Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).
Description

CROSS-REFERENCES

[0001] This application claims the benefit of U.S. Provisional Application Serial No. 61/535,565, filed September 16, 2011, which is incorporated herein by reference.

TECHNICAL FIELD

[0002] The present application relates to the general art of precast concrete bridge and culvert units, and to the particular field of four-sided bridge and culvert units.

BACKGROUND

[0003] Overfilled bridge structures are frequently formed of precast reinforced four-sided concrete units commonly referred to as arch units, arch culverts, box units or box culverts. As used herein the terminology four-sided bridge unit encompasses all of such structures. The units are used in the case of bridges to support one pathway over a second pathway, which can be a waterway. Four-sided bridge units have a bottom wall structure that facilitates on-site placement with reduced need for foundation preparation.

[0004] In the past, the four-sided bridge units of overfilled bridge structures have been constructed with bottom wall structures having a generally planar and continuous top surface and a generally uniform thickness. There is an increasing demand for construction efforts to provide more natural environments and/or to decrease impact on wildlife.

[0005] A four-side bridge unit adapted to create a more natural environment through the pathway defined by the bridge units and/or adapted to reduce impact on fish migrations would be desirable.

[0006] US 2010/226721 A1 discloses modules for use in an assembly for managing the flow of water beneath a ground surface and assemblies of such modules. The modules include supports and a deck portion and the supports are spaced apart and form channels with a main section of the deck portion. The deck portion also includes at least one section extending from a main section.

[0007] US 4360042 A discloses a foldable conduit having a generally parabolic arched portion and a flat base. The arched portion comprises a pair of corrugated side walls which are connected with a hinge. The corrugations comprise alternating peak portions and valley portions. The flat base is a flexible sheet which may be perforated to permit fluid ingress and egress.

SUMMARY

[0008] In one aspect, there is provided, a method of providing an environmentally appealing region for water flow along a surrounded pathway tunnel, the method comprising: providing a plurality of four-sided concrete bridge units in abutting relationship to create a surrounded pathway tunnel, one end of the tunnel located upstream along a water path and an opposite end of the tunnel located downstream along the water path; allowing water to flow through the surrounded pathway tunnel during a rain or other flow event; and providing a multiplicity of the four-sided bridge units with a corresponding bottom wall structure that interacts with the flowing water and earthen material in the flowing water such that capture and settling of the earthen material at locations along the tunnel occurs to produce a more natural water flow pathway along the tunnel; the method being characterized by providing the bottom wall structure of each of the multiplicity of the four-sided bridge units with a plurality of through openings such that at least forty percent of the bottom wall structure is open. For example, at least fifty percent of the bottom wall structure of each of the multiplicity of the four-sided bridge units may be open.

[0009] A lip structure may be provided at a top portion of at least some of the through openings, the lip structure facing upstream.

[0010] The plurality of openings of each bottom wall structure may be arranged in rows that extend along a span of the respective four-sided bridge unit.

[0011] The plurality of openings may be formed in the shape of elongated slots, each elongated slot defining a row, such that multiple beams are formed in the bottom wall structure and also extend along the span. At least one beam with a height that is greater than a height of another beam, the higher beam interacting with the flowing water and earthen material to reduce flow velocity and thereby enhance settling out of earthen material. By providing a lip structure along at least one beam, the lip structure extending in an upstream direction into an adjacent elongated slot, wash out of earthen material that has settled in the adjacent elongated slot can be limited.

[0012] The plurality of openings may be provided as multiple series of openings, each series of openings forming a respective row. By staggering openings of adjacent rows, nesting of the openings is achieved. By providing upper lip structure along one or more edges of at least some of the openings, the lip structure extending into its respective opening, wash out can be limited.

[0013] By providing the bottom wall structure of each of the multiplicity of the four-sided bridge units with a recessed portion, a low flow channel through which marine life can travel is created.

[0014] In another aspect, there is provided an overfilled bridge system, comprising a plurality of four-sided concrete bridge units arranged in abutting relationship to create a surrounded pathway tunnel, one end of the tunnel located upstream along a water path and an opposite end of the tunnel located downstream along the water path; wherein each of a multiplicity of the four-sided bridge units includes a corresponding bottom wall structure that is configured to interact with the flowing water and earthen material in the flowing water such that capture and settling of the earthen material at multiple loca-
tions along the tunnel occurs to produce a more natural water flow pathway along the tunnel; characterized in that the bottom wall structure of each of the multiplicity of the four-sided bridge units includes a plurality of through openings such that at least forty percent of the bottom wall structure is open.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

Fig. 1 is a perspective view of one embodiment of a four-sided bridge unit.

Fig. 2 is an end elevation of the bridge unit of Fig. 1;

Fig. 3 is a cross section along line 3-3 of Fig. 2;

Fig. 4 is bottom view of the bridge unit of Fig. 1;

Fig. 5 is a cross-sectional view of two bridge units of Fig. 1 arranged edge to edge;

Fig. 6 is an enlarged partial view of the cross-section of Fig. 5;

Fig. 7 shows a partial cross-section of an embodiment of a unit with both upstream and downstream facing lips;

Fig. 8 shows a partial cross-section of an embodiment of a unit in which the beams all have a common height;

Figs. 9 and 10 show perspective views of another embodiment of a four-sided bridge unit in which continuous haunches are provided in the corners where the bottom wall meets the side walls;

Fig. 11 is a perspective view of yet another embodiment of a four-sided bridge unit;

Fig. 12 is an end elevation of the bridge unit of Fig. 11;

Fig. 13 is a cross section along line 13-13 of Fig. 12;

Fig. 14 is bottom view of the bridge unit of Fig. 11;

Fig. 14A is a partial cross-section along line 14A of Fig. 14;

Fig. 15 is a perspective view of still another embodiment of a four-sided bridge unit;

Fig. 16 is an end elevation of the bridge unit of Fig. 15;

Fig. 17 is a cross section along line 17-17 of Fig. 16;

Fig. 18 is bottom view of the bridge unit of Fig. 15;

Figs. 19A-B show another embodiment of a bridge unit;

Fig. 20A-C show another embodiment of a bridge unit;

Fig. 21A-C show another embodiment of a bridge unit;

Fig. 22 shows a plurality of four-sided units arranged along a water flow path; and

Fig. 23 shows a schematic end elevation of the system of Fig. 22 as buried.

DETAILED DESCRIPTION

[0016] Referring to Figs. 1-4, a four-sided precast concrete bridge unit 10 is shown. In the illustrated embodiment bridge unit 10 is formed by a generally horizontal extending bottom wall 12, substantially vertically upward extending side walls 14 and 16 at the ends of the bottom wall and a top wall 18 having a generally arch-shaped configuration. However, four sided bridge units having top walls other than arch-shaped (e.g., flat top walls) are also contemplated. Likewise, side walls other than vertical are possible. As used herein, the terms "length" and "span" of an individual unit or portions of the unit refers to a horizontal dimension extending parallel with the direction of arrow 20 (which is substantially perpendicular to a horizontal through axis 22 of the unit) and the terms "width" and "depth" of the individual unit or portions of the unit refer to a horizontal dimension extending parallel to the through axis 22. As used herein the term "arch" and "arch-shaped" when referring to the top of an arch unit means a curved shape (including constant radius curves, curves with multiple radii, curves with continuously varying radius) or any top wall shape that is higher in the middle of the top wall as opposed to where the top wall meets the side walls (e.g., an inverted V-shape or a combination of three or more planar segments angularly arranged with respect to each other to produce a vaulted top wall or a combination of curved segments and flat segments that produce a vaulted top wall).

[0017] The bottom, top and side walls are preferably precast as a single monolithic structure in a single casting operation. However, in certain implementations, one or more walls may be cast separately and then connected together by suitable connecting structure (e.g., reinforcing bars or by casting one or more elements separately and then placing that cast element in the formwork that is used to cast the final structure).

[0018] The bottom wall 12 of the unit 10 is shaped and configured to facilitate both sedimentation within and passage of marine life once the unit is installed. Specifically, the bottom wall 12 includes a plurality of elongated, spanwise extending through openings that extend completely through the thickness of the bottom wall 12. As shown, each elongated opening 24 has a length L₁ that is at least about sixty percent of the overall width of the unit L₀ (e.g., L₁ is at least about 70% of L₀, such as for example, between 80% and 95% of L₀). However, other variations are possible. Intermediate beams 26 separate the elongated openings 24 and serve to maintain a rigid connection between the lower ends of the side walls 14 and 16. Edge located beams 28 are also provided, thereby providing a continuous peripheral support surface at the lower side of the bottom wall. The lower surface of each beam 28 is preferably in common plane with the continuous peripheral support surface to provide added stability and distribution of loads. As shown, roughly about 40% to 60% (e.g., about 45% to 55%) of the lower side of the bottom wall makes up the support or resting surface of the bridge unit and the remainder (about 60% to 40%) is open via the openings 24. However, other variations are possible. Lengthwise extending reinforcement may be provided in each of the beams for structural integrity, with some continuity provided between that re-
Referring to Fig. 6, as water flows through the vicinity of an opening 24 which tends to cause sediment to drop out of the flow and into the opening. The lip structure 32 helps prevent washout of any sediment that builds up in the openings 24. The lip structures 32 helps prevent washout of any sediment that tends to cause sedimentation and reduce washout effects. The lip structure may be upstream facing lip structure 66, downstream facing lip structure 64 and/or lengthwise facing lip structure 68.

In the illustrated embodiment, the connection of every other beam to the vertical side wall includes a haunch 46, which may include reinforcement, to resist the moment loads in the corners. Placing the haunches in a spaced apart manner, rather than providing a continuous haunch, can also help promote sedimentation. However, continuous haunches are also contemplated for some applications, as reflected in the embodiment of Figs. 9 and 10. In this embodiment, the relative length of the slotted openings 24 (as compared to overall length of the unit) is smaller than that shown in Fig. 4 in order to accommodate the haunch 46. Moreover, Figs. 9 and 10 show a four-sided bridge unit with a flat top wall structure rather than an arched top wall structure.

While the embodiment of Figs. 1-6 contemplates upstream facing lips only, in an alternative embodiment downstream facing lips may also be provided on the beams as shown in Fig. 7. Likewise, embodiments in which all the beams have a common height are contemplated, as shown in Fig. 8.

An alternative embodiment of a four-side bridge unit 50 adapted for sedimentation is shown in Figs. 11-14. As shown, the bottom wall 52 of the bridge unit 50 includes a plurality of openings 54. The openings are arranged in a plurality of lengthwise extending rows 56 and 58, with the rows 56 and 58 arranged in an alternating and staggered relationship that provides some nesting of the openings of one row into the spaces between the openings of another row. The openings are distributed along a lengthwise extending mid-portion LO of the bottom wall 52 that represents between about 50% to about 80% of the overall length LU of the bottom wall of the unit. In this manner, the bottom wall lacks any openings in roughly about the first 10% to 25% of the extent of the bottom wall from its ends. Reinforcement 60 may be located in this area for structural integrity. Likewise, as the edges of the bottom wall are continuous, lengthwise reinforcement 62 may be included along such edges as well. About 75% to about 90% of the bottom wall in the mid-portion LO may be open space, while only about 55% to about 70% of the overall area of the bottom wall (as viewed from the bottom) may be open space. As shown in Fig. 14A, the openings 54 may include lip structure to promote sedimentation and reduce washout effects. The lip structure may be upstream facing lip structure 66, downstream facing lip structure 64 and/or lengthwise facing lip structure 68.

A further embodiment of a four-sided bridge unit 70 is shown in Figs. 15-18. In this embodiment the openings 74 of the unit actually include rows of partial openings along each edge. The partial openings 74 are preferably about one half the size of a regular opening such that when one unit is abutted with another unit the partial openings combine to effectively form an opening similar in size and shape to the openings 74. The mid-point arrangements of the openings along the length of the bot-
tom wall 72 may be similar to that of the embodiment of Figs. 11-14, with reinforcement 76 in the end areas of the bottom wall 72. However, due to the edge openings 74’, no reinforcement is provided in the mid-section where the openings are located. The openings 74 of the unit 70 may also include lip structure as described relative to Fig. 14A.

[0027] It is to be clearly understood that the above description is intended by way of illustration and example only and is not intended to be taken by way of limitation, and that changes and modifications are possible. For example, other possible unit configurations are reflected in Figs. 19A-19B, 20A-C and 21A-C. For reference, the unit 90 of Figs. 19A-B, includes lengthwise extending openings 82 having ends adjacent the side walls 84, alternatingly raised 86 and lowered 88 beams and upstream facing lips, with no haunches or gusseting between the bottom wall and the side walls. The unit 90 of Figs.20A-C is similar to that of Figs. 19A-B but also includes reduced thickness sections in the beams to provide a low flow channel 92. The unit 100 of Figs. 21A-C includes beams and slots with ends spaced from the side walls, and no haunches or gussets, such that the corner areas between the bottom wall and the side walls form low flow areas.

[0028] Fig. 22 shows a plurality of four-sided concrete bridge units, which could be any of the unit configurations previously described, in abutting relationship to create a surrounded pathway tunnel 110. One end 112 of the tunnel is located upstream along a water path 114 and an opposite end 116 of the tunnel is located downstream along the water path 114. Fig. 23 shows the units in profile as buried in earthen material 118. Fig. 23 could also represent a series of buried units used for the purpose of storm water collection, with infiltration into the surrounding earth occurring through the openings in the bottom walls of the units.

[0029] At least some of the through openings may include an upper lip structure at least part of which faces upstream. The first beam may include an upper lip structure extending in an upstream direction into an adjacent elongated slot and be configured to limit wash out of earthen material that has settled in the adjacent elongated slot. The openings of adjacent rows may be staggered to provide nesting of the openings. Multiple openings of each of the multiplicity of four-sided bridge units may include an upper lip structure along one or more edges, the lip structure extending into its respective opening.

[0030] In accordance with another aspect, the invention may consist in a structure, comprising a four-sided concrete unit buried in earthen materials, the four sided bridge unit having a top wall, a bottom wall and a first and second side walls connecting the top wall to the bottom wall, wherein the bottom wall includes multiple openings therein for allowing water to infiltrate through the bottom wall into the earthen material. The plurality of openings of the bottom wall may be arranged in rows that extend along a span of the four-sided bridge unit. The plurality of openings may be in the shape of elongated slots, each elongated slot defining a row, such that multiple beams are formed in the bottom wall structure and also extend along the span and act to transfer load to the ground below the unit.

[0031] Other embodiments are contemplated and modifications and changes could be made without departing from the scope of the appended claims.

Claims

1. A method of providing an environmentally appealing region for water flow along a surrounded pathway tunnel, the method comprising:

   providing a plurality of four-sided concrete bridge units (10;50;70;90) in abutting relationship to create a surrounded pathway tunnel (110), one end (112) of the tunnel (110) located upstream along a water path (114) and an opposite end (116) of the tunnel (110) located downstream along the water path (114); allowing water to flow through the surrounded pathway tunnel (110) during a rain or other flow event; and

   providing a multiplicity of the four-sided bridge units (10;50;70;90) with a corresponding bottom wall structure (12;52,72) that interacts with the flowing water and earthen material in the flowing water such that capture and settling of the earthen material at locations along the tunnel (110) occurs to produce a more natural water flow pathway along the tunnel (110); the method being characterized by:

   providing the bottom wall structure (12;52,72) of each of the multiplicity of the four-sided bridge units (10;50;70;90) with a plurality of through openings (24;54;74;82) such that at least forty percent of the bottom wall structure (12;52,72) is open.

2. The method of claim 1, wherein at least fifty percent of the bottom wall structure (12;52,72) of each of the multiplicity of the four-sided bridge units (10;50;70;90) is open.

3. The method of claim 1 or 2, further comprising arranging the plurality of openings (24;54;74;82) of each bottom wall structure (12;52,72) in rows (56,58) that extend along a span of the respective four-sided bridge unit (10;50;70;90).

4. The method of claim 3, further comprising providing the plurality of openings (24) in the shape of elongated slots, each elongated slot defining a row, such that multiple beams (26,28) are formed in the bottom wall structure (12) and also extend along the span.

5.
5. The method of claim 4, further comprising providing at least one beam (26,28) with a height that is greater than a height of another beam (26,28), the higher beam interacting with the flowing water and earthen material to reduce flow velocity and thereby enhance settling out of earthen material.

6. The method of claim 3, further comprising providing the plurality of openings (54) as multiple series of openings, each series of openings forming a respective row (56,58).

7. The method of any preceding claim, wherein in each of the multiplicity of the four-sided bridge units (10;50;70;90) haunch sections (46) connect the bottom wall structure (12;52;72) with side walls (14,16) of the respective four-sided bridge unit (10;50;70;90).

8. An overfilled bridge system, comprising:

   a plurality of four-sided concrete bridge units (10;50;70;90) arranged in abutting relationship to create a surrounded pathway tunnel (110), one end of the tunnel (110) located upstream along a water path and an opposite end of the tunnel located downstream along the water path;

   wherein each of a multiplicity of the four-sided bridge units (10;50;70;90) includes a corresponding bottom wall structure (12;52;72) that is configured to interact with the flowing water and earthen material in the flowing water such that capture and settling of the earthen material at multiple locations along the tunnel (110) occurs to produce a more natural water flow pathway along the tunnel (110);

   characterized in that:

   the bottom wall structure (12;52;72) of each of the multiplicity of the four-sided bridge units (10;50;70;90) includes a plurality of through openings (24;54;74;82) such that at least forty percent of the bottom wall structure (12;52;72) is open.

9. The system of claim 8, further comprising:

   earthen material, deposited from flowing water, settled at the multiple locations.

10. The system of claim 8 or 9, wherein at least fifty percent of the bottom wall structure (12;52;72) of each of the multiplicity of the four-sided bridge units (10;50;70;90) is open.

11. The system of claim 8, 9 or 10, wherein the plurality of openings (24;54;74;82) of each bottom wall structure (12;52;72) are arranged in rows (56,58) that extend along a span of the respective four-sided bridge unit (10;50;70;90).

12. The system of claim 11, wherein the plurality of openings (24) are configured as elongated slots, each elongated slot defining a row, such that multiple beams (26,28) are formed in the bottom wall structure (12) and also extend along the span.

13. The system of claim 12, wherein at least a first beam (26,28) of each of the multiplicity of four-sided bridged units (10) has a height that is greater than a height of another beam (26,28), the first beam (26,28) configured to interact with the flowing water and earthen material to reduce flow velocity and thereby enhance settling out of earthen material.

14. The system of claim 11, wherein the plurality of openings (54) are arranged as multiple series of openings, each series of openings forming a respective row (56, 58).

15. The system of any one of claims 8 to 14, wherein the bottom wall structure (12;52;72) of each of the multiplicity of the four-sided bridge units (10;50;70;90) includes a recessed portion (48) to create a low flow channel (92) through which marine life can travel.

**Patentansprüche**

1. Verfahren zum Vorsehen eines umweltverträglichen Bereichs für einen Wasserstrom entlang eines umgebenden Durchgangstunnels, wobei das Verfahren umfasst:

   Vorsehen einer Mehrzahl vierseitiger Beton-Brücken-Einheiten (10; 50; 70; 90), die auf Stoß angeordnet sind, zum Erzeugen eines umgebenden Durchgangstunnels (110), wobei ein Ende (112) des Tunnels (110) stromaufwärts entlang eines Wasserwegs (114) und ein entgegengesetztes Ende (116) des Tunnels (110) stromabwärts entlang des Wasserwegs (114) angeordnet ist;

   Ermöglichen, dass Wasser während eines Regens oder eines anderen Fließereignisses durch den umgebenden Durchgangstunnel (110) fließt; und

   Vorsehen einer Vielzahl der vierseitigen Brücken-Einheiten (10; 50; 70; 90) mit einer entsprechenden Bodenwandungsstruktur (15; 52; 72), die mit dem fließenden Wasser und Erdreichmaterial in dem fließenden Wasser in Wechselwirkung tritt, sodass ein Auffangen und Ablagern des Erdreichmaterials an Orten ent-
lang des Tunnels (110) geschieht, um einen natürlicheren Wasserweg entlang des Tunnels (110) zu erzeugen; wobei das Verfahren gekennzeichnet ist durch:

Versehen der Bodenwandungsstruktur (12; 52; 72) einer jeden der Vielzahl der vierseitigen Brücken-Einheiten (10; 50; 70; 90) mit einer Mehrzahl von Durchgangsöffnungen (24; 54; 74; 82), sodass mindestens vierzig Prozent der Bodenwandungsstruktur (12; 52; 72) offen ist.

2. Verfahren gemäß Anspruch 1, wobei mindestens fünfzig Prozent der Bodenwandungsstruktur (12; 52; 72) einer jeden der Vielzahl vierseitigen Brücken-Einheiten (10; 50; 70; 90) offen ist.

3. Verfahren gemäß Anspruch 1 oder 2, ferner umfassend Anordnen der Mehrzahl von Öffnungen (24; 54; 74; 82) einer jeden Bodenwandungsstruktur (12; 52; 72) in Reihen (56, 58), die sich entlang einer Spannweite der jeweiligen vierseitigen Brücken-Einheit (10; 50; 70; 90) erstrecken.

4. Verfahren gemäß Anspruch 3, ferner umfassend Vorsehen der Mehrzahl von Öffnungen (24) in der Form länglicher Schlitz, wobei jeder längliche Schlitz eine Reihe definiert, sodass mehrere Balken (26, 28) in der Bodenwandungsstruktur (12) ausgebildet werden und sich auch entlang der Spannweite erstrecken.

5. Verfahren gemäß Anspruch 4, ferner umfassend Vorsehen mindestens eines Balkens (26, 28) mit einer Höhe, die größer als eine Höhe eines anderen Balkens (26, 28) ist, wobei der höhere Balken mit dem fließenden Wasser und Erdreichmaterial in Wechselwirkung tritt, um eine Strömungsgeschwindigkeit zu verringern und dadurch das Ablagern des Erdreichmaterials zu fördern.

6. Verfahren gemäß Anspruch 3, ferner umfassend Vorsehen der Mehrzahl von Öffnungen (54) als mehrere Serien von Öffnungen, wobei jede Serie von Öffnungen eine entsprechende Reihe (56, 58) bildet.

7. Verfahren gemäß einem der vorhergehenden Ansprüche, wobei in jeder der Vielzahl der vierseitigen Brücken-Einheiten (10; 50; 70; 90) Kehlab schnitte (46) die Bodenwandungsstruktur (12; 52; 72) mit Seitenwänden (14, 16) der jeweiligen vierseitigen Brücken-Einheit (10; 50; 70; 90) verbinden.

8. Überfülltes Brückensystem, umfassend:

   eine Mehrzahl vierseitiger Beton-Brücken-Ein-
guriert ist, mit dem fließenden Wasser und Erdreichmaterial in Wechselwirkung zu treten, um eine Strömungsgeschwindigkeit zu verringern und dadurch das Ablagern des Erdreichmaterials zu fördern.

14. System gemäß Anspruch 11, wobei die Mehrzahl von Öffnungen (54) als mehrere Serien von Öffnungen angeordnet sind, wobei jede Serie von Öffnungen eine entsprechende Reihe (56, 58) bildet.

15. System gemäß einem der Ansprüche 8 bis 14, wobei die Bodenwandungsstruktur (12; 52; 72) einer jeden der Vielzahl der viers seitigen Brücken-Einheiten (10; 50; 70; 90) einen vertief ten Teil (48) aufweist, um einen seichten Strömungskanal (92) zu erzeugen, durch den sich Wasserlebewesen fortbewegen kön nen.

Revendications

1. Procédé pour fournir une région respectueuse de l’environnement pour l’écoulement de l’eau le long d’un tunnel de passage entouré, le procédé comprenant les étapes suivantes :
   - prévoir une pluralité d’unités de pont en béton à quatre côtés (10 ; 50 ; 70 ; 90) en relation de butée afin de créer un tunnel de passage entouré (110), une extrémité (112) du tunnel (110) étant positionnée en amont le long d’une voie d’eau (114) et une extrémité opposée (116) du tunnel (110) étant positionnée en aval le long de la voie d’eau (114) ;
   - permettre à l’eau de s’écouler à travers le tunnel de passage entouré (110) pendant un épisode de pluie ou un autre événement d’écoulement ;
   - prévoir une multiplicité d’unités de pont à quatre côtés (10 ; 50 ; 70 ; 90) avec une structure de paroi inférieure (12 ; 52 ; 72) correspondante qui interagit avec l’eau qui s’écoule et le matériau terreux dans l’eau s’écoulant de sorte que la capture et le dépôt du matériau terreux aux emplacements le long du tunnel (110) ont lieu pour produire une trajectoire d’écoulement d’eau plus naturelle le long du tunnel (110) ;
   - le procédé étant caractérisé par l’étape :
     - prévoir la structure de paroi inférieure (12 ; 52 ; 72) de chacune de la multiplicité d’unités de pont à quatre côtés (10 ; 50 ; 70 ; 90) avec une pluralité d’ouvertures débouchantes (24, 54, 74, 82) de sorte qu’au moins quarante pour cent de la structure de paroi inférieure (12 ; 52 ; 72) sont ouverts.

2. Procédé selon la revendication 1, dans lequel au moins cinquante pour cent de la structure de paroi inférieure (12 ; 52 ; 72) de chacune de la multiplicité d’unités de pont à quatre côtés (10 ; 50 ; 70 ; 90) est ouverte.

3. Procédé selon la revendication 1 ou 2, comprenant en outre l’étape : agencer la pluralité d’ouvertures (24 ; 54 ; 74 ; 82) de chaque structure de paroi inférieure (12 ; 52 ; 72) en rangées (56, 58) qui s’étendent le long d’une envergure de l’unité de pont à quatre côtés (10 ; 50 ; 70 ; 90) respective.

4. Procédé selon la revendication 3, comprenant en outre l’étape : prévoir la pluralité d’ouvertures (24) sous la forme de fentes allongées, chaque fente allongée définissant une rangée, de sorte que plusieurs poutres (26, 28) sont formées dans la structure de paroi inférieure (12) et s’étendent également le long de l’envergure.

5. Procédé selon la revendication 4, comprenant en outre l’étape : prévoir au moins une poutre (26, 28) avec une hauteur qui est supérieure à une hauteur d’une autre poutre (26, 28), la poutre la plus haute interagissant avec l’eau qui s’écoule et le matériau terreux pour réduire la vitesse de l’écoulement et améliorer ainsi le dépôt du matériau terreux.

6. Procédé selon la revendication 3, comprenant en outre l’étape : prévoir la pluralité d’ouvertures (54) sous la forme de multiples séries d’ouvertures, chaque série d’ouvertures formant une rangée (56, 58) respective.

7. Procédé selon l’une quelconque des revendications précédentes, dans lequel, dans chacune de la multiplicité d’unités de pont à quatre côtés (10 ; 50 ; 70 ; 90), des sections de nervures (46) raccordent la structure de paroi inférieure (12 ; 52 ; 72) avec des parois latérales (14, 16) de l’unité de pont à quatre côtés (10 ; 50 ; 70 ; 90) respective.

8. Système de pont trop rempli comprenant :
   - une pluralité d’unités de pont en béton à quatre côtés (10 ; 50 ; 70 ; 90) agencées en relation de butée pour créer un tunnel de passage entouré (110), une extrémité du tunnel (110) étant positionnée en amont le long d’une voie d’eau et une extrémité opposée du tunnel étant positionnée en aval le long de la voie d’eau ;
   - dans lequel chacune d’une multiplicité d’unités de pont à quatre côtés (10 ; 50 ; 70 ; 90) comprend une structure de paroi inférieure (12 ; 52 ; 72) correspondante qui est configurée pour interagir avec l’eau qui s’écoule et le matériau terreux dans l’eau s’écoulant de sorte que la capture et le dépôt du matériau terreux à plusieurs
emplacements le long du tunnel (110) ont lieu pour produire une voie de passage d’écoulement d’eau plus naturelle le long du tunnel (110) ;

caractérisé en ce que :

la structure de paroi inférieure (12 ; 52 ; 72) de chacune de la multiplicité d’unités de pont à quatre côtés (10 ; 50 ; 70 ; 90) comprend une pluralité d’ouvertures débouchantes (24 ; 54 ; 74 ; 82) de sorte qu’au moins quarante pour cent de la structure de paroi inférieure (12 ; 52 ; 72) sont ouverts.

9. Système selon la revendication 8, comprenant en outre :

le matériau terreux, déposé à partir de l’eau qui s’écoule, se dépose à plusieurs emplacements.

10. Système selon la revendication 8 ou 9, dans lequel au moins cinquante pour cent de la structure de paroi inférieure (12 ; 52 ; 72) de chacune de la multiplicité d’unités de pont à quatre côtés (10 ; 50 ; 70 ; 90) est ouverte.

11. Système selon la revendication 8, 9 ou 10, dans lequel la pluralité d’ouvertures (24 ; 54 ; 74 ; 82) de chaque structure de paroi inférieure (12 ; 52 ; 72) sont agencées en rangées (56, 58) qui s’étendent le long d’une envergure de l’unité de pont à quatre côtés (10 ; 50 ; 70 ; 90) respective.

12. Système selon la revendication 11, dans lequel la pluralité d’ouvertures (24) sont configurées comme des fentes allongées, chaque fente allongée définissant une rangée, de sorte que plusieurs poutres (26, 28) sont formées dans la structure de paroi inférieure (12) et s’étendent également le long de l’envergure.

13. Système selon la revendication 12, dans lequel au moins une première poutre (26, 28) de chacune de la multiplicité d’unités de pont à quatre côtés (10) a une hauteur qui est supérieure à une hauteur d’une autre poutre (26, 28), la première poutre (26, 28) étant configurée pour interagir avec l’eau qui s’écoule et le matériau terreux afin de réduire la vitesse d’écoulement et améliorer ainsi le dépôt du matériau terreux.

14. Système selon la revendication 11, dans lequel la pluralité d’ouvertures (54) sont agencées sous la forme de multiples séries d’ouvertures, chaque série d’ouvertures formant une rangée (56, 58) respective.

15. Système selon l’une quelconque des revendications 8 à 14, dans lequel la structure de paroi inférieure (12 ; 52 ; 72) de chacune de la multiplicité d’unités de pont à quatre côtés (10 ; 50 ; 70 ; 90) comprend une partie évidée (48) afin de créer un canal à faible débit (92) à travers lequel la vie marine peut circuler.
REFERENCES CITED IN THE DESCRIPTION

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