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SOME MODERN SOLUTIONS FOR FASTENING RAIL SYSTEMS ON ROMANIAN BRIDGES

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Abstract: In this paper are presented some modern solutions for track fastening systems used on the bridges in Romania. It is analyzed the track fastening systems on bridges without and with ballast, referring to the Romanian experience in this field. It takes into account the current state of track on Romanian bridges and it is presents solutions to remedy the deficiencies.

Key words: fastening systems, bridges, noise and vibrations reduction, elasticity of track

1. INTRODUCTION

For the both types of track, with or without ballast, on aerial structure, the rail fastening systems arises additional requirements that those which characterize the railway track on the embankments [1]. The increase of velocities on railway track requires adapting the rail fastenings systems, so that they satisfy the requirements that warrant these increased speeds.

Thus, the principle of ensuring a uniform stiffness, both longitudinal and transverse of railway track, elastic elements of fastenings should be modified in terms of stiffness, taking into account the lower elasticity of the bridge structure in comparison with that of the embankment [4, 5, 6].

The railway track on bridge shall be provided with check rails to guide any derailed vehicles in the bridge area and their mounting need the adaptation of railway fastening system to this special requirement [2, 3].

For the CWR - continuous welded rail, track on the bridge further measures are needed as regards ensuring a good interaction between track and bridge. Thus, where it is necessary, it will be imposed expansion devices [4, 5].

Another measure to be considered for railway track without ballast on bridges is to provide a low longitudinal resistance to the relative displacement between the rails and bridge deck for not bring large axial stress into the rails and/or bridge [4, 5].

A modern trend – imposed by the EU regulations - is that the railway track on the bridge should provide a low level of noise and vibration.

All the above requirements mean that the railway track fastenings systems on bridge must be designed differently to those commonly used outside the bridge [1].

2. FASTENING SYSTEMS ON BRIDGES WITH BALLASTLESS RAILWAY TRACK

The main shortcoming of the ballastless railway track fastening systems on Danube bridges in Romania is the presence of wear arising from the operation of bridges for more than 25 years, which leading to projected distance between hole centres made in the plates of bridge or in the bridge covering differ to the project value.

In the following will be presented, like an example, the status of the Danube bridges which crossing Borcea branch and the Danube River. These bridges are located on railway line Bucharest - Constanța, part of the IV Pan-European Corridor [2].

The bridges over the Borcea branch and the Danube River has been made for double track line, by steel structure (the main bridge decks are half through truss bridge, with box, п stringers and orthotropic plate and the decks of viaducts are closed boxes).

The railway bridge over the Borcea branch has 970 m total length, it is in straight line, and it has 5.80 ‰ continuous gradient decreasing to Constanța.

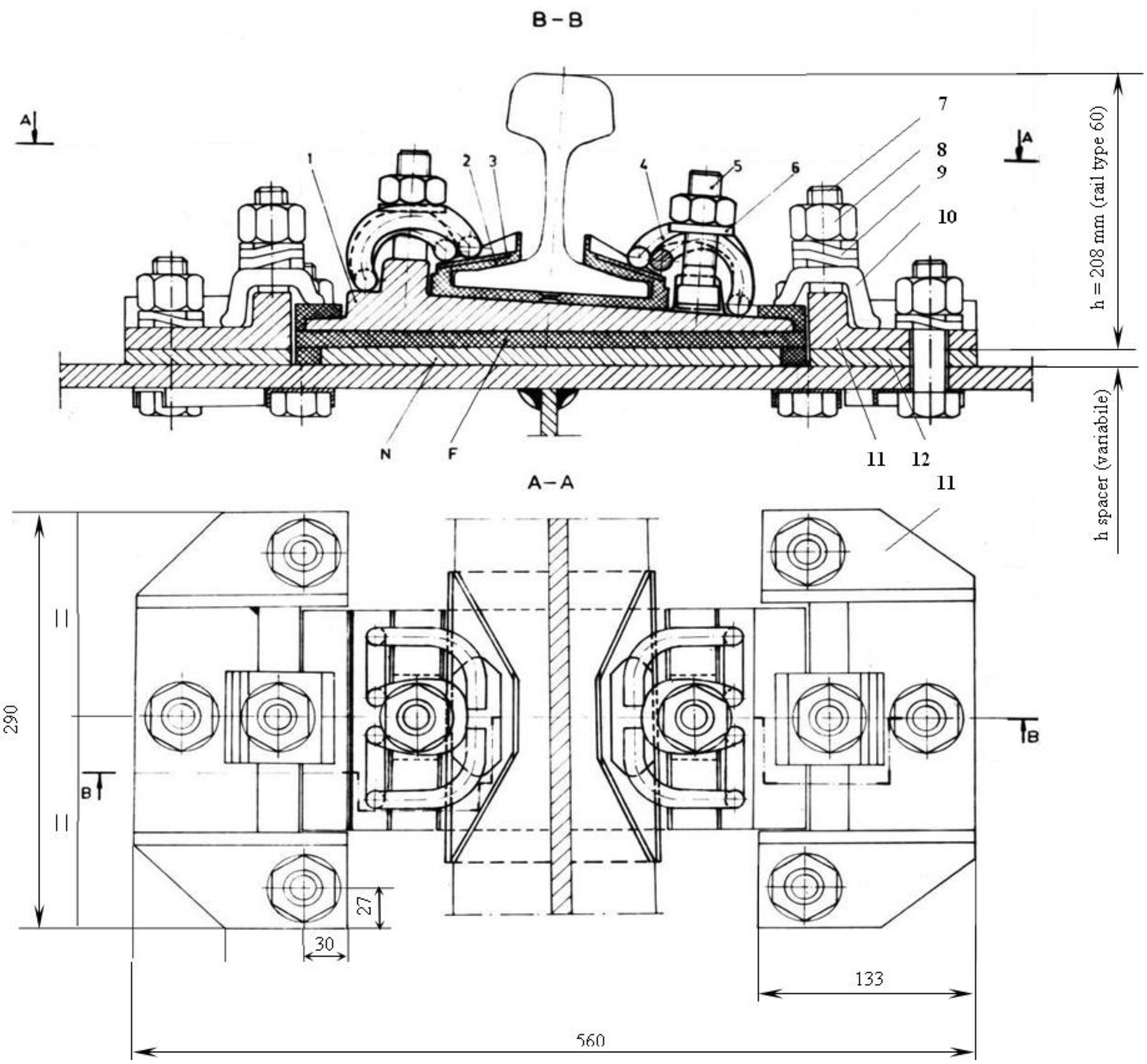

Fig. 1 The fastening system of railway track on the Borcea branch and the Danube River bridges and viaducts

In figure 1 the numbers are the follows: 1 - supporting base plate; 2 - rail electrical insulation; 3 - clamp electrical insulation; 4 - tension clamp S3 (Skl 3); 5 - vertical bolt M 22; 6 – washer; 7 - vertical bolt M22; 8 - hexagonal nut; 9 - double coiled spring washer; 10 - K rigid clip; 11 – lateral stopper; 12 - spacer stopper; F - metallic place spacer; N - neoprene pad.

Lengths and number of spans:

For Bridge Borcea:

Feteşti Viaduct: L = 149 m - 3 spans (2x49.50+50)

Borcea Bridge: L = 420 m - 3 spans (3 x 140)

Ovidiu Viaduct: L = 398 m - 8 spans (4x49.50 +4x50)

The railway bridge over the Danube River has 1593 m total length, it is in straight line, and it has 5.25 ‰ continuous gradient increasing to Constanța.

Lengths and number of spans:

For Cernavodă Bridge:

Danube Viaduct: L = 1045.50 m - 9 spans (4x181.70+1x60.90+2x60.40+2 x68.50)

Cernavoda Bridge: L = 470 m - 3 spans (140+190+140)

Cernavoda Viaduct: L = 68.50 m

At present the current state of track on the bridge superstructure is as follows:

- The track on bridges and viaducts is made of rails type 65 with direct fastening system.
- Rail type 65 is fixed by elastic clamps S3 (with the same profile as elastic clips Vossloh Skl 3) on base plates type 60 rehashed.
- Base plates type 60 are fixed, also, through the metallic lateral stoppers, vertical bolts, nuts and K rigid clamps type 49 by the orthotropic plate of deck or of viaduct sheet iron. Each lateral stopper is attached to the deck plate with 3 vertical bolts, so in the sheet iron there are six holes for every base plate for clamping – figure 1.

This general result made that between these four cores holes for attaching of lateral stoppers, for same plate, on the plate/sheet iron bridge there are the distances by figure 2.

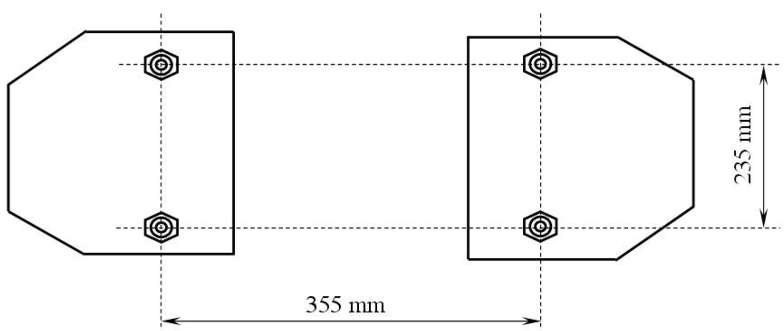

Fig. 2 The distances between the four core holes for attaching of lateral stoppers for same plate, on the plate/sheet iron bridge

- Due to wear arising from the operation of bridges for over 25 years the projected distances between hole centres of the plates, made in plate/sheet iron of bridge, differs from the projected value. For example, between the holes of plates corresponding of the rail, the cross track distances measured between the holes in the plate/sheet iron are shown in Fig. 3.
- Electrical insulation of fastening system was conducted on two levels - neoprene rubber insulation plates to the rail boundary base plates and rubber insulators (embedded type) to rail.

There are compensation devices. Bridge is provided along with the inner check rails mounted on deck of bridge. The distance between angle iron (active edge of rails) and the edge of the rail head by the inside of track is 85 mm.

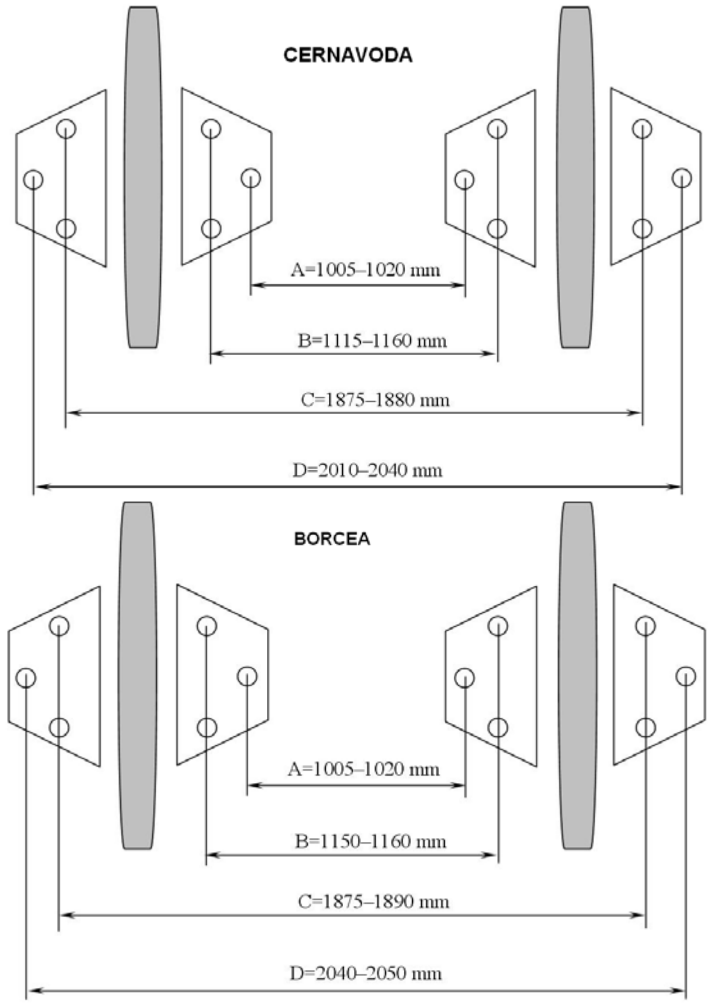

Fig. 3 The cross track distances measured between the holes in the plate/sheet iron

CNCF "CFR" SA - the administration of the railway track - imposed the following requirements for the fastening system of the track on Danube Bridges:

- Axle load: 22.5 t;
- Maximum speed: 80 km/h;
- Traffic type: mixed (passenger, freight);
- Type of rail: 60 E1;
- Normal gauge: 1435 mm;
- CWR - continuous welded rail track;
- Type of joint for the base plate by bridge sheet iron: screwed or welded;
- Bridge is provided for whole length with check inner rails mounted on deck of bridge;
- Vibrations and noise will be reduced.

Vossloh has redesigned, adapted and suggested for this special application the elastic fastening system Vossloh DFF 300-1 – figure 4, which is an adaptation of elastic fastening system Vossloh DFF 300 for Danube bridges situation, taking into account the overall situation and considering the current state of track on these bridges.

The application of elastic fastening system Vossloh DFF 300 (figure 5) is composed of ballastless track, track in tunnels and track on railway bridges.

So, the system can be mounted on concrete sleepers, embedded, on decks of steel bridges or it may be used to rehabilitation of existing monolithic concrete structures of ballastless track.

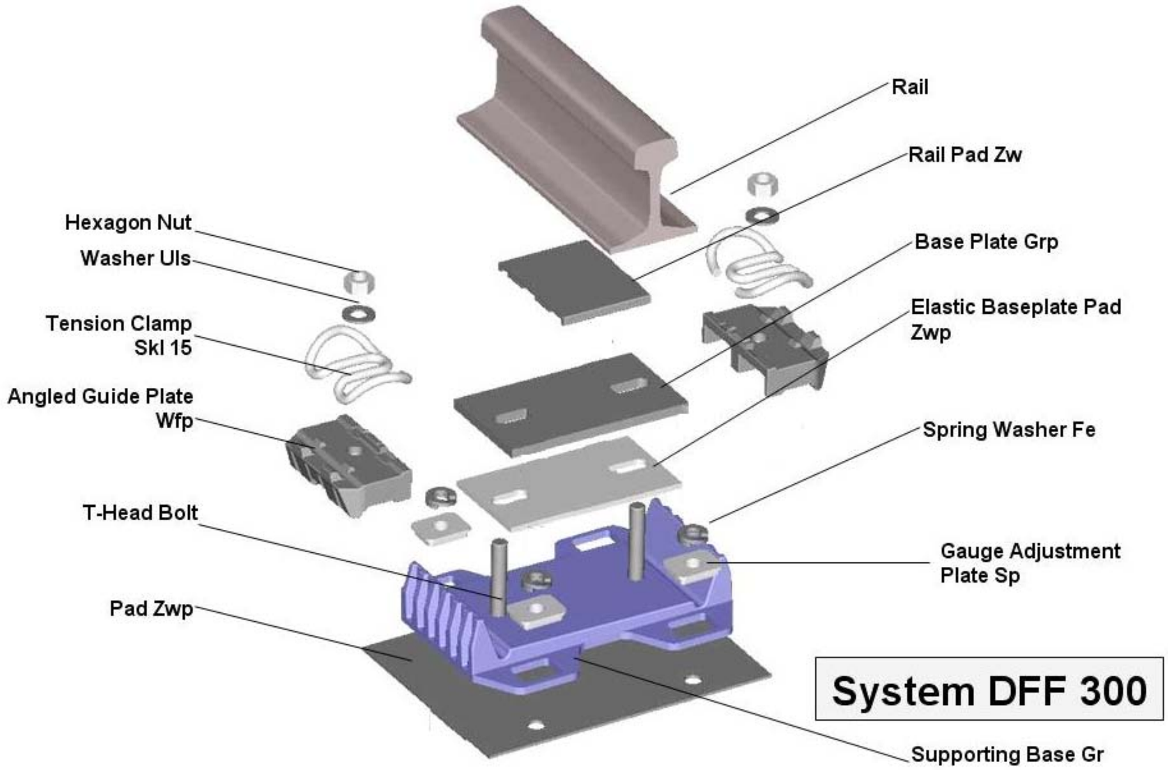

Fig. 4 The elastic fastening system Vossloh DFF 300-1

The system for use on decks of steel bridges consists of:

• Tension clamp	Skl 15	2 pieces
• Rail pad	Zw 692-6	1 piece
• Base plate	Grp 21	1 piece
• Elastic base plate pad	Zwp 104/NT-22,5 N/mm	1 piece
• Angled guide plate	Wfp 15a	2 pieces
• Gauge adjustment plate	Sp	4 pieces
• Protections pad	Ulb	4 pieces
• Supporting base	Gr 300-1/1:20	1 piece
• Pad	Zw 480x360x5	1 piece
• T-Head bolt	M24x130	2 pieces
• Washer	Uls 7	2 pieces
• Hexagon nut	M24 SW39	2 pieces
• Welding stud	M22x70	4 pieces
• Double coiled spring washer	Fe 6	4 pieces
• Hexagon nut	M22-5	4 pieces

Clamping force of the fastening system for one tension clamp is at least 1800 daN. The fastening system provides in the same time a greater elasticity by ≈ 15 mm.

The DFF 300 Vossloh rail fastening system allows a standard height adjustment by +56/-4 mm and additional adjustment by +/-15 mm.

The system allows, also, setting of the standard track gauge of +/- 8 mm and with additional +/- 10 mm.

The absence of ballast is compensated by the existence of elastic clamps Skl 15 (the clip elasticity increased to 15 mm), the pad under the rail, like the pad under the base plate and more elastic supplementary pad (with 22.5 N/mm spring coefficient). In this way the amplitude to fatigue was increased up to 2.6 mm, also.

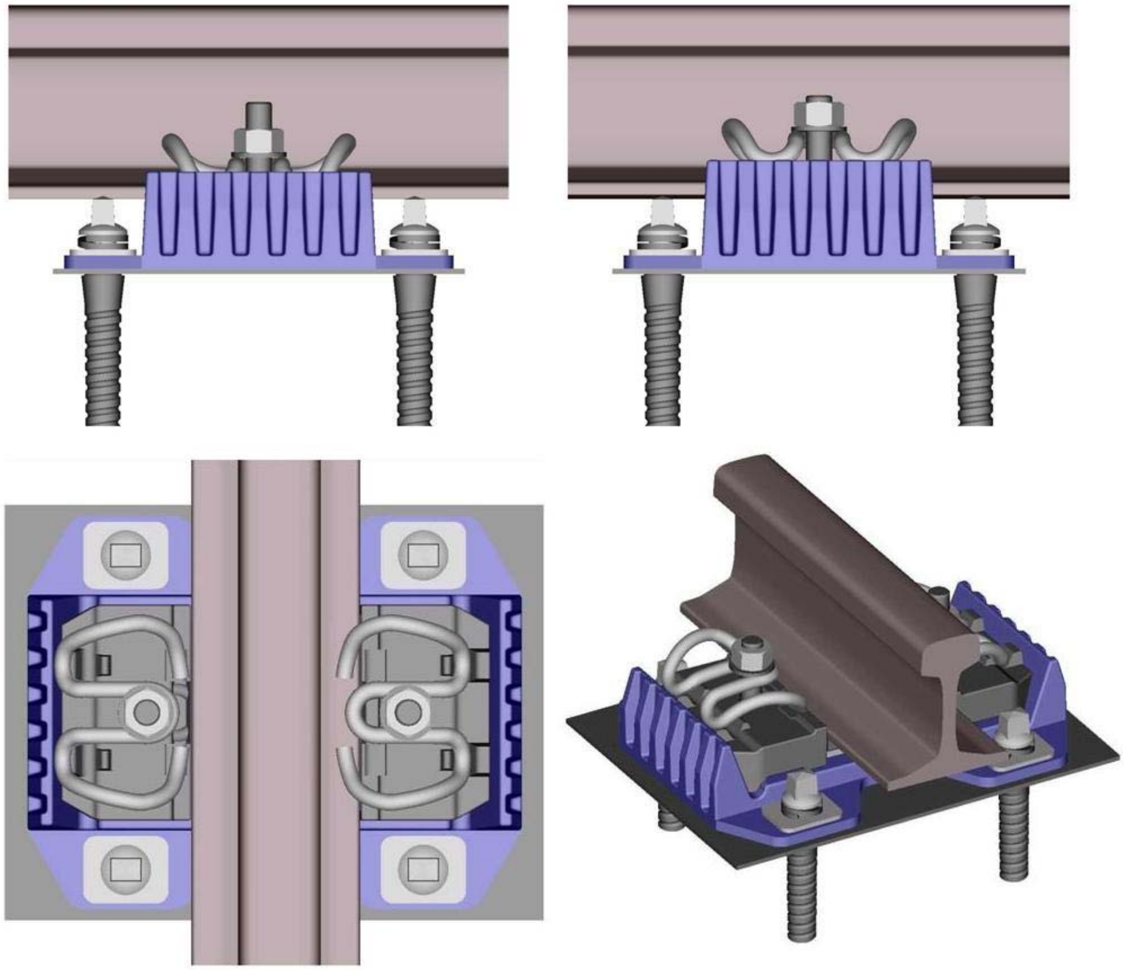

Fig. 5 The elastic fastening system Vossloh DFF 300

The DFF system 300 (figure 6) can be pre-assembled on the base plate - in this case, like any Vossloh fastening system.

The assembling of the fastening system is very simple, the fastening considering mounted when central branch of the tension clamp made contact with the upper surface of stopper/angled guided plate (≈20 daNm torque).

For mounting/dismounting in not need special tools, a simple key for bolts is enough. Obviously the system can be mounted mechanized, also.

Like all Vossloh fastening systems, it is not required the maintenance of this system and re-clamping of vertical bolts sometimes.

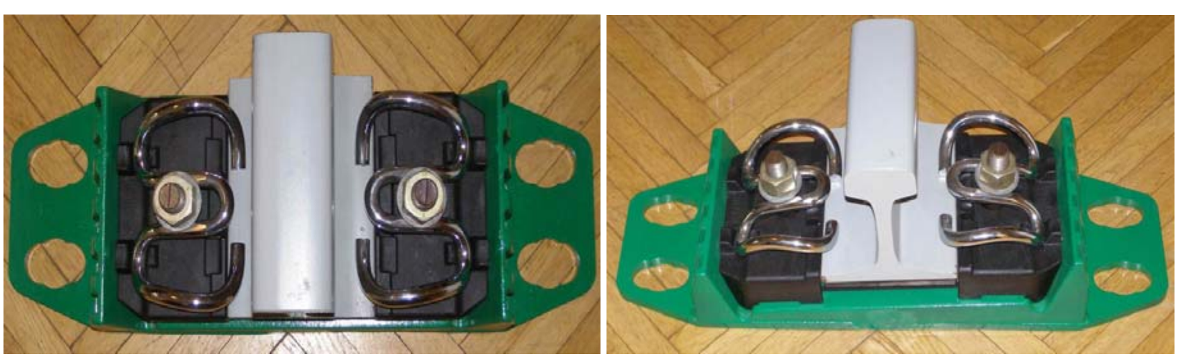

Fig. 6 The elastic fastening system Vossloh DFF 300-1 pre-assembled on the base plate

The system is permanently electrically isolated through insulating plate of rail, insulating plate of base plate and of guided plate.

From accidental damage, all pieces of fastening system can be replaced.

Electrical insulation is provided permanently by the following insulating clamping system: pad under the rail, angled guide plates, elastic insulating plate, gauge adjustment plates.

An overview of elements DFF 300-1 fastening system is made as follows:

a) Tension clamp Skl 15

Compared with other Vossloh fasteners, spring clips 15 Skl was designed to ensure:

• Flexibility and increased elastic settlement

Keeping all characteristics of the classic Vossloh clamps:

• increased and continue pushed force
• increased fatigue resistance
• High resistance to longitudinal displacement of rail along the track
• Fastening system "without maintenance"

Middle bend of the tension clamp

• Prevents:
  - Rotation,
  - Inclination or
  - Uplift of rail
  - Plastic deformation of the lateral arms

The Skl 15 clamps provide a pushed force on rail foot by minimum 1800 daN/clamp for an elasticity of about 15 mm. The characteristic curve of the Skl 15 clamp is shown in figure 7.

Also, because of its new form, the Skl clamp 15 has a higher fatigue resistance, the amplitude loading increasing up to 2.6 mm. (figure 8).

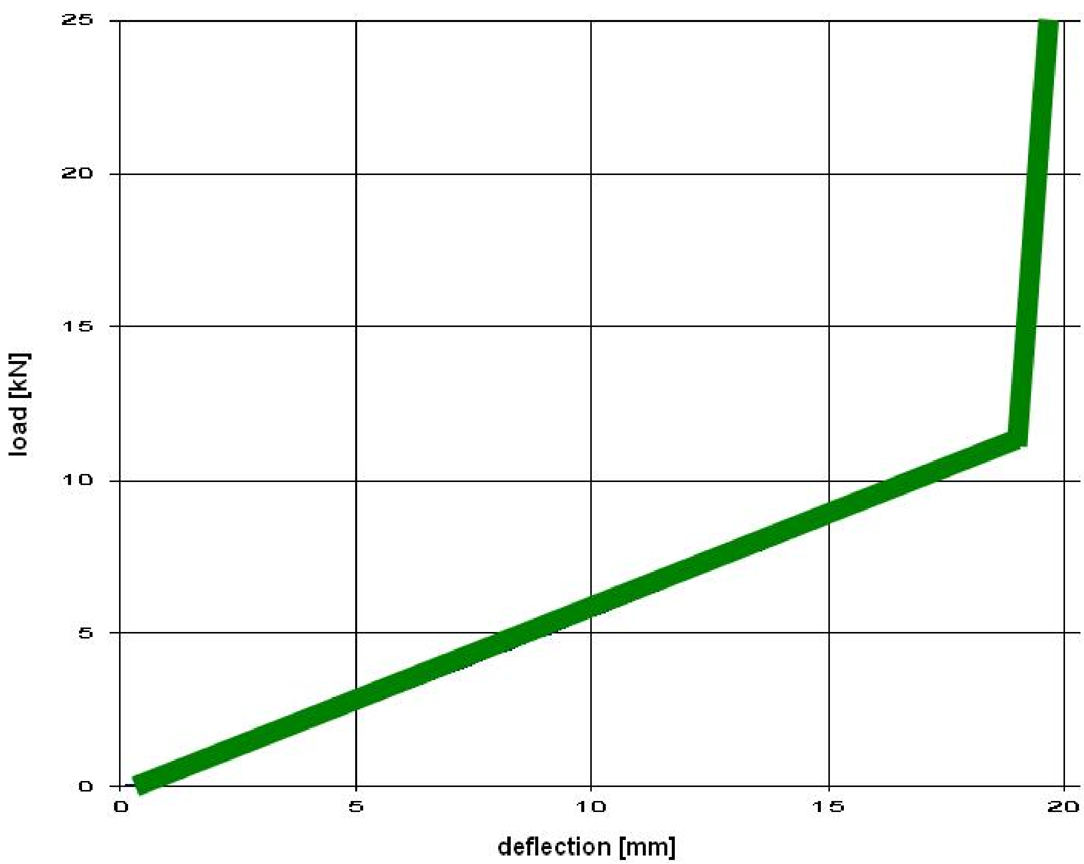

Fig. 7 The characteristic curve of the Skl 15 clamp

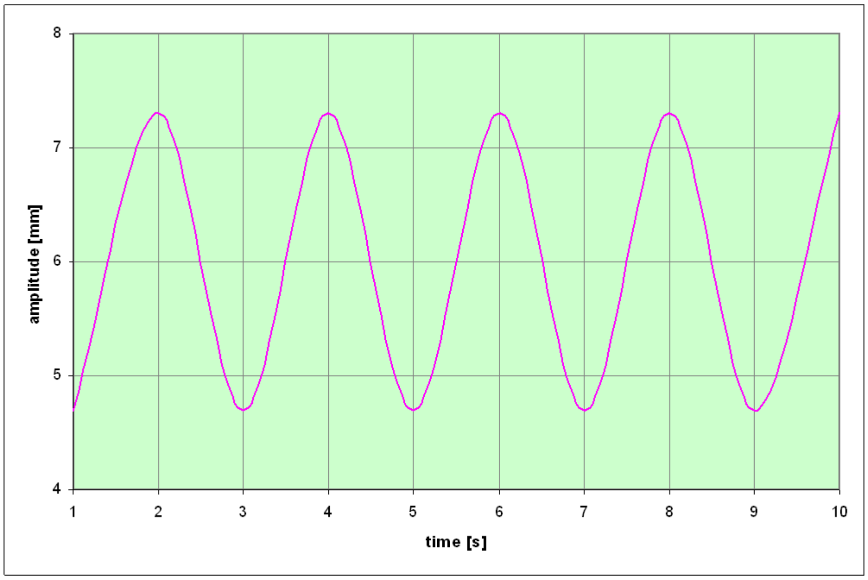

Fig. 8 The load cycle for fatigue resistance test

b) Elastic pad Zwp 104/NT-22.50 N/mm

The thickness of more elastic supplementary pad is 12 mm.

At this thickness it is static stiffness of 22.5 mm. This means that to increase its elasticity and compensation of ballast lack, the Vossloh DFF 300-1 system uses soft elastic pads. The elastic characteristic curve of elastic pad is shown in figure 9.

The pads were thus calculated and made that their behaviour is independent of frequency (Fig. 10) or ambient temperature (figure 11).

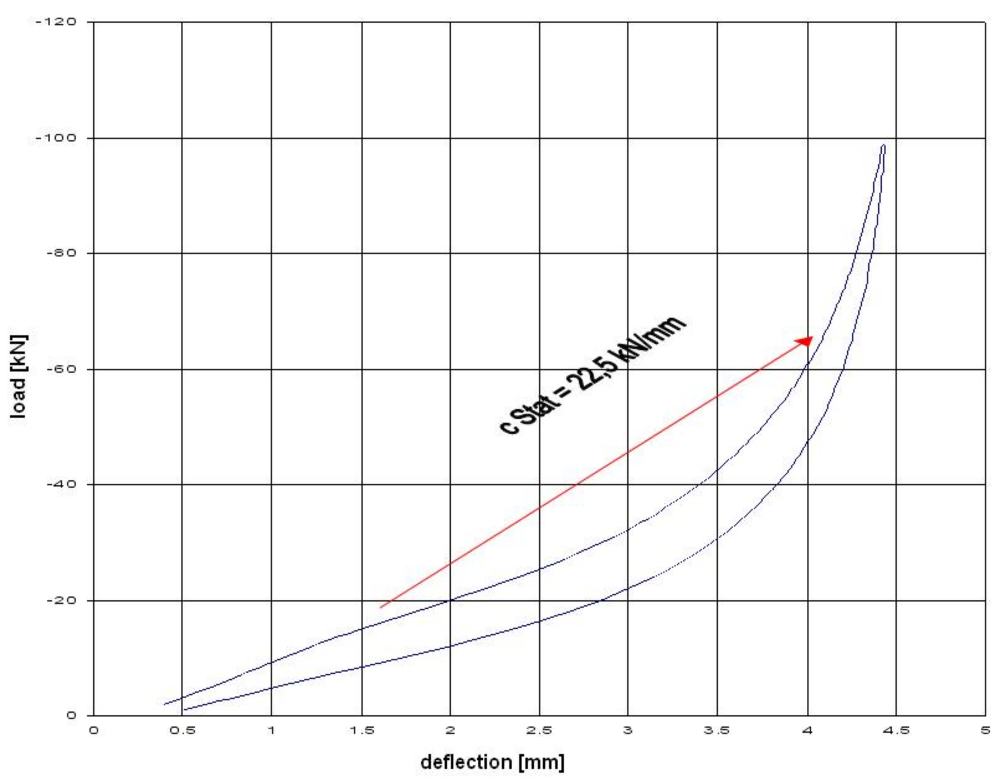

Fig. 9 The elastic characteristic curve of elastic pad

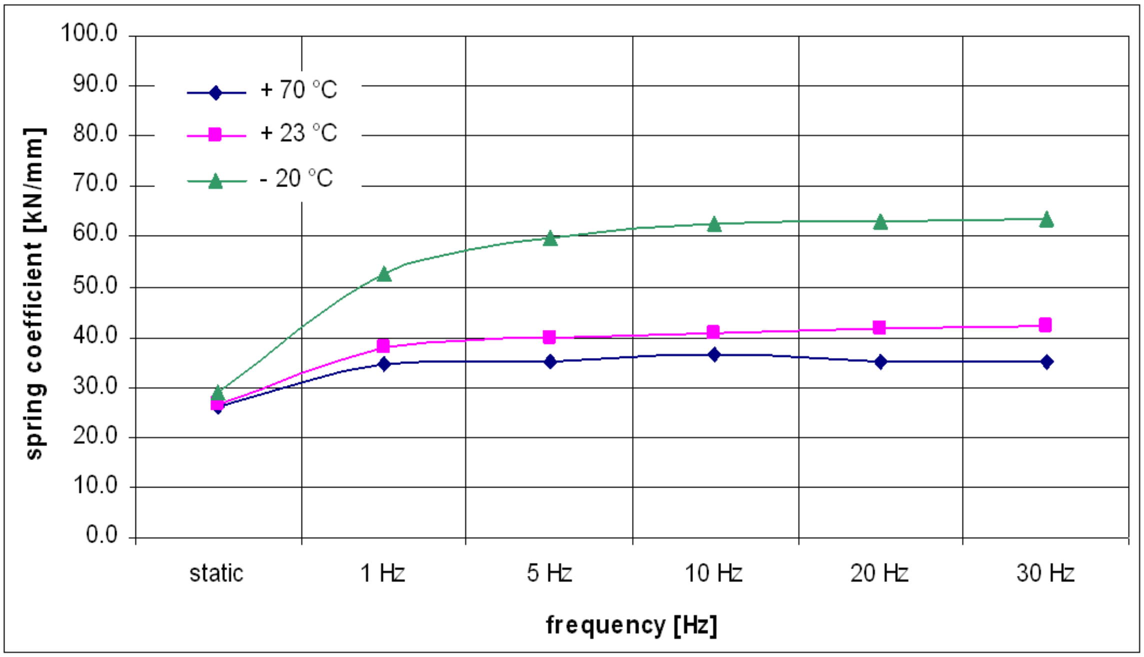

Fig. 10 The behaviour of pad (spring coefficient vs. frequency)

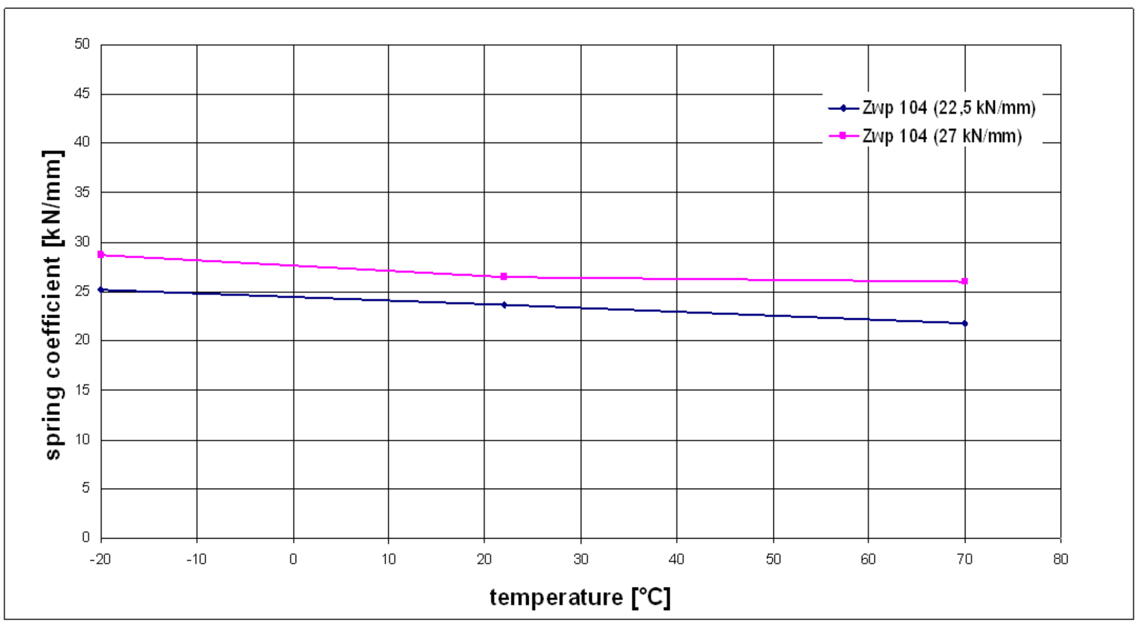

Fig. 11 The behaviour of pad (spring coefficient vs. temperature)

c) Rail pad Zw 692-6

The shape of the rail pad is similar to that used, for example, in the Vossloh W14 elastic direct fastening system. By design was thought the possibility to made longitudinal level adjustments within +6/-4 mm by varying the pad thickness.

d) Supporting base plate GRP 21

Its main role is transmission of the loads from vehicle to the elastic pad Zwp equal, continues and over the whole surface.

e) Angled guide plate Wfp 15a

The shape of guide plate is similar to that used, for example, in elastic Vossloh fastening system 300.

By design was thought the possibility to made an adjustment of gauge track up to + / -10 mm by varying the shape of guide plate.

f) Base plate Gr 300-1/1: 20

For this special application has been redesigned to ensure a rail vertical inclination of 1:20.

g) Intermediate plate Zw 480x360x5

The role of this plate is one by electrical insulation and vibration damping.

h) Gauge adjustment plate Sp

The role of this plate is to ensure electrical isolation and additional adjust of gauge track within +/-15mm.

i) Protection plates Ulb

The role of this plate is to protect of gauge adjustment plate against strong shocks.

j) T-Head vertical bolts M24x130

The role of this element is to assure the mounting of the Skl 15 tension clamps.

k) Flat washers Uls 7

The role of this element is to protect the Skl 15 tension clamps to assembly.

l) Hexagon nuts M24 SW39

The role of this element is to achieve prescribed torque.

m) Welded studs M22x70

The role of these elements is to mount the base plate on the bridge deck.

n) Double coiled spring washer Fe 6

The role of this element is to provide elasticity to the level of base plate on the bridge deck.

o) Hexagon nuts M22-5 / ISO 4034

p)

The role of these elements is to achieve prescribed torque for fixing the base plate.

The images of the Vossloh DFF 300-1 system installed on Danube – Cernavoda bridges is shown in figure 12

3. FASTENING SYSTEMS ON BRIDGES WITH BALLAST

The Vossloh solution for the composition of elastic clamping for the rail and check rail on railway bridges with ballast was applied in Romania first time on the Pan European Corridor IV - Bucharest - Campina Section, on Prahova Bridge [2] (Fig. 13 and Fig. 14).

The Prahova steel railway bridge has three equal spans, half through truss bridge, with ballast tank, pre-stressed concrete sleepers 60.200 B 93.1 (Fig. 15), Vossloh elastic fastening system [3].

Also, for the first time the check rails of ordinary rail profile was made flexible.

The length of inner check rails was increased, which allowed removing the outer check rails, in accordance with European standards in the field.

In Fig. 16 and Fig. 17 is shown the Vossloh solution used on Pan European Corridor IV, Bucharest - Constanta Section, Miorita Baneasa Bridge over National Road 1.

Fig. 12 The Vossloh DFF 300-1 system installed on Danube – Cernavodă bridges

4. CONCLUSIONS

Vossloh fastening systems are a modern and efficient solution to satisfy the technical requirements imposed on modern high speed rail tracks. All solutions presented have been used successfully in Romania and worldwide, confirming the status of world leader in railway fastening systems of the Vossloh Company. Similar solutions like those applied on the Prahova Bridge can be used to bridge over the Danube at Calafat - Vidin.

Figure 13. Pan European Corridor IV, Bucharest North - Campina Section, railway bridge over the river Prahova, Rail and guard rail Vossloh KS with Skl 12 fastening system

Figure 14. Pan European Corridor IV, Bucharest North - Campina Section, railway bridge over the river Prahova, Rail and guard rail Vossloh KS with Skl 12 fastening system

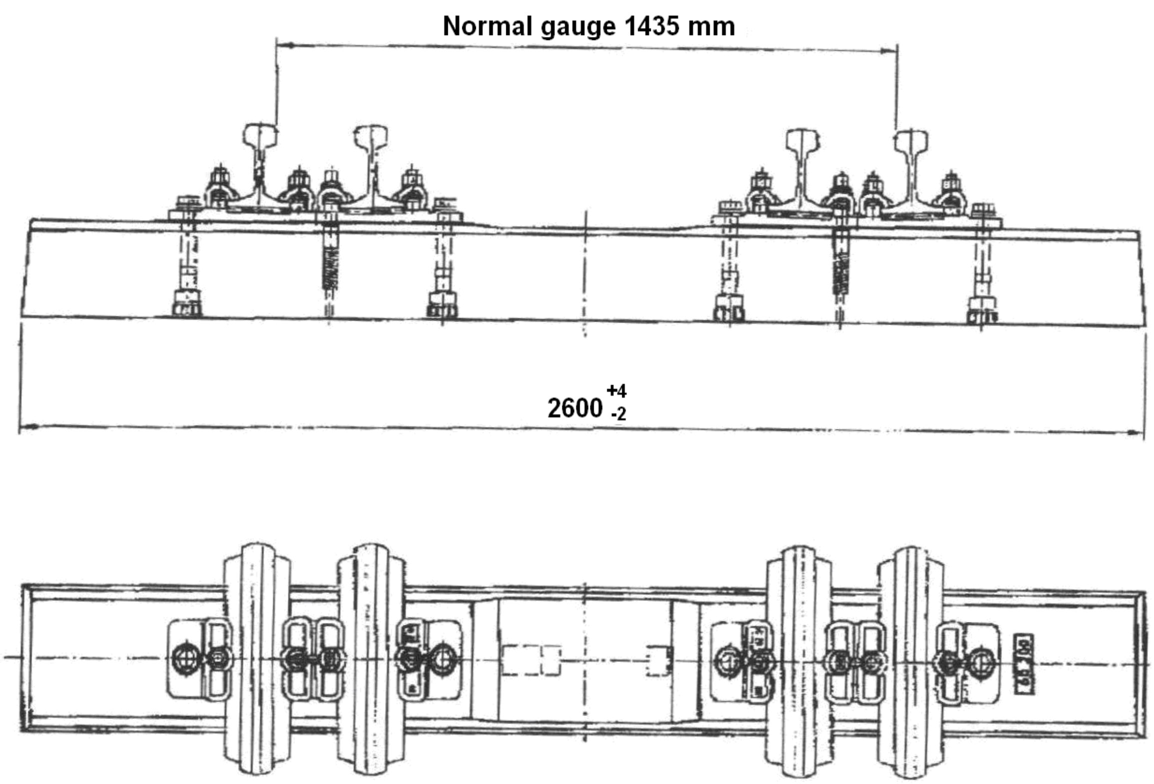

Figure 15. The pre-stressed concrete sleepers 60.200 B 93.1 used on Pan European Corridor IV, Bucharest North - Campina Section, railway bridge over the river Prahova, Rail and guard rail Vossloh KS with Skl 12 fastening system

Figure 16. Pan European Corridor IV, Bucharest - Constanta Section, Miorita Baneasa Bridge over National Road 1, Rail and guard rail Vossloh KS with Skl 12 fastening system

Figure 17. Pan European Corridor IV, Bucharest - Constanta Section, Miorita Baneasa Bridge over National Road 1, Rail and guard rail Vossloh KS with Skl 12 fastening system

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