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CONSTRUCTION OF THE COASTAL BRIDGE SUPPORT TAKING INTO ACCOUNT THE SPEED OF TRANSPORT AND THE EFFECT OF SEISMIC FORCES

Abdujabarov Abdukhamid Khalilovich[1], Mekhmonov Mashkhurbek Khusen Ugli[2], Matkarimov Abdurashid Khayitmat Ugli[3]

[1]Doctor of Technical Sciences, Professor, Tashkent Institute of Engineers of Railway Transport.
[2]Assistant, Tashkent Institute of Engineers of Railway Transport.
[3]Candidate of Technical Sciences, Associate Professor, Tashkent Institute of Engineers of Railway Transport.

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ABSTRACT: This article provides constructive strengthening of the coastal support of the bridge from the effects of seismic forces and high-speed traffic, which allows to save the structure at low additional cost and reduce operating costs.

KEYWORDS: Coastal support, Bridge support, High-speed train movement, Counter fort, Ledges, Retaining wall, Sub-grade, Pile, Active pressure, Seismic pressure.

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I. INTRODUCTION

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 [1-3].
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 [4-6].
3. When the vehicle moves along the rail-sleeper grid in the sub-grade, in the coastal support section and in the span section, which have different stiffness, which creates additional irregularities of the track and new shock loads [7-8].
4. 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.
5. Moving transport in front of the bridge most often reduces the speed of movement, which is also transmitted to the support of the coastal part of the bridge as horizontal braking forces [9-13].

II. EXPERIMENTAL RESEARCHES OF THE COASTAL BRIDGE SUPPORT

Basically, all experimental studies are carried out on models using a seismic platform and a centrifugal modeling machine based on the "Theory of similarity of solid deformable bodies" by academician A.G. Nazarov using the "Installation for reproducing dynamic effects on underground structures", senior scientist Teshabaeva Z.R., as well as using natural structures of bridges of various constructions [14-16].

III. RESULTS AND DISCUSSION

To reduce the impacts listed above in the design of coastal bridge supports, the following design solutions are proposed that can reduce the amount of deformation and increase the life of the structure [17-18].

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1. Coastal bridge supports should be designed with counter-supports, as in the structures of retaining walls of Figure 1. This construction is especially effective in earthquake-prone areas of construction, as part of the active seismic pressure of the soil reduces the impact on the structure. This reduces the weight of the structure, which leads to savings in concrete and reinforcement. Also, seismic inertial forces are reduced, which are directly proportional to the weight of the structure according to the static theory of seismic resistance. With these structural changes, the overall dynamic stiffness of the bridge support increases significantly, which is necessary for high-speed train traffic and increases the seismic resistance of the structure.

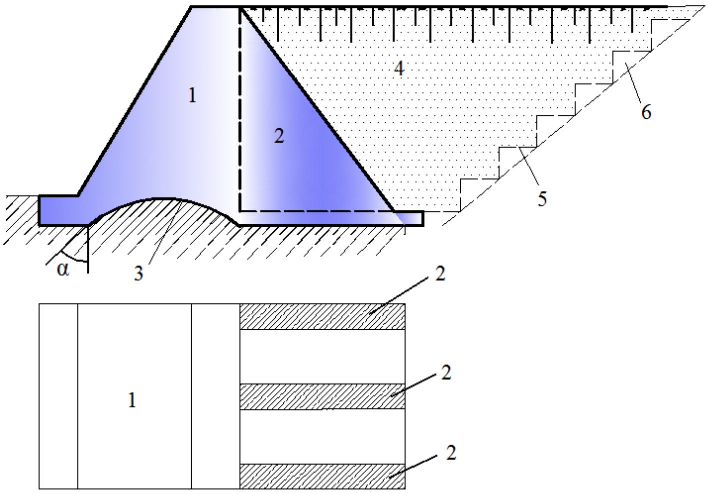


Fig. 1: Construction of the Shore Support of the Bridge with Counter Forts and the Concave Support Part at the Base

1-retaining wall; 2-buttresses;
3-concave supporting surface of retaining wall;
4-earthen roadbed, 5-ledges, 6-mass of creeping ground.

2. The concave support part of the base of the foundation increases the resistance of the bridge support from a possible horizontal shift. In addition, the contact area of concrete and base soil increases. The angle α of the transmission of forces to the base soil increases by 15-20%, which reduces the amount of stress in the soil and the thickness of the compressible layer, i.e. construction settlement is reduced.

3. Strengthening the bulk of the subgrade before the coastal support of the bridge by piles reduces the active soil pressure on the structure, part of the shock loads from the moving vehicle is transferred directly to the foundation soil. When driving piles, the soil of the embankment is additionally compacted and this leads to a more uniform distribution of stresses in the section of the structure - Fig. 2

Section I-I

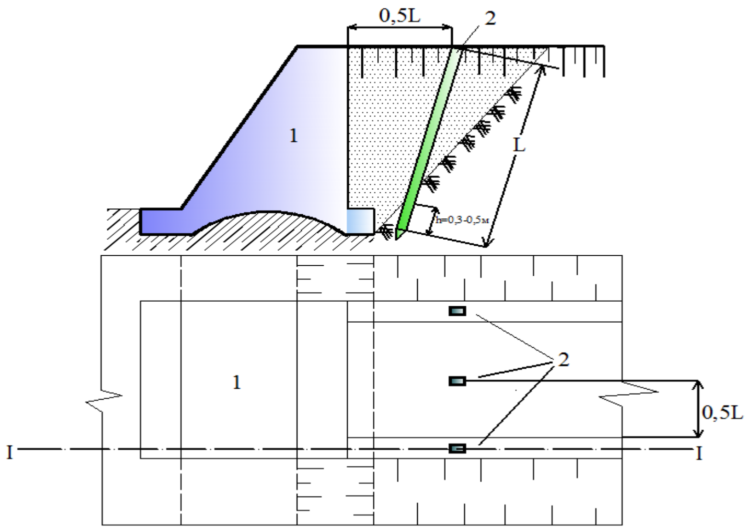


Figure 2: Strengthening the Bulk of the Subgrade of the Coastal Bridge Support Piles

1-shore bridge support; 2-reinforced concrete piles; L-length of piles.

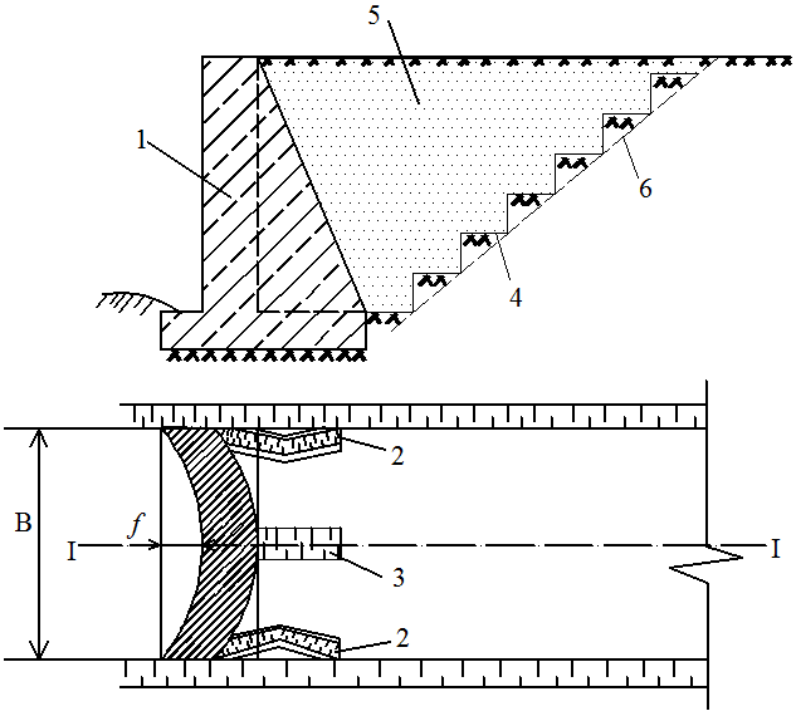
We developed a similar strengthening of the embankment of the roadbed in [2], to ensure the stability of high embankments of the roadbed on relatively weak soil bases during high-speed train traffic.

4. The use of piles to strengthen the embankment of the subgrade allows you to increase the stability of the entire structure in case of a possible earthquake, because is a relatively flexible reinforcement that allows deformation of the soil of the embankment without destruction, which is described in more detail in the work [3].

5. The most effective reinforced concrete piles are I-piles, which are much lighter than rectangular piles and have a large area of contact with the ground. For single-track railways, -2 piles are sufficient, for double-track-3 piles.

On the basis of previously obtained structural solutions of retaining walls, coastal bridge supports with an arched support part and a bending construction of retaining counterforts have been developed for stability in seismic regions and taking into account the high-speed movement of rolling stock - Fig. 3. The positive effect of the proposed structures is explained by the high value of holding forces from the effects of active and seismic soil pressure on the bridge support screen. Also, part of these efforts is transmitted by the counterforts to the lateral part of the embankment of the subgrade. The shore support from the impact of horizontal forces works in compression, which saves the consumption of concrete and reinforcement. As the experimental results showed, the proposed design has less rigidity, which allows the structure to slightly deform without being damaged in general, i.e. serviceable.

Section I-I



Support plan

Figure 3: Coastal bridge support with arched support.

1-arched bridge support; 2-curved buttress; 3-flat counter fort, 4-ledges, 5-embankment of the sub-grade, 6-plane of the cut of the ledges.

The construction of the arched shore support, with counter-ties of various shapes, has a deflection in the direction of the sub-grade soil. The magnitude of the arrows of the arch is determined by calculations and experiments using a seismic platform and a centrifugal acceleration machine:

$$f = 0{,}08B \; ; \qquad (1)$$

here f- is the arrow of the arch of the shore support, m

B - support width, m

It is easy to calculate how far the counterforts increase the stability of the entire structure of the shore support of the bridge, reduce the magnitude of the active and active seismic pressure of the soil on the structure, which occurs during the passage of a high-speed train or during an earthquake. Pressure reduction is determined experimentally and refined by mathematical calculations:

$$E_{ak} = E_a \cdot \alpha \cdot \beta; \quad (2)$$

$$S_{ak} = S_s \cdot \alpha \cdot \beta. \quad (3)$$

here E_a – active soil pressure of the embankment on the bridge support;

α – coefficient taking into account the reduction of active soil pressure on the bridge support, α=0,9 because there is a decomposition of forces into normal and tangent;

β – coefficient taking into account the retention function of the counterforts, which extinguish part of the soil pressure due to the friction forces of the soil on the side surface, β=0,8;

S_s – active seismic soil pressure on the shore support.

IV. CONCLUSION

The horizontal forces acting on the bridge support (E_{ak}, S_{ak}), to which brake loads can also join, create compression stresses, because the arch support of the bridge, taking into account the strengthening of the buttresses, ultimately allows to reduce the consumption of reinforcement-8%, concrete up to 12%.

In addition, the proposed design is capable of damping forced vibrations from rolling stock during high-speed movement and during an earthquake, because has high dynamic stiffness.

The ledges recommended in the technical literature on the sloping side of the base of the embankment under seismic effects, as well as in high-speed train traffic, do not give the effect of holding the embankment. As the experimental results showed, using a seismic platform, during vibrational vibrations, the ledges slide along with the embankment, increasing the volume of the embankment mass - Fig.1. This is probably due to a violation of the natural natural structure of the soil, and in the vertical part of the ledge, after the construction of the embankment, soil adhesion is absent. During construction, ledges to hold the embankment are carried out by bulldozers, which during operation create vibrational vibrations and are heavy, which disrupt the natural bonds of the soil and reduce its angle of internal friction.

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