

GROUND IMPROVEMENT BODY AND METHOD FOR CONSTRUCTING THE SAME

1. Field of the Invention

5 [0001]

The present invention relates to a ground improvement body and a method for constructing the same for laying banking on soft ground to construct a road on the same.

2. Description of the Related Art

10 [0002]

The applicants have already proposed the technique suitable for such a purpose and applicable for practical use. In accordance with the proposed technique, a construction period can be also shortened (See, Reference 1: Japanese registered patent No. 3528950.).

15 [0003]

Hereinafter, referring to Fig. 11 and Fig. 12, the conventional method for constructing a ground improvement body will now be explained.

Fig. 11 is a longitudinal sectional view of a ground improvement body in accordance with the conventional method for constructing the same, and Fig. 12 is a
20 horizontal sectional view thereof.

[0004]

Banking 3 (pavement may be included therein) is laid on a constructed ground improvement body finally, and then a vehicle 4 will run thereon.

As a result, unbalanced load caused by the running vehicle 4 dynamically acts

on the ground improvement body.

[0005]

In view of only below portions than the banking 3, the following levels are set up in order from the deepest within the soft ground 10.

5 A column bottom level LA is the lowest level of a column 1 constructed by means of a column construction machine provided with an auger motor.

A column top level LB is both the highest level of the column 1 and the lowest level of a slab 2.

A slab top level LC is both the highest level of the slab 2 and a level that
10 contacts with a bottom of the banking 3.

[0006]

As shown in Fig. 12, an improvement rate by columns in accordance with the columns 1, which is the density of the columns 1 (for example, 14.5 % or the like), is determined while taking the characteristics of the soft ground 10 into consideration.

15 [0007]

A method for constructing thereof is performed in accordance with the following procedures.

First of all, the plurality of columns 1 are formed from the column bottom level LA to the column top level LB by means of a column construction machine.

20 Next, the slab 2 are formed from the column top level LB to the slab top level LC by means of a heavy machine, such as a backhoe, or the like.

[0008]

In this way, each of columns 1 is formed from a bottom 1a to a top 1b thereof, and supports the slab 2 while contacting with a bottom surface of the slab 2.

Herein, in this specification, the column 1 whose top 1b contacts with the bottom surface of the slab 2 is called as a “normal” column.

[0009]

In accordance with this conventional technique, the effect of considerably shortening a construction period can be obtained.

[0010]

Based on such conventional technique, the inventors have aimed to further shorten a construction period, have conducted investigations and verified construction of slab, thereby having completed the present invention.

10 List of cited References

Reference 1: Japanese registered patent No. 3528950

Reference 2: Japanese registered patent No. 4038525

Reference 3: Japanese registered patent No. 3432802

Reference 4: Japanese registered patent No. 4504095

15 OBJECTS AND SUMMARY OF THE INVENTION

[0011]

In view of the above, an object in accordance with the present invention is to provide a ground improvement body and art related thereto wherein strength thereof can be maintained with less volume of improvement body than the conventional technique, and wherein a construction period can be further shortened.

[0012]

A first aspect in accordance with the present invention provides a ground improvement body, comprising: a first level, a second level, a third level, and a fourth level being set in order from the deepest to the shallowest within soft ground; a

plurality of short cylindrical columns formed from the first level to the second level by means of a column construction machine that rotates on a horizontal plane; and a slab that is supported by the plurality of short cylindrical columns, wherein: the slab includes: a slab body formed from the third level to the fourth level by means of a vertical slab construction machine that rotates in a vertical direction; and a beam directly under the slab body, the beam being formed from the second level to the third level by means of the vertical slab construction machine, the beam being provided between a top of the plurality of short cylindrical columns and a bottom of the slab body; and the slab has a T-shape in a perpendicular cross-sectional view.

- 10 [0012a] A second aspect in accordance with the present invention provides method for constructing a ground improvement body, comprising: setting a first level, a second level, a third level, and a fourth level in order from the deepest to the shallowest within soft ground; forming a plurality of short cylindrical columns from the first level to the second level by means of a column construction machine that rotates on a horizontal plane; and forming a slab that is supported by the plurality of short cylindrical columns by means of a vertical slab construction machine that rotates in a vertical direction, wherein: the slab includes: a slab body formed from the third level to the fourth level; and a beam directly under the slab body, the beam being formed from the second level to the third level and being provided between a top of the plurality of short cylindrical columns and a bottom of the slab body; and the slab has a T-shape in a perpendicular cross-sectional view.

[0013]

Herein, the plurality of short cylindrical columns may be arranged in a lattice shape or in a zigzag in a plan view.

[0014]

Normally, banking (pavement may be included thereon.) will be laid on an upper part of the slab.

[0015]

5 It is preferable that a plurality of normal columns formed from the first level to the third level, tops of the plurality of normal columns supporting the slab body, are further comprised.

[0016]

10 Herein, the slab includes the beam being provided between the top of the plurality of short cylindrical columns; and the slab has the T-shape in the perpendicular cross-sectional view. Accordingly, when a load caused by a running vehicle or the like acts on the ground improvement body, the load is distributed to reduce applied stress to

the soft ground existing between adjacent beams, thereby suppressing uneven settlement.

[0017]

In addition, tensile stress due to bending between the adjacent beams is also
5 suppressed so that an improvement rate by columns can be reduced.

[0018]

The vehicle may run in a transverse direction or in a longitudinal direction of
the ground improvement body.

In other words, width direction and length direction of the ground
10 improvement body may be exchanged, if needed.

[0019]

When the vehicle runs in the transverse direction of the above-mentioned
T-shape, the ground improvement body endures rigidly to unbalanced load in the
transverse direction so that uneven settlement in the transverse direction can be
15 prevented.

[0020]

On the contrary, when the vehicle runs in the longitudinal direction of the
above-mentioned T-shape, a part existing at an edge of the ground improvement body
plays a role of a separator for near building (for example, a house or the like.) to obtain
20 effects of suppressing deformation and/or vibration of the building. When a retaining
wall is installed at the edge of a road, stability of supporting against earth pressure
caused thereby can be secured.

Even if the improvement rate by columns is reduced and intervals between
columns are set up widely, the beams existing at the edge can prevent from sliding

failure.

Effect of the Invention

[0021]

As discussed in details below, in accordance with the present invention, about
5 ten percent of improvement volume and about twenty percent of construction period
can be reduced comparing with the prior art.

[0022]

Furthermore, theses effects can be obtained while maintaining strength of the
ground improvement body. As a result, the total costs for construction are remarkably
10 reduced, and the present invention is highly effective in practical use.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0023]

Referring now to the attached drawings, Embodiments in accordance with the
present invention will now be explained more concretely.

15 (Embodiment 1)

Fig. 1 is a longitudinal sectional view showing a ground improvement body in
Embodiment 1 in accordance with the present invention, and Fig. 2 is a horizontal
sectional view of the same.

[0024]

20 First of all, in the ground improvement body in Embodiment 1 as shown in
Fig. 1, a first level L1, a second level L2, a third level L3, and a fourth level L4 are set
up in order from the deepest to the shallowest within soft ground 10.

[0025]

The first level L1 is the lowest level of short columns 11 constructed by

means of a column construction machine 30 provided with an auger motor (See, Fig. 3.).

When adapting a grounding method, the first level L1 may be the level of a bottom to be ground or deeper. On the other hand, when adapting a floating method,
5 the first level L1 may be the level floated above the bottom.

[0026]

The second level L2 is both the highest level of the short columns 11 and is the lowest level of a beam 22 of a slab 20.

[0027]

10 The third level L3 is both the highest level of the beam 22 of the slab 20 and the lowest level of the slab body 21 of the slab 20.

[0028]

The fourth level L4 is both the highest level of the slab body 21 included in the slab 20 and the lowest level of banking (Not shown in Fig. 1).

15 [0029]

In this way, the slab 20 includes: the horizontal slab body 21 of equal thickness; a plurality of beams 22 that extends downward from the slab body 21 and that are formed successively to contact with tops 11a of the short columns 11. The slab 20 is a continuum showing a T-shape in a perpendicular cross-sectional view.

20 In other words upon taking two beams 22, it may be said that the slab 20 shows a π -shape.

[0030]

In a plain view as shown in Fig. 2, the plurality of short columns 11 are arranged directly under the plurality of beams 22, respectively.

[0031]

In Fig. 2, the plurality of short column 11 are arranged in a lattice shape. As clear to those skilled in the art of course alternatively, the plurality of short column 11 are arranged in a zigzag.

5 [0032]

Herein only for the simplicity of explanation, the horizontal dimension B in Fig. 2 is called as an improvement width, and the vertical dimension A is called as a road length. However as mentioned above, the vehicle 4 (See, Fig. 11.) may run in a transverse direction or in a longitudinal direction of a T-shaped structure composed by the slab 20. It should be understand that the above length and the above width can be exchanged to each other, respectively.

[0033]

As mentioned above, the levels and specification are set up beforehand, and then, actual construction will be performed as explained below.

15 [0034]

First of all, as shown in Figs. 3 and 4, by means of a column construction machine 30, the plurality of short columns 11 are constructed from the first level L1 to the second level L2.

Herein, the column construction machine 30 normally includes: a base machine 31; a leader 32 that stands up perpendicularly; a rotating shaft 33 supported by the leader 32 in a manner capable of horizontally rotating; and a head part 34 attached with a distal end of the rotating shaft 33.

[0035]

The head part 34 agitates a predetermined portion of the soft ground 10 and

discharges and mixes cement milk to construct the plurality of short columns 11, each of which is composed of soil cement.

Herein, the head part 34 normally includes: an auger; and preferably a screw and a co-rotation prevention blade. However, the screw and/or the co-rotation
5 prevention blade may be omitted, if needed.

[0036]

As shown in Fig. 4 by means of hatching, even in a state wherein all of the plurality of short columns 11 have been already constructed, a space for the slab 20 including the slab body 21 and the plurality of beams 22 may be hollow or be filled
10 with, for example, soil. However, the plurality of short columns 11 are not constructed within the space.

[0037]

Next, construction of the slab 20 will now be performed as follows.

As shown in Fig. 5 through Fig. 8 in Embodiment 1, considering working
15 efficiency, the slab 20 including: the slab body 21 from the third level L3 to the fourth level L4; and the plurality of beams 22 from the second level L2 to the third level L3 is constructed in a lump by means of a vertical slab construction machine 40.

Alternatively however, only the plurality of beams 22 may be constructed, and afterward the slab body 21 may be constructed.

20 [0038]

The vertical slab construction machine 40 is arbitrary as long as the vertical slab construction machine 40 includes: an actuation part 42 that rotates in a vertical direction, agitates soil, and discharges and mixes cement milk; a body 41 giving driving power to the actuation part 42; and that can control enough the depth to which

the actuation part 42 reaches.

For example, the vertical slab construction machine 40 may depend upon at least one of: a rotary (See, Reference 2: Japanese registered patent No. 4038525.); a trencher (See, Reference 3: Japanese registered patent No. 3432802.); and a chain
5 conveyor cutter (See, Reference 4: Japanese registered patent No. 4504095.).

[0039]

Upon forming only the slab body 21, the reaching depth H3 may be set up to be from the fourth level L4 to the third level L3. On the other hand, upon forming the slab body 21 and one of the plurality of beams 22, the reaching depth (H3 + H2) may
10 be set up to be from the fourth level L4 to the second level L2.

[0040]

Comparison of effects in accordance with the prior art, Embodiment 1, and Embodiment 2 will be explained after explanation of Embodiment 2 in a summarized manner.

15 [0041]

(Embodiment 2)

As shown in Fig. 9 in Embodiment 1, all of the plurality of columns are constituted only by the short columns 11.

On the contrary as shown in Fig. 10 in Embodiment 2, a plurality of “normal”
20 columns 1 are disposed at portions wherein no beam 22 is formed.

[0042]

Embodiment 2 is the same as those of Embodiment 1 except this point.

As mentioned above, in Embodiment 2, each of the plurality of “normal” columns 1 includes: a bottom 1a positioned at the first level L1; and a top 1b

positioned at the third level L3.

[0043]

(Comparison of the prior art, Embodiment 1, and Embodiment 2)

[0044]

5 [0045]

Fig. 13 shows a first example of calculation results with respect to the slab in Embodiment 1.

In the first example, the bending stress σ , which is the bending moment M divided by the section modulus Z , is equal to 38 [kN/m²] which is less than the
10 reference value (80 [kN/m²]). In this way, safety is guaranteed in the first example.

[0046]

[0047]

In a similar manner to the above, Fig. 14 shows a second example of calculation results with respect to the slab in Embodiment 2.

15 In the second example, the bending stress σ , which is the bending moment M divided by the section modulus Z , is equal to 65 [kN/m²] which is less than the reference value (80 [kN/m²]). In this way, safety is also guaranteed in the second example.

[0048]

[Table 1]

	unit	prior art	Embodiment 1	Embodiment 2
imp width	m	25.0	25.0	25.0
road length	m	100.0	100.0	100.0
imp area	m ²	2500.0	2500.0	2500.0
slab thickness	m	1.0	1.0	1.0
slab interval	m	0.0	2.9	4.0
beam height	m	0.0	1.0	1.5
beam width	m	0.0	1.0	1.0
beam number	-	0.0	9.0	7.0
imp ratio	%	14.5%	9.3%	9.8%
short column	diameter	m	0	1.0
	length	m	0	11.0
	cast length	m	0	13.0
	interval	m	0	2.9
	imp ratio	%	0	9.3%
normal column	number	-	0	296.0
	diameter	m	1.0	0.0
	length	m	12.0	0.0
	cast length	m	13.0	0.0
	interval	m	2.5	0.0
	imp ratio	%	14.5%	0.0
	number	-	461.5	0.0
	slab vol	m ³	2500.0	2500.0
imp vol	beam vol	m ³	0.0	900.0
	sc vol	m ³	0.0	2557.3
	nc vol	m ³	4349.5	0.0
	imp vol	m ³	6849.5	5957.3
			(1.00)	(0.87)
construction days		90.8	64.4	67.8
		(1.00)	(0.71)	(0.75)

sc: short column imp: improvement
nc: normal column

[0049]

- 5 Table 1 shows a list including: the respective specific values of the prior art, Embodiment 1, and Embodiment 2 for comparison in order from the left side thereof.

[0050]

- In Table 1, any one of the ground improvement bodies in accordance with the prior art, Embodiment 1 and Embodiment 2 possesses almost the same strength and external dimensions.
- 10

On the other hand, improvement rates by columns are 14.5 % in the prior art,

9.3 % in Embodiment 1, and 9.8 % in Embodiment 2, respectively. Accordingly, it can be understood that the ground improvement bodies in accordance with Embodiment 1 and Embodiment 2 possesses the same strength, although the improvement rates by columns in Embodiment 1 and in Embodiment 2 are less than that of the prior art.

5 [0051]

When it is assumed that the total improvement volume in the prior art is equal to 100 %, the total improvement volume in Embodiment 1 is equal to 87 % and the total improvement volume in Embodiment 2 is equal to 92 %. In accordance with Embodiment 1 and Embodiment 2, about 10 % of the total improvement volume in the
10 prior art can be reduced.

In addition similar to the above, when it is assumed that the total days for construction (construction period) in the prior art is equal to 100 %, the total days for construction in Embodiment 1 is equal to 71 % and the total days for construction in Embodiment 2 is equal to 75 %. In accordance with Embodiment 1 and Embodiment 2,
15 about 20 % or more of the total days for construction can be also reduced.

[0052]

As discussed above in accordance with the present invention, while securing strength equivalent to the prior art, both of about 10 % of the total improvement volume and about 20 % of the construction period can be reduced comparing with the
20 prior art. In this way, it can be understood that the whole costs for construction can be remarkably reduced in accordance with the present invention.

Of course, the respective values shown in Fig. 13, Fig. 14 and Table 1 are merely examples. The present invention is never limited to the values themselves. The scope of protection in accordance with the present invention as defined in claims

includes modification and/or variation therefrom.

In the above, examples wherein a road is constructed in a site have been explained. As clear to those skilled in the art, the site wherein the present invention is used is not limited to this case. The present invention can be used for well known
 5 foundations of structure such as a drain with an oblong cross-section, an open ditch, a retaining wall, or the like.

BRIEF DESCRIPTION OF THE DRAWINGS

[0053]

Fig. 1 is a longitudinal sectional view showing a ground improvement body in
 10 Embodiment 1 in accordance with the present invention;

Fig. 2 is a horizontal sectional view showing the ground improvement body in Embodiment 1 in accordance with the present invention;

Fig. 3 is a longitudinal sectional view showing the ground improvement body in Embodiment 1 in accordance with the present invention;

15 Fig. 4 is a horizontal sectional view showing the ground improvement body in Embodiment 1 in accordance with the present invention;

Fig. 5 is a longitudinal sectional showing the ground improvement body in Embodiment 1 in accordance with the present invention;

20 Fig. 6 is a horizontal sectional view showing the ground improvement body in Embodiment 1 in accordance with the present invention;

Fig. 7 is a longitudinal section view showing the ground improvement body in Embodiment 1 in accordance with the present invention;

Fig. 8 is a horizontal sectional view showing the ground improvement body in Embodiment 1 in accordance with the present invention;

Fig. 9 is a horizontal sectional view showing the ground improvement body in Embodiment 1 in accordance with the present invention;

Fig. 10 is a horizontal sectional view showing the ground improvement body in Embodiment 2 in accordance with the present invention;

5 Fig. 11 is a longitudinal section showing the ground improvement body in accordance with the prior art;

Fig. 12 is a horizontal sectional view showing the ground improvement body in accordance with the prior art;

10 Fig. 13 is a drawing showing a first example of calculation results in Embodiment 1; and

Fig. 14 is a drawing showing a second example of calculation results in Embodiment 2.

Description of Symbols

[0054]

15 1: Normal column

1a, 11a, 22a: Bottom

1b, 11b: Top

2: Slab

3: Banking

20 4: Vehicle

10: Soft ground

11: Short column

20: Slab

21: Slab body

- 22: Beam
- 30: Column construction machine
- 31: Base machine
- 32: Leader
- 5 34: Head part
- 40: Vertical slab construction machine
- 41: Body
- 42: Actuation part
- L1: First level
- 10 L2: Second level
- L3: Third level
- L4: Fourth level
- LA: Column bottom level
- LB: Column top level
- 15 LC: Slab top level
- H1: Column length
- H2: Beam height
- H3: Slab thickness

What is claimed is:

1. A ground improvement body, comprising:

a first level, a second level, a third level, and a fourth level being set in order from the deepest to the shallowest within soft ground;

5 a plurality of short cylindrical columns formed from the first level to the second level by means of a column construction machine that rotates on a horizontal plane; and

a slab that is supported by the plurality of short cylindrical columns,

wherein:

10 the slab includes:

a slab body formed from the third level to the fourth level by means of a vertical slab construction machine that rotates in a vertical direction; and

a beam directly under the slab body, the beam being formed from the second level to the third level by means of the vertical slab construction machine, the beam being provided between a top of the plurality of short
15 cylindrical columns and a bottom of the slab body; and
the slab has a T-shape in a perpendicular cross-sectional view.

2. The ground improvement body as defined in claim 1, wherein the plurality
20 of short cylindrical columns are arranged in a lattice shape in a plan view.

3. The ground improvement body as defined in claim 1, wherein the plurality of short cylindrical columns are arranged in a zigzag in a plan view.

4. The ground improvement body as defined in any one of claims 1 to 3, wherein banking is laid on an upper part of the slab.

5. The ground improvement body as defined in any one of claims 1 to 4, further comprising:

a plurality of normal columns formed from the first level to the third level, tops of the plurality of normal columns supporting the slab body.

6. A method for constructing a ground improvement body, comprising:
10 setting a first level, a second level, a third level, and a fourth level in order from the deepest to the shallowest within soft ground;

forming a plurality of short cylindrical columns from the first level to the second level by means of a column construction machine that rotates on a horizontal plane; and

15 forming a slab that is supported by the plurality of short cylindrical columns by means of a vertical slab construction machine that rotates in a vertical direction, wherein:

the slab includes:

a slab body formed from the third level to the fourth level; and
20 a beam directly under the slab body, the beam being formed from the second level to the third level and being provided between a top of the plurality of short cylindrical columns and a bottom of the slab body; and the slab has a T-shape in a perpendicular cross-sectional view.

7. The method for constructing the ground improvement body defined in claim 6, wherein the vertical slab construction machine utilizes at least one of a rotary, a trencher, and a chain conveyor cutter.

5 8. The method for constructing the ground improvement body defined in claims 6 to 7, further comprising

 forming a plurality of normal columns formed from the first level to the third level, tops of the plurality of normal columns supporting the slab body.