

## 1. Introduction

The main component of the infrastructure is rail transport. The strategic direction of the development of rail transport is to increase the speed of train traffic. With the increase in the speed of movement, axial load, freight traffic on the railways, there is a need to increase the strength and stability of the rail-track.

With the advent of CKД65-Б fastener assembly [1], it becomes possible to use reinforced concrete crossties in curves of any radius, without changing the design of the crosstie III-1. This fastener creates the necessary geometry of the track in the plan with an accuracy of 1 mm, for an extension from 0 mm to 14 mm, and for a narrowing from 0 mm to 28 mm. The practice of operating a continuous welded rail track in curves  $R \leq 350$  m proved its operability but not reliability in terms of its stability. The stability parameter is not ensured by the fact that typical reinforced concrete crossties III-1 have insufficient resistance to lateral displacement, which leads to emissions of the continuous welded rail track in summer. However, a number of shortcomings have been identified in the fasteners of the CKД65-Б type: many parts (13 kg/unit), high metal content (30 parts), and a large presence of a threaded joint.

The aim of the work is research on the issues of using elastic rail fastenings and track stability in a transverse horizontal plane in curves of sections with a radius of 350 m.

To achieve this aim, it is necessary to solve the following tasks:

- to investigate and substantiate the possibilities of using perspective designs of elastic rail fastenings in curved sections of the track with a radius of  $350 \pm 200$  m;

- to carry out theoretical studies to solve the problem of stability of continuous welded rail track in the transverse horizontal plane;

- to develop measures to solve the problem of construction stability of continuous welded rail track in curved sections with a radius of  $350 \pm 200$  m.

## INVESTIGATION OF THE TRAFFIC SAFETY AND PROVISION OF THE PERFORMANCE RELIABILITY OF THE TRANSPORT INFRASTRUCTURE

**Ruslan Markul**

PhD

Department of track and track facilities  
Dnipropetrovsk National University of Railway Transport  
named after Academician V. Lazaryan  
2 Lazaryana str., Dnipro, Ukraine, 49010  
guarangamr@gmail.com

**Vitalii Kovalchuk**

PhD

Department of rolling stock and track  
Lviv branch of Dnipropetrovsk National University of Railway Transport named after Academician V. Lazaryan  
12a I. Blazhkevich str., Lviv, Ukraine, 79052  
kovalchuk.diit@gmail.com

**Abstract:** In the track facilities over the past decade, the polygon for laying reinforced concrete crossties has significantly expanded for many reasons. The main ones are the shortage of wooden crossties, their high cost and low life. Due to frequent crossovers, the service life of wooden crossties in the curved sections of the track  $R \leq 350$  m is only 7 years. This is 5 times less than the life of reinforced concrete crossties. In the curves  $R \leq 350$  m under the action of the rolling stock, an intensive accumulation of residual deformations occurs, which causes a violation of the track geometry in the plan. Simultaneously, the stability of the assembled rails and crossties in the transverse plane decreases.

Given the shortcomings of the railway track on wooden crossties, a study is conducted to solve the problems of geometry, and the stability of the track in the transverse horizontal plane. To achieve this, the design of the fastener assembly KIII-5 (SB-3) has been improved, which makes it reliable and adjustable in all respects for 800 1000 million of tons of bruto. In order to ensure the stability of the track, an anchor crosstie structure has been created which can increase the resistance to transverse displacement of the assembled rails and crossties more than 2 times. The developed and justified measures will allow to create a highly efficient construction of a seamless track with reinforced concrete crossties and KIII-5 (SB3) fastener for curved sections with a radius of  $350 \pm 200$  m.

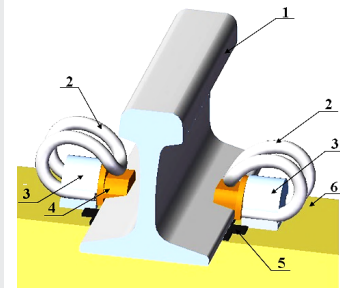
When considering these proposals with the possibility of practical use, it becomes possible to introduce a safe and reliable design of continuous welded rail track with KIII-5 fastener assembly in difficult operating conditions.

**Keywords:** infrastructure, traffic safety, railway track, stability, anchor crossties, intermediate rail fastenings, clamping force.

## 2. Methodology and main stages of research

### 2. 1. Research and substantiation of the analysis of the work of KIII-5 (SB-3) fastener during its operation

One of the intermediate rail fasteners, which are operated on the railways of Ukraine, Poland, Belarus, Kazakhstan [2–5] is a KIII-5 fastener (Fig. 1).



**Fig. 1.** Construction of KIII-5 fastener: 1 – rail; 2 – elastic terminal; 3 – anchor; 4 – polymeric bearing; 5 – laying; 6 – crosstie

In Ukraine about 5 thousand kilometers of the main ways are laid on the way. This fastener type is the prototype of the Polish SB-3 rail fastener.

At the initial stages of operation, KIII-5 rail fasteners, unlike the CKД65-Б fasteners, have a number of advantages such as: ease of installation and dismantling of the track content; absence of threaded connections; small number of parts (only 7 parts and not with thread) and low metal content ( $\approx 5$  kg). However, during long-term operation, a number of shortcomings have been revealed in the KIII-5 fastener, which is associated with an intensive decrease in the clamping force.

Until now, the reason for the intensive reduction in the power work of the KIII-5 fastener has been interpreted by the substandard manufacturing of elastic terminals. In this connection, the terminal lost its elastic properties, and its relaxation took place.

In order to verify such statements, the Dnipro National University of Railway Transport named after Academician V. Lazaryan (DNURT, Ukraine) carried out complex studies. The studies was carried out using the design of a track device designed for the measurement of the force of the rail pressing to the support (crosstie) in the case of using a KIII-5 (SB-3) fastener (Fig. 2).

The technique and technology for controlling the determination of the pressing force of the rail to the crosstie was developed for KIII-5 fastener [6].

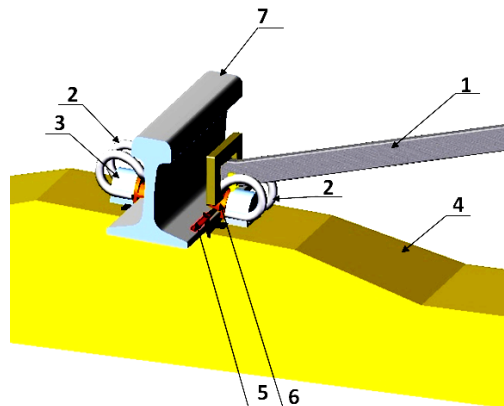


Fig. 2. Working position of the rail device for measuring the pressing force of the terminal to the rail: 1 – track device; 2 – elastic terminal; 3 – anchor embedded in the crosstie; 4 – crosstie; 5 – measuring probe; 6 – polymeric bearing; 7 – rail

It has been established that several factors influence the process of reducing the rail pressing force to the under-rail base for KIII-5 fastener [2]. The main factors are: terminal relaxation 26.2 %, wear of the under-rail base – 50.4 %, defects in centering of the anchor holes – 29.8 %, technological process – “assembly and dismantling” of the terminal – 6.6 %.

The above factors do not reduce the quality of the structural and operational parameters of the KIII-5 fastener. This allowed to continue the work on further improving the KIII-5 fastener. To date, DNURT has improved the design of the KIII-5 fastener, which makes it reliable and adjustable in all respects for 800–1000 million t. br. This opens up the possibilities for expanding the polygon laying of the improved design of KIII-5 fastener into curved sections of the rail of small radius. According to technical and economic calculations, the cost of work with the current content of the railway with improved KIII-5 fastener in comparison with the binding CKД65-B decreases 4.6 times.

But the decisive factor in the introduction of a continuous welded rail track in curved sections of small radius is the solution of the problem of its stability. This can be achieved by creating an alternative design of under-rail base with increased resistance to lateral movement in the horizontal plane.

## 2.2. Theoretical research on the solution of the stability problem of a continuous welded rail track in a transverse horizontal plane

Theoretical studies of DNURT shows that in curves with a radius of 300 m or less, the design of the continuous welded rail track should have a resistance to transverse displacement 1.8 times ( $\approx 2$  times) greater than the rail track with typical crossties. Then the stability of the continuous welded rail track in the curve sections  $R \leq 200$  m equates the stability of the construction of the continuous welded rail track in curves with a radius of 400 m [7].

## 2.3. Solution of the problem of the stability of continuous welded rail track in curved sections of small radius

Foreign countries (Austria, Germany, France, Russia, Italy) have been searching intensively for decades for a new under-rail base which increased the resistance to the transverse displacement of the assembled rails and crossties to prevent the release

of the continuous welded rail track [8–10]. Compared to conventional squared crosstie III1-1, the weight of these crossties is 20–25 % larger. Creation of a new under-rail base with increased resistance to transverse displacement of assembled rails and crossties is also performed by the DNURT. On the basis of laboratory studies of the DNURT, an anchor crosstie is constructed which can increase the resistance to a transverse displacement of assembled rails and crossties more than 2 times [7, 11] (Fig. 3).

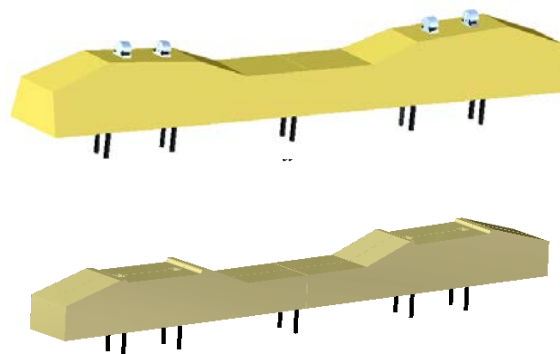


Fig. 3. The construction of anchor crossties: a – anchor crosstie SB-3; b – anchor crosstie III1-1

Advantages of using such anchor crosstie are: existing form of the concrete part of the crosstie does not change; practically does not change the technology: crosstie manufacture, compilation of assembled rails and crossties, laying in the rail track, the current content of the railway track; accessibility when using hand tools and mechanisms, as well as heavy machinery.

## 3. Results

DNURT develops a design of a track device for monitoring and determining the rail pressing force to the crosstie in the case of using a KIII-5 (SB-3) fastener. With the help of this device, it becomes possible: to determine by the non-destructive method the rail pressing force to the support; determine the elasticity of the terminal.

In order to reduce the costs for the current maintenance of the rail track with reinforced concrete crossties, while taking into account the above-mentioned shortcomings that are present in CKД65-B fasteners, the design of KIII-5 (SB-3) fastener has been improved. Based on the results of the economic calculations, it has been established, with the use of the improved design of fasteners of KIII-5 (SB-3) fastener, in comparison with the CKД65-B fastener, the work at the current content is reduced by 362 %.

To date, DNURT has solved the problem of the stability of a continuous welded rail track in curves of radius  $R \leq 350$  m. It is proposed to improve the design of a typical crosstie III1-1 and SB-3, installing anchors that protrude from the body of a crosstie by 80 mm. Laboratory studies have shown that the use of such crosstie will increase the resistance to displacement by more than 2 times. Then the stability of the rail track against ejection in curves of radius  $R=200$  m will be approximately equal to the stability of the existing rail track design, which is enclosed in curves of radius  $R=400$  m. That is, if the existing typical crosstie III1-1 has a displacement resistance of 5 kN in curves with a radius of 200 m, then the proposed design of the anchor crossties will provide resistance to displacement up to 10 kN for curves with the same radius.

#### 4. Discussion of research results

Creation of a highly efficient construction of a continuous welded rail track on reinforced concrete crossties in curved sections of small radius is not a fully resolved issue in many countries of the world. Especially in Europe, this issue has been addressed for decades. Simultaneously, the perspective designs of elastic rail fasteners do not correspond to the technical and operational parameters of the railway track in the curves  $R \leq 350$  m. This is explained by the insufficient rail force pressing to the under-rail base. Measures and proposals have been developed and substantiated by the main factors on the way of creating a highly efficient construction of a continuous welded rail track with ferroconcrete crossties and KПП-5 (SB-3) fastener for curved sections with a radius of  $350 \div 200$  m.

The advantage of the obtained results is invariability of the production technology, possibility to make a continuous welded rail track on reinforced concrete crossties with an intermediate KПП-5 fastener under difficult operating conditions. At the same time, work is done on the fulfillment of seasonal temperature discontinuities of continuous welded rail track lashes in the curved sections of small radius. With the possibility of practical use, it becomes possible to ensure the reliability of the railway track design and safety of traffic in difficult, including mountain operating conditions. According to the DNURT research, it is found that in the case of using such crossties on the rail track, the stability is increased so that the temperature of fastening the continuous welded rail track lashes can be reduced by  $10\text{--}15$  °C. This in turn will increase the lifetime of the rails by 1.5 times as the most expensive element of the upper structure of the rail track.

#### References

1. Nastechik, M. P., Marcul, R. V. (2016). Prospects for laying the fastening of the type СКД65 – Б in the curved track sections with small radius. Science and Transport Progress. Bulletin of Dnipropetrovsk National University of Railway Transport, 4 (64), 71–80. doi: 10.15802/stp2016/77923
2. Nastechik, N. P., Marcul, R. V., Savytskyi, V. V. (2015). Elastic deformations impact in elements of the rail fastening, type KПП-5 on a size of pressing force of the rail to the subrail basis. Science and Transport Progress. Bulletin of Dnipropetrovsk National University of Railway Transport, 4 (58), 110–120. doi: 10.15802/stp2015/49217
3. Antolik, L. (2011). Suitability of Rail Pads in View of the Requirements Set by EU Standards. Problemy Kolejnictwa, 152, 9–19.
4. Nehoroshev, Yu. P., Matvetsov, V. I. (2005). Rezultaty ispytaniy skrepleniya SB-3. Put i putevoe hozyaystvo, 6, 26–27.
5. Fink, V. K. (2007). Osobennosti ekspluatatsii promezhutochnogo skrepleniya KPP-5 na zheleznyih dorogah Kazahstana. Magistral (Almatyi), 14, 78–82.
6. Nastechyk, M. P., Markul, R. V., Savinochkin, H. M., Tulei, Yu. L. (2016). Pat. No. 107360 UA. Prystrii dlia vyznachennia sily prytyskannia pruzhnoi klemy reikovoho skriplennia do reiky. MPK 51 E01V 35/00. No. u201603029; declared: 24.03.2016; published: 25.05.16, Bul. No. 10.
7. Rybkin, V. V., Nastechik, N. P., Marcul, R. V. (2013). Stability issues of the continuous welded rail track on the concrete sleepers on the curves with radius  $R \leq 300$  m. Sciences in Cold and Arid Region, 5, 654–658. Available at: <http://eadnurt.diit.edu.ua/jspui/handle/123456789/2674>
8. Kryisanov, L. G., Serebrennikov, V. V., Resina, N. V. (2009). Shpali z povishenyim soprotivleniem sdvigu. Put i putevoe hozyaystvo. VNIIZhTa, 3, 24–25.
9. Klimenko, V. Ya., Klimenko, L. V. (2006). Povyishenie soprotivleniya zhelezobetonnykh shpal. Vestnyk nauchno-issledovatel'skoho instituta zheleznodorozhnogo transporta, 1, 27–31. Available at: <https://elibrary.ru/item.asp?id=9289083>
10. Ermakov, V. M., Bekish, A. A. (2009). Sovremennye konstruksii zhelezobetonnykh shpal i promezhutochnykh skreplenyi dlya besstykovogo puti. Saint Petersburg: PGUPS, 99.
11. Rybkin, V. V., Nastechyk, M. P., Markul, R. V., Yurkovskiy, Ye. Yu. (2012). Pat. No. 74528 UA. Pidreikova opora. MPK51: E01V 3/00. No. u201210484; declared: 05.09.2012; published 25.10.2012, Bul. No. 20.