MODERN METHODS OF EMBANKMENT REINFORCEMENT IN THE AREA WHERE THE BRIDGE MEETS THE RAILWAY TRACKBED

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Abstract: *The article presents a scheme of strengthening using modern methods of reinforcing the embankment in the area of the bridge interface with the railway trackbed. A method for driving reinforcement rods into the ground has been developed to strengthen the soil of the embankment by volumetric multi-element reinforcement in the transition zone.*

Key words: *Embankment, ground, strengthening of the transition section, volumetric multi-element reinforcement, rod length, coefficient of adhesion.*

Andbstract: *The article presents a reinforcement scheme using modern embankment reinforcement methods in the area where the bridge meets the railway roadbed. A method has been developed for driving reinforcing rods into the ground to strengthen the embankment soils with volumetric multi-element reinforcement in the transition zone.*

Keywords: *Embankment, soil, reinforcement of the transition area, volumetric multi-element reinforcement, rod length, coefficient of adhesion.*

Аннотация: *Мақолада темир йўл ер полотноси ва кўприк туташган зоналарида кўтармани армирлашнинг замонавий усулларини қўллаган ҳолда мустаҳкамлаш схемаси келтирилган. Ўтиш участкаларида кўтарма грунтларини ҳажмий кўп элементли армирлаш усулида мустаҳкамлаш учун арматура стерженларни грунтга қоқиш усули ишлаб чиқилган.*

Калит сўзлар: *Кўтарма, грунт, ўтиш участкасини мустаҳкамлаш, ҳажмий кўп элементли армирлаш, стержен узунлиги, ишқаланиш коэффициенти.*

INTRODUCTION

Analysis of the experience of reinforcing the roadbed shows that reinforcing elements need to be differentiated according to the basic design scheme of their operation. In this regard, there are three main types of reinforcing elements – linear, flat and three-dimensional.

When considering the ultimate state of failure for linear elements [1], it is necessary to take into account the penetration of soil through the elements and slipping along their side surface, and therefore the ultimate strength of the structure is determined by the actual resistance of the soil in contact with the side surface of the reinforcing elements. In the case of reinforcement of a ballast recess, coarse-grained soils with clay aggregate that is in a state of fluid consistency are subject to strengthening, which indicates the inability of reinforcing elements to provide significant resistance to ground penetration and slippage [2-5].

The ultimate state of failure for flat reinforcing elements is also characterized by ground slippage, but when ensuring proper adhesion of the element to the surrounding ground environment, the strength of the element material itself should be taken into account. In the case of ballast recesses, it is difficult to ensure the required adhesion between the recess filler and the reinforcing element.

Creating sufficient adhesion between the filler of the ballast recess and the reinforcing element is possible through theconstruction of volumetric reinforcement [6]. In this case, the strength of a structure consisting of a bulk element and the soil enclosed in it depends mainly on the strength of the reinforcing element. The main difficulty in implementing this method is the technical impossibility of creating a three-dimensional reinforcing element in the existing embankment without violating its integrity. However, despite this, this area of research is the most promising in solving the problem of strengthening the roadbed weakened by ballast depressions.

Currently, bulk reinforcing structures are usually represented by geocells, which are used for reinforcing the main site of the roadbed, preparing the foundation for filling the embankment, surface fixing of slopes, etc. Also, in world practice, the method of strengthening the foundation of embankments by constructing a pile field with subsequent coating it with geosynthetic nonwoven material is widely used [7]. In this case, at the level of the bottom of the embankment, the load is distributed to free-standing vertical reinforcing elements through geosynthetic material. This scheme of strengthening the base actually implements the principle of volumetric reinforcement, since the weak ground of the base is enclosed between the reinforcing elements and practically does not perceive the load from the higher-lying embankment.

A similar reinforcement principle can also be implemented in bulk soils, without violating the integrity of the soil mass (Fig. 1). This requires creating two levels of flat reinforcing elements – at the base and on the roof of the weakening zone and combining them with vertical elements that will ensure the coherence of the structure.

Analytically substantiate the effectiveness of creating a system of cross-located rods, in comparison with a parallel arrangement, by comparing the working surfaces of these structures (Fig. 2).

When using the scheme of parallel rods, the total resistance surface will be determined by the total working surface of the rods in the selected hardening volume. In this case, the resistance of one layer of hardening per L sq. m of the embankment can be estimated as follows:

$$T_{st} = (\frac{L}{a} + 1) n d l_{tp}, \qquad (1)$$

where Tt is the total surface resistance of the system, N; $T_{ст}$ – общее поверхностное сопротивление системы, Н;

L – the length of the section under consideration, m.

a – step of placement of rods, m;

d – rod diameter, m.

l – rod length, m.

τ_{tp} *is* the coefficient of friction, $N/^{m2}$.

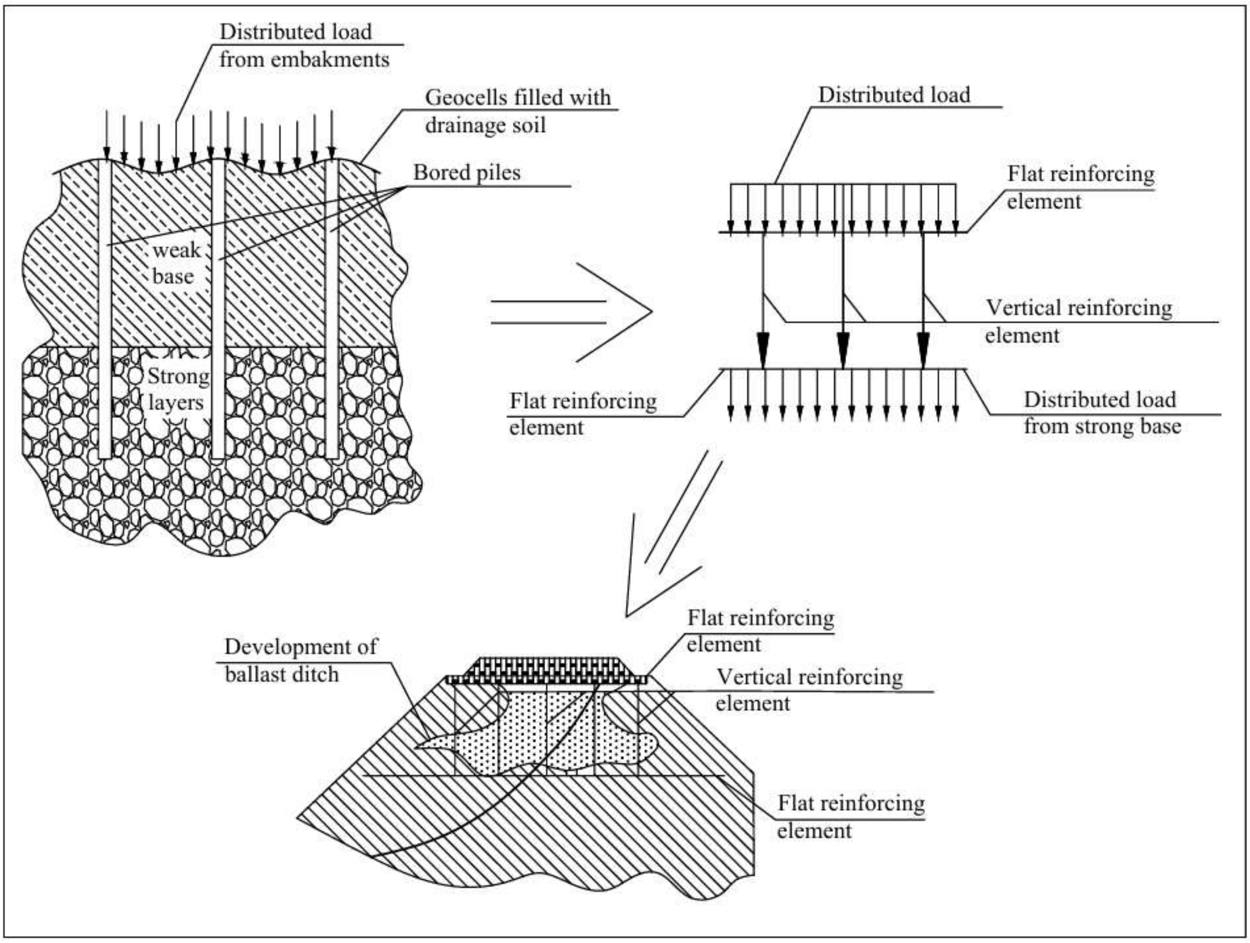

Fig. 1. Arrangement of a three-dimensional reinforcing element in the embankment body.

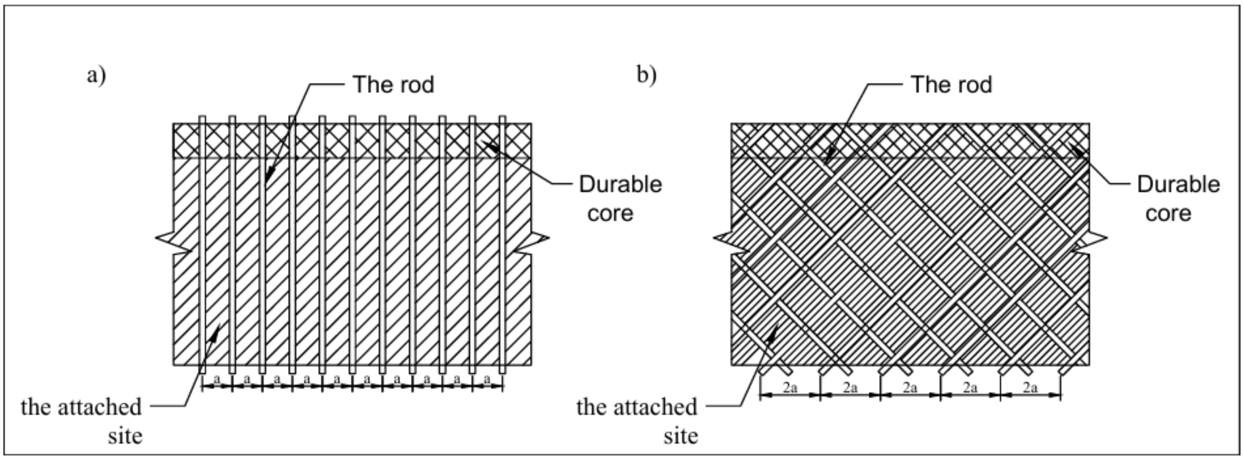

Fig. 2. Embankment hardening schemes:

a-rod mount; *b*-mesh mount

Analysis of the literature data shows that the most common limits for varying the step of rod placement in a tier are in the range from 20d to 50d [8]. Let's set the reinforcement pitch to 20d, and the calculated surface resistance of the structure will be:

$$T_{st} = \pi l(\frac{1}{2} + d)\tau_{tr} \quad (2)$$

In the case of using rods with a diameter of 28 mm, their number in one row will be 19 pcs., the total length with the length of one rod equal to 10 m will be 190 m. The calculated surface resistance of the structure will be determined by the dependence:

$$Tt_{\text{ст}} = 16.7\tau_{tp} \quad (3)$$

In the case of a cross arrangement of the rods, the work also includes the soil trapped in the formed cells, and it is assumed that this surface works as a flat reinforcing element. The width of the element is determined by the projection of the rod length into the embankment cross-sectional plane. The element length is limited by the length of the selected section:

$$S_{el} = l_{pr} \times L, \quad (4)$$

where l_{pr} is the length of the projection of the rod into the plane of the embankment cross-section, m;

L is the length of the section under consideration, m.

The surface resistance of a 10 m long section will be determined by the dependence

$$\text{T}_{Tl} = 200\tau_{tr}. \quad (5)$$

However, in this case, there is an increase in the length and number of rods:

$$n_c = (\frac{L}{2a} + 1) \cdot 2 \quad (6)$$

If the angle of inclination of the rod in the plan is equal to 300, the total length will be

$$L = n_c \cdot \frac{l}{cos30^0} \quad (7)$$

The amount of material used to form the mesh increases by 18% compared to the rod attachment. The technical effect of using a grid in comparison with the parallel arrangement of rods is determined by the ratio T_{el}/T_{st} and is 12 times.

Thus, the essence of the proposed soil reinforcement scheme consists in the formation of a three-dimensional anisotropic structure in the body of the roadbed, consisting of horizontally oriented linear reinforcing elements united into a single frame by vertically oriented irregular pillars formed by injecting hardening mortar into certain areas of the embankment (creating a three-dimensional multi-element reinforcement). It is assumed that this design will improve the strength and deformation characteristics of the soil mass operating as a single system (Fig. 3).

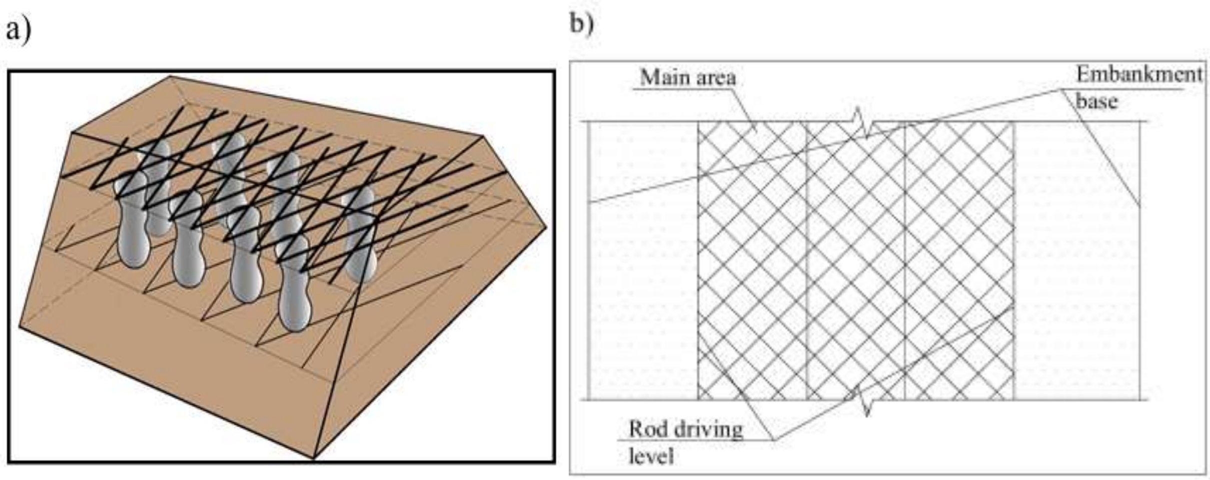

Fig. 3. Strengthening of the embankment by volumetric multi-element reinforcement:

a-general view of the embankment; *b* - scheme for driving rebar rods (in plan)

Conclusions

1. The scheme of embankment reinforcement structures in the area of the bridge interface with the railway roadbed is calculated using mathematical expressions taking into account various parameters of the rods.

2. The scheme of placement of rods is developed to ensure the stability coefficient, increasing the strength of the embankment at the transition site by volumetric multi-element reinforcement.

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