Oct. 12, 1965 H. R. SVEE 3,210,944

PROTECTIVE LAYER ON SLOPE OF MOLES AND BREAKWATERS

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Fig. 1

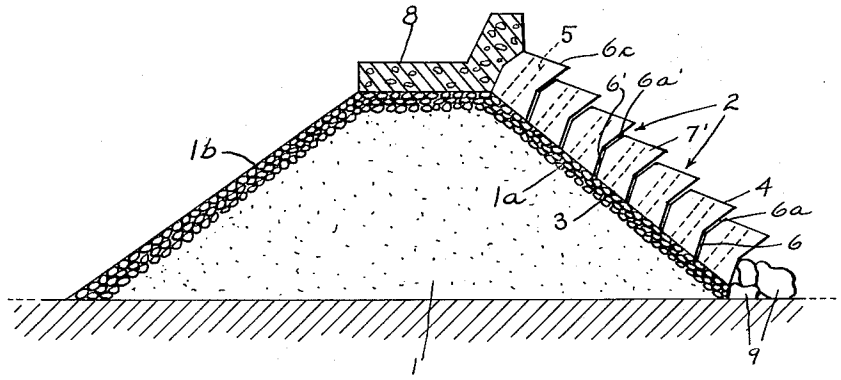


Fig. 2

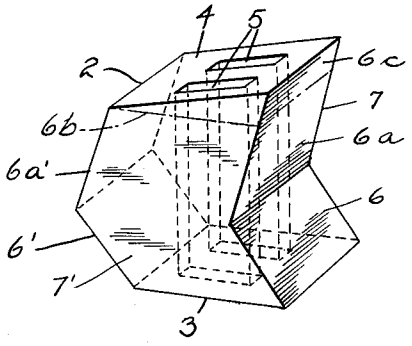


Fig. 3

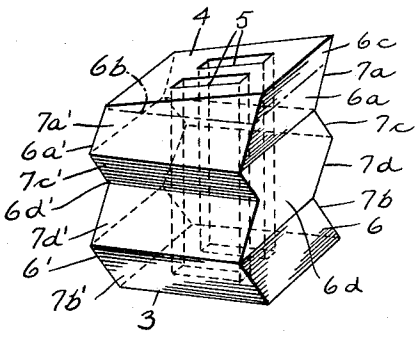
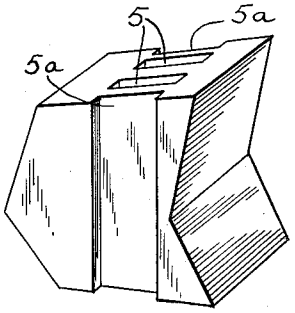


Fig. 4



INVENTOR
HALLBJÖRN ROALD SVEE

BY Robert K. Jacob

AG'T.

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PROTECTIVE LAYER ON SLOPE OF MOLES AND BREAKWATERS

Hallbjörn Roald Svee, Njords vei 6, Nardosletta, Strinda, Norway

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3 Claims. (Cl. 61—4)

The present invention relates to blocks for making protecting layers on slopes of moles and breakwaters exposed to water in motion. Constructions of this kind often have slopes which are exposed to very large wave attack. The outer protecting layer forming a surface of the slope, therefore, consists of blocks or stones of large dimensions. It is sometimes necessary to produce these blocks artificially because it is not always possible to find stones of suitable dimensions in the neighborhood of the building spot or in a stone quarry in a suitable position.

In recent times blocks have often been used for forming such protecting layers. These blocks are constructed in such way that certain spaces or openings between neighboring blocks are obtained, and at the same time the center of gravity of every single block is low to prevent the blocks from turning over. This is obtained by providing the blocks with protrusions of different kinds, such as short frusto-conical arms which, in certain embodiments, point out in different directions from a center core. Thereby is also obtained that the blocks are prevented from sliding along the inclined stone base of the slope, or one upon the other if the blocks are laid out in several layers. In order to further impede the sliding along the slope such known blocks are made with as few plane surfaces as possible.

By making the blocks in this way they are prevented from being moved in the direction which has, until now, been regarded as the decisive one, namely, up and down along the slope. However, calculations and laboratory tests, which have recently been carried out (see Roald Svee: Formulas for Design of Rubble-Mound Breakwaters, Journal of the Waterways and Harbors Division, Proceedings of the American Society of Civil Engineers, Vol. 88, No. WW2, May 1962) show that a movement substantially at right angles to the slope is of greater importance to the stability of the protecting cover than the movement along the slope. For this reason the blocks should, first of all, be prevented from being moved in a direction normal to the slope. The spaces which are obtained between the known blocks due to their form more or less prevent them from holding each other in place and, for this reason, there are preferably used two layers laid out in a special way and with a certain accuracy to obtain an interlocking in the said direction at right angles to the slope. If these known blocks are laid out in one layer only it is practically impossible to obtain an interlocking effect which will have any influence in the decisive direction.

It is also previously known to make protecting covers for moles and breakwaters from blocks which more or less engage each other, so that each single block will contribute to keep the other blocks in place against the lifting force of the water. However, blocks of this type are not able to withstand the forces created by large waves since the pressure difference between the upper and lower side of the blocks will be of such magnitude that the cover is disrupted. A certain improvement may be obtained if the base on which the blocks are resting, consists of large stones or is provided with channels for leading away the water which flows back, but neither of these

precautions have been found sufficient when the waves are large.

It is also known to make use of blocks which have through-going openings in direction normal to the base in order to reduce the pressure difference, but this precaution is also insufficient when the mole or breakwater is subjected to large water forces.

The object of the present invention is to arrive at a block for forming protective layers on slopes of moles and breakwaters and, according to the invention, this is obtained by forming each block in such way that of its sides facing the neighboring blocks at least one is made for interlocking with one of the neighboring blocks so that the blocks will prevent one another from moving in a direction up from the slope, and in such way that the cover made from the blocks will have at least one through-going opening per block from the waterside to the surface resting on the slope so that the pressure and suction forces to which the blocks are subjected due to the movement of the water are reduced.

By combining these two features as known per se it has surprisingly been found that it is possible to form a protective cover which will withstand waves of more than the double height as compared with blocks having only one or the other of the known features, which result is obtained by a weight of the cover of about the half of that of covers made from the hitherto known blocks.

On the water side the blocks are preferably provided with upwardly directed protrusions serving to break the force of the waves and to, simultaneously, obstruct large uprush of the water.

The invention is now to be described with reference to the drawing in which:

FIG. 1 shows a section of a mole or breakwater with a protecting cover consisting of cast blocks according to the invention,

FIG. 2 shows a block in larger scale and in perspective formed for interlocking with the upper and lower blocks,

FIG. 3 shows a block, also in perspective, made for interlocking with the upper and lower blocks and with the other neighboring blocks as well, and

FIG. 4 shows a block, also in perspective, having recesses in its side walls.

The mole or breakwater **1** shown in cross section in FIG. 1 has two slopes **1***a* and **1***b*, of which the first mentioned is directed against the uprushing waves (the water side), and which is, therefore, provided with a protecting cover made from cast concrete blocks **2**, the lower surfaces **3** of which rest on the slope **1***a*. The lowermost block is kept in place by stones **9**, and the surface of it facing the next upper block is made with a rib or protrusion **6'**, **6***a'* (see also FIG. 2) which engages a correspondingly shaped recess **6**, **6***a* in the lower side of the said upper next block. Since all the blocks **2** are equal they will, as seen in direction down the slope, be in engagement with the respective upper and lower blocks. At the top the mole or breakwater has a cast head or crest **8** of substantially angular cross section, the upright leg of which engages the uppermost block.

As appears especially from FIG. 2, the block **2** is defined by a flat lower resting surface **3**, two vertical and mutually parallel side surfaces **7** and **7'**, and at right angles to same, mutually parallel and inclined upwardly directed surfaces **6** and **6'** which continue in two oppositely inclined, also mutually parallel surfaces **6***a* and **6***a'*. The top surface **4** of the block forms an acute angle with bottom surface **3** so that there will be an inclined, upwardly directed cam or rib **6***c*, the section of which has the form of a saw tooth. This upper portion **6***c* is located above plane **6***b* which is parallel to the bottom surface **3**. Between the upper and lower surfaces **3** and **4**

there are arranged through-going openings 5, in the shown example two such openings.

It is obvious, as FIG. 4 shows, that each block may be formed with either openings 5, as shown, or with recesses 5*a* in its side walls, or both, so that two such recesses 5*a* will together define a through-going opening between the neghboring blocks, preferable in addition to openings 5.

A cover for the water side of a mole or breakwater built up from blocks according to FIG. 2 will withstand high waves which is due to the combination of the features that the blocks are in engagement with each other, at least in the vertical direction, and that the blocks are provided with through-going openings. A wave rushing up along the slope will not act with the same force upon all the blocks simultaneously. That block which is at a certain moment subjected to the largest lifting force caused by one wave will, therefore, be kept in place by the upper and lower blocks. At the same time the openings 5 and also the spaces between the blocks will act to reduce the suction force upon the block caused by the waves.

As appears from FIG. 1, the protecting cover will have a saw blade formed cross section, so as to impede the uprush of the waves and break at least a part of the living force of same. This feature in combination with both the above mentioned features will give a protective cover which will withstand very large waves without the blocks being displaced in any direction. It is to be observed that this advantage is obtained in connection with a layer of a substantially low weight, which is of special importance when the blocks have to be produced at one place and transported to the mole or breakwater to be provided with a protective layer.

The form of the blocks as shown in the drawing also brings with it the advantage that the blocks may easily be slid in place along the slope 1*a*. This facilitates the laying work and the later maintenance of the cover. If, for instance, the lowermost block should for some reason slide away, a new block may be placed at the top and slid down so as to cover the opening thereby formed.

FIG. 3 shows a block similar to FIG. 2 and modified so that it will also engage the neighboring blocks in the horizontal direction, there being in addition to the upper protrusions and lower recesses also arranged a protrusion and a recess respectively in the two side faces 7 and 7'. The middle portions 6*d* and 6*d'* of the upper and lower surfaces respectively are in this embodiment perpendicular to the bottom surface 3 but they may also be formed according to FIG. 2. According to FIG. 3 this block is defined by the following surfaces: A plane bottom surface 3, two inclined and mutually parallel surfaces 6 and 6', two vertical, mutually parallel surfaces 6*d* and 6*d'*, two inclined surfaces 6*a* and 6*a'*, of which the first continues in the surface forming the short face of the rib 6*c* directed against the waves. The other sides of the block are defined by mutually parallel surfaces 7*b*, 7*b'* and 7*a*, 7*a'* respectively with two intermediate and mutually parallel, inclined surfaces 7*d*, 7*d'* and 7*c*, 7*c'* respectively forming a protrusion in one side and a correspondingly shaped recess in the other side. Also in this case it is possible to slide the blocks in place along the slope.

In this embodiment also an interlocking between the neighboring blocks in the sidely direction is obtained so that the protecting cover will be able to withstand still higher waves than a cover built up from blocks according to FIG. 2. However, it will be obvious that the interlocking between the blocks in the vertical direction will be of greater importance for the stability of the cover than that between the blocks in the horizontal direction, since substantially all the blocks in the same height will be subjected to the same lifting force when a wave is rushing up the slope.

I claim:

1. A protective layer for the slope of a mole, breakwater or the like comprising a plurality of blocks arranged in inclined rows and horizontal rows on a slope, each of said blocks having a top surface, a bottom surface lying against said slope in an inclined plane common to other of said blocks, a pair of laterally facing sides, an upwardly facing side and a downwardly facing side, said top surface of each block lying in a plane which intersects at an acute angle the inclined plane in which said bottom surface lies so that an edge defined by said top surface and said downwardly facing side is a greater distance from said slope than an edge defined by said top surface and said upwardly facing side, said first named edge of each block in adjacent ones of said horizontal rows being vertically disposed above and with its downwardly facing side overhanging the top surface of a block in the horizontal row next below, each of said blocks having interlocking means provided on said upwardly facing and downwardly facing sides thereof, said means of the block of adjacent one of said horizontal rows being interlocked to prevent the blocks from moving in a direction away from said slope under the force of waves, and each block having a passageway extending therethrough from its bottom to its top surface for reducing pressure and suction forces to which said layer is subjected due to movement of waves thereon.

2. A protective layer according to claim 1 wherein each of said blocks has interlocking means provided on said pair of laterally facing sides, said latter means interlocking each block with an adjacent block in its horizontal row.

3. A protective layer according to claim 1 wherein each of said blocks has said passageway formed in a side of said pair of laterally facing sides.

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EARL J. WITMER, *Primary Examiner.*

JACOB L. NACKENOFF, *Examiner.*