Causes of destruction of gabion retaining walls on coastal areas

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Abstract. The article deals with the design and scheme of gabions destruction in coastal areas under the action of frontal sea waves in the city of Sochi and on the Curonian Spit. The durability of gabions varies depending on the mesh materials, and the place of application. In case of gabion coastal retaining walls, the construction is made of metal and anticorrosive coated wire with an additional polymer coating, their durability is claimed to be several dozens of years but observations show that the structure may be destroyed much earlier. The actual scheme of destruction of these structures differs from those given in the regulatory documents. In spite of their possible destruction gabions prevent the development of landslide and suffusion processes along the coastline during their short lifetime. The article deals with the problems of gabion retaining walls failure under the influence of frontal sea waves which are not stipulated in the normative documents.

Keywords: gabions, retaining walls, gabion deformation, frontal waves, coastal structures.

1 Introduction

Gabions are lattice (mesh) prismatic structures filled with medium-sized clastic rock. Gabion retaining walls retain their position due to gravitational loads of the filler material. Such structures are usually erected in three to four rows (Fig.1).
In Russia, gabions are used everywhere as they have good water permeability, aesthetic appearance, are easy to install and prevent landslide and suffusion processes. In coastal areas, gabions serve as retaining walls for soil slopes. According to the normative documents [1] the lifetime of gabion constructions varies from 35 to 75 years and depends not only on the mesh material, but to a considerable degree on the unfavorable influence of storm waves. As a rule, in the coastal area’s gabion retaining walls are used only when the height and speed of waves are low. However, in the case of direct exposure to sea waves, gabion structures are subject to failure, depending on the frequency and intensity of storm events.

The failure patterns of gabion retaining walls and the location of the structures, namely near the sea, are not prescribed in the regulatory documents. The purpose of this article is to review regulatory documents and analyze the nature of gabion retaining wall failures.

2 Types of gabion retaining walls and causes of their destruction

The types of gabion mesh structures, according to Section 4 of GOST R 52132, are classified by shape and by the type of coverage of the mesh used. The types of gabion mesh products have their own letter designations:
- KA - boxed with a reinforcing panel;
- M - mattress-tufted;
- C - cylindrical.
According to their functional purpose, gabions, depending on their location and operating conditions, are divided into:
- H - Overhead;
- Poo - variable water level;
- Pd's - underwater;
Gabion mesh products must be made of twisted wire mesh with hexagonal cells, corresponding to the requirements of Sections 4 - 5 and Annex B of GOST R 51285 (Fig.2)

![Scheme of hexagonal grid cells](image)

1 - edging wire; 2 - main wire; B - cell size; B₁ - cell diagonal size

**Fig. 2.** Scheme of hexagonal grid cells

For coastal structures, mostly box gabions are used, which allows optimal use of their drainage properties and high tensile strength. Before installing the gabion wall, the mesh nodes are tested (Fig.3) for tensile strength according to GOST 59287-2020.

![Tensile testing of mesh weave knots on a tensile testing machine](image)

**Fig. 3.** Tensile testing of mesh weave knots on a tensile testing machine.

The tensile strength $P$[kN/m] of the mesh is calculated as the ratio between the breaking force and the working width of the sample according to the formula:

$$P = \frac{P_{\text{max}}}{b}$$

where: $P_{\text{max}}$ - maximum load (breaking force) corresponding to the destruction of the mesh sample, kN;

$b$ - working width of the sample, m.

The normative document describes the choice of the mesh, only depending on the pressure of the soil slope on the retaining walls, for coastal marine gabions the choice depends only on the corrosive properties of the polymer-coated mesh [2]. Offshore coastal gabions take the main load from the impact of waves on the structure and the internal pressure of rock boulders. They rest against the outer wall and try to move out under the action of the returning waves. Therefore, the fracture pattern does not coincide with that of conventional retaining walls.
3 Destruction of gabion retaining walls

The main factor is the fatigue of the structure, from the effects of natural influences during a storm. Since gabions are gravitational structures, their center of gravity is always distributed over the volume of the prism, but because of frontal impacts and rapid filtration, the contents of the box are transferred to the edge of the structure and the mesh is greatly deformed (Fig. 4).

The return wave imposes a short-term load on the structure and, when the mesh breaks, carries the contained large stones outside the mesh. The fracture stage of the retaining wall occurs after the ultimate strength and fracture of the mesh section is reached. The wire tensile strength should be 35 to 55 kgf/mm$^2$ (340 to 540 N/mm$^2$) and the minimum elongation is 12% on a reference sample length of 100 mm [1].

![Fig. 4. Scheme of deformation of gabion structures](image)

The gabion mesh is mainly subject to destruction during storms, when the wave velocity and its height are at their maximum. After storms, the gabion is severely deformed or destroyed (Fig.5,6), but the structure does not lose its drainage functions and counteracts the subsoil extraction.

![Fig. 5. Coastline near the city of Adler](image)
4 Structural solutions to prevent gabion wall collapse from the impact of frontal waves

In Russia, protective measures are provided by frontal concrete structures in front of the gabion or gabion retaining walls above the possible height of the storm waves.

In order to increase the bearing capacity of gabion walls Malaysian geotechnicians M. Ramli, T., J.R. Karasu and their Iraqi colleague I.T. Davood proposed an interesting solution. They investigated the possibility of increasing the reliability of gabion protection of foundations, foundations and over the foundation parts of the intermediate and end supports of bridges from water erosion, scouring and destruction. The result of the work was a proposal to use blocks in the form of hexagonal prisms and their interlocking stacking in the form of bee honeycombs to create a continuous protective wall (Fig. 7).

The hexagonal gabion wall proved to be much more resistant to deformation and much less prone to failure even under increased horizontal pressures. These gabions should be installed vertically facing the wave. Undoubtedly, these constructions are of great practical importance, since they have shown the promise of using hexagonal gabion blocks for the construction of protective walls, which must withstand horizontal loads. This type of structures is still under development because of the difficulties in installation. It should also be taken into account that during the construction of prismatic gabions, the hydrostatic pressure of the soil is much lower than that of hexagonal gabions.
5 Conclusions

When gabion retaining walls reinforce the sea coastal slopes, their destruction occurs as a result of the dynamic effect of frontal and return sea waves, leading to the rupture of the metal mesh, undermining the retaining wall base and carrying the stone material out of the gabion volume. Gabion itself is a flexible structure, which has a drainage effect, preventing for some time, even in a nearly destroyed state, the erosion processes in the soil. Destruction of gabions - this is only the first stage of erosion processes of coastal slopes, which can be followed by landslides and affected nearby structures. The article is aimed at pointing out the problems in the design of gabion structures, since the regulatory documents do not provide for factors of destruction of structures by frontal waves in coastal areas.

References


