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(54) BLOCK FOR BUILDING HYDRAULIC STRUCTURES

(57) A block (1) for building hydraulic structures, such as dams or groynes, the block (1) having a prismatic shape, with a bottom surface (2) and a top surface (3) extending parallel to each other and each having a polygonal shape, said polygonal shape being formed from a basic shape (5) being a regular polygon that comprises projections (6) each extending from a corner of the regular polygon (5) and being spaced from one another by recesses (7), and wherein the block (1) comprises a through-opening (12) that extends through the block (1) from the bottom surface (2) to the top surface (3).

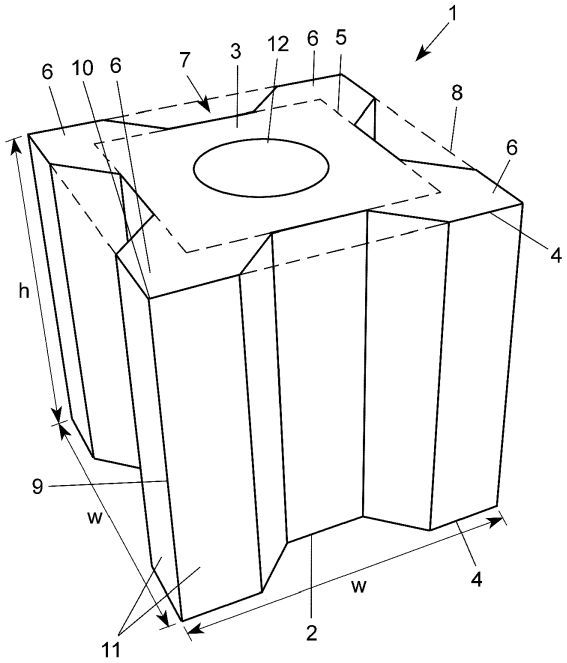

Fig. 1

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Description

[0001] The invention refers to a block for building hydraulic structures, such as dams, scour protection, bed protection or groynes.

[0002] Further, the invention refers to a hydraulic structure, such as a dam or a groyne, made of a plurality of blocks, and to a method of manufacturing such a block.

[0003] Submerged or partially submerged hydraulic structures are built to divert, disrupt or completely stop the natural flow of water. Hydraulic structures can be arranged in rivers, a sea, or any body of water where there is a need for a change in the natural flow of water.

[0004] Hydraulic structures may have a protective function, such as in the case of breakwaters, dams and the like that are exposed to the beating of the waves. The waves break as soon as they strike the blocks of the hydraulic structure, with the result that the underlying parts are better protected against the forces of the water.

[0005] Hydraulic structures can also be applied as groynes, longitudinal dams, shore protection and scour protection.

[0006] Hydraulic structures have since long time been built from natural blocks of stone piled up in a random orientation, wherein the interlocking nature of the natural shape of such blocks provides for the required stability of the hydraulic structure. In other prior art embodiments, hydraulic structures are build up in layers using natural materials with a core of sand or clay and outer layers of granular material increasing in size, number and size of the material in the layer depending on the function and the hydraulic loading typical for the application.

[0007] In more recent times, blocks made of concrete have been used instead of blocks of natural stone, which allows to optimize the shape of the blocks and to impart specific properties to the hydraulic structure. The blocks are usually made of non-reinforced concrete, which means that the strength of the blocks has to be provided by the concrete material alone. It is therefore necessary to choose as advantageous as possible a shape for the block.

[0008] An optimized shape of a block for building hydraulic structures has been disclosed in WO 2004/009910 A1. The block comprises a plate portion with a nose projecting from the plate portion on one side of the plate and a nose projecting in the opposite direction on the other opposite side of the plate. The plate portion in these known blocks is X-shaped.

[0009] Other embodiments of blocks for building hydraulic structures are disclosed in WO 2018/052292 A1 and WO 2020/242295 A1.

[0010] The main advantages of concrete blocks, such as those described in WO 2004/009910 A1, are that blocks can be placed in bulk, using a crane with hydraulic grab, and that they can be transported in bulk using river barges. Further, groynes or guide dams can be made of such blocks only, avoiding the construction of different layers, joints and transition to other structures.

[0011] However, building groynes and dams from such concrete blocks requires a huge amount of blocks. For example, about 1 to 2 million blocks would be needed per kilometer of longitudinal dam. Therefore, blocks are needed that can be produced at a high production rate and at a low cost. The blocks disclosed in WO 2004/009910 A1 have to be produced in two pieces, when a dry cast process shall be applied. The first piece constitutes the plate portion of the block and the second piece is a beam that is inserted into a passage of the plate portion in order to form a nose projecting from the plate portion on one side of the plate and a nose projecting in the opposite direction on the opposite side of the plate. Thus, the manufacturing of such blocks requires an assembly step, in which the beam is introduced into the plate portion, which constitutes a bottleneck in the production process.

[0012] Therefore, it is an object of the invention to provide a block for building a hydraulic structure that can be produced at a high production rate and at low cost, and that at the same time has a favorable shape in order to achieve a sufficient strength of the block and an interlocking capability with adjacent blocks present in the hydraulic structure.

[0013] In order to solve this and other objects, a first aspect of the invention provides a block for building hydraulic structures, such as dams or groynes, the block having a prismatic shape, with a bottom surface and a top surface extending parallel to each other and each having a polygonal shape, said polygonal shape being formed from a basic shape being a regular polygon that comprises projections each extending from a corner of the regular polygon and being spaced from one another by recesses, and wherein the block comprises a through-opening that extends through the block from the bottom surface to the top surface.

[0014] The prismatic shape of the block allows the block to be produced in a single piece by means of a dry cast process. This removes the bottleneck previously existing due to the requirement of assembling each block from two separately produced pieces. Manufacturing the blocks by means of a dry cast process allows to significantly increase the production rate, since the dry castable material, such as concrete or mortar, does not need to remain in the form until the material has become self-sustaining. Rather, the dry castable material is self-sustaining immediately after the casting step, so that the casting form may be removed without delay and used for the production of the next block.

[0015] An additional advantage of the prismatic shape of the blocks of the invention is that the blocks can easily be stacked and that they can be transported without pallets.

[0016] Preferably, the prismatic shape of the block of the invention corresponds to a right prism.

[0017] Further, the projections of the prismatic shape of the block allow for an efficient interlocking of the block with adjacent blocks, wherein a projection of one block may engage into a recess that is formed between neighboring projections of an adjacent block, irrespective of the relative orientation of adjacent blocks in the three-dimensional space. Thus, interlocking does not require adjacent blocks to be oriented with their prismatic shapes being arranged in parallel.

[0018] Further, the block of the invention is characterized by a through-opening that extends through the block from the bottom surface to the top surface, which creates empty spaces within the hydraulic structure that in turn result in an increase of the porosity of the hydraulic structure. Due to the through-opening, the blocks may be produced with larger dimensions and a larger volume when compared to prior art blocks, without compromising the porosity of the hydraulic structure and without increasing the material consumption in relation to its outer dimensions. Consequently, a lower number of blocks is required per volume of hydraulic structure, which increases the speed of manufacturing and building a hydraulic structure.

[0019] Due to its porosity, the hydraulic structure may form a habitat for aquatic life. The porous structure is also able to absorb wave energy created by inland shipping.

[0020] Further, because the blocks may be produced with larger dimensions and a larger volume, their stability is increased to due to the higher own weight of each block.

[0021] In principle, any kind of regular polygon may be used for the basic shape of the bottom and the top surface. Advantageously, a regular hexagonal, a regular pentagonal, regular tetragon (square) or a equilateral triangle can be used. According to the invention, the regular polygon is provided with projections that are each extending from a corner of the regular polygon so that recesses are formed between adjacent projections. Preferably, but not necessarily, each corner of the regular polygon is provided with a projection.

[0022] According to a preferred embodiment of the invention, the basic shape is a square and four projections are provided, each extending from a corner of the square.

[0023] Preferably, the through-opening has a circular cross-section. This allows for an easy production of the blocks of the invention by means of a dry casting process in a single piece.

[0024] Preferably, the through-opening is arranged concentric with the regular polygon of the basic shape. Herein, the center of a regular polygon is defined as the point from which all the vertices or corners of the polygon are equidistant.

[0025] According to a preferred embodiment of the block of the invention, a bounding box of the projections is a square that is concentric to the square of the basic shape. In this way, the shape of the projections is defined more specifically, so as to provide for a certain symmetry of the projections. This is particularly the case, if the square of the bounding box is concentric to the square of the basic shape in accordance with a preferred embodiment.

[0026] More generally, a bounding box of the projections may have a shape that is the same kind of regular polygon as the regular polygon of the basic shape and that is concentric to the regular polygon of the basic shape.

[0027] Further, the projections each comprise an edge that is arranged in a corner of the bounding box. In this way, a X-shape of the bottom and the top surface, and of the cross section of the block, is provided.

[0028] Preferably, the projection each comprise side surfaces that are converging to the edge and are flush with sides of the bounding box.

[0029] In order to provide a block of sufficient volume, the height of the block being defined as the distance between the bottom surface and the top surface preferably corresponds to 0.8 to 1.2 of a side length of the bounding box. In order to achieve a cubic bounding box of the block, the height of the block is equal to its width, i.e. to the side length of the bounding box.

[0030] The blocks of the invention may be produced in different sizes. Preferably, the width of the bottom or top surface is in the range of 20-50cm and the height of the block is in the range of 20-50cm. Preferably, the width of the bottom or top surface is in the range of 30-40cm. In case the bottom or top surface of the block comprises a bounding box having a square shape, the width of the bottom or top surface is understood to correspond to the side length of said bounding box.

[0031] In order to optimize the porosity of the hydraulic structure to be built from the blocks of the invention, a preferred embodiment provides that the diameter of the circular cross-section of the through-opening is at least 1/5, preferably at least 1/4 of the diagonal of the bounding box.

[0032] As mentioned above, the block may preferably be made of concrete or mortar. Any type of concrete or mortar may be used. Further, the concrete or mortar may contain any type of cement, such as Portland cement. Suitable cements comprise cements according to the European standard EN 197-1 of April 2012 or mixtures thereof, preferably cement of the types CEM I, CEM II, CEM III, CEM IV or CEM V.

[0033] The aggregates used in the concrete may comprises sand, gravel, crushed stone, slag, recycled concrete and geosynthetic aggregates.

[0034] The blocks are preferably made of a concrete that is suitable for dry cast processes. In particular, the compressive strength of the blocks after 28 days of curing is > 20 MPa.

[0035] According to a second aspect of the instant invention, a hydraulic structure, such as a dam or a groyne, is provided that is made of a plurality of blocks according to the first aspect being piled up in a random orientation, wherein adjacent blocks are in an interlocking relationship with each other. A random orientation is understood to define an

orientation, wherein the blocks are arranged relative to each other as a result of a bulk of blocks being poured or dropped from a crane or a conveying means. In particular, a random orientation does not comprise an arrangement of blocks, wherein the prismatic shapes of the blocks are arranged parallel to each other.

[0036] Preferably, the hydraulic structure has a porosity of 0.5 to 0.75. Herein, the porosity is a measure of the void spaces in the hydraulic structure in relation to the total volume of the hydraulic structure. Preferably, the porosity is between 0.6 and 0.7.

[0037] According to a third aspect of the instant invention, a method of manufacturing a block according to the first aspect is provided, comprising the steps of:

- providing a form,
- pouring a dry castable concrete or mortar into the form,
- compacting the concrete or mortar within the form,
- removing the form,
- allowing the concrete or mortar to harden.

[0038] The method may be used to cast the block in a single piece.

[0039] Preferably, the dry castable concrete or mortar has a water to cement ratio of < 25 wt.-%. The dry cast process is characterized by the use a dry concrete mix, i.e., a concrete mix containing a relatively low amount of water and having a low slump. Ideally, the mix contains only that amount of water which is necessary for hydration of the cement and desired workability. The water to cement ratio is usually less than 0.25 and the slump is less than 1/2 inch, preferably zero or less.

[0040] The dry cast process is further characterized by the ability to remove the form immediately after the dry castable concrete has been compacted within the form, such as by vibration. The block of concrete formed in this way can support itself without the presence of the form.

[0041] In the following, the invention will be described with reference to an exemplary embodiment of a block illustrated in Fig. 1.

[0042] Fig. 1 shows a block 1 made of concrete having a prismatic shape. The block 1 comprises a bottom surface 2 and a top surface 3, each having a polygonal shape or outline 4. The polygonal outline of the bottom surface 2 and the top surface 3 is formed form a basic shape being a regular polygon, which is a square 5 in the embodiment of Fig. 1 as shown with dotted lines. The bottom surface 2 and the top surface 3 are further formed from projections 6 each extending from a corner of the square 5 and being spaced from one another by recesses 7. A bounding box of the projections 6 is shown with dotted lines 8 and is a square that is concentric to the square 5 of the basic shape.

[0043] The projections 6 each comprise an edge 9 that is arranged in a corner 10 of the bounding box 8. Further, the projections 6 each comprise side surfaces 11 that are converging to the edge 9 and are flush with sides of the bounding box 8.

[0044] The block 1 comprises a through-opening 12 that extends through the block 1 from the bottom surface 2 to the top surface 3.

[0045] The block 1 has a width w and a height h that are equal so that a three-dimensional bounding box of the block 1 corresponds to a cube.

[0046] Exemplary blocks have been produced in three sizes, having a width/height of 33cm, 30cm and 40cm. As can be seen from the table below, the blocks have been poured into a bin having a volume of 32 m^3, in order to measure the porosity of a hydraulic structure that is built from the blocks. Based on the number of blocks (3rd column) that fit into the bin, the volume of each block (2nd column) and the volume of the bin (5th column), the porosity was calculated as indicated in the 6th column of the table. As can be seen, a very high porosity can be achieved with the blocks of the instant invention.

Type block	Volume block [m3]	# blocks in bin	Total volume blocks [m3]	Volume bin [m3]	Porosity [-]	Weight block
Block 33cm	0,02406	479	11, 52	32	0, 64	± 57 kg
Block 30cm	0,01775	645	11, 45	32	0, 64	± 42 kg
Block 40cm	0,04208	265	11, 15	32	0, 65	± 100 kg

Claims

1. A block (1) for building hydraulic structures, such as dams or groynes, the block (1) having a prismatic shape, with a bottom surface (2) and a top surface (3) extending parallel to each other and each having a polygonal shape, said polygonal shape being formed from a basic shape (5) being a regular polygon that comprises projections (6) each extending from a corner of the regular polygon (5) and being spaced from one another by recesses (7), and wherein the block (1) comprises a through-opening (12) that extends through the block (1) from the bottom surface (2) to the top surface (3).

2. Block according to claim 1, wherein the basic shape (5) is a square and wherein four projections (6) are provided, each extending from a corner of the square (5).

3. Block according to claim 1 or 2, wherein the through-opening (12) has a circular cross-section.

4. Block according to claim 1, 2 or 3, wherein the through-opening (12) is arranged concentric with the regular polygon of the basic shape (5).

5. Block according to any one of claims 1 to 4, wherein a bounding box (8) of the projections (6) has a shape that is the same kind of regular polygon as the regular polygon of the basic shape (5) and that is concentric to the regular polygon of the basic shape (5).

6. Block according to claim 5, wherein the bounding box (8) of the projections (6) is a square that is concentric to the square of the basic shape (5).

7. Block according to claim 5 or 6, wherein the projections (6) each comprise an edge (11) that is arranged in a corner (10) of the bounding box (8).

8. Block according to claim 5, 6 or 7, wherein the projections (6) each comprise side surfaces (11) that are converging to the edge (9) and are flush with sides of the bounding box (8).

9. Block according to any one of claims 5 to 8, wherein the height (h) of the block (1) being defined as the distance between the bottom surface (2) and the top surface (3) corresponds to 0.8 to 1.2 of a side length (w) of the bounding box (8).

10. Block according to any one of claims 5 to 9, wherein the diameter of the circular cross-section of the through-opening (12) is at least 1/5, preferably at least 1/4 of the diagonal of the bounding box (8).

11. Block according to any one of claim 1 to 10, wherein the block (1) is made of concrete or mortar.

12. A hydraulic structure, such as a dam, scour protection or a groyne, made of a plurality of blocks (1) according to any one of claims 1 to 11 being piled up in a random orientation, wherein adjacent blocks (1) are in an interlocking relationship with each other.

13. Hydraulic structure according to claim 12, wherein the hydraulic structure has a porosity of 0.5 to 0.75.

14. A method of manufacturing a block according to any one of claims 1 to 11, comprising

    - providing a form,
    - pouring a dry castable concrete or mortar into the form,
    - compacting the concrete or mortar within the form,
    - removing the form,
    - allowing the concrete or mortar to harden.

15. Method according to claim 14, wherein the a dry castable concrete or mortar has a water to cement ratio of < 25 wt.-%.

16. Method according to claim 14 or 15, wherein the block is casted in a single piece.

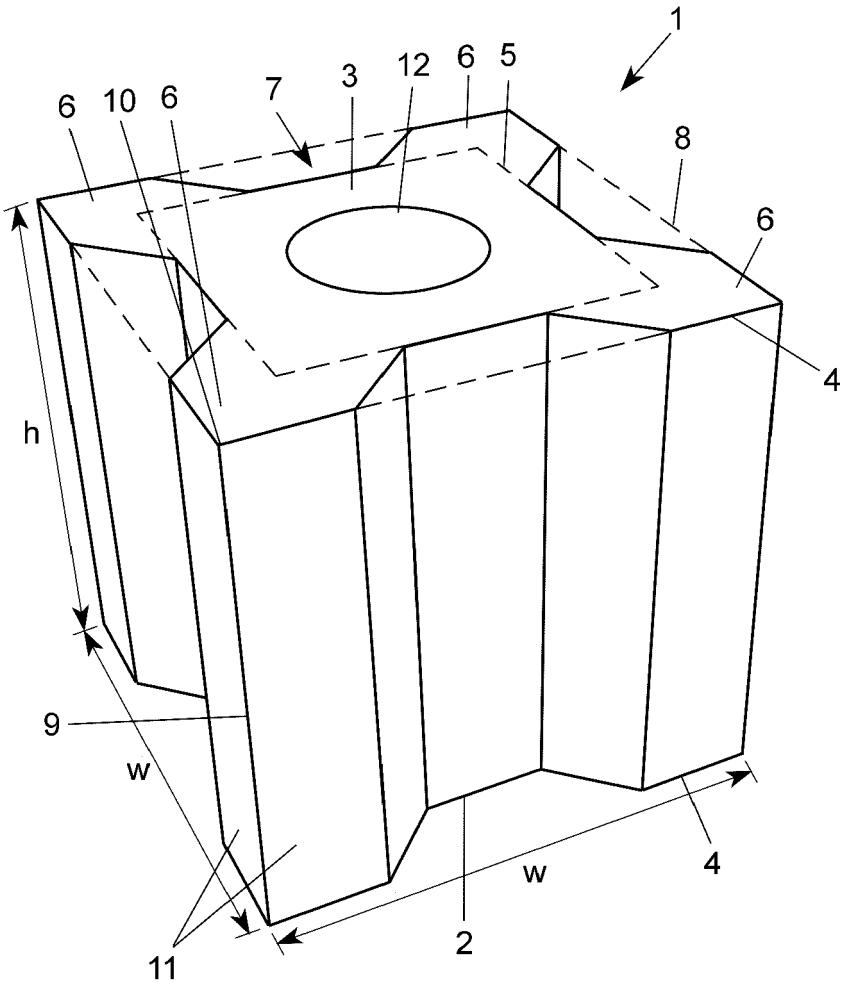

Fig. 1

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EUROPEAN SEARCH REPORT

Application Number
EP 22 02 0119

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 9 644 334 B2 (O'NEILL RAYMOND [US]; CARR DENNIS [US] ET AL.) 9 May 2017 (2017-05-09) * column 36, lines 36-58; figures 6A, 17A-17C * * column 10, lines 19-25 * -----	1-12, 14-16	INV. E02B3/14 E02B3/12 E02D29/02
X	US 4 594 023 A (O'NEILL RAYMOND J [US]) 10 June 1986 (1986-06-10) * column 2, lines 39-49; figures 1-5 * * column 2, lines 7-11 * -----	1-7,10, 11,13,15	

TECHNICAL FIELDS SEARCHED (IPC)
E02B E02D E02C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	5 September 2022	Boyer, Olivier

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 22 02 0119

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05-09-2022

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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- WO 2018052292 A1 **[0009]**
- WO 2020242295 A1 **[0009]**