

A DISPOSABLE WASTE MATERIAL STRUCTURE

FIELD OF THE INVENTION

The invention relates to a disposable waste material structure. More particularly, but not
5 exclusively, the invention relates to a disposable waste material structure of excavated earth having anchoring members protruding therefrom which can be disposed to an underwater surface in an environmentally-friendly form. The invention also
10 relates to the use of waste material structures in underwater foundations of a marine structure, such as a dam or sea-wall, and to the formation of artificial coral reefs.

BACKGROUND OF THE INVENTION

15 Land pollution is a widespread problem in many parts of the world today. The related problems of how and where to dispose of waste accumulations on land including excavated earth, construction and other industrial waste are particularly acute in
20 small-sized, highly-populated areas.

Conventional methods of waste disposal include land reclamation from the sea and indiscriminate dumping of waste into the sea. Land reclamation as landfill offers a limited solution; waste deposition
25 on land today poses a potential pollution threat to

others in the future. Indiscriminate dumping as for example into the sea is not an acceptable solution; this has a deleterious effect on reefs and destroys marine habitants. Further, the use of containers for dumping waste into the sea, such as is used for radioactive waste, can be both expensive and harmful to the environment.

The present invention aims to overcome at least some of the above-discussed problems.

An object of the invention is to provide a disposable waste material structure and a method of manufacturing the same.

Another object of the invention is to provide a structure which is easy to make and transport.

Another object of the invention is to provide a structure for disposing excavated earth, construction and other industrial by-products to an underwater surface, for example a riverbed or a seabed, in an environmentally-friendly form.

SUMMARY OF THE INVENTION

According to one aspect of the present invention there is provided a disposable waste material structure for the disposal of solid waste material to an underwater surface, the structure comprising: a solid waste body comprising the waste material and means for securing the waste material together to form

the body; and one or more anchoring members for substantially preventing movement of the structure at the underwater surface in use, the one or more anchoring members being connectable to the solid waste
5 body to protrude therefrom.

An underwater foundation structure may be advantageously provided for building marine structures including sea-walls, dams and coral reefs. This is made possible through the use of anchoring members
10 which may be connected to a structure for anchoring the structure to an underwater surface.

Further, anchoring members may have different shapes and sizes, thereby providing relatively high-density or low-density packing of a structure
15 with other similar structures at an underwater surface. Relatively short anchoring members may be used, for example, to reduce porosity so as to enable formation of mounds and barriers at an underwater surface. Conversely, relatively long anchoring
20 members may be used to increase porosity and to keep a structure apart from other similar structures, thereby encouraging artificial reefs and marine ecosystems to form at an underwater surface.

Advantageously, a body of a disposable waste
25 material structure may be easily fabricated in various forms. A body in a cuboid form may be preferred for

enabling easier mechanically assisted movement and more efficient storage of the body than would otherwise be possible. A body in a spherical or a cylindrical form may be preferred for enabling easier non-mechanically assisted movement of the body than would otherwise be possible. For example, a spherical or cylindrical body may be rolled onto a particular site when mechanical aids are not available or cannot be used for handling.

A body of a disposable waste material structure may be made from a mixture of waste material, a binder such as concrete and aggregates such as sand and/or pebbles. Anchoring members may be made from cheap, biodegradable material such as from wood, tree branches or tree trunks. Alternatively, anchoring members may comprise excavated earth or other constructional or industrial waste with a binder such as concrete so as to maximise the amount of waste to be disposed. These anchoring members preferably include a steel reinforcing member about which the anchoring member is formed.

Anchoring members may be configured to engage anchoring members of similar structures. For example, anchoring members may have hooked interlocking portions at their free ends for enabling similar structures to be interlocked at an underwater surface.

Furthermore, a body and anchoring members of a structure may advantageously have an outer protective layer for providing the structure with increased resistance to erosion.

5 According to another aspect of the present invention there is provided a waste material structure for the disposal of solid waste to an ocean floor, the structure comprising: a solid waste body comprising the waste material and means for securing the waste
10 material together to form the body; and at least one leg member protruding from a surface of the body, the at least one leg member providing an anchoring effect for the structure when the structure has been disposed to the ocean floor.

15 According to another aspect of the present invention there is provided a method of manufacturing a disposable waste material structure comprising a waste material body and at least one anchoring member, the method comprising: mixing a solid waste material
20 with a binding means to form an aggregate; casting the aggregate in a mould to form the body of the waste material structure.

 A mould made from commonly-available building materials may be used in the method for forming a cast
25 body. For example, the mould may comprise metal plates welded together, wood pieces nailed together,

empty oil drums, plastic pipes or bamboo tubes. Further, moulds made from metal plates may comprise a coating of zinc or other suitable agent, to reduce long-term rusting or oxidation effects.

5 The above and further features of the invention are set forth with particularity in the appended claims and together with advantages thereof will become clearer from consideration of the following detailed description of exemplary embodiments of the invention given with reference to the accompanying
10 drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

Figure 1(a) is a plan view of a first disposable waste material structure embodying the invention, the
15 structure having a cube-shaped body and short tapering inserts connected thereto;

Figure 1(b) is a perspective view of the structure of Figure 1(a);

20 Figure 2(a) is a plan view of a second disposable waste material structure embodying the invention, the structure having a cube-shaped body and long bar inserts connected thereto;

Figure 2(b) is a perspective view of the structure of Figure 2(a);
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Figure 3(a) is a perspective view of a third

disposable waste material structure embodying the invention, the structure having a spherical body and short tapering inserts connected thereto;

5 Figure 3(b) is a plan view of the structure of Figure 3(a);

Figure 4(a) is a perspective view of a fourth disposable waste material structure embodying the invention, the structure having a spherical body and relatively long tubular inserts connected thereto.

10 Figure 4(b) is a plan view of the structure of Figure 4(a);

Figure 5(a) is a perspective view of a fifth disposable waste material structure embodying the invention, the structure having a cylindrical body and relatively long inserts connected thereto;

15 Figure 5(b) is a plan view of the structure of Figure 5(a);

Figure 5(c) is another plan view of the structure of Figure 5(a);

20 Figure 6(a) is a plan view of a sixth disposable waste material structure embodying the invention, the structure having a cube-shaped body and dog-leg shaped inserts connected thereto;

Figure 6(b) is a perspective view of the structure of Figure 6(a);

25 Figure 7 is a perspective view of an insert and

a two part mould used in the fabrication of the waste material structure of Figures 2(a) and 2(b); and

Figure 8 is a plan view of a two part cast body obtained from the moulds of Figure 7.

5 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figures 1 to 6 illustrate preferred waste material structures embodying the invention. Each waste material structure, generally indicated at 1,
10 11, 21, 31, 41, 51 is made up of a body of specific shape and form, and a plurality of elongate anchor members or legs protruding from the surfaces of the body.

Referring now to Figures 1(a) and (b), a first disposable waste material structure 1 comprises body
15 2 and 6 legs 3 protruding from the body 2. The body 2 has a cubic shape which makes the body 2 easy to transport using mechanical apparatus such as forklift trucks, cranes and the like, and also provides for efficient storage of the body 2 with other like bodies
20 2. The legs 3 are connectable to the body 2 by location in holes 4 formed in the body 2. In this embodiment, one leg 3 is provided on each side of the body 2 and protrudes radially outwardly from the surface of the body 2.

25 The legs 3 can have varying shapes and sizes. In this embodiment, the leg 3 is in the form of a

relatively short tapering insert. The legs 3 perform two key functions. First, they function as anchor members which serve to anchor the structure 1 to a sea-bed after deployment into the sea. Second, they are configured by virtue of their relative dimensions to provide a tight or a loose formation of several structures. In a formation formed by structures 1 having relatively short sized legs 3, the distance between adjacent structures is relatively short thereby forming a tightly packed or relatively dense formation. Such a structure has a low porosity and traps sand on the sea-bed so as to enable formation of undersea mounds and barriers quickly. Such tightly packed structures can also provide underwater foundation structures in dams and sea-walls.

Each of the legs 3 has a tapered portion 5 which extends towards a free end of the leg 3. At the opposing end of the leg 3, a connecting portion 6 is shaped to fit into the corresponding hole 4 in the body 2. The legs 3 are secured within their respective holes 4 by use of retention means (not shown) such as a binder which can be concrete, or by a simple pin or stud insert.

Each leg 3 is made from an aggregate of waste material which is cast into the desired shape using a mould. A binder and an aggregate are used with the

waste material and the exact mixture depends on the desired characteristics e.g. hardness or rate of deterioration in use. An external shell or layer may be applied for increasing the resistance of each leg.

- 5 The legs 3 are required to be strong and therefore are preferably reinforced by use of one or more steel members (not shown) set inside each leg 3.

The body 2 also comprises a mass of solid waste material which has been cast into the desired shape
10 using a mould. The body 2 can be of various sizes but typically has a volume of 0.5 to 2.0 cubic metres (m³). The body 2 may be configured to have an external shell of durable (harder) material, thereby enabling it to withstand high pressures or corrosion undersea. The
15 detailed method of manufacturing the body 2 is described later in this description.

Figures 2(a) and 2(b), show a waste material structure 11 of a second embodiment of the present invention. The structural features of the structure 11
20 of the second embodiment are very similar to those described above in the first embodiment and, to avoid unnecessary repetition only the differences between the second and first embodiments are described hereinbelow.

The legs 13 of the waste material structure 11 are
25 in the form of elongate bar inserts. The bar

inserts 13 are relatively long and straight, and may have carrying loops 17 at their protruding ends to assist in their handling. These loops 17 are parts of the one or more steel members (not shown) set inside each leg 13 which protrude from the cast leg 13 after the casting process. Not only can the loop be used as a lifting point, but also they can be useful in binding one cast leg 13 inserted mid-way into the inside of the body 12 of the structure 11 with another cast leg 13 which is to be coupled thereto (see Figure 6(b)). Typically, the legs 13 are bound to the body 12 and to other legs 13 by use of cement as a binder.

Each insert 13 is a single-piece member which is long enough to extend through and protrude from the body 12. In this regard, the body 12 has 3 appropriately-dimensioned holes 14 formed therein in which extend from one face of the body 2 to an opposing face. The legs 13 are secured within the through holes 14 by use of a binder such as concrete, or by locking pins or studs.

The protruding parts 15 of the legs 13 of this embodiment are relatively long. Therefore, contrary to the previous embodiments, in a formation of structures 11 having these relatively long sized legs 13, the distance between adjacent structures 11 is relatively far thereby forming a relatively loosely

packed or low-density formation. Such a structure has a high porosity and encourages the formation of artificial reefs and marine ecosystems.

5 Figures 3(a) and 3(b) show a waste material structure 21 of a third embodiment of the present invention. For the sake of convenience, only the differences between the previously described and present embodiments are described hereinbelow.

10 The structure 21 has a body 22 of spherical shape. Advantageously, the spherical shape is easy to fabricate and easy to handle manually through the use of ropes, hoists, loading and unloading bays and chutes. More particularly spherical shaped structures 21 are easy to roll onto ships and the like prior to
15 disposal into the sea or river; this is an important consideration when heavy mechanical moving aids are not available or cannot be used for handling of these structures.

20 The legs 23 are in the form of relatively short tapering inserts 23. The legs 23 are connectable to the body 22 through appropriately dimensioned holes 24 formed in the body 22.

25 Figures 4(a) and 4(b) show a waste material structure 31 of a fourth embodiment of the present invention. For the sake of convenience only the differences between the previously described and

present embodiments are described hereinbelow.

The body 32 of the structure 31 has a spherical shape as in the third embodiment. Each of the legs 33 is a single piece relatively long, straight member 33 which is long enough to extend through and protrude from the body 32. In this way, each member 33 provides two of the six legs of the structure 31. Typically, each member 33 is formed from cast waste material with a steel bar reinforcing insert (not shown) and this may simply be formed by using a plastics pipe section as a mould. In addition, a carrying handle in the form of a loop 37 is provided at one end of each member 33. The body 32 has 3 through holes 34 of circular cross section which extend diametrically across the body 32. Each through hole 34 is orthogonally positioned with respect to the other through holes 34. The legs 33 are each secured to the body 32 by use of a binder such as an adhesive or by retention members (not shown) such as locking pins or studs. Assembly of the legs 33 to the body is preferably carried out just prior to disposal at sea.

Referring to Figures 5(a), 5(b) and 5(c) a waste material structure of a fifth embodiment of the present invention is described. However, the following description is directed only to the differences between the fifth and previously described

embodiments.

The waste material structure 41 comprises a cylindrical body 42 and relatively long legs 43 projecting orthogonally therefrom. The legs 43 are connectable to the body 42 through appropriately dimensioned holes 44 formed in the body 42 in a similar way to that described in the second and fourth embodiments. The cylindrical shape of the body 42 is easy to fabricate by the use of disused oil drums for example. In addition, the cylindrical body 42 makes the structure 41 easy to handle manually through the use of ropes, hoists, loading and unloading bays and chutes in a similar way to that of the abovedescribed third embodiment. The legs 43 are insertable into the through holes 44 of the body 42 when convenient prior to disposal into the sea.

Figures 6(a) and 6(b) show a waste material structure 51 of a sixth embodiment of the present invention. The structure 51 has a similar body 52 and legs 53 to those of the second embodiment shown in Figures 2(a) and 2(b). Accordingly, to avoid unnecessary repetition, the following description of the structure 51 is restricted to these differences between the second and sixth embodiments.

The body 52 has six square cross-section holes 54, one provided in each face 55 of the body. Each

hole 54 is of a predetermined depth but does not extend completely through to the opposed face 55 of the body 52. Each of the legs 53 is in the form of a dog-leg shaped insert 53 having a square cross-section. The legs 53 are connectable to the body 52 by location in the appropriately-dimensioned holes 54 at the appropriate time. As described in the first embodiment, each legs 53 is held in place with a retention means such as a binder, or a pin or a stud insert.

The legs 53 are each provided with a hook portion 56 at one end of the leg 53 which is to be used as the free end of the leg 53 in use. The hook portions 56 are provided for enhancing the function of the legs 53, namely for preventing the body 52 from being moved or rolled away by fast underwater currents. In particular, the hook portions 56 provide an effective means for digging into the seabed and thereby anchoring the structure. In addition, the hook portions 56 help the structure 51 to cling to other similar structures 51 thereby keeping an underwater formation of several structures 51 together to aid in the development of an artificial reef, for example.

As described previously the legs 53 are made from cast waste material with integral steel reinforcing bars (not shown). However, the steel reinforcing bars

may be allowed to protrude from the end of the leg to aid lifting or binding within the body 52. Depending on the requirements, the legs 53 may alternatively be made of local biodegradable material like wood, typically in the form of tree trunks or tree branches.

The above described waste material structures 1, 11, 21, 31, 41, 51 are manufactured by transforming raw waste products into a desirable and environmentally friendly product, namely into the form of a solid waste body, for subsequent disposal into a sea or a river. The waste material is preferably in the form of excavated earth, but can also be constructional and other industrial by-products such as incinerator waste.

The transformation process involves washing and, if necessary, processing the waste, followed by mixing the waste with an aggregate and a binder. The binder functions to hold the mixture together when the manufacturing process is completed and is preferably Portland cement though other adhesives could also be used. Different mixtures of waste aggregate and binder give rise to different body characteristics; for example, the shape and hardness of the body can be modified appropriately. The thus formed aggregate is then cast in a mould of a specific shape and size to form the required shape of body. This casting process

may involve heating of the mould to set the aggregate. Once the thus formed body has set, it is removed from the mould and the legs can be attached thereto. The mould can then be used again for forming further waste material structures.

In particular, if the excavated earth is of a suitable granular size, then mixing it with Portland cement as a binder is sufficient to provide a suitable mixture for setting in an appropriate mould.

Alternatively, if the excavated earth contains marine clay, then suitable amounts of sand as an aggregate need to be mixed in to have a suitable consistency before mixing in the Portland cement as binder. Aggregates can be small pebbles, granite chips, fibrous material or even crushed bricks or concrete waste. Binders are merely the glue that holds the waste particles together to retain a shape. There are different binders available commercially.

A similar process can be used for forming each of the legs though a steel reinforcing bar is preferably provided in the cast leg to provide a greater degree of strength.

Alternatively, the body part of the waste structure may be formed by compacting the excavated earth into the desired shape and then encapsulating the compacted waste material. The encapsulation is

required to ensure that the waste material can retain its shape when disposed of in water. This encapsulation is, for the avoidance of doubt, to be considered as means for securing the waste material together as this is precisely the function of the encapsulation.

Figures 7 and 8 illustrate how the above described second embodiment is manufactured using a two part mould. The mould comprises a top half 60 and a bottom half 61. The top half mould 60 is designed to produce a top half 62 of the body 12 whereas the bottom half mould 61 is used to cast the bottom half 63 of the body 12. Each half mould 60, 62 is made from steel plates that are welded into the appropriate shapes. The top half mould 60 has a vertical groove 64 of square cross-section extending from one side 65 to an opposite side 66 thereof along an inner face 67 thereof. In addition, a horizontal passageway 68 of square cross-section extends from the inner face 67 to an outer face 69 of the mould 60. The groove 64 and the passageway 68 correspond to two through holes 14 of the assembled body 12. A pouring hole 70 (see bottom mould 61) is provided for enabling the waste material aggregate to be poured into the mould 60.

The bottom mould 61 is identical to the top mould 60 and its corresponding parts have been labelled with

appropriate reference numerals corresponding to the top mould 60. The top and bottom moulds 60, 61 are advantageously coated with zinc to reduce rusting or oxidation.

5 The top and bottom moulds 60,61 produce top and bottom halves 62,63 of the body 12 which are shown in Figure 8. With each half 62,63 appropriately oriented, their inner faces 67 are secured together to form the body 12 with three through holes 14.
10 Accordingly, the body 12 may be readily fabricated at a convenient site using relatively unskilled labour.

 The above described moulds 60,61 comprise welded steel or iron plates. However, these moulds 60,61 may be made from various readily available inexpensive
15 materials including wood, oil drums, bamboo tubes or PVC or other plastics pipe. In these cases, the moulds 60,61 could be put together on site for example nailing together the materials to form the moulds 60,61.

20 Having thus described the invention by reference to various embodiments it is to be well understood that the embodiments in question are exemplary only and that modifications and variations as will occur to those possessed of the appropriate knowledge and
25 skills may be made without departure from the spirit and scope of the invention as set forth in the

appended claims and equivalents thereof. For example,
even though the above described structures have a
separate body and legs, so that the body can be
transported to the disposal location and assembled
5 just prior to disposal, it is possible for the body
and legs to be formed as an integral unit. In
addition even though the hook portions 56 have been
shown as single bent end portions of the legs 53,
various other shapes of hook portion can be utilized
10 such as curved hooked portions and arrow head shaped
formations.

**CLAIMS:**

1. A disposable waste material structure for the disposal of solid waste material to an underwater surface, the structure comprising:

5 a solid waste body comprising the waste material and means for securing the waste material together to form the body; and

 one or more anchoring members for substantially preventing movement of the structure at the underwater
10 surface in use, the one or more anchoring members being connectable to the solid waste body to protrude therefrom.

2. A structure according to claim 1, wherein said one or more anchoring members comprise waste material
15 and additional means for securing the waste material together to form the one or more anchoring members.

3. A structure as claimed in claim 1 or 2, wherein the one or more anchor members and/or the body comprise an outer protective layer for providing the
20 structure with increased resistance to erosion.

4. A structure as claimed in any preceding claim, wherein the one or more anchoring members are



relatively short, thereby permitting relatively high-density packing of the structure with other similar structures.

5. A structure as claimed in any of claims 1 to 3,
5 wherein the one or more anchoring members are relatively long, thereby permitting relatively low-density packing of the structure with other similar structures.

6. A structure as claimed in any preceding claim,
10 wherein the one or more anchoring members each comprise an elongate member having a tapered portion extending to one end of the member.

7. A structure as claimed in any preceding claim,
wherein the one or more anchoring members comprise
15 interlocking portions which are arranged to engage anchoring members of other similar structures.

8. A structure as claimed in claim 7, wherein each interlocking portion comprises a hooked portion provided at one end of the member.

20 9. A structure as claimed in any preceding claim wherein the one or more anchoring members comprise



tree trunks, or tree branches or reinforcing steel bars.

10. A structure as claimed in any preceding claim,
wherein the waste material comprises excavated earth,
5 or other constructional or industrial waste.

11. A structure as claimed in any preceding claim,
wherein the means for securing the waste material
together comprises a binder material such as concrete
or an encapsulant.

10 12. A structure as claimed in any preceding claim,
wherein the solid waste body is in a spherical or a
cylindrical form to enable easier non-mechanically
assisted movement of the body than would otherwise be
possible.

15 13. A structure as claimed in any of claims 1 to 11,
wherein the solid waste body is in a cuboid form to
enable easier mechanically assisted movement and more
efficient storage of the body than would otherwise be
possible.

20 14. A structure as claimed in any preceding claim,
wherein the body comprises two or more constituent



parts, the parts being assembled together to form said body in use.

15. A structure as claimed in any preceding claim, wherein the body or constituent parts of the body
5 comprise a moulded body or moulded constituent parts.

16. A structure as claimed in any preceding claim, wherein the body comprises one or more mounting holes for the location of the one or more anchoring members.

17. A structure as claimed in claim 16, wherein the
10 one or more mounting holes extend through the body and the one or more anchoring members each comprise an elongate bar, wherein each elongate bar is connectable to the body by location in one of the mounting holes extending through the body.

18. A structure as claimed in any preceding claim, wherein the body is arranged to locate the one or more anchoring members such that when the body and one or more anchoring members are assembled together, the one or more anchoring members extend radially outwardly
20 from the body.

19. A waste material structure for the disposal of



solid waste to an ocean floor, the structure comprising:

a solid waste body comprising the waste material and means for securing the waste material together to
5 form the body; and

at least one leg member protruding from a surface of the body, the at least one leg member providing an anchoring effect for the structure when the structure has been disposed to the ocean floor.

10 20. A method of manufacturing a disposable waste material structure comprising a waste material body and at least one anchoring member, the method comprising:

mixing a solid waste material with a binding
15 means to form an aggregate;

casting the aggregate in a mould to form the body of the waste material structure.

21. A method as claimed in claim 20, further comprising pre-processing the waste prior to the
20 mixing step.

22. A method as claimed in claims 20 or 21, wherein the mixing step further comprises mixing the waste material with other aggregates.



23. A method as claimed in any of claims 20 to 22, wherein the casting step further comprises casting the aggregate in another mould to form each of the at least one anchoring member of the structure.

5 24. A method as claimed in any of claims 20 to 23, further comprising encapsulating the body and/or the at least one anchor members with a protective covering to increase the resistance of the structure to erosion.

10 25. A method as claimed in any of claims 20 to 24, further comprising assembling the at least one anchoring member with the cast body of the structure.

15 26. A method as claimed in any of claims 20 to 25, wherein the casting step comprises casting the aggregate into two or more moulds, each mould forming a portion of the body, and assembling the cast portions of the body to form the complete body of the structure.

20 27. A mould for use in a method of manufacturing a waste material structure according to any of claims 20 to 26, the mould comprising commonly available building materials.



28. A mould as claimed in claim 27, wherein the mould comprises metal plates shaped and welded together, wood pieces nailed together, empty oil drums, plastic pipes or bamboo tubes.

5 29. A mould as claimed in claim 28, where the mould comprises metal plates, the mould further comprising a coating of zinc on the metal plates to reduce the long term rusting or oxidation effects.

10 30. A method of manufacturing a disposable waste material structure comprising a waste material body and at least one anchoring member, the method comprising: compacting the solid waste into a predetermined body shape and encapsulating the thus formed body with an encapsulant, the encapsulant being
15 arranged to retain the compacted waste in the predetermined shape.

31. Use of a plurality of waste material structures, as claimed in any of claims 1 to 19, in an underwater foundation of a marine structure such as a dam or a
20 sea wall.

32. An artificial coral reef comprising a plurality of waste material structures as claimed in any of



claims 1 to 19.

33. A structure, method or mould substantially as described herein with reference to the accompanying drawings.