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Problems and damages in road and bridge structures, as well as increasing their bearing capacity with gabion structures

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Abstract: This article examines the increase in the load-bearing capacity of road and bridge structures and the causes of failures. The scientific basis for the application of composite-type gabion structures in the protection of transport structures, protection from erosion, water flows, and other external factors is highlighted, and the purpose of this article is to review innovations in the field of bridge construction, to describe advanced materials and structural solutions. Possibility of sustainability, environmental safety with the help of gabions. Highly effective and universal methods of strengthening, stabilizing, and protecting slopes and road surfaces in operation using gabion structures, bridge cones, bridge supports, regulating dams, embankments, and other structures. The work on increasing the load-bearing capacity of gabion structures is considered.

Keywords: bridge construction, load-bearing capacity, materials, structures, structural solutions, innovative bridge construction, composite mesh gabion structures

1. Introduction

In accordance with the provisions of the Transport Strategy of the Republic of Uzbekistan for the next period, the main task of the transport complex is the transition to an innovative, socially oriented type of development, which requires appropriate strategic solutions for the development of the road sector and the construction of long-term transport facilities in the medium and long term.

It is impossible to construct a modern highway that preserves the load-bearing capacity of road and bridge structures, the service life, and the smoothness of the pavement for a long time, without high quality of the earthwork, especially on weak soil foundations, under hydrological and climatic conditions, as well as under conditions of seismic activity of construction areas characteristic of different regions of the Republic of Uzbekistan.

The construction and operation of bridge structures and highways in mountainous areas, near mountain rivers, in landslide and avalanche zones, in zones of constant flooding and flooding, is always accompanied by great difficulties. The construction of roads near unstable mountain slopes often disrupts their balance, causes landslides, rockfalls, and activates landslides. Bridge construction is not only a technical activity, but also a scientific activity aimed at the development of new materials and technologies. The construction, reconstruction, and repair of bridges is one of the most complex types of construction work. Many bridges are monuments of engineering thought that have already entered urban architecture. Bridge construction is carried out taking into account the specific features of the terrain and requires complex calculations that take into account the specific properties of the soil, the loads on the supports, and much more. In addition, it is necessary to take into account the intensity of movement and the influence of external factors.

In the Republic of Uzbekistan, more and more bridges are deteriorating or being destroyed year by year. Many bridges and many other artificial structures are already dilapidated, and repair and construction work is underway. This article examines modern technologies of bridge construction, innovations in the field of bridge construction, describes advanced materials and design solutions used in bridge construction.

The purpose of this article is to consider the problems of road and bridge structures and their solutions, as well as innovations, to describe advanced materials and constructive solutions.

2. Methodology

Analysis of damage to road structures shows that the degree of their destruction depends on the engineering and geological properties of the terrain, the properties of the soils, the roadbed and foundations, the structural features of the structures, the seismological situation, the quality of road construction, etc.

A distinctive feature of long-distance transport structures, i.e., highways, is that these structures intersect areas with different geotectonic structures. For such structures, the problem of ensuring viability, i.e., functionality under conditions of operation, maintenance, and the influence of the geological environment, is especially relevant.

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Fig. 1. Sections of the road damaged due to the loss of bearing capacity of the base

These routes pass through territories with different geological environments and climatic conditions. This means that it is necessary to make specific decisions for each region. In areas consisting of soils susceptible to heavy rainfall or various influences, it is necessary to adopt specific design solutions, otherwise, after the construction of the above-mentioned engineering structures and structures, over time, loess soils usually become moist and lose their strength properties, leading to the loss of the structure's load-bearing capacity and its destruction (Fig. 1).

The main part of the territory of the Republic of Uzbekistan consists of loess and alluvial soils with a thickness of 5-25 meters, unstable to various influences. Currently, many road and bridge structures in our Republic are in need of repair. The reason for this can be attributed to the fact that appropriate diagnostic work was not carried out during operation, and measures against various minor failures were not taken in a timely manner. One such case is the emergency of a transport facility located in the territory of the Kosjap MFY of the Republic of Karakalpakstan (Fig. 2). The reason for this is that, in addition to what we mentioned above, the soil lost its load-bearing capacity, that is, due to the absence of a special protective layer on the sides of the structure, it could not withstand the water flow and washed the pipes.

Fig. 2. Loss of load-bearing capacity of a structure as a result of soil erosion

One of such solutions is the use of gabion structures that prevent the mixing of excessively moistened clay soil with road pavement materials, distribute the load from vehicle wheels over a large area of the road pavement, reduce the unevenness of pavement deformations under dynamic and seismic impacts, and allow for more complete realization of the strength of soils and road-building materials, reducing their consumption and the volume of work on the transportation, laying, and compaction of incoming materials. Global experience shows that gabion structures have always been and remain an alternative option for strengthening the slopes of not only flooded, but also non-flooded road structures.

In world practice, gabion structures have been used for more than 100 years. They are used for reinforcing slopes of embankments and embankments, slopes, banks of intersected watercourses, ravines, water intake, regulation, and other road and bridge structures. In domestic practice, these structures have limited application, and in standard solutions of previous years, they are provided only for reinforcing flooded slopes of the earthwork.

Gabion structures are widely used to ensure uniform load on cones, their reliable fastening, and long-term service. They allow protecting the supports from deformation and reducing their operating time. In addition, gabions perform the function of protecting the support from damage. Fillers for the soil are selected depending on the soil type[2]. They are used in the construction of railways and tunnels. They possess high operational properties. Valuable properties of metal pipes and prefabricated structures made from them are strength, durability and cost-effectiveness, ease of installation and transportation, and seismic resistance.

Calculations based on mathematical modeling show that composite gabion structures serve to reduce soil displacement around the bridge foundation to a certain extent. This guarantees long-term use. In addition, retaining walls made of gabions are used as supporting structures for reinforcing road embankment slopes, strengthening landslide and collapse areas, and unstable slopes on weak soils. Walls made of gabions can be made both vertical and stepped with a front edge.

Fig. 3. Gabion structures

For the analysis of the embankment's condition, the determination of the forces acting on the supporting structures from gabions, the calculation of the main parameters of the structure, their strengthening, the development of technologies, and the feasibility study of the proposed solutions, the materials of engineering studies of the precise embankment on section PK 183+55 of the A380 Guzar-Bukhara-Nukus-Beyneu road are presented [7].

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As a result of the conducted research, it was established that the primary factors affecting the roadbed, leading to a violation of the overall stability of the roadbed, are rainfall, the flow of snow and rainwater along the slope surface, groundwater filtration, and changes in air temperature. When calculating the stability of embankments and designing gabion support structures, permanent loads, movable axial loads (kN/axis), and short-term seismic loads were taken into account. Conducted model calculations and studies showed that soil reinforcement and hardening from gabions gave the embankment additional positive properties.[8]

Fig. 4. Coating water pipes with gabions

It is advisable to cover the above-mentioned water pipes with gabion structures. Because it is much more convenient and economical in terms of ecology, construction, and economy. The long-term stability of bridge structures largely depends on the condition of the soil around the supports. As a result of the action of the water flow, the soil around the support is subjected to erosion, which reduces the overall stability of the bridge. Therefore, the use of gabion structures in protecting the support area has been widely used in recent years. Composite mesh gabions are distinguished by high durability and low weight compared to traditional types of metals. Composite gabions showed high stability to the water flow. They do not rust, have a long service life, are lightweight, and are easy to install. The mechanical strength of polymer-based networks is high, and the displacement index of the soil around the bridge is significantly reduced with the help of composite materials.

3. Conclusion

As a result of the analysis of the capabilities of gabion structures, it was established that in a number of cases they are more expedient and economical than traditional structures. The purpose of this article was to review innovations in the field of bridge construction, to describe progressive materials and constructive solutions. Thus, modern construction technologies and modern building materials allow increasing the pace of construction without compromising the quality of construction or the coating, as well as reducing the labor intensity and costs of construction. Currently, in the world, traditional materials are being gradually replaced by polymers, composites, and other materials. Along with traditional materials such as concrete, steel, and wood, new composites have appeared that optimize the properties of materials. Composite material is very popular in bridge construction abroad. This will allow bridge structures based on composites to successfully compete with bridges made of traditional materials, and will also contribute to the spread of modern bridge structures in Uzbekistan. In the future, technological improvements in this area will contribute to the creation of more efficient systems. The goal of the article has been achieved.

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