Historic Railway Spans Modernization with the Use of Modern Slab Track Surfaces, on the Example of the Wroclaw Główny – Wroclaw Main Railway Station Reconstruction

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Modernization or revitalization of a railway line involves the necessity of reconstruction or renovation of practically all the engineering objects and constructions on its premises. While, in the case of objects, not protected by the Historic Preservation Maintenance of City-Owned Buildings, the situation is relatively easy, in the case of historical buildings, the scope of possible construction works can be significantly reduced.
On the example of the modernization of the Wroclaw Główny railway station track system, the use of modern slab track is presented, whose aim is to obtain the required performance parameters of the engineering structures (old boreholes) located in its area. The non-skid surfaces used are ERS - rails in the cover and block rails of the EBS type. The use of pavement-free pavements allowed the historic bays to be preserved. Their main girders are made of riveted baffles, without interfering with their historical material.
The presented solutions can also be used for the modernization of different types of engineering objects and construction, not necessarily recorded in the register or records of historical monuments - for example, in riveted constructions of those of or unique shape, located on lower category railway lines. It gives opportunity to preserve and continue to use old objects, exposing their beauty and technology, currently not used (for example riveting).

Keywords: Modernization, slab track, surface railway, railway bridges, monument protection.

1. INTRODUCTION

Since the accession of Poland to the European Union (2004), significant development of transport infrastructure - road, rail and airway, has been observed. This process was particularly intense in 2010-2012, before the finals of the EURO 2012 European Championship - Poland was one of the co-organizers of the tournament. In the case of roads, investments usually involve the construction of new high-quality sections (motorways, express roads and bypasses of large cities) and the redevelopment of existing roads in order to improve their technical state. In terms of railway infrastructure the situation looks different. On the basis of socio-economic analyzes, it has been discovered, that, in order to improve and make rail transport more attractive, the construction of new railway lines is not a necessary condition. It is sufficient to carry out the modernization or revitalization of major railway lines, e.g. E-30 / CE 30 [1], E 59 [2] or 273 [3], by improving their technical standards or by introducing original design (Renovation as defined in the Construction Law [4]).

Construction works, related to modernization or revitalisation of a railway line, usually include technical railway infrastructure of track sections, stops and small stations within its structure, while medium and large stations constitute a separate investment task. In the case of Wroclaw Główny, which can be defined as a large station, similarly - the modernization of its area was a separate investment task. The aim of its renovation was to increase the capacity and attractiveness of rail transport in Wroclaw- the host city of the tournament- before the UEFA EURO2012 final tournament.

The investment involved four areas within the station:

- The area in front of the station building - A;
- Building of the station - B;
- Main track system of the station along with platforms - C;
- Part of the station from the bus station - D

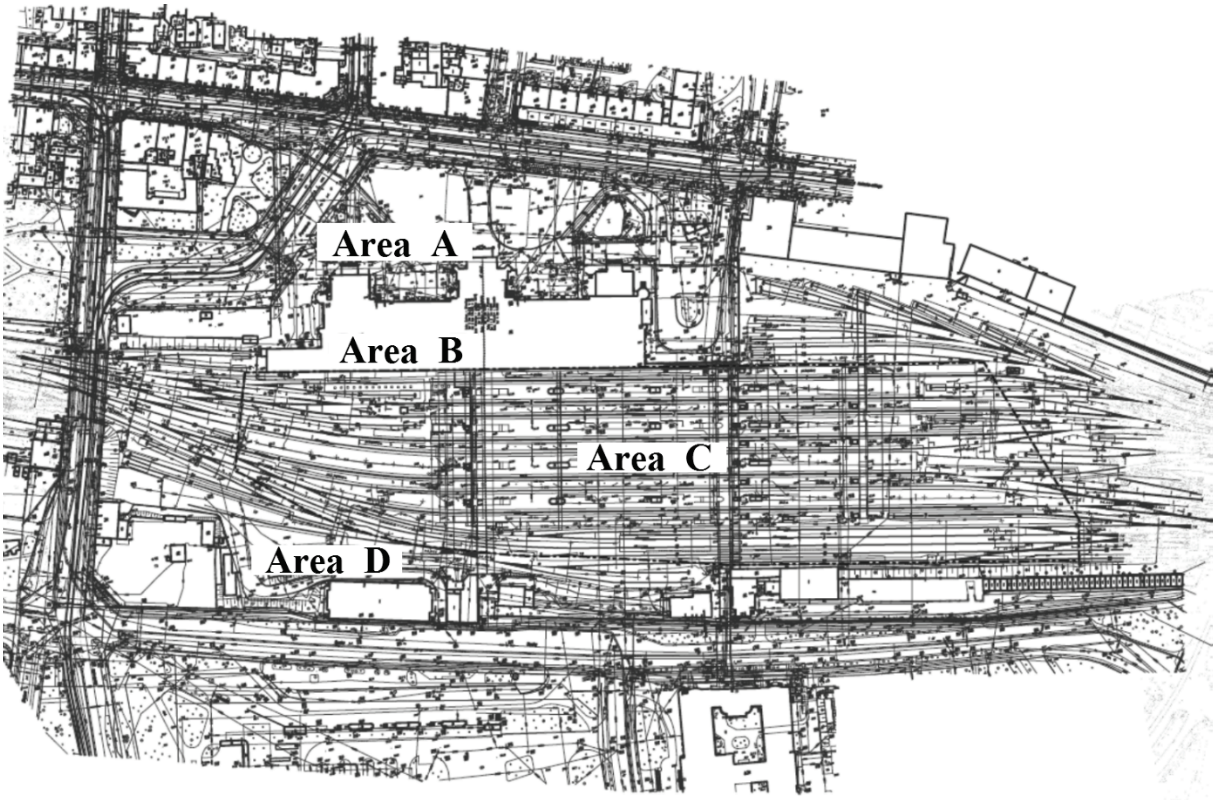


Fig. 1. Modernization areas of Wroclaw Główny railway station.

Due to the scope of this article, only the issues related to the engineering features of the upgraded track system are covered, including:

- correction of existing tracks grade lines, so that in the cross-section of the station all rails are on one level;
- exchange of the railway pavement, of the pavement on passenger platforms, and cleaning and repair of the pavement castings on crossings - former cargo platforms;
- engineering repairs.

There were as many as 60 engineering objects in the investment area C:

50 steel riveted spans, 9 reinforced concrete slabs and 2 double tunnels (sectional ceiling vaulted under track No.1) - Fig.2.

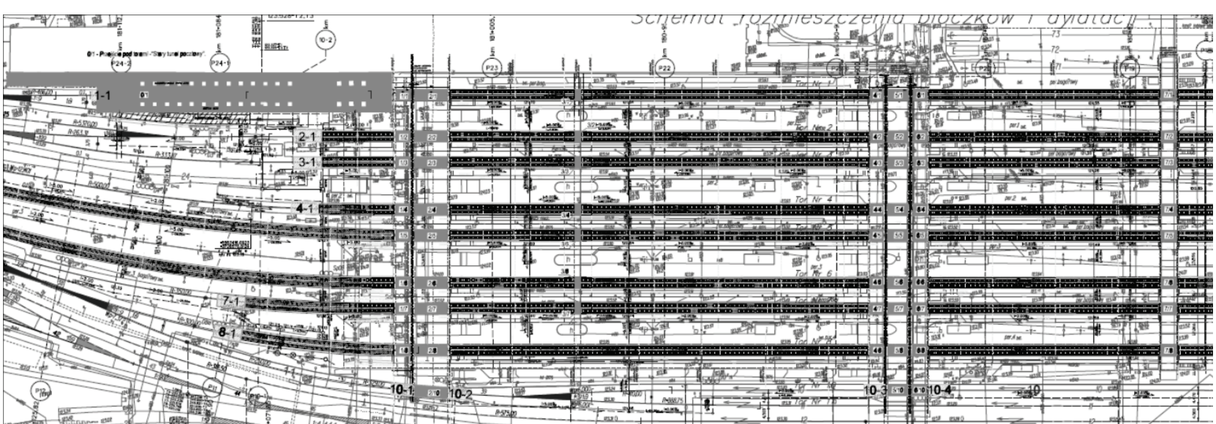


Fig. 2. Location of the engineering facilities in the C area of the Wroclaw Główny station.

2. PROJECT ASSUMPTIONS

The architectural qualities, the distant construction period (1855-1857), and the rich history of the railway station were the reasons for both the railway station and surrounding areas [5] to be protected by Historic Preservation Maintenance of City-Owned Buildings. This meant, at the time of renovation, that all construction works from the moment of their design to completion were the subject to agreement and acceptance of the City Monuments Conservator in Wroclaw. The same procedure concerned the modernization of the track system of stations and engineering facilities located in its area. As a result, it was necessary to preserve the historical substance of all buildings to the maximum extent,. required by the preservation permit. Therefore, when designing the design documentation, the possibility of using the old flashy bays with the complete replacement of the existing track and the drainage system was considered.

When approaching the design of construction works related to the modernization of the engineering facilities, a comprehensive assessment of the technical condition of the spans and their supports was made. This evaluation included geometric inventories of the objects, inventory of damages and their influence on the current standard carrying capacity. Considering the years of construction of the steel riveted spans (1899-1904), steel analysis has also been done, to determine the approximate steel grade, estimate its strength, and also to confirm potential weldability.

Static-strength analysis showed, that the bearing capacity of the riveted steel spans corresponds to the load class k = +2, according to PN-85 / S-10030 [6]. This was due to the maximum design values of normal stresses in the individual components of the structure at 170 MPa, with a design strength of 180 MPa, for the assumed steel type - on the basis of steel specimens it was determined that the strength parameters of the steel used correspond to the current steel, grade St3M.

Obtaining the capacity corresponding to the class k = +2, required by the Investor, i.e. PKP PLK joint stock company, was possible with the following assumptions:

- Wroclaw Główny – main railway station is a passenger station (without trains);
- The speed of rolling stock within the station will be limited to 40 km / h - reduction of the dynamic factor.

In addition, the investor required the new pavement to be durable and easy to maintain (lack of mechanization of track work) [7]. Further restrictions stem from the assumed track grade (electric traction gauge) and the pedestrian crossings under the tracks, which imposed a strict height position of the steel spans. In order to meet the above requirements and assumptions, the choice of type of railway pavement was restricted to slab track. The use of the cheapest classical crushed stone did not meet the requirements of the technical regulation [8] and the instruction [9] - the minimum thickness of the crushed ballast under railway sleepers.

3. TECHNICAL STATE OF THE OBJECTS BEFORE THE RECONSTRUCTION

There are four tunnels in the C area, two of which serve the public interest. The two, above mentioned, strings (2 and 4) are the main passageways for passengers and are the link between Piłsudskiego street and Sucha Street.

Detailed survey and load capacity analysis was carried out, on the engineering sites located at the following train station passes:

- "Postal" passage - 180,818 km of the line No 132 Bytom - Wroclaw Główny (1);
- Passage of the "expedition" – km 180,890 of the line No. 132 Bytom - Wroclaw Główny (2);
- "Dyrekcyjna Street" passage - km 180,897 of the line No. 132 Bytom - Wroclaw Główny (2');
- Passage "platform" - km 180,902 of the line No. 132 Bytom - Wroclaw Główny (2 ");
- "Beer tunnel" - km 180,989 of the line No. 132 Bytom - Wroclaw Główny (3);
- "Main" passage - 181,031 km of the lines No 132 . Bytom - Wroclaw Główny (4);
- "Gastronomic" passage - km 181,039 of line No. 132 Bytom - Wroclaw Główny (4 ').

As a result of the detailed inspection as well as testing and measurements it was discovered that the technical condition of majority of the objects was similar.

The following damage to steel spans and their supports were observed:

- local deformations of sheet metal strips made of angles and overlays - without affecting the load capacity of the structure;

- intensive leaks and water fouling along with corrosion products in the nodes between the spans;
- significant loss of the top plate belts, to complete destruction, in the case of two objects;
- numerous cracks and crumbling, and even displacement of cracked fragments of stone yew;
- lack of possibility of free movement on the contact ball bearings as a result of the significant corrosion of bearing components and bearing niche contamination;
- streaks on the side walls of the tunnels, that indicated malfunction or damage to the drainage system and expansion joints.

Figures 3 and 4 show the representative damage to the engineering objects in two selected passages: the main and the management passages.

Among the listed damages to steel structures, corrosion damage is predominant. On the structural components, no damage was found to indicate that the work was inadequate or overloaded. Therefore it was decided to leave the existing spans while the stone struts and the railroad and the drainage system had to be replaced.

The technical condition of the surface of the railway was insufficient. Numerous deformations of the rails, both vertically and horizontally, collapsed in front of objects and significant pollution required immediate repair work. The surface state of the surface is shown in Fig. 5.

Fig. 3. Main passage: general view of the span and corrosion damage and cracking of the construction.

Fig. 4. Dyrekcyjna street passage: general view of the span, corrosion damage and cracking of the construction.

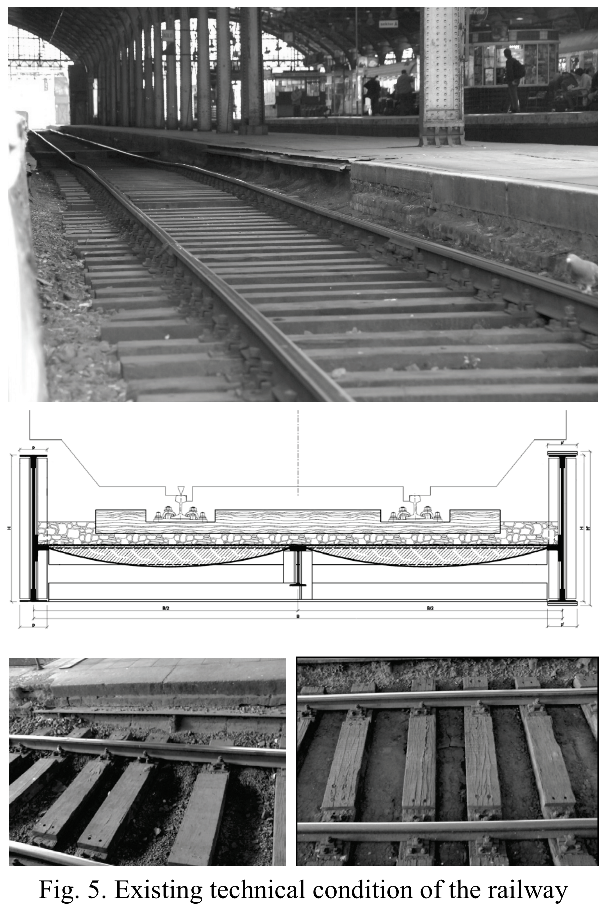


Fig. 5. Existing technical condition of the railway pavement: general view; Cross section through the span; lack of the prime of broken stone, moving undercut railway sleepers undercut and laying in wrong positions.

4. ADOPTED DESIGN SOLUTIONS

During the implementation of the task "Revitalization of the Dworzec Główny- Main Railway Station in Wroclaw", it was planned to renovate all bridges located in the passages and tunnels of the Main Railway Station. Repair works, on the engineering objects, included the following elements:

- **supports**: replacement of granite slabs on reinforced concrete benches with stone facings;
- **support structure**: repair of damages, cleaning, painting and assembly of new pot bearings;
- **pavement**: removal of old pavement and mounting the new slab track, along with rail of the EBS and ERS type mounting

Taking into account the replacement of the pavement-free surface, a double calculation was made, which yielded very similar stresses in the steel to those determined before reconstruction. This means, that, after the repairs, the load capacity of the objects remained unchanged, i.e. they still corresponded to the load capacity k = +2, but their durability and operational usefulness increased considerably.

The cross-section of the selected steel span after the repairs is shown in the Fig. 6. Adoption of the slab track on repaired objects (i.e. EBS) was also compatible with the assumed concept of the track system reconstruction in the remaining area of the Dworzec Główny- Main Railway Station.

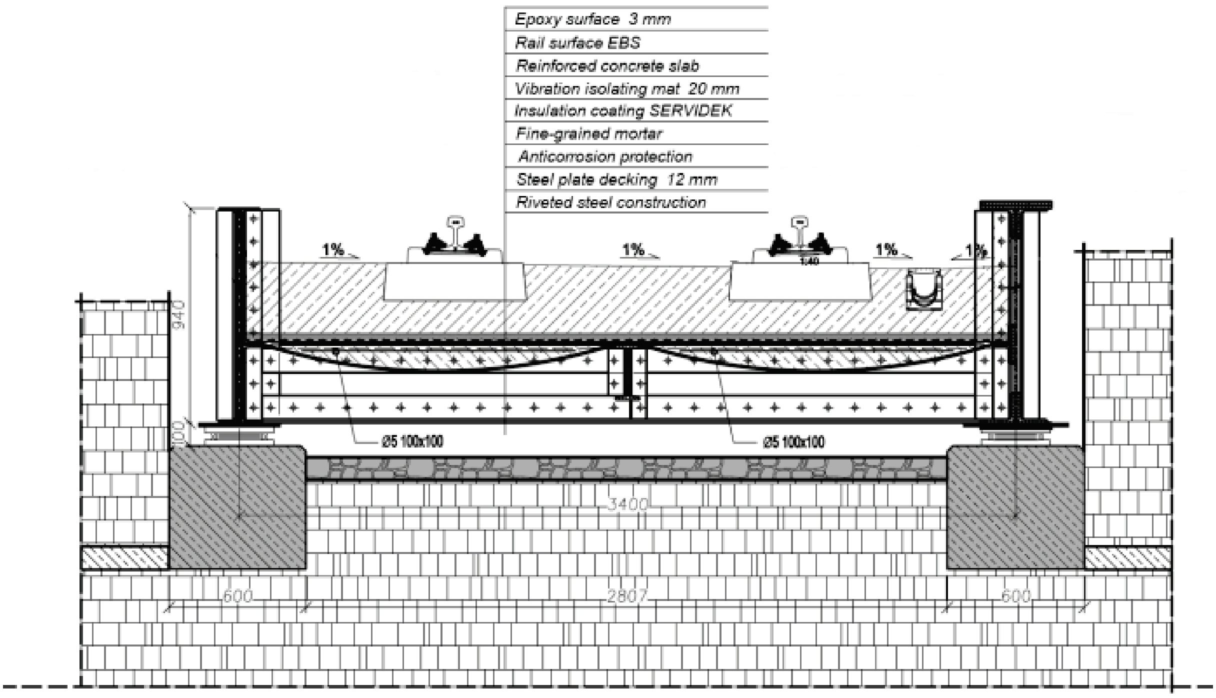


Fig. 6. Cross section of the baffle span after the renovation.

Supporting constructions

Due to the numerous cracking of granite lower bossages, a decision was taken, that they should be replaced. The current legislation does not allow the use of stone elements subjected to dynamic loads, therefore it was assumed that the bossages would be exchanged for reinforced concrete slabs, with stone facings imitating granite blocks. The solution adopted and the final effect are shown in the Figure 7.

Spans bearing structures

Conservation requirements for leaving the existing sheet metal spans, as well as their outstanding bearing capacity (class k = +2) and sufficient technical condition were the basis for the design of repair works (see the Figure 6). Repair of steel (baffle) spans covered:

– Demolition and removal of the old, worn-out railway pavement,
– removal of the layers of waterproof insulation, laid on the concrete filling of sheet metal panes,
– deflection and removal of concrete fillings,
– disassembly of the spans and their transport to the repair yard,

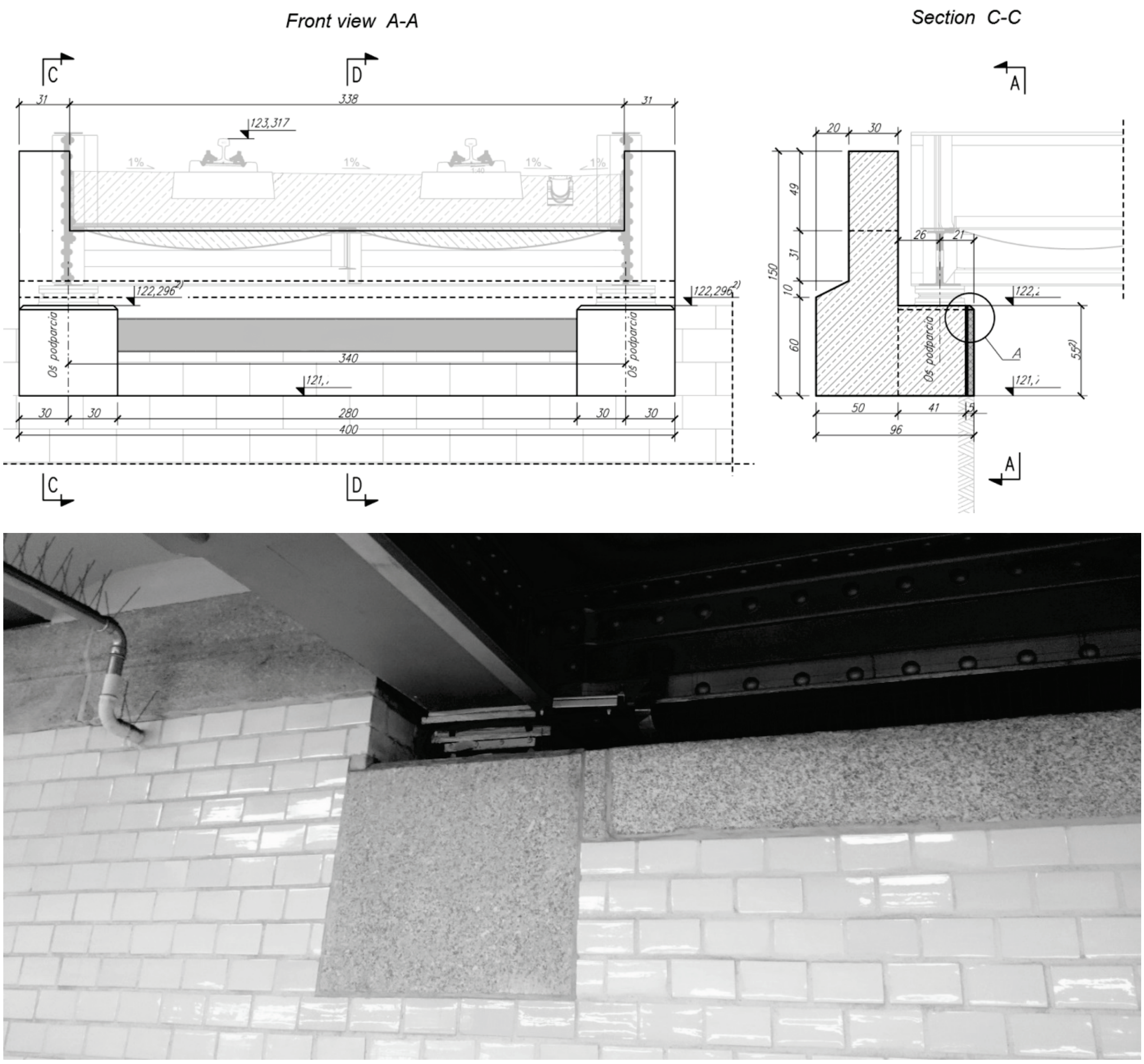


Fig. 7. Design assumptions and the final effect of lower bossages reconstruction.

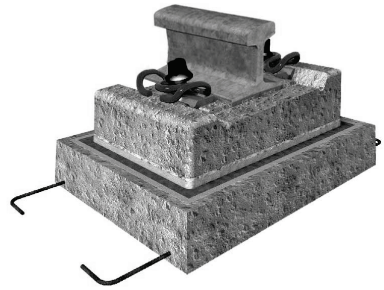
- cleaning the steel splines to a degree of cleanliness of Sa 2 ½ and repairing with replacement or replacement of overly corroded components,
- spray metallization and anti-corrosion coatings,
- replacement of the bearing system of repaired spans,
- incorporating refurbished spans,
- filling of sheet metal with B30concrete,
- making waterproof insulation on the equalizing layer of concrete,
- making the reinforced concrete slab with a thickness of 30 cm with EBS block support system

Slab track

The proposed slab track pavement is Edilon's Embedded Block System (EBS), a Corkelast® block embedding system [10]. The system is universal, applicable to every section of the railroad track - on a straight line, on curves with small radii and in turns. It is used in railways and underground railways (in the metro), in dedicated tramway tracks, in tunnels, on viaducts and bridges. It is characterized primarily by the high efficiency of vibration damping (vibration), caused by the motion of rail vehicles. The resilient foundation of the block supports and rails is conducive to reducing the noise level emitted from the traffic of rail vehicles, which is particularly important in urban agglomerations and in areas of large railway stations, mostly with a roof or covered in a way. Placement of the block supports, in the resilient resinous sheath, provides further high electrical insulation of the track. The high elasticity of the rails support is conducive to the transmission of vertical and horizontal loads from the wheels, reducing the wear of the rails. This system can be used on light rail tracks and also for axle loads up to 225 kN and high-speed trains (up to 300 km / h).

Below, the components of the system and the assembly phase of blocks and reinforcement of the reinforced concrete slab (fig. 8), as well as the finished surface, are presented. Figure 9 compares the appearance of the pavement after six years of its exploitation. Currently only the soiling of the resin layer was observed, which is the result of lack of current maintenance. Visual inspection of the track design showed no signs of wear or other defects, which shows the durability of the system and the right choice, meeting the requirements set by the Investor.

The second kind of backfill surface, i.e. the ERS system, was used in the course of the track No. 1 over the old luggage tunnel. The change of the system was due to insufficient construction height above the ceiling of the tunnel - under the EBS blocks it was impossible to make a reinforced concrete slab of adequate thickness (at least 15 cm). Therefore, a system has been used, in which the rails are fastened in rail channels with a polyethylene terephthalate based on Edilon Corkelast® and the continuous rail support is provided by the Edilon Resilient Strip under its lower part. Due to the high adhesive strength of concrete and steel, it is unnecessary to attach the rails directly to the plate, or to the steel structure. Wet-cast reinforced concrete slab with shaped railways replaces rubble and sleepers. The ERS system provides a continuous, spring-loaded rail support, which significantly reduces noise and increases damping caused by rail travel.



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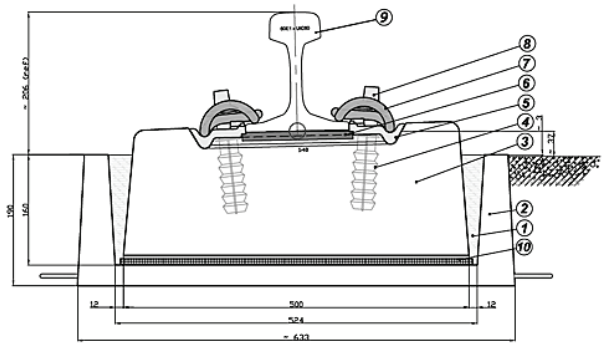

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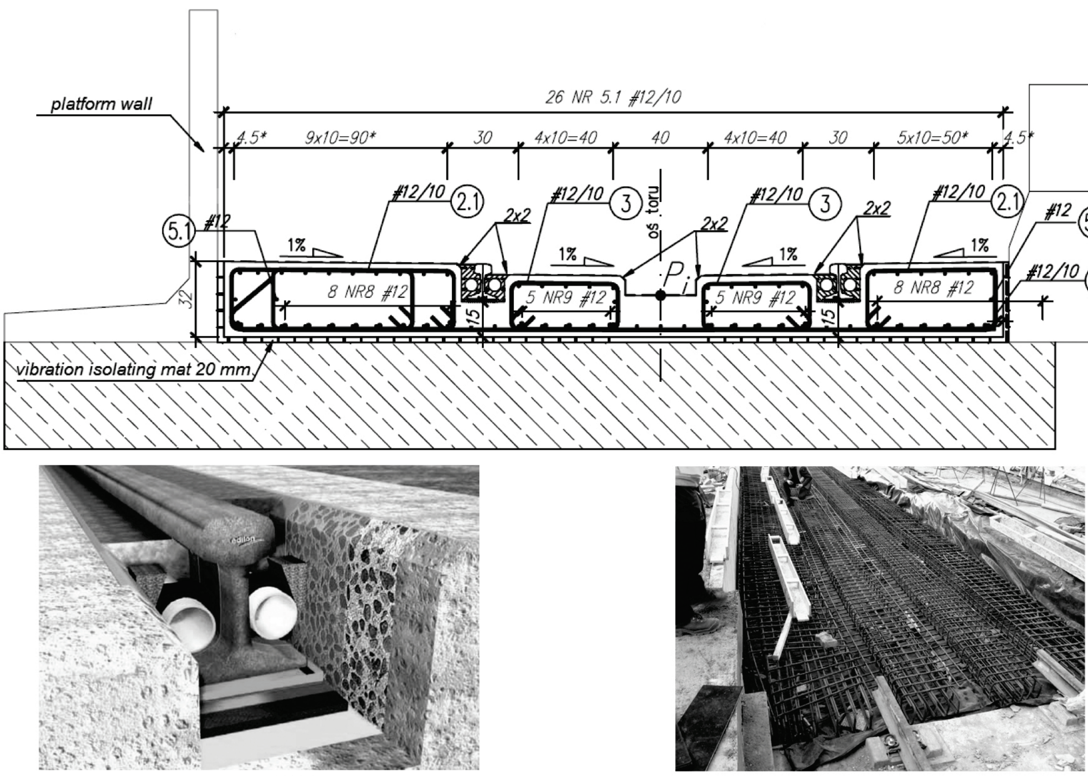
Fig. 8. Composition of EBS type pavements and stages of its construction.

Fig. 9. EBS surface immediately after it has been made and six years of its exploitation.

Fig. 11. Surface ERS, immediately after it has been made and six years of its exploitation.



source: [13]

Fig. 10. Cross-section of ERS pavement as well as components and the construction process.

The use of different types of pavement surface in the C area of the main track system, as well as the classical pavement outside of it, required the appropriate combination of pavements. The combination of the classic surface with slab track surface, required the use of transition boards. Classical solutions, known and commonly used in bridges, in the form of inclined reinforced concrete slabs (10%) were used. The combination of EBS and ERS required an expansion gap between them and an effective seal. The method of connecting the pavement is shown in Fig. 12.

Fig. 12. Combination of pavements: slab track and classic and slab track.

5. FINAL REMARKS

The use of EBS and ERS slab track for the modernization of the track system of the Wroclaw Główny station allowed to keep the old, riveted baffles. Thanks to the new pavement, the durability and usefulness of the facilities have increased considerably. At the same time the current requirements were met, both for railway and the pedestrian traffic under gauge and the traction gauge.

The surface used is characterized by considerable durability and minimal maintenance costs. After six years of exploitation no significant damage has been observed, which would indicate that the railway track - engineering object, system was not working properly. It confirms that design solutions were chosen properly- increased financial expenditures at the construction stage are reimbursed during the operation of the station.

In addition, it is worth noting that the advantages of slab tracks surfaces, indicated in the article, make them more and more often used on existing or newly built objects - for example in gauge constraints [14].

The described modernization of the track system of the Wroclaw Główny railway station was the second investment in Poland, during which, large modern, non-moving surfaces were used on such a large scale.

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