Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 189 (2017) 587 – 592

Procedia Engineering

www.elsevier.com/locate/procedia

Transportation Geotechnics and Geoecology, TGG 2017, 17-19 May 2017, Saint Petersburg, Russia

Solution of the Problem of Providing Railway Track Stability in Joint Sections Between Railroad Facilities and Subgrade

G.M. Stoyanovich[a], V.V. Pupatenko[a]*, D.Y. Maleev[a], K.V. Zmeev[b]

[a]*Far Eastern State Transport University, Khabarovsk, Russia*
[b]*Khabarovsk center of track span lines and machinery of PDO I JSC "Russian Railways" Khabarovsk, Russia*

Abstract

The paper presents the results of design, implementation and operational observations of nonstandard track structures with variable stiffness in joint sections of bridges and tunnels with regular subgrade. Technical and economic efficiency evaluation based on long-term real data analysis was carried out.

It was experimentally confirmed that the sub-rail base stiffness changes reach 5-8 times, force unevenness exists and intensive residual deformations accumulate on the approaches to bridges and tunnels under passing trains. Several designs of reinforced concrete slabs, frames and monolithic concrete were developed to smoothly change the stiffness, reduce intensive accumulations of residual deformations. Empiric relationships between the development of settlements within the structures of variable stiffness and the tonnage passed were found. Additional technical decisions were proposed to improve the performance of the structures invented. Maintenance of track approaches to bridges and tunnels cost reduction was proven.

Peer-review under responsibility of the scientific committee of the International conference on Transportation Geotechnics and Geoecology

Keywords: sub-rail base modulus of elasticity; variable stiffness; subsidence; efficiency; rigid layer.

* Corresponding author.
E-mail address: pvv@festu.khv.ru, mdy@list.ru

Peer-review under responsibility of the scientific committee of the International conference on Transportation Geotechnics and Geoecology
doi:10.1016/j.proeng.2017.05.093

Introduction

It is necessary to take into consideration specific conditions of railway track operation while implementing more stable, reliable and economically efficient ballastless type superstructure units within zones of tunnels and bridges junction with conventional ballast types of track in the form of rails-and-ties "grid" and subgrade.

Operational experience of such sections on Far Eastern Railroad showed continuous malfunctions of track, more frequent fails of superstructure elements [1, 4, 14, 15, 16].

The codes developed for engineering practices [2] using installation of slabs and variable numbers of ties per running length of track into superstructure as well as implementation of geo-synthetic materials inside the ballast are not settling this problem as expected [10, 12, 13].

By MSTU reports regular levelling out of tracks appears to be unsatisfactory because after only 100 000 gross tons passed the force unevenness returns and settlement accumulation proceeds [8, 9, 11].

It is necessary to carry out daily levelling out of track on the bridge across one of the rivers in Khabarovsk Territory due to 100 000 gross tons yearly load intensity. Analogous situation has arisen immediately after putting into operation of one of the reconstructed tunnels in October 1999. Daily 20-80 millimeters levelling out of track was performed by the track maintenance team with limited train velocities during one month preceding to subgrade soils freezing. The situation repeated during the springtime of 2000 in an analogy to the Fall period, although the rates of track lifting reduced to 20-30 millimeters. During Spring-Summer time the levelling out was performed no less than twice a week.

Besides, the rolling-stock wheels are passing significant loads onto the first bearings of the ballastless track. This phenomenon has manifested itself after putting into operation of the two new tunnels where the concrete ties immersed into concrete were used as a sub-rail base.

Such a character of the track operation in the joint zone of different structures is, first of all, affected by variable stiffness of sub-rail base (or correlated to it modulus of elasticity value).

Thus, by the data obtained by V.P. Novichkov [3] modulus of elasticity valued 27 MPa is realized by the percentage of main track elements as follows: 11 % for tie, 17 % for ballast and 72 % for subgrade; by 47 MPa modulus of elasticity these elements of the system produce 23, 25 and 52 per cent respectfully.

Therefore, sub-rail base modulus of elasticity value of the track both on timber and concrete ties is largely affected by subgrade stiffness and if wide range gradual change of stiffness is in question it is necessary to gradually change the stiffness of all the systems' "sub-rail bearings-subgrade-basement" elements.

Main part

A design model was created, multivariant computations were carried out and long-term settlement observations were made after implementation of the variable stiffness track structure to solve this problem.

Deformations and strains in ballast and subgrade soils containing rigid layers were determined by Finite Elements Method using a numerical modelling "Geomekhanika" [5, 6] software with 2-D elasticoplastic statement of the problem. This assumption reduces the calculated modulus of elasticity.

The dynamic load was increased to the designed one. The points of application of the load were taken on the level of tie bed, the greatest load value – in under-rail cross-section.

Field observations of the settlements development were made for eleven years by regular level measurements of the marks installed on each upper reinforced concrete slab of the structure.

As a result, force characteristics and elastic settlement values were obtained which allowed to estimate modulus of elasticity of sub-rail base using available relationship. The computation results were compared with the in-situ data for standard cross-section and dimensions of track superstructure.

The results of the calculations defined rational variable depth of slab installation with crushed stone thickness 0.4 meters on the right abutment and 0.8 meters next to closure rail (Fig. 1).