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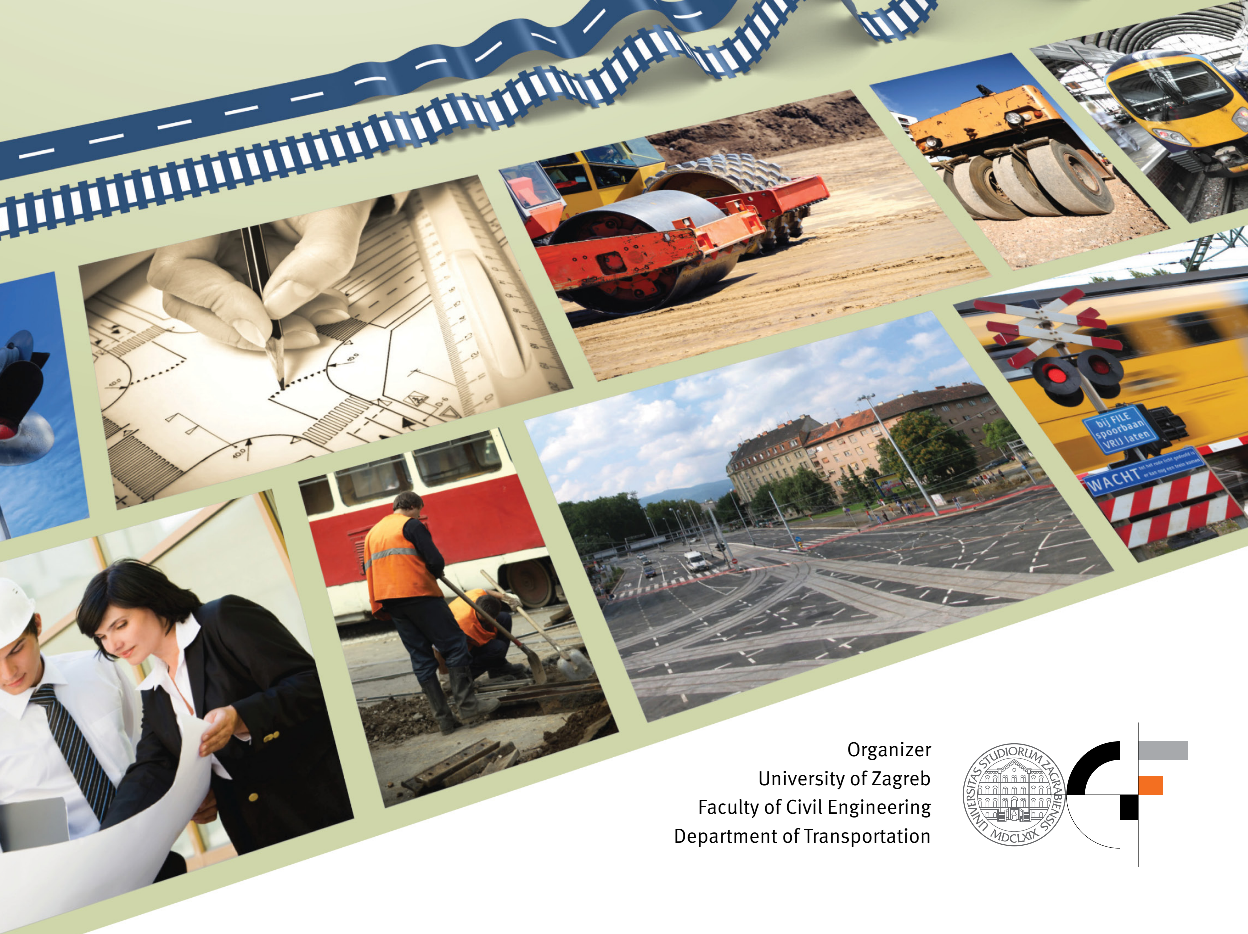
2nd International Conference on Road and Rail Infrastructure
7–9 May 2012, Dubrovnik, Croatia

Road and Rail Infrastructure II

Stjepan Lakušić – EDITOR



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TECHNICAL PARAMETERS FOR SELECTION OF ELASTIC RAIL FASTENINGS

Tatjana Simić
COWI doo, Serbia

Abstract

According to the Agreement for the establishing of a high performance railway network in South East Europe (Official Gazette of RS nr.102/2007), an initiative has been set up in Republic of Serbia to fulfil all measures defined in the Agreement. Driving speed increment in the existing railway track conditions requires an improvement of superstructure elements, especially of the rail fastening, the role of which is to transfer load from rails to the sleepers with retaining pulling force as long as possible. Significant attention, in the process of track construction and future maintenance, should be given to the thorough analysis of modern fastening types and their unification on the „Serbian Railways" network. It is even more important as nowadays plenty of different types exist.
Position of the UIC is that selection of rail fastenings should be left to the national railway administrations. Selection of the manufacturer/type of rail fastening and its installation and inspection during the exploitation should be the result of a compatibility between technical (permanent) track elements and fastening features, which is the subject of this report. Technical parameters, concerning the track are: axis load, driving speed, track geometry (situation and levelling), superstructure features (rail and sleeper types), modes of installation and level of mechanized maintenance. Elastic rail fastening characteristics which are relevant for manufacturer/type selection are: constructive elements of considered system (mass, tensile strength, material in use and it's properties), purchasing price, installation simplicity, changes of its characteristics during exploitation and maintenance costs.
This report will consider elastic rail fastening systems for concrete sleepers manufactured by Pandrol (UK) and Vossloh (Germany), which have been leaders in technical improvement and development of high speed railway tracks on the European railway network for a long time now. Some of these fastening systems were also applied on the „Serbian Railways"network. Experiences gained through the installation and exploitation are also included in this report.

Keywords: elastic /resilient rail fastening, installation, exploitation, maintenance

1 Introduction

Pursuant to the European integration processes, planned renewal and development of the railway infrastructure will have great significance in the future. Planned measures should enhance traffic infrastructure across Serbia and South East Europe and lead to faster and higher quality connections between industry and trade centres.
Since none of the existing main railway lines in Serbia comply with contemporary traffic demands concerning capacity, service quality and journey time, the final objective is to make railways more attractive for both passenger and freight traffic by reconstruction/extension of existing railway lines and driving speed increment.

2 Track parameters influencing the selection of resilient rail fastening in the superstructure

Data that has affect on the selection of superstructure elements should be defined in the Terms of Reference, such as: railway line category, axis/traffic load and line speed-limit. Additionally, track design as well as radius in curves and gradient, should also be considered.
Based on these data a selection of elastic rail fastening can be made, despite the fact that domestic regulations don't give unique criteria.
Selection of a rail type is in close connection with the traffic load/axle load (speed dependant) and speed-limit. Some researches have showed that with heavier rail type a more stable, low maintenance railway track is achieved. This way the maintenance cycle is prolonged and exploitation costs are decreased.
On new railway lines and on reconstructed main railway lines new standardized 49E1 and 60E1 rails are built, with quality mark 260 (according to the new EN standards), which corresponds to former rails with 880 N/mm^2 tensile strength. In the current rail production this is the lowest quality. 49E1 type rails are built in case of axle load up to 225 kN, total annual traffic load up to 10 millions bruto tons(BT) and speed-limits up to 120 km/h. When any of these criteria is exceeded, 60E1 type rails are built.
These criteria are based on the regulations of 'Serbian Railways'network, many European railway authorities (primarily DB of Germany) and UIC-ORE data.
Criteria are set according to the technical and economical parameters (safety vs. investment and maintenance costs). Selection of heavier 60E1 type rails increases safety and reduces superstructure maintenance costs, but because of construction weight can also increase substructure maintenance cost if it's not built as designed (which is very often the case of the overhaul of the main lines). During the investment planning we should have in mind that the weight difference between the 49E1 and 60E1 type rails is about 21,80 kg/(m' of track), which increases purchasing price of the 60E1 type rails, i.e. price of works for laying and regulation of the rail track.
Selection of the fastening system is conditioned with functional and constructive characteristics, i.e. with the degree of fulfilment of exploitation requirements for contemporary superstructure constructions.

2.1 Parameters for fastening system selection

a

- unctional:
- Permanent holding of the designed track geometry with blocking of longitudinal movement and bending of the rail (Figure 1),
- Providing of continuous friction between rail and sleeper (Figure 2),
- Providing of spatial elasticity for rail support on sleepers (Figure 3).

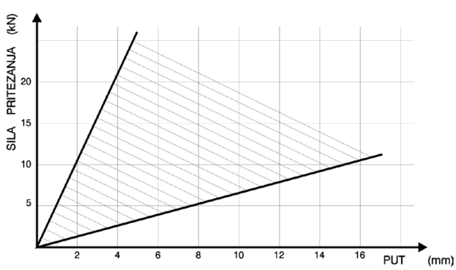


Figure 1 Area of operation 'fastening force vs. longitudinal movement' for elastic connection rail - sleeper

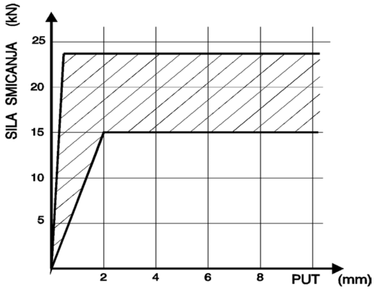


Figure 2 Area of functioning for longitudinal movement for elastic connection rail - sleeper

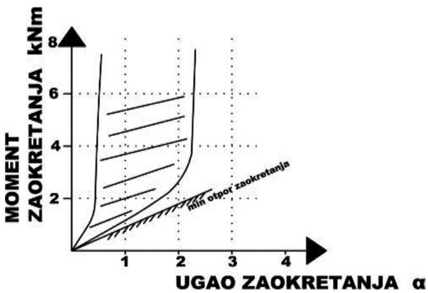


Figure 3 Area of functioning for rail bending resistance for elastic connection rail - sleeper

b

- constructive:
- minimal number of parts, minimal mass
- electrical insulation of track,
- simple and fast installation,
- easy component replacement,
- controlled degree of distortion,
- simplicity of operation during the loosening and reformation of continuous welded rail (CWR),
- possibility of installation in turnouts, diamonds and expansion joints (basic type or modification) and prevention of easy deinstallation from unauthorized persons (vandalism).

c

- production effectiveness, maintenance and environmental protection:
- cost-effective production,
- possible production in Serbia (parts or whole system),
- minimal installation and maintenance costs,
- environmental friendly materials.

In addition to previous parameters, during the fastening selection process, it is also necessary to meet the requirements from standards EN 13146-1/8 and EN 13481-1/7.

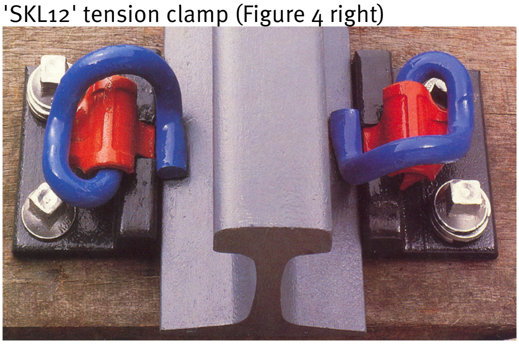
3 Resilient rail fastening

3.1 General features

As it's been previously stated, factors depending on rail fastening selection are traffic load, axle load, speed-limit, possibility of mechanized maintenance, simple installation and maintenance, frequency in necessity for maintenance, etc. Combined with the rubber pad, elastic fastening gets a double elastic connection. Rubber pad accepts downward impacts and amortizes high-frequency oscillations (1000-3000Hz), reducing the energy that transmit to the sleepers and ballast, and steel elastic element – tension clamp keeps rail foot from the top side and resists to the uplifting, due to the permanent attachment to the rail. In this way a connection between the rail and pad is permanent, there are no rail impacts on the sleeper and loosening of the connection. Such fastening is resilient in both directions - upwards and downwards.
Fastening force in such cases is almost constant. There should be no need for additional tightening during the exploitation. Longitudinal movement resistance is constant (high friction between the rail and rubber pad), which disables rail movements and there is no need for anti-movement tools. Fastening itself is less in weight, with less maintenance and installation and deinstallation is faster and simpler. Superstructure (rails, sleepers and fastening) under certain conditions enables transmission of:
· return traction current between the vehicles and substations,
· current for signalling and CTC purposes
As for the return traction current, specifications for rail steel quality are usually enough to provide this function. But, track should also be compatible with regulations concerning the electrification system. In order to provide an adequate transmission of the current for signalling and CTC purposes, a certain level of insulation between rails must be guaranteed, which is a characteristical function of the resilient fastening and sleepers. Since this request can differ depending on signalling and CTC systems and their functional demands, resilient fastening should be confirmed as an interoperative element.
Comparative technical-economical analysis of fastening systems show that for open line tracks and station main tracks/loops the required criteria are fulfilled by resilient fastening systems VOSSLOH, Pandrol and NABLA. Final selection of the elastic fastening system should be done through elaborate based on the multicriterial optimization principle, consisting of precise quantification of technical, economical and environmental criteria.

3.2 Resilient rail fastening systems – wooden sleepers – ballasted track

In cases of usage of resilient rail fastening for wooden sleepers, following suppliers and products exist: Pandrol ''K'' CONVERSION SYSTEM (Figure 4 left) and Vossloh FASTENING with 'SKL12' tension clamp (Figure 4 right)



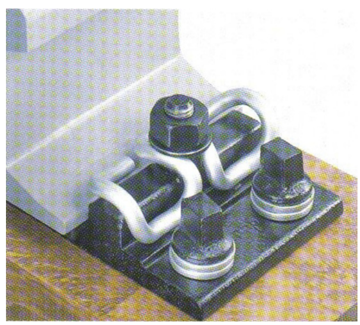


Figure 4 Resilient rail fastening for wooden sleepers

3.3 Resilient rail fastening systems - concrete sleepers – ballasted track

In cases of usage of resilient rail fastening for concrete sleepers, the following suppliers and products are available: Pandrol 'e' Clip (Figure 5 left) and FASTCLIP (Figure 5 middle), Vossloh 'SKL14' tension clamp (Figure 5 right).

Figure 5 Resilient rail fastening for concrete sleepers

Principal orientation on the 'Serbian Railways' network is the installation of prestressed concrete sleepers with resilient rail fastening on both new and reconstructed tracks wherever it is possible. For mixed traffic railway lines (both passenger and freight traffic), when the 49E1 rail type should be installed, concrete sleepers should be 2,40m long with vertical rail inclination of 1:40. This combination of rail and sleeper fulfils all necessary criteria for the 49E1 rail type, and also has better influence on the substructure due to the weight. With the 60E1 rail type, sleepers should be 2,60m long with vertical rail inclination of 1:40. This criterion has been adopted by almost all European railway administrations.
Considering large quantity of sleepers (1667 pcs per km of rail), despite the small difference in price between the 2,40m and 2,60m long sleepers, total cost difference can be significant. Elastic fastening for concrete sleepers is practically the same for both sleeper types. But, it must be considered that there are places across the line(track) where wooden sleepers will also be installed and in such cases it is recommended that the same type of fastening is used (elastic, not rigid).
The Pandrol FASTCLIP system is a resilient, threadless rail fastening system for application on concrete, steel and wooden sleepers. The unique switch on – switch off of rail clip enables fast track installation and reduced maintenance costs. FASTCLIP has been designed as a system in which all components are delivered to the construction site pre-assembled on the sleepers. Once the sleepers are laid and the rail installed, the clip is simply pushed onto the rail foot either by using hand tools or by mechanized process. FASTCLIP system content cast shoulder insert in sleeper mould before concrete is cast, with same modulus of elasticity as concrete and with same life time as sleeper itself. FASTCLIP system is completely electrically insulated. Change of the track gauge is achievable by using insulators with different thickness. FASTCLIP can be used in curves with minimum radius of 80m.
VOSSLOH W 14 system is resilient for application on concrete sleepers having SKL 14 tension clamp and screw spikes which connect them to the sleeper with plastic dowel inserted in sleeper mould before the concrete is cast. Fastening force of the tension clamp on the rail foot is obtained by tightened of the screw spike with torque of approx. 250 Nm either by using a hand tool or mechanized process. All components can be pre-assembled in the sleeper factory and delivered to the construction site. W 14 system is completely electrically insulated. Gauge adjustment of +-10 mm in steps of 2,5 mm is available. The screw spikes merely have to be loosened but not disassembled. System W 14 can be adjusted in height by using regulating plates.

3.4 Resilient rail fastening systems – hard base (slab track)

The application of a track construction on the hard base (so called 'slab track') has its advantages in shallow city tunnels, where it is especially important to prevent transmission of vibrations to the foundations of neighbouring buildings and appearance of irritating secondary noise. In these cases solutions with track on the concrete slab are applied, as well as in cases of passenger station tracks and on places where limited superstructure height is demanded (e.g. reconstruction due to electrification). There are several systems in usage: Pandrol VANGUARD and Pandrol VIPA and Vossloh System 300 with SKL 15 tension clamp - standard fastening on the DB network for slab tracks, Vossloh system 1403, 336.

4 Overview of the sections of the 'Serbian Railways' network with the resilient rail fastening installed

In accordance with the determination and the wish of 'Serbian Railways' to modernize and revitalize the railway network, resilient rail fastening has found its application. Recognized world manufacturers showed their interest for participation in 'Serbian Railways' network, so these are the following installations:

Railway line – section (from km to km)	Installation Fastening type-manufacturer	Installation year
Line:Beograd-Mladenovac-Niš (from km 15+246 – to km 15+306 st. Resnik – st. Pinosava)	K-Lock Pandrol	2003.
Line:Resnik-Vreoci-Valjevo (Resnik-Stepojevac)	SKL12, SKL14 Vossloh	2004
Section: Niš-Dimitrovgrad Section:Kusadak-Velika Plana	SKL12, SKL14 Vossloh	2003
Line: Beograd – Novi Sad Section: Čortanovci-Petrovaradin	SKL12, SKL14 Vossloh	2005
Line:Beograd-Bar (from km 51+605 to km 51+671 Lazarevac-Lajkovac)	Fast-Clip Pandrol	2004
Line:Beograd-Šid-state border Section: Batajnica-Golubinci	SKL12, SKL14 Vossloh	2009
Section: Beograd Centar	Fast-Clip,VIPA-SP,Vanguard Pandrol	2010

Installations of Pandrol (UK) fastenings were done according to the issued directives from Serbian Railway Directorate: Directive 345 from 1988 for 'e' Clip , Directive 344 from 2002 for Fast-Clip , Directive 343 from 2004 for K-Lock, and from 2010 for VIPA-SP and VANGUARD. Vossloh rail fastening systems (Germany) have been installed according to the technical specifications of the manufacturer, with the prepared Draft of the Directive (from 2009), but it is still without Directive on usage from Serbian Railway Directorate.

During the exploitation period it was noticed by 'Serbian Railways' representatives that resilient rail fastening Vossloh on certain sections got loosen, while with measuring trolley track widening has been found up to 25mm. Having in mind the necessity for installation of resilient rail fastening in the countries with existing small track curve radius (less then 350m), it is recommended by the manufacturer to extend the gauge (see GENERAL CONDITIONS under the Draft of the Directive for delivery, installation and maintenance of resilient rail fastening system 'VOSSLOH').

As for resilient rail fastening system from Pandrol, which has been in service from 2004 in the test section with radius R=500, there were no additional interventions and track gauge irregularities. Since there is no sufficient number of test sections on the 'Serbian Railways' network with the installed Pandrol rail fastening system, we still can't give a complete analysis of the behaviour and quality of these systems.

5 Conclusion

Author's intention was to give a short demonstration of parameters influencing the selection of resilient rail fastening systems and experiences gained on the sections on „Serbian Railways" network, without preferring any advantages and disadvantages of mentioned manufacturers. It can be said that based on the previous measurements and tests during the exploitation period, maintenance is almost minimal. Complete elastic connection is made between rail and sleeper with the elastic spring, i.e. tension clamp. Technical-economical analyses have shown justifiability of application of the resilient rail fastening during the future construction of new high speed railway lines and reconstruction of existing ones, because faster and more comfortable traffic, i.e. increase of railway attractiveness for both passenger and freight traffic, as main goals have been achieved.

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