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XVII SCIENTIFIC-EXPERT CONFERENCE ON RAILWAYS RAILCON '16

PERFORMANCE REQUIREMENTS FOR RAIL FASTENING SYSTEMS ON EUROPEAN RAILWAY NETWORK

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Abstract *– In order to realize interoperability of railway system, the reconstruction and modernization plan of railway network in the Republic of Serbia should be harmonized with technical requirements of European railway network. The paper presents hierarchical approach to harmonization of legal and technical regulations in the area of railway infrastructure, with special attention drawn to the rail fastening systems. Performance requirements for rail fastening systems were analysed according to the adopted standard series SRPS EN 13481 and SRPS EN 13146.*

Keywords – track, rail fastening systems, performance requirements, harmonization, interoperability.

1. INTRODUCTION

Harmonization of the technical regulation in the area of railway infrastructure is still in progress in the Republic of Serbia. European Committee for Standardization (CEN) has created a group of standards EN 13481-Railway applications - Track - Performance requirements for fastening systems, which consists of eight parts as listed below:

- Part 1: Definition [1],
- Part 2: Fastening systems for concrete sleepers [2],
- Part 3: Fastening systems for wood sleepers [3],
- Part 4: Fastening systems for steel sleepers [4],
- Part 5: Fastening systems for slab track with rail on the surface or rail embedded in a channel [5],
- Part 6 (European Prestandard): Special fastening systems for attenuation of vibration [6],
- Part 7: Special fastening systems for switches and crossings and check rails [7],
- Part 8: Fastening systems for track with heavy axle loads [8].

The above mentioned parts 1-8 are adopted by the Institute for standardization of Serbia (ISS) [9]. The Serbian standard series SRPS EN 13481 is identical with the European EN 13481 standard series.

Furthermore, the standard series EN 13146 "Railway applications - Track - Test methods for fastening systems" supports the requirements in the EN 13481 series and consists of the following parts:

- Part 1: Determination of longitudinal rail restraint [10] (Fig.1),
- Part 2: Determination of torsional resistance [11],
- Part 3: Determination of attenuation of impact loads [12],
- Part 4: Effect of repeated loading [13] (Fig.2),
- Part 5: Determination of electrical resistance [14] (Fig.3),
- Part 6: Effect of severe environmental conditions [15],
- Part 7: Determination of clamping force [16],
- Part 8: In service testing [17],
- Part 9: Determination of stiffness [18] (Fig.4).

The parts 1-9 of the standard series EN 13146 are adopted by the ISS [19]. The Serbian SRPS EN 13146 standard series is identical with the EN 13146 European standard series.

The adopted SRPS EN 13481 and SRPS EN 13146 standard series are not translated into Serbian language except the Serbian titles and scopes. Significant obstacle to the effective implementation of the adopted SRPS EN standards in engineering practice is the lack of their sense expressed in Serbian technical language.

In this paper, performance requirements for rail fastening systems on rail lines with design speed up to 160 km/h and axle load up to 225 kN were considered according to the adopted SRPS EN 13481 and SRPS EN 13146 standard series.

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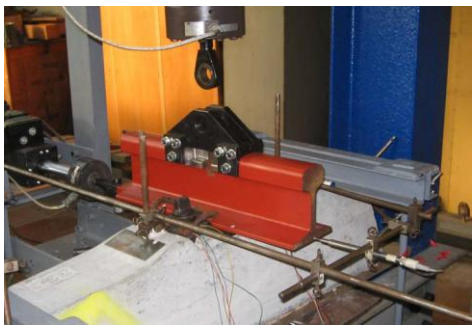

Fig.1. Test arrangement for determination of axial force during the longitudinal displacement of the rail [20]

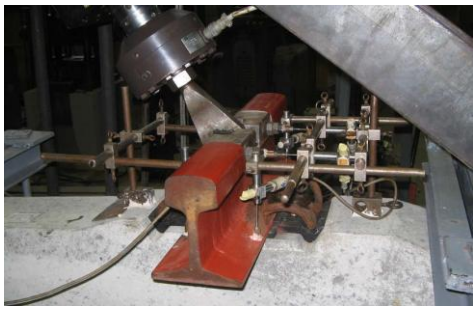

Fig.2. Laboratory test with repeated loading [20]

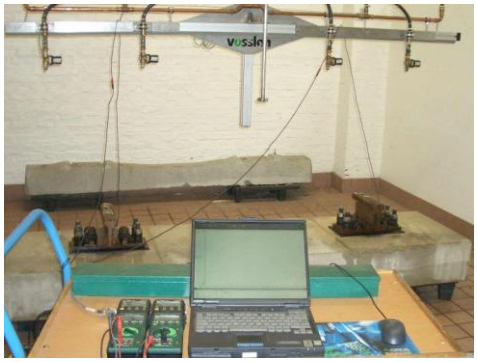

Fig.3. Determining the electrical resistance in wet conditions, in laboratory

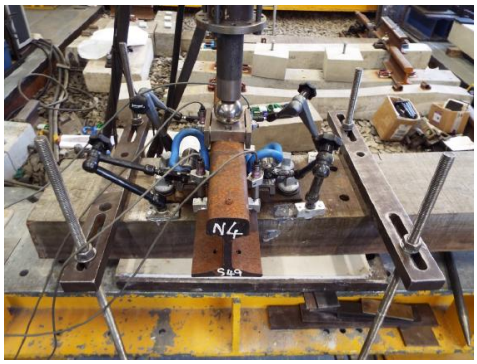

Fig.4. Dynamic stiffness test arrangement for complete rail fastening assemblies

2. PERFORMANCE REQUIREMENTS FOR FASTENING SYSTEMS ON CONCRETE SLEEPERS

The definitions of the terms used in the EN 13481 series were specified in the European Standard EN 13481-1:2012 [1]. In accordance with [1], "fastening system is assembly of components which secures a rail to the supporting structure and retains it in the required position whilst permitting any necessary vertical, lateral and longitudinal movement".

This standard series considers specific requirements for fastening systems depending on the type of supporting structure (concrete sleepers [2], wood sleepers [3], steel sleepers [4], slab track [5]), as well as requirements for special fastening systems (for attenuation of vibration [6], switches and crossings and check rails [7] and for track with heavy axle loads [8]).

Since the fastening systems on concrete sleepers in ballasted track are usually in use, the paper presents the performance requirements for fastening systems in accordance with [2]. These requirements apply to main lines having a radius of curvature greater than 150 m and a maximum design axle load of 260 kN, as well as to light rail systems having a radius of curvature greater than 40 m and a maximum design axle load of 130 kN (Tab. 1).

Tab. 1. Fastening categories in accordance with [2]

Categories of fastening system	Maximum design axle load [kN]	Minimum curve radius [m]
A	130	40
B	180	80
C	260	150
D	260	400
E	350	150
Note: The maximum axle load for A and B categories does not apply to maintenance vehicle		

The requirements apply to direct and indirect fastening systems which act on the foot and/or web of the rail. Further, they apply for the rail sections in accordance with [21] (excluding 49 E4) and with [22]. It should be noted that this standard is not applicable to fastening rigid fastening systems (e.g. K fastening system which is often represented on the railway lines in Serbia).

Performance requirements for fastening systems for use on concrete sleepers in ballasted track include longitudinal rail restraint, torsional resistance, attenuation of impact loads, effect of repeated loading, electrical resistance of fastening system and sleeper, effect of exposure to severe environmental conditions, overall dimensions, effect of fastening system tolerances on track gauge, clamping force, cast-in fastening components, and in-service testing.

Required longitudinal rail resistance depends on the speed limit and the special requirements of substructure. In that sense, the longitudinal rail resistance shall be not less than 7 kN (controlled over the measurement process according to EN 13146-1)

on the conventional rail lines and not less than 9 kN on high-speed lines (≥250 km/h).

In accordance with the design of the track supporting structure, the minimum requirement for longitudinal restraint may be reduced by agreement between the purchaser and manufacturer. For example, the utilization of expansion devices to prevent excessive longitudinal displacements and forces on the long railway bridges, is expensive and bad solution in regard to traffic safety and comfort, as well as maintenance costs. Therefore, it can be applied an alternative solution of fastening system with reduced rail longitudinal restraint. Fig.5 and Fig.6 show the PANDROL® ZLR (Zero Longitudinal Restraint) system designed to keep track forces from being transmitted to bridge, to hold the rail vertically in place, to provide lateral restraint and to prevent rail rollover.

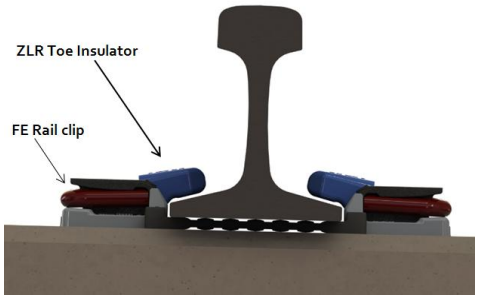

Fig.5. Pandrol ZRL fastening systems with the gap under toe insulator and foot of rail

Fig.6. Installed fastening system with ZLR clips (Pandrol VIPA system) on a bridge

The torsional resistance is measured in accordance with [2] and the result reported.

For fastening systems described as having medium or high attenuation of dynamic loads, test shall be conducted in accordance with [3] and the result reported. Test results for medium attenuation shall be in the range from 15 % to 30 % and for high attenuation > 30 %.

The assembly static stiffness and assembly low frequency dynamic stiffness shall be measured in accordance with [19]. At the request of the customer, the rail pad static stiffness, the pad low frequency dynamic stiffness and the assembly high frequency dynamic stiffness should be measured in accordance with [19] and [2] (loads for measurement of stiffness were defined in [2]).

The effect of repeated loading shall be determined by the procedure defined in [13] using the test loads and positions defined in [2].

In accordance with [13], the following measurements shall be performed before and after repeated loading:

- longitudinal rail restraint (permitted change ≤ 20 %),
- vertical static stiffness change (permitted change ≤ 25 %), and
- clamping force (permitted change for fastening systems which act on the foot of the rail ≤ 20 %).

The electrical insulation shall be not less than 5 kQ when measured in accordance with [14]. The user may specify a higher value for use with certain track circuits (guidance on traction currents is given in [23] and SRPS EN 50122-2:2011).

Effect of exposure to severe environmental conditions is determined in accordance with [15] based on the salt spray test. After the test, the fastening assembly shall be capable of being dismantled, without failure of any component and re-assembled using manual tools provided for this purpose.

Fig.7 shows the envelope for rail fastening systems (which act on the foot of the rail) for concrete sleepers in ballasted track and rail section in accordance with [21] excluding 49 E4 and [22]. This envelope is necessary to avoid interference with vehicles including track maintenance vehicles.

It should be noted, for web support fastening systems, the minimum flangeway shall comply with national regulations and the envelope of the fastening systems shall be provided by the supplier.

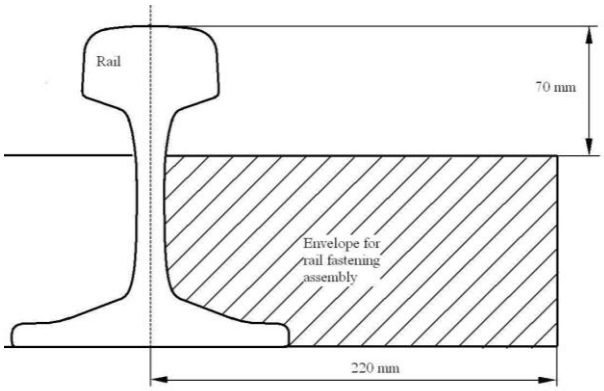

Fig.7. Envelope for rail fastening systems (which act on the rail foot) for concrete sleepers in ballasted track

The manufacturer shall provide a drawing of the interface between the fastening system and the sleeper. The variation in the static track gauge which

can arise from the fastening system shall not exceed ± 1 mm.

Clamping force for fastening systems (acting on the rail foot) shall be determined by the procedure prescribed in [16] and the result shall be reported. The requirement for clamping force is not applicable to web support fastening systems.

In-service testing shall be carried out in accordance with [17] at the request of the customer.

Other specific requirements for fastening system must be defined by the customer.

3. CONCLUSION

In this paper, technical requirements for rail fastening systems on rail lines with design axle load up to 350 kN were considered in accordance with EN 13481 European Standard series. It points to the mandatory requirements and according to the European standards and specific requirements according to the conditions of the project.

The paper presents the performance requirements for fastening systems on concrete sleepers in ballasted track since these fastening systems are usually in use.

European standards series EN 13481 and EN 13146 were adopted by the Institute for Standardization of Serbia as the Serbian standards SRPS EN 13481 (Parts 1-8) and SRPS EN 13146 (Parts 1-9). Implementation of SRPS EN standards is difficult because they were published only in English.

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REFERENCES

[1] CEN/TC 256: EN 13481-1:2012, Railway applications - Track - Performance requirements for fastening systems - Part 1: Definitions, 2012.
[2] CEN/TC 256: EN 13481-2:2012, Railway applications - Track - Performance requirements for fastening systems - Part 2: Fastening systems for concrete sleepers, 2012.
[3] CEN/TC 256: EN 13481-3:2012, Railway applications - Track - Performance requirements for fastening systems - Part 3: Fastening systems for wood sleepers, 2012.
[4] CEN/TC 256: EN 13481-4:2012, Railway applications - Track - Performance requirements for fastening systems - Part 4: Fastening systems for steel sleepers, 2012.
[5] CEN/TC 256: EN 13481-5:2012, Railway applications - Track - Performance requirements for fastening systems - Part 5: Fastening systems for slab track with rail on the surface or rail embedded in a channel, 2012.
[6] CEN/TC 256: ENV 13481-6:2002, Railway applications - Track - Performance requirements for fastening systems - Part 6: Special fastening systems for attenuation of vibration, 2002.
[7] CEN/TC 256: EN 13481-7:2012, Railway applications - Track - Performance requirements for fastening systems - Part 7: Special fastening systems for switches and crossings and check rails, 2012.
[8] CEN/TC 256: EN 13481-8:2006, Railway applications - Track - Performance requirements for fastening systems - Part 8: Fastening systems for track with heavy axle loads, 2006.
[9] http://www.iss.rs/en/standard/?keywords=13481&Submit=
[10] CEN/TC 256: EN 13146-1:2012+A1:2014, Railway applications - Track - Test methods for fastening systems - Part 1: Determination of longitudinal rail restraint, 2014.
[11] CEN/TC 256: EN 13146-2:2012, Railway applications - Track - Test methods for fastening systems - Part 2: Determination of torsional resistance, 2012.
[12] CEN/TC 256: EN 13146-3:2012, Railway applications - Track - Test methods for fastening systems - Part 3: Determination of attenuation of impact loads, 2012.
[13] CEN/TC 256: EN 13146-4:2012+A1:2014, Railway applications - Track - Test methods for fastening systems - Part 4: Effect of repeated loading, 2014.
[14] CEN/TC 256: EN 13146-5:2012, Railway applications - Track - Test methods for fastening systems - Part 5: Determination of electrical resistance, 2012.
[15] CEN/TC 256: EN 13146-6:2012, Railway applications - Track - Test methods for fastening systems - Part 6: Effect of severe environmental conditions, 2012.
[16] CEN/TC 256: EN 13146-7:2012, Railway applications - Track - Test methods for fastening systems - Part 7: Determination of clamping force, 2012.
[17] CEN/TC 256: EN 13146-8:2012, Railway applications - Track - Test methods for fastening systems - Part 8: In service testing, 2012.
[18] CEN/TC 256: EN 13146-9:2009+A1:2011, Railway applications - Track - Test methods for fastening systems - Part 9: Determination of stiffness, 2011.
[19] http://www.iss.rs/en/standard/?keywords=13146&Submit=
[20] Vojnotehnički institut: Izveštaj o ispitivanjima kolosečnog pričvrsnog pribora Vossloh W14, Beograd, 2007.
[21] CEN/TC 256: EN 13674-1:2011, Railway applications - Track - Rail - Part 1: Vignole railway rails 46 kg/m and above, 2011.
[22] CEN/TC 256: EN 13674-4:2006+A1:2009, Railway applications - Track - Rail - Part 4: Vignole railway rails from 27 kg/m to, but excluding 46 kg/m, 2009.
[23] CLC/SC 9XC: EN 50122-2:2010, Railway applications - Fixed installations - Electrical safety, earthing and the return circuit - Part 2: Provisions against the effects of stray currents caused by d.c. traction systems, 2010.