PATENT SPECIFICATION

(11) S85406

(21) Application No. S2008/0170

(22) Date of Filing of Application: 05/03/2008

(45) Specification Published: 09 December 2009

(51) Int. Cl. (2009)
E02B 11/00

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(54) Title: Water attentuation system suitable for water infiltration and/or water harvesting

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Title

Water Attenuation System Suitable for Water Infiltration and/or Water Harvesting

Field of the Invention

The invention relates to a water attenuation system, more particularly subterranean water attenuating systems that can be assembled from modular units. In particular, the invention relates to a water infiltration system to allow storage of surface or storm water in the system. The as also relates to a water-harvesting device for the provision of water, as it is required.

Background to the Invention

Existing sustainable urban drainage systems typically comprise drainage or irrigation systems, several of which have been developed to aid in the directing and storing of rain, flood or irrigation water drainage on or below the lands surface. Typically, a modular box or crate assembly is provided to aid in drainage or irrigation and placed underground.

For example, European patent number 0 943 737, filed in the name of Wavin B.V., discloses a modular assembly having at least one drainage box comprising a base which is provided with perforations, and side walls which are provided with perforations and are substantially perpendicular to the base and integrally connected thereto. The box is open on the side that lies opposite the base. The box furthermore comprises columns that extend substantially vertically from the base towards the open side. On the open side, the box is designed in such a manner that two identical boxes can be placed with the open sides towards one another, and can be connected to one another without the need for further accessories. For this purpose, at least some of the columns are provided, on the open side of the box, with first connection parts in the form of projections. At least some of the other columns are provided, on the open side of the box, with second connection parts in the form of cavities, so that in use, when two boxes are placed with the open sides towards one another, first connection parts of one box are able to interact with second connection parts of the other box in order to form a connection between the two boxes.

However, this device has several associated shortcomings. First, where large assemblies are required, the system can be expensive to transport since it is supplied in a disassembled state which occupies a large amount of space. This means that only a relatively small number of boxes can be transported in a typical container and so transport costs are significant if a large system is required. Secondly a second problem arises since, generally, the Wavin system is assembled and stacked at the installation stage. Such assembly is labour intensive, specialised and increases the installation costs. Thirdly, the Wavin box design means where a large system is required, the

boxes must be secured together for stability, strength and security. This requires use of additional connector components of suitable size and type to hold the units in the assembled state. The need for additional components adds to the overall cost of the system.

In order to address such deficiencies currently associated with the prior art, there is therefore a need to provide a water attenuation system that can be used for water infiltration and/or water harvesting, that is stronger, more robust and more stable than existing systems. It is also desired to provide a system which can be more easily stored, transported and installed, while having an increases degree of strength, stability, an increased void ratio, yet does not require use of additional connectors to hold the larger systems in place securely.

Summary of the Invention

According to the present invention, as set out in the appended claims, there is provided a modular system having at least one module suitable for water attenuation, said module having

a base comprising a plurality of linking elements; and

a plurality of columns adapted to project from the base and being adapted to permit water to flow through the column, each of said columns having a column base and a column head, wherein at least one of said plurality of column heads is configured to engage at least one column base of another module;

wherein the linking elements are dimensioned to connect the base of one of said columns to the base of at least one adjacent column to form a mesh structure such that stability of the system is increased.

Advantageously, the modular system is such that a water attenuation system of varying dimensions and shapes can be quickly and easily assembled at the factory or at the installation site. The design and shape of the linking mechanism increases the stability and/or strength of each module. As a result of the features described herein, the system is light, robust, and convenient to install, and has a desirably high void ratio for maximising water infiltration and storage capabilities. Specific advantages arise from fact that system can be pre-assembled at the factory which reduces installation time and cost. Another advantage arises from the unique stacking of the modules prior to assembly, which allows for easier and more efficient transport and storage.

Such a system is preferably used below ground as an underground drainage system, where in use, it intercepts, collects and regulates fluids, in particular fluids such as rain, storm or irrigation water thereby providing a versatile and controllable subsurface water attenuation

system, wherein water can be stored and slowly released to prevent flooding to the surrounding area.

The system can be used advantageously beneath, for example, urban developments such as housing or town development areas, transport system such as motorways or roads or in landscaped environments such as gardens, golf courses or sports areas. Indeed, the system is suitable for use in any vicinity where there is little or no natural drainage routes or where it is required to have reliable drainage, to prevent water logging or to minimise the risk of flooding to the area or where it is required to capture and store high volumes of water associated with extreme weather conditions. The system is also useful in areas where water conservation and recycling is desired, for example, vehicle wash areas or in vicinities where it is important to prevent pollution from run off of contaminated water, which may contain contaminants such oils, pesticides, fertilizers, animal wastes and the like.

Suitably, the linking elements are configured to connect the bases of more than two of said columns. Use of such linking elements adds further to the stability and strength of the system by increasing the load bearing capacity of the columns. It is particularly advantageous to simultaneously use of both types of link means since this will provide an even more stable mesh base having a high void ratio. Further more, the mesh type structure resulting from use of the cross liking elements, is desirable since the mesh base structure lends lightness to each of the modular components and consequently allows assembly of a relatively light assembled water attenuation system. The mesh structure of the present invention provides stability and strength to the structure and yet allows a large internal volume to allow fluid to pass freely through the structure. In addition, the mesh structured module base acts as a type of scaffold means for the supporting column projections and provides for maximum safety during installation.

Preferably, the linking elements are dimensioned to be substantially arch shaped wherein the arch shape supports the bases of said columns. Arch shaped linking elements are preferred as they surprisingly increase the load bearing capacity of the units, since the arch shape provides enhanced support to the column to increase the overall stability of each module to increase the overall stability of each module. In some embodiments, the system further comprises at least one other linking element along said columns.

In preferred embodiments, the columns comprise eight sides to form a substantially octagonal shape. This is particularly advantageous when octagonal columns are used in conjunction with arch shaped linking elements. Such a configuration is capable of withstanding greater horizontal force exerted by water inlet and water outlet flow and so the combination

provide the water attenuation system with superior strength and load bearing capabilities, such structures will be resistant to collapse, compacting, crushing or settling.

Suitably, the column head perimeter is smaller than said column base perimeter. This is advantageous since it facilitates engagement of the column head with the column base of another module or module layer.

Preferably, the columns are substantially hollow and open at both ends. Advantageously, this provides for lightness of structure and allows fluid intake, absorption and storage of large volume water in the columns depending on the requirements and installation of the system.

In a preferred embodiment, the column head comprises at least one aperture defining a slot.

Preferably, the slot is elongated and the elongated slot is in a vertical position along the periphery of said column head.

In preferred embodiments, the slot is open at one end and adapted to engage the base of a next module of said modular system.

In another embodiment, a first portion of said elongated slot is suitably dimensioned to engage the linking element or a column base of a next module.

In a further preferred embodiment, a second portion of said elongated slot is adapted to allow water into said column for water attenuation.

In a related embodiment, the system further comprises a cover module comprising a plurality of linking elements and at least one column cap adapted to receive at least one of said column heads. The linking elements connect the base of one of said column caps to the base of an adjacent column cap to form a cover. The cover module is of a complementary design to the stacking module and advantageously allows a surface to be placed on top of the assembled system which can provide an area for walking and/or inspection.

In certain embodiments relating to the water harvesting applications the modular system is encapsulated in a watertight material. Advantageously, this allows water to be collected and stored and when required, to be harvested from the bottom of the assembled column structure in a controlled fashion when and where it is needed.

In certain embodiments, the columns are arranged in a cubic array.

In all embodiments of the invention, the system is such that a different module can be inverted to co-operate with another module for transport or storage. This feature is particular

advantageous as it facilitates transport and storage of the modular units which make up the layers of the assembled system. It will be appreciated that the columns of an inverted module can fit into the voids or spaces in an opposing module, and visa versa for the columns of the opposing module, such that the area taken up by the two modules is reduced by approximately fifty percent for subsequent storage and/or transport.

In a related embodiment, the invention provides a cover for a modular system suitable for water attenuation comprising

a plurality of linking elements and at least one column cap adapted to receive at least one of said column heads;

wherein the linking elements connect one of said column caps to an adjacent column cap to form a mesh structure.

Brief Description of the Drawings :

The invention will be more clearly understood from the following description of an embodiment thereof, given by way of example only, with reference to the accompanying drawings, in which:-

Figure 1 shows an Individual module, based on cubic array;

Figure 2 shows module vertical stacking;

Figure 3 shows examples of different stacking patterns;

Figure 4 shows the column linking elements – straight and cross-shaped intersecting linking ribs;

Figure 5 shows the mesh structure of the base;

Figure 6 shows the arch shaped links in-between the columns;

Figure 7 shows the module-module engaging mean on octagonal column heads & substantially arch shaped linking ribbing;

Figure 8 shows the cover module and stack module and how they engage together; and

Figure 9 shows the offset module nesting for optimization of storage and transport.

Detailed Description of the Drawings

Referring now to the drawings and specifically Figures 1 to 9 inclusive and initially Figure 1. Figure 1 shows a water attenuating system module according to the present invention

illustrated generally by reference number (1) having a plurality of columns (2). Each column (2) comprises a head (3) and a base (4) projecting upwards from a module base (5).

Referring now to Figure 2A and 2B, there is shown in Figure 2A, a side profile of a vertically stacked arrangement of four water attenuating system modules (1A – 1D) as illustrated generally by reference number (6). Figure 2B shows an angled profile view of two water attenuating system modules (1) as illustrated generally by reference number (6). Figures 2A and 2B illustrate the engagement of the column head (3) of a first module (1A) with the column base (1) of a second adjacent module (1B). The base structure (5) is preferably in the form of a mesh.

Referring now to Figure 3A, 3B and 3C, there is shown in Figure 3A a water attenuation system comprising stacking arrangement of 4 x 2 x 3 modules. Figure 3B shows a larger system having approximate dimensions of 4 x 2 x 25 modules (1). Both Figures 3A and 3B show simple side-to-side vertical stacking of the modules (1). Figure 3C shows an alternative stacking arrangement of one layer in a perspective view. As subsequent layers are added, they may be aligned in an offset manner to provide additional stability to the system.

Referring now to Figure 4, there is shown a perspective view of underneath a section of a module (1) and linking element arrangement linking four columns (2). The four columns (2) are supported by linking elements (7, 8). Linking element (7) can be in the form of an straight arch shaped rib, while linking element (8) can take the form of a cross shaped rib. The bottom end of the column base (4) is clearly shown, as are the linking elements ends (10) that can engage elongated slots on the column heads of another module, as discussed below.

Referring now to Figure 5, there is shown a perspective view of the top of a module (1) to clearly illustrate the mesh structure (5) of the module base. Both linking ribs (7, 8) support the column bases as shown in the drawing. Elongated slots can be provided on the side wall of the octagonal column (3).

Referring now to Figure 6, there is shown a side profile of a module (1) column row comprising three columns (2) and the arch shaped linking rib (7). At least one elongated slot is provided to engage column bases of another module. In a preferred embodiment, four elongated slots (10) are used on an octagonal shaped column (2). The slots can engage the linking element ends.

Referring to Figure 7, there is illustrated the column head (3) adapted to engage a column base of another module (not shown). In this drawing the column head (3) engages a column base by means of a lip (12) on the periphery of the column head (3).

Referring to Figure 8, there is illustrated a module (1) section and a cover module (12) section that is used as a cover or a cap to provide a surface on the water attenuating system. The cover module (12) is complementary in arrangement to the column heads of the module (1) so that they can engage together to form a surface. The cover module comprises a complementary mesh structure to that of module (1). Four elongated slots (10) and the engaging lip (12) on each of the column heads can be seen. The cover module (12) is dimensioned to sit over the column head lip (12) which has the effect closing off a first portion of the elongated slot (10), but leaves exposed a second portion of said elongated slot (10) to allow water into said column for water attenuation.

Finally, Figure 9 illustrates two modules (1, 1'), one module inverted, which are offset relative to each other. It can be seen from the drawing that the voids between the columns of one module (1) can be occupied by the column heads of a second module (1'). The nesting arrangement significantly reduces the storage or transport volume of the units.

In operation, the modular water attenuation system can be assembled together using two or more of the modules described above, as illustrated in Figure 1. The modules, or units, can be adjacently positioned to form a first layer of any required dimension or shape. Additionally modules (1) or units can be horizontally position over an existing module or layer to form a second or third layer and so on, depending on the system requirements. Each individual module (1) comprises a base having a mesh structure and a column array, wherein the columns project away from the base. The module (1) can be made from a strong thermosetting plastic such as a polypropylene co-polymer. Polypropylene co-polymers are preferred since they are chemical resistant, relatively lightweight and can be used to make the modules by injection moulding or other existing moulding methods. Light modular units are preferred, since they are easier to handle, assemble, transport and they allow bigger systems to be assembled, since increased weight bearing is possible with these modules. Additional modules (1) or module layers can be added to the system as required conveniently at a factory location or at an installation site.

Modules can be assembled in a number of configurations, for example, into layers adopting a perfectly stacked configuration whereby one module neatly sits directly over another module, or a module can be offset in a type of interlocking stacking pattern arrangement as illustrated in Figures 2 and 3. Such assembly is advantageous in so far as the layers of modules can be assembled in different directions and at different 90 or 180 ° top to base angles. Such robustness and variation in assembly positions provide an extremely stable and secure assembly, whilst allowing different overall interlocking patterns, for example, rectangular or L-shaped.

The linking elements (7) of the base provide support and strength to the module as illustrated in Figure 4. Linking elements (7) are intended to mean, but are not limited to, structural support lending components which includes ribs, webbing, struts, spines, arms or any other supporting arrangement which will allow the base to be supported, yet provides increased void ratio.

The void ratio is the ratio of free space to construct material. A particularly suitable shape of linking elements are arched ribs. Higher void ratios mean higher volume capacity. The skilled person will appreciate it is possible to use many different types of linking element material, but it is preferable to use a light strong plastic material for easy of manufacture and maintenance of structural lightness.

In one embodiment, the water attenuator module comprise linking elements (7) configured to connect the bases of two columns. Such linking elements involve a straight linking element which can directly connect one column to an adjacent column. In this case, the straight linking element simply transverses the space between the base of two adjacent columns, as shown in Figure 4.

In some embodiments, different linking elements are configured to connect the bases of more than two of said columns. This can be achieved by using more complex linking elements (8), for example, a cross-shaped linking element can be used to connect and support four columns arranged in a square configuration. A cross-shaped linking element adopts an intersecting configuration, so as to simultaneously connect the base of more than two of said columns. Preferably, such intersecting linking element can be positioned between four adjacent columns, each intersecting link being diagonally connected to an opposing column base. Use of both types of link means is preferable since this will provide a more stable mesh base as shown in Figure 4. Such linking elements connect and support the columns in a diagonal manner and thus lend strength and support along the diagonal. The shape of the linking element (7,8) will depend on the column array type used, for example, triangular linking elements could be used for linear offset arrays, however, it is preferable to use cross shaped linking elements since cubic or square based column arrays are preferred. It will be appreciated that depending on the geometric array of column projections uses, such intersecting link means can be cross shaped, radial, triangular, hexagonal, octagonal etc. It will be appreciated that a variety of projecting column arrays can be provided for example, a cubic, hexagonal or other regular geometrical array may be provided. It is preferable to use a cubic array system since the square arrangement of columns provides excellent strength and load bearing capacity.

When the linking elements and columns are connected, the arrangement provides the base with an overall mesh type structure as shown in Figure 5. Such a structure is advantageous, since it provides strength and stability but allows an increased high void ratio. Use of the mesh base structure is advantageous in so far as it lends lightness to each of the modular components and consequently allows assembly of a relatively light assembled water attenuation system. A mesh structure provides stability and strength to the structure and yet allows a large internal volume to allow fluid to pass freely through the structure. In addition, the mesh structured module base acts as a type of scaffold means for the supporting column projections and provides for maximum safety during installation.

In a preferred embodiment, the linking elements (7) are substantially arch shaped wherein the arch shape supports the bases of said columns, as shown in Figure 6. Arch shaped linking elements are preferred since surprisingly the arch shape increases the load bearing capacity of the units, since the arch shape provides enhanced support to the columns over other shapes. In certain preferred embodiment, preferably, the link means are of an inverted arch shape, wherein at least one arch rise supports the base of said column at least one the end of the link means. Such a construction and use of arched supporting link means, supports the load bearing columns and gives increased strength to the assembled structure. Arched link design reduces the horizontal column deflection which greatly increases the load capacity of the structure when assembled when compared to prior art systems. This is particularly the case when such arch shaped links are used in conjunction with octagonal shaped columns. Such a configuration is capable of withstanding greater horizontal force exerted by water inlet and water outlet flow.

In another embodiment, the modules can comprise at least one other linking element along said columns, for example, two or more linking elements can be located along the length of the column to provide additional support. However, use of a single linking element located at the base of the columns is preferred, since this provides a system with the highest void ratio.

In a preferred embodiment, the columns comprise eight sides to form a substantially octagonal shape, since use of an octagonal shape provides a stable arrangement as shown in Figure 4. The octagonal arrangement is found to be convenient for use of cross-shaped linkers. However, it will be appreciated that columns of other shapes will function in a similar manner. The columns of the modules of the present invention are not restricted to being columnar in shape or configuration. Circular, octagonal, square, rectangular, triangular shaped column projections can all be equally well used, as can other geometrically shaped columns. It is preferred that the columns are octagonal in shape, since octagonal shaped columns will provide the best strength to

the assembly. Increased strength means that more module layers can be stacked on top of each other and so therefore can have a higher overall system.

In another embodiment, the column head perimeter is smaller than said column base perimeter. This is advantageous since it facilitates engagement of the column head with the column base of another module layer. In some embodiments, the columns can be substantially the same width dimensions from column base to column head. However, alternatively, a column having a tapered shape from column base to column head could also be used. The former construction is preferred however, since it will provide the drainage assembly with superior strength and load bearing capabilities, such structures will be resistant to collapse, compacting, crushing or settling.

In a further embodiment, the column is substantially hollow and open at both ends. Advantageously, this provides for lightness of structure and allows fluid intake, absorption and storage of large volume water depending on the requirements and installation of the system.

In will be appreciated that in some embodiments, it is preferred that the slot or aperture comprises a mouth which is adapted to engage the base of a next module of said modular system. In preferred embodiments, the slot comprises an inner portion suitably dimensioned to accommodate the linking element of a next module. It is particularly preferred that the inner portion of said aperture is adapted to allow water into said column for water attenuation as shown in Figure 6.

In a further embodiment there is provided a cover module suitable for use with a modular system suitable for water attenuation wherein the cover module (12) comprises a plurality of linking elements and at least one column cap adapted to receive at least one of said column heads, as illustrated in Figure 8. The linking elements connect the base of one of said column caps to the base of an adjacent column cap to form a cover. The cover module is of a complementary design to the stacking module and simply allows a surface to be placed on top of the assembled system which provides an area for walking, inspection etc.

It will be appreciated that the system can be used for water harvesting, it is preferred that the modular system is encapsulated in a watertight material such as an impermeable, watertight geo-membrane, for example. In this embodiment, water can be directed from the bottom of the assembled column structure and can be drained away in a controlled fashion when and where it is needed. Such embodiment can involve use of pumps, drains, pipes and other hydraulic systems as required, that are known in the art.

In a further embodiment, there is provided a modular system wherein a different layer is inverted to co-operate with the layer for transport or storage. This feature is particular advantageous as it facilitates transport and storage of the modular units which make up the modules/layers of the assembled system. The columns occupy the void area surrounding the columns of another module when the modules are inverted and stacked in an offset position, as shown in Figure 9. This has the effect of saving a substantial amount of space, when compared to the space required if the modules where simply stacked on top of each other when stored or being transported. Such a design, allows one module to nest into another module by offsetting the modules relative to each other, such that the column projection can sit into the free space provided by a second module. The improvement in transport and storage allows for a practical increase in dimension of the basic crate module. Thus, for example, with the systems described herein, it is possible to manufacture sub-assembled modules of up to 10 cubic meters in size. This is desirable, since larger modules will lead to a reduction in installation size. Another advantage associated with the system of the invention arises from the fact that the systems can be sub-assembled before being sent to the installation site. This is beneficial since it eliminates the need for expensive specialist installation contractors on site and installation time is greatly reduced.

It will be further appreciated that system can be installed in an upward direction, wherein the base of the modules lies against the ground surface and columns project upwards away from the ground surface, or the system can also be installed in a downward directions, wherein the column heads lie facing the ground and the module base lies further away from the ground surface. If the former configuration is used, a cover layer can be used to provide support to the column heads to avoid the column heads sinking into the ground surface. The first arrangement is preferred since it is desirable to have a flat bottom surface which can bear the load weight of the water attenuation system and attenuated water, whereas positioning of the first module layer column end down would not be idea, since sinking, settling could occur when weigh is applied to the bottom layer, as shown in Figure 5.

The words "comprises/comprising" and the words "having/including" when used herein with reference to the present invention are used to specify the presence of stated features, integers, steps or components but does not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof.

It is appreciated that certain features of the invention, which are, for clarity, described in the context of separate embodiments, may also be provided in combination in a single embodiment. Conversely, various features of the invention which are, for brevity, described in

the context of a single embodiment, may also be provided separately or in any suitable sub-combination.

The invention is not limited to the embodiments hereinbefore described but may be varied in both construction and detail.

Claims

1. A modular system having at least one module suitable for water attenuation, said module having

a base comprising a plurality of linking elements; and

a plurality of columns adapted to project from the base and being adapted to permit water to flow through the column, each of said columns having a column base and a column head, wherein at least one of said plurality of column heads is configured to engage at least one column base of another module;

wherein the linking elements are dimensioned to connect the base of one of said columns to the base of at least one adjacent column to form a mesh structure such that stability of the system is increased.

2. A system according to claim 1 wherein said linking elements are configured to connect the bases of two columns.

3. A system according to claim 1 wherein said linking elements are configured to connect the bases of more than two of said columns.

4. A system according to any preceeding claim wherein the linking elements are dimensioned to be substantially arch shaped wherein the arch shape supports the bases of said columns.

5. A system according to any preceeding claim further comprising at least one other linking element along said columns.

6. A system according to any preceeding claim wherein said columns comprise eight sides to form a substantially octagonal shape.

7. A system according to any preceeding claim wherein said column head perimeter is smaller than said column base perimeter.

8. A system according to any preceeding claim wherein said column is substantially hollow and open at both ends.

9. A system according to any preceeding claim wherein said column head comprises at least one aperture defining a slot.

10. A system according to claim 9 wherein said slot is elongated, wherein the elongated slot is in a vertical position along the periphery of said column head.

11. A system according to claim 9 or 10 wherein the slot is open at one end and adapted to engage the base of a next module of said modular system.

12. A system according to claim 10 or 11 wherein a first portion of said elongated slot is suitably dimensioned to engage the linking element of a next module.

13. A system according to claim 10 to 12 wherein a second portion of said elongated slot is adapted to allow water into said column for water attenuation.

14. A system according to any proceeding claim further comprising

a cover module comprising a plurality of linking elements and at least one column cap adapted to receive at least one of said column heads;

wherein the linking elements connect the base of one of said column caps to the base of an adjacent column cap to form a cover.

15. A system according to any preceding claim wherein the modular system is encapsulated in a watertight material.

16. A system according to any preceeding claim wherein said columns are arranged in a cubic array.

17. A system according to any preceeding claim wherein a different layer is inverted to co-operate with the layer for transport or storage.

18. A cover for a modular system suitable for water attenuation comprising

a plurality of linking elements and at least one column cap adapted to receive at least one of said column heads;

wherein the linking elements connect one of said column caps to an adjacent column cap to form a mesh structure.

19. A system according to claims 1 to 17 as hereinbefore described with reference to the accompanying description and drawings.

20. A cover according to claim 18 as hereinbefore described with reference to the accompanying description and drawings.

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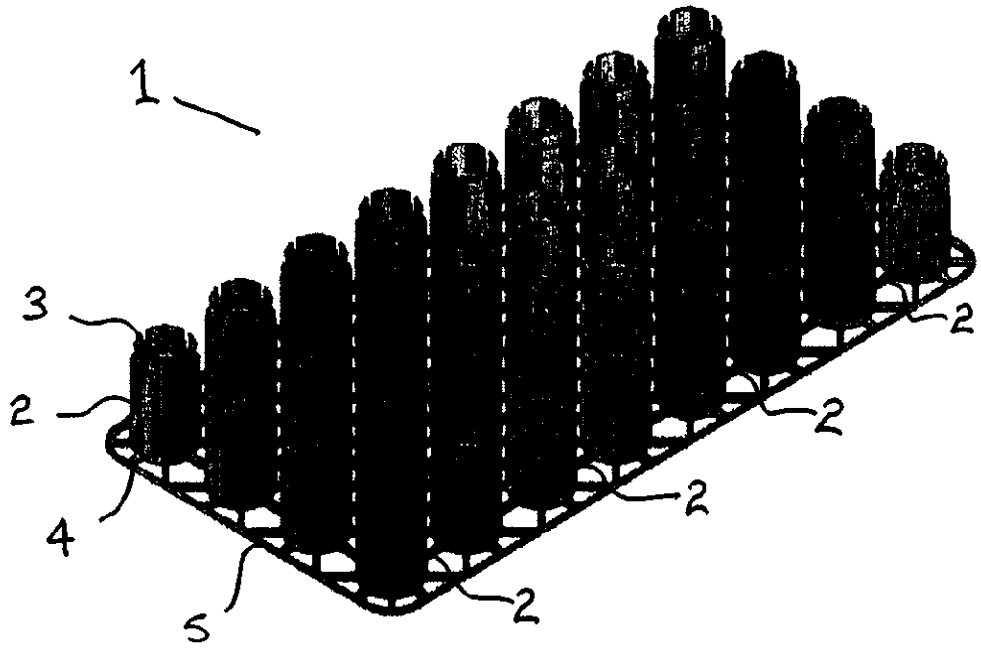


Figure 1: Individual module, based on cubic array

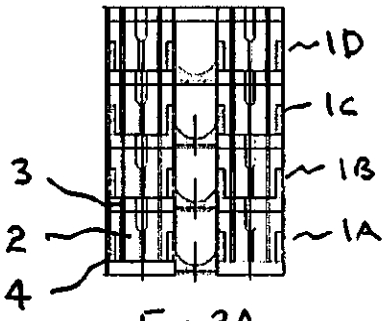


Fig 2A

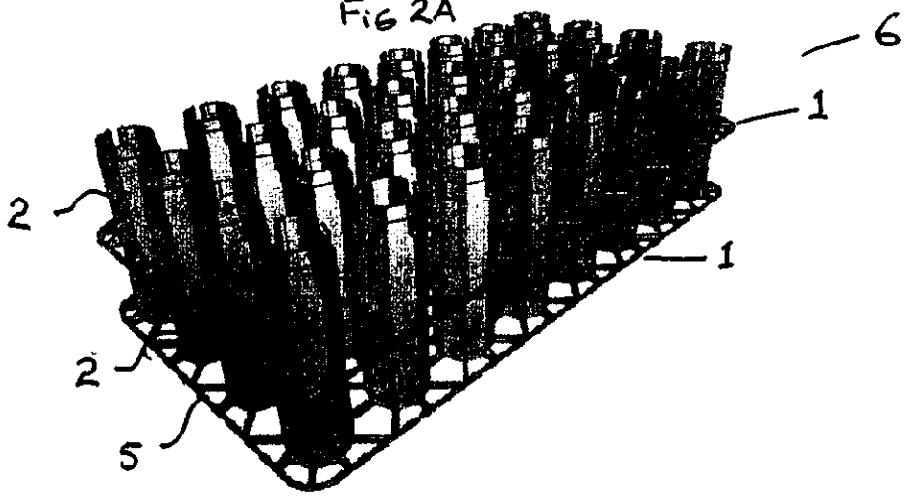
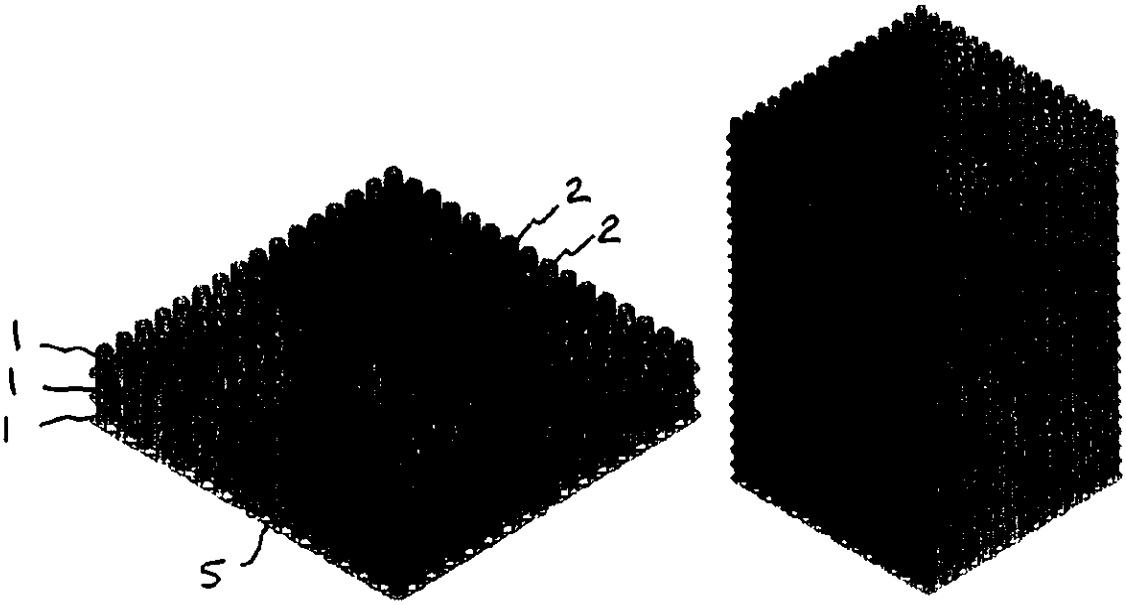


Figure 2B Module vertical stacking



A B

Fig 3A Fig 3B

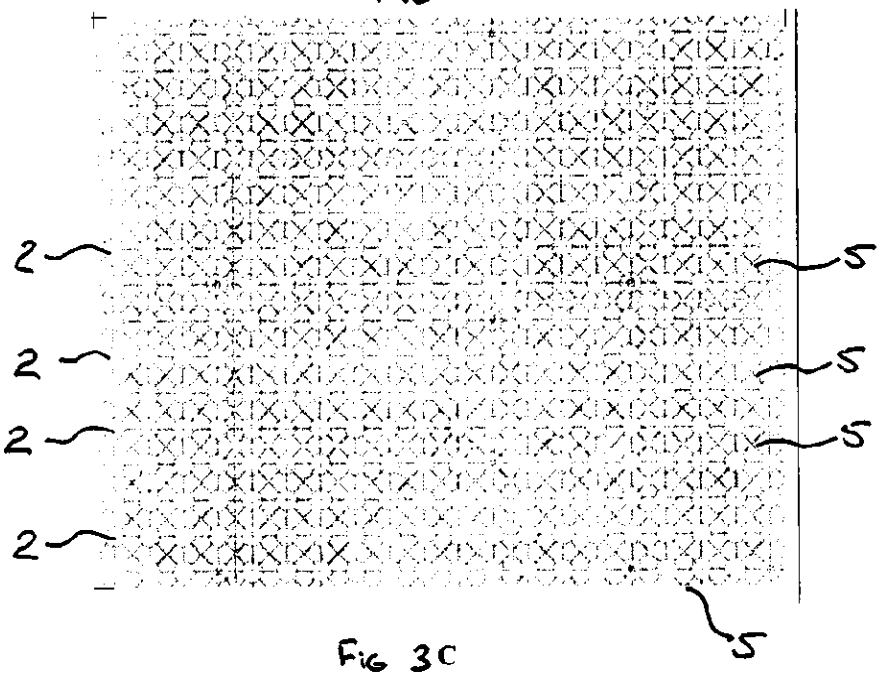


Fig 3C

Figure 3: Different stacking patterns

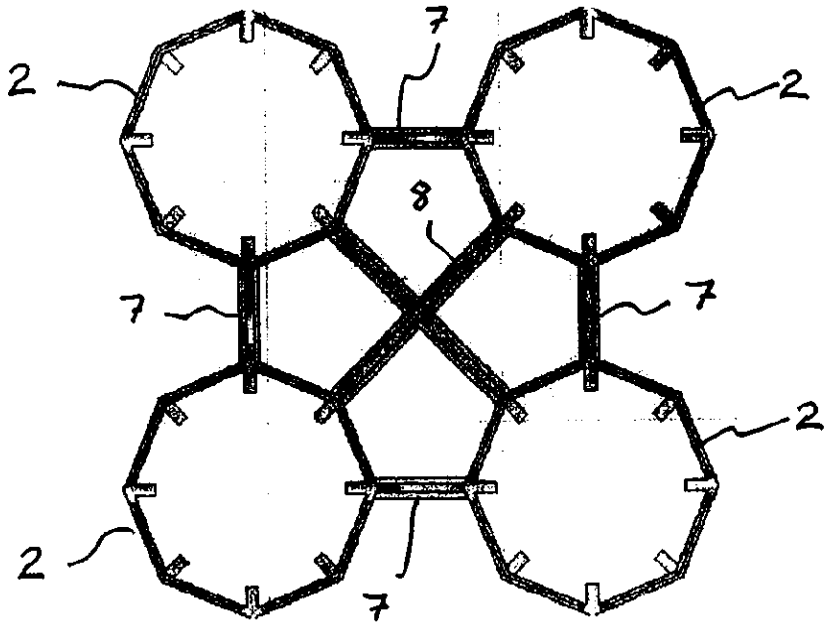


Figure 4: Column linking elements – straight and cross-shaped intersecting linking ribs

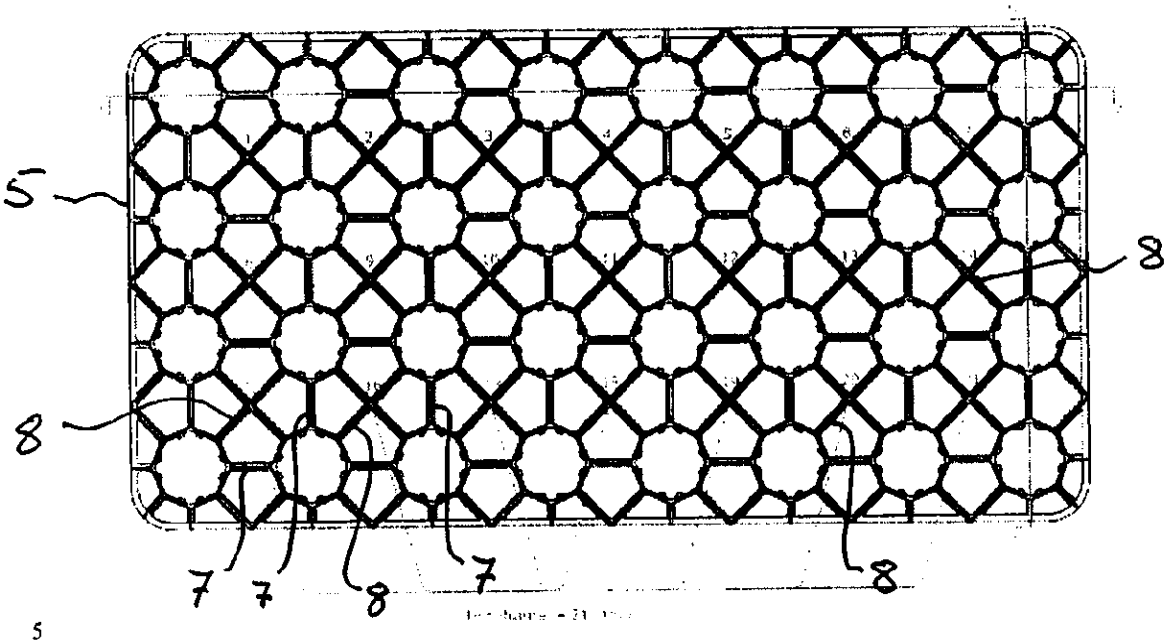


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Figure 5: Mesh structure of the base

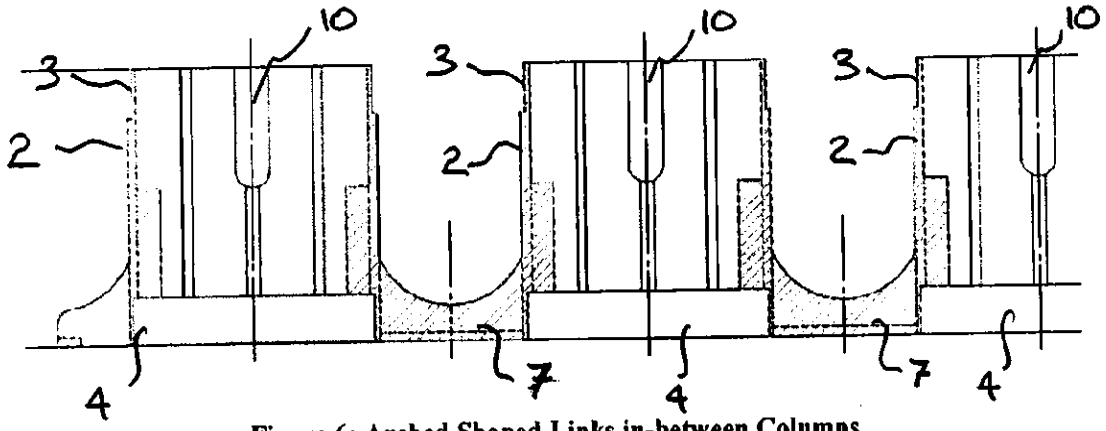

Figure 6: Arched Shaped Links in-between Columns

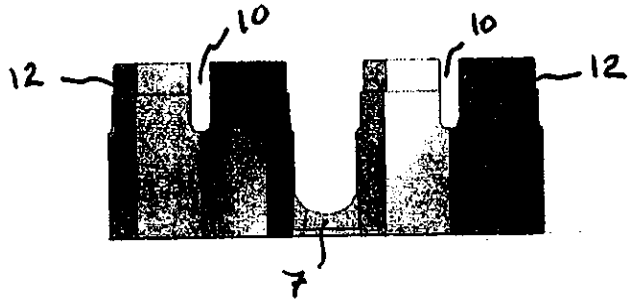

Figure 7: Engaging mean on octagonal column heads & substantially arched shaped linking ribbing

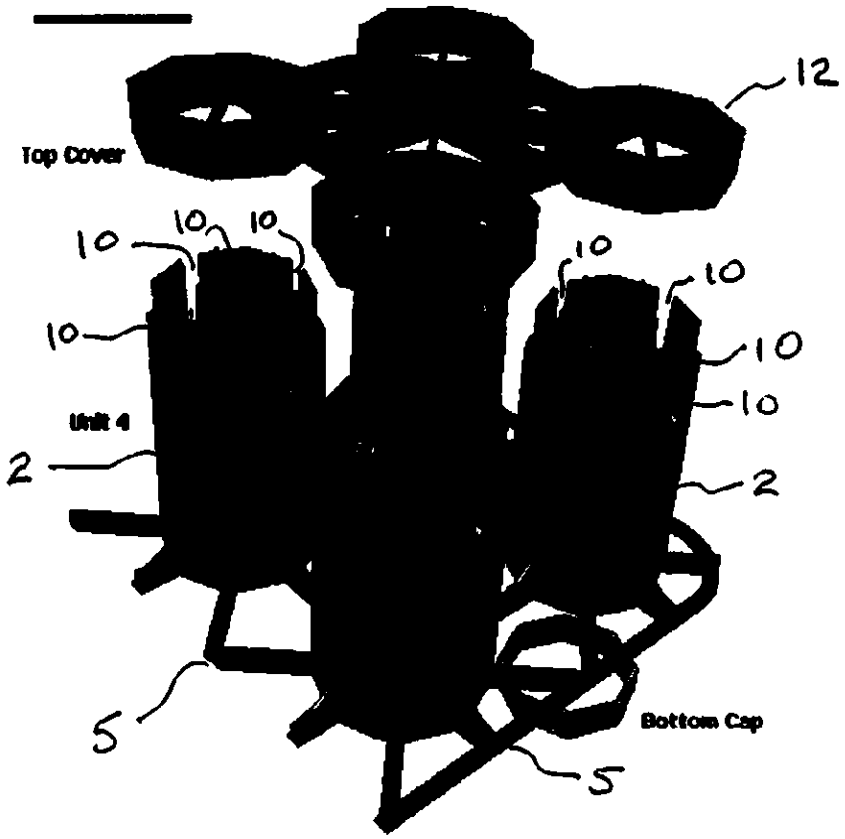

Figure 8: Cover module and stack module

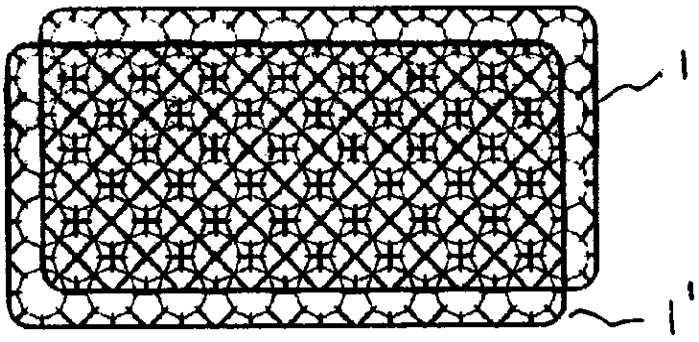

Figure 9: Offset module nesting for optimises storage and transport