinale d'une structure hydraulique (10) comprenant des couches compactées (16) de matériau en vrac, selon lequel le chemisage d'étanchéité (13) comprend des feuilles flexibles (13n) d'un matériau synthétique fixées à la paroi latérale (12), le procédé comprenant en outre les étapes consistant à :

définir une surface de dépose de la paroi latérale (12) pour déposer le chemisage d'étanchéité (13), en dotant la surface de dépose d'une pluralité de bandes d'assemblage continues (14) pour le chemisage d'étanchéité (13), en matériau synthétique ;
fixer le chemisage d'étanchéité (13) à la paroi latérale (12) de la structure hydraulique (10) en assemblant le chemisage d'étanchéité (13) aux bandes d'assemblage continues (14) ;
**caractérisé par** les étapes consistant à :

configurer la paroi latérale (12) de la structure hydraulique (10) avec une pluralité de bordures de béton (15, 23) fournissant ladite surface de dépose pour le chemisage d'étanchéité (13) ;
ancrer la pluralité de bandes d'assemblage continues (14) aux bordures de béton (15, 23) en agençant les bandes d'assemblage continues (14) dans une direction transversale d'une position supérieure à une position inférieure de la paroi latérale (12) ;
déposer le chemisage d'étanchéité (13) sur la surface de dépose des bordures de béton (15, 23) ; et
ancrer le chemisage d'étanchéité (13) aux bordures de béton (15, 23) par assemblage du chemisage d'étanchéité (13) aux bandes d'assemblage continues (14).

**2.** Procédé d'ancrage du chemisage d'étanchéité (13) selon la revendication 1, **caractérisé en ce que** chaque bande d'assemblage (14) est constituée d'une pluralité de rubans d'ancrage modulaires (14.1 - 14.n) alignés axialement, assemblés conjointement et fixés aux bordures de béton (15, 23).

**3.** Procédé d'ancrage du chemisage d'étanchéité (13) selon la revendication 1, **caractérisé par** les étapes consistant à :

extruder ou couler une pluralité de bordures de béton (15, 23) dans une direction longitudinale à la paroi (12) de la structure hydraulique (10) ;
fournir une pluralité de bandes d'assemblage continues (14) pour le chemisage d'étanchéité (13) s'étendant transversalement aux bordures de béton (15), dans lequel chaque bande d'assemblage continue (14) comprend une pluralité de rubans d'ancrage modulaires alignés axialement (14.1 - 14.n), chaque ruban d'ancrage (14.1 - 14.n) comprenant une partie d'assemblage avant (14') et une partie d'ancrage arrière (14") pour l'ancrer à une bordure de béton (15, 23) ;
former progressivement chaque bande d'assemblage continue (14) en fixant la partie d'an-

crage arrière (14") de chaque bande d'ancrage (14.1 - 14.n) à une première bordure de béton (15, 23) ; et
superposer en partie et assembler la partie d'assemblage avant (14') de chaque ruban d'ancrage (14.1 - 14.n) à la partie de couture avant (14') d'un ruban d'ancrage contigu (14.1 - 14.n) précédemment fixé à une seconde bordure de béton (15, 23) contiguë avec la précédente.

**4.** Procédé d'ancrage d'un chemisage d'étanchéité (13) à une paroi (12) d'une structure hydraulique (10) selon la revendication 3, **caractérisé par** les étapes consistant à :

superposer chaque ruban de bande d'ancrage (14.1 - 14.n) transversalement à une bordure extrudée (15) et replier la partie d'ancrage arrière (14") du ruban d'ancrage (14.1 - 14.n) contre la bordure extrudée (15) ; et
bloquer la partie d'ancrage arrière repliée (14") de chaque ruban d'ancrage (14.1 - 14.n) contre la bordure précédemment extrudée (15) par une couche compactée (16) de matériau en vrac et par une bordure de béton contiguë ultérieurement extrudée (15).

**5.** Procédé d'ancrage d'un chemisage d'étanchéité (13) à une paroi (12) d'une structure hydraulique (10) selon la revendication 4, **caractérisé en ce que** chaque ruban d'ancrage (14.1 - 14.n) est fixé à titre provisoire à une bordure extrudée (15) avant l'extrusion d'une bordure de béton suivante (15).

**6.** Procédé d'ancrage d'un chemisage d'étanchéité (13) à une paroi (12) d'une structure hydraulique (10) selon la revendication 3, **caractérisé par** la configuration des bordures de béton (15) avec des éléments d'épaulement opposés (15"", 20).

**7.** Procédé d'ancrage d'un chemisage d'étanchéité (13) à une paroi (12) d'une structure hydraulique (10) qui s'étend dans une direction longitudinale selon la revendication 1, **caractérisé par** les étapes consistant à :

configurer chaque bordure de béton (23) avec une pluralité de blocs modulaires de béton (23n) alignés axialement dans une direction transversale à la paroi (12) ; et
fournir une bande d'assemblage continue (14) longitudinalement à chaque bordure de béton (23), constituée d'une pluralité de rubans d'ancrage modulaires (14.1 - 14.n) comprenant chacune une partie d'ancrage arrière fixée à un bloc modulaire respectif (23n) et une partie d'assemblage avant assemblée à un ruban d'ancrage avant (14.1 - 14.n) contigu au précédent.

**8.** Procédé d'ancrage d'un chemisage d'étanchéité (23) selon l'une quelconque des revendications précédentes, **caractérisé en ce que** les bordures de béton (15, 23) pour ancrer le chemisage d'étanchéité (13) sont constituées de béton poreux.

**9.** Procédé d'ancrage d'un chemisage d'étanchéité (13) selon la revendication 7, **caractérisé par** la fixation de chaque ruban d'ancrage (14.1 - 14.n) en l'enroulant en partie ou en totalité sur chaque bloc modulaire (23) et la configuration de chaque ruban d'ancrage (14.1 - 14.n) avec au moins une aile d'assemblage latérale (14.1n) pour le chemisage d'étanchéité (13).

**10.** Système convenant à l'ancrage d'un chemisage d'étanchéité (13) en matériau synthétique à une paroi latérale (12) s'étendant dans une direction longitudinale d'une structure hydraulique (10) en matériau en vrac compacté selon le procédé de la revendication 1, dans lequel le chemisage d'étanchéité (13) est fixé à des bandes d'assemblage continues (14) en matériau synthétique ancrées à la paroi latérale (12), **caractérisé en ce qu'**il comprend :

une pluralité de bordures de béton agencées en parallèle (15, 23) définissant une surface de dépose pour le chemisage d'étanchéité (13) ;
une pluralité de bandes d'assemblage continues (14) s'étendant transversalement d'une position supérieure à une position inférieure de la paroi latérale (12) ;
chaque bande d'assemblage continue (14) comprenant une pluralité de rubans d'ancrage modulaires (14.n) agencés en série le long de la bande d'assemblage (14), chaque ruban d'ancrage (14.n) comprenant une partie d'ancrage arrière fixée à une bordure de béton (15, 23) et une partie d'assemblage avant assemblée à un ruban d'ancrage continu.

**11.** Système convenant à l'ancrage du chemisage d'étanchéité (13) à la paroi (12) de la structure hydraulique (10) selon la revendication 10, **caractérisé en ce qu'**il comprend une pluralité de bordures de béton extrudées (15) qui s'étendent en contact mutuel longitudinalement vis-à-vis de la paroi (12) de la structure hydraulique ; et
dans lequel chaque bande d'assemblage (14) comprend une pluralité de rubans d'ancrage axialement alignés (14.1 - 14.n), dans lequel chaque ruban d'ancrage (14.1 - 14.) est agencé en pontant transversalement chaque bordure de béton (15).

**12.** Système convenant à l'ancrage du chemisage d'étanchéité (13) à la paroi (12) de la structure hydraulique (10) selon la revendication 10, **caractérisé en ce que** chaque ruban d'ancrage (14.1-14.n)

d'une bande d'assemblage continue (14) comprend une partie d'assemblage avant (14') superposée et assemblée à une partie d'assemblage avant (14") d'un ruban d'ancrage contigu (14.1 - 14.n) et une partie d'ancrage arrière fixée à une bordure de béton (15).

**13.** Système d'ancrage d'un chemisage d'étanchéité (13) à la paroi (12) de la structure hydraulique (10) selon la revendication 10, **caractérisé en ce que** les bordures de béton (15, 23) s'étendent transversalement et/ou longitudinalement vis-à-vis d'une paroi inclinée (12) de la structure hydraulique (10).

**14.** Système d'ancrage du chemisage d'étanchéité (13) à la paroi (12) de la structure hydraulique (10) selon la revendication 13, **caractérisé en ce que** chaque bordure de béton (23) comprend une pluralité de blocs modulaires de béton (23n) alignés axialement dans une direction transversale à la paroi (12) de la structure hydraulique (10).

**15.** Système convenant à l'ancrage du chemisage d'étanchéité (13) à la paroi (12) de la structure hydraulique (10) selon la revendication 14, **caractérisé en ce que** chaque ruban d'ancrage (14.1 - 14.n) est replié en partie ou en totalité autour d'un bloc modulaire de béton (23).

**16.** Système convenant à l'ancrage du chemisage d'étanchéité (13) à la paroi (12) de la structure hydraulique (10) selon l'une quelconque des revendications précédentes, **caractérisé en ce que** chaque bordure de béton ou chaque bloc modulaire (15, 23n) est constitué(e) d'un béton poreux.

**17.** Système d'ancrage du chemisage d'étanchéité (13) à la paroi (12) de la structure hydraulique (10) selon l'une quelconque des revendications précédentes, dans lequel les bordures de béton individuelles (15) comprennent des blocs modulaires (23) qui s'étendent transversalement à la paroi (12) de la structure hydraulique (10), **caractérisé en ce qu'**il comprend une couche (24) de béton poreux entre des bordures de béton contiguës (23n).

**18.** Système convenant à l'ancrage du chemisage d'étanchéité (13) à la paroi (12) de la structure hydraulique (10) selon l'une quelconque des revendications 10 à 17, **caractérisé en ce qu'**il comprend des éléments mécaniques pour fixer le chemisage d'étanchéité (13) aux bordures de béton (15, 23).

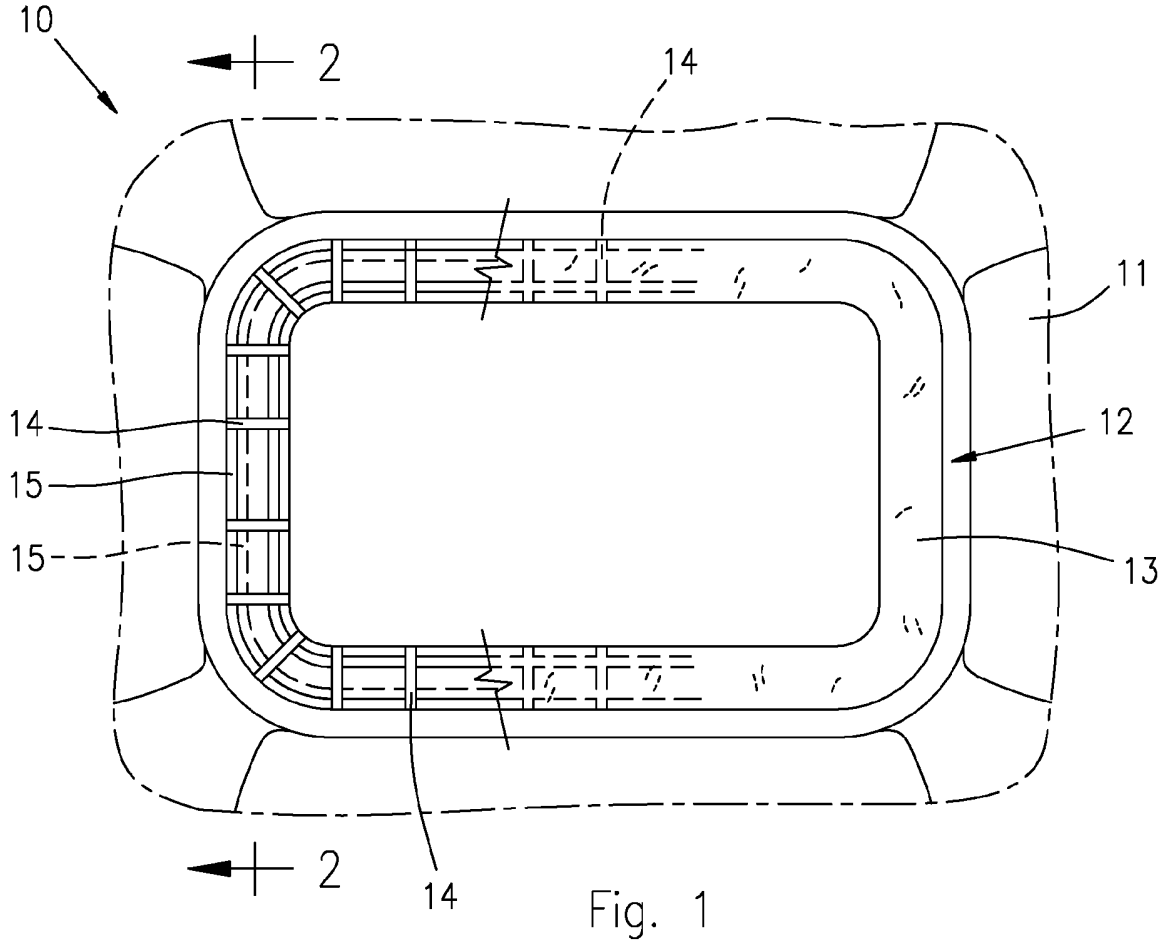
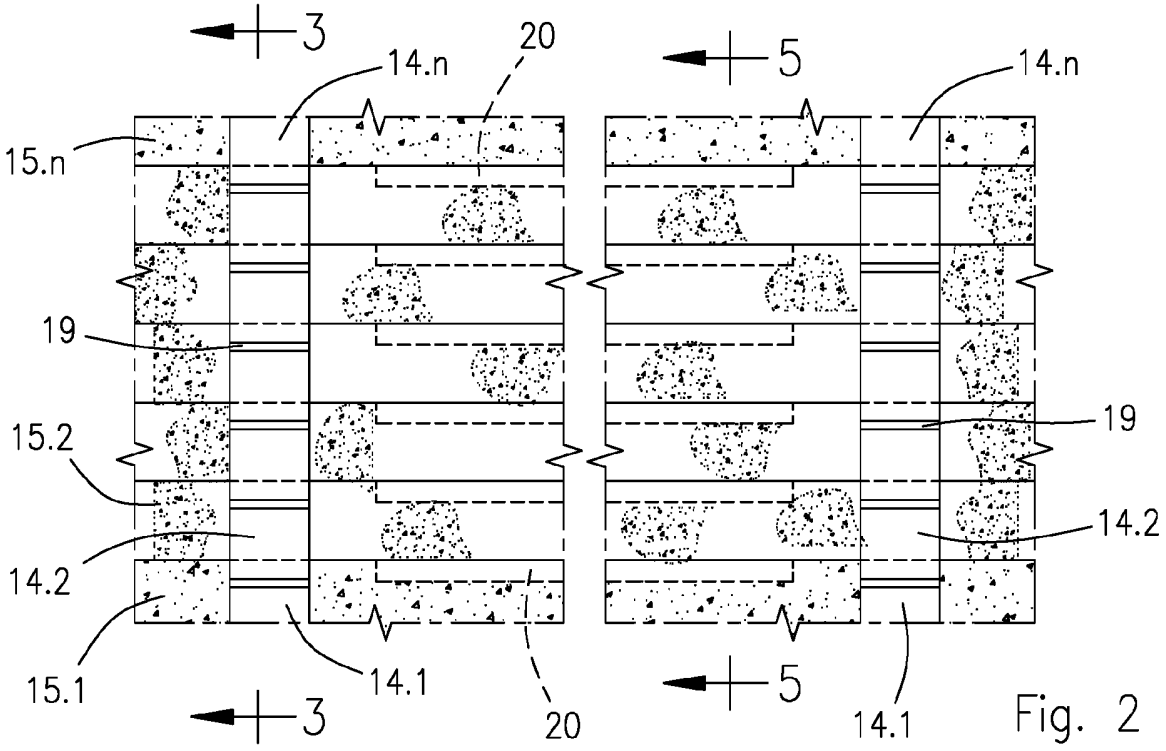

10
2
14
11
14
12
15
15
13
2
14

Fig. 1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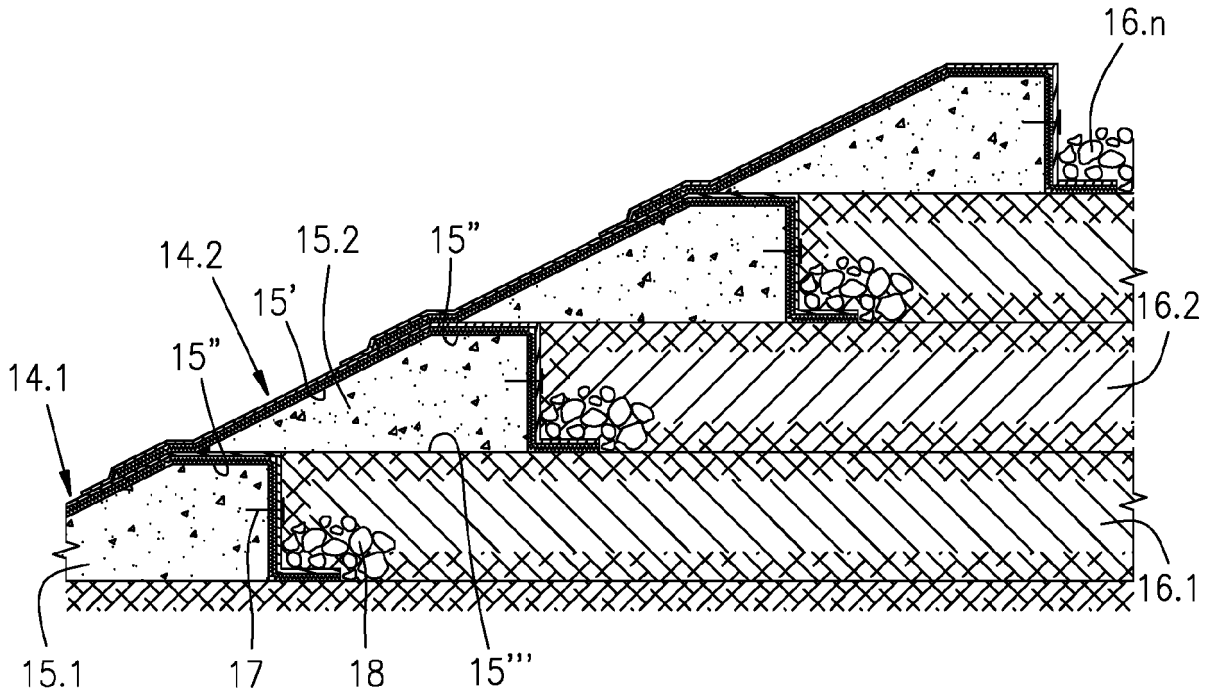
20
5
14.n
15.n
19
19
15.2
14.2
14.2
15.1
14.1
20
5
14.1
3

Fig. 2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15"
15'
15"
14.1
16.2
16.1
15.1
17
18
15'''

Fig. 3

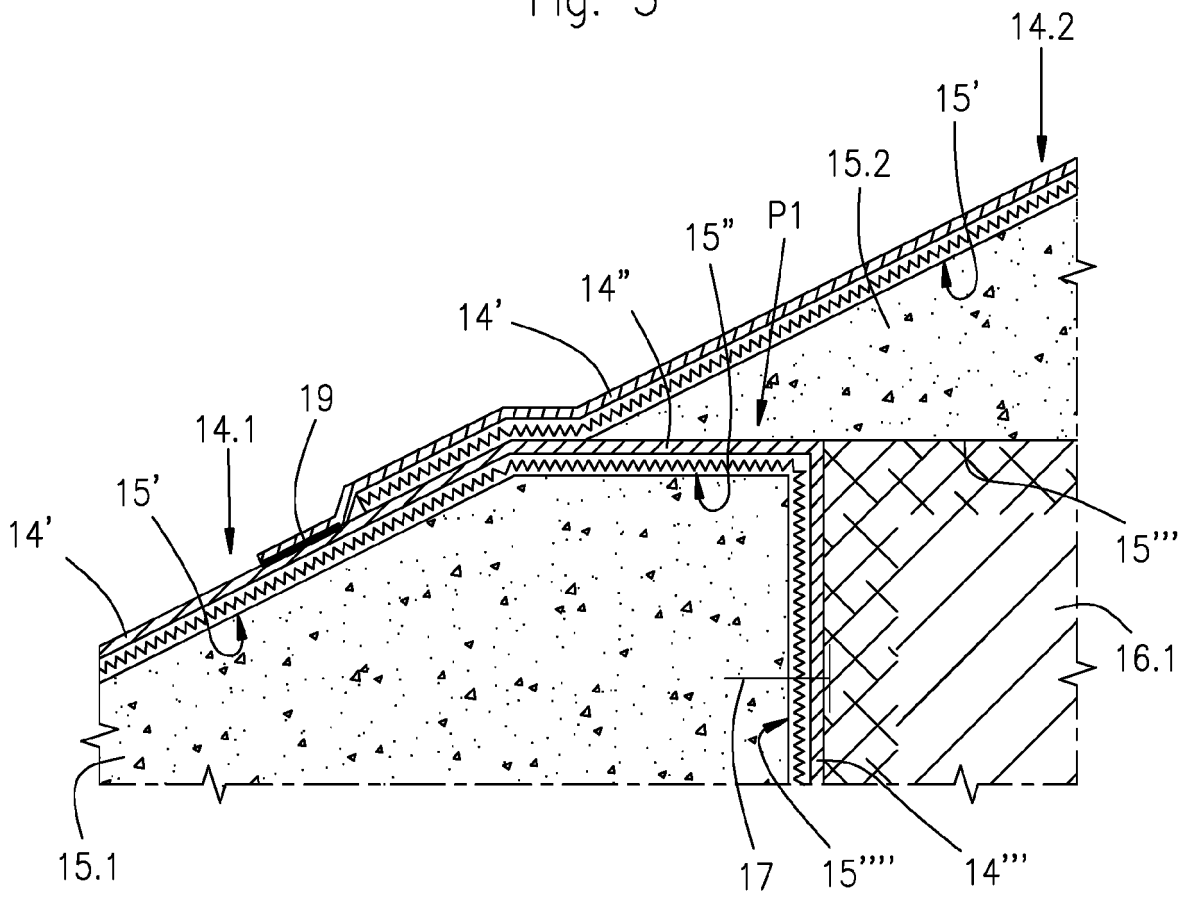

14.2
15'
15.2
P1
15"
14"
14'
19
14.1
15'
14'
15'''
16.1
15.1
17
15''''
14'''

Fig. 4

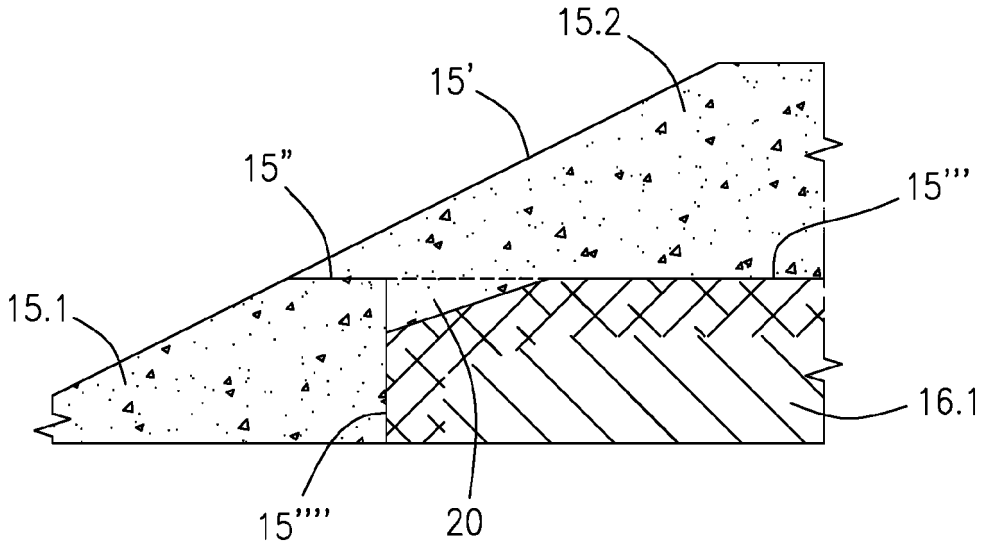



Fig. 5

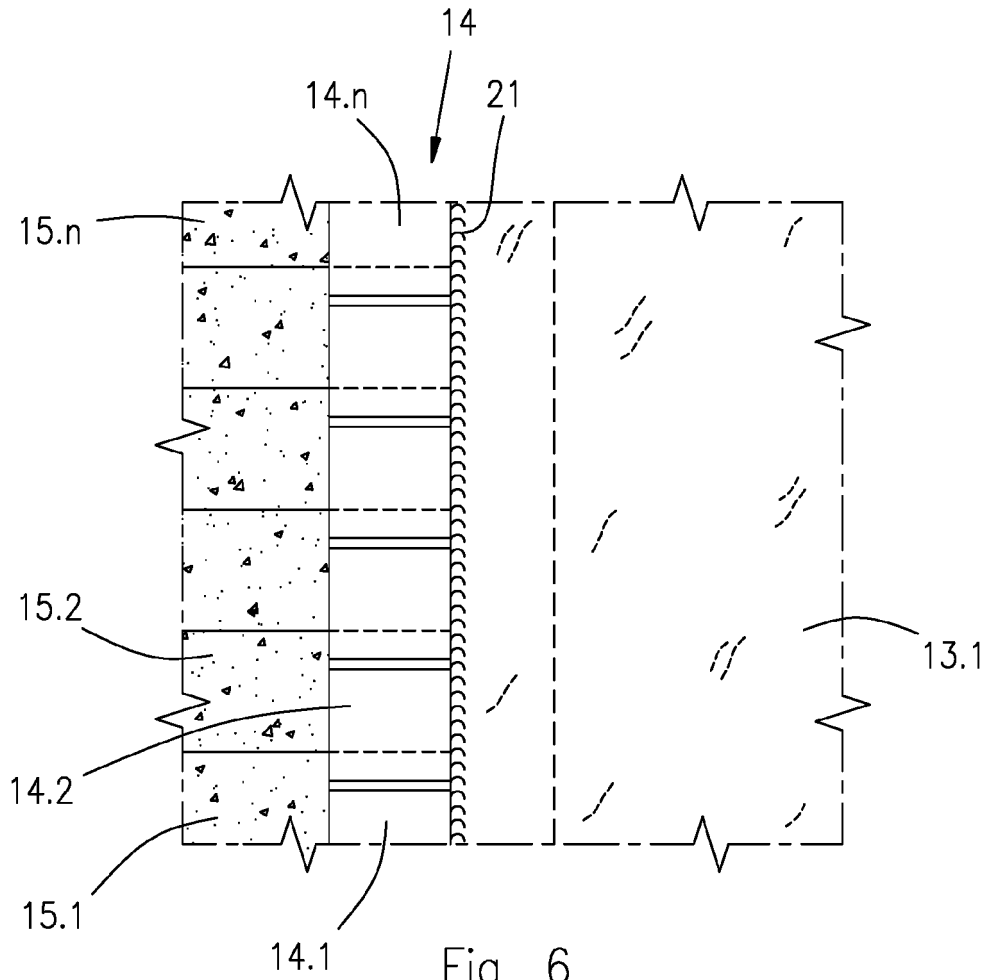



Fig. 6

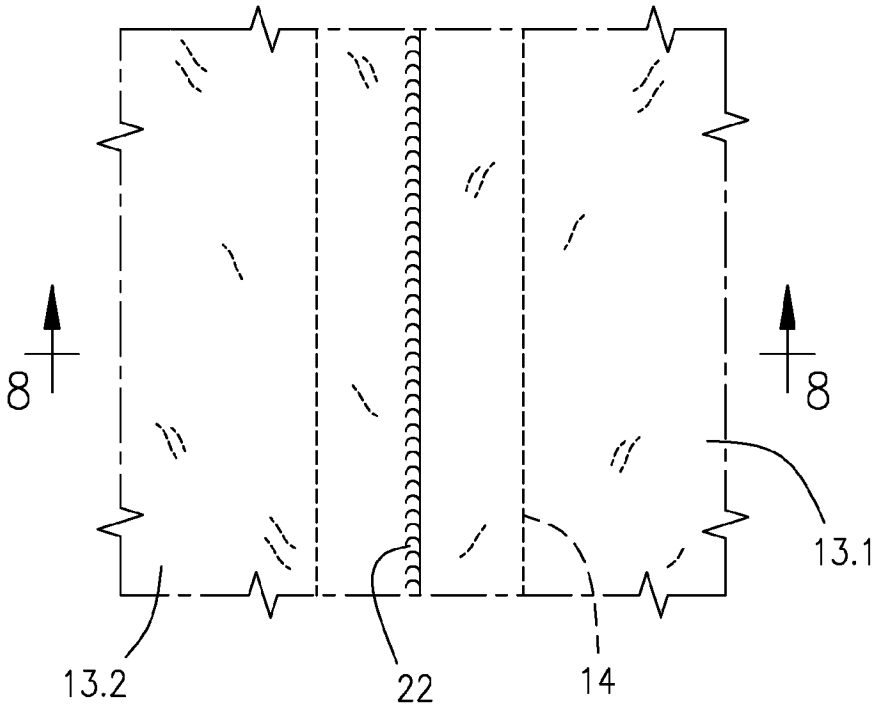



Fig. 7

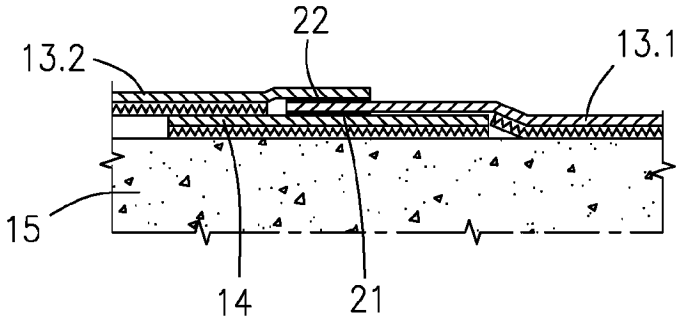



Fig. 8

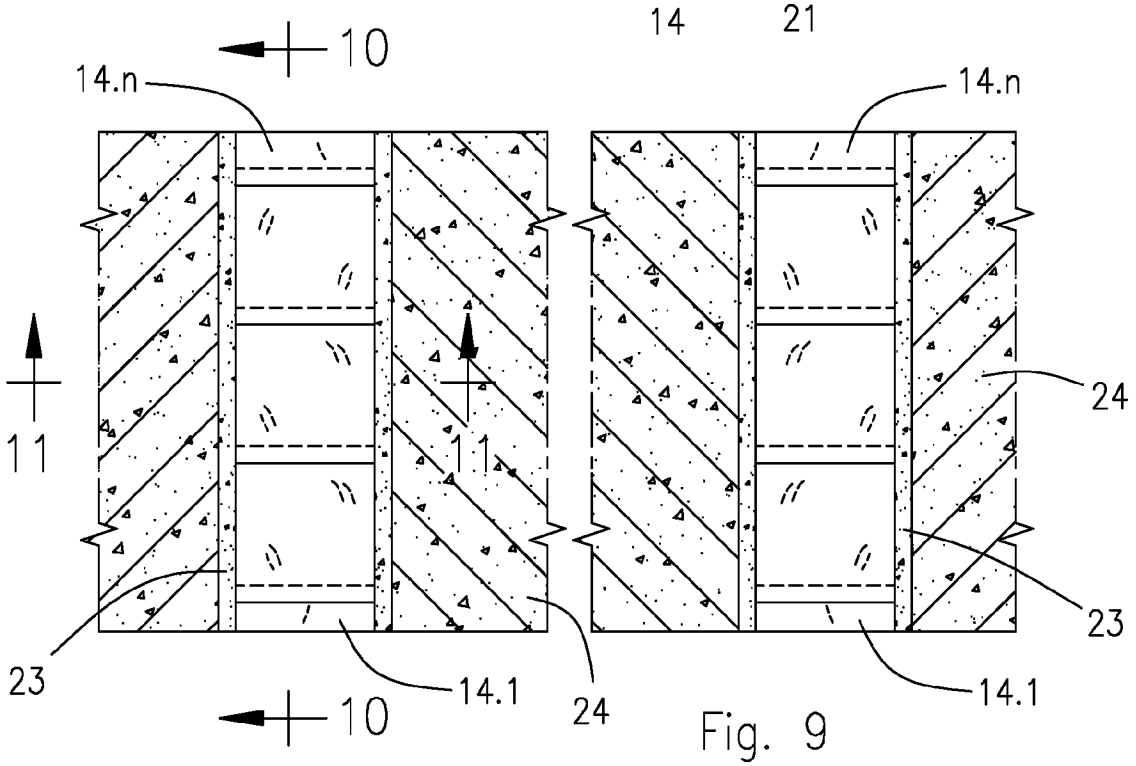



Fig. 9

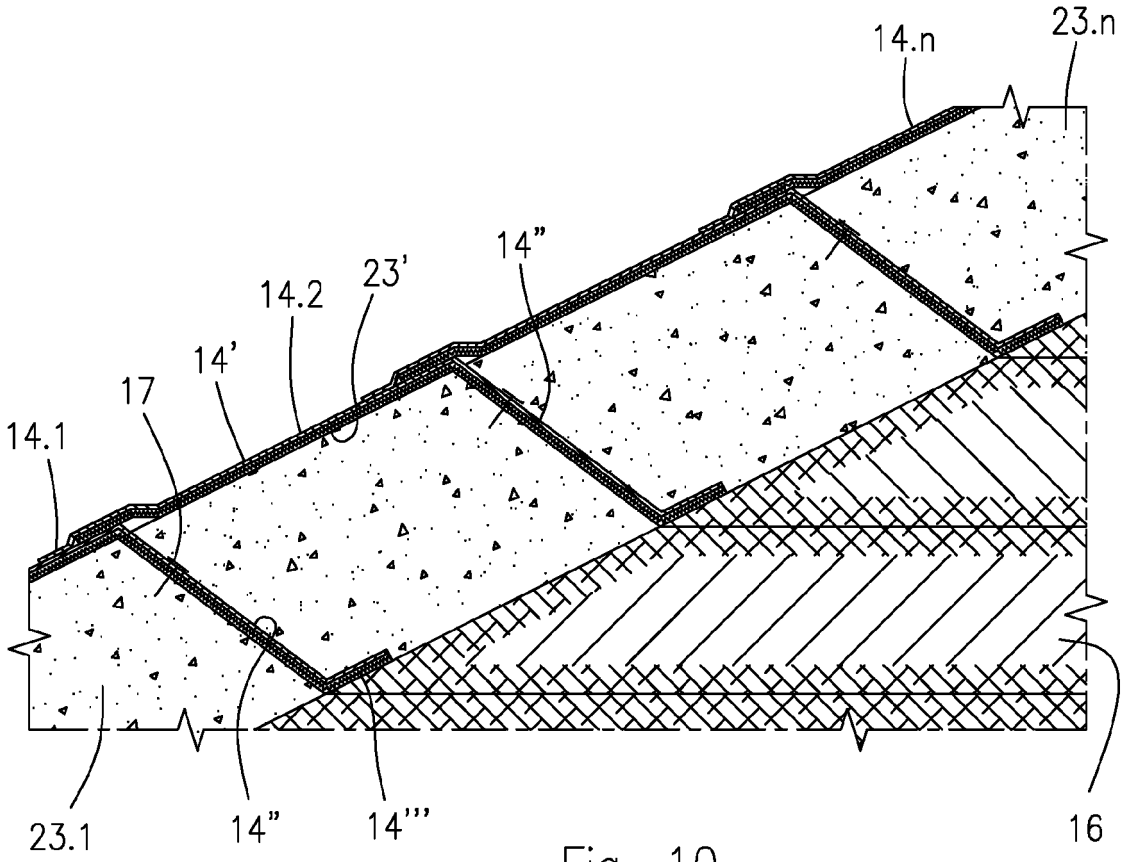



Fig. 10

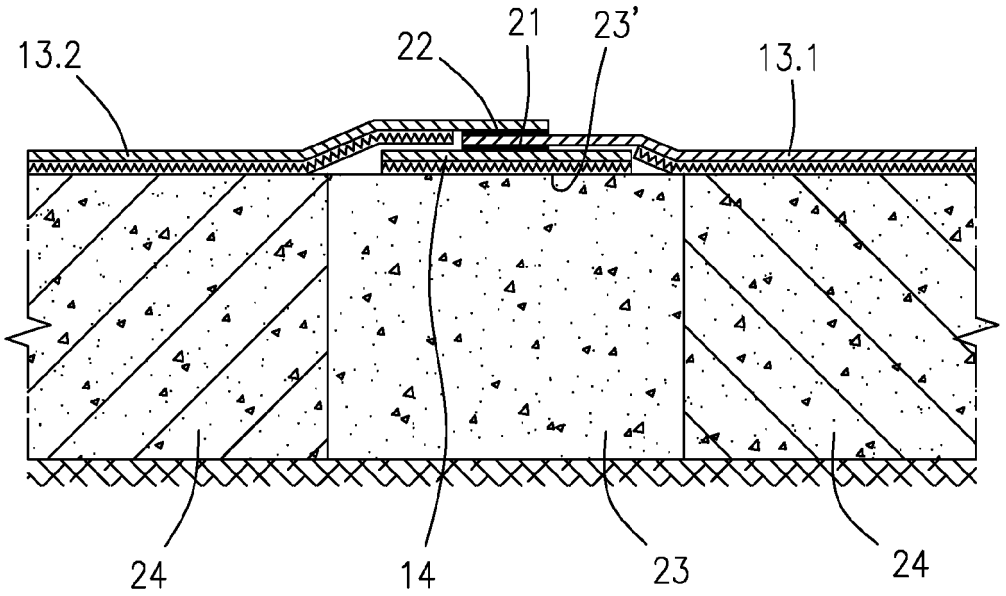
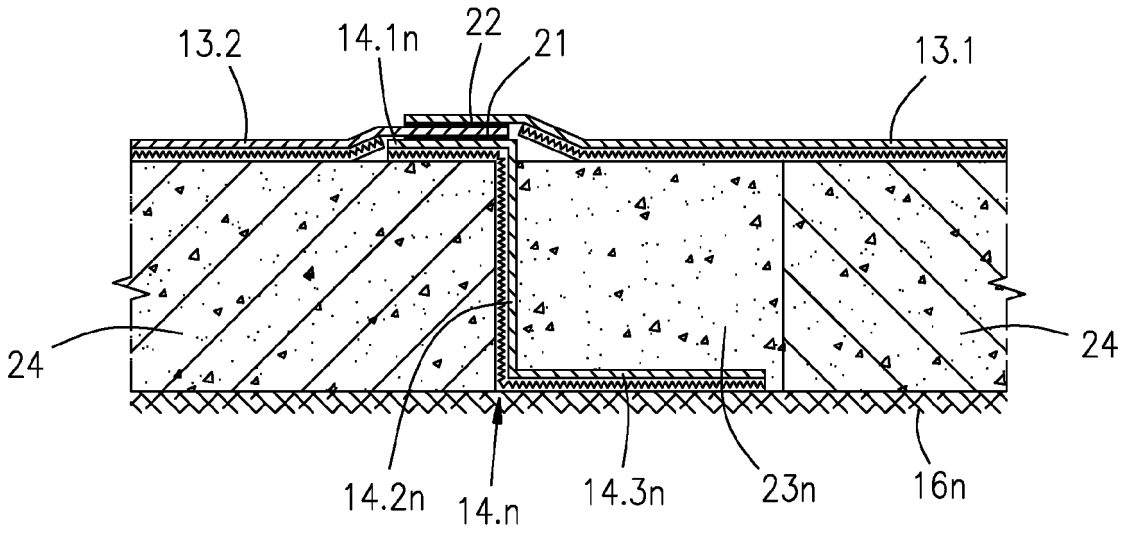



Fig. 11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22
21
13.1
24
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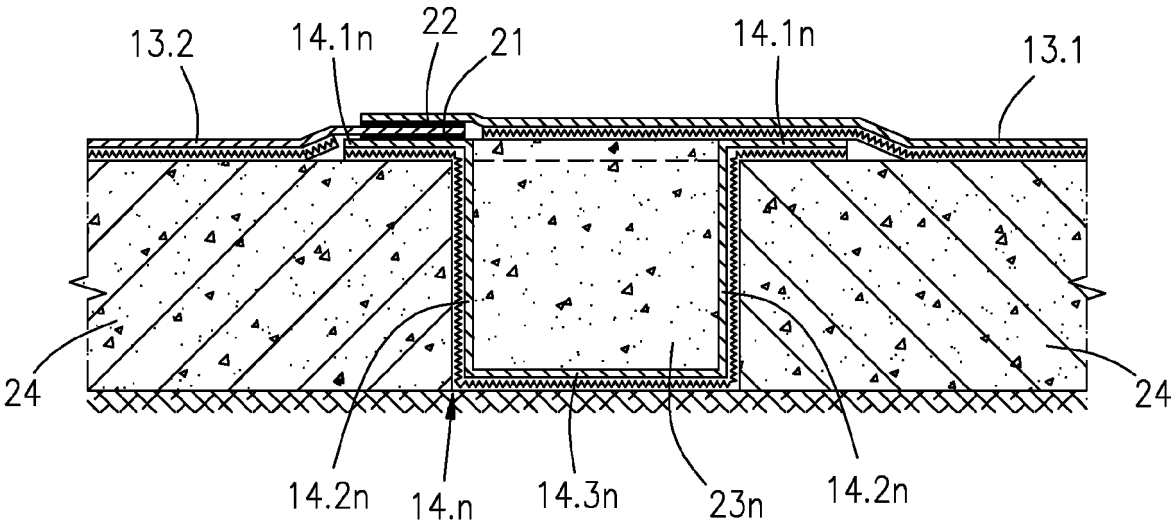
14.2n
14.n
14.3n
23n
16n

Fig. 12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24
24
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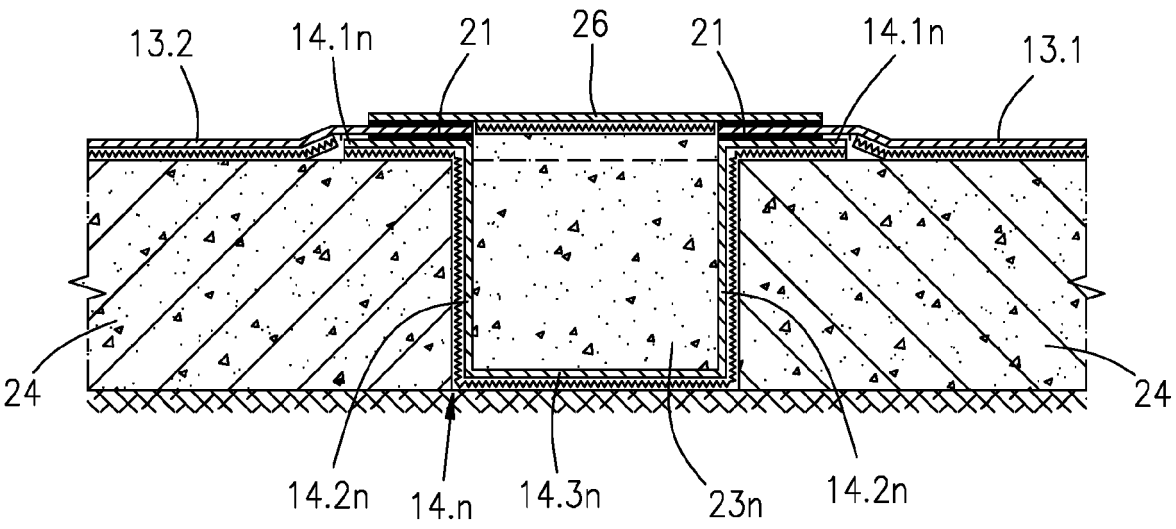
14.3n
23n
14.2n

Fig. 13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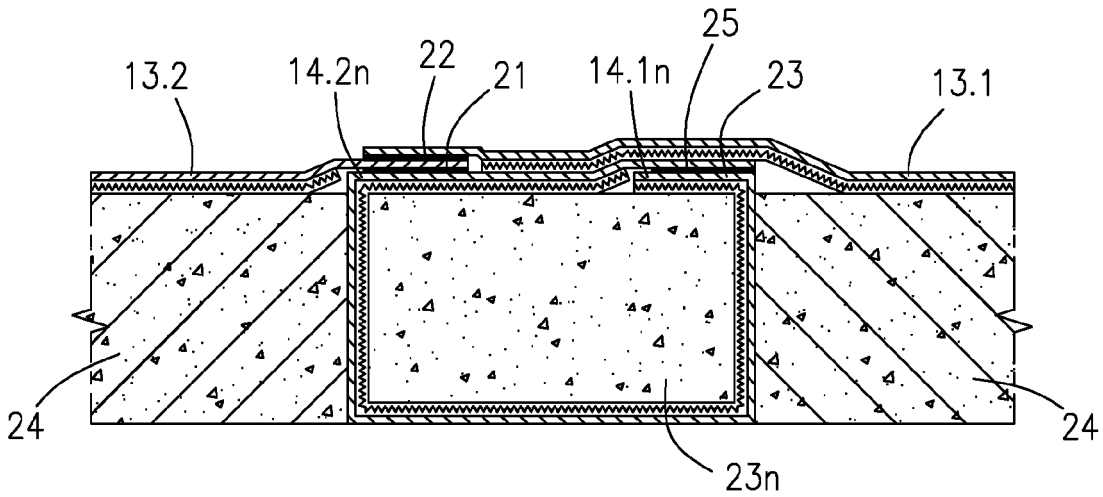
14.2n
14.n
14.3n
23n
14.2n

Fig. 14


25
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14.2n
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21
14.1n
23
13.1
24
24
23n

Fig. 15

## REFERENCES CITED IN THE DESCRIPTION

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