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IMPACT OF SOIL ON THE SHORE SUPPORT OF THE BRIDGE

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Abstract:
The article considers a method for reducing the total active pressure as a result of the self-weight of the soil layer and the vibrodynamic force of the rolling stock acting on the shore support of the bridge by driving piles.

Keywords: Coastal support, high-speed train traffic, retaining wall, roadbed, pile, active pressure, plot.

INTRODUCTION

Questions of soil pressure on fences are the most important in engineering calculations and solve them on the basis of the theory of the ultimate stress state of soils and general methods for solving its problems:

1. Analytical;
2. Graph-analytical analysis;
3. Graphic.

Currently, a large number of separate works (more than 300) are devoted to the issues of soil pressure on retaining walls and other fences, the presentation and analysis of which would require a multi-volume work. Without setting such a task, we will consider only the most important provisions of the theory of soil pressure on fences and their applications to the calculation of soil pressure on retaining walls in the light of the latest data of soil mechanics [1].

All this leads to the need for a thorough scientific approach to solving this design and additional calculation of the connection node of the coastal bridge support [2].

Numerous studies of the increased damage to the coastal bridge supports during operation and especially under the action of seismic effects, as well as from high-speed train movements, revealed a number of reasons that influenced the deformation of the structure to varying degrees:

1. The effect of active soil pressure on the coastal support, which increases sharply with increasing speed of transport and seismic effects during an earthquake.
2. The dynamic stiffness of the sub-grade, which is interrupted at the coastal bridge support, is significantly reduced and depends on the rigidity of the bridge span and the interface with the bridge support.
3. The bulk of the sub-grade of the coastal support most often has a riverbed at the base with a slope in the direction of the river, which creates a separation of vertical forces into two components, one of which contributes to the shift of the embankment towards the channel and affects the bridge support [3].

In this case, basically, the shore support should perceive the active ground pressure (E_a) arising from the oscillatory force of the rolling stock and transmit it to the base, as well as ensure the safe operation of the structure [4].

MAIN PART

The active pressure of the ground (E_{a1}) acting on the shore support of the bridge occurs as a result of the rolling stock and the ground's own weight. The plot in the form of a trapezoid of these forces is considered in Figure 1.

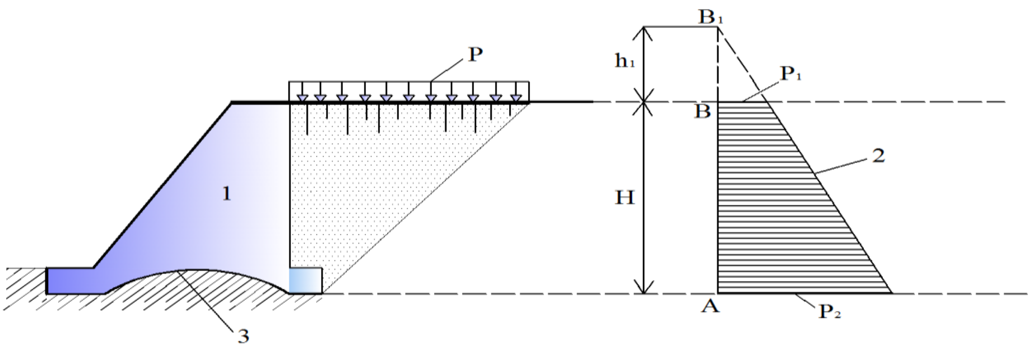

Fig. 1. Plot of the active ground pressure acting on the shore support.

1-the shore support of the bridge, 2-the plot of the active ground pressure, 3-the concave support surface of the retaining wall, H-the height of the shore support.

Let us consider the expressions for determining the effect of a continuous uniformly distributed load from the rolling stock. We determine the fictitious height of the vertical soil layer:

$P = \gamma_0 \cdot h_1, \quad h_1 = \frac{P}{\gamma_0} = \frac{50}{18{,}7} = 2{,}7$ m; (1)

where, P - evenly distributed load, $P = 50\ kPa$;

γ_0-specific gravity of the soil,$\left(\frac{kN}{m^3}\right)$, $\gamma_0 = 18{,}7\left(\frac{kN}{m^3}\right)$;

h_1- fictitious height of the vertical ground layer (m).

We find the pressure at the top point of the ground acting on the shore support of the bridge using the following formula:

$P_1 = \gamma_0 \cdot h_1 \cdot tg^2\left(45 - \frac{\varphi}{2}\right) = 18{,}7 \cdot 2{,}7 \cdot tg^2\left(45 - \frac{32}{2}\right) = 15{,}5$ kPa; (2)

We find the pressure at the lower point of the ground acting on the shore support of the bridge using the following formula:

$P_2 = \gamma_0 \cdot (H + h_1) \cdot tg^2\left(45 - \frac{\varphi}{2}\right)$; (3)

$P_2 = 18{,}7 \cdot (2{,}7 + 16{,}75) \cdot tg^2\left(45 - \frac{32}{2}\right) = 111{,}8$ kPa,

The total active pressure of the soil acting on the support is determined by the area of the trapezoid using the above-defined pressures P_1 and P_2.

$E_{a1} = \frac{P_1+P_2}{2} \cdot H = \frac{15{,}5+111{,}8}{2} \cdot 16{,}75 = 1066{,}14$ kN/m (4)

where, P_1, P_2 – pressure affecting the retaining wall $\left(\frac{kN}{m^2}\right)$;

H- retaining wall height (m), $H = 16{,}75$ m.

Determine the point of application of the active pressure by the formula:

$e_{a1} = \frac{H}{3} \cdot \frac{H+3h_1}{H+2h_1} = \frac{16{,}75}{3} \cdot \frac{16{,}75+3\cdot 2{,}7}{16{,}75+2\cdot 2{,}7} = 6{,}3$ m (5)

RESULTS

We achieve a reduction in the actin pressure of the soil acting on the bridge support by driving piles. The driving pile resists the active pressure of the ground, perceiving the pressure, directly transmits it to the base. In addition, the soil layer is compacted when driving piles into the ground. After that, the active pressure (E_{a2}) on the shore support of the bridge decreases (2-fig.).

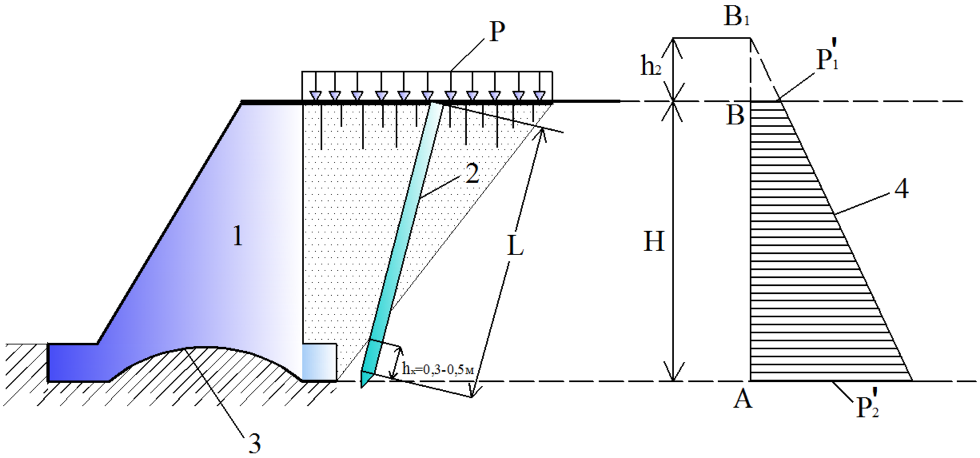

Fig. 2. Plot of active ground pressure acting on the shore support after piling.

1-the shore support of the bridge, 2-reinforced concrete piles, 3-the concave support surface of the retaining wall, 4-the plot of the active ground pressure, L - the length of the piles, H-the height of the shore support, h-the fictitious height of the vertical soil layer.

Due to the fact that the pile transfers to the base one part of the force acting on the ground (P), the fictitious height decreases (h_2):

$h_2 = \frac{P}{\gamma_0} = \frac{35}{18{,}7} = 1{,}87$ m; (6)

P - evenly distributed load, $P = 35\ kPa$;

We find the pressure at the upper and lower points of the ground acting on the shore support of the bridge using the following formula:

$P_1 = \gamma_0 \cdot h_2 \cdot tg^2\left(45 - \frac{\varphi}{2}\right) = 18{,}7 \cdot 1{,}87 \cdot tg^2\left(45 - \frac{35}{2}\right) = 9{,}5$ kPa;

$$P_2 = \gamma_0 \cdot (H + h_2) \cdot tg^2\left(45 - \frac{\varphi}{2}\right); \qquad (7)$$

$$P_2 = 18{,}7 \cdot (1{,}87 + 16{,}75) \cdot tg^2\left(45 - \frac{35}{2}\right) = 94{,}35 \text{ kPa},$$

The active pressure of the soil acting on the shore support after driving the piles into the ground is determined by the following expression:

$$\mathrm{E}_{a2} = \frac{P_1' + P_2'}{2} \cdot H = \frac{9{,}5 + 94{,}35}{2} \cdot 16{,}75 = 869{,}74 \text{ kN/m} \qquad (8)$$

where, P_1', P_2'- acting pressure on the retaining wall $\left(\frac{kN}{m^2}\right)$;

H- retaining wall height (m), $H = 16{,}75$ m.

Determine the point of application of the active pressure by the formula:

$$e_{a2} = \frac{H}{3} \cdot \frac{H + 3h_2}{H + 2h_2} = \frac{16{,}75}{3} \cdot \frac{16{,}75 + 3 \cdot 1{,}87}{16{,}75 + 2 \cdot 1{,}87} = 6{,}1 \text{ m} \qquad (9)$$

Let's draw the active pressure of the above-mentioned soil on the graph-fig. 3.

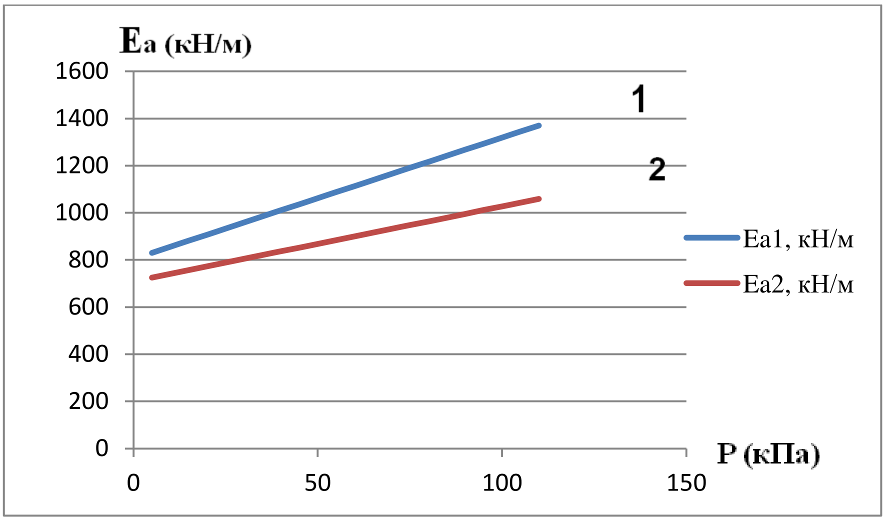

Fig. 3. Dependence of the active ground pressure on the uniform distributed load.
1-active ground pressure acting on the shore support,
2 - active ground pressure acting on the shore support after piling.

CONCLUSION

Based on the graph above, the recommended method is used to reduce the impact of the active pressure resulting from the self-weight of the soil layer and the vibration-dynamic force of the rolling stock on the shore support of the bridge by driving piles into the ground. This allows you to increase the period of operation of the bridges.

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