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DETERMINATION OF THE WORKING CONDITION OF THE TRANSITION SECTIONS ON THE APPROACHES TO THE BRIDGES

Mekhmonov Mashkhurbek Khusen o'g'li[1], Makhamadjonov Shukhratjon Shavkat o'g'li[2]
[1]Candidate of Technical Sciences (PhD), Acting Associate Professor, Tashkent State Transport University, Uzbekistan
[2]Assistent, Tashkent State Transport University, Uzbekistan

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Abstract:
The article presents the dependence of the length of the transition sections on the speed of trains on the approaches to the bridges, methods for determining the modulus of elasticity of the transition section depending on the upper structure of the track and the rigidity of the shore support of the bridge.

Keywords: Roadbed, shore support, transition section, sleeper, modulus of elasticity, bridge, bridge pit.

INTRODUCTION

When an earthquake occurs and the speed of traffic increases, longitudinal, transverse, and vertical vibrations are created on the roadbed. The active pressure (E_a) that affects the shore support of the bridge increases, creating the possibility of deep ground shift [1].

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 [2]. Supports are needed to transfer vertical and horizontal loads from the weight of spans, mobile load, wind, etc. to the ground of the base [3].

Transport on the road section under consideration overcomes additional irregularities, and this creates new shock loads that negatively affect the roadway and the chassis of the transport, reducing its service life [4].

Today, rail transport is becoming an important mode of transport of national transport networks with important advantages, such as a large volume of traffic, reducing environmental pollution, improving passenger safety and comfort compared to other modes of transport.

One of the strategic directions of the development of public railway transport is the organization of heavy traffic, including with increased axial loads. As part of this strategy, it is planned to introduce wagons with an axial load of up to 30 tons, while it is assumed that the mass of freight trains will increase to 9100 tons or more. It is obvious that in order to increase the axial loads and the weight of the train, it is necessary to strengthen the entire railway infrastructure.

Another priority task facing JSC "UTY" is the development of a low-maintenance structure of the upper structure of the track. The creation of such a structure will significantly reduce the costs of the current maintenance of the track, reduce losses caused by speed restrictions and the need to provide "windows" for track repairs. The solution of these tasks can be performed by increasing the power of the upper structure of the track or by reducing the loads on the elements of the track subject to the accumulation of residual deformations. Increasing the capacity of the upper structure of the track is not always an expedient and economically advantageous step. Since, on the one hand, it requires significant capital investments, on the other hand, some elements of the upper structure of track 5 have a sufficient margin of safety (for example, rails). Path disorders in some cases are of a natural nature and manifest themselves, as a rule, in the same places. For example, this happens on the approaches to the artificial structures, where characteristic irregularities are formed, which are called bridge pits. Sections with pre-bridge pits become "barrier" places when axial loads and speeds of movement increase.

In order to fulfill the tasks set to increase axial loads and create a low-maintenance upper structure of the track, it is necessary either to exclude the possibility of the appearance of bridge pits, or to reduce the intensity of their development so that there is no need to perform work on their correction between scheduled repairs.

Dynamic loads of trains with high speed, have a great impact on the disorder of the way. The process of deterioration of the quality of the rail track of the transition zone is pronounced with different track designs (on ballast on the approach and without ballast on the bridge), and shown in Figure 1.

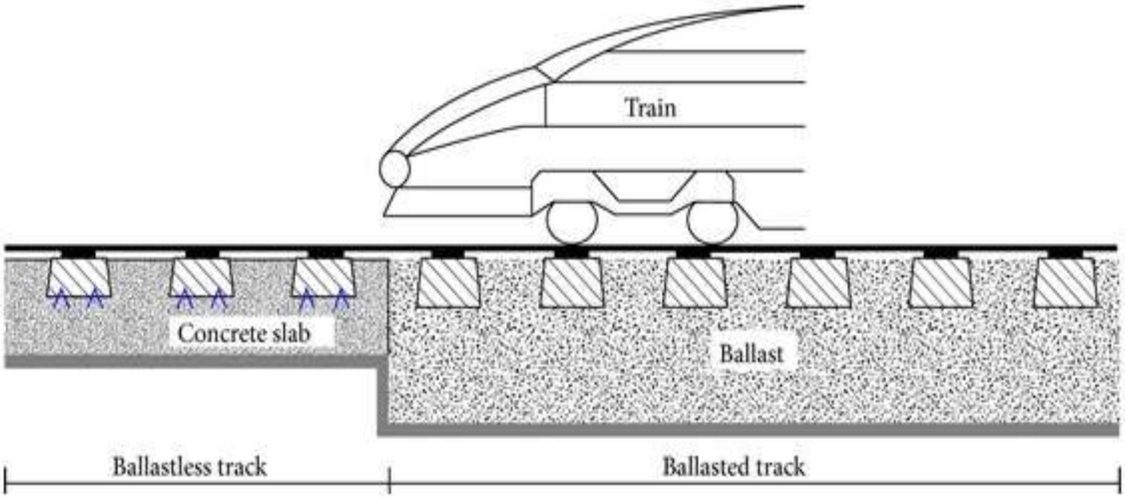


Fig. 1. Transitional sections on approaches to bridges

MAIN PART

The length of the transition path section with variable stiffness on the approach to the $L_{v.s}$ artificial structure is determined for each specific object by the length of the actual zone of increased path disorders. To identify these zones, the data of track measuring cars, the results of tests by load trains are used.

The minimum length of the section of stiffness change on the approach ($L_{v.s}$) at the same time, depending on the speed of trains, is taken according to Table 1.

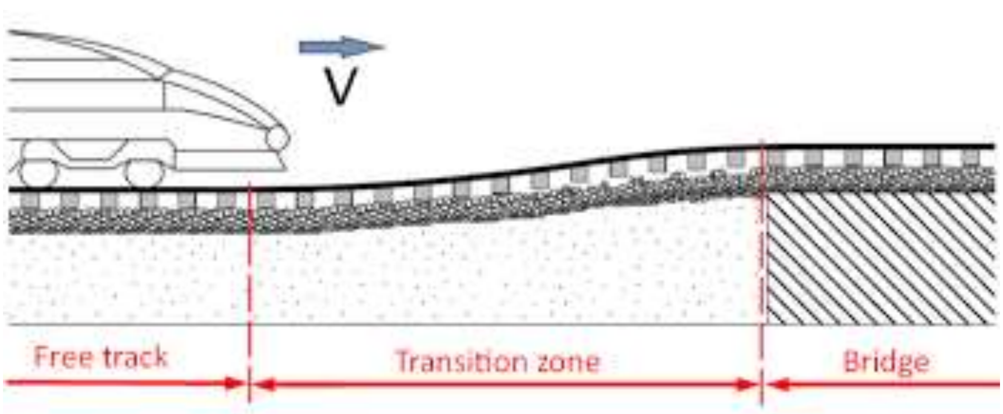
Table 1.

Minimum lengths of the stiffness change section on the approach

Maximum train speed, km/h	more 120	80 - 120	less than 80
Minimum length of the $L_{v.s}$ section, m	25	20	15

The coupling of embankments with a bridge is an important element of railways, designed to ensure a smooth transition from a relatively pliable roadbed to a rigid superstructure. At the same time, it is in the places where the roadbed interacts with artificial structures that deformations are very often observed, which lead to the destruction of the roadbed (fig. 2.).

a)



b)

Fig. 2. Structures of the way of the transition sections on the approaches to the bridges
a) - the zone of the transition section; b) - the "bridge pit" on the transition section

RESULTS

In [5], the currently accepted definition is given: "The elastic modulus of the rail base U is numerically equal to the uniformly distributed reaction of the base that occurs per unit length of the rail with an elastic sediment of the base equal to one." In turn, the elastic sediment of the base consists, among other things, of elastic deformations of the roadbed. The magnitude of elastic deformations of the roadbed was first experimentally determined by G.G. Konshin [6], which, according to his data, can reach values up to 2.02 mm under four-axle and eight-axle cargo gondolas. When the protective layers are installed, the elastic deformations of the roadbed decrease, respectively, the modulus of elasticity of the path increases, but the strength of the main platform increases. As a result, the amount of residual deformations in the roadbed decreases and, as a result, the stability of the path increases. Let's consider how the magnitude of the elastic modulus of the path affects the stresses in the ballast layer.

The stresses under the sleeper are determined by the formula [7]

$$\sigma = \frac{Q}{\omega}, \quad (1)$$

where: Q – the force acting on the sleeper, kN;
ω – the reference area of the half-span adjusted for bending, m^2.
The force acting on the sleeper is determined by the formula [7]

$$Q = \frac{k \cdot l_{sh}}{2} \cdot P, \quad (2)$$

where: k – the coefficient of relative rigidity of the rail;
l_{sh} – distance between sleeper axes, m;
P – load from a wheel or wheel system, kN.
In turn, the coefficient of relative rigidity is determined [7] by the formula:

$$K = \sqrt[4]{\frac{U}{4EI}}, \quad (3)$$

where: U – modulus of elasticity of the path, MPa;
As is known, the modulus of elasticity of the path and stiffness are related by the following relation [6]:

$$U = \frac{Ж}{l}, \quad (4)$$

where: U – modulus of elasticity of the path, MPa;
Ж – rigidity of the path, MN/m;
l – distance between axes of adjacent sleepers, m
In turn, the rigidity of the path and the rigidity of its individual elements are related by the following relation:

$$\frac{1}{Ж} = \sum \frac{1}{Ж_i}, \quad (5)$$

where: $Ж_i$ – rigidity of individual elements of the track structure MN/m.

Accordingly, the smaller the modulus of elasticity of the path, the less the load on a single support and, consequently, less load on the ballast and the main platform of the roadbed. Thus, a decrease in the modulus of elasticity will reduce the loads on elements subject to the accumulation of residual deformations, and the use of protective layers will increase the strength of the roadbed. Therefore, it is necessary to reduce the modulus of elasticity of the path by using various elastic elements in the VSP structure [8, 9], and not by reducing the modulus of deformation of the roadbed or ballast prism.

Measurements of ground vibrations of the subgrade carried out by G.G. Konshin, G.N. Zhinkin, and T.G. Yakovleva showed that the characteristics of the ground decrease with distance from the bottom of the ballast prism, depending on the speed of movement and axial load [10].

Research shows that the amplitude-frequency characteristics of high-speed trains are similar to low-intensity seismic impacts [11].

CONCLUSION

1. The dependence of the change in the length of the transition section on the speed of the rolling stock on the approaches to the bridges is substantiated.

2. The methods of calculating the stiffness of the track depending on the modulus of elasticity of railway tracks and coastal bridge supports are clarified in order to ensure the elastic operation of the railway on the transition sections.

3. Bringing the rigidity of the railway track to one state on difficult sections leads to an improvement in the working condition of the transition section, which will ensure the safe operation of the rolling stock.

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