(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 963 582 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
12.02.2014 Bulletin 2014/07

(21) Application number: **06840549.7**

(22) Date of filing: **22.12.2006**

(51) Int Cl.:
E02D 29/045 *(2006.01)* ***E01F 5/00*** *(2006.01)*

(86) International application number:
PCT/CA2006/002123

(87) International publication number:
WO 2007/071067 (28.06.2007 Gazette 2007/26)

(54) **Method of controlling deformation of a cut end region of an arch type structure**

Verfahren zur Verformungskontrolle von abgeschrägten/schiefen Enden einer bogenförmigen Struktur

Méthode pour contrôler la déformation des extrémités biseautées/obliques d' une structure de type arche.

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI SK TR

(30) Priority: **23.12.2005 CA 2531547**

(43) Date of publication of application:
03.09.2008 Bulletin 2008/36

(73) Proprietor: **AIL International Inc.**
Dorchester, New Brunswick E4K 3V5 (CA)

(72) Inventor: **WILSON, Michael, W.**
Sackville, New Brunswick E4L 1M7 (CA)

(74) Representative: **Howson, Richard G.B.**
Kilburn & Strode LLP
20 Red Lion Street
London WC1R 4PJ (GB)

(56) References cited:
CA-A- 1 340 179
CA-A1- 2 254 595
CA-A1- 2 460 081
JP-A- 10 183 653
US-A- 4 610 572
US-A- 4 618 283
US-A- 4 618 283
US-A- 6 050 746
US-B1- 6 640 505

Printed by Jouve, 75001 PARIS (FR)

Description

FIELD OF THE INVENTION

[0001] This invention generally relates to structural metal plate arch-type structures. In particular, this invention relates to a method of controlling deformation of a cut end region of an erected arch-type structure for use in underpass construction and the like, where the cut end region has at least one extended leg portion.

BACKGROUND OF THE INVENTION

[0002] As rural and urban infrastructure continues to age and develop, there is a continual demand for cost-effective technologies relating to the construction and maintenance of highways, railways and the like. Often unappreciated but vitally important to the construction of such infrastructure is the underpass system. Underpass systems are typically designed to carry not only dead loads, but also live loads. While some of the most impressive underpass systems are used in mining or forestry applications where spans can exceed 20m, they are also very common in regular highway construction to allow passage of railway, watercourses or other vehicular/pedestrian traffic. While concrete structures have been regularly employed for these purposes, they are very expensive to install, are cost prohibitive in remote areas and are subject to strength weakening due to corrosion of the reinforcing metal.

[0003] In the field of arch-type structures, there have been significant advances in respect of the use of corrugated metal culverts, arch culverts and box culverts. For example, U.S. Patent No. 5,118,218 discloses the use of sheets of metal having exceptionally deep corrugations whereby, using significant material on the crown portions of the culvert and perhaps as well in the haunch portions of the culvert, significant loads can be carried by the culvert design. Ovoid and circular structures are described in U.K. Patent Application No. 2,140,848 where wing members are used to increase the load carrying capabilities, and in particular avoid bending of the crown or roof structure as live loads pass thereover.

[0004] U. S. Patent No. 5,326,191 discloses a reinforced metal box culvert which is provided with a special form of continuous reinforcement along at least the crown or top portion of the culvert. Significant advantages are provided in load carrying characteristics, reduced overburden requirements and the ability to provide large span structures that reduce the cost. These systems greatly facilitate the installation of large span structures with the ability to carry live loads under a variety of conditions. Improvements to the box culvert and arch culvert designs are also described in U.S. Patent No. 5,375,943 and International PCT Application No. PCT/CA97/00407.

[0005] The use of mechanically-stabilized earth in archway construction is described in U.S. Patent No. 4,618,283. This construction technique avoids arching of the structure because the sidewalls of the archway are built as successive layers of mechanically-stabilized earth which are deposited along side and over top of the structure. The technique involves building on each side of the archway, mechanically-stabilized earth which constitutes vertical support sections, and then building across the top of the arch again using mechanically-stabilized earth to define the roof of the archway. As the archway is built step-by-step, facings are applied to contain the mechanically-stabilized earth and prevent such compacted unbound fill of the mechanically-stabilized earth structure from coming loose and falling into the archway. Such facing may be simply attached to vertical portions of wire mesh which terminate at the edge of the archway envelope. Alternatives to the facing material include spraying of concrete to provide a liner within the archway or the use of a corrugated metal liner. Optionally, the facing of the mechanically-stabilized earth vertical structures may be attached to the corrugated metal liner. The liner is not designed to carry any structural load either live or dead. Rather, instead the live and dead loads are carried by the mechanically-stabilized earth vertical support sections as well as the mechanically-stabilized earth roof section.

[0006] A further method of controlling deformation of an erected structure, principally during the backfilling process is described in U.S. Patent No. 6,050,746.

[0007] US6640505B1 describes a hybrid arched overfilled structures that includes a combination of precast side elements and at least one cast-in-place crown sector element.

[0008] US4618283 describes an archway construction positioned over a pathway for supporting a crossroad or the like. The archway has three primary sections including an upper ceiling section which spans the pathway and which is supported on two vertical support sections positioned on opposite sides of the pathway.

SUMMARY OF THE INVENTION

[0009] Accordingly in one aspect of the invention, there is provided a method of controlling deformation of a cut end region of an erected arch-type structure for use in underpass construction where the cut end region defines at least one extended leg portion, said method comprising:

i) building progressively a mechanically-stabilized earth structure adjacent said extended leg portion by alternately layering a plurality of compacted layers of fill with interposed layers of reinforcement generally to the height of said extended leg portion;

ii) securing to said extended leg portion each layer of reinforcement during said progressive building, whereby securement of said layers of reinforcement to said extended leg portion provides support in controlling deformation of the cut end region during backfilling and regular service; and

iii) positioning a load distribution device between each layer of reinforcement and said extended leg portion to distribute load across said extended leg portion, thereby reducing point loads.

[0010] In one embodiment, the load distributing device may be a segment of angle iron.

[0011] In one embodiment, each layer of reinforcement may comprise at least wire grid mat comprising interconnected rods. The reinforcement layers extend laterally away from the arch-type structure in a generally horizontal configuration. Alternatively, each layer of reinforcement may comprise a plurality of strips. Still further, each layer of reinforcement may comprise a combination of grid wire mats and a plurality of strips.

[0012] There is disclosed a method of controlling deformation of a cut end region of an erected arch-type structure for use in underpass construction and the like, where the cut end region has at least one extended leg portion, said method comprising:

i) building progressively at least one layer of mechanically-stabilized earth adjacent said at least one extended leg portion by alternately layering a plurality of compacted layers of fill with interposed layers of reinforcement; and

ii) securing to said extended leg portion each layer of reinforcement during said progressive building, whereby securement of said layers of reinforcement to said at least one extended leg portion provides support in controlling deformation of the cut end region during backfilling and regular service.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Embodiments will now described more fully with reference to the accompanying drawings wherein:

Figure 1 is a perspective view of a representative type of beveled/skewed arch-type structure;

Figure 2 is a partial perspective view of the cut end region of the arch- type structure of Figure 1 ; Figure 3 is a partial top view of the cut end region of the arch-type structure of Figure 1;

Figure 4a is a partial perspective view of the cut end region of the arch- type structure of Figure 1 showing a single layer of a wire grid mat reinforcement;

Figure 4b is a partial front view of the arch-type structure of Figure 1, showing consecutive layers of backfill and reinforcement on each side of the arch-type structure;

Figure 5a is a side sectional view through a portion of the arch-type structure of Figure 1, showing the connection of the reinforcement to the sidewall;

Figure 5b is a top sectional view through a portion of the arch-type structure of Figure 1, showing the placement of a plurality of reinforcements on the sidewall;

Figures 6a, 6b, 6c and 6d are sequential elevational views showing placement of the reinforcements at the cut end region of the arch-type structure of Figure 1;

Figure 7 is a top sectional view through a portion of the arch-type structure showing an alternate embodiment for connecting the reinforcement to the sidewall;

Figures 8a, 8b, 8c and 8d are sections through alternate embodiments for connecting the reinforcement to the sidewall;

Figures 9a, 9b, 9c, 9d and 9e are sections through alternate embodiments for the reinforcement connection;

Figures 10a to 10l are top plan views of various types of reinforcement;

Figures 11 a and 11 b show an alternate embodiment for connecting the reinforcement to the sidewall;

Figure 12a and 12b show a further alternate embodiment for connecting the reinforcement to the sidewall; and

Figures 13a and 13b show yet a further alternate embodiment for connecting the reinforcement to the sidewall.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0014] The construction of underpass systems or similar thoroughfare infrastructure using large and/or long span metal arch-type structures presents certain challenges. As one can appreciate, these structures are subject to extreme stresses, not only during the intended use (i.e. anticipated live/dead loads), but also during the initial construction process. Technology has enabled the construction of larger and longer structures, as evidenced by U.S. Patent Nos. 5,326,191 and 5,375,943 and International PCT Application No. PCT/CA97/00407, assigned to the assignee of the subject application. With larger structures, the susceptibility of deformation and/or failure due to extreme forces imparted during the backfill process has required further technological development, as evidenced by U.S. Patent No. 6,050,746, assigned to the assignee of the subject application. With the core technology now available to provide a wide-ranging number of applications, new challenges have presented themselves.

[0015] With arch-type structures not comprising beveled or skewed ends, the structural metal plates at each end region are configured to form a complete span defining the effective topside circumference of the structure. It will be appreciated that these complete spans provide a degree of stability to the structure. In many applications, however, there is a requirement for such structures to have beveled/skewed ends, whether it is simply a matter of aesthetics, or for specific properties such as hydraulics relating to a watercourse passing therethrough. In such structures comprising a beveled or skewed end, the structural metal plates are truncated at the end region, resulting in a lack of stability. As such, these arch-type structures are at increased risk of deformation due to pressures exerted by backfill and standard loads experienced during regular use. While beveled/skewed structures are known, their installations have traditionally required reinforcement using steel, concrete or tie-back arrangements (i.e. steel rods tied to an anchoring device) to provide the necessary support. It has been found that these reinforcement techniques are labor intensive and can substantially increase the overall cost of installing such a structure.

[0016] A representative underpass or similar thoroughfare infrastructure comprising a metal arch-type structure 10 constructed of structural metal plate is shown in Figure 1. Above the metal arch-type structure 10 is a prescribed depth of overburden 12, on top of which is a roadway 14 constructed in a usual manner. As better shown in Figure 2, the structure 10 is generally comprised of a pair of footings 16 and a plurality of corrugated, structural metal plates 18. The structural metal plates 18 are fastened together using bolts so as to achieve the desired erected structure. Although bolts are described to fasten the various plates together, it will be appreciated that other alternate suitable fasteners that meet the specific structural and load requirements (welds, rivets, etc...) can be used.

[0017] In Figure 3, shown is a top view of the arch-type structure 10 comprising a cut end region 22 having both a beveled and skewed configuration. The structural metal plates 18 are fastened together in a staggered stepwise arrangement to achieve the desired erected structure. Note the truncated structural metal plates 20 at the cut end region 22. With the arch-type structure 10 being both beveled and skewed, there is defined at the cut end region 22 both a long leg portion 24, and a short leg portion 26. To ensure structural integrity during the construction process, it is advisable to first assemble at least two complete spans 28 of metal plates comprising the sidewalls 30, haunch 32 and crown 34 (see Figure 2) and have these affixed to the respective footings 16 before proceeding with the assembly of the cut end region 22. Once fastened in place, the cut end region 22 comprising the truncated structural metal plates 20 are erected using plate-by-plate assembly. If necessary, in certain applications, extra temporary support may be used.

[0018] During the backfilling process, as mentioned above, the cut end region 22 is susceptible to deformation and/or failure before installation is complete. This is particularly true for structures in which the sidewalls 30 are vertically extended. To enable backfilling in the cut end region 22, the truncated structural metal plates 20 are reinforced in accordance with the method shown in Figures 4a and 4b.

[0019] As shown in Figures 4a and 4b, mechanically-stabilized earth is installed on each side of the cut end region 22 of the arch-type structure 10 in a manner which minimizes deformation of this region during backfilling. Mechanically-stabilized earth has been used extensively in providing retaining walls, headwalls and the like such as described in the aforementioned U.S. Patent No. 4,618,283.

[0020] In the cut end region 22, the mechanically-stabilized earth is developed by alternately layering a plurality of compacted layers of fill 36 with interposed layers of reinforcement 38 to form the mechanically-stabilized earth as shown in Figure 4b. In this embodiment, the reinforcement layers each comprise a wire grid mat (see Figure 4a), formed of a plurality of interconnected intersecting rods 40 and 42. Fill is provided on top of the excavation bed 44 and along the slopes 46 to form a first layer 36a of compacted fill. The fill may be any type of granular material such as various types of sand, gravel, broken rock and the like. The unbound fill even when compacted remains granular and has a relatively low resistance to sheer forces. After the first layer of compacted fill is installed a layer of reinforcement 38a is laid down where that layer of reinforcement 38a is connected to the sidewalls 48 of the extended short and long leg portions of the cut end region 22, so as to secure the layer of reinforcement 38a to the sidewalls 48. Such manner of connection to the truncated structural metal plates will be described further below. The next layer of fill 36b is then applied over top of the reinforcement layer 38a. After the layer of fill 36b is completed the next layer of reinforcement 38b is laid down over top this layer of compacted fill 36b. Reinforcement layer 38b is also connected to the sidewalls as described above. This procedure is repeated several times as required to backfill the excavated space between the slopes 46 and the sidewalls 48 of the arch-type structure 10. In the structure shown in Figure 4b, the long leg portion 28 has eight (8) reinforcement layers 38a, 38b, 38c, 38d, 38e, 38f, 38g and 38h attached to it, and the short leg portion 26 has one reinforcement layer 38a attached to it. The backfilling is then completed to the level of the crown and the usual overburden 50 is then applied.

[0021] Overburden 50 is developed in the usual manner such that when the overburden is in place, both the live and dead loads applied to the structure are accommodated by the capacity of the structural metal plate. For example, with the design criteria set out in assignee's above noted U.S. patents and International PCT application, the live and dead loads are accommodated by the backfilled structure in the usual manner where the loads are resisted by the structural strength of the metal plate, as well as the backfill resisting outward movement of the sidewalls which is commonly referred to as "Positive Arching."

[0022] As shown in Figures 4a and 4b, for an arch-type structure having both a beveled and skewed profile, the use of reinforcement layers on each leg extension may not be symmetrical. As can be appreciated, the short leg portion 26 will require less reinforcement as there are fewer truncated structural metal plates 20 to support. As shown, for the arch-type structure represented, the short leg portion 26 receives one reinforcement layer 38a, whereas the long leg portion 24 receives eight (8) reinforcement layers 38a through 38h.

[0023] By following the procedure of this method the reinforced soil system controls deformation and/or failure of the cut end region 22 of the arch-type structure 10. It will be appreciated, however, that while reinforcement has only been provided in the region of the beveled/skewed end region, it may also be advantageous to provide reinforcement at other regions of the structure as well. As described in assignee's U.S. Patent No. 6,050,746, which is herein incorporated by reference, reinforcement of the structure may also be configured to provide only an interim function which becomes obsolete at the end of the backfilling operation.

[0024] In this embodiment represented in Figures 5a and 5b, end section 52 of each reinforcement layer 38 is fixedly retained between a length of angle iron 54 and a length of flat bar 56. As better shown in Figure 5b, a first set of fasteners 58 are used to capture the reinforcement layer 38 between the angle iron 54 and flat bar 56, while a second set of fasteners 60 are used to impart further clamping pressure, while also attaching the angle iron 54 and flat bar 56 to the sidewall 48 of the structural metal plate 20. Use of the angle iron 54 and length of flat bar 56 ensures distribution of load across the corrugations of the sidewall of the extended leg portions, reducing the likelihood of deformation and localized failure due to point loads associated with prior art tie-back systems. The reinforcement layer 38 is configured at point 62 with a bend such that the extending portion of the reinforcement layer 38 lays in a generally horizontal position. While the reinforcement layer 38 generally extends laterally away from the structure in a generally horizontal position, other non-horizontal configurations may be possible, if for example certain obstructions are present in the backfill zone.

[0025] Figures 6a to 6d show a series of successive elevational views illustrating placement of the reinforcement 38 relative to the cut end region 22. As will be noted, the reinforcement 38 is generally present as a plurality of reinforcements (i.e. a plurality of wire grid mats), but it will be appreciated that any number from a single unit through to a large number can be used, depending on the particular support requirements. Referring specifically to Figure 6a, shown on the short leg portion 26 is a reinforcement layer 38a comprising three adjacently positioned wire grid mats. On the long leg portion 24, the reinforcement layer 38a comprises four adjacently positioned wire grid mats. Further, the length of each of the reinforcement layers can be tailored to the particular application, depending on the support requirements and the available space between the structure and any adjacent structure, or the slopes of the excavated area. Reference is made to Figure 6d which shows a reinforcement layer 38d that not only comprises six (6) wire grid mats, but mats that are approximately three (3) times longer than those in Figure 6a. Figures 6b and 6c show intermediate reinforcement layers 38b and 38c, respectively. The length and quantity of the reinforcement layers will be a factor of the particular situation in which they are being installed. As a general rule, reinforcement layers may be configured with a length that is approximately 70% of the height of the wall. In situations where there is low cover (i.e. close to the top of the structure), the mats may be lengthened to increase the frictional capacity of the mat itself. Approaching the base of the structure, the mats may be shortened as they are subject to higher frictional forces. Also, in certain situations it may be necessary to increase the diameter of the rods used to construct the wire grid mats so as to handle higher forces and resist tearing under extreme load. As mentioned, the above are general guidelines and in no way are meant to be interpreted as limitations to the configuration of the reinforcement mats. In actual practice, the specifics of the installation, the expected loads and the engineered capacity of the structure will dictate the final configuration of these reinforcements.

[0026] While one method of connecting the reinforcement layers to the sidewall is discussed above, one skilled in the art may choose to implement a suitable alternative. The following presents a number of alternates for achieving this connection. Referring to the structure shown in Figure 7, the reinforcement layer 38 once again is a wire grid mat. The longitudinal rods are connected in accordance with the embodiments of Figures 8a to 8d or 9a to 9e to a length of structural material (i.e. angle iron) which distributes the loads along the sidewall of the extended leg portions. This reduces the likelihood of deformation due to point loads associated with prior art tie-back systems. As shown, the angle iron 62 is bolted at 64 to the interconnected structural metal plates 48. Bolts are normally used to connect the plates 48; hence, a second nut 68 may be used to connect the angle iron to the bolt 64 in assembling the structure.

[0027] The alternate embodiments of Figures 8a to 8d and 9a to 9e show various types of connection of the reinforcement layer to the angle iron 62. As shown in Figure 8a, the longitudinally extending rods 70 have their end portions 72 extending through an opening 74 in the upright portion 76 of the angle iron. The distal end 78, of each longitudinally extending rod 70 is then deformed to provide a button 80, which is greater than the opening 74 in the upright portion, so as to retain the reinforcement layer in the angle iron. The deformation of the distal end and forming the button 80, is such to accommodate both the tensile stress applied to the reinforcement layer during the backfilling operation, as well as the expected stresses due to normal usage of the structure. As shown in Figure 8b the distal end 82 of each longitudinally extending rod 70 is flattened to define a butterfly button 84 which holds the rod in place. As shown in Figure 8c the distal end 86 of each rod 70 is bent upon itself to define an enlarged end 88 which retains the reinforcement 38. As shown in Figure 8d, the distal end 90 of each rod 70 is bent upwardly to form leg 92 which retains the reinforcement layer in place in the angle iron 62.

[0028] As shown in Figure 9a to 9e, alternative arrangements may be used where the reinforcement layer

38 has the longitudinally extending rods 70 secured to the lower leg 94 of the angle iron 62. The lower leg 94 has an opening 96 formed therein to accommodate the rods 70. At the distal end 98 of each rod 70 is a deformed button 100 to secure the rod in place. Similarly with embodiments of Figures 9b, 9c and 9d, the respective distal end of each rod is deformed to secure the rod 70 in the lower leg portion 94. In Figure 9b, the distal end is flattened to define a butterfly button 102 which holds the rod 70 in place. In Figure 9c, the distal end is bent upon itself to define and enlarged end 104 which retains the rod 70 in place. In Figure 9d, the distal end is bent downwardly to form leg 106 which retains the rod 70 in place. In the embodiment in Figure 9e the rod 70 is bent upon itself at 108 and secured in place by rod wire 110.

[0029] It should be appreciated that the reinforcement layer interposed at each compacted layer of fill for the reinforced soil may take on a variety of structures and shapes. In addition to the wire grid structure set out above, it will be understood that other types of reinforcement may be used such as, individual strips 112 (see Figures 10a to 10l). As shown in Figure 10a, each end 114 of the strip is connected to the sidewall either directly or via a load distributing device such as the angle iron 62 of Figure 7. This type of strip is very common to the system originally developed by "VIDAL" which is described for example in French Patent No. 75/07114 published Oct. 1, 1976. As shown in Figure 10b, the strip 116 may be corrugated to enhance its load carrying capacity. An alternate corrugated strip 118 is shown in Figure 10c. A spiral strip 120 is shown in Figure 10d. In Figure 10e the reinforcement may be rods 122 with enlargements 124. Alternatively, ladder-like strips 126 and 128 may be used such as in Figures 10f and 10g.

[0030] The strips may also have enlarged portions such as shown in Figure 10h for strip 130 with enlarged sections 132. Alternatively, the strip 134 Figure 10i may have auger or propeller shaped units 136, as shown in Figure 10i. The outwardly extending rods 138 of Figures 10j, 10k and 10l may have enlarged disks 140, enlarged concrete masses 142 or flat plates 144 connected thereto to anchor the strips in the compacted fill. Alternatively, the strips, as well as the aforementioned wire grid mat may be configured to anchor into surrounding rock using suitable rock anchors.

[0031] With respect to the use of strips as reinforcement, the load distributing member 62, which is in the form of an angle iron, is connected to the sidewall 74 of the plate 48 by bolts 64 as shown in Figure 11 a. The strip for example 112 is then bolted to the angle iron 62 by bolt 146 to complete the connection. Alternatively, in Figure 11b the angle iron 62 may have the strip 118 connected thereto by the use of a pin 148, which extends through aperture 150 in the strip and aperture 152 in the leg 94 of the angle iron 62.

[0032] A further alternative configuration for the connection of the reinforcement to the arch-type structure is to use hook bolts 154 that capture the reinforcement. The application of backfill upon this connection maintains the reinforcement in place relative to the hook 154, obviating the need for the reinforcement to be locked in position. Shown in Figures 12a and 12b is the use of hook bolts for connecting the wire grid mats to the arch-type structure by way of an angle iron 62 to distribute the load. Figures 13a and 13b show the use of hook bolts 154 for connecting the wire grid mats wherein the bolts are connected directly to the sidewall 48 of the arch-type structure.

[0033] It will be appreciated that for the various types of reinforcement the strips and/or grid mats may be made of any type of material (i.e. steel, aluminum, composites, plastics, etc) which has sufficient structural strength to resist movement in the sidewall of the erected structure during backfilling and subsequent usage. It will be further appreciated that a combination of reinforcements (i.e. a combination of wire grid mats and corrugated strips) could be used in a single installation. This provides maximum flexibility when engineering into the design the required load bearing characteristics.

[0034] In applications where there are two or more adjacent structures, each having similar beveled/skewed ends, the reinforcements discussed above could be configured to attach to one another between the adjacent structures, thereby providing a level of enhanced support. Alternatively, the reinforcements could be arranged to lie atop one another, without connection, or arranged in a staggered, alternating configuration in the region between the structures, thereby strengthening the backfill contained therebetween.

[0035] While the above discussion has centered on an arch-type structure comprised of a plurality of interconnected structural metal plates to obtain the desired shape, the aforementioned reinforcement could be used with other corrugated metal plate technologies. It will be appreciated that the reinforcement described above could be used on similar structures wherein each circumferential span of the structure is defined by a single plate or a plurality of interconnected plates. Further, it will be appreciated that the geometry of the arch-type structure is not limited to those shown in the Figures, but may include any arch type structure including, but not limited to an ovoids, a re-entrant arch, a box culvert, round culvert or elliptical culvert.

[0036] It will be appreciated that while the above discussion refers to an arch-type structure having both a bevel and skew on a cut end, the aforementioned reinforcement may find application in structures that are solely beveled, or solely skewed. Further, it will be appreciated that while straight bevels and skews have been represented, inwardly or outwardly curved bevels and skews are also possible. It will also be appreciated that in providing a beveled/skewed cut end region, the cut section may be configured with either a smooth or stepped profile, as deemed appropriate for the particular application.

[0037] It will be noted that the completed arch-type structure shown in Figure 1 has at each end a concrete collar. This collar not only provides a finished appearance to the structure, but also provides an additional amount of support to the beveled/skewed ends. It is important to note, however, that a significant advantage of this technology is that this collar is no longer the primary support for the beveled/skewed end. As such, this concrete collar is not required to be as robust as in prior art structures, thereby simplifying construction and reducing cost.

[0038] A further advantage of this technology is that the structural metal plates used can be of lighter gauge as the ability to withstand the pressures exerted by the backfill in the beveled/skewed region is assisted by the aforementioned reinforcements.

[0039] In applications where round pipes or culverts are used to direct a watercourse, there is a tendency at the ends of a beveled/skewed pipe for the extended portions of the pipe to rise upwards due to pressures exerted by the water flow. The ability to reinforce the cut end region of these pipes would assists in inhibiting this deformation which generally has the end result of completely and/or partially blocking the opening.

[0040] In accordance with the above discussed embodiments, arch-type structures comprising at least one beveled/skewed end may be erected and backfilled in an efficient controlled cost-effective manner. The backfilling procedure does not require special fill or special techniques other than those already commonly used in developing reinforced soils. The procedure for securing the reinforcement to the sidewalls is achieved in a variety of ways where localized stress on the structure is minimized. Such a structure greatly reduces costs because it is no longer required to 'over-engineer' the structure to withstand the stresses in the beveled/skewed region, nor are costly reinforcements such as concrete end caps and tie-backs with anchors required.

[0041] Although embodiments have been described herein in detail, it will be understood by those skilled in the art that variations may be made thereto without departing from the spirit and scope thereof as defined by the appended claims.

Claims

1. A method of controlling deformation of a cut end region (22) of an erected arch-type structure (10) for use in underpass construction where the cut end region (22) defines at least one extended leg portion, said method comprising:

    i) building progressively a mechanically-stabilized earth structure adjacent said extended leg portion by alternately layering a plurality of compacted layers of fill (36) with interposed layers of reinforcement (38) generally to-the height of said extended leg portion;
    ii) securing to said extended leg portion each layer of reinforcement during said progressive building, whereby securement of said layers of reinforcement (38) to said extended leg portion provides support in controlling deformation of the cut end region (22) during backfilling and regular service; and
    iii) positioning a load distribution device between each layer of reinforcement and said extended leg portion to distribute load across said extended leg portion, thereby reducing point loads.

2. The method of claim 1 wherein said cut end region (22) defines extended leg portions on opposite sides of said arch-type structure (10) and wherein said building, securing and positioning steps are performed for each extended leg portion.

3. The method of claim 2 wherein the extended leg portions are of different heights and wherein the mechanically-stabilized earth structures adjacent the extended leg portions have differing numbers of fill (36) and reinforcement layers (38).

4. The method of claim 3, wherein said cut end region (22) of said arch-type structure (10) defines a beveled or skewed configuration.

5. The method of any one of claims 1 to 4, wherein the layers of reinforcement (38) are comprised of a combination of grid wire mats and a plurality of strips and wherein each layer of reinforcement is maintained in position by frictional forces within said associated mechanically-stabilized earth structure.

6. The method of claim 1, wherein each load distributing device is a segment of angle iron.

7. The method of any one of claims 1 to 4, wherein each layer of reinforcement comprises at least one wire grid mat comprising interconnected rods.

8. The method of claim 7, wherein at least one layer of reinforcement comprises a plurality of wire grid mats.

9. The method of any one of claims 1 to 4, wherein each layer of reinforcement is maintained in position by frictional forces within said associated mechanically-stabilized earth structure.

10. The method of any one of claims 1 to 4, wherein each layer of reinforcement is comprised of a plurality of strips.

11. The method of any one of claims 1 to 10, wherein each layer of reinforcement extends laterally away from said arch-type structure (10) in a generally horizontal configuration.

Patentansprüche

1. Verfahren zum Steuern der Verformung eines geschnittenen Endbereichs (22) einer errichteten gewölbeartigen Struktur (10) zur Verwendung bei Unterführungskonstruktionen, wobei der geschnittene Endbereich (22) wenigstens einen verlängerten Schenkelabschnitt bildet, wobei das Verfahren umfasst:

   i) progressives Bauen einer mechanisch stabilisierten Erdstruktur nahe dem verlängerten Schenkelabschnitt durch alternierendes Übereinanderschichten einer Vielzahl verdichteter Lagen von Schüttungen (36) mit dazwischen eingefügten Bewehrungsschichten (38) im Allgemeinen bis zur Höhe des verlängerten Schenkelabschnitts;
   ii) Sichern jeder Bewehrungsschicht während des progressiven Bauens an dem verlängerten Schenkelabschnitt, wobei das Sichern der Bewehrungsschichten (38) an dem verlängerten Schenkelabschnitt Unterstützung beim Steuern der Verformung des geschnittenen Endbereichs (22) während der Verfüllung und der regelmäßigen Wartung bereitstellt; und
   iii) Positionieren einer Lastverteilungsvorrichtung zwischen jeder Bewehrungsschicht und dem verlängerten Schenkelabschnitt, um Last über den verlängerten Schenkelabschnitt zu verteilen und dadurch Punktlasten zu reduzieren.

2. Verfahren nach Anspruch 1, wobei der geschnittene Endbereich (22) verlängerte Schenkelabschnitte an gegenüberliegenden Seiten der gewölbeartigen Struktur (10) bildet, und wobei die Schritte des Bauens, Sicherns und Positionierens für jeden verlängerten Schenkelabschnitt durchgeführt werden.

3. Verfahren nach Anspruch 2, wobei die verlängerten Schenkelabschnitte verschiedene Höhe haben, und wobei die mechanisch stabilisierten Erdstrukturen nahe der verlängerten Schenkelabschnitte eine unterschiedliche Anzahl von Schüttungs- (36) und Bewehrungsschichten (38) haben.

4. Verfahren nach Anspruch 3, wobei der geschnittene Endbereich (22) der gewölbeartigen Struktur (10) eine angeschrägte oder schräge Konfiguration bildet.

5. Verfahren nach einem der Ansprüche 1 bis 4, wobei die Bewehrungsschichten (38) aus einer Kombination von Drahtgittermatten und einer Vielzahl von Streifen bestehen, und wobei jede Bewehrungsschicht durch Reibungskräfte in der zugehörigen mechanisch stabilisierten Erdstruktur an Ort und Stelle gehalten wird.

6. Verfahren nach Anspruch 1, wobei jede Lastverteilungsvorrichtung ein Segment eines Winkeleisens ist.

7. Verfahren nach einem der Ansprüche 1 bis 4, wobei jede Bewehrungsschicht wenigstens eine Drahtgittermatte aufweist, die miteinander verbundene Stäbe aufweist.

8. Verfahren nach Anspruch 7, wobei wenigstens eine Bewehrungsschicht eine Vielzahl von Drahtgittermatten aufweist.

9. Verfahren nach einem der Ansprüche 1 bis 4, wobei jede Bewehrungsschicht durch Reibungskräfte in der zugehörigen mechanisch stabilisierten Erdstruktur an Ort und Stelle gehalten wird.

10. Verfahren nach einem der Ansprüche 1 bis 4, wobei jede Bewehrungsschicht aus einer Vielzahl von Streifen besteht.

11. Verfahren nach einem der Ansprüche 1 bis 10, wobei sich jede Bewehrungsschicht in im Allgemeinen horizontaler Konfiguration von der gewölbeartigen Struktur (10) seitlich weg erstreckt.

Revendications

1. Procédé de contrôle de la déformation d'une région d'extrémité de coupe (22) d'une structure de type arche construite (10) destinée à être utilisée dans une construction souterraine où la région d'extrémité de coupe (22) définit au moins une partie de montant étendue, ledit procédé comprenant :

   i) la construction progressive d'une structure terrestre mécaniquement stabilisée adjacente à ladite partie de montant étendue en superposant alternativement en couches une pluralité de couches compactées de remblai (36) avec des couches interposées de renforcement (38) généralement à la hauteur de ladite partie de montant étendue ;
   ii) la fixation à ladite partie de montant étendue de chaque couche de renforcement durant ladite construction progressive, moyennant quoi la fixation desdites couches de renforcement (38) à ladite partie de montant étendue fournit un support pour contrôler la déformation de la région d'extrémité de coupe (22) durant le remblaiement et le service normal ; et
   iii) le positionnement d'un dispositif de distribution de charge entre chaque couche de renforcement et ladite partie de montant étendue pour distribuer la charge à travers ladite partie de montant étendue, en réduisant de ce fait les

charges ponctuelles.

2. Procédé selon la revendication 1, dans lequel ladite région d'extrémité de coupe (22) définit des parties de montant étendues sur des côtés opposés de ladite structure de type arche (10) et dans lequel lesdites étapes de construction, de fixation et de positionnement sont exécutées pour chaque partie de montant étendue.

3. Procédé selon la revendication 2, dans lequel les parties de montant étendues sont de hauteurs différentes et dans lequel les structures terrestres mécaniquement stabilisées adjacentes aux parties de montant étendues ont des nombres différents de couches de remblai (36) et de renforcement (38).

4. Procédé selon la revendication 3, dans lequel ladite région d'extrémité de coupe (22) de ladite structure de type arche (10) définit une configuration biseautée ou inclinée.

5. Procédé selon l'une quelconque des revendications 1 à 4, dans lequel les couches de renforcement (38) sont constituées d'une combinaison de tapis à grillage métallique et d'une pluralité de bandes et dans lequel chaque couche de renforcement est maintenue en position par les forces de frottement au sein de ladite structure terrestre mécaniquement stabilisée associée.

6. Procédé selon la revendication 1, dans lequel chaque dispositif de distribution de charge est un segment d'une cornière.

7. Procédé selon l'une quelconque des revendications 1 à 4, dans lequel chaque couche de renforcement comprend au moins un tapis à grillage métallique comprenant des tiges interconnectées.

8. Procédé selon la revendication 7, dans lequel au moins une couche de renforcement comprend une pluralité de tapis à grillage métallique.

9. Procédé selon l'une quelconque des revendications 1 à 4, dans lequel chaque couche de renforcement est maintenue en position par les forces de frottement au sein de ladite structure terrestre mécaniquement stabilisée associée.

10. Procédé selon l'une quelconque des revendications 1 à 4, dans lequel chaque couche de renforcement est constituée d'une pluralité de bandes.

11. Procédé selon l'une quelconque des revendications 1 à 10, dans lequel chaque couche de renforcement s'étend latéralement à l'écart de ladite structure de type arche (10) dans une configuration généralement horizontale.

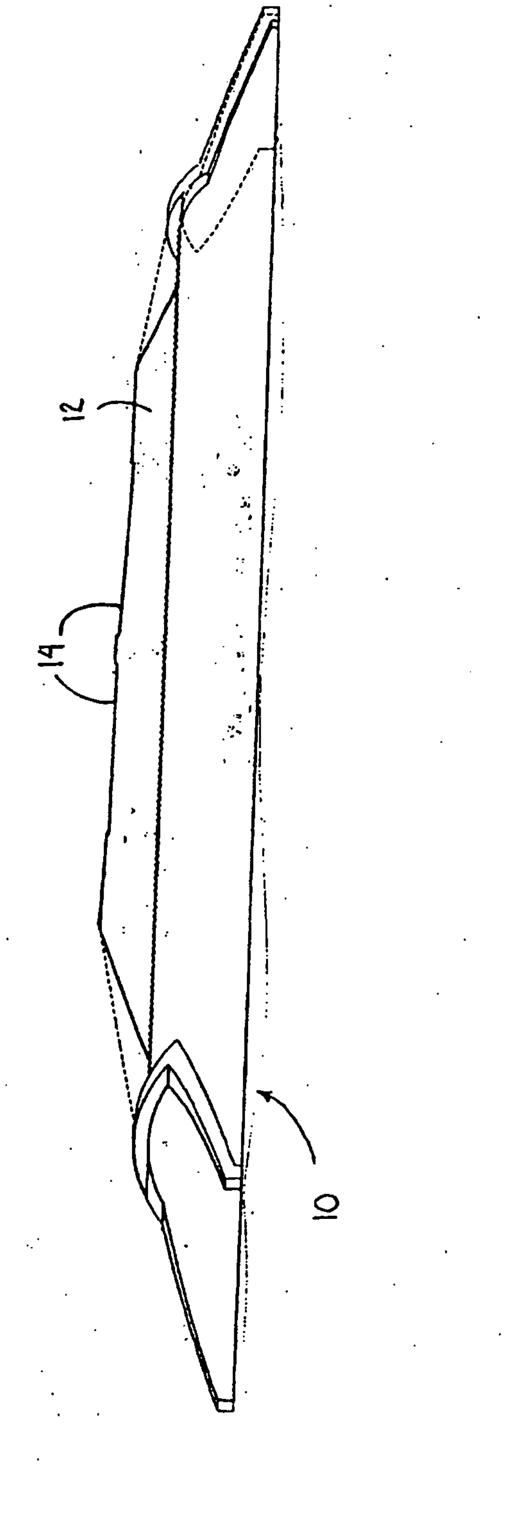


FIGURE 1

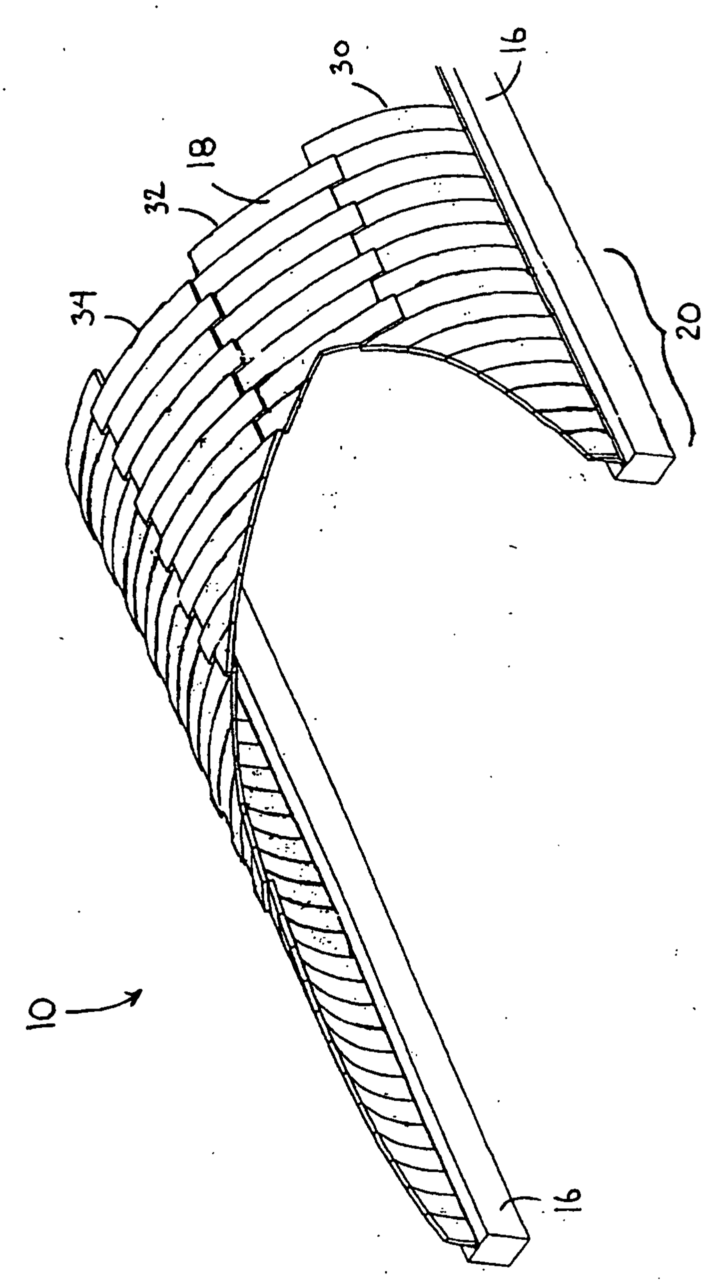


FIGURE 2

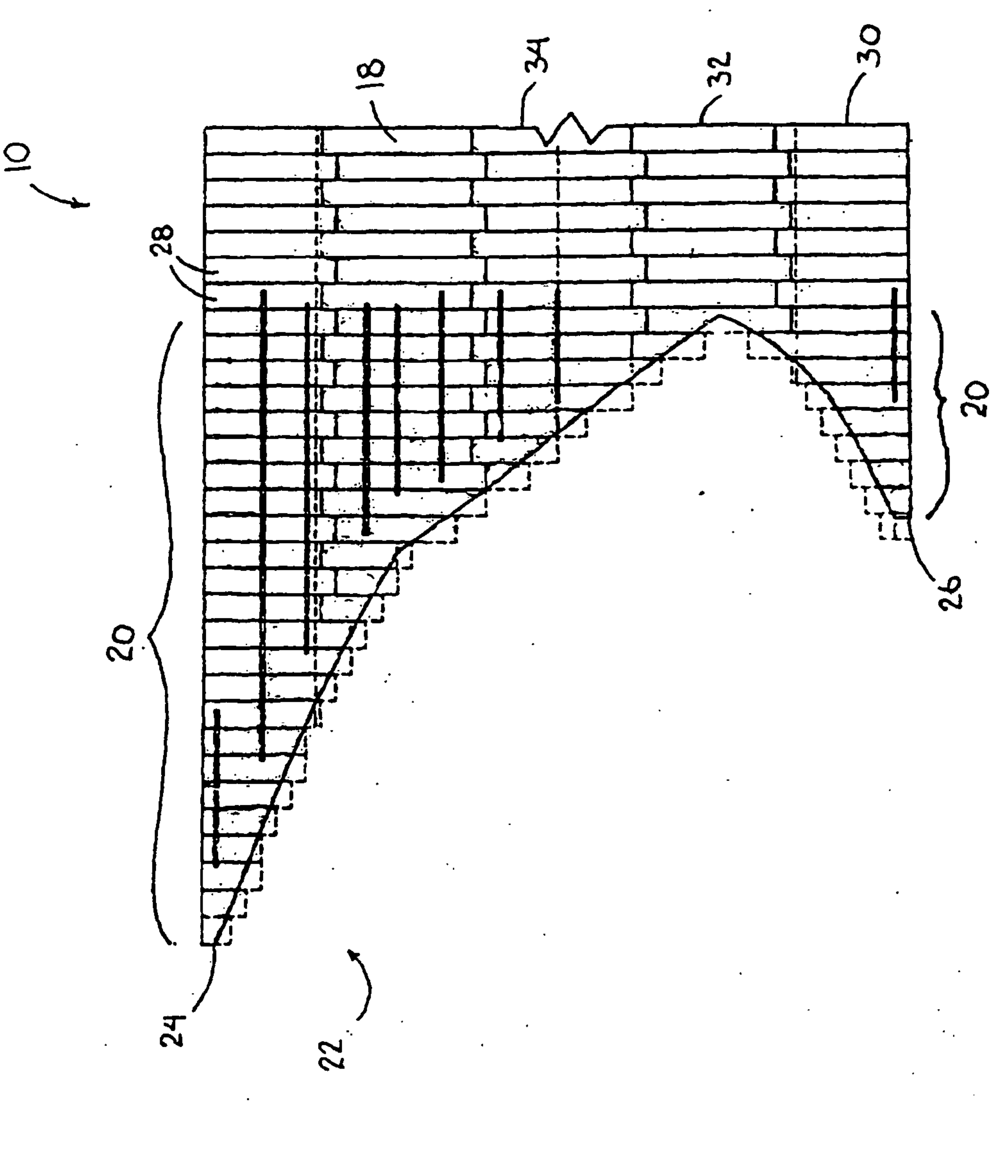


FIGURE 3

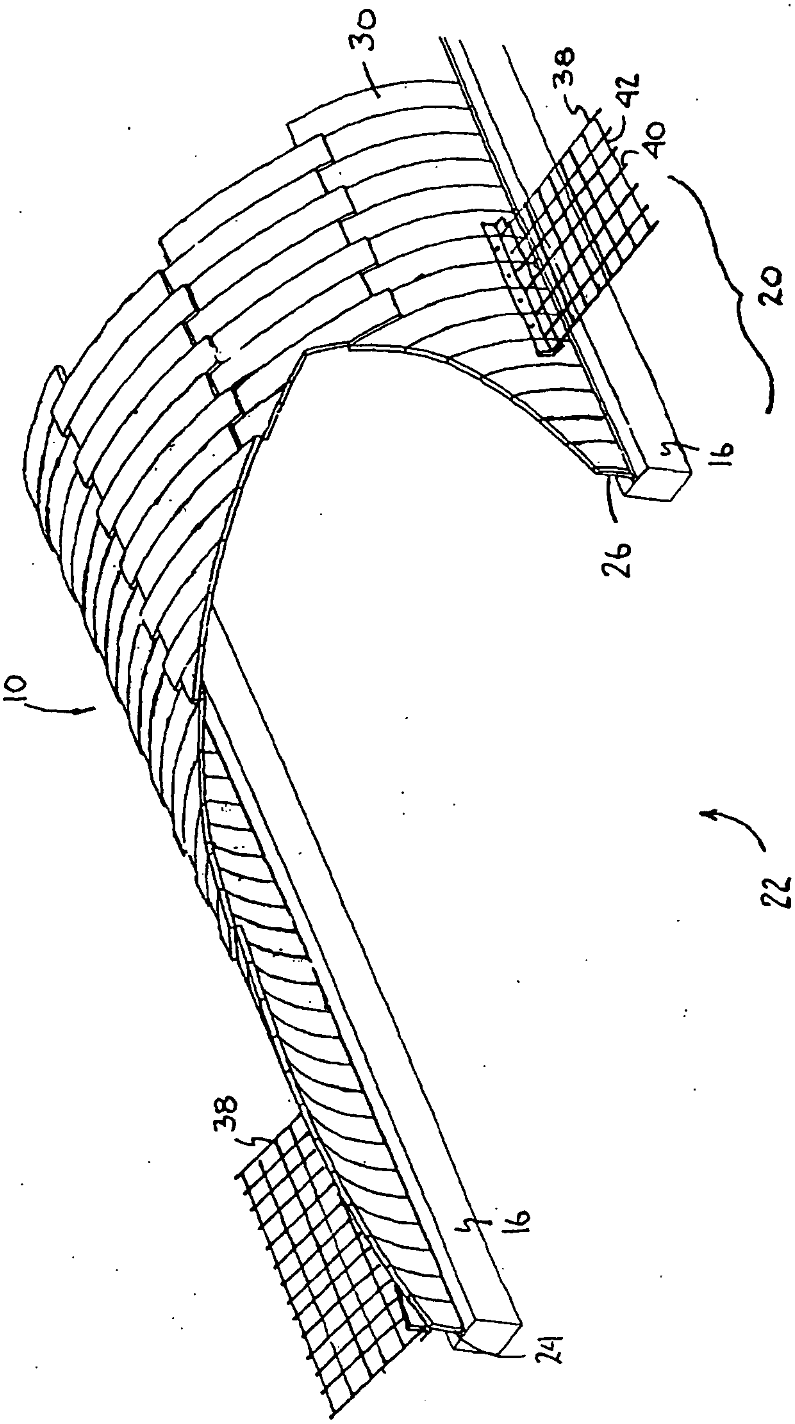


FIGURE 4a

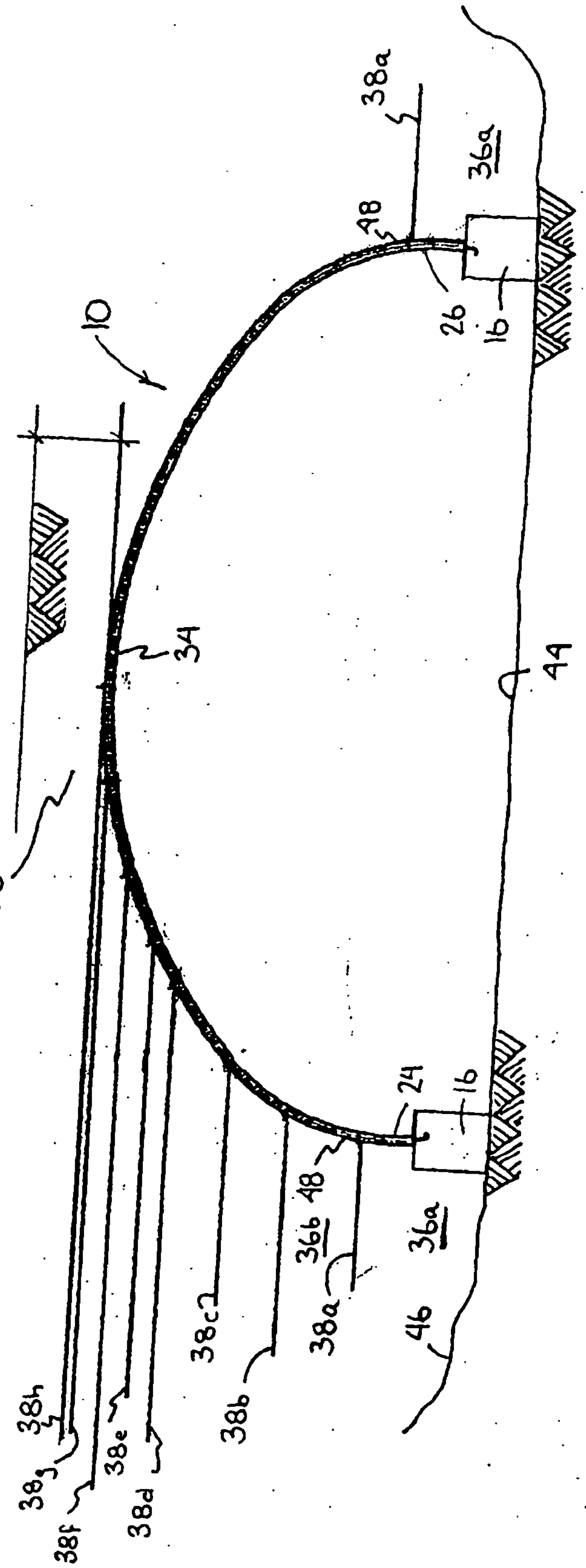


FIGURE 4b

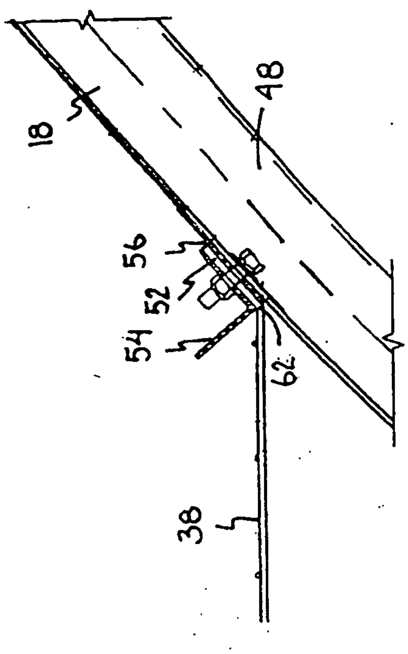


FIGURE 5a

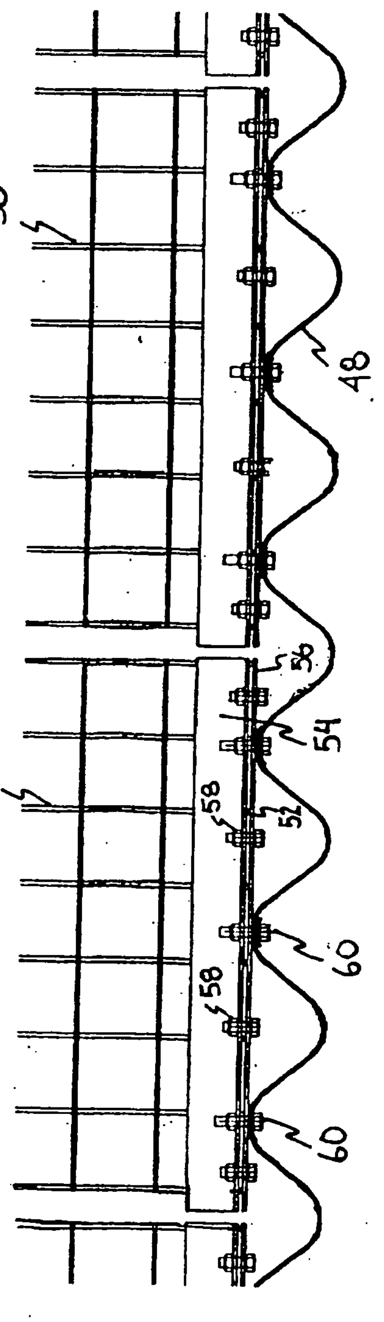


FIGURE 5b

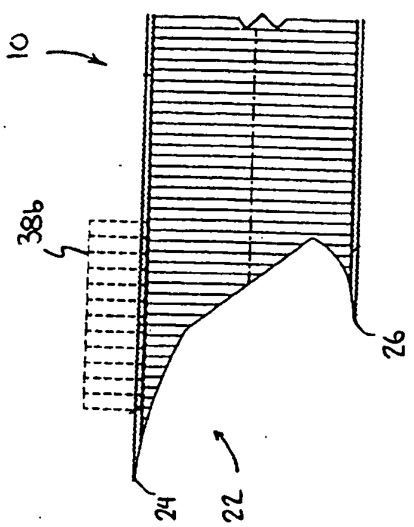


FIGURE 6b

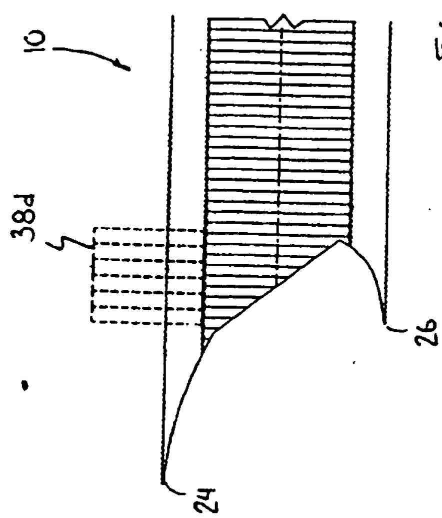


FIGURE 6d

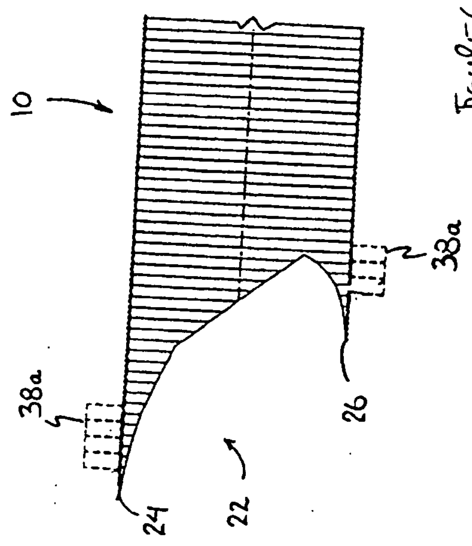


FIGURE 6a

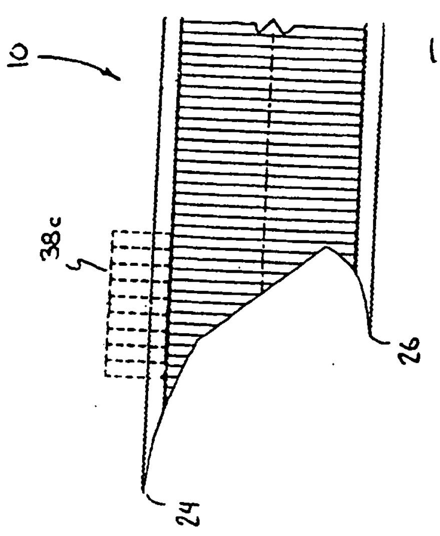


FIGURE 6c

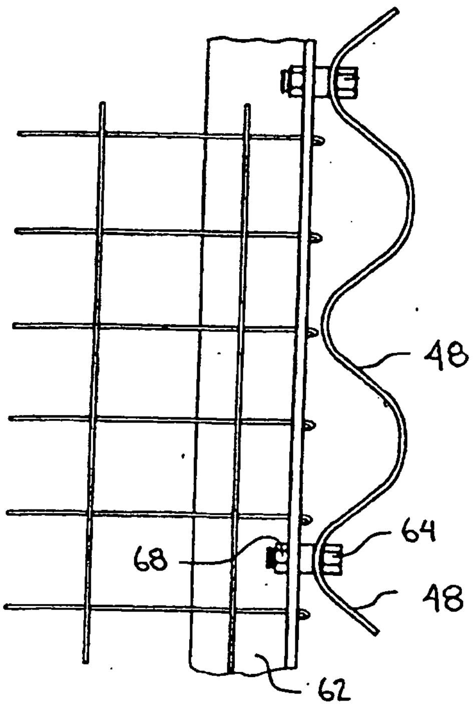


FIGURE 7

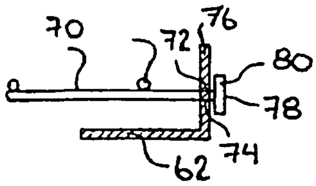


FIGURE 8a

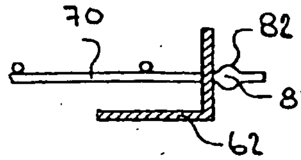


FIGURE 8b

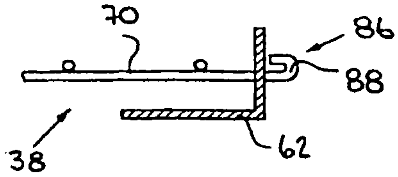


FIGURE 8c

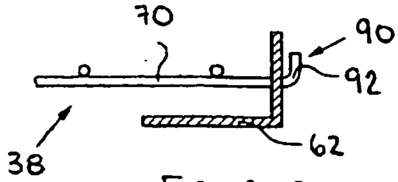


FIGURE 8d

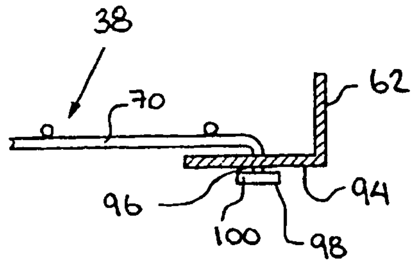


FIGURE 9a

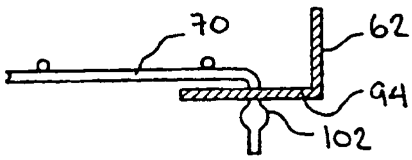


FIGURE 9b

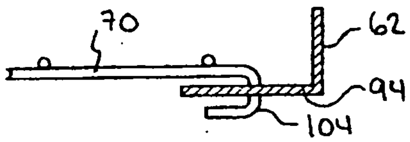


FIGURE 9c

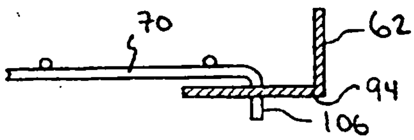


FIGURE 9d

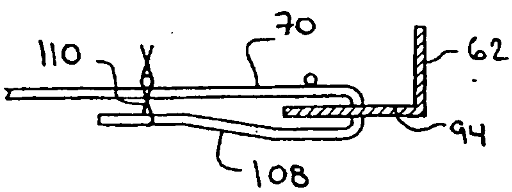


FIGURE 9e

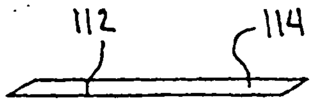


FIGURE 10a

FIGURE 10b

FIGURE 10c

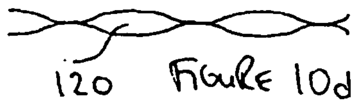


FIGURE 10d

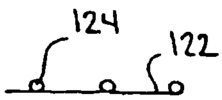


FIGURE 10e

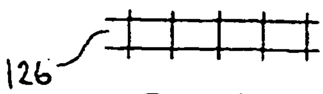


FIGURE 10f

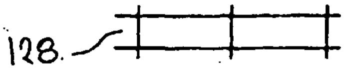


FIGURE 10g

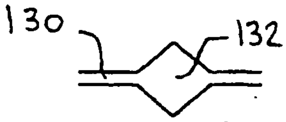


FIGURE 10h

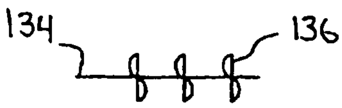


FIGURE 10i

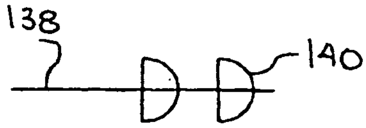


FIGURE 10j

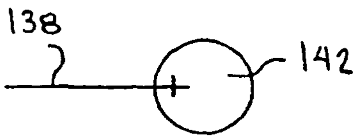


FIGURE 10k

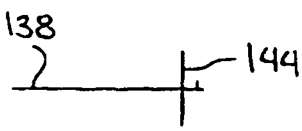


FIGURE 10l

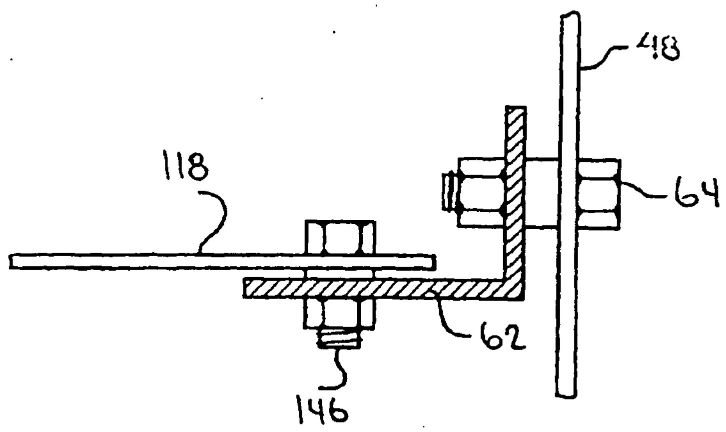


FIGURE 11a

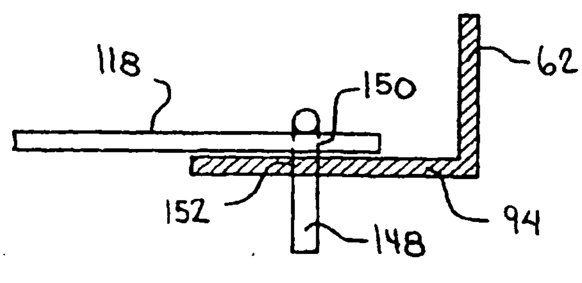
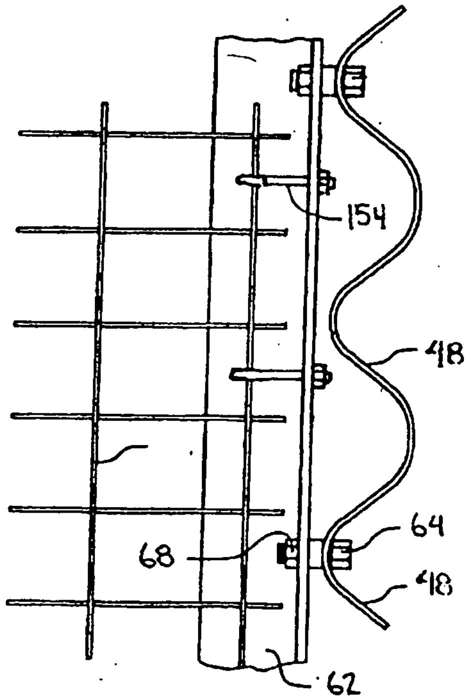


FIGURE 11b



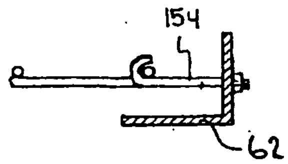


FIGURE 12b

FIGURE 12a

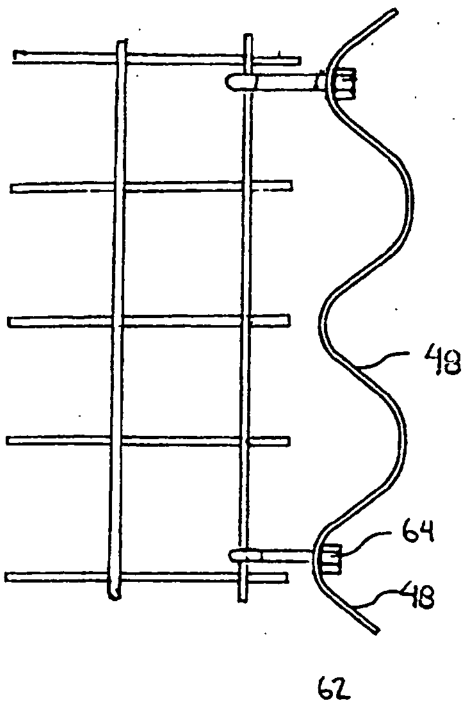


FIGURE 13a

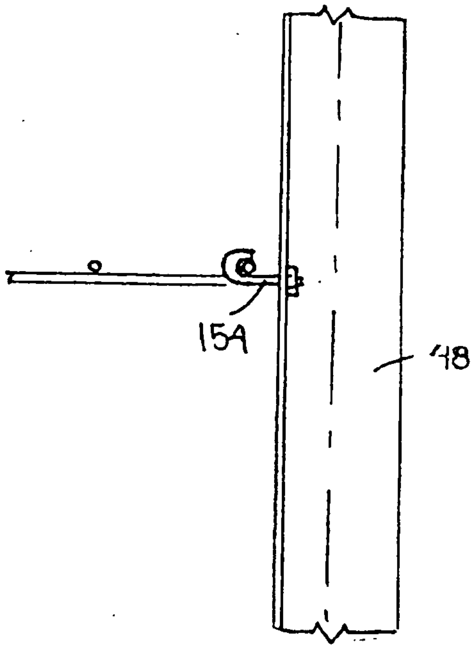


FIGURE 13b

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 5118218 A **[0003]**
- GB 2140848 A **[0003]**
- US 5326191 A **[0004] [0014]**
- US 5375943 A **[0004] [0014]**
- CA 9700407 W **[0004] [0014]**
- US 4618283 A **[0005] [0008] [0019]**
- US 6050746 A **[0006] [0014] [0023]**
- US 6640505 B1 **[0007]**
- FR 7507114 **[0029]**