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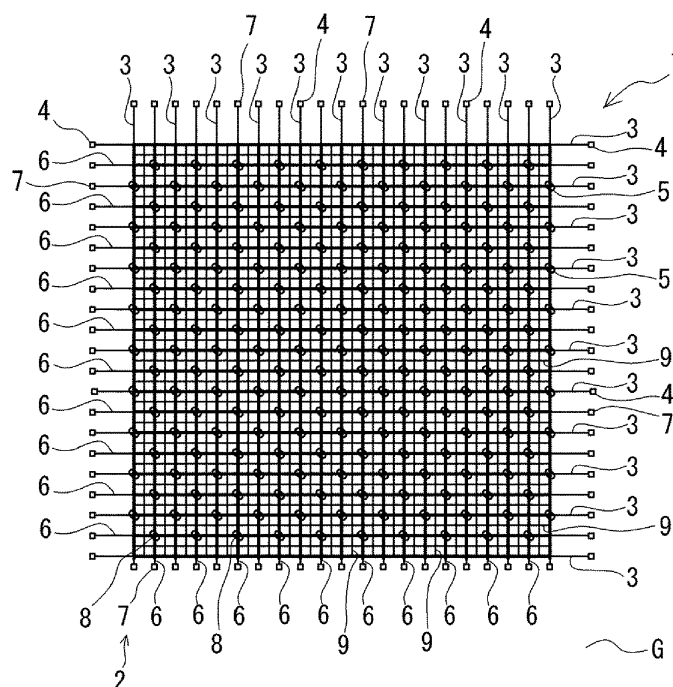
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**(54) Net structure and construction method thereof**

(57) Net structure comprising a first grid-like structure 1 which comprises a plurality of first main wires 3 placed on a sloped mounting surface in a grid-like fashion, and a plurality of first fixing tools 4, 5 fixing the first main wires 3 to the mounting surface; and a second grid-like structure 2 which comprises a plurality of second main wires 6 placed on the mounting surface in a grid-like fashion, and a plurality of second fixing tools 7, 8

fixing the second main wires 6 to the mounting surface. The second main wires 6 are placed at positions different from positions of the first main wires 3, and placed on the first main wires 3 in contact therewith at intersections with the first main wires 3. At least one of the second fixing tools 7, 8 is placed within at least one grid in the first grid-like structure 1.

FIG.1



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## Description

### Technical Field

**[0001]** The present invention relates to rockfall prevention works used as a measure against rockfall sources on slopes, and in particular, relates to a net structure comprising grid blocks bearing the loading of a fallen rock, and a construction method thereof.

### Background Art

**[0002]** Rope netting works is known as the rockfall prevention works, which is intended for floatstones or rolling stones of various sizes acceptable in terms of design extensively interspersed on a slope, and stops initial movement of the floatstones or rolling stones to prevent them from sliding or falling (Patent Documents 1 and 2).

**[0003]** The rope netting works is a construction method for forming, along a slope, a plurality of grid blocks comprised of main ropes placed in a grid-like fashion and anchors fixing intersections between the main ropes to the slope. For example, a net structure formed by the rope netting works is constructed as follows:

First, wire ropes of the same kind are prepared as main ropes and auxiliary ropes; underground anchors and rock anchors are prepared as end anchors and intermediate anchors; and cross anchor grips and cross clips are prepared as splicing fittings.

Then, a plurality of main ropes are placed vertically and horizontally along a slope in a grid-like fashion, and ends of the main ropes are fixed to the slope by the end anchors in a tensioned state. The intermediate anchors are driven into portions of the slope corresponding to the intersections between the main ropes, and the intersections between the main ropes are connected to the intermediate anchors by the cross anchor grips, such that the main ropes are fixed to the slope in a tensioned state. This forms the plurality of grid blocks described above.

Furthermore, the auxiliary ropes are placed between the main ropes, and intersections between the auxiliary ropes and main ropes are connected by the cross clips.

**[0004]** In such a net structure constructed by the rope netting works, if a large floatstone or rolling stone (hereinafter referred to as a target rock lump) is within one grid block as shown in Fig. 5, and a load due to sliding, etc. of the target rock lump R (hereinafter referred to as loading) acts on the grid block, the loading is shared by the intermediate anchors constituting the grid block (four intermediate anchors, in this case) via the main ropes constituting the grid block. This reduces the loads on respective intermediate anchors.

**[0005]** If an intermediate anchor is driven into the target rock lump R, when the loading acts on the intermediate

anchor, the loading is shared by the intermediate anchors constituting four surrounding grid blocks including that intermediate anchor (eight intermediate anchors, in this case) via the main ropes constituting the four grid blocks.

5 As a result, the loading on the one intermediate anchor is shared by other eight intermediate anchors, thereby reducing a load on the one intermediate anchor.

**[0006]** In Fig. 5, the intermediate anchors are shown as ellipses, and in particular, the intermediate anchors bearing the loading from the target rock lump are shown as black ellipses.

**[0007]** In the standard specification for the rope netting works, a diameter of the main rope is 12mm; the spacing of the main ropes is 2m; the size of one grid block is 2m x 2m = 4m<sup>2</sup>; and the spacing between the auxiliary ropes is 0.5m. The embedded length of the underground anchor used as the end anchor or intermediate anchor is 1.3m.

**[0008]** At a designing step in the rope netting works, acceptable weight of a fallen rock load per a grid block of the standard specification (2m x 2m = 4m<sup>2</sup>) with respect to the fallen rock positioned between the main ropes (hereinafter referred to as an acceptable load) is calculated for every inclination of the slope. This acceptable load is an indicator showing the loading that each grid block of the constructed net structure is permitted to bear.

**[0009]** The acceptable load is calculated to be 6kN at 70 degrees of inclination, 10.2kN at 50 degrees of inclination, and 69.5kN at 30 degrees of inclination. That is, at a gentle inclination, the calculated acceptable load is large, which allows for a larger target rock lump to be handled. On the other hand, at a steep inclination, the calculated acceptable load is small, and the target rock lump to be handled is also small. At the identical inclination, the net structure with a high level of acceptable load calculated allows each grid block to bear larger loading and is safer than the net structure with a low level of acceptable load calculated.

**[0010]** Therefore, there are measures for increasing the acceptable load.

**[0011]** For example, one measure is diameter enlargement of the main ropes.

**[0012]** This measure changes the diameter of the main ropes from 12mm as the standard to 14mm, and increases a load-bearing capacity of metal fittings or anchors in association with the diameter enlargement of the main ropes.

**[0013]** With this measure, the acceptable load may be increased from 6kN as the standard specification to 8.5kN at 70 degrees of inclination, from 10.2kN as the standard specification to 14.7kN at 50 degrees of inclination, and from 69.5kN as the standard specification to 99.2kN at 30 degrees of inclination.

**[0014]** For example, since the number of anchors is linked to the calculation of the acceptable load, a measure to increase the number of anchors in order to enhance the acceptable load may be contemplated. In the rope netting works of the standard specification, while anchors

are provided at intersections between the main ropes, no anchor is provided at intersections between the main ropes and auxiliary ropes. Thus, the number of anchors may be increased by further providing anchors at the intersections between the main ropes and auxiliary ropes. However, this measure has the following problems:

(1) In the standard specification, the auxiliary ropes are placed in intermediate positions between the main ropes. Thus, if anchors are further provided at the intersections between the main ropes and auxiliary ropes, the shortest spacing between the anchors is 1m. Substantially, this is a measure to set the spacing between the main ropes to 1m.

In this case, unlike in the case of the standard specification, the acceptable load is calculated per grid block (1m x 1m = 1m<sup>2</sup>). For example, it is 24kN at 70 degrees of inclination, which means that the loading from a target rock lump with a diameter of 1.2m is acceptable.

That is, this measure targets a rock lump having a size unable to be fit within the 1m<sup>2</sup>-sized grid block. As described above, when the inclination is gentle, the acceptable load is large, thereby targeting a larger rock lump. Therefore, when the rock lump with the diameter of 1.2m or more is targeted, there is not much point in setting the spacing between the main ropes to 1m, and thus, it is not a practical measure.

(2) In the standard specification, the embedded length of the intermediate anchors (underground anchors) used at intersections is 1.3m, as described above. With the above measure, since the anchors lie next to each other with the anchor spacing (1m) shorter than the standard embedded length, the anchors are too close to each other. As a result, arrangement of the anchors is poorly balanced. Thus, this measure is not practical or effective.

**[0015]** For example, it is possible to increase the acceptable load by increasing the number of anchors sharing the loading (hereinafter referred to as the number of sharing anchors).

**[0016]** However, as described above, since the rope netting works provides the anchors at the intersections between the main ropes, there is no installation site effective for sharing the loading. Thus, it is not so easy to further increase the number of sharing anchors.

**[0017]** Even if anchors are provided at intersections between the main ropes and auxiliary ropes as described above, the number of sharing anchors cannot be increased. Rather, the spacing between anchors sharing the loading becomes narrowed, and the anchors share only the loading within the grid block (1m x 1m = 1m<sup>2</sup>) narrower than the standard specification. Thus, it is not a practical measure.

## Prior Art Documents

### Patent documents

#### 5 **[0018]**

Patent document 1: Japanese Patent No. 2679966

Patent document 2: Japanese Patent No. 3390987

#### 10 Summary of the Invention

### Problems to be solved by the invention

**[0019]** In conventional rope netting works, since the anchors are provided at intersections between the main ropes as described above, there is no installation site effective for sharing the loading. Thus, there is a problem of difficulty in further increasing the number of sharing anchors.

**[0020]** The present invention was made to solve the above problems, and intends to provide a net structure and a construction method thereof, wherein the net structure has a larger number of anchors sharing the loading generated due to sliding, etc. of a target rock lump, and may further improve safety.

### Means for solving the problems

**[0021]** The net structure according to the present invention comprises:

a first grid-like structure which comprises a plurality of first main wires placed on a sloped mounting surface in a grid-like fashion, and a plurality of first fixing tools fixing both ends of each of the first main wires to the mounting surface and fixing intersections between the first main wires to the mounting surface; and

a second grid-like structure which comprises a plurality of second main wires placed on the mounting surface in a grid-like fashion, and a plurality of second fixing tools fixing both ends of each of the second main wires to the mounting surface and fixing intersections between the second main wires to the mounting surface,

wherein the net structure is characterized in that:

the second main wires are placed at positions different from positions of the first main wires, and placed on the first main wires in contact therewith at intersections with the first main wires, and at least one of the second fixing tools is placed within at least one grid in the first grid-like structure.

**[0022]** The net structure according to the present invention is characterized in that the second fixing tool is placed at a position shifted in a direction along a diagonal

line of the at least one grid in the first grid-like structure.

**[0023]** The net structure according to the present invention is characterized in that a shift distance of the second fixing tool is half the length of the diagonal line.

**[0024]** The net structure according to the present invention is characterized in that at least one of the first fixing tools and second fixing tools is a sediment anchoring device having a load-bearing capacity in a pull-out direction and a shearing direction.

**[0025]** The net structure according to the present invention is characterized in that auxiliary wires are placed at least one of between the first main wires and between the second main wires.

**[0026]** The net structure according to the present invention is characterized in that a wire net is attached to at least one of the first grid-like structure and the second grid-like structure.

**[0027]** A method for constructing a net structure according to the present invention is a method for constructing the net structure on a sloped mounting surface, wherein the net structure comprises:

a first grid-like structure which comprises a plurality of first main wires placed on the sloped mounting surface in a grid-like fashion, and a plurality of first fixing tools fixing both ends of each of the first main wires to the mounting surface and fixing intersections between the first main wires to the mounting surface; and

a second grid-like structure which comprises a plurality of second main wires placed on the mounting surface in a grid-like fashion, and a plurality of second fixing tools fixing both ends of each of the second main wires to the mounting surface and fixing intersections between the second main wires to the mounting surface, and

wherein the method is characterized in that the first main wires are placed; the second main wires are placed at positions different from positions of the first main wires, and placed on the first main wires in contact therewith at intersections with the first main wires; and at least one of the second fixing tools is placed within at least one grid in the first grid-like structure.

**[0028]** The method for constructing the net structure according to the present invention is characterized in that the first fixing tools and the second fixing tools are placed; the first fixing tools and the first main wires are connected to fix the first main wires to the mounting surface in a tensioned state; and the second fixing tools and the second main wires are connected to fix the second main wires to the mounting surface in a tensioned state.

**[0029]** The method for constructing the net structure according to the present invention is characterized in that after the first main wires and the second main wires are placed, the first fixing tools and the second fixing tools are driven into the mounting surface, thereby fixing the

first main wires and the second main wires to the mounting surface in the tensioned state.

#### Effect of the Invention

**[0030]** The net structure according to the present invention comprises a first grid-like structure which comprises a plurality of first main wires placed on a sloped mounting surface in a grid-like fashion, and a plurality of first fixing tools fixing both ends of each of the first main wires to the mounting surface and fixing intersections between the first main wires to the mounting surface; and a second grid-like structure which comprises a plurality of second main wires placed on the mounting surface in a grid-like fashion, and a plurality of second fixing tools fixing both ends of each of the second main wires to the mounting surface and fixing intersections between the second main wires to the mounting surface. The second main wires are placed at positions different from positions of the first main wires, and placed on the first main wires in contact therewith at intersections with the first main wires, and at least one of the second fixing tools is placed within at least one grid in the first grid-like structure. Therefore, it may exhibit the following working-effect.

**[0031]** That is, the first main wires are subjected to pushing force toward the mounting surface from the second main wires at intersections with the second main wires. The intersections between the first main wires and second main wires, where the pushing force acts, transmit a mechanical action between the side of the first main wires and the side of the second main wires. That is, the first fixing tools and second fixing tools share the loading together via the intersections. Each of the first fixing tools or second fixing tools constituting the same grid shares the loading applied to the other first fixing tools or second fixing tools. Thus, since the number of fixing tools sharing the loading may be increased, one target rock lump may be held down by more fixing tools, thereby further improving the safety of net structures based on the rockfall prevention works.

**[0032]** With the method for constructing the net structure according to the present invention, constructed on a sloped mounting surface is the net structure comprising a first grid-like structure which comprises a plurality of first main wires placed on the sloped mounting surface in a grid-like fashion, and a plurality of first fixing tools fixing both ends of each of the first main wires to the mounting surface and fixing intersections between the first main wires to the mounting surface; and a second grid-like structure which comprises a plurality of second main wires placed on the mounting surface in a grid-like fashion, and a plurality of second fixing tools fixing both ends of each of the second main wires to the mounting surface and fixing intersections between the second main wires to the mounting surface. In this method, the first main wires are placed; the second main wires are placed at positions different from positions of the first main wires, and placed on the first main wires in contact therewith at

intersections with the first main wires; and at least one of the second fixing tools is placed within at least one grid in the first grid-like structure. Thus, since the number of fixing tools sharing the loading may be increased as described above, this method may construct the net structure which further improves the safety of net structures based on the rockfall prevention works.

#### Brief Description of the Drawings

##### [0033]

Fig. 1 is a plan view illustrating the net structure according to Embodiment 1 of the present invention. Fig. 2 is a magnified plan view illustrating the first fixing tools sharing the loading from a target rock lump acting on the second fixing tool in the first grid-like structure of the net structure shown in Fig. 1. Fig. 3 is a magnified plan view illustrating the second fixing tools sharing the loading from a target rock lump acting on the first fixing tool in the second grid-like structure of the net structure shown in Fig. 1. Fig. 4 is a plan view illustrating the net structure according to Embodiment 2 of the present invention. Fig. 5 is a plan view illustrating the net structure based on the rope netting works.

#### Description of Embodiments

##### Embodiment 1

[0034] Fig. 1 is a plan view illustrating the net structure according to Embodiment 1 of the present invention; Fig. 2 is a magnified plan view illustrating the first fixing tools sharing the loading from a target rock lump acting on the second fixing tool in the first grid-like structure of the net structure shown in Fig. 1; and Fig. 3 is a magnified plan view illustrating the second fixing tools sharing the loading from a target rock lump acting on the first fixing tool in the second grid-like structure of the net structure shown in Fig. 1.

[0035] In Figs. 1-3, ellipses show the first fixing tools and second fixing tools for fixing intersections between the first main wires and between the second main wires, respectively, in a tensioned state. In particular, Figs. 2 and 3 depict the first fixing tools and second fixing tools bearing the loading from the target rock lump as dark ellipses, in order to distinguish them from other first and second fixing tools.

[0036] The net structure according to Embodiment 1 comprises a first grid-like structure 1 and a second grid-like structure 2 placed on a slope (sloped mounting surface) G.

[0037] The first grid-like structure 1 is comprised of a plurality of first main ropes (first main wires) 3 placed along the slope G in a grid-like fashion, a plurality of first end anchors (first fixing tools) 4 fixing both ends of each of the first main ropes 3 to the slope G in a tensioned

state, and a plurality of first intermediate anchors (first fixing tools) 5 fixing intersections between the first main ropes 3 to the slope G in a tensioned state.

[0038] The second grid-like structure 2 is comprised of a plurality of second main ropes (second main wires) 6 placed along the slope G in a grid-like fashion, a plurality of second end anchors (second fixing tools) 7 fixing both ends of each of the second main ropes 6 to the slope G in a tensioned state, and a plurality of second intermediate anchors (second fixing tools) 8 fixing intersections between the second main ropes 6 to the slope G in a tensioned state.

[0039] The net structure according to Embodiment 1 further comprises the following configurations.

[0040] The second main ropes 6 are placed between the first main ropes 3 at positions different from positions of the first main ropes 3. The positions of the second main ropes 6 are intermediate positions between the first main ropes 3. Thus, the spacing between the first main ropes 3 and the spacing between the second main ropes 6 are equal, for example, but not limited to, 2m or 3m. When the spacing is 2m, the shortest distance between a first intermediate anchor 5 and a second intermediate anchor 8 is 1.414m, which is shorter than the case of 2m spacing in the standard specification of the rope netting works. Further, even with the use of standard underground anchors having 1.3m of embedded length, well-balanced anchor arrangement may be achieved, which may exhibit an anchor's load-bearing capacity without bringing the anchors too close to each other.

[0041] The second main ropes 6 are placed on the first main ropes 3 in contact therewith at intersections with the first main ropes 3. Thus, the first main ropes 3 at the intersections receive pushing force toward the slope G from the second main ropes 6 thereon. This pushing force is generated by fixing the second main ropes 6 in the tensioned state by the second end anchors 7 and second intermediate anchors 8.

[0042] The second intermediate anchors 8 are placed within grids, as a minimum unit, of a plurality of grids in the first grid-like structure 1. They are in positions shifted in a direction along diagonal lines of respective grids. A shift distance of the second intermediate anchors 8 is half the length of the diagonal lines of the grids.

[0043] As described above, since the spacing between the first main ropes 3 and the spacing between the second main ropes 6 are equal, most of the first intermediate anchors 5 are placed within grids, as a minimum unit, of a plurality of grids in the second grid-like structure 2 on intersections of two diagonal lines of the respective grids. Since the second main ropes 6 are placed between the first main ropes 3, some of the first intermediate anchors 5 which are placed on the outermost first main ropes 3 among vertically extending first main ropes 3 are outside the grids of the second grid-like structure 2.

[0044] In the net structure having this configuration, at intersections with the second main ropes 6, the first main ropes 3 receive the pushing force toward the slope G

from the second main ropes 6. The intersections between the first main ropes 3 and second main ropes 6 where the pushing force acts transmit a mechanical action between the side of the first main ropes 3 and the side of the second main ropes 6. That is, the first intermediate anchors 5 and second intermediate anchors 8 share the loading together via the intersections. Further, each of the first intermediate anchors 5 or second intermediate anchors 8 constituting the same grid shares the loading applied to the other first intermediate anchors 5 or second intermediate anchors 8.

**[0045]** The first intermediate anchors 5 sharing the loading from a target rock lump acting on the second intermediate anchor 8 are described below.

**[0046]** As shown in Fig. 2, when the target rock lump R is within a grid in the first grid-like structure 1, the loading from the target rock lump R acts on the second intermediate anchor 8 within the grid. The loading acting on this second intermediate anchor 8 is shared by other second intermediate anchors 8 constituting the grid including the above second intermediate anchor 8. This loading is transmitted through intersections between the first main ropes 3 and second main ropes 6 to the first intermediate anchors 5 constituting the grid of the first grid-like structure 1 containing therein the second intermediate anchor 8 receiving the loading, and thus, these first intermediate anchors 5 share this loading. Therefore, in this case, the number of loading-sharing anchors is eight, i.e., there are four more loading-sharing anchors than the net structure based on the rope netting works shown in Fig. 5.

**[0047]** The second intermediate anchors 8 sharing the loading from a target rock lump acting on the first intermediate anchor 5 are described below.

**[0048]** When the target rock lump R is below the first intermediate anchor 5 of the first grid-like structure 1 as shown in Fig. 3, the loading from the target rock lump R acts on this first intermediate anchor 5. This loading acting on the first intermediate anchor 5 is shared by other first intermediate anchors 5 constituting grids including the above first intermediate anchor 5. This loading is also shared, via intersections between the first main ropes 3 and second main ropes 6, by the second intermediate anchors 8 constituting the grid of the second grid-like structure 2 containing therein the first intermediate anchor 5 receiving the loading. Therefore, in this case, the number of loading-sharing anchors is thirteen, i.e., there are four more loading-sharing anchors than the net structure based on the rope netting works shown in Fig. 5.

**[0049]** Components of the first grid-like structure 1 and second grid-like structure 2 are particularly described below.

**[0050]** Wire ropes that are flexible and have high strength are used as the first main ropes 3 and second main ropes 6. Such wire ropes include, for example, but not limited to, a wire rope formed by intertwining three strands each comprising seven steel wires having plated surfaces. The wire ropes preferably have on their plated surface layers the surface coating for further enhancing

resistance to peeling, resistance to damage, adhesiveness, and an antirust property, in view of an environment surrounding the slope G. When the surface coating is applied, the useful life of the net structure may be further increased. While wire ropes with a diameter of 12mm are preferably used, wire ropes used as the main ropes are not limited thereto. For example, wire ropes with a diameter of 14mm, 16mm, or 18mm may be used.

**[0051]** The first end anchor 4 and second end anchor 7 may include, but are not limited to, a cement anchor or resin anchor that are rock anchors, and a cast-in anchor that is a sediment anchor. The cement anchor is used for driving the anchor into rock or sediment. Cement is cast into a perforation, and the anchor is fixed by peripheral frictional resistance force of the cured cement. The cement anchor has a strong load-bearing capacity in a pull-out direction (vertical direction with respect to the surface of the slope G) and a shearing direction (surface direction of the slope G). Thus, the cement anchor may be preferably used as a fixing tool driven into the rock or sediment on the slope G in that even if a large load in the pull-out direction acts on the cement anchor, it is hard to pull out the cement anchor, thereby further improving the safety of the net structure according to Embodiment 1. The resin anchor utilizes resin as a fixing agent, and may be preferably used in place of the above cement anchor in cold areas where it is difficult to obtain the peripheral frictional resistance force of the cement. As with the cement anchor, the resin anchor has a strong load-bearing capacity in the pull-out direction (vertical direction with respect to the surface of the slope G) and the shearing direction (surface direction of the slope G). Any resin may be used as long as the peripheral frictional resistance force necessary for the anchor fixing may be obtained in the cold areas. Well-known resin may be appropriately selected for use depending on the environment in the cold areas.

**[0052]** The cast-in anchor is used to drive the anchor into the sediment.

**[0053]** The cast-in anchor may include, for example, a sediment anchoring device, or a swing anchor.

**[0054]** When the first end anchor 4 or second end anchor 7 is driven into concave and convex portions (especially the concave portion) in sediment on the slope G, it is preferable to use the sediment anchoring device having a strong load-bearing capacity in the pull-out direction and the shearing direction similarly to the above cement anchor.

**[0055]** The sediment anchoring device comprises, for example, a hollow anchor pipe with both ends opened, an anchor rod extending through the anchor pipe and having a head engageable with a lower end of the anchor pipe, and a pull-out prevention mechanism for preventing the pull-out of the anchor pipe from within the ground. The anchor pipe is placed in the ground of the slope G with its upper end protruding from the surface of the slope G. Fastened to the upper end of the anchor pipe is a wire rope such as the first main rope 3 or second main rope

6 provided between a pin bolt attached to the upper end and the surface of the slope G. The anchor rod is inserted into the anchor pipe with the head up, and the head of the anchor rod is engaged with the lower end of the anchor pipe, to position the anchor rod below the anchor pipe. In this state, the anchor rod is coated therearound with a coagulant and fixed in the ground of the slope G. The pull-out prevention mechanism is comprised of the lower end of the anchor pipe and the head of the anchor rod engaging therewith. In the sediment anchoring device installed in this way, even if unexpected collapse occurs on the slope G, the anchor rod and pull-out prevention mechanism fixed deep in the ground prevent the pull-out of the anchor pipe, thereby further improving the safety the net structure according to Embodiment 1. This sediment anchoring device is preferably used as at least one anchor of the first end anchors 4 and second end anchors 7.

**[0056]** While the sediment anchoring device comprising the anchor pipe, anchor rod, and pull-out prevention mechanism is illustrated above, the sediment anchoring device is not limited thereto, and any sediment anchoring device may be used as long as the anchor pipe is fixed in a pull-out prevention direction as described above.

**[0057]** When the first end anchor 4 or second end anchor 7 is driven into flat sediment on the slope G, the above swing anchor may be used. In the flat sediment, a load in the pull-out direction is less likely to act on the anchor. Thus, necessary shear force may be obtained by using the swing anchor without using the above sediment anchoring device. Of course, the above sediment anchoring device may be used in the flat sediment on the slope G. Even if the sediment is flat during construction, it may cave in after the construction because of subsidence due to a natural disaster such as unexpected localized torrential rain. In this case, the above sediment anchoring device having the strong load-bearing capacity in the pull-out direction is installed, such that even if a large load in the pull-out direction acts on the sediment anchoring device, the sediment anchoring device is less likely to be pulled out, thereby guaranteeing the safety of the net structure according to Embodiment 1.

**[0058]** In order to obtain the strength required for the first end anchors 4 and second end anchors 7 (pull-out strength, shear strength, etc.), it is preferable to appropriately select types, combination, or embedded depth of anchors, considering several conditions, e.g., whether the slope G where the anchors are driven is comprised of rock or sediment, or whether the surface profile of the sediment on the slope G is concave and convex, or flat.

**[0059]** The metal fitting for connecting the first end anchor 4 or second end anchor 7 to an end of the first main rope 3 or second main rope 6 may include, for example, a winding grip. The winding grip comprises a grip member having a ring at its tip. This grip member is attached to the end of the first main rope 3 or second main rope 6, and the ring is fit over an anchor bolt, which is put between two steel plates and bolted down for connection.

**[0060]** Anchors similar to the above first end anchors 4 and second end anchors 7 are preferably used as the first intermediate anchors 5 and second intermediate anchors 8. When the second intermediate anchor 8 is driven into the target rock lump on the slope G within a grid of the first grid-like structure 1, or the first intermediate anchor 5 is driven into the target rock lump on the slope G within a grid of the second grid-like structure 2, it is preferable to use the above cement anchor. When the second intermediate anchor 8 is driven into the concave and convex portions (especially the concave portion) in the sediment on the slope G within a grid of the first grid-like structure 1, or the first intermediate anchor 5 is driven into the concave and convex portions (especially the concave portion) in the sediment on the slope G within a grid of the second grid-like structure 2, it is preferable to use the above sediment anchoring device. With the use of the sediment anchoring device having a good load-bearing capacity both in the shearing direction and the pull-out direction, even if the large load in the pull-out direction acts on the sediment anchoring device, the sediment anchoring device is less likely to be pulled out, thereby further improving the safety of the net structure according to Embodiment 1. This sediment anchoring device is preferably used as at least one anchor of the first intermediate anchors 5 and second intermediate anchors 8.

**[0061]** When the first intermediate anchor 5 or second intermediate anchor 8 is driven into the flat sediment on the slope G, the above swing anchor achieving the necessary shear force may be used, as is the case in the above first end anchor 4 or second end anchor 7. Of course, the above sediment anchoring device may be used as the first intermediate anchor 5 or second intermediate anchor 8 in the flat sediment on the slope G.

**[0062]** In order to obtain the strength required for the first intermediate anchors 5 or second intermediate anchors 8 (pull-out strength, shear strength, etc.), it is preferable to appropriately select types, combination, or embedded depth of anchors, considering several conditions, e.g., whether the slope G where the anchors are driven is comprised of rock or sediment, or whether the surface profile of the sediment on the slope G is concave and convex, or flat.

**[0063]** The metal fitting for connecting the first intermediate anchor 5 or second intermediate anchor 8 to the first main rope 3 may include, for example, a cross anchor grip. The cross anchor grip puts an intersection between the first main ropes 3 or between the second main ropes 6 between two plate fittings crossing the intersection diagonally, and then bolts them down to connect the intersection to the anchor.

**[0064]** The net structure according to Embodiment 1 is provided with auxiliary ropes 9 placed at regular intervals between the first main ropes 3 and between the second main ropes 6, respectively, as shown in Fig. 1. The interval between the auxiliary ropes 9 is, for example, but not limited to, 0.5m.

**[0065]** Wire ropes similar to the wire ropes used as the

first main ropes 3 or second main ropes 6 are used as the auxiliary ropes 9.

**[0066]** The metal fitting for connecting an intersection between the auxiliary ropes 9 or an intersection with the first main rope 3 or second main rope 6 may include, but not limited to, for example, a cross grip, cross clip, and V-shaped clip. For example, the cross grip puts the intersection between two plate-like fittings crossing the intersection diagonally, and bolts them down for connection.

**[0067]** At least one of the first grid-like structure 1 and second grid-like structure 2 may be provided with a wire net (not shown) as necessary. This wire net may include, for example, a wire net having a mesh shape of a rhombus, etc., or a thick net. For example, when small floatstones are already present on the slope G, or when a large stone is broken during the construction and small floatstones or rolling stones are expected to be produced, the wire net is useful to prevent falling of relatively small floatstones or rolling stones. The wire net is also useful to stabilize a large floatstone.

**[0068]** The wire net may be attached between the auxiliary ropes 9. In this case, if respective spacing between the first main ropes 3 and between second main ropes 6 is, for example, 3m, the spacing between the auxiliary ropes 9 may be expanded to 0.75-1m to attach the wire net between the auxiliary ropes 9.

**[0069]** The wire net may be attached between the first main ropes 3 or between the second main ropes 6 instead of between the auxiliary ropes 9.

**[0070]** Next, a method for constructing the net structure according to Embodiment 1 is described.

**[0071]** First, as shown in Fig. 1, the first end anchors 4, second end anchors 7, first intermediate anchors 5, and second intermediate anchors 8 are driven into the slope G at predetermined positions.

**[0072]** Then, the first main ropes 3 are placed in a grid-like fashion, the first end anchors 4 are connected to respective ends of the first main ropes 3, and the first intermediate anchors 5 are connected to respective intersections between the first main ropes 3, thereby fixing the first main ropes 3 to the slope G in a tensioned state. The first grid-like structure 1 is constructed in this way.

**[0073]** After that, the second main ropes 6 are placed at intermediate positions between the first main ropes 3. At intersections with the first main ropes 3, the second main ropes 6 are placed on the first main ropes 3 in contact therewith. Then, the second end anchors 7 are connected to respective ends of the second main ropes 6, and the second intermediate anchors 8 are connected to respective intersections between the second main ropes 6, thereby fixing the second main ropes 6 to the slope G in a tensioned state. The second grid-like structure 2 is constructed in this way, and as a result, the net structure comprised of the first grid-like structure 1 and second grid-like structure 2 may be obtained.

**[0074]** The auxiliary ropes 9 may be placed, for example, after the construction of the first grid-like structure 1

and second grid-like structure 2. However, the auxiliary ropes 9 may be temporarily positioned at the predetermined positions on the slope G during the placement of the first main ropes 3 and second main ropes 6.

**[0075]** In the net structure according to Embodiment 1, the second main ropes 6 are placed at the intermediate positions between the first main ropes 3 different from the positions of the first main ropes 3, and placed on the first main ropes 3 in contact therewith at intersections with the first main ropes 3; and at least one second intermediate anchor 8 is placed within at least one grid in the first grid-like structure 1. Thus, at intersections with the second main ropes 6, the first main ropes 3 receive pushing force toward the slope G from the second main ropes 6. These intersections between the first main ropes 3 and second main ropes 6 where the pushing force acts transmit a mechanical action between the side of the first main ropes 3 and the side of the second main ropes 6. That is, the first intermediate anchors 5 and second intermediate anchors 8 share the loading together via the intersections. Each of the first intermediate anchors 5 or second intermediate anchors 8 constituting the same grid shares the loading applied to the other first intermediate anchors 5 or second intermediate anchors 8. Therefore, since the number of the first intermediate anchors 5 and second intermediate anchors 8 sharing the loading may be increased, one target rock lump may be held down by a larger number of the first intermediate anchors 5 and second intermediate anchors 8, thereby further improving the safety of the net structure based on the rock-fall prevention works.

**[0076]** Furthermore, when the above cement anchor or sediment anchoring device having the load-bearing capacity in the pull-out direction and the shearing direction is used as the first end anchor 4, first intermediate anchor 5, second end anchor 7, or second intermediate anchor 8, the cement anchor or sediment anchoring device may not be easily pulled out even if a large load in the pull-out direction acts on the cement anchor or sediment anchoring device. Thus, the above loading may be surely shared, thereby further improving the safety of the net structure.

**[0077]** In Embodiment 1, the present invention is applied to the construction method of the net structure in which the first end anchors 4, second end anchors 7, first intermediate anchors 5, and second intermediate anchors 8 are firstly driven into the slope G at the predetermined positions, and then the first main ropes 3 and second main ropes 6 are placed. However, the first main ropes 3 and second main ropes 6 may be initially temporarily positioned at the predetermined positions on the slope G, and then, the first end anchors 4, second end anchors 7, first intermediate anchors 5, and second intermediate anchors 8 are driven into the slope G, thereby fixing the first main ropes 3 and second main ropes 6 to the slope G in a tensioned state.

**[0078]** In Embodiment 1, the present invention is applied to the constitution in which anchors requiring con-

necting operations are used during fixation of the first main ropes 3 and second main ropes 6. However, anchors which do not require the connecting operations may be used. For example, by using cast-in anchors which may fix the first main ropes 3 and second main ropes 6 to the slope G in the tensioned state simultaneously with the driving of the anchors, working efficiency of construction may be improved, thereby reducing the time and cost.

**[0079]** In Embodiment 1, while the present invention is also applied to the constitution in which the second main ropes 6 are placed at the intermediate positions between the first main ropes 3 different from the positions of the first main ropes 3, the present invention is not limited thereto.

**[0080]** Further, in Embodiment 1, the present invention is also applied to the constitution in which the second main ropes 6 are placed between the first main ropes 3. However, the second main ropes 6 may be placed outside the first main ropes 3 constituting edges of the first grid-like structure 1. In this case, the loading on the first intermediate anchors 5 fixing those first main ropes 3 in the tensioned state may be shared by the second intermediate anchors 8 fixing the second main ropes 6 in the tensioned state outside the first main ropes 3. In Embodiment 1, the present invention is also applied to the constitution in which the second grid-like structure 2 is placed at a position shifted along a diagonal line of a grid as a minimum unit in the first grid-like structure 1. However, the second grid-like structure 2 may be placed at a position shifted in a direction along a diagonal line of a larger grid formed by arranging more than one grid as the minimum unit. Further, while the shift distance of the second grid-like structure 2 shifted in the direction along the diagonal line of the grid as the minimum unit in the first grid-like structure 1 is half the length of the diagonal line of the grid as the minimum unit, the present invention is not limited thereto.

**[0081]** In Embodiment 1, the present invention is also applied to the constitution in which one first intermediate anchor 5 is placed within each of all grids as a minimum unit in the second grid-like structure 2, and one second intermediate anchor 8 is placed within each of all grids as the minimum unit in the first grid-like structure 1. However, more than one first intermediate anchor 5 may be placed within at least one grid in the second grid-like structure 2, and more than one second intermediate anchor 8 may be placed within at least one grid in the first grid-like structure 1.

**[0082]** In Embodiment 1, the present invention is also applied to the constitution in which the auxiliary ropes 9 are placed between the first main ropes 3 and between the second main ropes 6. However, the auxiliary ropes 9 may be placed at least one of between the first main ropes 3 and between the second main ropes 6. For example, the mechanical strength may be partially improved by placing the auxiliary ropes 9 only at appropriate locations.

**[0083]** In Embodiment 1, the present invention is also applied to the constitution in which the auxiliary ropes 9 are placed at the intermediate positions between the first main ropes 3 and second main ropes 6. However, if the spacing between the first main ropes 3 and between the second main ropes 6 is 3m and the spacing between the auxiliary ropes 9 is 0.5m, for example, the auxiliary ropes 9 may be placed at positions at which the spacing between the first main ropes 3 and second main ropes 6 is trisected.

## Embodiment 2

**[0084]** Fig. 4 is a plan view illustrating the net structure according to Embodiment 2 of the present invention, in which the identical reference numerals are applied to components identical to Fig. 1 to avoid repeating the description.

**[0085]** The net structure according to Embodiment 2 differs from Embodiment 1 in that Embodiment 2 uses the above sediment anchoring devices and cement anchors having the load-bearing capacities in the pull-out direction and the shearing direction for all of the anchors.

**[0086]** Outer edge parts of the net structure shown in Fig. 4 are comprised of large square grids comprising the first main ropes 3 and second main ropes 6. The first end anchors 4 fixing both ends of each of the first main ropes 3 to the slope G and the second end anchors 7 fixing both ends of each of the second main ropes 6 to the slope G, which are shown in Embodiment 1, are not provided nor projected outside the large grids.

**[0087]** This net structure is configured so that the above cement anchors are driven into rock on the slope G as the first intermediate anchors 5 or second intermediate anchors 8, and the above sediment anchoring devices are driven into sediment on the slope G as the first intermediate anchors 5 or second intermediate anchors 8.

**[0088]** Next, a method for constructing the net structure according to Embodiment 2 is described.

**[0089]** First, as shown in Fig. 4, the first intermediate anchors 5 and second intermediate anchors 8 are driven into the slope G at predetermined positions.

**[0090]** Then, the first main ropes 3 are placed in a grid-like fashion, and the first intermediate anchors 5 are connected to ends of the first main ropes 3 and intersections between the first main ropes 3, thereby fixing the first main ropes 3 to the slope G in a tensioned state. The first grid-like structure 1 is constructed in this way.

**[0091]** After that, the second main ropes 6 are placed at intermediate positions between the first main ropes 3. At intersections with the first main ropes 3, the second main ropes 6 are placed on the first main ropes 3 in contact therewith. Then, the second intermediate anchors 8 are connected to ends of the second main ropes 6 and intersections between the second main ropes 6, thereby fixing the second main ropes 6 to the slope G in a tensioned state. The second grid-like structure 2 is con-

structed in this way, and as a result, the net structure, which is comprised of the first grid-like structure 1 and second grid-like structure 2 and has the outer edge parts comprising large square grids, may be obtained.

**[0092]** As with Embodiment 1, the auxiliary ropes 9 may be placed, for example, after the construction of the first grid-like structure 1 and second grid-like structure 2. However, the auxiliary ropes 9 may be temporarily positioned at the predetermined positions on the slope G during the placement of the first main ropes 3 and second main ropes 6.

**[0093]** The net structure according to Embodiment 2 uses only the above sediment anchoring devices and cement anchors for all of the anchors. Therefore, even if the large load in the pull-out direction acts on any one of the anchors, the anchor may not be easily pulled out. Thus, any anchors may surely bear the loading to be shared, thereby further improving the safety of the net structure.

**[0094]** The safety of the net structure according to Embodiment 2 may be sufficiently secured by using the above sediment anchoring devices and cement anchors for all of the anchors. Thus, it is not necessary to use the first end anchors 4 and second end anchors 7 projecting outside the large grids of the net structure. Therefore, in comparison to Embodiment 1 utilizing the first end anchors 4 and second end anchors 7 projecting outside the net structure, the number of the anchors may be reduced, and sites for projecting placement of the end anchors are no longer required. Since the sites for projecting placement of the end anchors are no longer required, the length of the first main ropes 3 and second main ropes 6 may be accordingly shortened. If the square net structure according to Embodiment 2 is constructed to extend to the sites for projecting placement of the end anchors, it may be a measure to prevent rockfall on the entire slope G including the sites for projecting placement of the end anchors.

**[0095]** In the described constitution of Embodiment 2, the first end anchors 4 and second end anchors 7 are not provided at the outer edge parts of the net structure, the first intermediate anchors 5 are used for fixation of the ends of the first main ropes 3, and the second intermediate anchors 8 are used for fixation of the ends of the second main ropes 6. However, as long as the anchors do not project outwardly from the outer edge parts of the net structure, the first end anchors 4 and second end anchors 7 may be provided at the outer edge parts and used to fix the ends of the first main ropes 3 and second main ropes 6. In either case, the safety of the net structure may still be further improved by using the above sediment anchoring devices and cement anchors for all of the anchors.

## Examples

### Example 1

**[0096]** The net structure according to Embodiment 1 shown in Fig. 1 was constructed.

#### (1) Preparatory stage

**[0097]** Wire ropes with a diameter of 12mm of a standard specification for the rope netting works were used as the first main ropes 3, second main ropes 6, and auxiliary ropes 9. In order to place the second main ropes 6 between the first main ropes 3, eleven pieces of the first main rope 3 were prepared for each of a longitudinal direction and a transverse direction, ten pieces of the second main rope 6 were prepared for each of the longitudinal direction and the transverse direction, and twenty pieces of the auxiliary rope 9 were prepared for each of the longitudinal direction and the transverse direction.

**[0098]** Swing anchors 25 for sediment (made by TOKYO ROPE MFG. CO., LTD.) with embedded length of 1.3m, TSK cement anchors for rock (made by TOKYO ROPE MFG. CO., LTD.), and TSK pull stop anchor systems (made by TOKYO ROPE MFG. CO., LTD.) that were sediment anchoring devices were prepared as the first end anchors 4, first intermediate anchors 5, second end anchors 7, and second intermediate anchors 8, and used depending on conditions of mounting portions on the slope G.

**[0099]** Cross anchor grips, cross grips, winding grips, cross clips, and V-shaped clips were prepared as splicing fittings.

#### (2) Construction stage

**[0100]** The first end anchors 4, second end anchors 7, first intermediate anchors 5, and second intermediate anchors 8 were initially driven into the slope G at predetermined positions. As these anchors, the above sediment anchoring devices were driven in concaves on the slope G at the predetermined positions.

**[0101]** Then, the first main ropes 3, second main ropes 6, and auxiliary ropes 9 were placed at predetermined positions on the slope G. The spacing between the first main ropes 3 and between the second main ropes 6 was 2m, the second main ropes 6 were placed at intermediate positions between the first main ropes 3, and the auxiliary ropes 9 were placed at 50cm intervals between the first main ropes 3 and second main ropes 6.

**[0102]** The cross anchor grips or winding grips were used to connect the ends of the first main ropes 3 to the first end anchors 4, and connect the ends of the second main ropes 6 to the second end anchors 7. The cross anchor grips were used to connect intersections between the first main ropes 3 to the first intermediate anchors 5, and connect intersections of the second main ropes 6 to the second intermediate anchors 8. On this occasion, the

first main ropes 3 and second main ropes 6 were fixed to the slope G in a tensioned state with adjustment so as to generate predetermined tension.

[0103] The cross grips, cross clips, or V-shaped clips were used to connect intersections between the auxiliary ropes 9, as well as intersections between the auxiliary ropes 9 and the first main ropes 3/second main ropes 6.

[0104] In this way, the net structure with the size of 20m x 20m was constructed.

[0105] A grid as a minimum unit in the first grid-like structure 1 and second grid-like structure 2 in this example had a size of 2m x 2m of a standard specification for the rope netting works. The number of the grids as the minimum unit in the first grid-like structure 1 was 100, and the number of the grids as the minimum unit in the second grid-like structure 2 was 81.

### (3) Calculation of acceptable loads

[0106] In the net structure constructed as above, the result of calculation of the acceptable load with respect to each of various inclinations was 12kN at 70 degrees of inclination, 15kN at 60 degrees of inclination, 20.7kN at 50 degrees of inclination, 35.7kN at 40 degrees of inclination, 56.7kN at 35 degrees of inclination, and 139kN at 30 degrees of inclination.

### Comparative Example 1

[0107] The net structure based on the rope netting works shown in Fig. 5 was constructed.

#### (1) Preparatory stage

[0108] Wire ropes with a diameter of 12mm of a standard specification for the rope netting works were used as the main ropes and auxiliary ropes. Eleven pieces of the main rope were prepared for each of a longitudinal direction and a transverse direction, and ninety pieces of auxiliary rope were prepared for each of the longitudinal direction and the transverse direction.

[0109] Swing anchors 25 for sediment (made by TOKYO ROPE MFG. CO., LTD.) with embedded length of 1.3m, TSK cement anchors for rock (made by TOKYO ROPE MFG. CO., LTD.), and TSK pull stop anchor systems (made by TOKYO ROPE MFG. CO., LTD.) that were sediment anchoring devices were prepared as end anchors and intermediate anchors, and used depending on conditions of mounting portions on the slope G.

[0110] Cross anchor grips, cross grips, winding grips, cross clips, and V-shaped clips were prepared as splicing fittings.

#### (2) Construction stage

[0111] The end anchors and intermediate anchors were initially driven into the slope G at predetermined positions. As these anchors, the above sediment anchor-

ing devices were driven in concaves on the slope G at the predetermined positions.

[0112] Then, the main ropes and auxiliary ropes were placed at predetermined positions on the slope G. Spacing between the main ropes was 2m, and the auxiliary ropes were placed at 50cm intervals between the main ropes.

[0113] The cross anchor grips or winding grips were used to connect ends of the main ropes to the end anchors. The cross anchor grips were used to connect intersections between the main ropes to the intermediate anchors. On this occasion, the main ropes were fixed to the slope G in a tensioned state with adjustment so as to generate predetermined tension.

[0114] The cross grips, cross clips, or V-shaped clips were used to connect intersections between the auxiliary ropes and main ropes.

[0115] In this way, the net structure with the size of 20m x 20m was constructed.

[0116] A grid as a minimum unit in this net structure had a size of 2m x 2m of the standard specification for the rope netting works. The number of the grids as the minimum unit was 100.

### (3) Calculation of acceptable loads

[0117] In the net structure constructed in this example, the result of calculation of the acceptable load with respect to each of various inclinations was 6kN at 70 degrees of inclination, 7.5kN at 60 degrees of inclination, 10.2kN at 50 degrees of inclination, 17.5kN at 40 degrees of inclination, 28.2kN at 35 degrees of inclination, and 69.5kN at 30 degrees of inclination.

[0118] When comparing the calculated values of acceptable loads in the above Example 1 and Comparative Example 1, the acceptable loads of Example 1 are about twice those of Comparative Example 1. This may be due to the increase in the number of anchors sharing the loading from one target rock lump in the net structure of Example 1.

[0119] The calculated values of the acceptable loads in Example 1 correspond to calculated values of the acceptable loads when spacing between the main ropes in the net structure based on the rope netting works is 1.414m (grid blocks of about 2m<sup>2</sup>).

### Example 2

[0120] The net structure was constructed in the same fashion as Example 1 except that wire ropes with a diameter of 14mm were used as the first main ropes 3, second main ropes 6, and auxiliary ropes 9.

[0121] In the net structure constructed in this example, the result of calculation of the acceptable load with respect to each of various inclinations was 17kN at 70 degrees of inclination, 21.5kN at 60 degrees of inclination, 29.7kN at 50 degrees of inclination, 51kN at 40 degrees of inclination, 81kN at 35 degrees of inclination, and

198.7kN at 30 degrees of inclination.

#### Comparative Example 2

**[0122]** The net structure was constructed in the same fashion as Comparative Example 1 except that wire ropes with a diameter of 14mm were used as the main ropes and auxiliary ropes.

**[0123]** In the net structure constructed in this comparative example, the result of calculation of the acceptable load with respect to each of various inclinations was 8.5kN at 70 degrees of inclination, 10.7kN at 60 degrees of inclination, 14.7kN at 50 degrees of inclination, 25.5kN at 40 degrees of inclination, 40.5kN at 35 degrees of inclination, and 99.2kN at 30 degrees of inclination.

**[0124]** When comparing the calculated values of acceptable loads in the above Example 2 and Comparative Example 2, the acceptable loads of Example 2 are higher than those of Comparative Example 2. As for the calculated values of acceptable loads at respective inclinations, the difference between Example 2 and Comparative Example 2 is larger than the difference between Example 1 and Comparative Example 1. This indicates a combined effect of the increase in the number of sharing anchors and the increase in diameter of the wire ropes.

#### Comparative Example 3

**[0125]** The net structure was constructed in the same fashion as Comparative Example 1 except that wire ropes with a diameter of 16mm were used as the main ropes and auxiliary ropes.

**[0126]** In the net structure constructed in this comparative example, the result of calculation of the acceptable load with respect to each of various inclinations was 10.2kN at 70 degrees of inclination, 12.7kN at 60 degrees of inclination, 17.7kN at 50 degrees of inclination, 30.5kN at 40 degrees of inclination, 48.7kN at 35 degrees of inclination, and 119.2kN at 30 degrees of inclination.

**[0127]** When comparing the calculated values of acceptable loads in the above Example 1 and Comparative Example 3, the acceptable loads of Example 1 are higher than those of Comparative Example 3. This indicates that the effect caused by the increase in the number of sharing anchors is greater than the effect caused by the increase in diameter of the wire ropes from 12mm based on the rope netting works to 16mm.

#### Comparative Example 4

**[0128]** The net structure was constructed in the same fashion as Comparative Example 1 except that wire ropes with a diameter of 18mm were used as the main ropes and auxiliary ropes.

**[0129]** In the net structure constructed in this comparative example, the result of calculation of the acceptable load with respect to each of various inclinations was 13.7kN at 70 degrees of inclination, 17.2kN at 60 degrees

of inclination, 23.7kN at 50 degrees of inclination, 40.7kN at 40 degrees of inclination, 64.7kN at 35 degrees of inclination, and 159kN at 30 degrees of inclination.

**[0130]** When comparing the calculated values of acceptable loads in the above Example 1 and Comparative Example 4, the acceptable loads of Example 1 are slightly lower than those of Comparative Example 4. Further, when comparing the calculated values of acceptable loads in the above Example 2 and Comparative Example 4, the acceptable loads of Example 2 are higher than those of Comparative Example 4. This indicates that the effects caused by the increase in the number of sharing anchors and the increase in diameter of the wire ropes from 12mm to 14mm are greater than the effect caused by the increase in diameter of the wire ropes from 12mm based on the rope netting works to 18mm.

#### Example 3

**[0131]** The net structure having a size of 21m x 21m was constructed in the same fashion as Example 1 except that eight pieces of the first main rope 3 were used for each of the longitudinal direction and the transverse direction, seven pieces of the second main rope 6 were used for each of the longitudinal direction and the transverse direction, twenty eight pieces of the auxiliary rope 9 were used for each of the longitudinal direction and the transverse direction, the spacing between the first main ropes 3 and between the second main ropes 6 was 3m, and the spacing between the auxiliary ropes 9 was 1.5m.

**[0132]** In the net structure constructed in this example, the result of calculation of the acceptable load with respect to each of various inclinations was 5.3kN at 70 degrees of inclination, 6.6kN at 60 degrees of inclination, 9.2kN at 50 degrees of inclination, 15.8kN at 40 degrees of inclination, 25.2kN at 35 degrees of inclination, and 61.7kN at 30 degrees of inclination.

**[0133]** When comparing the calculated values of acceptable loads in the above Example 3 and Comparative Example 1, the acceptable loads of Example 3 are almost the same as Comparative Example 1. This indicates that even if the spacing between the main ropes is enlarged, the effect caused by the increase in the number of sharing anchors may increase the acceptable loads.

#### Example 4

**[0134]** The net structure having a size of 21m x 21m was constructed in the same fashion as Example 3 except that wire ropes with a diameter of 14mm were used as the first main ropes 3, second main ropes 6, and auxiliary ropes 9.

**[0135]** In the net structure constructed in this example, the result of calculation of the acceptable load with respect to each of various inclinations was 7.5kN at 70 degrees of inclination, 9.5kN at 60 degrees of inclination, 13.2kN at 50 degrees of inclination, 22.6kN at 40 degrees of inclination, 36kN at 35 degrees of inclination, and

88.3kN at 30 degrees of inclination.

**[0136]** When comparing the calculated values of acceptable loads in the above Example 4 and Comparative Example 1, the acceptable loads of Example 4 are equal to or higher than those of Comparative Example 1. This indicates that even if the spacing between the main ropes is enlarged, the effect caused by the increase in the number of sharing anchors may increase the acceptable loads.

#### Example 5

**[0137]** The net structure according to Embodiment 2 shown in Fig. 4 was constructed.

#### (1) Preparatory stage

**[0138]** As with Example 1, wire ropes with a diameter of 12mm of a standard specification for the rope netting works were used as the main ropes and auxiliary ropes. Six pieces of the first main rope 3 were prepared for each of the longitudinal direction and the transverse direction, five pieces of the second main rope 6 were prepared for each of the longitudinal direction and the transverse direction, and ten pieces of the auxiliary rope 9 were prepared for each of the longitudinal direction and the transverse direction.

**[0139]** TSK cement anchors for rock (made by TOKYO ROPE MFG. CO., LTD.), and TSK pull stop anchor systems (made by TOKYO ROPE MFG. CO., LTD.) that were sediment anchoring devices were prepared as the intermediate anchors.

**[0140]** Cross anchor grips, cross grips, winding grips, cross clips, and V-shaped clips were prepared as splicing fittings.

#### (2) Construction stage

**[0141]** First, the above cement anchors were driven into rock on the slope G at predetermined positions, and the above sediment anchoring devices were driven into sediment at predetermined positions.

**[0142]** Then, the main ropes and auxiliary ropes were placed at predetermined positions on the slope G. Spacing between the main ropes was 2m, and the auxiliary ropes were placed at 50cm intervals between the main ropes 3.

**[0143]** The cross anchor grips or winding grips were used to connect ends of the main ropes and intersections between the main ropes to the above cement anchors or sediment anchoring devices. On this occasion, the main ropes were fixed to the slope G in a tensioned state with adjustment so as to generate predetermined tension.

**[0144]** The cross grips, cross clips, or V-shaped clips were used to connect intersections between the auxiliary ropes and main ropes.

**[0145]** In this way, the square net structure with the size of 10m x 10m was constructed.

**[0146]** A grid as a minimum unit in this net structure had the size of 2m x 2m, which is similar to the standard specification for the rope netting works. The number of the grids as the minimum unit in the first grid-like structure 1 was 25, and the number of the grids as the minimum unit in the second grid-like structure 2 was 16.

#### (3) Calculation of acceptable loads

**[0147]** In the net structure constructed in this example, the result of calculation of the acceptable load with respect to each of various inclinations was 12kN at 70 degrees of inclination, 15kN at 60 degrees of inclination, 20.7kN at 50 degrees of inclination, 35.7kN at 40 degrees of inclination, 56.7kN at 35 degrees of inclination, and 139kN at 30 degrees of inclination.

**[0148]** When comparing the calculated values of acceptable loads in the above Example 5 and Comparative Example 1, the acceptable loads of Example 5 are about twice those of Comparative Example 1. This may be due to the increase in the number of anchors sharing the loading from one target rock lump, as well as the use of the above sediment anchoring devices and cement anchors having load-bearing capacities in the pull-out direction and shearing direction for all of the anchors, in the net structure of Example 5.

#### Explanations of Numerals

#### **[0149]**

- 1: first grid-like structure
- 2: second grid-like structure
- 3: first main rope (first main wire)
- 4: first end anchor (first fixing tool)
- 5: first intermediate anchor (first fixing tool)
- 6: second main rope (second main wire)
- 7: second end anchor (second fixing tool)
- 8: second intermediate anchor (second fixing tool)
- 9: auxiliary rope
- G: slope
- R: target rock lump

#### **Claims**

##### 1. A net structure comprising:

a first grid-like structure which comprises a plurality of first main wires placed on a sloped mounting surface in a grid-like fashion, and a plurality of first fixing tools fixing both ends of each of the first main wires to the mounting surface and fixing intersections between the first main wires to the mounting surface; and  
a second grid-like structure which comprises a plurality of second main wires placed on the mounting surface in a grid-like fashion, and a

plurality of second fixing tools fixing both ends of each of the second main wires to the mounting surface and fixing intersections between the second main wires to the mounting surface,

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wherein the net structure is **characterized in that**:

the second main wires are placed at positions different from positions of the first main wires, and placed on the first main wires in contact therewith at intersections with the first main wires, and

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at least one of the second fixing tools is placed within at least one grid in the first grid-like structure.

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2. The net structure of claim 1, **characterized in that** the second fixing tool is placed at a position shifted in a direction along a diagonal line of the at least one grid in the first grid-like structure.

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3. The net structure of claim 2, **characterized in that** a shift distance of the second fixing tool is half the length of the diagonal line.

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4. The net structure of any one of claims 1-3, **characterized in that** at least one of the first fixing tools and second fixing tools is a sediment anchoring device having a load-bearing capacity in a pull-out direction and a shearing direction.

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5. The net structure of any one of claims 1-4, **characterized in that** auxiliary wires are placed at least one of between the first main wires and between the second main wires.

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6. The net structure of any one of claims 1-5, **characterized in that** a wire net is attached to at least one of the first grid-like structure and the second grid-like structure.

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7. A method for constructing a net structure on a sloped mounting surface, the net structure comprising:

a first grid-like structure which comprises a plurality of first main wires placed on the sloped mounting surface in a grid-like fashion, and a plurality of first fixing tools fixing both ends of each of the first main wires to the mounting surface and fixing intersections between the first main wires to the mounting surface; and  
a second grid-like structure which comprises a plurality of second main wires placed on the mounting surface in a grid-like fashion, and a plurality of second fixing tools fixing both ends of each of the second main wires to the mounting surface and fixing intersections between the second main wires to the mounting surface, and

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wherein the method is **characterized in that** the first main wires are placed; the second main wires are placed at positions different from positions of the first main wires, and placed on the first main wires in contact therewith at intersections with the first main wires; and at least one of the second fixing tools is placed within at least one grid in the first grid-like structure.

8. The method for constructing a net structure of claim 7, **characterized in that** the first fixing tools and the second fixing tools are placed; the first fixing tools and the first main wires are connected to fix the first main wires to the mounting surface in a tensioned state; and the second fixing tools and the second main wires are connected to fix the second main wires to the mounting surface in a tensioned state.

9. The method for constructing a net structure of claim 7, **characterized in that** after the first main wires and the second main wires are placed, the first fixing tools and the second fixing tools are driven into the mounting surface, thereby fixing the first main wires and the second main wires to the mounting surface in the tensioned state.

FIG.1

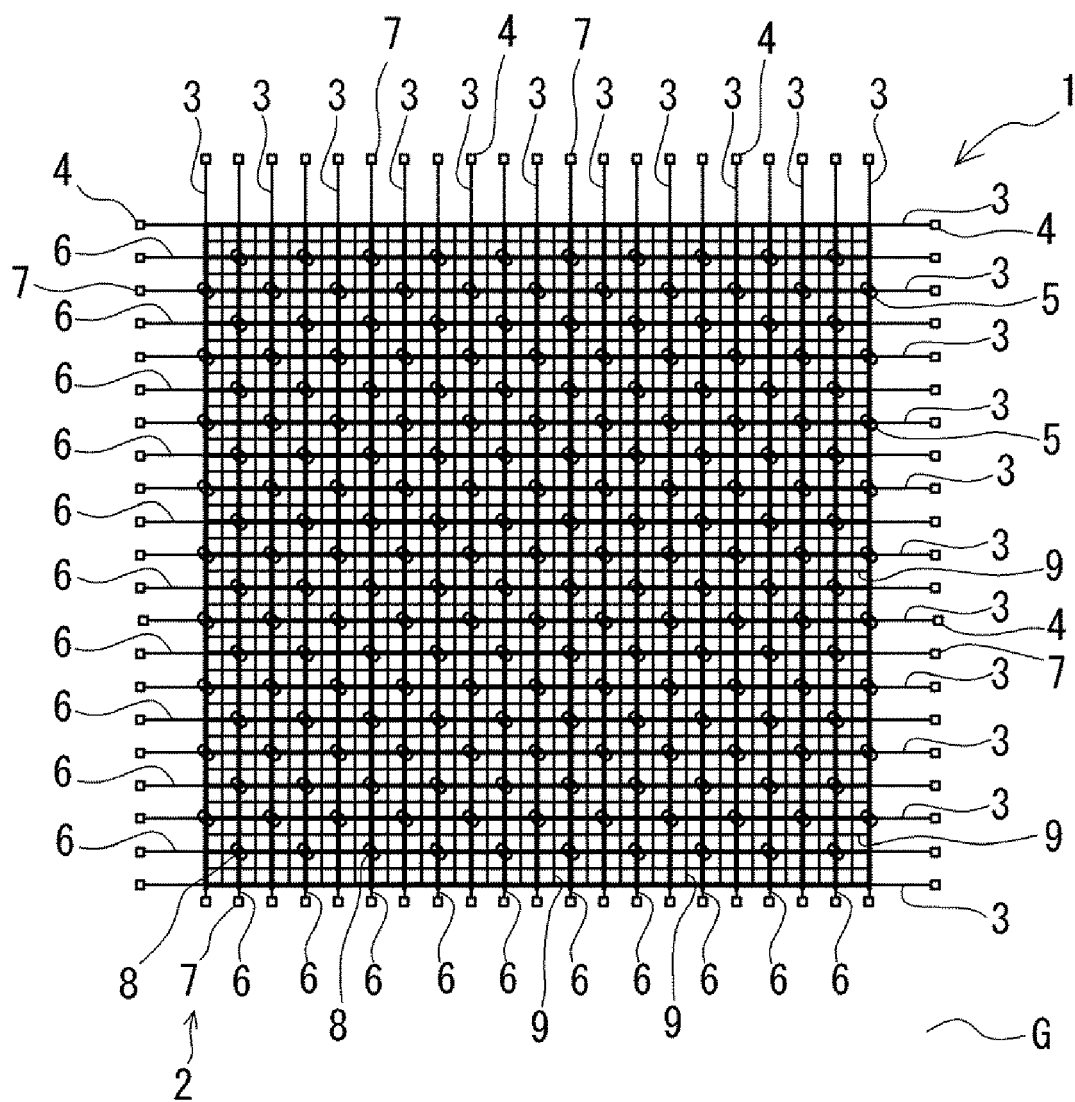


FIG.2

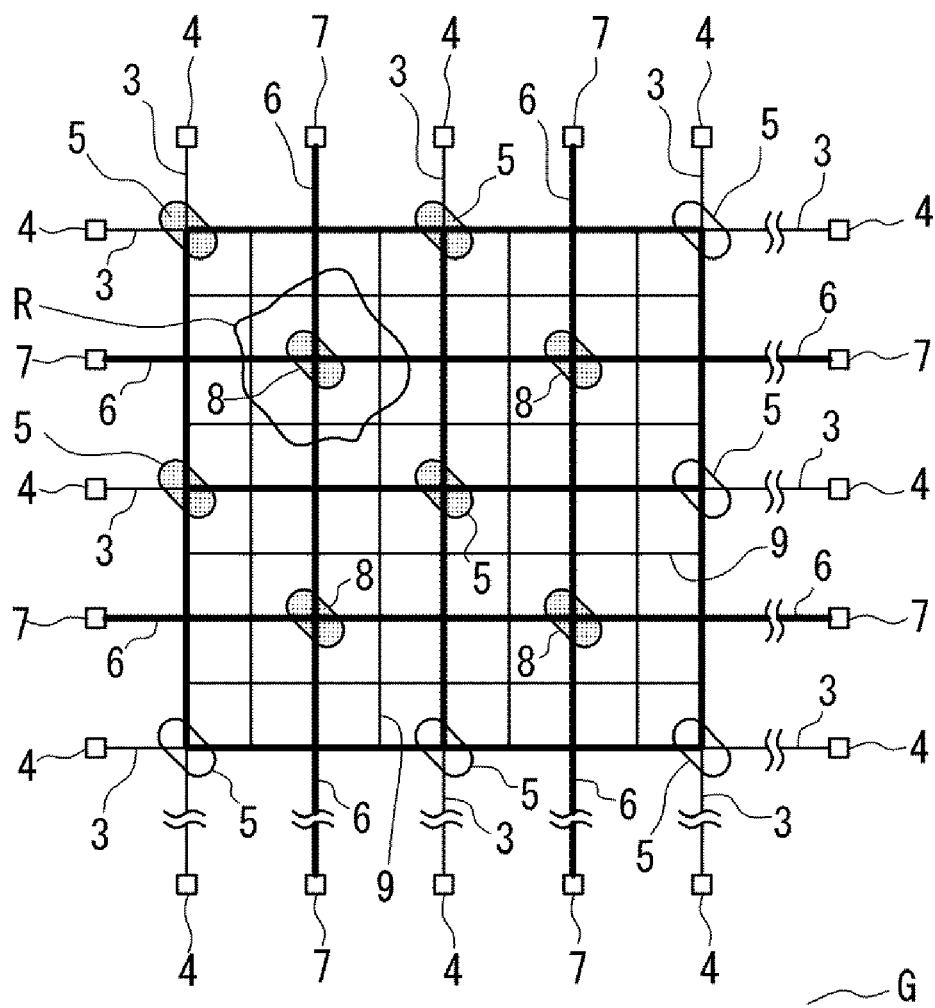


FIG.3

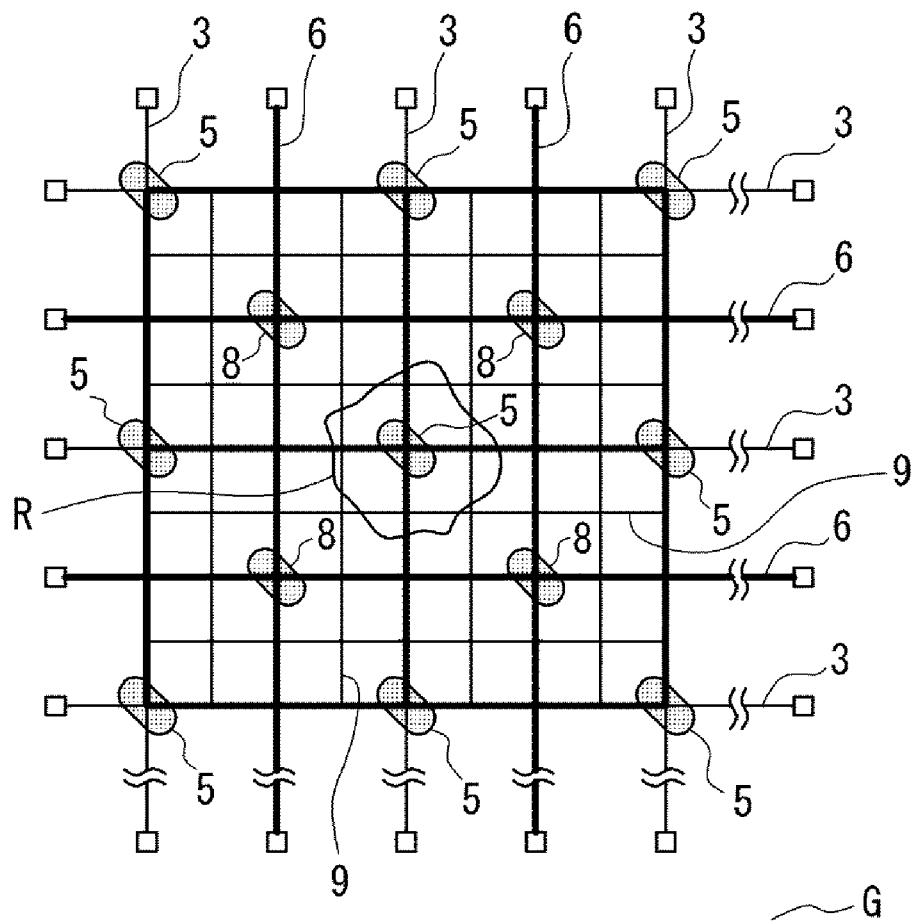


FIG.4

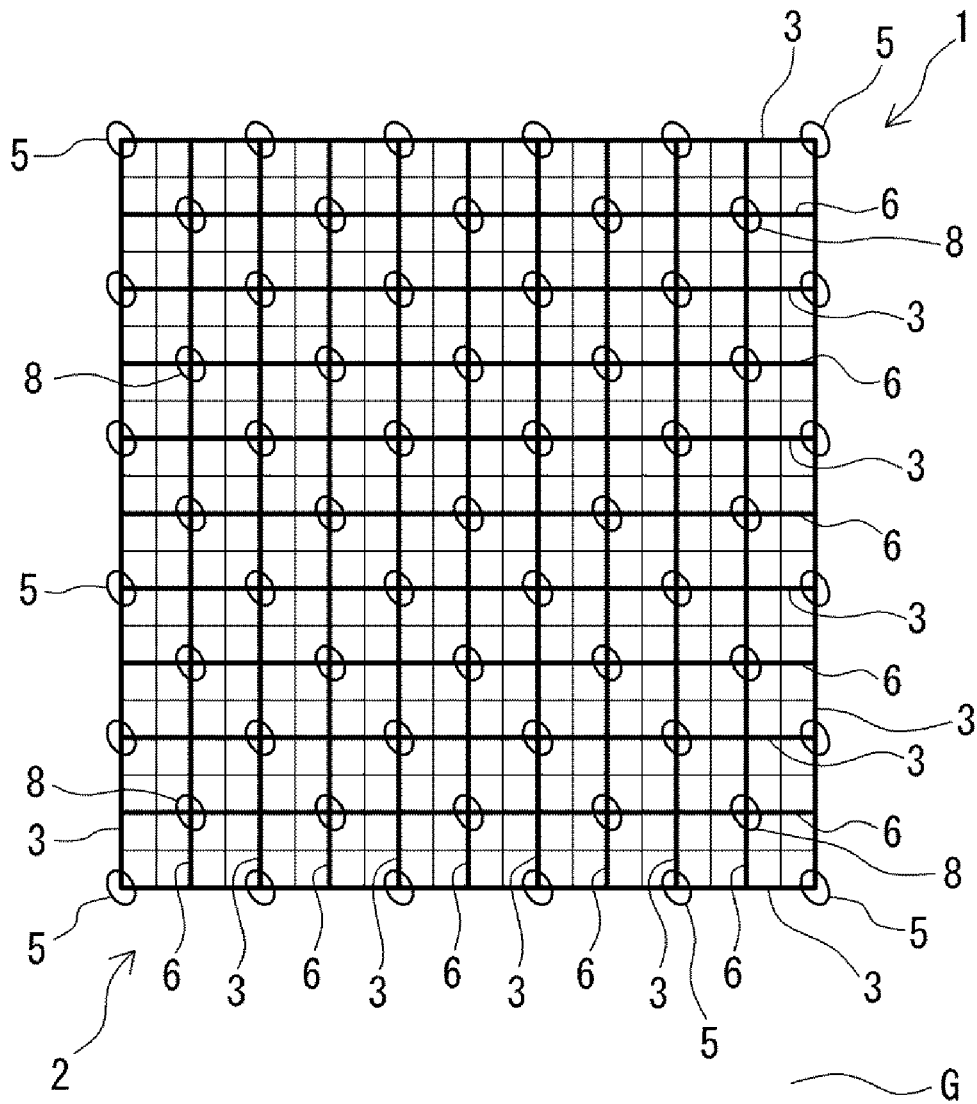
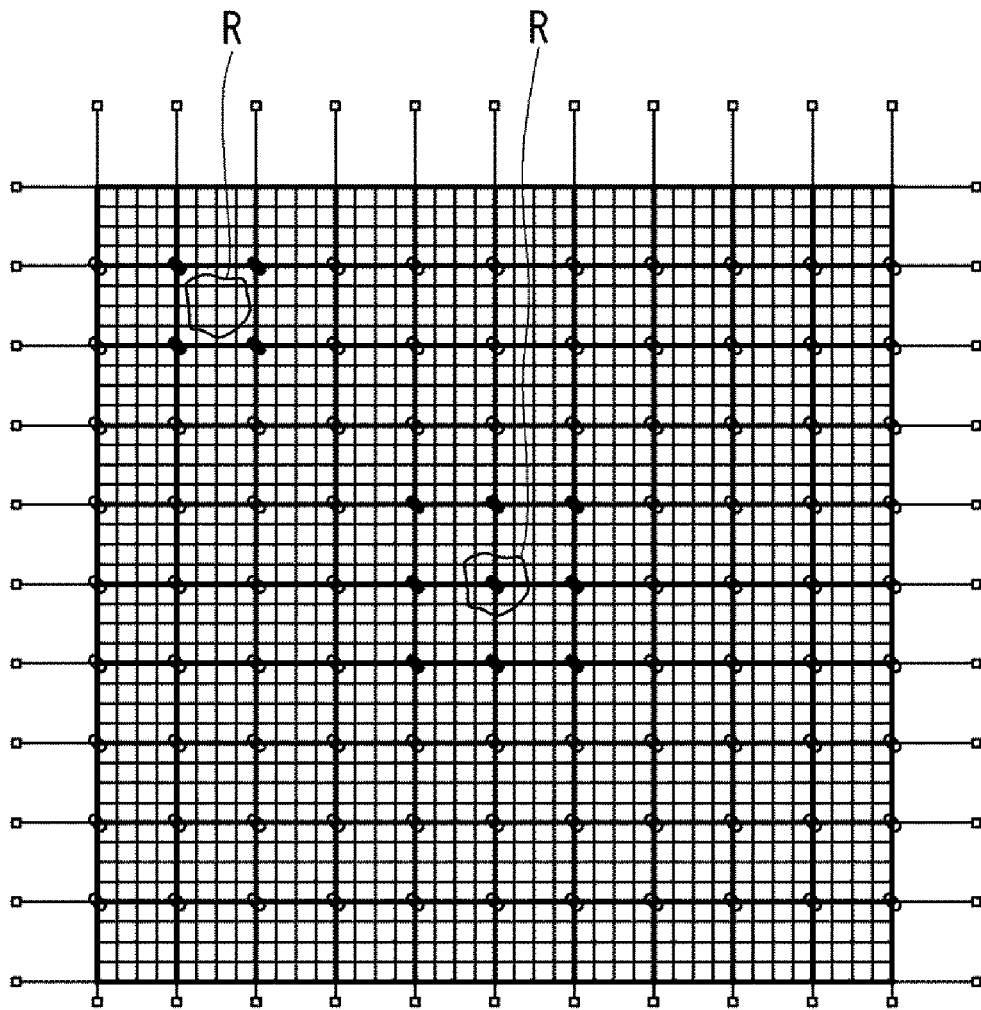


FIG.5





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