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Chang

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[54] **POLYHEDRAL, POROUS, AND HOLLOW BLOCK**

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May 3, 1973 South Korea 719

[52] **U.S. Cl.** **61/4;** 61/4

[51] **Int. Cl.²** **E02B 3/04**

[58] **Field of Search** 61/3, 4, 5; 52/608, 609, 52/610, 611; 249/118, 155, 156, 153, 163; 46/23, 24, 25

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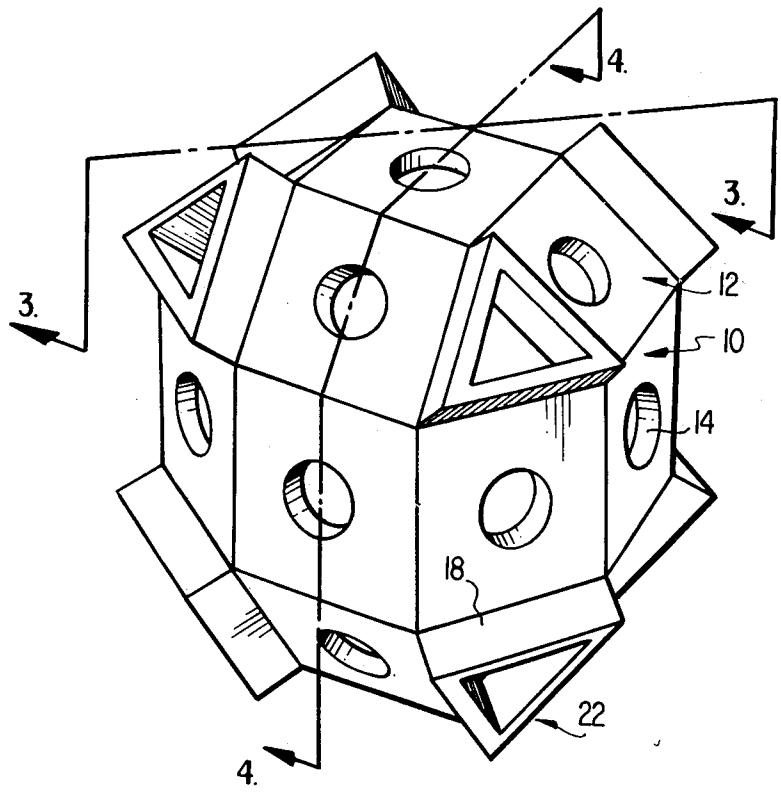
[57] **ABSTRACT**

A polyhedral structural block having a hollow core and perforated surfaces, which is useful in forming underwater structural foundations for revetments, breakwaters, dikes, jettiers, piers, abutments and the like, comprising six apertured, flat rectangular sides and twelve apertured, flanged rectangular sides wherein the adjacent flanges of the latter are arranged so as to form eight open triangular sides.

5 Claims, 10 Drawing Figures



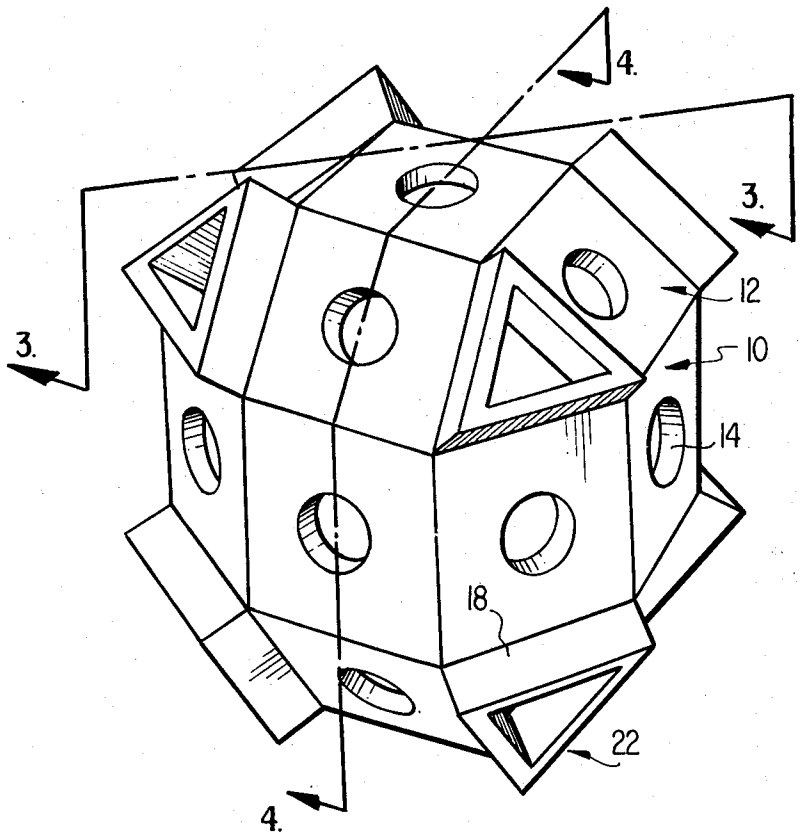


Fig. 1

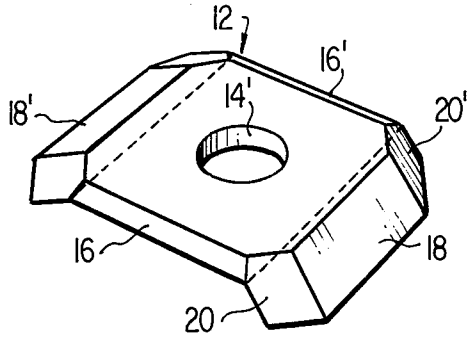


Fig. 2A

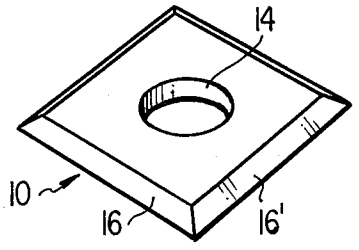


Fig. 2B

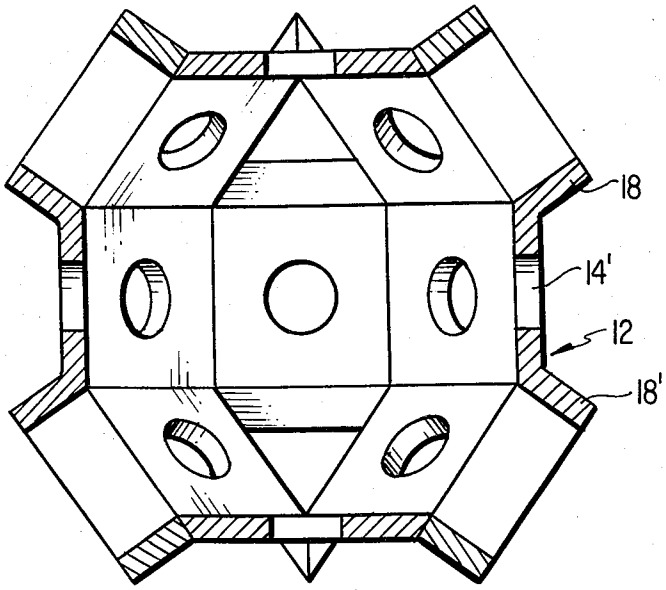


FIG. 3

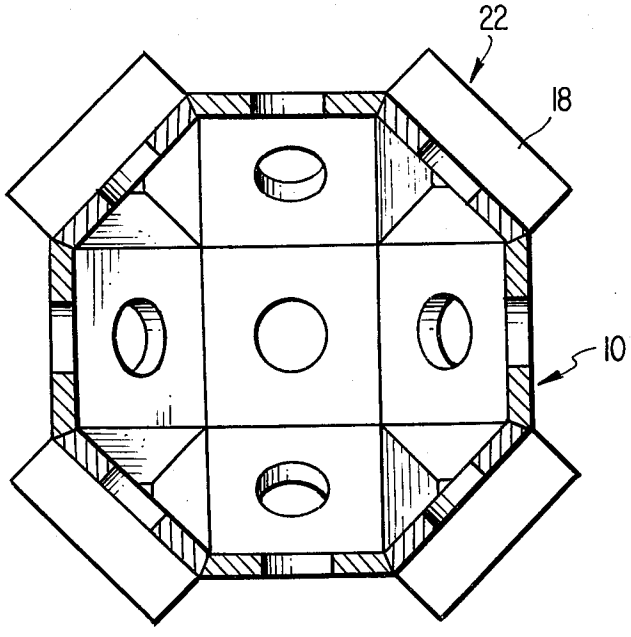


FIG. 4

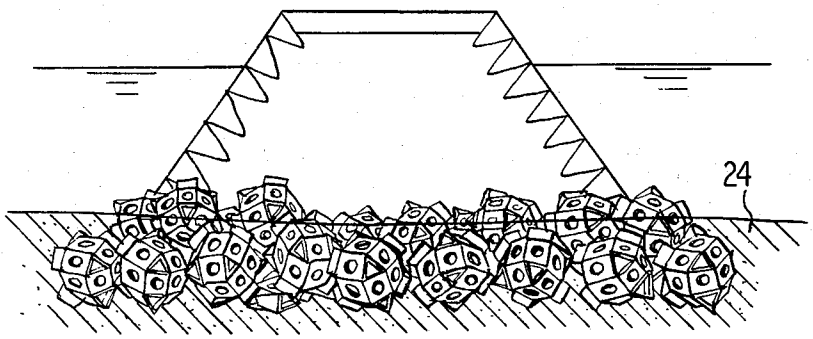


FIG. 5

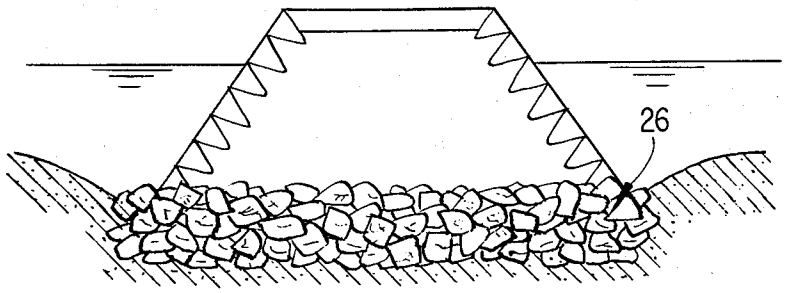


FIG. 6

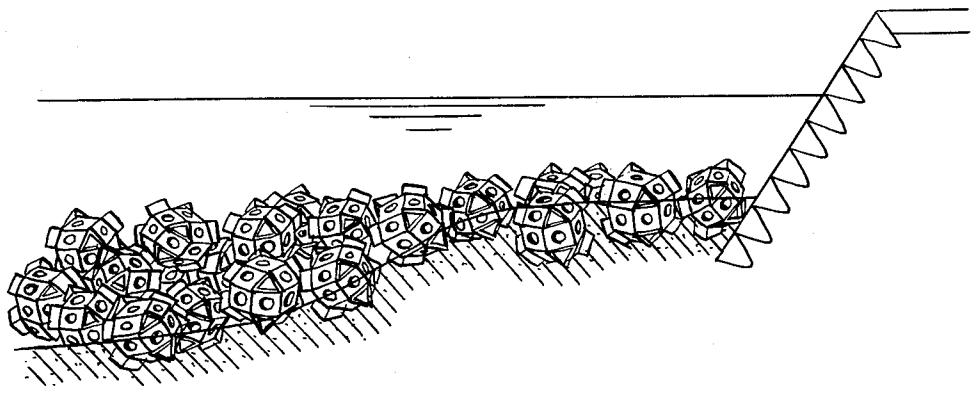


FIG. 7

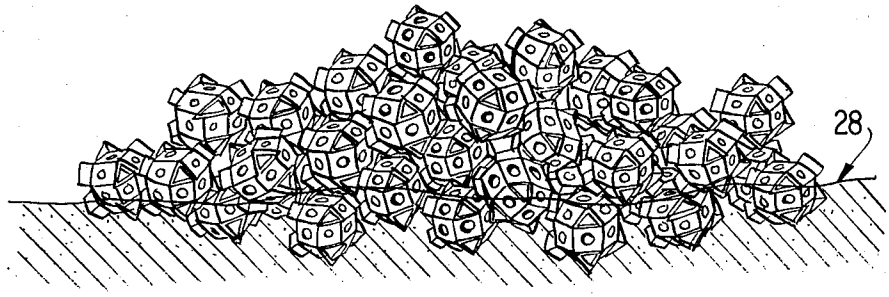


FIG. 8

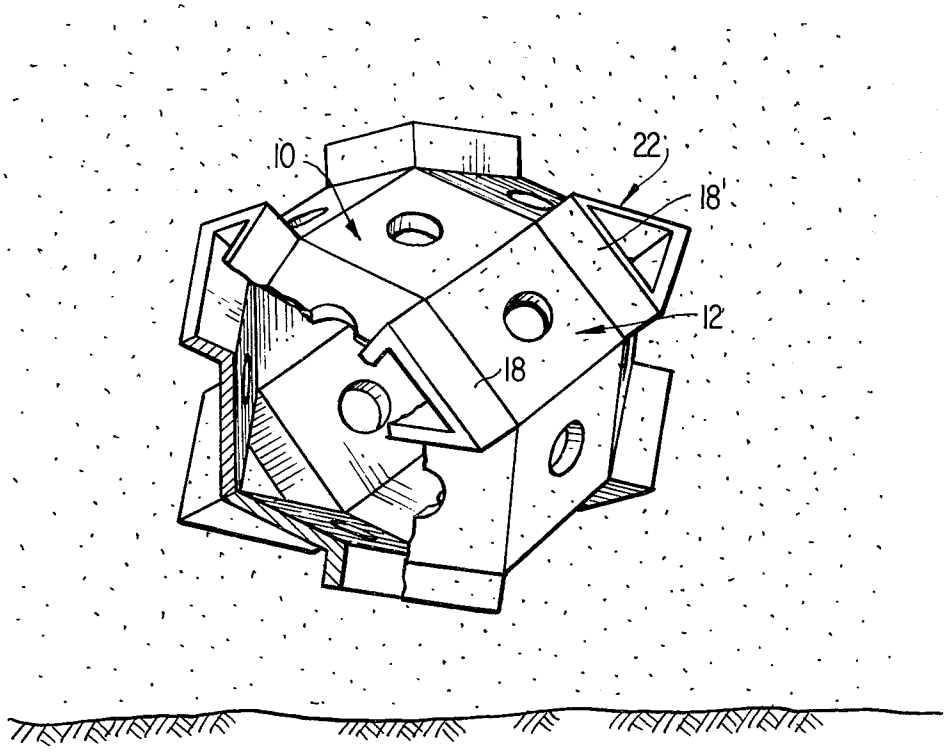


FIG. 9

POLYHEDRAL, POROUS, AND HOLLOW BLOCK

BACKGROUND OF THE INVENTION

This invention relates to a polyhedral, structural block having a hollow core and perforated surfaces, which is useful in forming underwater structural foundations and in river and shore engineering construction. More particularly, this invention relates to a polyhedral structural block which will provide a stable foundation on underwater mud layers for the construction of a breakwater, dike, seawall, quaywall, revetment or the like.

Silt and mud layers often found at the bottom of rivers and shores are often soft and floating, so that when solid foundation material such as rock, concrete blocks or the like is dropped into the mud layer, the vertical center portion of a structure constructed thereon will sink due to the heavy deadload, while the inner and outer areas around the periphery subside to a lesser extent, resulting in an unstable foundation. At the same time, mud which is pushed out by the sinking center of the foundation will accumulate at the sides of the structure bottom, so that the mud foundation itself of the sea bottom accumulated about the structure over a period of time will be spread out. In such a state, the wave forces generated by storms and tidal currents often cause the structure to collapse or wash away.

Another disadvantage frequently encountered in the use of the above objects is due to the small surface area and frictional resistance of the individual objects which do not bind to each other when dropped into a mud layer. Thus, slippage is relatively easy and the deadload of structures constructed thereon results in an uneasy support. When waves generated by heavy storms or tidal currents strike the upper portion of such structures, the structure itself often collapses. Due to the strength of the currents and tides in water waves and overflows, this usually occurs and often causes a revetment, embankment, breakwater or guide structure to collapse prematurally.

It is furthermore heretofore been impossible to accurately estimate by good engineering design the quantity and weight of rock required to be dropped into a given mud layer. Even a rough survey requires driving piles into the mud, but such efforts are generally unsatisfactory in yielding the desired data, and design work has been largely based on inaccurate or incomplete data obtained from past experience. During the construction process, the increase or decrease in the quantity of rock required over that calculated has been determined by the quantity of rock being sunken into a mud layer or being washed away. Thus, any errors in determining this increase or decrease result in either an early destruction of the structure or in a waste of construction funds.

Underwater structures in both fresh and salt water provide shelter for many types of aquatic and marine life. However, even these relatively sheltered populations have been threatened due to a rapid improvement of fishery techniques and reckless catches. In order to preclude reckless catches and to provide an inhabitable place to protect and breed fishes while still permitting sport fishing, porous blocks have recently been utilized to serve as objects with which to damage fishing nets in an effort to discourage fishing in a specific area.

OBJECTS OF THE INVENTION

Accordingly, it is a general object of the present invention to provide a structural block which is useful in constructing underwater foundations.

Another object of this invention is to provide such a structural block which is three dimensionally symmetrical and therefore need not be self-righting.

A further object of this invention is to provide a hollow-core structural block which is self-draining, thereby avoiding damage caused by filling and draining stresses.

An additional object of this invention is to provide a structural block capable of retaining particulate matter therein while permitting water to flow therethrough.

Yet another object of this invention is to provide a structural block which discourages heavy fishing in the sheltered area which it provides.

A still further object of this invention is to provide increased frictional resistance between adjacent structural elements of an underwater foundation.

Still another object of this invention is to provide a structural block which can be prefabricated from only two component parts, which can be transported for assembly at a construction site.

Other objects of the present invention will become apparent to those skilled in the art upon further study of the specification and appended claims.

SUMMARY OF THE INVENTION

Briefly, the above and other objects are attained in one aspect of the present invention by providing a polyhedral structural block having a hollow core and perforated surfaces which is fabricated from six flat rectangular first structural members, preferably having an aperture formed through the planar surface thereof, and twelve flat rectangular second structural members, also preferably having an aperture formed in the planar surface thereof, the second members having a pair of flanges extending outwardly from a pair of parallel edges thereof. The assembled block is hollow and perforated, and is assembled in such a manner that three adjacent flanges from the second members form triangular openings to permit the flow of water therethrough and protruberances which can damage fishing nets and therefore discourage heavy fishing.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present invention will become more fully apparent to those skilled in the art to which this invention pertains from the following detailed discussion, taken in conjunction with the annexed drawings wherein like or corresponding reference numerals refer to like or corresponding parts in the several figures, and in which:

FIG. 1 is a perspective view of the assembled polyhedral, perforated hollow block of the present invention;

FIGS. 2A and 2B show a perspective view of the two rectangular members used to construct the block, FIG. 2A showing a member with flanges and FIG. 2B showing a member without flanges;

FIG. 3 is a plan view taken along vertical section 3—3 of FIG. 1;

FIG. 4 is a plan view taken along horizontal section 4—4 of FIG. 1;

FIG. 5 is a schematic illustration, partially in cross-section, of an underwater foundation constructed in accordance with the present invention;

FIG. 6 is an analogous view of a similar structure constructed of a rock base on a layer of mud;

FIG. 7 schematically illustrates a section of reservoir revetment built on a foundation in accordance with this invention;

FIG. 8 is a schematic view of a fish shelter provided by blocks of the present inventions; and

FIG. 9 is a perspective view, partially in cross-section, schematically illustrating flow through the block.

DETAILED DISCUSSION

The rectangular members used to form the blocks of this invention can be constructed of any material suitable for underwater use, e.g., steel, concrete, bound aggregate and the like, the only requirement being that the material have sufficient structural strength, a non-slippery surface, and be suitable for use under water. Preferably, either the flat rectangular members or the flanged rectangular members, or preferably both, are formed about centrally located apertures of a suitable size. This functions to not only reduce the weight of the block itself without a significant decrease in the strength thereof, but also permits improved circulation of water, silt and mud into the hollow block core. By the provision of multiple faces and angles, frictional resistance between adjacent blocks is increased and the resistance to movement of the block itself in a layer of mud is greatly enhanced. Furthermore, the mud surrounding a pile of such blocks on a sea or river bottom can enter into the inside of the inner blocks, thereby minimizing mud accumulation around the periphery and greatly enhancing the stability of the foundation. The blocks are particularly useful in constructing structures such as a closing dike, sea wall or temporary revetment for reclamation which connects the river embankments or shore ends, or a groin, guide wall or the like to control currents, or a low water revetment which protects an area of shore from errosion. The large volume, heavy weight, multi-holed block will provide not only a stable foundation, but also decrease the velocity of water flowing therethrough and retain deposits in the hollow inner core. This is especially valuable in situations where tidal currents or river water flow is encountered, since the hollow core will fill with particulate material to form a heavy block and the flow of water through the holes thereof is at a decreased velocity. Thus, the blocks can be firmly set so that a structure constructed thereon will not be destroyed but rather will be safely protected. The provision of both large and small holes further allows fish to enter and leave the shelter which is naturally provided by an accumulation of such blocks.

Referring to the drawings, it can be seen that the block can be constructed in accordance with the principles of this invention using only two modular members **10** and **12.** Six flat rectangular first members **10,** preferably having an aperture **14** formed through the planar surfaces thereof, e.g., of the type shown in FIG. **2B,** are preferably bevelled along the edges **16, 16'** as shown. Twelve flat rectangular second members **12** also preferably having an aperture **14'** formed through the planar surfaces thereof and having a pair of flanges **18, 18'** extending outwardly from a pair of parallel edges thereof are also employed, giving a total of eighteen flat surfaces having holes in the center. When assembled, the flanges form eight triangular protruberances **22** defining triangular holes in each block. Therefore, the preferred hollow block has eighteen holes on eighteen faces and another eight triangular holes, each formed by the edges of three adjacent flanges, for a total of **26** holes. The bevelled edges **16, 16'** of the first and second members **10** and **12,** respectively, facilitate joint welding or adhesive bonding, e.g., with a polyester resin of adjacent flat surfaces at a **45°** angle. Alternatively, exposed reinforcing bars or other structural equivalents can be provided in place of the flanges.

It will be appreciated that while the presently preferred embodiment of this invention is constructed by assembling eight flat members and **12** flanged members, the exact configuration of the polyhedral structural block can be modified in accordance with known principles of solid geometry to a greater or lesser number of total members, including modifying the shape of the protruberances if necessary. However, as the number of sides of the polyhedron increases, the resistance against sliding and rotation decreases because the block becomes more spherical, which is undesirable.

Referring to FIG. **2B,** flat rectangular member **10** is shown in a preferred apertured configuration with all edges thereof bevelled at an angle of **67.5°** to eliminate alignment problems in assembly. Two such adjacent bevelled surfaces when fitted together form a right angle and impart a **22.5°** offset to the plane of each member on which they are formed, resultng in a net **45°** angle between adjacent members and the formation of a generally annular closed **360°** ring when eight modular members are brought together at sixteen such parallel bevelled edges.

Referring to FIG. **2A,** the second flat rectangular members are preferably of the same dimensions and configuration around the inner perimeter as the first members, and two parallel outer edges thereof are similarly bevelled at an angle of **67.5°.** The other two parallel sides extend at an obtuse angle to the rectangular surface to form a flange which terminates laterally in angularly faceted surfaces such that assembly of three such flanges by mating the faceted surfaces will form a closed, hollow triangular protruberance **22.** As can be seen from FIG. **3,** the flanges and accordingly the plane of the triangle so formed is preferably at a **135°** angle to the surface of each adjacent second member, whereby the axis of the triangular protruberance extends outwardly from the center of the polygon.

The faceted portion **20, 20'** of flanges **18, 18'** are formed at an outwardly obtuse angle with respect to the flat bottom surface of the second members and the plane thereof is perpendicular to the center of the rectangle, such that six such mated surfaces of three flanges fit smoothly together to form the solid corners of the triangle. The facet plane will preferably intersect inner surface at a **45°** angle to each intersecting edge of the inner surface and the flange segment thereof extends outwardly at an angle of **135°** from the flat surface of said member.

The provision of both rectangular and triangular joining surfaces in various planes is an important aspect of this invention, since the stability and structural strength of the block is greatly increased thereby.

Referring to FIG. **1,** it can be seen that the assembled block forms a polyhedron characterized by

a. a first generally annular ring formed from a plurality of alternating first and second rectangular members, the surfaces of each member being at an acute angle to the surfaces of abutting members and the flanges of said second members extending radially and outwardly along the outer perimeter of said ring;

b. a second generally annular ring disposed at right angles to said first ring and having an imaginary axis which intersects an imaginary axis of the first ring at a point inside a hollow core, said second ring being formed from a plurality of alternating first and second members and having a pair of opposed first members in common with said first ring, the flanges of the second members thereof extending radially and outwardly along the perimeter of the second ring and each flange abutting an adjacent flange on the first ring to form an acute angle therewith; and

c. a third generally annular ring disposed at right angles to both said first and second rings and having an imaginary axis which intersects the intersecting axes of said first and second rings, said third ring being formed from a plurality of alternating first and second members and having one pair of opposed first members in common with said first ring and a second pair of opposed first members in common with said second ring, the flanges of the second members thereof extending radially and outwardly along the perimeter of the third ring and abutting adjacent flanges on the first and second rings to form acute angles thereto, whereby a protruberant triangular opening is defined by abutting flanges of the three rings protruding outwardly from said members.

In a preferred embodiment, the flat first members are bevelled along edges **16** thereof at an acute slope, e.g., of about **67.5°**, while the flanges on the second members slope from the outer surface at an obtuse angle, e.g., about **135°**, preferably of about **126°**. Assembly is facilitated by first forming a triangle **22** from three abutting flanges, and then covering and welding the first flat members **10** to the spaces provided to complete assembly of the polyhedral, hollow block.

Both the first and second members **10, 12** can be easily mass produced at a distant factory and cured prior to transporting the prefabricated slabs to a construction site for assembly, e.g., using a concrete polyester joining composition to fasten the side faces together, prior to dropping the blocks into the water.

In actual operation, the blocks when dropped into the sea will sink due to their own weight. Once the block reaches a soft mud layer **24** at the bottom, the mud enters the hollow interior through both the triangular holes formed by the flanges and the apertures in the faces of the rectangular members as is illustrated in FIG. **9**. Thus, the undesirable mud accumulation which occurs when using solid rock or similar materials, indicated as **26** in FIG. **6**, does not occur. Furthermore, the weight of the blocks is increased due to the mud fill, which facilitates passage through the mud layer to rest on a hard bottom surface **28.**

Because flanges **18** and protruberant portions **22** function to increase the frictional resistance between adjacent blocks, and because contact with mud **24** increases shear resistance, the blocks are prevented from free rotation in a soft mud layer. Since the block is geometrically symmetrical and water permeable, it sinks vertically of its own weight and the blocks are easily dropped to the bottom at equal intervals.

When dropped into a river, the bottom blocks become gradually embedded into the silt and settle firmly. As silt is carried by the current and the blocks permit the passage of water therethrough, the silt and sand accumulation will eventually take place in downstream blocks as well, causing these blocks also the settle firmly.

For use in conducting revetments or sea walls in land reclamation, the holes serve not only as a means of increasing the weight of the block by collecting silt or soil therein, but further to drain water therethrough from changing tides or waves, thereby obviating stresses which normally occur during the drainage of large volumes of water from a solid object. In order to reduce the water velocity inside the block, a bundle of branches can be inserted to slow down the velocity and aid in accumulating silt, which contributes to building up and protecting a stable structural foundation. The protruding triangular portion **22** formed by flanges **18** provides increased rotational resistance in a bed of silt or mud; portions of these protruding triangles can be accidentally broken off without impairing the structural strength and functioning of the block. Portions protruding from the sea or river bed further act as a hook to damage fishing nets, thereby discouraging heavy fishing of the sheltered area provided.

From the foregoing description, one skilled in the art can easily ascertain the essential characteristics of this invention, and without departing from the spirit and scope thereof, can make various changes and modifications of the invention to adapt it to various usages and conditions.

What is claimed is:

1. A polyhedral structural block suitable for use in constructing underwater foundations, having a hollow core and perforated surfaces, comprising in combination:

a. a plurality of flat rectangular first members;

b. a plurality of flat rectangular second members having a pair of flanges extending outwardly at an obtuse angle from a pair of parallel edges thereof, said plurality being twice the number of flat rectangular first members;

c. a first generally annular ring formed from a plurality of alternating first and second rectangular members, the surfaces of each member being at an acute angle to the surfaces of abutting members and the flanges of said second members extending radially and outwardly along the outer perimeter of said ring;

d. a second generally annular ring disposed at right angles to said first ring and having an imaginary axis which intersects an imaginary axis of the first ring at a point inside said hollow core, said second ring being formed from a plurality of alternating first and second members and having a pair of opposed first members in common with said first ring, the flanges of the second members thereof extending radially and outwardly along the perimeter of the second ring and each flange abutting an adjacent flange on the first ring to form an acute angle therewith;

e. a third generally annular ring disposed at right angles to both said first and second rings and having an imaginary axis which intersects the intersecting axes of said first and second rings, said third ring being formed from a plurality of alternating first

and second members and having one pair of opposed first members in common with said first ring and a second pair of opposed first members in common with said second ring, the flanges of the second members thereof extending radially and outwardly along the perimeter of the third ring and abutting adjacent flanges on the first and second rings to form acute angles thereto, whereby a protruberant triangular opening is defined by abutting flanges of the three rings protruding outwardly from said members.

2. A structural block according to claim **1**, comprising six first members and **12** second members, wherein each generally annular ring is formed of eight of said members.

3. A structural block according to claim **2**, wherein the edges of said first members are bevelled at about a **67.5°** angle.

4. A structural block according to claim **3**, wherein the flanges on said second members extend at an obtuse angle of about **126°**.

5. A structural block according to claim **4**, wherein the edges of said flanges are faceted at about a **67.5°** angle.

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