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Dependence of the Load-Carrying Capacity of the Contaminated Ballast Prism on the Value of Vibrodynamic Influence

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ABSTRACT: With increasing axle loads and train speeds, the vibrodynamic load of the wheels on the ballast layer, which is characterized by vibration amplitude, frequency, vibration velocity and other parameters, increases.

The main indicators of the track condition, their deviations from the standard position in the profile and in the plan directly depend on the bearing capacity of the ballast layer.

Vibrodynamic effects on the ballast layer are known to have a negative impact on the strength and deformation characteristics, which leads to a decrease in the bearing capacity of the ballast layer.

KEYWORDS: crushed stone, amplitude, vibrations, railway, vibrodynamic load, ballast prism, train movements, velvet sand.

I. INTRODUCTION

Ballast prism of railways works only in difficult conditions, with vibrodynamic loads, the maximum values of which are generally random, depending on a large number of factors. The probability of stresses from external influences on the main site, which are much higher than their average values, is quite high, which creates the possibility of the appearance for a short period of time beyond the bounds of tension. In addition, the ballast prism is not protected from the harmful effects of natural factors, especially sand drifts, which causes quite significant changes in the carrying capacity of the ballast prism. For a ballast prism this is completely unacceptable, as it leads to the loss of strength characteristics. This, in turn, results in subsidence in soils and a sharp decrease in the bearing capacity of the earth's surface. In order to eliminate large irregularities in the deformation of the ballast prism and taking into account the above features in his work, it seems necessary to limit the effective stress values within which there is a close to a rectilinear dependence of deformation on stress. Such limitation is carried out with the help of a coefficient that takes into account the working conditions of the ballast layer of the railway track. According to [1, 2] its value is assumed to be 0.8. Then the calculated maximum stresses at the main site are determined by the following formulas:

$$\sigma_z \leq 0{,}8\sigma_z^{пр} \qquad \sigma_z \leq 0{,}8\sigma_z^{пр} \quad (1)$$

Where:

σ_z and σ_y - the largest calculated vertical and horizontal voltages;

σ_z^{lim} and σ_y^{lim} - the maximum vertical and horizontal voltages calculated at the main site.

$$\sigma_z = \sigma_z^{вр} + \sigma_z^{prom} + \sigma_z^{rrt} \quad (2)$$

Where:

σ_z^{ver} - vertical voltages at the main site from the mobile load, kPa;

σ_z^{prom} - vertical voltages at the main site from the ballast layer, kPa;

$$\sigma_z^{prom} = \gamma_{prom} \cdot h_{prom} \quad (3)$$

Where:

γ_{point} - volumetric weight of ballast, kN/m3;

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h_{point}- ballast prism power, m;

σ_z^{rrt}- vertical voltages at the main site from the railroadties, kPa.

$$\sigma_y = \sigma_y^{ver} + \beta \cdot (\sigma_z^{prom} + \sigma_z^{rrt}) \quad (4)$$

where:

σ_y^{ver} - horizontal voltages at the main site from the mobile load, kPa;

β - side pressure coefficient in ballast, β =0.4.

II.EXAMPLE FOR CALCULATING THE LOAD-BEARING CAPACITY OF A BALLAST PRISM CONTAMINATED WITH VELVET SAND

Calculation of the bearing capacity of the ballast prism polluted by velvet sands and embankments, located at 3975 km on the section of the railway line Bukhara - Misken, where the earth bed is built entirely of velvet sands.

The estimated embankment has the following baseline data:

1) Embankment height $H_н$=10 m;
2) Embankment slope placement 1:2;
3) Main site width $b_{пл}$=7.6 m;
4) Ballast prism thickness h_{bal}=0.40 m;
5) Velvet sand in the embankment has the following strength characteristics: specific adhesion $C_{ст}$=0,13 kg/cm^2; internal friction angle φ=37°; relative adhesion reduction coefficient k_c=0,150; internal friction angle reduction coefficient kφ=0,070; volume weight of crushed stone clogged with velvet sands γ=1,65 t/m3;
6) Vibratory destruction coefficient of soil k=0.010;
7) Attenuation coefficient by depth δ_1=0.45;
8) Attenuation coefficients perpendicular to the path axis δ_2’=0.210 and δ_2’’=0.010;
9) Maximum amplitude of oscillations A0=470.80 µm;
10) Calculation error ε=0,005 rads.

The results of calculation of ballast prism load-carrying capacity of the polluted velvet sands and embankment on the Bukhara-Misken line are shown in Fig. 1 and shown in Table 1.

Fig. 1 shows that crushed stone polluted by velvet sand has a significant impact on the bearing capacity of the earth bed. Absolute values of limiting tensions at a distance of 1 m are equal as in the horizontal and vertical planes under the action of vibrodynamic loads σ_y=4,024 t/m2 and σ_z=14,906 t/m2.

Table 1. Limit voltages at the main site

Point	Y, м	Z, м	D, м	S, т/м^2	S_z, т/м^2	S_y, т/м^2
20.0	Y=0,005	Z=0,00	D=1,57	S=5,201	S_z=8,233	S_y=2,170
21.1	Y=-0,24	Z=0,00	D=1,57	S=5,875	S_z=9,287	S_y=2,463
22.2	Y=-0,6	Z=0,00	D=1,57	S=7,699	S_z=12,142	S_y=3,256
23.3	Y=-1,07	Z=0,00	D=1,57	S=9,823	S_z=15,467	S_y=4,180
24.4	Y=-1,41	Z=0,00	D=1,57	S=11,676	S_z=18,367	S_y=4,985
25.5	Y=-1,69	Z=0,00	D=1,57	S=13,235	S_z=20,807	S_y=5,663
26.6	Y=-1,96	Z=0,00	D=1,57	S=14,724	S_z=23,137	S_y=6,311
27.7	Y=-2,25	Z=0,00	D=1,57	S=16,185	S_z=25,425	S_y=6,946
28.8	Y=-2,53	Z=0,00	D=1,57	S=17,622	S_z=27,673	S_y=7,571
29.9	Y=-2,82	Z=0,00	D=1,57	S=19,052	S_z=29,912	S_y=8,193
30.10	Y=-3,11	Z=0,00	D=1,57	S=20,466	S_z=32,126	S_y=8,806

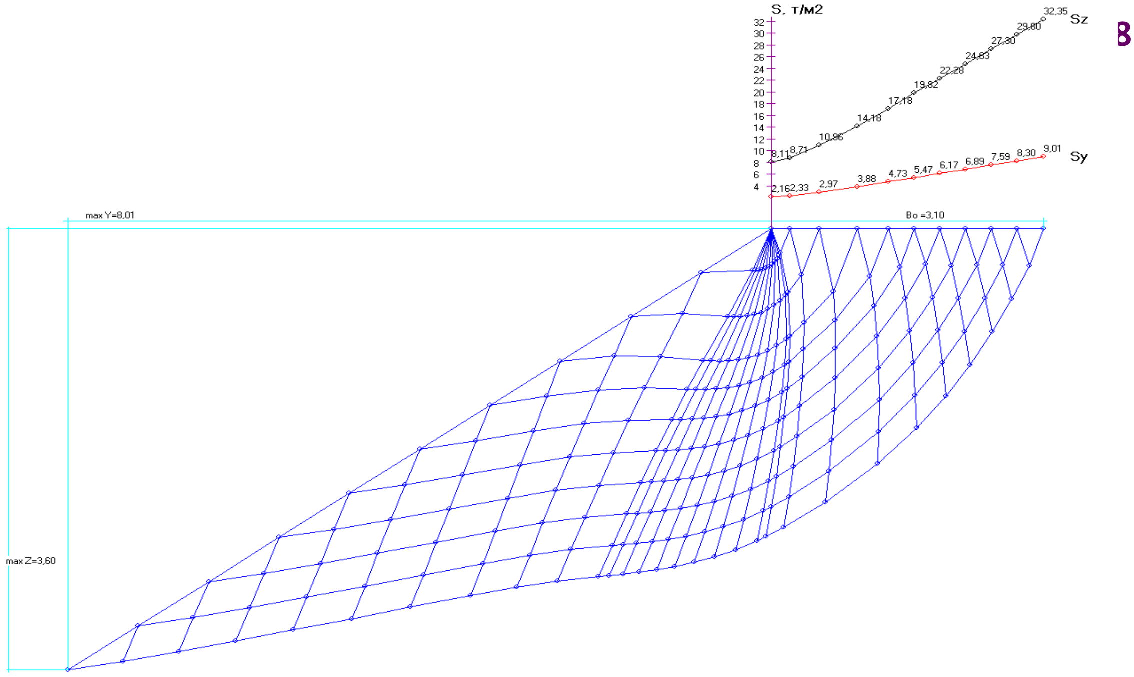

Fig. 1. Results of the calculation of the load-bearing capacity of the contaminated ballast prism and embankment in the Bukhara-Misken section.

One of the factors causing a decrease in the load-bearing capacity of the ballast prism polluted with velvet sands [2, 3] is the value of the vibrodynamic influence. Influence of the resulting amplitude of the earth bed soil oscillations on the maximum allowable stresses is shown in Fig. 2.

The general dependence of bearing capacity on the value of vibrodynamic influence is described by the exponential dependence. The greatest decrease is observed in the range of amplitudes from 50 to 200 microns.

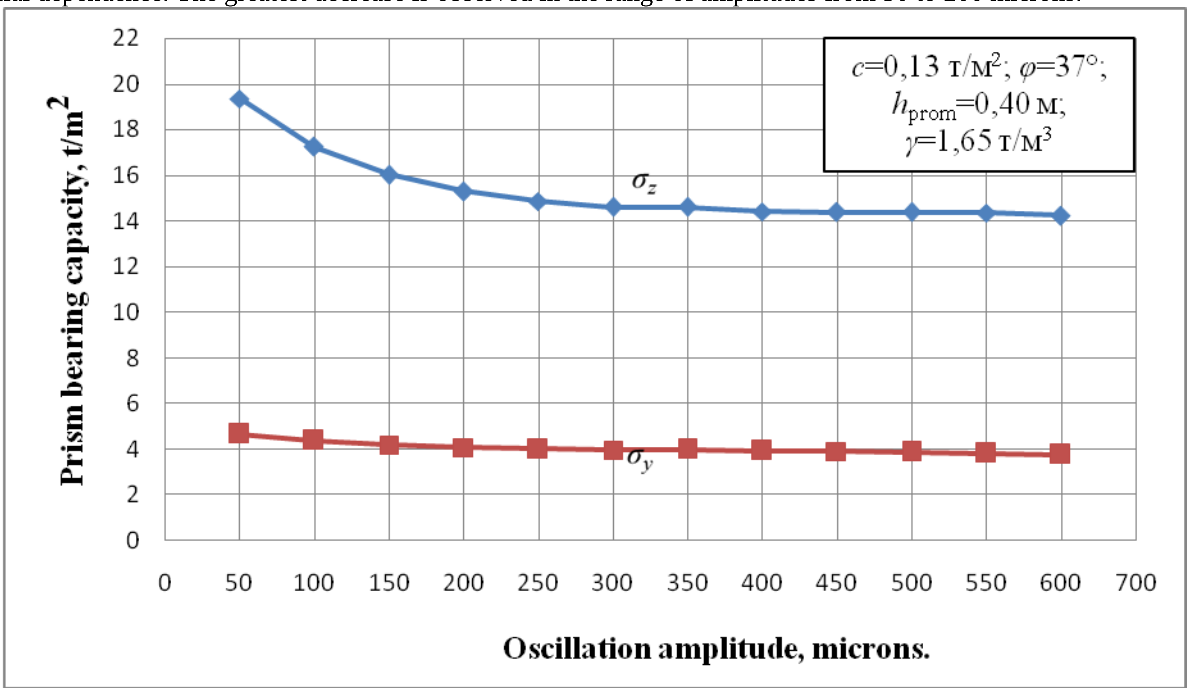

Fig. 2. Dependence of load-bearing capacity of ballast prism polluted by barchan sands on vibration amplitudes at the main site surface.

III. CONCLUSION

1. Significant influence on the bearing capacity of the ballast prism is caused by the value of vibrodynamic influence.
2. At increase in amplitude of fluctuations to 200 microns sharp decrease in bearing capacity is observed.
3. Increasing the amplitude reduces the strength of the ballast layer with a lower intensity.

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