A facing anchor for securing a soil reinforcing element to a facing comprising an unbroken length of continuous wire originating with a pair of lateral extensions cast into a concrete wall and including a series of loops extending from the concrete wall, wherein the loops each include an angularly inclined distal end segment configured to receive corresponding ends of the soil reinforcing element.
SOIL REINFORCING RETAINING WALL ANCHOR

CROSS-REFERENCE TO RELATED APPLICATION


BACKGROUND OF THE DISCLOSURE

[0002] Retaining wall structures that use horizontally positioned soil inclusions to reinforce an earth mass in combination with a facing element are referred to as Mechanically Stabilized Earth (MSE) structures. MSE can be used for various applications including retaining walls, bridge abutments, dams, seawalls, and dikes.

[0003] The basic MSE technology is a repetitive process where layers of backfill and horizontally placed soil reinforcing elements are positioned one atop the other until a desired height of the earthen structure is achieved. Typically, grid-like steel mats or welded wire mesh are used as reinforcement elements. In most applications, the reinforcing mats consist of parallel transversely extending wires welded to parallel longitudinally extending wires, thus forming a grid-like mat or structure. The backfill material and soil reinforcing mats are combined and compacted to form a solid earthen structure, taking the form of a standing earthen wall.

[0004] A substantially vertical concrete wall may then be constructed a short distance from the standing earthen wall. The concrete wall not only serves as decorative architecture, but also prevents erosion at the face of the embankment. The concrete wall is customarily formed in at least two ways. The wall may consist of a uniform, unbroken expanse of concrete or the like which is poured on site. Alternatively, the wall may comprise a plurality of premanufactured interlocking precast concrete panels, or wall modules, which are assembled into an interlocking stacked relationship once on site.

[0005] The soil reinforcing mats extending from the backfill may then be attached directly to the back face of the vertical concrete wall. Via this attachment, outward movement and shifting of the concrete wall is effectively prevented. In operation, MSE walls derive their strength and stability from the frictional and mechanical interaction between the backfill material and the soil reinforcement mats, resulting in a permanent and predictable load transfer from backfill to reinforcements.

[0006] To facilitate its connection to the earthen formation, the concrete wall will frequently consist of a series of facing anchors cast into the back face of the concrete at predetermined and spaced-apart locations. A facing anchor typically comprises a single bent wire that defines an outwardly protruding loop. Each facing anchor is positioned so as to correspond with and couple directly to an end of a soil reinforcing mat.

[0007] A potentially serious problem emerges, however, when a single-loop facing anchor and the corresponding end of a soil reinforcing mat fail to align properly. The reinforcing mats are generally manufactured to exact measurements and the wire ends are designed to align with corresponding facing anchors. In the field, however, it is not uncommon to encounter anchors that are misaligned relative to the ends of the soil reinforcing mats or are otherwise misplaced or bent. In well-compacted backfills, the configuration (e.g., squareness) of the grid-like reinforcing mats will be fixed and virtually unable to deform to connect properly to a bent or misplaced anchor, rendering the concrete panel useless.

[0008] Ideally, the stresses applied to the soil reinforcing mat within the reinforced backfill are substantially distributed evenly to the grid members. During loading, the transverse wires of a reinforcing mat act in a manner analogous to that of a continuous multiple span beam uniformly loaded and simply supported. The load transfer to the longitudinal wires is uniform and proportional. Intuitively, the load at the connection is also uniform and proportional. This analogy is acceptable assuming that all facing anchors make perfect contact with corresponding ends of the reinforcing mats (i.e., assuming all beam reactions are present).

[0009] However, if the anchors are positioned incorrectly, poor connection contact between anchor and reinforcing mat will occur and the stress transfer to the longitudinal wires will not be uniform and proportional. Because of unequal stress distribution, it is possible for the longitudinal wires to have stresses equal to 110 percent to 117 percent of the product of the span length and uniform load. This is equivalent to removal of one of the beam reactions at the connection. The above-described misalignment results in significantly higher tensile stresses in the working wires than if all connections were made equally. In those instances, if only one wire of a reinforcing mat fails to make contact at the concrete wall, the remaining connecting wires may be required to bear an increase in stress as much as 212 percent of the calculated value in the uniformly loaded beam analogy. This uneven stress distribution, due to poor transfer load at the connection, may result in seriously overstressed reinforcing wires that may lead to tensile failure of the welded wire reinforcing mats.

[0010] Bending the reinforcement mat wires or the facing anchors to create a connection does not solve this problem as it only results in poor conformance to tolerances. It has been commonly observed that a bent connection may not pick up its share of the load or may not receive any load at all. Certainly in those instances an uneven stress distribution will occur at the panel connection and may result in a future soil reinforcement failure.

[0011] In practice, because of the single-loop anchoring system, every anchor placement is different, thus making every connection different. This is dependent on the inconsistencies of the wire bends and of placement of the facing anchors in the panel during precasting. Whether cast into the concrete on site or in a manufacturing facility, the single-loop facing anchors are prone to both horizontal and vertical misalignment, in addition to axial twisting and inconsistent depth placement.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. 1A is a perspective view of a system according to one or more aspects of the present disclosure.

[0013] FIG. 1B is a sectional view of a portion of the system shown in FIG. 1A.

[0014] FIG. 1C is a perspective view of a portion of the system shown in FIG. 1A.

[0015] FIG. 2A is a perspective view of a system according to one or more aspects of the present disclosure.

[0016] FIG. 2B is a perspective view of a portion of the system shown in FIG. 2A.
FIG. 2C is a sectional view of a portion of the system shown in FIG. 2A.

DETAILED DESCRIPTION

0018. It is understood that the following disclosure provides several different embodiments, or examples, for implementing different features of the disclosure. Specific examples of components and arrangements are described below to simplify the present disclosure. These are, of course, merely examples and are not intended to be limiting. In addition, the present disclosure may repeat reference numerals and/or letters in the various examples. This repetition is for the purpose of simplicity and clarity and does not in itself dictate a relationship between the various embodiments and/or configurations discussed.

0019. The present disclosure may be embodied as an improved apparatus and method of connecting an earthen formation to a concrete facing of a MSE structure. In particular, the facing of the MSE may comprise either a series of concrete panels stacked one atop the other or a uniform, unbroken expanse of concrete. In either case, the back of the concrete facing may comprise at least one continuous-wire facing anchor consisting of a plurality of horizontally-aligned equi-distant loops that are configured to correspond precisely to the ends of a soil reinforcing mat. The improved facing anchor may comprise any number of continuous-wire loops positioned in a predetermined location for easy attachment to the corresponding soil reinforcing elements.

0020. Because the improved facing anchor consists of a continuous wire that forms the multiple loops, it is thereby configured to eliminate the risk of horizontal and/or vertical loop misalignment, twisting misalignment, and depth misalignment relative to a corresponding soil reinforcing element. In this manner, the likelihood of a perfectly secure soil reinforcement connection across a continuous span of anchors is greatly increased. This secure connection will allow for the stresses placed on the wires of the soil reinforcing mat to be distributed evenly, thus reducing the risk of tensile overstress and failure.

0021. Besides the evident advantages described above, other advantages of the improved facing anchor include its ease of manufacture and installation. For example, instead of casting multiple single-loop anchors one-by-one into the back of a concrete wall, the improved multi-loop anchor, consisting of any number of loops, may be installed in one fell swoop. And because the loops are made from the same continuous wire, all resulting loops will be located in the same 3-dimensional plane for easy attachment to the corresponding soil reinforcing elements.

0022. Referring to FIGS. 1A-1C, illustrated is a system 100 according to one or more aspects of the present disclosure. In an exemplary embodiment, the system 100 may be used to secure a facing 102 to an earthen formation 104. The facing 102 may comprise an individual precast concrete panel or, alternatively, a plurality of interlocking precast concrete modules or wall members that are assembled into interlocking relationship on the site. In another embodiment, the precast concrete panels may be replaced with a uniform, unbroken expanse of concrete or the like which is poured on site. The facing 102 may define an exposed face 106 and a back face 108; the exposed face 106 generally comprising exposed decorative architecture and the back face generally adjacent to the earthen formation 104.

0023. Cast into the facing 102, or attached thereto, and protruding from the back face 108, is at least one facing anchor 110. In an exemplary embodiment, the facing anchor 110 may comprise one continuous wire rod defining a plurality of symmetrical loops 112. The series of loops 112 may be formed by a 180° arcuate bend in the continuous wire rod. In the exemplary illustrated embodiment, the facing anchor 110 comprises a series of 4 symmetrical loops 112, but it will be appreciated that the facing anchor 110 may comprise any number of loops 112 to fit any particular application.

0024. In an exemplary embodiment, the facing anchor 110 may be disposed generally horizontally, but alternatively and depending on the application, the facing anchor 110 may be configured to seat vertically or at a predetermined angle relative to the facing 102. In the illustrated exemplary embodiment, the loops 112 of the facing anchor 110 are exposed to the earthen formation 104 and comprise distal end segments 116 extending downwardly at an angle of about 20° to 50° from horizontal; such as about 35° from horizontal. Extending oppositely into the facing 102, the facing anchor 110 may terminate at a pair of lateral extensions 114.

0025. In an exemplary embodiment, the earthen formation 104 may encompass a mechanically stabilized earth (MSE) structure including soil reinforcing elements 118 that extend into the earthen formation 104 to add tensile capacity thereto. In an exemplary embodiment, the soil reinforcing elements 118 may comprise tensile resisting elements positioned in the soil in a substantially horizontal alignment at spaced-apart relationships to one another across compacted soil. Depending on the application, grid-like steel mats or welded wire mesh may be used as reinforcement elements. In an exemplary application, as illustrated, a reinforcing element 118 may typically consist of generally parallel transversely extending wires welded to generally parallel longitudinally extending wires, thus forming a welded wire gridworks.

0026. Referring to FIGS. 1B and 1C, the ends of the reinforcing element 118 gridwork may define vertically disposed loops 120 extending downwardly relative to the horizontal plane of the reinforcing element 118. The loops 120 may further be proportioned for receipt in the symmetrical anchor loops 112. In an exemplary embodiment of operation, a reinforcing element 118 gridwork is coupled to the facing 102 by extending or inserting the vertically disposed loops 120 from one side of the anchor loops 112 to the other, as illustrated in FIG. 1B.

0027. In an exemplary embodiment, the anchor loops 112 may be manufactured from a continuous wire segment defining equi-distant loops that automatically directly correspond to the longitudinally extending wires of the reinforcing element 118 gridwork. Therefore, the multi-loop anchor 110 effectively eliminates the common inconsistencies encountered in a single-loop anchor system like, for example, horizontal and vertical misalignment or misplacement of the anchors 110 in the panel during precasting and axial twisting (e.g., loop 112 bending).

0028. In an exemplary embodiment, as a result of the precise alignment between the anchor loops 112 and corresponding longitudinal wires of the reinforcing element 118 gridworks, a retaining rod 122 may then be extended through the vertically disposed loops 120 along the bottom side of the anchor loops 112. The rod 122 may act to secure the facing 102 to the reinforcing element 118 gridwork and, therefore, to the earthen formation 104. In an exemplary embodiment, the retaining rod 122 may comprise any elongate member with
the structural strength and capacity to maintain the reinforcing elements 118 in tension with the facing anchors 110. Depending on the application, the rod 122 may comprise, but is not limited to, such materials as steel, plastic, wood, and ceramics.

[0029] Due to the downward inclination of the distal end segments 116 of the facing anchor 110, tension applied to the wires of the reinforcing element 118 functions to engage or draw the rod 122 against the segments 116. When the wires of the reinforcing elements 118 are subjected to tension, the vertically disposed loops 120 frictionally bind between the anchor loops 112 and the wires, thus preventing the loops 120 from straightening out. This frictional binding is aided by the engagement of the rod 122 against the inclined segments 116 of the anchor loops 112 as the result of such tension.

[0030] Referring to FIGS. 2A-2C, illustrated is an exemplary embodiment of a system 200 according to one or more aspects of the present disclosure. In an exemplary embodiment, the system 200 may be operable to connect a facing 102 to an earthen structure 104. In particular, a facing anchor 110 may be disposed in a facing 102 and further attached to a soil reinforcing element 202 gridwork. The facing 102 and soil reinforcing element 202 gridwork correspond to those used and depicted in FIGS. 1A-1C. Here, however, in the illustrated exemplary embodiment, the reinforcing element 202 differs in that extensions in the form of kinked V-shaped sections 204 are formed on the wires in place of the vertically disposed loops. Also, a cross-rod 206 may be fixed to and extend across the distal ends of the V-shaped sections 204. As illustrated, the cross-rod 206 may be welded, or otherwise attached, to the tops of the portions of the wires forming the V-shaped sections 204.

[0031] In use, the V-shaped sections 204 of the reinforcing element 202 are extended through the anchor loops 112, as illustrated in FIG. 2C. In this exemplary embodiment, the cross-rod 206 rests against the top of the anchor loops 112 to limit the degree to which the V-shaped sections 204 extend through the anchor loops 112. The connection is made secure by extending a retaining rod 208 through the V-shaped sections 204 to the under side of the anchor loops 112. The rod 208 may be identical to that as illustrated in FIGS. 1A-1C.

[0032] Because the facing anchor 110 may be manufactured from a continuous wire segment thereby defining a series of equidistant loops 112, in an exemplary embodiment each loop 112 may precisely line-up with a corresponding V-shaped section 204. Therefore, the multi-loop facing anchor 110 effectively eliminates the inconsistencies commonly encountered in single-loop anchor systems, like, for example, horizontal and vertical misalignment or misplacement of the anchors 110 in the panel during precasting, and axial twisting (e.g., loop 112 bending).

[0033] A facing anchor for securing a soil reinforcing element to a facing has been described. The facing anchor may comprise an unbroken length of continuous wire originating with a pair of lateral extensions cast into a concrete wall and include a series of generally horizontally disposed loops extending from the concrete wall, wherein the loops may each include a downwardly inclined distal end segment configured to receive corresponding ends of the soil reinforcing element. The wire of the facing anchor may substantially comprise steel and the series of loops may comprise at least two symmetrical U-shaped loops formed on equidistant centers corresponding to the soil reinforcing element. The series of loops may be formed by a corresponding series of 180 degree arcuate bends in the continuous wire. The downwardly inclined distal end segment may be inclined in the range of 20 to 50 degrees relative to a horizontal plane of the facing anchor or to 35 degrees relative to a horizontal plane of the facing anchor.

[0034] A method of manufacturing a facing anchor has also been described. The method may comprise providing a wire, bending the wire to form a series of substantially uniform and U-shaped arcuate loops that are substantially orthogonal to the wire, and bending the distal ends of the loops downwardly. The wire may substantially comprise steel and the series of uniform arcuate loops may comprise at least two symmetrical loops wherein the distal ends of the loops are bent downwardly in the range of 20 to 50 degrees relative to a horizontal plane of the facing anchor or to 35 degrees relative to a horizontal plane of the facing anchor.

[0035] A system for securing a soil reinforcing element to a facing has also been described. The system may comprise a facing anchor made from a continuous wire rod and extending from the facing, the facing anchor defining a series of generally horizontally disposed loops, a series of generally circular vertically disposed loops formed on the soil reinforcing element and configured to extend through the horizontally disposed loops from one side of the facing anchor to the other, and a rod extensible through the vertically disposed loops along the other side of the facing anchor and engageable with the facing anchor when disposed to secure the vertically disposed loops against removal from the horizontally disposed loops. The series of generally horizontally disposed loops may comprise at least two symmetrical U-shaped loops formed on equidistant centers corresponding to the soil reinforcing element and may further include a downwardly inclined distal end segment and wherein tension applied to the soil reinforcing element draws the rod against the segment. The rod may comprise a steel shaft, and the facing may comprise a plurality of precast concrete panels stacked atop the other, or a cast-on-site continuous concrete wall.

[0036] The foregoing disclosure and description of the disclosure is illustrative and explanatory thereof. Various changes in the details of the illustrated construction may be made within the scope of the appended claims without departing from the spirit of the disclosure. While the preceding description shows and describes one or more embodiments, it will be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the present disclosure. For example, various steps of the described methods may be executed repetitively, combined, further divided, replaced with alternative steps, or removed entirely. In addition, different shapes and sizes of elements may be combined in different configurations to achieve the desired earth retaining structures. Therefore, the claims should be interpreted in a broad manner, consistent with the present disclosure.

We claim:

1. A facing anchor for securing a soil reinforcing element to a facing, comprising:

   an unbroken length of continuous wire originating with a pair of lateral extensions cast into a concrete wall and including a series of loops extending from the concrete wall, wherein the loops each include an angularly inclined distal end segment configured to receive corresponding ends of the soil reinforcing element.
2. The facing anchor of claim 1 wherein the series of loops is a series of generally horizontally disposed loops, and wherein the angularly inclined distal end segment is downwardly inclined.

3. The facing anchor of claim 1 wherein the wire substantially comprises steel.

4. The facing anchor of claim 1 wherein the series of loops comprises at least two symmetrical U-shaped loops.

5. The facing anchor of claim 1 wherein the downwardly inclined distal end segment is inclined in the range of 20 to 50 degrees relative to a horizontal plane of the facing anchor.

6. The facing anchor of claim 1 wherein the downwardly inclined distal end segment is inclined at 35 degrees relative to a horizontal plane of the facing anchor.

7. The facing anchor of claim 1 wherein the series of loops are formed on equidistant centers corresponding to the soil reinforcing element.

8. The facing anchor of claim 1 wherein the series of loops are formed by a corresponding series of 180 degree arcuate bends in the continuous wire.

9. A method of manufacturing a facing anchor, comprising:
   - Providing a wire;
   - Bending the wire to form a series of substantially uniform and U-shaped arcuate loops that are substantially orthogonal to the wire; and
   - Bending the distal ends of the loops downwardly.

10. The method of claim 9 wherein the series of uniform arcuate loops comprise at least two symmetrical loops.

11. The method of claim 9 wherein the wire substantially comprises steel.

12. The method of claim 9 wherein the distal ends of the loops are bent downwardly in the range of 20 to 50 degrees relative to a horizontal plane of the facing anchor.

13. The method of claim 9 wherein the distal ends of the loops are bent downwardly to 35 degrees relative to a horizontal plane of the facing anchor.

14. A system for securing a soil reinforcing element to a facing, comprising:
   - A facing anchor made from a continuous wire rod and extending from the facing, the facing anchor defining a series of generally horizontally disposed loops;
   - A series of generally circular vertically disposed loops formed on the soil reinforcing element and configured to extend through the horizontally disposed loops from one side of the facing anchor to the other; and
   - A rod extendible through the vertically disposed loops along the other side of the facing anchor and engageable with the facing anchor when so disposed to secure the vertically disposed loops against removal from the horizontally disposed loops.

15. The system of claim 14 wherein the horizontally disposed loops include a downwardly inclined distal end segment and wherein tension applied to the soil reinforcing element draws the rod against the segment.

16. The system of claim 14 wherein the series of generally horizontally disposed loops comprise at least two symmetrical U-shaped loops.

17. The system of claim 14 wherein the series of generally horizontally disposed loops are formed on equi-distant centers corresponding to the soil reinforcing element.

18. The system of claim 14 wherein the rod comprises a steel shaft.

19. The system of claim 14 wherein the facing comprises a plurality of precast concrete panels stacked one atop the other.

20. The system of claim 14 wherein the facing comprises a cast-on-site continuous concrete wall.

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