



Structure for reinforcing an earth embankment

This invention relates to a reinforced earth or soil embankment comprising a plurality retaining members on the outer surface of the embankment secured to reinforcing members embedded in the embankment, the upper and lower ends of adjacent retaining members being connected to one another.

Fig. 7 shows a reinforced earth embankment as known in the prior art. This figure shows retaining members in the form of concrete wall panels or shutters 18 that are built up to form a wall. The wall retains a soil embankment 19 having reinforcing or anchoring members 20 deeply embedded in it. The reinforcing members 20 are connected to each wall panel 18 to fix each wall panel 18 to the soil embankment 19.

A problem with such a construction is that the concrete wall panels are extremely heavy, causing difficulty in handling, transportation and erection.

Problems have also occurred with the wall becoming deformed, overhung or thrust forward as a result of looseness in the connections between the wall panels 18 and the reinforcing members 20, and the elastic deformation or the like of each reinforcing members 20. Such deformation can be caused by earth pressure or increases in earth pressure resulting from an increase of the banking height or from rolling and compacting of the layers of the soil embankment.

The present invention seeks to mitigate the above disadvantages by providing a reinforcement for an earth embankment which can prevent the deformation or overhanging of the surface of the embankment, can enhance the appearance of the embankment by permitting the growth of vegetation, and which is of simple construction to enable it to be erected with ease.



In accordance with the present invention, there is provided a reinforced earth embankment as hereinafter set forth in claim 1 of the appended claims.

5 Because the retaining members are in the form of a grid they are relatively light allowing them to be transported and erected easily. Furthermore, the open lattice of the retaining members permit plants and vegetation to cover the surface of the embankment and the lattice itself, to give
10 the embankment aesthetic appeal. The strength of the retaining members is achieved by their anchoring to reinforcement members deeply embedded within the embankment and by their being additionally connected to one another to form one continuous retaining structure over the surface of
15 the embankment.

Preferred features of the invention as claimed in the dependent claims will be further explained by reference to the described preferred embodiments of the invention.

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The invention will now be described further, by way of example, with reference to the accompanying drawings, in which:

25 Fig. 1 is a longitudinal cross-sectional view showing a reinforced earth embankment of a preferred embodiment of the present invention,

Figs. 2(a) and 2(b) are perspective views showing grids
30 forming retaining members,

Fig. 2(c) is a longitudinal cross-sectional view showing a reinforced earth embankment;

35 Figs. 3(a) and 3(c) are cross-sectional views, drawn to an enlarged scale, of a portion of Fig. 1, illustrating connections between upper and lower retaining members,



Figs. 3(b) and 3(d) are vertical cross sectional views of retaining members of an alternative embodiment,

5 Figs. 4(a) and 4(b) are fragmentary side views showing connections between retaining members and reinforcing members,

Fig. 4(c) is a longitudinal cross-sectional view showing a retaining member;

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Fig. 4(d) is a side view showing part of a connecting member;

15 Figs 4(e) and 4(f) are longitudinal cross-sectional views of a retaining member showing a method of connection to a reinforcing member,

Fig. 4(g) is a longitudinal cross-sectional view showing a retaining member,

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Figs. 5(a) and 5(b) are longitudinal cross sectional views showing a connecting method for a reinforcing member,

25 Fig. 5(c) is a longitudinal cross-sectional view showing a retaining member;

Figs. 5(d), 5(e) and 5(f) are fragmentary cross sectional views showing a connecting method for a reinforcing member,

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Figs. 6(a), 6(b), 6(c) and 6(d) are views showing steps of a method for constructing a reinforced earth embankment according to the present invention, and

35 Fig. 7 is a longitudinal cross-sectional view showing a prior art reinforced earth embankment.



Throughout the drawings, like reference numerals are used to designate like components.

Fig. 1 shows a reinforced earth embankment 1 banked up to a predetermined height while being compacted by rolling. A retaining structure formed of individual grid-like retaining members 2 extends continuously over the front surface of the embankment 1 in the vertical and lateral directions so as to hold the embankment 1 against collapse. The individual retaining members 2 vertically overlap one another and are connected to another by a connecting rod 3.

Reinforcing members 4 are embedded deeply in the embankment 1 in order to anchor each retaining member 2 to the surface course portion of the embankment 1. A connecting member 5 connects the reinforcing member 4 to each retaining member 2. An anchoring plate 6 is mounted on the tip end of the reinforcing member 4 so as to firmly fix the reinforcing member 4 deep within the embankment 1. A vegetation mat 7 is positioned over the surface of the embankment 1 so as to prevent the collapsing of the surface portion of the embankment 1 and for improving afforestation.

The retaining member 2 constituted by the reinforcing grid as shown in Figs. 2(a) and 2(b) is integrally composed of a riser 2a overlying the surface of the embankment 1 and a leg 2b formed by bending at least one of the upper and lower ends of the retaining member 2 and embedded horizontally in the embankment 1.

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Both the riser 2a and the leg portion 2b of the retaining member 2 are constituted by arranging a plurality of vertical and horizontal cross bars 2c, 2d into a lattice so as to approximately cross at right angles, while welding each intersecting portion between the vertical bar 2c and the cross bar 2d.



The retaining member 2 can be constituted as an L-shaped retaining member as shown in Fig. 2(a) or a channel-shaped retaining member as shown in Fig. 2(b).

- 5 The retaining member shown in Fig. 2(a) is composed of the riser 2a and the leg portion 2b which are formed by bending each vertical bar 2c in an L-shape.

The retaining member shown in Fig. 2(b) is constituted in a
10 channel shape by bending both upper and lower ends of the retaining member.

The reason for arranging the vertical and horizontal bars 2c, 2d in a lattice so as to cross at right angles is that
15 the mesh of the vertical and horizontal bars may effectively withstand earth pressure without deformation even though the earth pressure acts as axial force on the vertical and horizontal bars 2c, 2d.

- 20 Furthermore, each retaining member 2 has sufficient flexural rigidity so that it can be stood up by itself on the embankment 1. Therefore, there is no need to pack the inside of the retaining member with sandbags to prevent it from falling over. For this reason, the retaining member 2 gives
25 advantages of labour saving as well as stability and ease of installation.

Additionally, the earth or soil inside the retaining member 2 is restrained and blocked due to the presence of the
30 horizontal bars 2d, and thus integrated. As a result, a block-like wall body A composed of portions a, b, c and d as shown in Fig. 2(c) is constructed by the embankment 1 held by the retaining members 2, so that the wall body A can be prevented from falling down or sliding by the reinforcing
35 members 4.



Because the block-like wall body A can gain stability from its own weight, little movement of the wall surface can occur and the overall reinforced embankment results in a stable structure which does not move appreciably.

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The upper end of the riser 2a of the retaining member 2 shown in Figs. 3(a) and 3(b) has a convex portion 8 that projects outward through the mesh of the riser 2a of the upper retaining member 2. A space 8a is defined between
10 the convex portion 8 and the vertical bar 2c of the upper retaining member 2, and a connecting rod 3 for connecting the upper and lower retaining members is inserted into the space 8a [see Figs. 3(a) and 3(c)].

15 Each convex portion 8 is formed by bending the upper end of each vertical bar 2c in a U-shape outward from the embankment 1, so that the convex portions 8 are formed successively in the lateral direction of the riser 2a.

20 Although the upper and lower retaining members 2 can be fixed to each other only by using such convex portions 8 without inserting the connecting rod 3 into the space 8a, the upper and lower retaining members 2, 2 can be more completely integrated by inserting the connecting rod 3 into
25 the space 8a. By so doing, a more stable block-like wall body A as shown in Fig. 2(c) can be constructed.

Figs. 3(b) and 3(d) show sections of an arc-shaped riser 2a of the retaining member 2. If the riser 2a is formed in an
30 arc shape, only a tensile force acts on each vertical bar 2c of the retaining member 2 and no bending forces act on it. As a result, a reinforced embankment of excellent stability can be constructed by using a small number of reinforcement bars.

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As for each reinforcing member 4, use can be made of a round bar, a bent bar, a bar such as a threaded bar, a reinforcing



member [see Fig. 4(a)] having an anchoring plate 6 attached to its end, a reinforcing grid [see Fig. 4(b)], a banked-earth reinforcing member (see Fig. 4(f)) such as a synthetic resin grid and a sheet, or a reinforcing member 5 with a steel band.

The connection between the retaining member 2 and the reinforcing member 4 can be simply done by connecting the reinforcing member 4 to the leg portion 2b depending on the 10 kind of the reinforcing member 4.

For example, Fig. 4(a) shows the connection by means of a screw coupler 5. Fig. 4(b) shows the construction of a connection by welding a steel band 10 to the leg portion 2b 15 and then welding a threaded rod 2' to the steel band. The threaded rod 2' is used to connect the retaining member to the reinforcement member 4 by means of a turn buckle 5.

Fig. 4(c) shows a retaining member 2 bent into a ring 22 at 20 the end of the leg portion 2b, and Fig. 4(d) shows a reinforcing member composed of a reinforcing grid provided with a ring 22a at the end. Fig. 4(e) shows how the retaining member 2 of Fig. 4c and the reinforcing member 4 of Fig. 4d can be interconnected by overlapping the rings 22 25 and 22a and passing a rod 17 through the two sets of rings.

Fig. 4(f) shows a connection effected by forming convex portions at the end of a reinforcing member 16 that is itself constructed as a mesh, passing the bends through the 30 meshes of the legs of two channel-shaped retaining members 2 and inserting a connecting rod 17 into the space between convex portions and the reinforcing members 2.

Fig. 4(g) shows a retaining member constituted in a channel 35 shape, having a steel band 10 for connecting the reinforcing member to the retaining member mounted on the end of each of the upper and lower leg portions 2b, 2b by means of welding.



Fig. 5(a) shows the assembled state of the retaining members 2 shown in Fig. 4(g). In this case, the channel-shaped upper and lower retaining members 2 are connected to each other by a connecting bolt 11, while clamping a band-like reinforcing member 9 between the upper and lower steel bands 10.

Fig. 5(b) shows the assembled state of alternative channel-shaped retaining members 2. In this case, the upper and lower retaining members 2 are overlapped vertically to each other so that the convex portion 8 formed on the leg portion 2b of the lower retaining member 2 projects on the upper end side of the mesh of the upper retaining member. The two retaining members are then connected to each other by inserting the connecting rod 3 into the convex portion 8. Further, the reinforcing member 4 is connected to the retaining members by the connecting rod 17.

Fig. 5(c) shows a retaining member constituted in an L-shape, and a band steel 10 for connecting the reinforcing member 4 to the retaining member is mounted on the tip end of the leg portion 2b by means of welding.

Fig. 5(d) shows a method of connecting a reinforcing member 14 composed of a reinforcing grid to the retaining member 2. In this method, the reinforcing member 14 is connected to the leg portion 2b of the retaining member 2 by the connecting rod 17.

Fig. 5(e) shows an embodiment of a method of connecting a band-like reinforcing member 9 to the retaining member 2. In this method, the reinforcing member 9 is connected by a connecting bolt 13 to a 12 wound around the horizontal bar 2d of the leg portion 2b of the retaining member 2.

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Fig. 5(f) shows a further method for connecting a reinforcing member 16 to the retaining member 2. In this



method, the end of the reinforcing member 16 is wound around the band steel 10, and the band steel 10 is clamped by a curved portion 2e of the leg portion 2b to connect the reinforcing member 16 to the retaining member 2.

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There now follows a description with reference to Fig. 6 of a method of constructing a reinforced earth embankment according to the present invention.

10 (1) First, the lowermost reinforcing grid 2A is set up on the ground surface, and a reinforcing member such as a bar is connected to the leg portion 2b of the retaining grid 2A [See Fig. 6(a)]. Further, a sheet 7 for preventing the outflow of earth and sand is mounted on the inside of a wall
15 surface portion 2a of the retaining grid 2A. Alternatively, a vegetation mat may be used as the sheet.

(2) Next, earth and sand are piled on to the reinforcing member 4, and then sufficiently compacted by rolling to
20 construct an embankment layer 1a [See Fig. 6(a)].

In this case, since the reinforcing member 4 is connected to the leg portion 2b, the retaining grid 2A can stand up by itself without any additional support because of the
25 rigidity and shape of the retaining grid 2A.

(3) The operation described in step (1) above is then repeated to construct an embankment layer 1b overlying the embankment layer 1a [See Fig. 6(b)]. In this case, the
30 reinforcing grid 2A is connected to a reinforcing grid 2B set up on the upside of the reinforcing grid 2A [see Fig. 6(b)].

When the upper and lower reinforcing grids 2A, 2B are
35 connected to each other, the upper end 2a of the wall surface of the reinforcing grid 2A is overlapped with the inside of the wall surface portion 2a of the reinforcing



grid 2B immediately after the reinforcing grid 2B is set up on the embankment 1a. At this time, the convex portion 8 of the reinforcing grid 2A projects from the mesh of the wall surface portion 2a of the reinforcing grid 2B to the outside of the embankment 1, and the connecting rod 3 is inserted horizontally into the convex portion 8 from the lateral direction [see Figs. 3(a) and 3(c)].

Earth and sand are now dropped through the mesh of the leg portion 2b of the reinforcing grid 2B onto the leg portion 2b of the reinforcing grid 2A and then sufficiently compacted by rolling [see Fig. 6(b)].

In this case, since the upper end of the riser 2a of the reinforcing grid 2A is connected to the upper reinforcing grid 2B according to the method as described above, there is no possibility of inclining the riser 2a of the reinforcing grid 2A forward due to the compaction by rolling.

(4) The operation described in the preceding item (3) is next repeatedly carried out in a similar manner to construct embankment layers 1c, 1d, [see Figs. 6(c) and 6(d)], and as a result, the overall embankment 1 is constructed (see Fig. 1).

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As for the soil material for use in the present invention, one may use a lightweight banking material or improved soil mixed with a consolidating material other than the ordinary earth and sand. Further, foam mortar or like hardening fluid having a fluidity at the time that the work is carried out can be also used.

The reinforced earth embankment in the present invention can be also utilised for a levee widening process by anchoring the reinforcing member to a natural ground.

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By virtue of the construction of the retaining member proposed by the present invention, it may be extremely lightweight, it can stand up by itself and it can easily be transported and erected. Furthermore, by the use of a U-shaped convex portion as described above, the upper and lower retaining members can be connected simply either by relying on the convex portions alone or by inserting a connecting rod into the convex portion. Such construction considerably simplifies assembly.

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Moreover, with the retaining members assembled from a plurality of vertical and horizontal bars into a lattice so as to cross at right angles, and also firmly fixed to the deep part of the embankment by a plurality of reinforcing members, they are capable of withstanding considerable pressure without deformation or overhanging of the surface of the embankment. Also, because the embankment itself held by the retaining member acts as an integrated block, a very strong construction is created.

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CLAIMS

1. A reinforced earth embankment comprising a plurality retaining members on the outer surface of the earth
5 embankment secured to reinforcing members embedded in the embankment, the upper and lower ends of adjacent retaining members being connected to one another, wherein the retaining members are grids formed of a plurality of generally vertical risers connected to one another by
10 generally horizontal cross bars, the risers being bent at at least one of their upper and lower ends to form legs embedded in the embankment and connected to the reinforcing members.
- 15 2. A reinforced earth embankment as claimed in claim 1, wherein, in order to connect the upper and lower retaining members to one another, the retaining members vertically overlap one another and the risers of the lower retaining member have at their upper ends convex portions that project
20 through the grid of the upper retaining member.
3. A reinforced earth embankment as claimed in claim 2, wherein a rod for connecting the upper and lower retaining members to each other is inserted between the projecting
25 convex portions of the risers of the lower retaining member and the upper retaining member.
4. A reinforced earth embankment as claimed in any preceding claim, wherein the risers of the retaining members
30 are bent in the shape of an arc.
5. A reinforced earth embankment constructed substantially as herein described with reference to and as illustrated in Figures 1 to 6 of the accompanying drawings.