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(54) **METHOD FOR CONSTRUCTING A CHAIR-TYPE, SELF-SUPPORTED EARTH RETAINING WALL**

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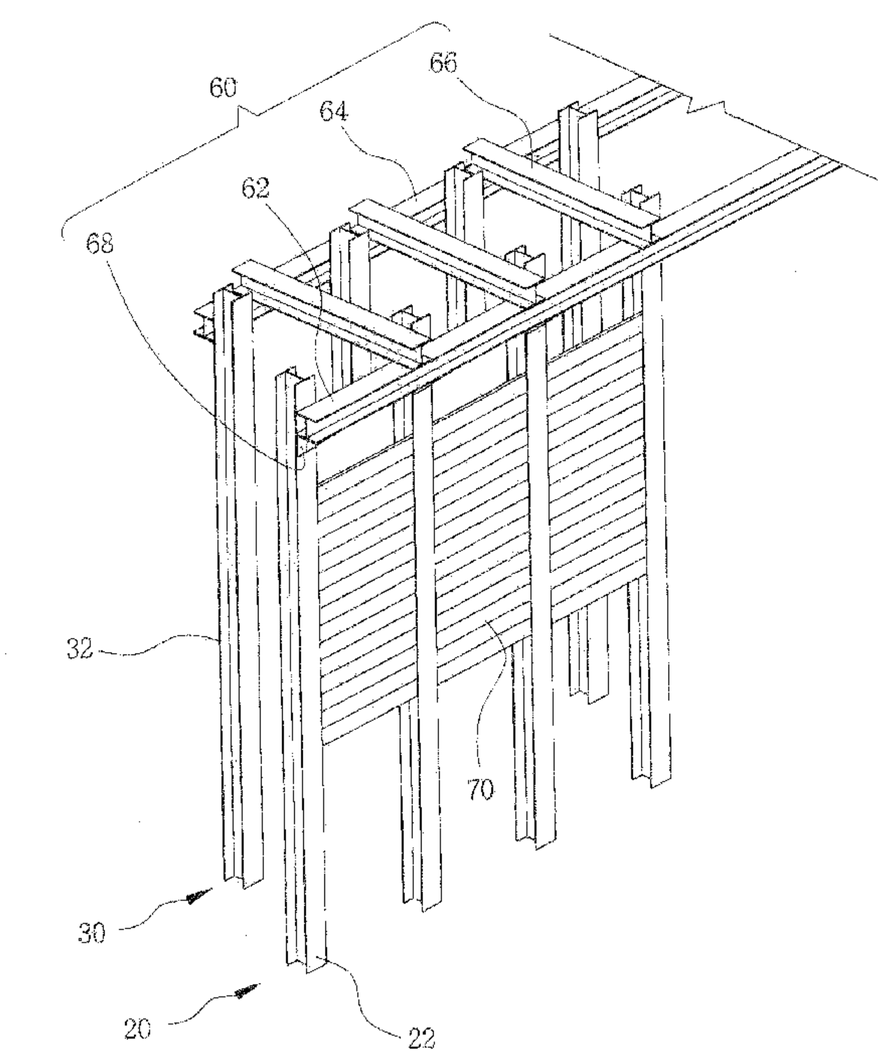
(57) **ABSTRACT**

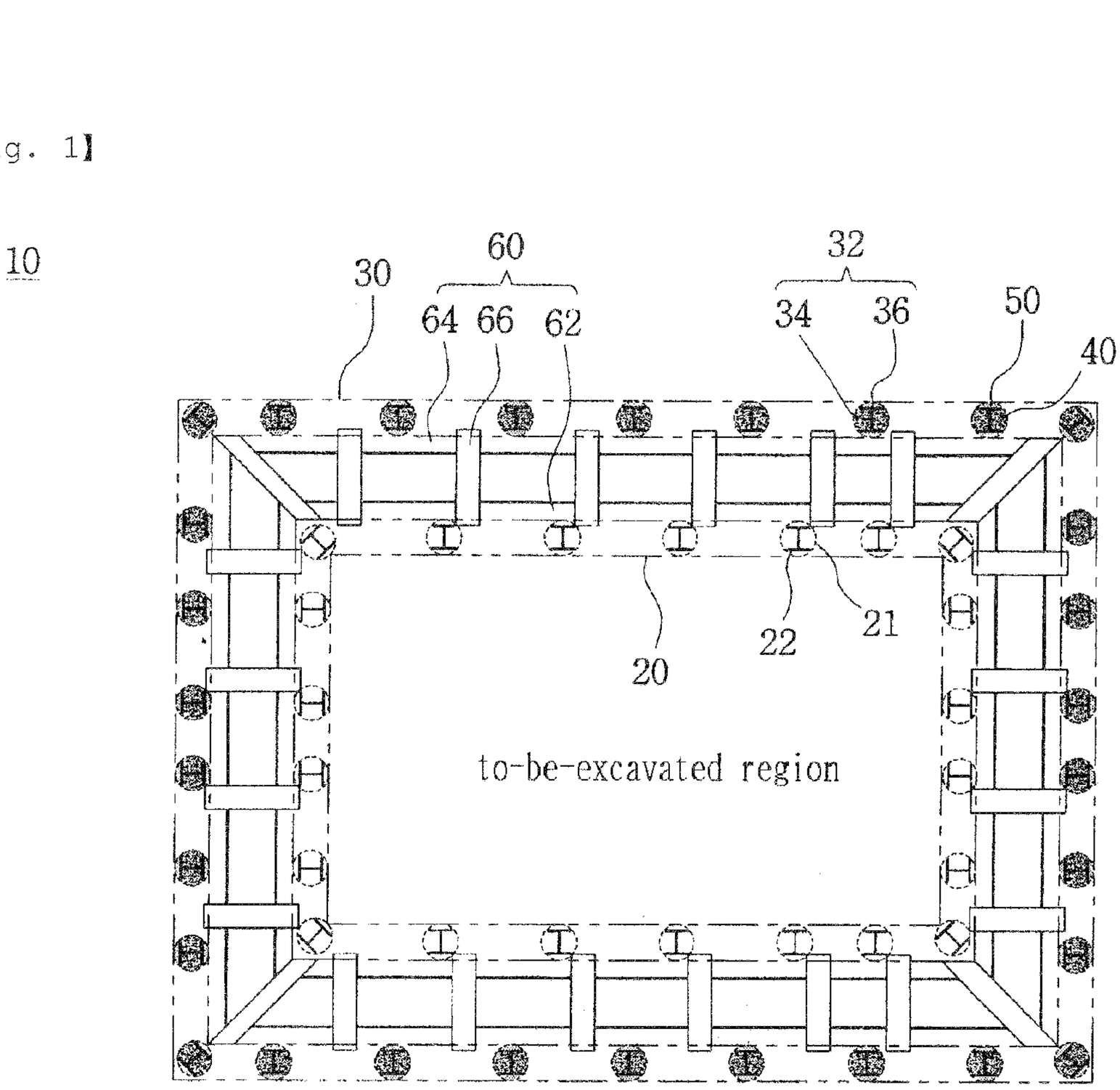
The present invention provides a method for constructing a chair-type, self-supported earth retaining wall used for retaining external forces such as earth pressure prior to an excavation. The method of the present invention forms a first column of piles having a plurality of piles arranged along the circumference of the region to be excavated. Subsequently, the method comprises forming a second column of piles having a plurality of piles by consecutively perforating a plurality of holes by a predetermined spacing at predetermined positions outwardly from the first column of piles, along the circumference of the region to be excavated, inserting H-beams into the respective holes, filling left and right spaces of the webs of the H-beams with soil, and filling the outer spaces of the flanges of the H-beams with a flowable stiffening material. The method subsequently comprises interconnecting the first column of piles and the second column of piles by a connection member. The first column of piles and the second column of piles are formed along the circumference of the region to be excavated, with an outward spacing, and connected to each other by the connection member.

The present invention provides a method for constructing a chair-type, self-supported earth retaining wall used for supporting external forces such as earth pressure prior to an excavation. The method of the present invention comprises forming a first pile array **20** having a plurality of piles **22** arranged along a circumference of an region to be excavated. Subsequently, the method comprises forming a second pile array **30** having a plurality of piles arranged along a circumference of the to-be-excavated region by consecutively drilling a plurality of boreholes **31** at predetermined intervals at predetermined positions outwardly spaced apart from the first pile array, inserting H-beams into the respective boreholes, filling left and right spaces of webs **34** of the H-beams **32** with soil **40**, and filling the outer spaces of flanges **36** of the H-beams with a flowable hardening material **50**.

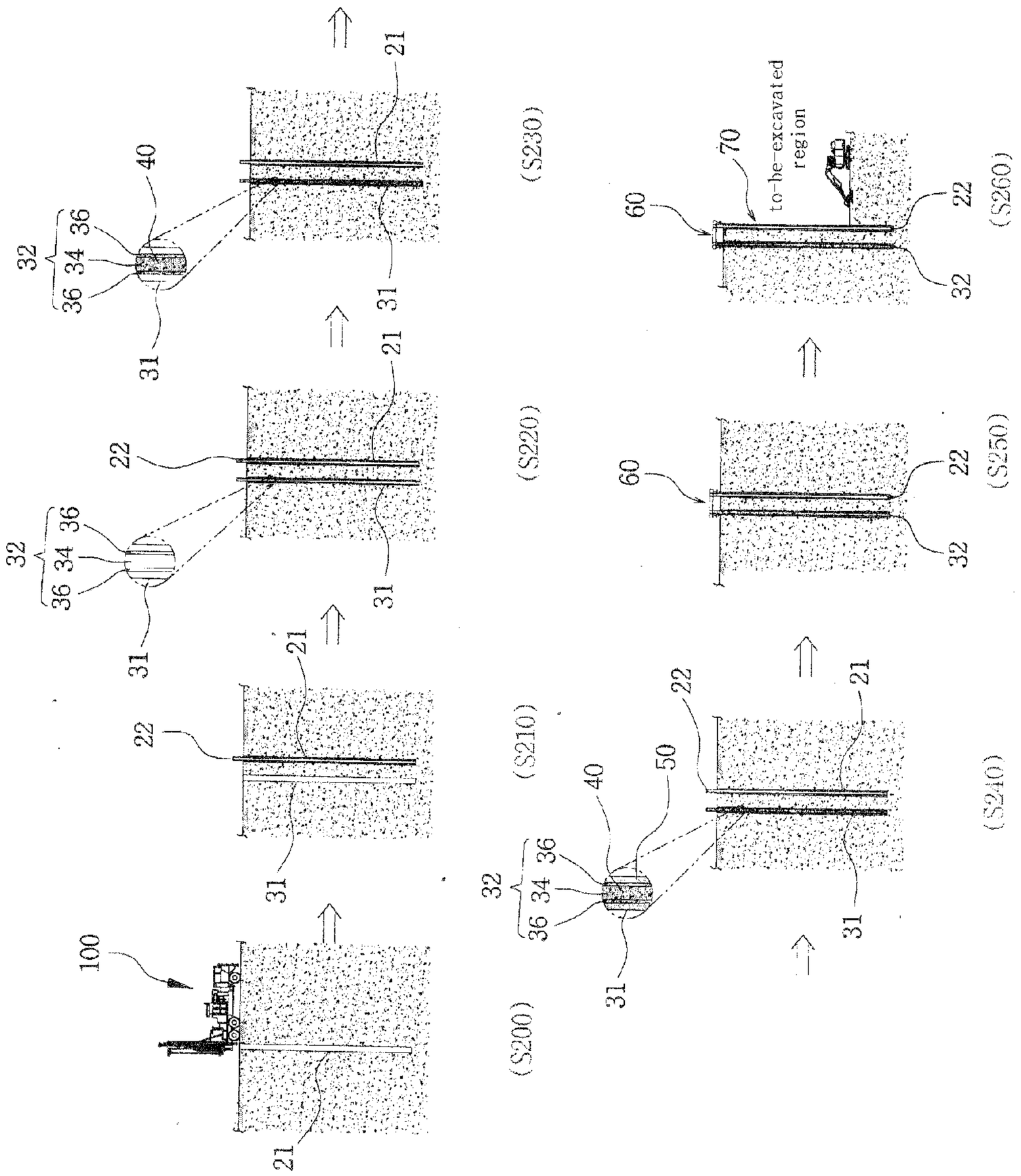
The method subsequently comprises fixedly interconnecting the first pile array and the second pile array using a connection member. The first pile array and the second pile array are formed in such a fashion as to be outwardly spaced apart from each other along the circumferences of the to-be-excavated region, and are connected to each other by the connection member to construct an underground earth retaining wall.



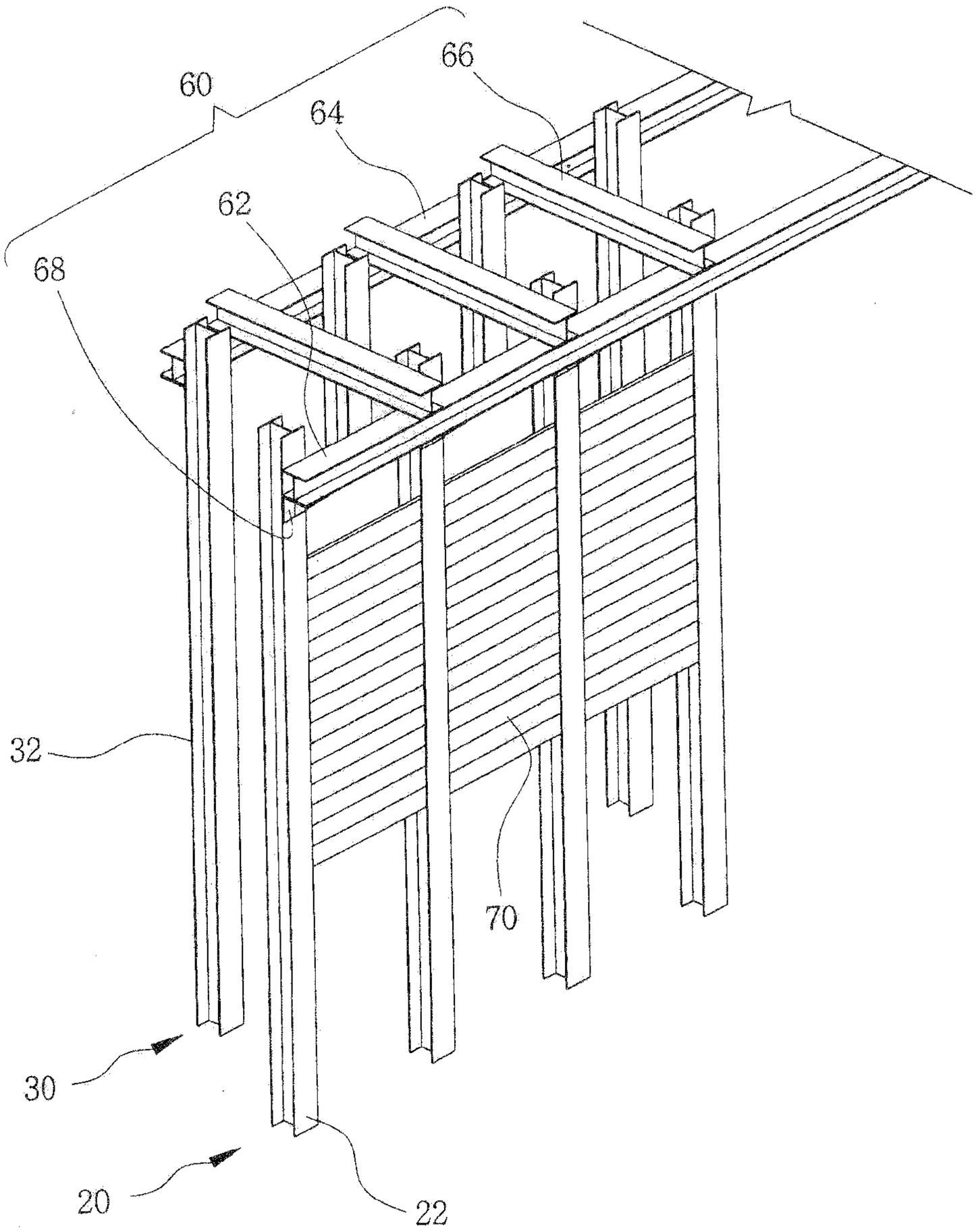
【Fig. 1】



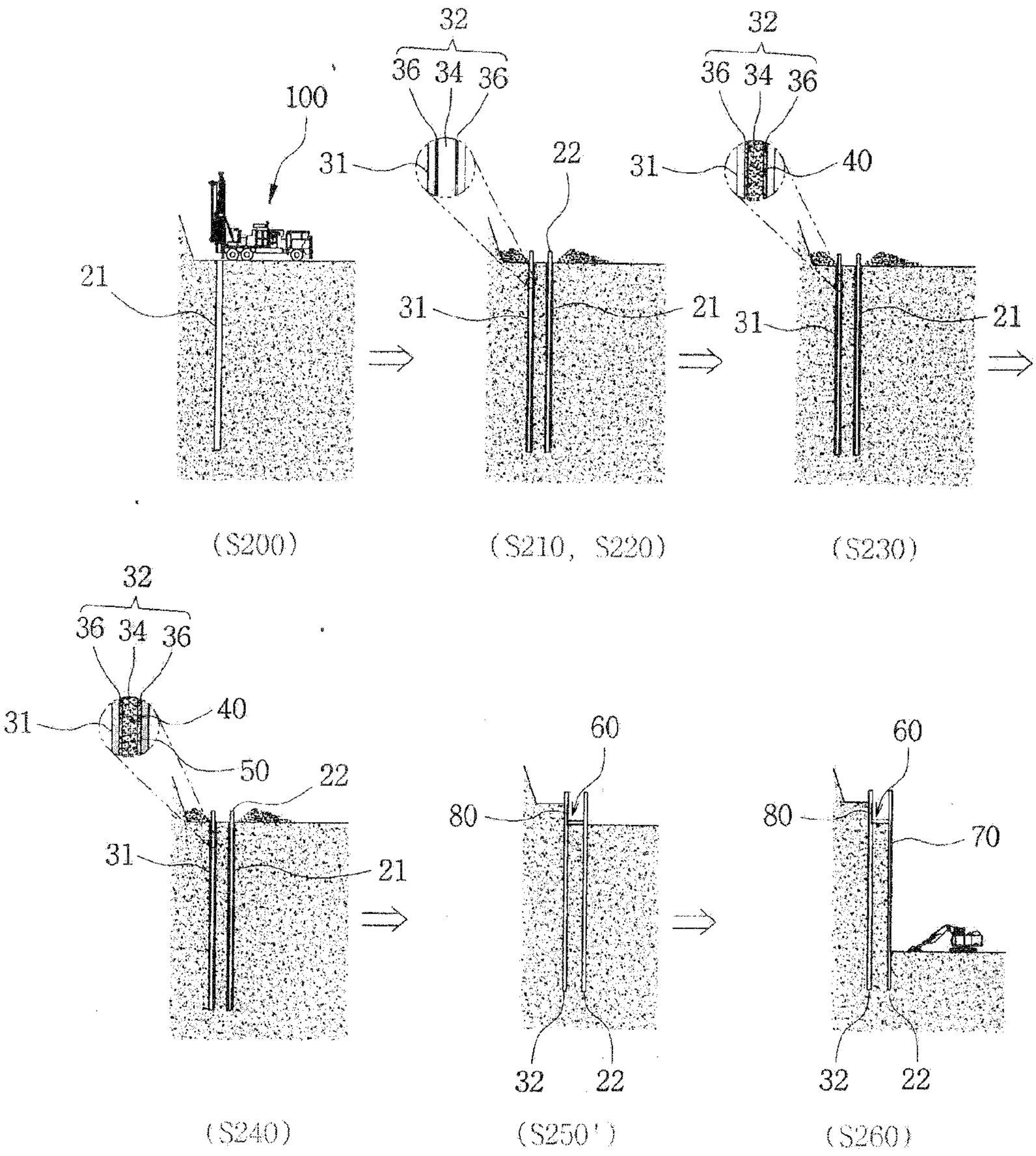
[Fig. 21]


(S200)
(S210)
(S220)
(S230)
(S240)
(S250)
(S260)
100
21
22
31
32
34
36
40
50
60
70
to-be-excavated region

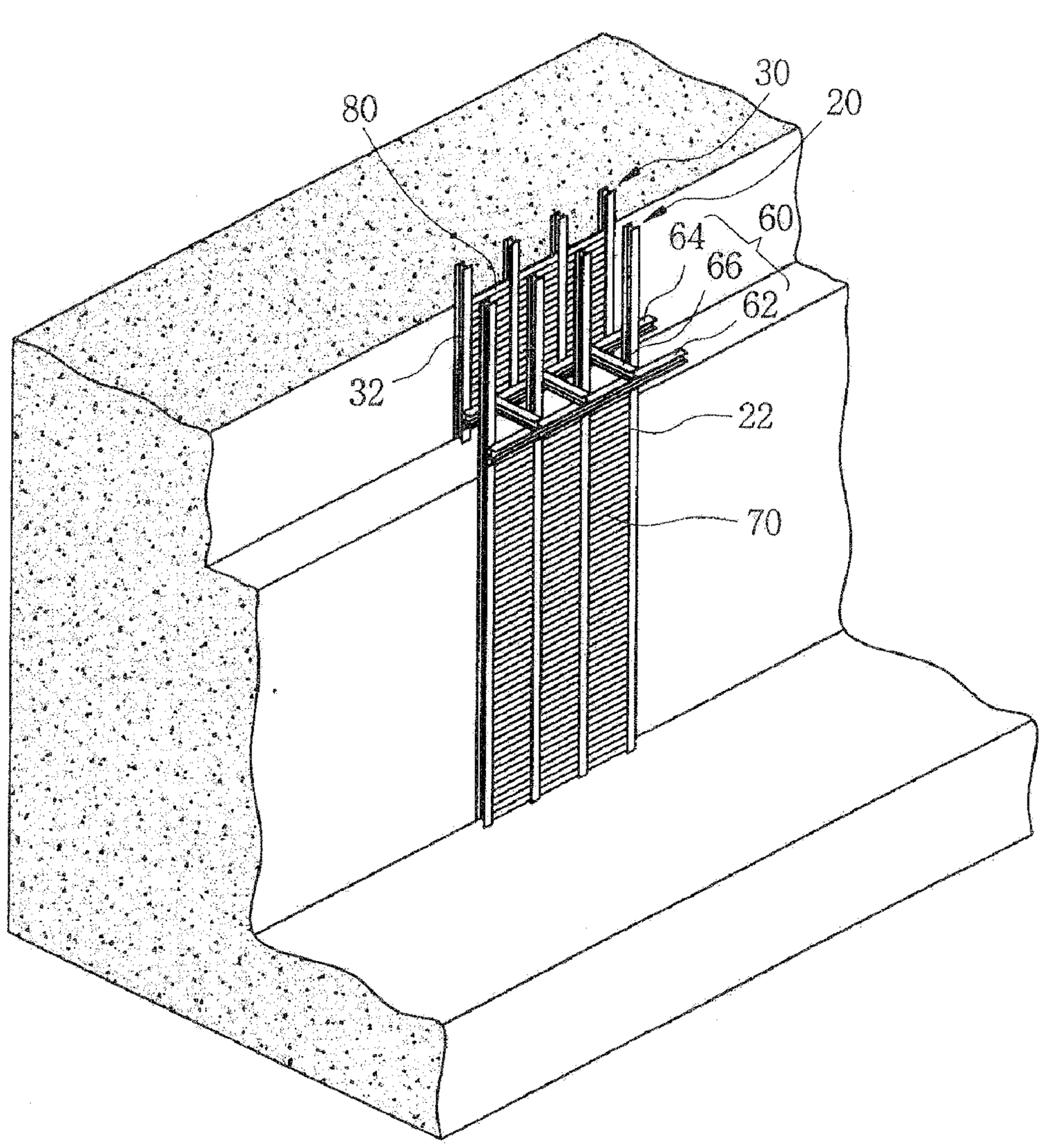
【Fig. 3】

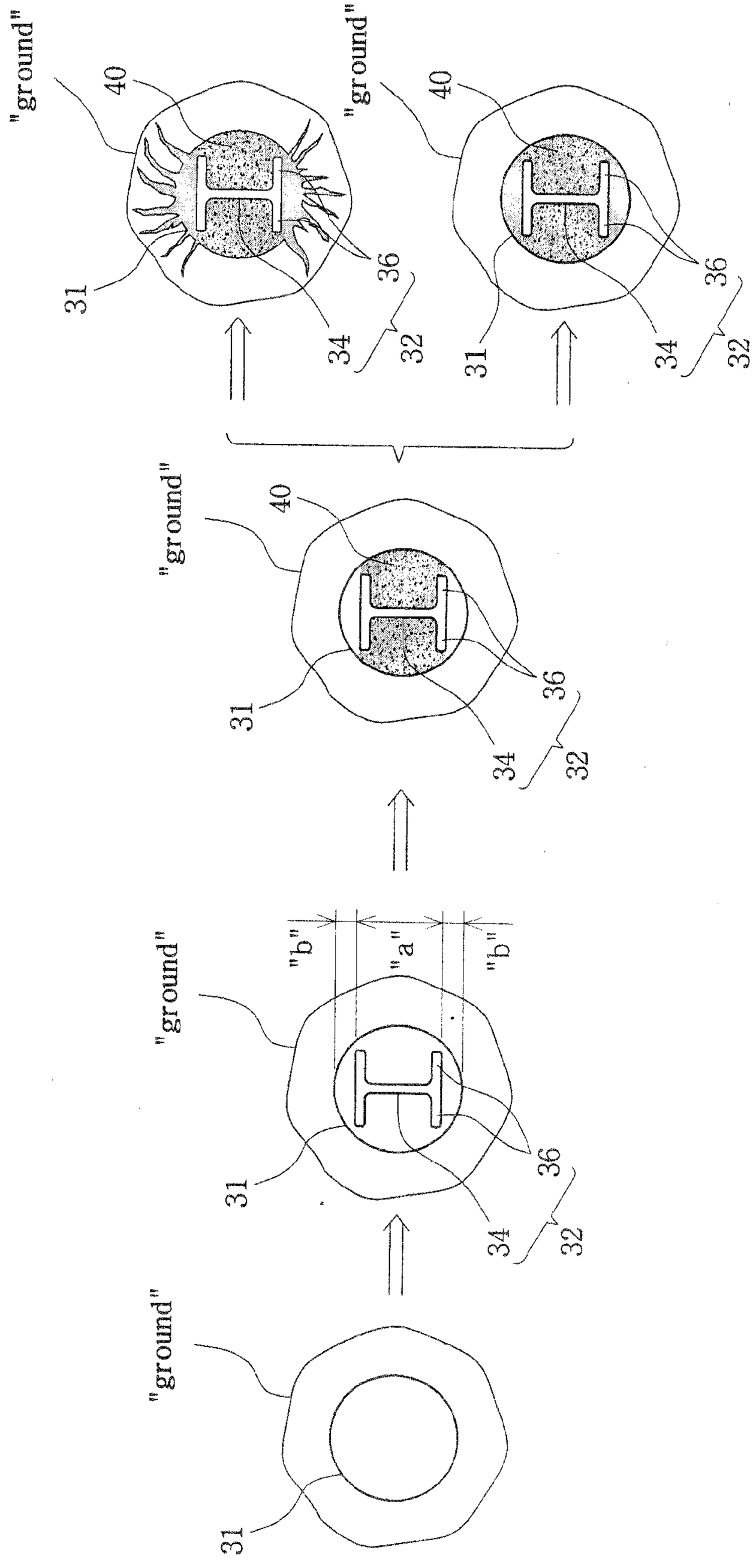


【Fig. 4】


32
36 34 36
100
31
22
21
40
(S200)
(S210, S220)
(S230)
50
60
80
70
32
22
(S240)
(S250')
(S260)

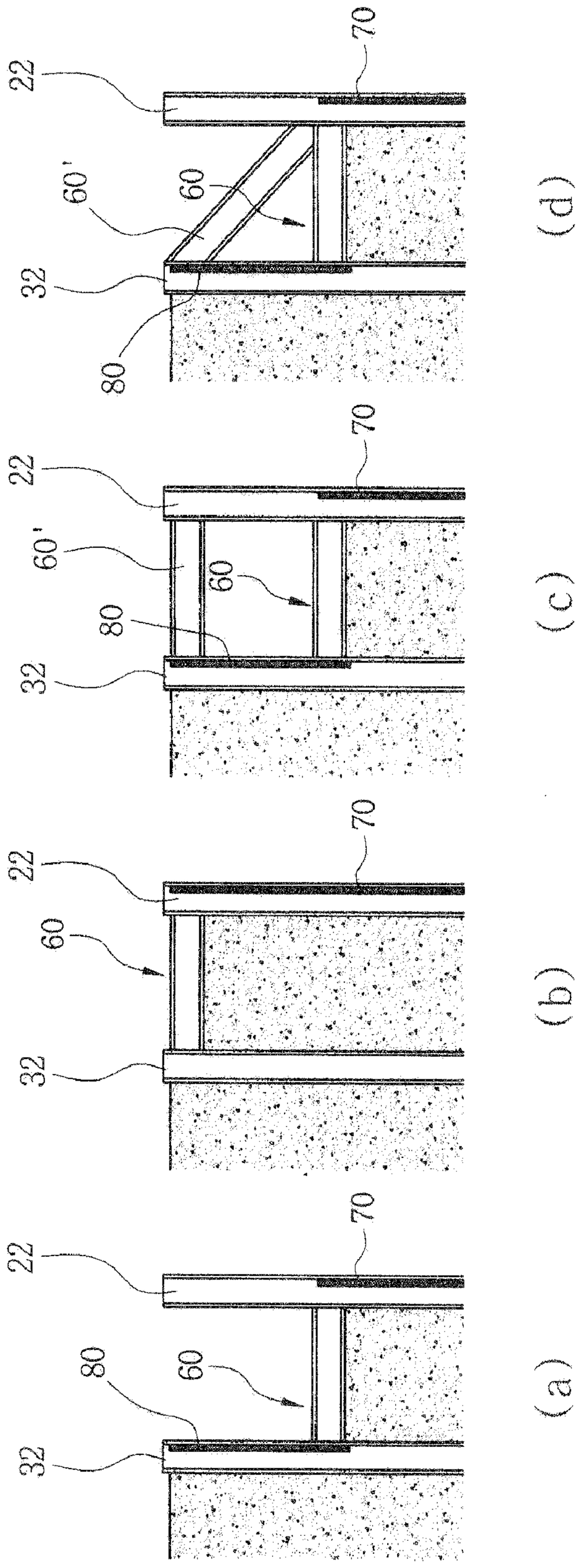
【Fig. 5】



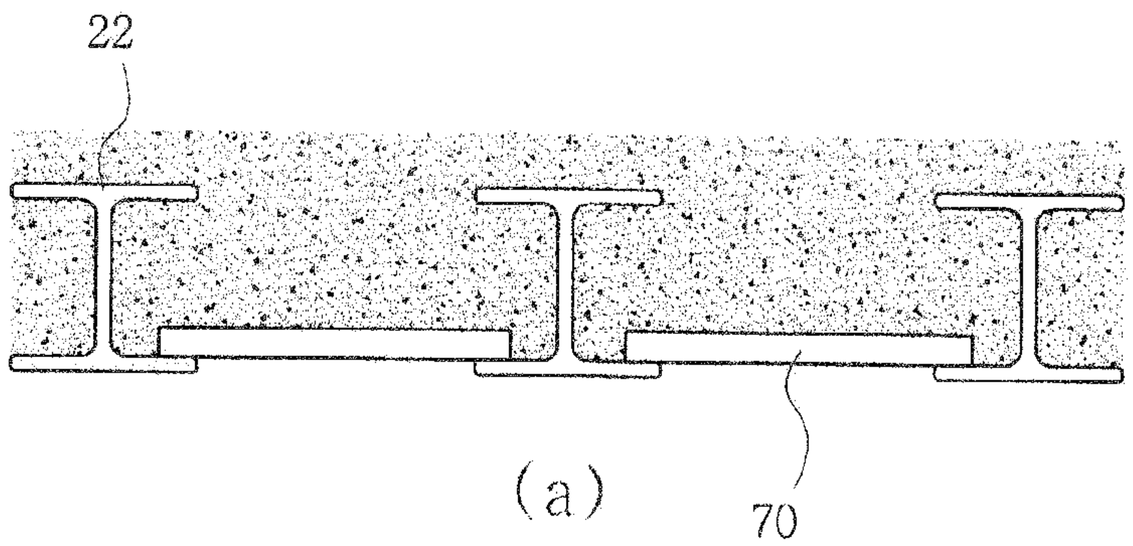


[Fig. 6]

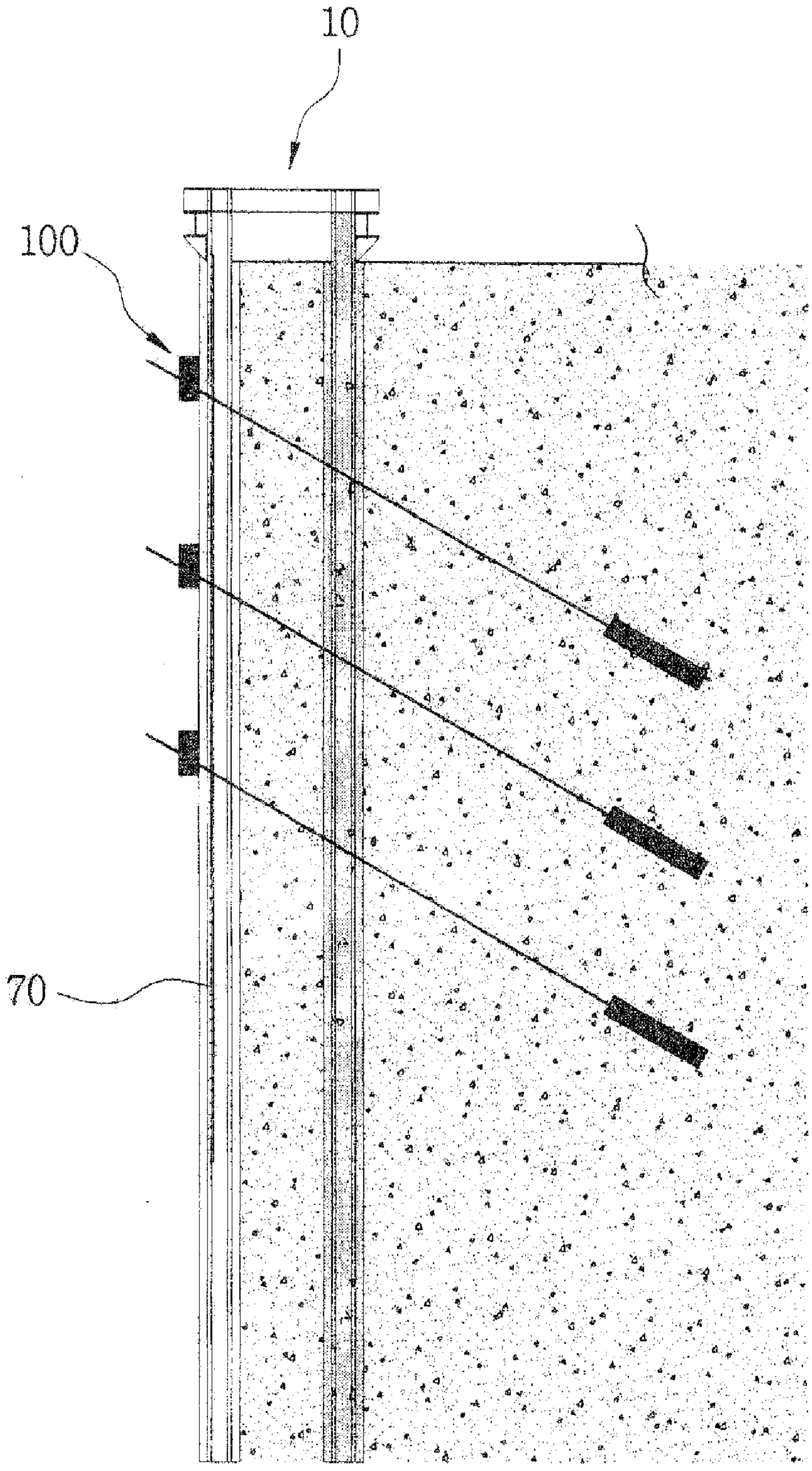
[Fig. 7]



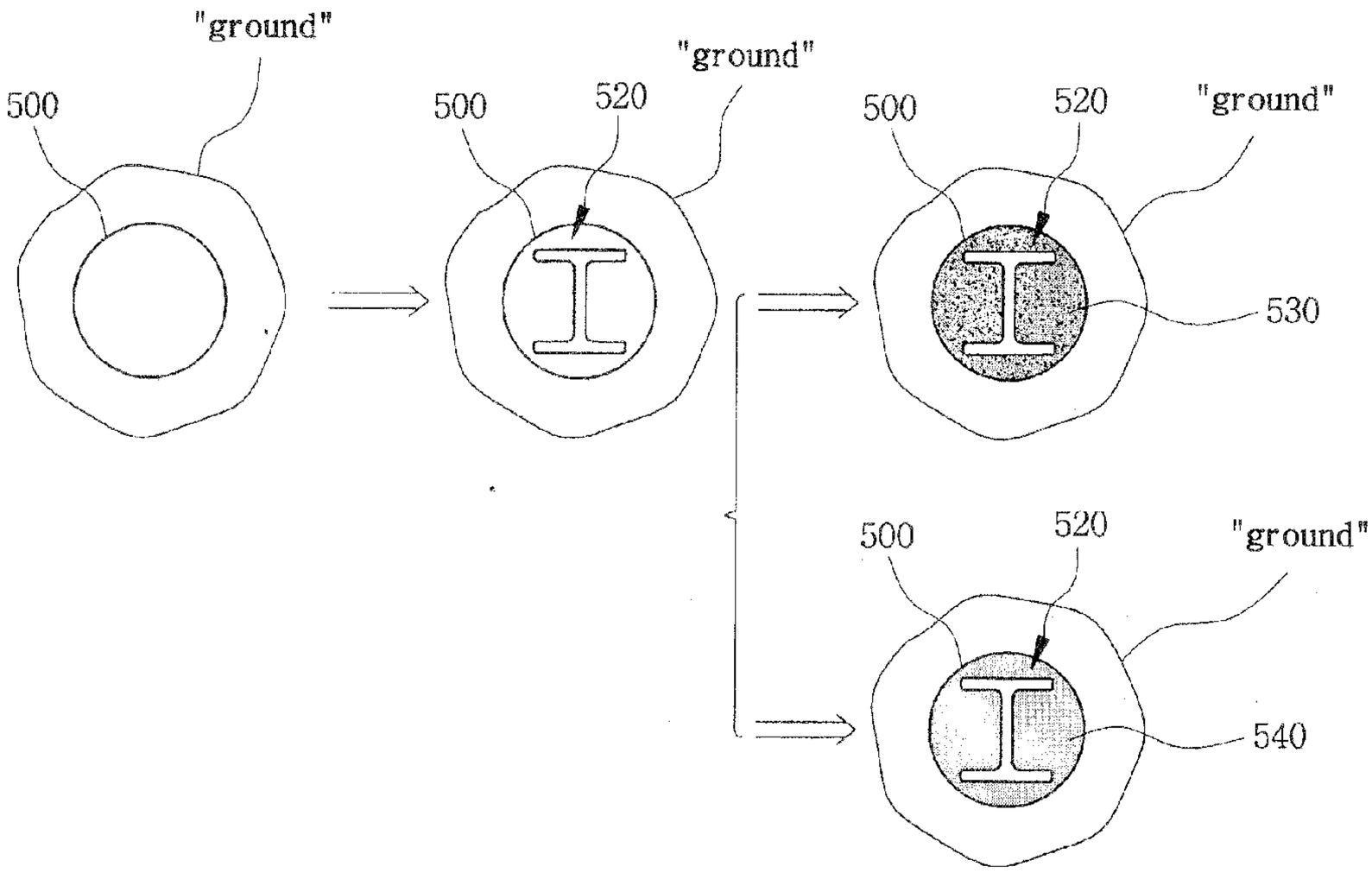
【Fig. 8】



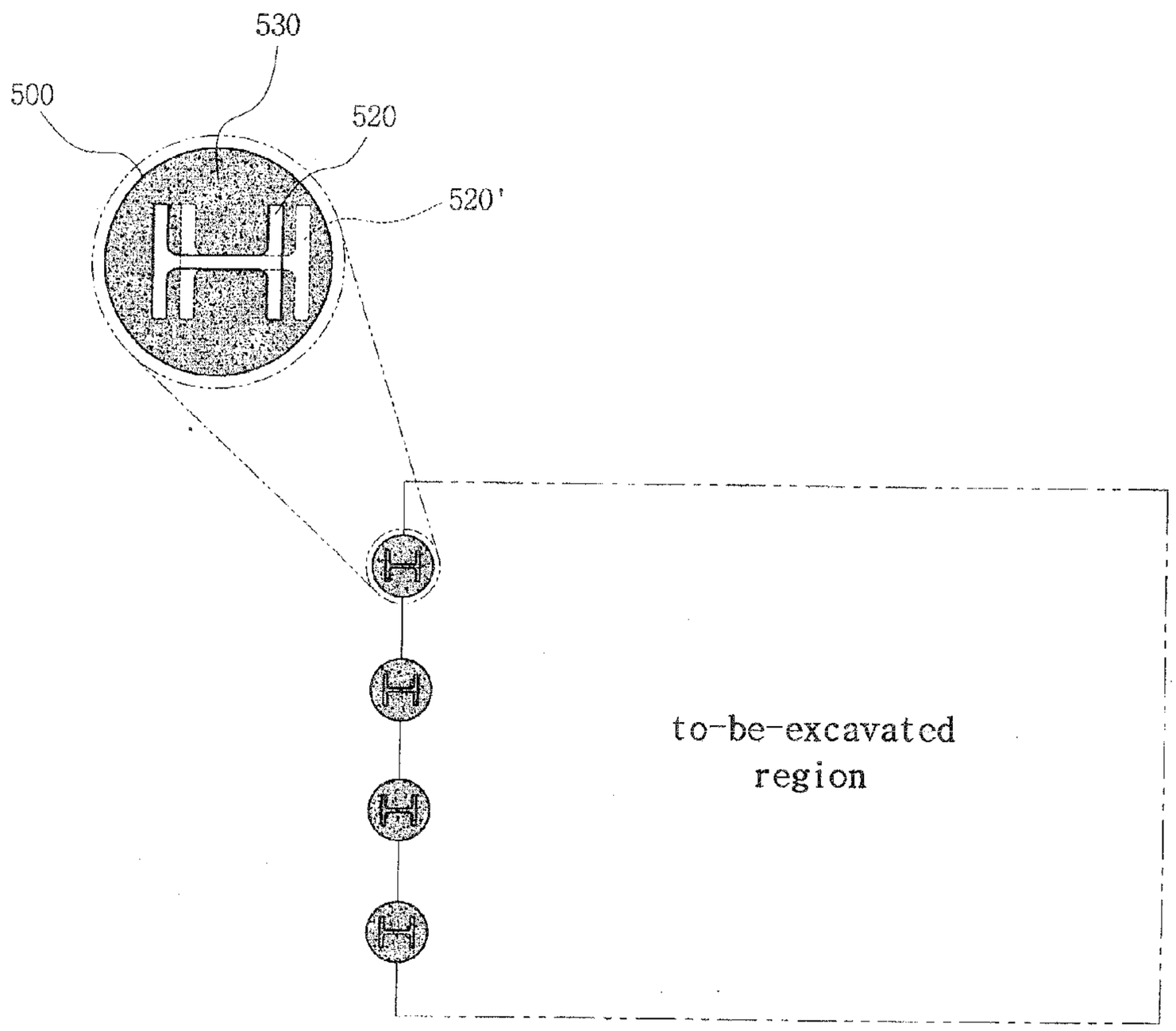
【Fig. 9】



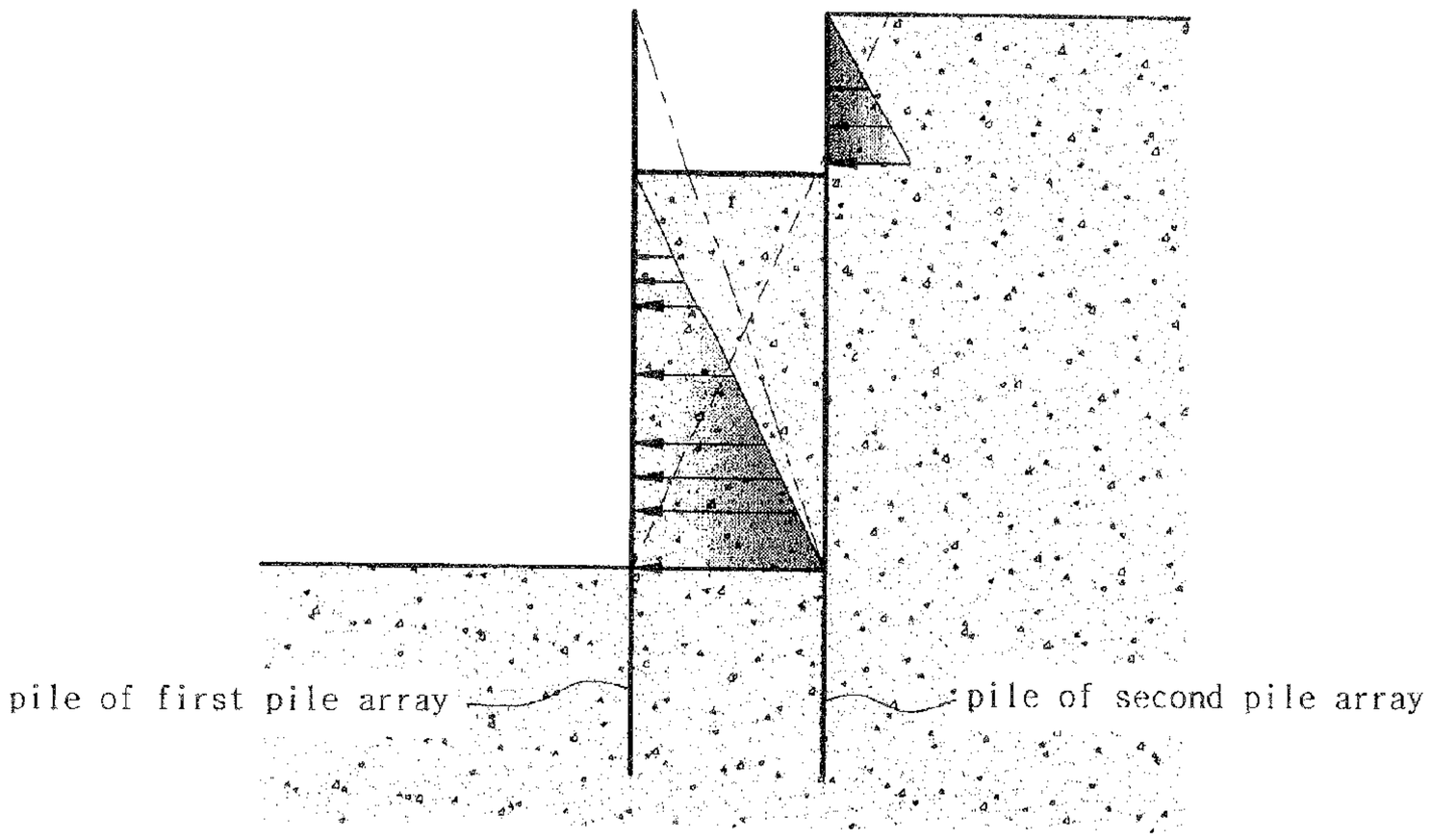
【Fig. 10】


"ground"
500
"ground"
500
520
"ground"
500
520
"ground"
530
500
520
"ground"
540

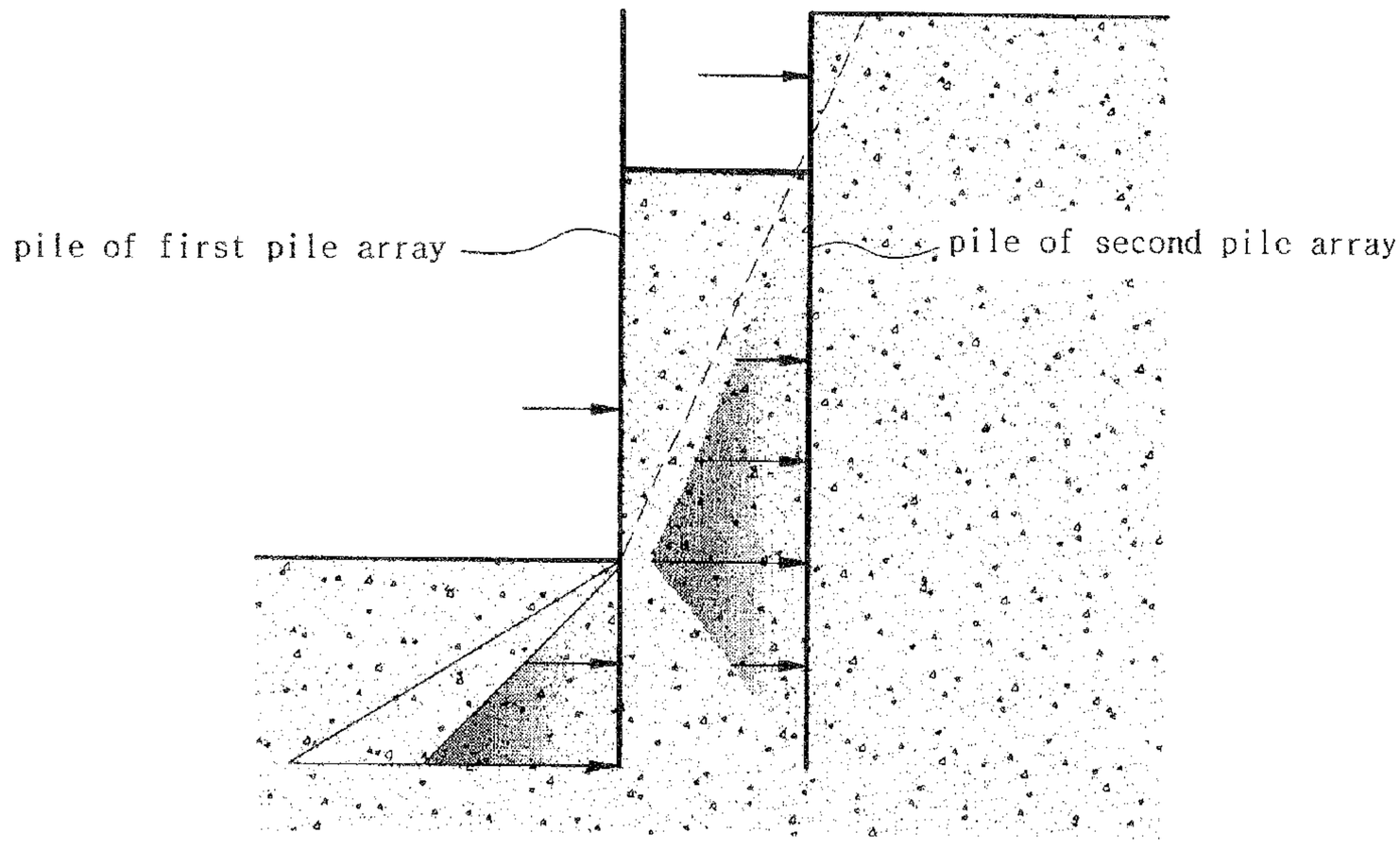
【Fig. 11】



【Fig. 12】



(a) active earth pressure(Pa)



(b) passive earth pressure(Pp)
and rigidity

METHOD FOR CONSTRUCTING A CHAIR-TYPE, SELF-SUPPORTED EARTH RETAINING WALL

TECHNICAL FIELD

[0001] The present invention relate to a method for constructing a chair-type, self-supported earth retaining wall, and particularly to, such a method for constructing a chair-type, self-supported earth retaining wall, in which an earth retaining wall used for supporting an external force such as earth pressure or the like prior to an excavation can be constructed by a supporting construction technique employing an improved double-row pile structure so as to complement various shortcomings involved in a conventional temporary facility construction technique such as a strut supporting construction technique, an earth anchor construction technique or the like.

BACKGROUND ART

[0002] In general, when filling the ground, cutting the ground, or drilling the ground, and the like are performed, while a slope surface is generally formed to maintain the stability of the ground. However, when the excavation is performed to improve the utility of the land more effectively or to improve the foundation of a structure in an urban area and construct a basement of a building, a vertical excavation is performed without the formation of the slope surface. In this regard, an earth retaining wall is necessarily installed around the vertical wall surface to prevent the breakage of the adjoining ground due to the vertical excavation. However, a temporary facility construction technique for installing the earth retaining wall should be selected in consideration of the conditions of the earth, the conditions of the ground, the effect of the earth retaining wall on the surroundings of the ground, construction expense, construction period, and the construction capacity, and the like, as well as the characteristics of the respective construction methods sufficiently.

[0003] Nowadays, one of the most generally known techniques of constructing the earth retaining wall is a strut supporting construction technique. Since this construction technique is designed to endure the soil pressure by the compression force of the strut, a plurality of struts is densely arranged at intervals of several meters in the longitudinal and transverse directions. Accordingly, in case of a large drilling work, the use of a large quantity of steel sheets greatly increases the construction expense, and the arranged struts obstruct the field works such as the movement of the drilling equipment, the conveyance of the drilled earth and sand, and the construction materials, and the like. In addition, the above strut supporting construction technique causes impediments to works of the reinforcing steel bar of a structure or a mold, thereby reducing the working efficiency. Also, in the strut supporting construction technique, a number of through-holes produced in the structure causes problems of durability and waterproof property of an completed underground structure.

[0004] Meanwhile, there has been proposed an earth anchor construction technique as a method of constructing the earth retaining wall without any strut among the conventional earth retaining construction techniques. This construction technique has an advantage in that since sufficient inside space can be secured, following works become easy. However, this construction technique has serious disadvantages in that there is a restriction in the conditions for the construction field in case of downtown area construction work because it could encroach adjoining private lands, and the construction expense becomes high in case of non-large sized drilling works.

[0005] As another conventional art, there is a soil nailing construction technique in which boreholes are formed at the rear side of the drilling wall together with the drilling work, nails are inserted into the boreholes and then grouts are filled therein, and shotcrete is cast onto the wall surface, thereby forming the earth retaining wall body. Since this construction technique is simple in construction and has no impediment due to struts, it has advantages in that construction period of a following process can be reduced, and the soil pressure acting on the underground structure is reduced, thereby decreasing the cross-section of the structure. However, in case of a ground having a high underground water level and a ground having a subsidence property, there is a risk of slope breakage, and the modification of the inclined surface due to cutting off of the earth is serious, thereby causing the sinking of the adjoining ground. Further, the above soil nailing construction technique has a disadvantage in that it is difficult to apply to the ground of specific conditions, and it requires a careful attention.

[0006] As still another conventional art, there has been proposed a raker construction technique in which an earth retaining wall is first constructed, a slope surface is formed at the inside of the earth retaining wall, a reaction force is applied to the previously constructed foundation structure, an inclined strut is installed on the earth retaining wall to thereby progress the drilling work. This construction technique has an advantage in that it is simple in construction, requires less strut holes, and the inclined strut is short in length, thereby decreasing contraction or flow of a moving joint portion. However, there occur problems in that stability of the inclined surface is difficult to secure in a weak ground, it is improper for a deep drilling work, a space is narrow and the workability is poor at the time of constructing a structure in the raker.

[0007] As yet another conventional art, there has bee proposed a prestressed girth construction technique. This construction technique is one of widening an interval between the struts by additionally installing a girth above the previously installed girth to tension a steel wire, thereby reinforcing an additional girth or a flange of an existing H-beam. However, the above construction technique has disadvantages in that since the steel wire is disposed linearly, and a moment produced in the girth due to the soil pressure is different from a resistance moment produced by prestressing, so that an unbalanced moment always acts on in the members, and the girth is weak to a local unbalanced load when the length thereof is made long. In addition, such a construction technique has a limitation in extending the length of the prestressed girth because of restriction in increasing eccentricity due to limitation in the rigidity of the installation device.

[0008] As a further conventional art, there has been proposed a truss girth construction technique, which is expected to be applicable to a case of a relatively shallow depth, and in which H-beams are installed doubly in a lattice shape at the adjoining place of the ground surface, so that the soil pressure can be received by the trusses of two layers installed at the upper portion by reinforcing the beams with the vertical members and inclined members. This construction technique was devised to overcome difficulties arising in the drilling and construction of the main structure due to the struts of the

temporary facility structure for supporting the ground, and is one which can be used when a larger structure is disposed at the lower portion of the drilled ground and a smaller structure is disposed at the upper portion of the drilled ground.

[0009] The above temporary facility construction techniques for constructing the earth retaining wall mostly employ H-beam to construct the earth retaining wall. In some cases, sheet piles are often used, but in the case where there is no great need for a waterstop and the like, an earth retaining wall installation work is performed in such a fashion that H-beams are inserted into boreholes at intervals of approximately two meters, and then laggings, i.e., soil retaining plates made of wood are fitted between the H-beams while digging a region to be excavated. In such a temporary facility construction technique for constructing the earth retaining wall, a method of inserting the H-beams into the ground may include driving the H-beams into soil using a direct pile driving technique. However, there frequently occurs the case where a pile driving work is not performed smoothly because of gravel existing in soil or other ground conditions. In particular, the H-beams are inserted into the ground by a ground boring method employing Augering instead of the pile driving in most fields due to a driving noise generated during the pile driving. In the case where the construction is performed in the above manner, when the H-beams are inserted into the boreholes of the ground, a noise is prevented from being generated during the pile driving and the construction can be advantageously continued without any interruption of the excavation by the gravel and the like existing in the ground.

[0010] In this case, as shown in FIG. **10**, since a clearance is required for insertion of the H-beam **520** between a borehole **500** formed by the augering technique and an H-beam **520** inserted into the borehole **500**, the inserted H-beam **520** is held under the condition where a displacement can occur within a range of about of 10 cm. Thus, the borehole **500** is filled up with several kinds of soil **530** including on-site soil after insertion of the H-beam **520** in order to minimize a possibility of the displacement of about 10 cm on the construction site. However, this filling work cannot be performed well due to a relatively deep boring depth as compared to a small clearance space because the boring depth of the borehole **500** is more than 10 m. In addition, although the filling work is performed well, soil must be well tamped down in order to achieve an expected and desired effect. However, in this tamping work, it is difficult to expect the desired effect at the regions beyond a region within a range of 1 m on the ground surface. For this reason, as shown in FIG. **11**, there occurs a problem in that an initial H-beam **520** is inclined to be at a position **520'** toward a to-be-excavated region in the borehole **500** at the time of digging the to-be-excavated region.

[0011] The problem of the excessive displacement of the H-beam can be solved by applying a method of inserting the H-beam **520** into the borehole **500** and then injecting cement paste **540** into the borehole **500** in a conventional construction method. However, such a method of employing the cement paste **540** entails problems in that it makes difficult a pullout work for collecting the inserted H-beam **520** after the completion of the construction, and hardened cement lumps surrounding the surface of the H-beam **520** must be removed for the reuse of the H-beam although the inserted H-beam **520** is collected. Accordingly, such a cement paste injection method involves a drawback in that it is difficult to apply to the construction in which the H-beam must be substantially recollected.

[0012] In particular, in the case where the H-beam is constructed in a self-supported earth retaining construction method, the filling work-associated problem is very important. That is, the present inventor has proposed a self-supported earth retaining construction method in PCT international publication No. WO 2007/117050 entitled "UNDERGROUND RETAINING WALL FOR PUBLIC WORKS AND METHOD FOR CONSTRUCTING THE SAME". In the self-supported earth retaining construction method, a load action is depicted as shown in FIG. **12**. It can be seen from FIG. **12** that there is a great effect of displacement of the H-beam occurring due to a horizontal force (active earth pressure and passive earth pressure) acting on the H-beam. Thus, it is required that the filling work of the borehole should be performed entirely. However, as mentioned above, the earth retaining construction method encounters many drawbacks in terms of construction. In most self-supported earth retaining construction in which the H-beams must be collected, an incomplete borehole filling work causes great displacement of the self-supported earth retaining wall, which contributes to a reduction in self-supporting capability.

DISCLOSURE OF INVENTION

Technical Problem

[0013] Accordingly, the present invention has been made in order to satisfy the above-mentioned necessities, and it is an object of the present invention to provide a method for constructing a novel chair-type, self-supported earth retaining wall, which can utilize a limited land efficiently and eliminate the necessity of using struts in a to-be-excavated region where an architectural construction is executed to improve economic efficiency and construction capacity of a subsequent work, and which can resolve a problem of an encroachment into adjacent private lands and can further reduce land settlement and displacement caused by the temporary facility construction work, thereby minimizing a damage due to earth excavation and maximizing the excavatable depth.

[0014] Another object of the present invention is to prove a method for constructing a novel chair-type, self-supported earth retaining wall, which can facilitate the reuse of H-beams and can effectively prevent the displacement of the H-beams occurring in boreholes in construction of an earth retaining wall used for supporting an external force such as earth pressure or the like.

[0015] Particularly, yet another object of the present invention is to provide an advanced method for constructing a chair-type, self-supported earth retaining wall, which can resolve a problem of an incomplete borehole filling work inducing the displacement of the H-beams and can facilitate the collection of the H-beams after the construction to maintain economic efficiency and construction capacity and resolve a displacement occurrence problem, thereby remarkably improving the performance of an earth retaining construction method employing a double-row pile structure in the self-supported earth retaining construction method proposed by the present inventor in PCT international publication No. WO 2007/117050 entitled "UNDERGROUND RETAIN-

ING WALL FOR PUBLIC WORKS AND METHOD FOR CONSTRUCTING THE SAME".

Technical Solution

[0016] To achieve the above objects, in one aspect, the present invention provides a method for constructing a chair-type, self-supported earth retaining wall used for supporting external forces such as earth pressure, the method includes the steps of: forming a first pile array having a plurality of piles arranged along a circumference of an region to be excavated; forming a second pile array having a plurality of piles arranged along a circumference of the to-be-excavated region by consecutively drilling a plurality of boreholes at predetermined intervals at predetermined positions outwardly spaced apart from the first pile array along the circumference of the to-be-excavated region, inserting H-beams into the respective boreholes, filling left and right spaces of webs of the H-beams with soil, and filling the outer spaces of flanges of the H-beams with a flowable hardening material; and fixedly interconnecting the first pile array and the second pile array using a connection member, whereby the first pile array and the second pile array are formed in such a fashion as to be outwardly spaced apart from each other along the circumferences of the to-be-excavated region, and are connected to each other by the connection member to construct an underground earth retaining wall.

[0017] In the method for constructing a chair type, self-supported earth retaining wall according to the present invention, the plurality of piles of the first pile array may be formed by consecutively drilling a plurality of boreholes at predetermined intervals along the circumference of the to-be-excavated region, inserting H-beams into the respective boreholes, filling left and right spaces of webs of the H-beams with soil, and filling the outer spaces of flanges of the H-beams with a flowable hardening material.

[0018] In the method for constructing a chair-type, self-supported earth retaining wall according to the present invention, the plurality of piles of the first pile array may be formed of any one selected from the group consisting of H-piles and soil retaining plates, sheet piles, cast-in-place piles, and soil cement walls.

[0019] In the method for constructing a chair-type, self-supported earth retaining wall according to the present invention, the step of fixedly interconnecting the first pile array and the second pile array using a connection member may include the following steps of: joining a first girth to the plurality of piles constituting the first pile array such that the piles are arranged in parallel with each other; joining a second girth to the plurality of piles constituting the second pile array such that the piles are arranged in parallel with each other; and mounting fixing bars on the first girth and the second girth in such a fashion as to be joined at both ends thereof to the first girth and the second girth.

[0020] In the method for constructing a chair-type, self-supported earth retaining wall according to the present invention, the step of fixedly interconnecting the first pile array and the second pile array using a connection member may include the following steps of: forming a sub-excavation region communicating extending from the second pile array on the ground to the to-be-excavated region during excavation of the to-be-excavated region; joining loggings to the second pile array while forming the sub-excavation region along the second pile array; joining a first girth to the plurality of piles constituting the first pile array such that the piles are arranged in parallel with each other on the ground of the sub-excavation region; joining a second girth to the plurality of piles constituting the second pile array such that the piles are arranged in parallel with each other; mounting fixing bars on the first girth and the second girth in such a fashion as to be joined at both ends thereof to the first girth and the second girth; and joining loggings to the first pile array while forming the to-be-excavated region along the first pile array.

Advantageous Effects

[0021] The method for constructing a chair-type, self-supported earth retaining wall of the present invention can improve several disadvantages involved in an existing temporary facility construction technique such as the strut supporting construction technique, the earth anchor construction technique, or the like. That is, according to the present invention, the necessity of using struts is eliminated, so that the quantity of the steel sheets used is reduced, thereby saving the construction expense, shortening the construction period, making the construction of heavy equipment in the excavation site smooth, and facilitating a subsequent mold work to improve the construction capacity. In addition, since the present invention implements a self-supported temporary facility structure to resolve a problem of an encroachment into adjacent private lands occurring when the anchor is installed on the ground, the restriction in the downtown area construction work, etc., is mostly removed as compared to the earth anchor construction technique. Moreover, the present invention can further reduce land settlement and displacement caused by the temporary facility construction work thereby minimizing a damage of adjacent structure due to earth excavation and further increasing the excavatable depth as compared to the self-supported earth retaining construction method that has been proposed by the present inventor in PCT international publication No. WO 2007/117050 entitled "UNDERGROUND RETAINING WALL FOR PUBLIC WORKS AND METHOD FOR CONSTRUCTING THE SAME". In particular, the flowable hardening material such as cement paste is charged into the outer spaces of both flanges of the H-beam, soil such on-site soil is poured into the inner spaces of the both flanges of the H-beam to support the H-beam in the boreholes. Thus, the H-beam is discarded into the ground in case of an existing traditional construction method, but the reuse of the H-beam is facilitated and the displacement the H-beam occurring in the boreholes can be effectively prevented in case of a novel construction method. Accordingly, since the stable support of the H-beams within the boreholes minimizes the occurrence of the displacement of the earth retaining wall, the merit of the self-supported earth retaining wall employing a double-row pile structure can be maximized. In addition, since the present invention uses various walls such as cast-in-place piles (CIPs), soil cement walls (SCWs), sheet piles, and the like as the first pile array, it enables the inventive earth retaining wall to bind to various kinds of walls to provide a water stopping function and exhibit a heaving prevention effect, thereby ensuring its excellent usability. Moreover, the chair-type, self-supported earth retaining wall construction method according to the present invention can be utilized complementarily together with the existing traditional earth retaining construction method. In case of this construction, the conventional construction method can show the effect of the present invention and simultaneously can further increase the underground excavation depth. If the present invention is used together

with the strut supporting construction method as a complementary supporting construction method, the construction distance and use quantity of the struts is reduced, thereby improving the construction capacity and the economic efficiency. In addition, if the present invention is used together with the earth anchor construction method as a complementary supporting construction method, the construction distance and use quantity of the earth anchors is reduced, thereby improving the construction capacity and the economic efficiency.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] FIG. **1** is a schematic top plan view illustrating an earth retaining wall constructed by a method for constructing a chair-type, self-supported earth retaining wall according to the present invention;

[0023] FIG. **2** is a view for explaining a method for constructing a chair-type, self-supported earth retaining wall according to a preferred embodiment of the present invention;

[0024] FIG. **3** is a perspective view illustrating a constitution of an earth retaining wall constructed by the method for constructing the chair-type, self-supported earth retaining wall shown in FIG. **2**;

[0025] FIG. **4** is a view for explaining a method for constructing a chair-type, self-supported earth retaining wall according to another preferred embodiment of the present invention;

[0026] FIG. **5** is a perspective view illustrating a constitution of an earth retaining wall constructed by the method for constructing the chair-type, self-supported earth retaining wall shown in FIG. **4**;

[0027] FIG. **6** is a view for explaining a second pile array construction method in a method for constructing a chair-type, self-supported earth retaining wall according to the preferred embodiment of the present invention;

[0028] FIG. **7** is a view for explaining the applicable examples of a connection member in a method for constructing a chair-type, self-supported earth retaining wall according to the preferred embodiment of the present invention;

[0029] FIG. **8** is a view for explaining various examples of a first pile array in a method for constructing a chair-type, self-supported earth retaining wall according to the preferred embodiment of the present invention;

[0030] FIG. **9** is a view for explaining the applicable examples of an earth anchor in a method for constructing a chair-type, self-supported earth retaining wall according to the preferred embodiment of the present invention;

[0031] FIG. **10** is a view for explaining an H-beam construction method in a method for constructing an earth retaining wall according to the prior art;

[0032] FIG. **11** is a view for explaining a problem involved in the prior art; and

[0033] FIG. **12** is a view illustrating the effect of displacement caused by a horizontal force acting on H-beams in a chair-type, self-supported earth retaining wall.

BEST MODE FOR CARRYING OUT THE INVENTION

[0034] Now, preferred embodiments of the present invention will be described hereinafter in detail with reference to FIGS. **1** to **9**.

[0035] In the meantime, the illustration and detailed description of the constitution, operation, and effects that can be easily understood from a general earth retaining construction technique and a related technique applied to the present invention in the drawings will be omitted or only portions related with the present invention will be shown and described.

[0036] FIG. **1** is a schematic top plan view illustrating an earth retaining wall constructed by a method for constructing a chair-type, self-supported earth retaining wall according to the present invention, FIG. **2** is a view for explaining a method for constructing a chair-type, self-supported earth retaining wall according to a preferred embodiment of the present invention, FIG. **3** is a perspective view illustrating a constitution of an earth retaining wall constructed by the method for constructing the chair-type, self-supported earth retaining wall shown in FIG. **2**, FIG. **4** is a view for explaining a method for constructing a chair-type, self-supported earth retaining wall according to another preferred embodiment of the present invention, FIG. **5** is a perspective view illustrating a constitution of an earth retaining wall constructed by the method for constructing the chair-type, self-supported earth retaining wall shown in FIG. **4**, and FIG. **6** is a view for explaining a second pile array construction method in a method for constructing a chair-type, self-supported earth retaining wall according to the preferred embodiment of the present invention.

[0037] As shown in FIG. **1**, the method for constructing a chair-type, self-supported earth retaining wall according to the present invention is provided to construct an open cut surface or an earth retaining wall for preventing a landslide generated during the underground excavation construction in road construction, subway construction, new building construction, and the like. Such a method for constructing a chair-type, self-supported earth retaining wall according to the present invention enables construction of an earth retaining wall **10** including a first pile array **20**, a second pile array **30**, and a connection member **60**.

[0038] In this case, a first pile array **20** of the earth retaining wall **10** constructed by the method for constructing a chair-type, self-supported earth retaining wall according to the present invention is formed by arranging a plurality of piles **22** along a circumference of the to-be-excavated region. In the present invention, the first pile array **20** may be formed by applying a method of forming the second pile array **30** and various construction techniques that have been previously known in this field as in the embodiment, which will be described later. In this case, a plurality of piles **22** of the first pile array **20** is formed along a circumference of the to-be-excavated region by consecutively drilling a plurality of boreholes **21** at predetermined intervals along the circumference of the to-be-excavated region, inserting H-beams **22** into the respective boreholes **21**, filling left and right spaces of webs of the H-beams **22** with soil, and filling the outer spaces of flanges of the H-beams **22** with a flowable hardening material in the same manner as the second pile array **30**, which will be described later, as shown in FIGS. **2** and **4**. In addition, the various construction techniques can use an H-beam and soil retaining plate, a cast-in-place pile (CIP), a PHC pile, a soil cement wall (SCW), a sheet pile, and the like.

[0039] As shown in FIGS. **2**, **6** and **6**, the second pile array **30** is formed by consecutively drilling a plurality of boreholes **31** at predetermined intervals at predetermined positions outwardly spaced apart from the first pile array **20** along a circumference of the to-be-excavated region, inserting H-beams **32** as a plurality of piles into the respective boreholes, filling

left and right spaces of webs **34** of the H-beams **32** with soil **40**, and filling the outer spaces of flanges **36** of the H-beams with a flowable hardening material **50**. At this time, in the filling step, the soil **40** filled up in the left and right spaces of the webs **34** includes various kinds of aggregate materials such as on-site soil, sand and fine aggregate supplied at the construction field. In addition, the soil **40** does not need a dense filling work or a consolidation work. Like this, the soil **40** in a loosened state provides an effect of reducing a pull-out force imposed on a mechanical apparatus when pulling out the H-beam **32** to collect the H-beam **32** later, and thus the pullout is further facilitated. Moreover, the flowable hardening material **50** as the filling material filled in the outer spaces of the flanges **36** of the H-beam **32** is a material that has both flowability and hardenability characteristics. This flowable hardening material **50** is excellent in flowability, and thus is well filled such that an empty space is not defined even in a tiny space, which is difficult to fill up. In particular, as shown in FIG. **6**, in the case where the flowable hardening material **50** is injected into the borehole **31** by pressurization, it is also filled into a gap around the borehole **31** as shown at the right upper side of FIG. **6**, thereby achieving an effect of ameliorating the ground around the borehole **31** in its entirety. Thus, it is possible to apply construction method of the present invention even in the case where the earth condition of the ground is poor. Since the flowable hardening material **50** has hardenability, it is well filled into the borehole **31** without forming any empty space and then becomes hard through a hardening reaction over time. This phenomenon exhibits a superior effect to the performance of soil subjected to sufficient consolidation. Therefore, the construction labor necessary for the soil consolidation is not needed and the construction period and cost are reduced. In addition, the compression performance of a constructed portion is excellent, and thus a possibility of occurrence of displacement of the self-supported earth retaining wall is further reduced.

[0040] Like this, after the construction of the first pile array **20** and the second pile array **30**, the first pile array **20** and the second pile array **30** are fixedly connected with each other by means of the connection member **60** to form a chair-type, self-supported earth retaining wall as shown in FIG. **3** or **5**. In this case, the connection member **60** includes a first girth **62** joined to the plurality of piles **22** (applying H-beams in FIGS. **1** to **5**) constituting the first pile array **20** such that the piles **22** are arranged in parallel with each other, a second girth **64** joined to the plurality of H-beams **32** constituting the second pile array **30** such that the H-beams **32** are arranged in parallel with each other, and fixing bars **66** joined at both ends thereof to the first girth **62** and the second girth **64**.

[0041] The earth retaining wall **10** having the above structure is formed by the following method for constructing a chair-type, self-supported earth retaining wall according to the present invention. That is, as shown FIGS. **1** and **2**, according to a chair-type, self-supported earth retaining wall construction method for constructing an earth retaining wall used for supporting an external force such as earth pressure or the like, first, a plurality of boreholes **21** is consecutively drilled at predetermined intervals along the circumference of the to-be-excavated region (S**200**), and piles **22** are insertedly installed into the respective boreholes **21** (S**210**) to form the first pile array **20**. In addition, a plurality of boreholes **31** is consecutively drilled at predetermined intervals at predetermined positions outwardly spaced apart from the first pile array **20** along the circumference of the to-be-excavated region (S**210**), and H-beams **32** are insertedly installed into the respective boreholes (S**220**).

[0042] In this case, a borehole drilling and pile inserting apparatus **100** typically used in this field is employed in the construction of the boreholes and the H-beams **22** and **32**. In addition, the borehole drilling and H-beam inserting work for forming the first pile array **20** and the second pile array **30** will set the order and method of other work in consideration of convenience of the work. For example, the first pile array may be formed by a pile driving technique and other conventional methods. Also, in the present invention, the second pile array **30** is provided only in the form of a single row that can be typically applied, but may be configured in the form of plural rows depending on the need, which falls within the technical spirit of the present invention.

[0043] In the meantime, as shown in FIGS. **2** and **6**, in the method for constructing a chair-type, self-supported earth retaining wall according to the present invention, the boreholes **31** for the second pile array **30** are drilled at predetermined positions outwardly spaced apart from the first pile array **20** along the circumference of the to-be-excavated region (S**210**), the H-beams **32** are inserted into the boreholes such that both flanges **36** of the H-beams are arranged horizontally relative to the to-be-excavated region to form a second pile array **30** (S**220**), and soil **40** is poured into a section "a" between the both flanges **36** of each H-beam **32**, i.e., spaces at both sides of the web **34** of each H-beam **32** to fill soil **40** in the section "a" between the both flanges **36** of each H-beam **32** (S**230**). Thereafter, a flowable hardening material **50** is supplied to the outer spaces (i.e., sections "b") of both flanges **36** of each H-beam of the second pile array **30** to fill up the outer spaces of the both flanges with the flowable hardening material **50** (S**240**).

[0044] After a predetermined time period has elapsed by the above construction method, the H-beam **32** of the second pile array **30** is stably supported within the borehole **31** by means of the soil **40** filled in the section "a" and the flowable hardening material **50** filled in the section "b", so that displacement of the H-beam **32** can be effectively prevented and the flowable hardening material **50** filled in the section "b" can be easily separated from the H-beam **32** when the H-beam **32** is pulled out to be collected, thereby making the-use of the H-beam **32** convenient.

[0045] More specifically, referring to FIG. **6**, in the preferred embodiment of the present invention, the H-beam **32** used in the second pile array **30** is H-300×300×10×15 in size, and the borehole **31** is 450 mm in diameter. In this case, a clearance distance ranging from about 1 cm to 8 cm is secured in the borehole **31** for insertion of the H-beam **32**. In a state where the H-beam **32** is inserted into the borehole **31**, a process of filling up the borehole **31** consists of two steps. A first step is one in which soil **40** consisting of on-site soil, sand or other filling aggregate is supplied to the section "a" between the both flanges **36** of each H-beam **32** of the second pile array **30** to fill up the soil **40** in the section "a" (S**230**). Also, a second step is one in which the flowable hardening material **50** is supplied to the outer spaces (i.e., sections "b") of both flanges **36** of each H-beam **32** of the second pile array **30** to fill up the outer spaces of the both flanges with the flowable hardening material **50** such as cement paste, soil cement, or the like (S**240**). Of course, the first step (S**230**) and the second step (S**240**) may be changed in the construction order or may be performed simultaneously.

[0046] In the filled H-beam **32** of the second pile array **30**, the flowable hardening material **50** is filled up in the sections "b" of both flanges of each H-beam **32** in a state where the flowable hardening material **50** flows. When the flowable hardening material **50** is hardened over time, it becomes a filling material having a deformation resistance capability higher than that of consolidated soil. In addition, the soil **40** filled up in the section "a" between the both flanges **36** of each H-beam **32** is not subjected to an additional consolidation process and is maintained in a relaxed and loosened state, but is positioned at both sides of the web **34** (see FIG. **6**) of the H-beam **32**. Thus, the filled soil **40** is irrelevant to occurrence of displacement of the H-beam **32** toward the earth retaining wall. Owing to the loosened soil **40** positioned at the both sides of the web **34**, the H-beam **32** is readily pulled out to be collected. In addition, since a lump of the flowable hardening material **50** is prevented from adhering to the web **34** thanks to the filled soil, a collection work for reuse of the H-beam **32** is much facilitated.

[0047] Therefore, according to the method for constructing a chair-type, self-supported earth retaining wall of the present invention, the displacement occurrence in a double-row pile construction technique is greatly restricted, the pullout work of the H-beam **32** is facilitated for the reuse of the H-beam **32** as a temporary facility constructing steel sheet, and the necessity of cleaning and washing the H-beam is eliminated, thereby improving the construction capacity and economic efficiency of the construction method and removing a displacement inducing factor that is, inter alia, important, which results in achievement of an effect to significantly improve the performance of the construction method.

[0048] In this case, in the present invention, the H-beams (e.g., H-piles) that are particularly used in the second pile array **30** are referred to a beam having an H-shaped transverse cross-section. However, the shape of the transverse cross-section is not limited thereto, and the H-beams may be referred to as I-section steels, asymmetrical H-beams and various shapes of piles, which are proposed pursuant to provisions of each country in connection with the present invention.

[0049] In addition, for the order in which the soil **40** and the flowable hardening material **50** are supplied, preferably, the soil **40** is first supplied, but is not limited thereto. Also, in consideration of continuity of the use of a construction equipment, all the H-beams **32** of the second pile array **30** are inserted into the boreholes **31**, and then the soil **40** and the flowable hardening material **50** are preferably supplied sequentially, but is also not limited thereto. Each step of the process can be processed in various forms in consideration of the work situation of the construction site in conformity with the technical spirit of the present invention. Besides, in the present invention, the soil **40** is preferably supplied by applying on-site soil, but may be selected from the group consisting of on-site soil, sand, other aggregate, and the like. In the present invention, the flowable hardening material **50** may be preferably cement paste, soil cement or the like.

[0050] In this manner, after the first pile array **20** and the second pile array **30** are formed, the first pile array **20** and the second pile array **30** are allowed to be fixedly connected with each other by means of the connection member **60** in consideration of two steps (S**250** and, S**250'**). That is, as shown in FIGS. **2** and **3**, in one step (S**250**), the connection member **60** is installed in such a fashion that the first girth **62** is joined to the plurality of piles **22** constituting the first pile array **20** such that the piles **22** are arranged in parallel with each other on the ground before excavating the ground of the to-be-excavated region, the second girth **64** is joined to the plurality of piles **32** constituting the second pile array **30** such that the piles **32** are arranged in parallel with each other, and fixing bars **66** are mounted on the first girth **62** and the second girth **64** in such a fashion as to be joined at both ends thereof to the first girth **62** and the second girth **64**. In this case, in FIGS. **2** and **3**, there is shown an example in which the H-beams **22** and the loggings **70** are applied to the first pile array **20**. In the case where the first pile array **20** is formed by various construction techniques as shown in FIG. **8**, the piles **22** of the first pile array **20** referred to in the present invention correspond to H-beams **22**, **22***c* and **22***d* and a sheet **22***b* functioning as the piles in each construction technique.

[0051] In another step (S**250'**), as shown in FIGS. **4** and **5**, the connection member **60** is installed in the above-mentioned form on the ground of the sub-excavation region in such a fashion that a sub-region to be excavated (also, called a "sub-excavation region") communicating extending from the second pile array **30** on the ground to the to-be-excavated region is formed during excavation of the to-be-excavated region, and a logging **80** is joined to the second pile array **30** while forming the sub-excavation region along the second pile array **30**. In this case, the sub-excavation region is referred to as a space of a stepped shape defined between the first pile array **20** and the second pile array **30** as shown in FIGS. **4** and **5**. This step has an effect of capable of reducing an influence of earth pressure on the lower portion of the to-be-excavated region.

[0052] The connection member **60** is designed to have a self-supported structure formed by fixedly interconnecting the first pile array **20** and the second pile array **30** arranged at predetermined intervals in such a fashion as to be outwardly spaced apart from each other along the circumference of the to-be-excavated region. In this case, the connection member can adopt various kinds of materials including sectional steel, bar steel, deformed steel bar, and the like. The first girth **62**, the second girth **60** and the fixing bars **66** of the connection member **60** are joined to one another by means of welding, bolts, couplers, or the like, and are fixedly mounted on the respective H-beams **22** and **32** of the first and second pile arrays **20** and **30** by means of brackets **68** (see FIG. **3**). In addition, although not shown, a brace may be constructed together with the fixing bars **66** to reinforce a restraint force of the fixing bars **66**. A method of joining the first girth **62**, the second girth **60** and the fixing bar **66** mainly employs a bolt engagement manner for the sake of the convenience of the construction and the dismantling of the temporary facility structures. But other joining methods including welding and couplers can be selected to conform to the conditions of the construction site depending on the need.

[0053] Then, like a typical earth retaining wall, loggings **70** are mounted on the inner side of the to-be-excavated region along with excavation of the to-be-excavated region (S**260**).

[0054] FIG. **7** is a view for explaining the applicable examples of a connection member in a method for constructing a chair-type, self-supported earth retaining wall according to the preferred embodiment of the present invention, FIG. **8** is a view for explaining various examples of a first pile array in a method for constructing a chair-type, self-supported earth retaining wall according to the preferred embodiment of the present invention, and FIG. **9** is a view for explaining the applicable examples of an earth anchor used along with a

conventional construction technique in a method for constructing a chair-type, self-supported earth retaining wall according to the preferred embodiment of the present invention.

[0055] Referring to FIG. **7**, the connection member **60** applied to the method for constructing a chair-type, self-supported earth retaining wall according to the preferred embodiment of the present invention may be disposed on the ground of the sub-excavation region defined by excavating to a predetermined depth between the piles **22** of the first pile array and the piles **32** of the second pile array (see FIG. **7**(*a*)), or may be disposed on the ground before excavating the ground of the to-be-excavated region as described above. In addition, as shown in FIGS. **7**(*c*) and **7**(*d*), the method for constructing a chair-type, self-supported earth retaining wall according to the present invention may adopt an auxiliary connection member **60'** by employing various methods used for the purpose of reinforcement in this field.

[0056] Referring to FIG. **8**, as described above, the method for constructing a chair-type, self-supported earth retaining wall according to the preferred embodiment of the present invention may adopt a method of applying the first pile array (see FIG. **2**) to the second pile array **20** (see FIG. **2**) of the present invention, or various construction methods that are well known in this field. In other words, in FIG. **8**(*a*), there is shown an applicable form of a construction technique of loggings and air piles formed by driving the H-beams **22** into the ground along the circumference of the to-be-excavated region or inserting the H-beams **22** into previously bored boreholes, and then fitting loggings **70** between the adjacent H-beams **22**. In addition, in FIG. **8**(*b*), there is shown an applicable form of the sheet pile construction technique of consecutively forming a number of sheet piles **22***b* along the circumference of the to-be-excavated region in such a fashion that the joints of the sheet piles **22***b* are engaged with each other, and then driving the sheet piles **22***b* in the underground using a driving apparatus to thereby form the earth retaining wall. Moreover, in FIG. **8**(*c*), there is shown an applicable form of the cast-in-place pile construction technique of consecutively forming a number of boreholes at given intervals along the circumference of the to-be-excavated region, filling up prefabricated bar mats **22***c'* and coarse aggregate in the boreholes, and injecting mortar or pouring concrete into the boreholes. Further, in FIG. **8**(*d*), there is shown an applicable form of the soil cement wall construction technique of disposing a cutter at a front end of a pipe stirring shaft of a boring equipment and excavating the ground while mixing a hardening material and soil, erupting cement milk at a front end of the excavation device, and pulling out the pipe while mixing soil and mortar to thereby form a continuous pile wall. Likewise, the method for constructing a chair-type, self-supported earth retaining wall according to the preferred embodiment of the present invention has an advantage in that since the first pile array **20** can be constructed by applying various construction techniques, the construction range of the present invention can be easily extended. Of course, the work of the girths and the fixing bars for installation of the connection member is also applied. In this embodiment, H-piles and soil retaining plates, sheet piles, cast-in-place piles, soil cement walls, and the like for formation of the plurality of piles **22** of the first pile array **20** are construction techniques that are widely known in the art. Such construction techniques including a chemical grouting method such as Labiles Wasserglass (LW) grouting can be selected and combined depending on the need of a client or a person of ordinary skill in the art, and thus their detailed description will be omitted to avoid redundancy.

[0057] Referring to FIG. **9**, the method for constructing a chair-type, self-supported earth retaining wall according to the preferred embodiment of the present invention has an advantage of effectively increasing the excavation depth of the to-be-excavated region by adopting a soil nailing technique that is typically applied to increase the bearing capacity of the earth retaining wall **10** in the art. That is, conventionally, the earth anchor **100** has been also applied in the construction of the earth retaining wall, but the method for constructing a chair-type, self-supported earth retaining wall according to the present invention has an advantage in that it enables more effective deep excavation while reducing the number of the earth anchors **100**. In this case, the construction and operation of the earth anchor **100** is previously widely known in the art, and thus its detailed description will be omitted for brevity.

[0058] While the method for constructing a chair-type, self-supported earth retaining wall according to the preferred embodiments of the present invention has been described and illustrated in connection with specific exemplary embodiments with reference to the accompanying drawings, it will be readily appreciated by those skilled in the art that it is merely illustrative of the preferred embodiments of the present invention and various modifications and changes can be made thereto within the technical spirit and scope of the present invention.

BEST MODE

[0059] As shown in FIG. **1**, the method for constructing a chair-type, self-supported earth retaining wall according to the present invention is provided to construct an open cut surface or an earth retaining wall for preventing a landslide generated during the underground excavation construction in road construction, subway construction, new building construction, and the like. Such a method for constructing a chair-type, self-supported earth retaining wall according to the present invention enables construction of an earth retaining wall **10** including a first pile array **20**, a second pile array **30** and a connection member **60**.

[0060] In this case, a first pile array **20** of the earth retaining wall **10** constructed by the method for constructing a chair-type, self-supported earth retaining wall according to the present invention is formed by arranging a plurality of piles **22** along a circumference of the to-be-excavated region. In the present invention, the first pile array **20** may be formed by applying a method of forming the second pile array **30** and various construction techniques that have been previously known in this field as in the embodiment, which will be described later. In this case, a plurality of piles **22** of the first pile array **20** is formed along a circumference of the to-be-excavated region by consecutively drilling a plurality of boreholes **21** at predetermined intervals along the circumference of the to-be-excavated region, inserting H-beams **22** into the respective boreholes **21**, filling left and right spaces of webs of the H-beams **22** with soil, and filling the outer spaces of flanges of the H-beams **22** with a flowable hardening material in the same manner as the second pile array **30**, which will be described later, as shown in FIGS. **2** and **4**. In addition, the various construction techniques can use an H-beam and soil retaining plate, a cast-in-place pile (CIP), a PHC pile, a soil cement wall (SCW), a sheet pile, and the like

[0061] As shown in FIGS. **2**, **6** and **6**, the second pile array **30** is formed by consecutively drilling a plurality of boreholes **31** at predetermined intervals at predetermined positions outwardly spaced apart from the first pile array **20** along a circumference of the to-be-excavated region, inserting H-beams **32** as a plurality of piles into the respective boreholes, filling left and right spaces of webs **34** of the H-beams **32** with soil **40**, and filling the outer spaces of flanges **36** of the H-beams with a flowable hardening material **50**. At this time, in the filling step, the soil **40** filled up in the left and right spaces of the webs **34** includes various kinds of aggregate materials such as on-site soil, sand and fine aggregate supplied at the construction field. In addition, the soil **40** does not need a dense filling work or a consolidation work. Like this, the soil **40** in a loosened state provides an effect of reducing a pull-out force imposed on a mechanical apparatus when pulling out the H-beam **32** to collect the H-beam **32** later, and thus the pullout is further facilitated. Moreover, the flowable hardening material **50** as the filling material filled in the outer spaces of the flanges **36** of the H-beam **32** is a material that has both flowability and hardenability characteristics. This flowable hardening material **50** is excellent in flowability, and thus is well filled such that an empty space is not defined even in a tiny space which is difficult to fill up. In particular, as shown in FIG. **6**, in the case where the flowable hardening material **50** is injected into the borehole **31** by pressurization, it is also filled into a gap around the borehole **31** as shown at the right upper side of FIG. **6**, thereby achieving an effect of ameliorating the ground around the borehole **31** in its entirety. Thus, it is possible to apply construction method of the present invention even in the case where the earth condition of the ground is poor. Since the flowable hardening material **50** has hardenability, it is well filled into the borehole **31** without forming any empty space and then becomes hard through a hardening reaction over time. This phenomenon exhibits a superior effect to the performance of soil subjected to sufficient consolidation. Therefore, the construction labor necessary for the soil consolidation is not needed and the construction period and cost are reduced. In addition, the compression performance of a constructed portion is excellent, and thus a possibility of occurrence of displacement of the self-supported earth retaining wall is further reduced.

[0062] Like this, after the construction of the first pile array **20** and the second pile array **30**, the first pile array **20** and the second pile array **30** are fixedly connected with each other by means of the connection member **60** to form a chair-type, self-supported earth retaining wall as shown in FIG. **3** or **5**. In this case, the connection member **60** includes a first girth **62** joined to the plurality of piles **22** (applying H-beams in FIGS. **1** to **5**) constituting the first pile array **20** such that the piles **22** are arranged in parallel with each other, a second girth **64** joined to the plurality of H-beams **32** constituting the second pile array **30** such that the H-beams **32** are arranged in parallel with each other, and fixing bars **66** joined at both ends thereof to the first girth **62** and the second girth **64**.

[0063] The earth retaining wall **10** having the above structure is formed by the following method for constructing a chair-type, self-supported earth retaining wall according to the present invention. That is, as shown FIGS. **1** and **2**, according to a chair-type, self-supported earth retaining wall construction method for constructing an earth retaining wall used for supporting an external force such as earth pressure or the like, first, a plurality of boreholes **21** is consecutively drilled at predetermined intervals along the circumference of the to-be-excavated region (S**200**), and piles **22** are insertedly installed into the respective boreholes **21** (S**210**) to form the first pile array **20**. In addition, a plurality of boreholes **31** is consecutively drilled at predetermined intervals at predetermined positions outwardly spaced apart from the first pile array **20** along the circumference of the to-be-excavated region (S**210**), and H-beams **32** are insertedly installed into the respective boreholes (S**220**).

[0064] In this case, a borehole drilling and pile inserting apparatus **100** typically used in this field is employed in the construction of the boreholes and the H-beams **22** and **32**. In addition, the borehole drilling and H-beam inserting work for forming the first pile array **20** and the second pile array **30** will set the order and method of other work in consideration of convenience of the work. For example, the first pile array may be formed by a pile driving technique and other conventional methods. Also, in the present invention, the second pile array **30** is provided only in the form of a single row that can be typically applied, but may be configured in the form of plural rows depending on the need, which falls within the technical spirit of the present invention.

[0065] In the meantime, as shown in FIGS. **2** and **6**, in the method for constructing a chair-type, self-supported earth retaining wall according to the present invention, the boreholes **31** for the second pile array **30** are drilled at predetermined positions outwardly spaced apart from the first pile array **20** along the circumference of the to-be-excavated region (S**210**), the H-beams **32** are inserted into the boreholes **31** such that both flanges **36** of the H-beams are arranged horizontally relative to the to-be-excavated region to form a second pile array **30** (S**220**), and soil **40** is poured into a section "a" between the both flanges **36** of each H-beam **32**, i.e., spaces at both sides of the web **34** of each H-beam **32** to fill soil **40** in the section "a" between the both flanges **36** of each H-beam **32** (S**230**). Thereafter, a flowable hardening material **50** is supplied to the outer spaces (i.e., sections "b") of both flanges **36** of each H-beam of the second pile array **30** to fill up the outer spaces of the both flanges with the flowable hardening material **50** (S**240**).

[0066] After a predetermined time period has elapsed by the above construction method, the H-beam **32** of the second pile array **30** is stably supported within the borehole **31** by means of the soil **40** filled in the section "a" and the flowable hardening material **50** filled in the section "b", so that displacement of the H-beam **32** can be effectively prevented and the flowable hardening material **50** filled in the section "b" can be easily separated from the H-beam **32** when the H-beam **32** is pulled out to be collected, thereby making the-use of the H-beam **32** convenient.

INDUSTRIAL APPLICABILITY

[0067] The method for constructing a chair-type, self-supported earth retaining wall according to the present invention is provided to construct an open cut surface or an earth retaining wall for preventing a landslide generated during the underground excavation construction in road construction, subway construction, new building construction, and the like.

1. A method for constructing a chair-type, self-supported earth retaining wall used for supporting external forces such as earth pressure, the method comprising the steps of:

forming a first pile array having a plurality of piles arranged along a circumference of an region to be excavated;

forming a second pile array having a plurality of piles arranged along a circumference of the to-be-excavated region by consecutively drilling a plurality of boreholes at predetermined intervals at predetermined positions outwardly spaced apart from the first pile array along the circumference of the to-be-excavated region, inserting H-beams into the respective boreholes, filling left and right spaces of webs of the H-beams with soil, and filling the outer spaces of flanges of the H-beams with a flowable hardening material; and

fixedly interconnecting the first pile array and the second pile array using a connection member,

whereby the first pile array and the second pile array are formed in such a fashion as to be outwardly spaced apart from each other along the circumferences of the to-be-excavated region, and are connected to each other by the connection member to construct an underground earth retaining wall.

2. The method according to claim **1**, wherein the plurality of piles of the first pile array is formed by consecutively drilling a plurality of boreholes at predetermined intervals along the circumference of the to-be-excavated region, inserting H-beams into the respective boreholes, filling left and right spaces of webs of the H-beams with soil, and filling the outer spaces of flanges of the H-beams with a flowable hardening material.

3. The method according to claim **2**, wherein the plurality of piles of the first pile array is formed of any one selected from the group consisting of H-piles and soil retaining plates, sheet piles, cast-in-place piles, and soil cement walls.

4. The method according to any one of claims **1** to **3**, wherein the step of fixedly interconnecting the first pile array and the second pile array using a connection member comprises the following steps of:

joining a first girth to the plurality of piles constituting the first pile array such that the piles are arranged in parallel with each other on the ground before excavating the ground of the to-be-excavated region;

joining a second girth to the plurality of piles constituting the second pile array such that the piles are arranged in parallel with each other; and

mounting fixing bars on the first girth and the second girth in such a fashion as to be joined at both ends thereof to the first girth and the second girth.

5. The method according to any one of claims **1** to **3**, wherein the step of fixedly interconnecting the first pile array and the second pile array using a connection member comprises the following steps of:

forming a sub-excavation region communicating extending from the second pile array on the ground to the to-be-excavated region during excavation of the to-be-excavated region;

joining loggings to the second pile array while forming the sub-excavation region along the second pile array;

joining a first girth to the plurality of piles constituting the first pile array such that the piles are arranged in parallel with each other on the ground of the sub-excavation region;

joining a second girth to the plurality of piles constituting the second pile array such that the piles are arranged in parallel with each other;

mounting fixing bars on the first girth and the second girth in such a fashion as to be joined at both ends thereof to the first girth and the second girth; and

joining loggings to the first pile array while forming the to-be-excavated region along the first pile array.

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