საქართველოს მეცნიერებათა ეროვნული აკადემიის მოამბე, ტ. 19(193), №4, 2025
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Hydraulic Engineering

Sea Wave Breaker Innovative Structure

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(Presented by Academy Member David Gurgenidze)

Abstract. The major conditions for the stability of the sea coastline, including both natural factors (establishing equilibrium between solid sediment transported by rivers flowing into the sea and coastal erosion resulting from sea wave impact) and the implementation of engineering-technical solutions through the construction of coastal protection hydrotechnical structures are discussed in the article. Currently, due to the hydrological regulation of rivers flowing into the sea, and consequently, the significant reduction of solid sediment transported into the sea by rivers, natural protection of the sea coastline is impossible. It is established that the current deficit of solid sediment transported by Georgian rivers into the sea amounts to approximately 15-16 million tons per year. Based on the above, an innovative sea wave dissipating hydrotechnical structure model is proposed, for which a "Sakpatent" Certificate was obtained, and which we recommend for use in highly sensitive areas of the Black Sea coastline. *© 2025 Bull. Natl. Acad. Sci. Georg.*

Keywords: sea, solid sediment, abrasion, wave, hydrotechnical structure

Introduction

Protection of the coastal zone from abrasive processes (coastal erosion and encroachment) induced by wave action is a highly problematic issue. Today, it has become even more critical in the context of ongoing climate change on planet Earth. Due to rising temperatures, the accelerated melting of glaciers is causing an increase in sea and ocean levels. The Black Sea is no exception, particularly because its connection to the World Ocean, specifically the Mediterranean Sea. It is limited due to the shallow depth of the Bosporus Strait that connects them. Consequently, water circulation between these two seas is restricted, making sea level rise in the Black Sea more significant.

As such, the protection of the Black Sea coast and the development of appropriate preventive measures is one of the most pressing issues.

There are two recognized types of coastal protection: natural and engineering-based. The natural factor consists of maintaining a balance between erosion caused by wave impact and the volume of solid sediment transported into the sea by rivers. If such a balance is established, coastal stability is, to some extent, achievable. The engineering factor involves the construction of appropriate coastal defense hydraulic structures, which help protect the shoreline.

Given that the hydrological regimes of rivers flowing into the Black Sea are currently regulated and that hydraulic structures are built on them, natural coastal protection becomes virtually impossible. A striking example of this is the Chorokhi River, which, before the construction of the Deriner Dam, accounted for 57% of the solid sediment transported into the Black Sea by Georgian rivers. Today, this figure has dropped to zero. A similar situation exists for nearly all major rivers discharging into the Black Sea. It is determined that Georgian rivers currently supply approximately 15-16 million tons of solid sediment to the Black Sea annually, almost half of the volume (30-31 million tons per year) that previously maintained a natural equilibrium between river sediment input and wave-induced coastal erosion. The current sediment deficit amounts to 15-16 million tons per year (Diakonidze et al., 2011; Diakonidze et al., 2025; Shuisky et al., 2017).

Based on the above, the need arises to design and construct various types of coastal and beach protection hydraulic structures (Kodua & Tebidze, 2024). Among such structures are the recently developed shore protection structures at the Georgian Technical University: "Engineering-Hydraulic Structure for Beach Protection, Patent U 2024 2160Y, 17.01.2024" 202 (Georgia Patent No. 2160 Y, 7, 2024), and "Link Complex of a New-Type Floating Wave-Dampening Hydraulic Structure for Coastal Protection, Conirmation Certificate of Deposition No. 8130, 25.08. 0" (Georgia Patent No. 2030, 2020).

It should be noted that constructing structures against sea wave action is quite complex, as their reliability depends on numerous factors. First of all, the following must be considered: the wave impact force (determined by the wave's length, height, and speed), the geological structure of the shore, the slope of the coast and the seabed shelf, among others. The difficulty lies in the fact that all the above-mentioned factors vary significantly across different locations along the coastal zone.

Consequently, during the design and construction of shore protection structures, one must rely on empirical formulas, graphical dependencies, and tables obtained through various studies, in order to determine the values of different coefficients included in the formulas. This is precisely why the construction of such structures is challenging, since the characteristics mentioned above vary sharply across different points along the coastline. Therefore, it is advisable that appropriate studies be carried out for each set of conditions, and that all the necessary parameters be determined for the specific location.

It should also be noted that in most existing shore protection structures, the focus is placed on their weight, volume, and strength; however, they quickly become non-functional – even though construction norms are strictly followed. The main reason for this is that the base of the structure is washed away due to sea wave action, causing the structure to lose stability and cease functioning.

Based on all of the above, we attempted to consider the aforementioned reason for the failure of shore protection structures and to create a new, innovative type of "Sea Wave Dissipating Structure." The presented model received a positive decision from the National Intellectual Property Center of Georgia "Sakpatenti", and the corresponding certificate U 2025 2205Y was issued (Georgia Patent No. U2025 2205 Y, 8, 2025). Below is a description of the aforementioned structure and its capabilities.

The tiers of the sea wave dissipating structure are composed of concrete outer-shaped blocks and pairs of T-shaped blocks placed between steel or plastic support pipes embedded in hard-to-erode seabed layers. In each pair, the height of the head of one block corresponds to the height of the foot of the other block. Pipes are embedded lengthwise through the body of the blocks, inside of which are inserted continuous stainless steel or fiber ropes.

The ends of these ropes are fixed and tensioned on the support pipes, which, after installation, are filled with concrete.

The utility model relates to construction, specifically to the construction of hydraulic structures, and it can be used to protect the sea coastal strip from wave impact, particularly in vulnerable areas.

The technical result of the utility model is the increase in the operational lifespan and reliability of the structure.

The technical result is achieved by the fact that, in the sea wave dissipating structure, the tiers consist of pairs of Γ-shaped and T-shaped concrete blocks placed between support pipes embedded in the seabed, with the blocks fitted together in an inverted configuration. In each pair, the height of the head of one block matches the height of the foot of the other block. Pipes made of steel or plastic run longitudinally through the blocks, inside of which continuous stainless steel or fiber ropes are passed, whose ends are secured and tensioned on the support pipes, which are filled with concrete after installation.

This structural configuration prevents the movement of the blocks and protects the entire structure from deformation in the event of seabed erosion caused by wave impact, which significantly strengthens the structure, increases its stability, and thereby its reliability.

The sea wave dissipating structure is illustrated by three Figures: Fig. 1 shows the plan of the structure, Fig. 2 – the longitudinal section of the structure as shown in Fig. 1, Figs. 3a–3d – the structural components of the blocks in isometric view.

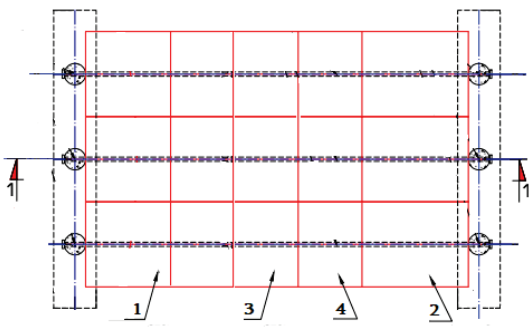

Fig. 1. Plan of the sea wave dissipating structure.

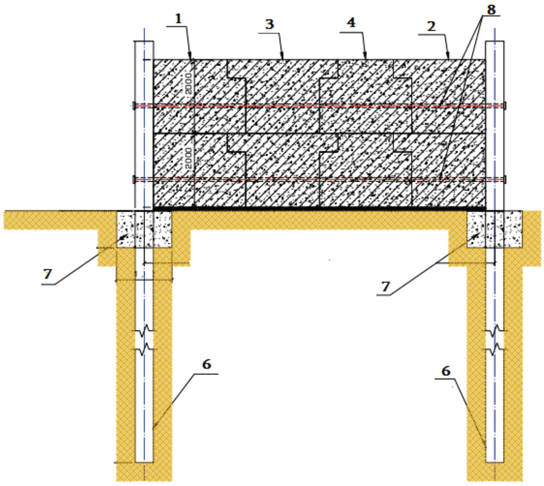

Fig. 2. Longitudinal section of the structure.

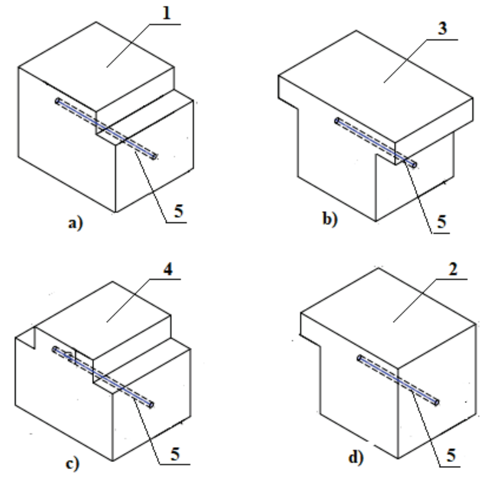

Fig. 3. Structural blocks of the structure in isometric view.

The structure consists of pairs of outer-shaped blocks (1, 2) arranged in multiple tiers on the seabed, and T-shaped blocks (3, 4) placed between them. In each pair, the height of the head of one block corresponds to the height of the foot of the other block. To allow the blocks to fit together in an inverted configuration during assembly, plastic or metal pipes (5) are pre-installed at the same height along the body of the modular blocks 1, 2, 3, and 4.

Steel support pipes (6) are embedded down to hard-to-erode seabed layers and are interconnected by a grade beam (7) at the seabed level. The tiers of the structure are built upon this grade beam so that the Γ-shaped blocks (1 and 2) are placed on the outer sides of each tier, and the T-shaped blocks (3 and 4) are placed between them in an inverted arrangement. Across the entire length of each tier, stainless steel or fiber ropes (8) are threaded through the plastic or metal pipes (5) embedded within the blocks. The ends of these ropes are fastened and tensioned on the support pipes (6), which are then filled with concrete (9) after installation.

The structure is mounted along the protective shoreline on a pre-prepared bedding layer on the seabed in such a way that the uppermost tier is located near the sea surface. The number of tiers and rows of the structure is determined based on the maximum allowable wave height. The number and height of tiers increase stepwise toward the shore.

The sea wave dissipating structure operates as follows: due to its tiered wall design, incoming sea waves strike the structure gradually, rather than impacting the entire surface at once. This significantly reduces the wave impact force on the structure and leads to the gradual dissipation of wave energy, thereby reducing wave height. The dynamic loads caused by wave impact on the structure, as described above, are not instantaneous; instead, they act progressively across the different tiers. This causes the wave energy to be distributed across the structure and the total acting force to be dispersed, which significantly reduces the load on the construction and extends the stability and service life of the structure.

The tiers of the sea wave dissipating structure are composed of pairs of concrete outer-shaped blocks and T-shaped blocks placed between steel or plastic support pipes embedded in hard-to-erode seabed layers. In each pair, the height of the head of one block corresponds to the height of the foot of the other block. Pipes are embedded longitudinally through the blocks, through which continuous stainless steel or fiber ropes are threaded, with their ends fixed and tensioned on the support pipes, which are filled with concrete after installation.

Conclusions

- One of the main drawbacks of existing shore-reinforcement hydraulic structures, including sea wave energy dissipating structures, is the scouring of the foundation and the resulting failure of the structure.
- In the sea wave energy dissipating structure proposed, this issue was taken into account, and the design of the structure ensures that it maintains stability even under conditions of strong sea agitation.
- Implementation of the proposed innovative type of sea wave dissipating coastal hydraulic structure is recommended, in particularly complex and sensitive areas of the sea coastal zone.

ჰიდრავლიკური ინჟინერია

ზღვის ტალღის ჩამქრობი ინოვაციური ნაგებობა

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(წარმოდგენილია აკადემიის წევრის დ. გურგენიძის მიერ)

სტატიაში განხილულია ზღვის სანაპირო ზოლის მდგრადობის ძირითადი პირობები, როგორც ბუნებრივი ხასიათის (წონასწორობის დამყარება ზღვაში ჩამდინარე მდინარეების მიერ ტრანსპორტირებული მყარი ნატანისა და ზღვის ტალღური ზემოქმედების შედეგად სანაპიროს გარეცხვას შორის), ისე საინჟინრო ტექნიკური გადაწყვეტილებების განხორციელება – ნაპირდამცავი ჰიდროტექნიკური ნაგებობების მშენებლობით. დღეისათვის, ზღვაში ჩამდინარე მდინარეების ჰიდროლოგიური დარეგულირებისა და, აქედან გამოდინარე, მდინარეების მიერ ზღვაში ტრანსპორტირებული მყარი ნატანის მნიშვნელოვნად შემცირების გამო ზღვის სანაპირო ზოლის დაცვა ბუნებრივი გზით შეუძლებელია. დადგენილია, რომ დღეისათვის საქართველოს მდინარეების მიერ ზღვაში ტრანსპორტირებული მყარი ნატანის დაფიციტი დაახლოებით შეადგენს 15-16 მლნ ტონას წელიწადში. ზემოაღნიშნულიდან გამომდინარე, ჩვენ მიერ შემოთავაზებულ იქნა ზღვის ტალღის ჩამქრობი ინოვაციური ჰიდროტექნიკური ნაგებობის მოდელი, რაზედაც მიღებულია საქპატენტის მოწმობა. მიგვაჩნია, რომ აღნიშნული მოდელი გამოყენებული უნდა იქნეს შავი ზღვის სანაპირო ზოლის რთული სენსიტიური უბნების პირობებში.

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