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Track superstructure solutions for High Speed Rail

Abstract: The first concepts for the construction of High-Speed Rail (HSR) in Poland date back to 1995. However, it is only in recent years that these projects have begun to take concrete shape. A key investment within the HSR program is the "Y" line, connecting Warsaw, Łódź, Poznań, and Wrocław, where trains will reach speeds of up to 320 km/h. An essential infrastructure element is the construction of the long-distance tunnel in Łódź, which will become part of a multimodal railway hub. Celebrating its 20th anniversary in 2024, TINES has played a significant role in the development of modern railway track structures in Poland, particularly in slab track construction. Its innovative solutions help reduce vibrations and noise while enhancing infrastructure durability. TINES actively participates in infrastructure projects, adapting its products to meet EU and national technical standards. However, regulatory and legal challenges continue to pose a risk to the full utilization of Polish companies' potential in HSR construction. Nevertheless, the industry's commitment and growing expertise inspire optimism regarding the implementation and future development of Poland's high-speed rail system.

Keywords: High-Speed Rail; Ballastless Track; Infrastructure Development

Introduction

The first concepts for the construction of high-speed rail (HSR) lines in Poland date back to 1995 with the Directional Programme for High-Speed Rail Lines in Poland [1]. Thirty years ago, the assumptions regarding the development of HSR lines in Poland seemed rather unrealistic. However, in retrospect, it can be concluded that they laid the initial conceptual foundations for creating an efficient and integrated railway transport system in Poland. Currently, the investment priority of Central Communication Port (CPK) remains the so-called 'Y' (HSR 'Y') line, connecting Warsaw and Łódź with Poznań and Wrocław, where trains will reach speeds of 300–320 km/h [2]. As part of the ongoing tender procedure for the construction of a long-distance tunnel on railway line no. 85 in Łódź, the construction of a ballastless railway tunnel is planned from the 'Fabryczna' chamber to the 'Retkinia' chamber, including the necessary infrastructure. The planned structure will connect with the multimodal Łódź Fabryczna railway station, which was commissioned on 11 December 2016, creating a central railway hub for the planned 'Y' high-speed rail network. The geometric parameters of the future double-track high-speed rail line, located within one of the largest and most modern railway stations in Europe, were already adapted to HSR requirements in 2016.

TINES 20th anniversary celebrations

The year 2024 marked the 20th anniversary of TINES, a period of reflection and intensive efforts to promote Polish manufacturers, technical universities, research institutes, engineering associations, business chambers, and key clusters. Throughout a series of industry meetings, we shared knowledge and experience gained both in Poland and internationally, developed in collaboration with infrastructure managers, designers, construction contractors, and the Polish scientific and research community. The TINES anniversary was warmly received, earning honorary patronage from the most important technical institutions in the country—see Figure 1.



1. Honorary Patrons of the TINES 20th Anniversary Celebrations

The beginnings of ballastless track in Poland

One of TINES' key achievements was introducing systematic solutions for ballastless track superstructures in Poland. Modern transport infrastructure increasingly prioritises failure-free rail track surfaces, and TINES has consistently sought to meet these expectations by offering comprehensive systems tailored to new requirements. The first major railway contract in which a modern ballastless track system was implemented—designed to reduce vibrations and noise—was the reconstruction of the Warsaw cross-city tunnel in 2006—see Photograph 2. The construction featured prefabricated rail block supports encased in an EBS (Embedded Block System) polymer shell. The supplied components included a concrete support block with a rail fastening system, a concrete socket with an additional vibro-isolating pad at its base, and a permanently elastic polymer casing connecting both concrete elements. The specialised prefabricated components were installed using a ‘top-down’ method. Rails were fastened to the prefabricated elements delivered to the tunnel, after which assembly work commenced. The prepared rail tracks were secured in adjustment frames, which lifted the track grid, enabling precise vertical and horizontal alignment. The final stage involved pouring the track slab, permanently integrating all components with the structure. Once the concrete had set, the assembly frames were dismantled, completing the work. Train traffic on the new track surface began in 2007.

Despite the challenging operating conditions in the leaky tunnel, which was commissioned in 1933, on-site inspections carried out by the TINES team, in cooperation with the Railway Line Plant of PKP PLK S.A. in Warsaw, confirm the validity of the adopted solutions and the fault-free operation of the track superstructure for nearly 20 years. Based on positive technical assessments from both domestic and international infrastructure managers, the TINES® EBS embedded block support system used in ballastless track superstructures continues to evolve in response to the growing demand for reliable, long-lasting, and low-maintenance infrastructure.



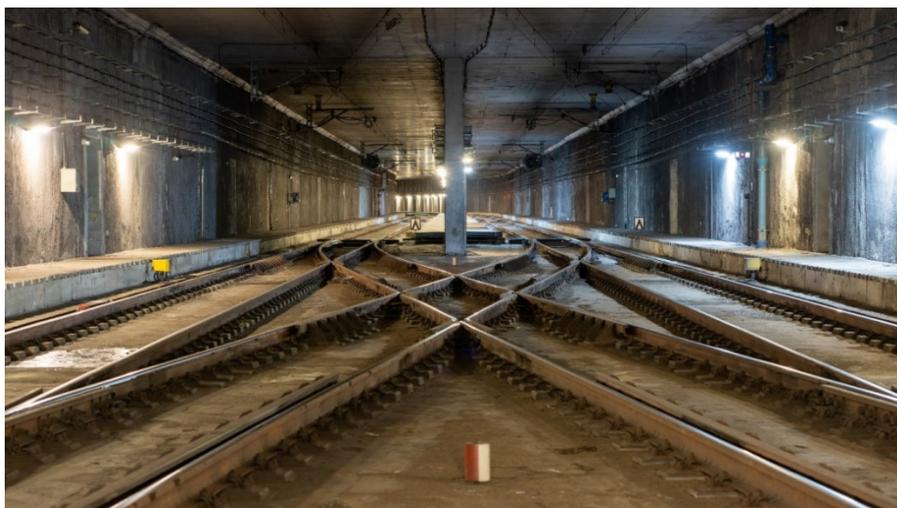
2. Warsaw, cross-city tunnel, 2023, own materials

When using ballastless track on earthworks structures (such as embankments or cuttings), where settlement may occur, additional stabilisation and reinforcement work must be carried out in the substructure—i.e., directly beneath the track slab—as well as additional reinforcement of concrete elements. However, this is not required in tunnels, where, after installation, the track substructure slab forms a uniform monolithic structure with the tunnel tubing. The key advantages of the TINES® EBS system include vibration and noise reduction, as well as low maintenance costs throughout its operational lifecycle, although this comes at a higher initial cost compared to a ballast track. The structural solution incorporating the embedded block support system is designed for a service life of no less than 50 years, ensuring a stable track geometry. This directly contributes to a high level of travel comfort while significantly improving the condition and durability of other track components and reducing rail wear.

A turning point in the development of this track superstructure was the first-ever installation of railway turnouts in a ballastless track system in Poland. The system solution designed by TINES for a double track connection, consisting of three standard right-hand turnouts of type 60E1-300-1:9, one left-hand turnout, and a diamond crossing of type 60E1-1:4.444 used to connect two adjacent tracks, was implemented in 2012 on the newly built railway line No 440, linking the Warszawa Służewiec station with the Warszawa Chopin Airport station—see Photograph 3. A series of studies and measurements conducted by the Railway Research Institute concluded that the embedded block support system could be used in turnouts and railway crossings for all types of turnouts made from Vignole rails and special rail profiles (in switch points and crossings) in tracks with gauges of 1,435 mm or 1,520 mm [3].

The installation of ballastless track superstructures has become a standard solution for demanding investment projects undertaken by railway infrastructure managers in Poland. TINES' involvement in the construction of the cross-city tunnel in Łódź, together with the Łódź Fabryczna railway station, which forms part of the future High-Speed Rail network, marks the beginning of a transformation in the Polish railway system—see Photograph 4.

The long-term investment plan of the Central Communication Port includes the construction of the railway component using modern ballastless track superstructure solutions.



3. Warsaw, tunnel leading to Chopin Airport, 2024, own materials



4. Cross-city tunnel in Łódź, 2015, TINES Rail S.A.

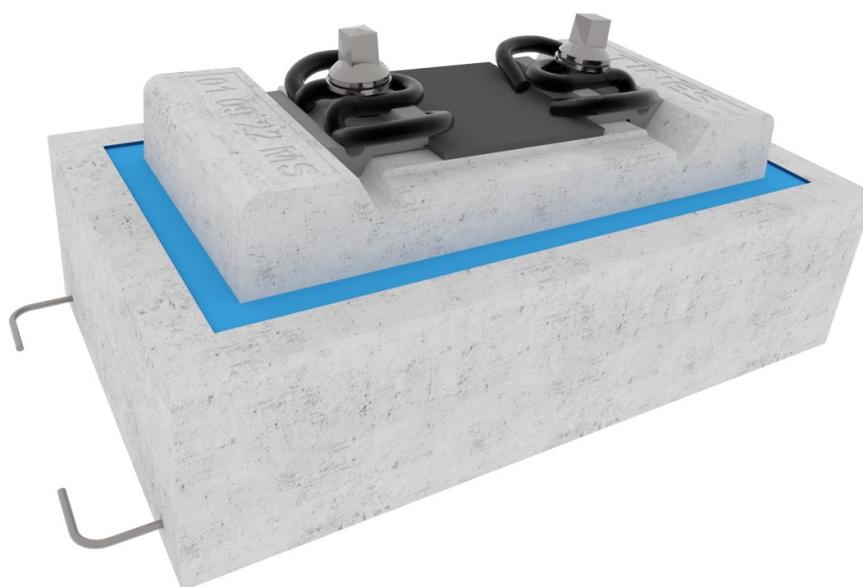
TINES® EBS Fastening System in Light of EU Requirements – TSI relating to the ‘infrastructure’ subsystem

The compliance of solutions used in the railway transport market within the European Union is based on the so-called ‘legislative pyramid,’ which includes the following elements:

1. Interoperability directives, defining essential requirements,
2. Technical Specifications for Interoperability (TSI), defining fundamental parameters,
3. Detailed documents (standards and technical specifications) referenced in the TSI specifications as mandatory, as well as harmonised standards (not referenced in TSI specifications), the application of which remains voluntary but ensures presumed compliance with essential requirements [4].

Until recently, the definition of the TINES® EBS system in normative terms remained a subject of debate. The solution has been proven to comply both with the standard PN-EN 13481-5+A1:2017-04 [5], listed by the President of the Office of Rail Transport, and with the latest update PN-EN 13481-5:2022-12 [6], which, as of 2022, explicitly recognises this as the appropriate reference document. Until recently, the definition of the TINES® EBS system in normative terms remained a subject of debate. The solution has been proven to comply both

with the standard PN-EN 13481-5+A1:2017-04 [5], listed by the President of the Office of Rail Transport, and with the latest update PN-EN 13481-5:2022-12 [6], which, as of 2022, explicitly recognises this as the appropriate reference document. According to Commission Regulation (EU) No 1299/2014 [7], the TINES® EBS fastening system (see Illustration 5) is classified as an ‘interoperability constituent.’ Section 5.3.2. *The rail fastening systems*, paragraph 2 of the document details the specific technical requirements that the solution must meet. Although the system was introduced to the Polish market in 2006, it is continuously developed, monitored, and maintained to ensure production quality by the TINES Technical Department. The intensive work carried out between 2021 and 2024 has allowed us to fully meet all the requirements outlined in the TSI Infrastructure. To confirm compliance with the updated normative requirements concerning fastening system operational performance, we conducted a full-scale structural type test using only the most up-to-date procedures based on harmonised standards—ensuring full conformity with essential requirements.



5.Embedded Block Rail Support – TINES® EBS HR 60E1 MS.B

The achievements of 2024 marked a groundbreaking milestone not only for TINES as a company but also for the intellectual capital of Poland’s railway sector. Following comprehensive research programmes conducted for the TINES® EBS and TINES® EBS-R embedded block rail supports, the company obtained:

1. A Technical Opinion on the fastening system – TINES® EBS system, dated 13 December 2024, which, for the first time, recommends a solution developed by a Polish manufacturer: ‘(...) the TINES® EBS rail fastening system, in the variants of TINES® EBS and TINES® EBS-R embedded block rail supports, may be used in tracks designed for high-speed trains ($V > 250$ km/h)’ [8], and
2. A Permanent Type Compliance Certificate, issued on 20 December 2024, confirming that: ‘(...) the structure meets the requirements and operational properties specified in technical specifications and standardisation documents (...)’ [9].

Is the construction of high-speed rail truly an opportunity for Polish companies?

The preparation and execution of infrastructure projects represent one of the key challenges for both Poland’s public administration and its technical community. As representatives of the latter, we do not see any technological or competency-related obstacles that could limit the participation of Polish companies in the construction of high-speed rail (HSR)—see

Photograph 6. Nevertheless, the market entry barrier remains high, primarily due to rapidly changing formal and regulatory requirements, which make it difficult for Polish firms to fully prepare for tender proceedings on equal terms. The Technical Standards of Central Communication Port (CPK) [10], which have been undergoing continuous updates since 2021, have already reached their sixth version. The most recent version of the document was published on 15 January 2024, imposing new requirements just six months before the launch of the tender procedure for the construction of the tunnel on railway line 85, from the Fabryczna chamber to the Retkinia chamber, along with the necessary infrastructure for the tunnel, chambers, and railway line.



6.Track Superstructure with the TINES® EBS System

Some of these requirements may appear excessive and not entirely justified. Notably, certain provisions are not included in the technical specification for interoperability (TSI) relating to the ‘infrastructure’ subsystem [7] or the technical specification for interoperability relating to ‘safety in railway tunnels’ [11], both of which define the technical standards for designing and constructing HSR tunnel infrastructure. These requirements are also absent from industry standards regarding the operational criteria for fastening systems or the design of ballastless track systems, subsystems, and components. Yet, these documents were developed within the framework of European CEN standards (European Committee for Standardization) and adopted by PKN (Polish Committee for Standardization) as national standards.

Summary

The construction of Central Communication Port (CPK) and the development of high-speed rail (HSR) present a unique opportunity for the dynamic growth of Polish enterprises, research institutes, and laboratories, as well as the implementation of innovative solutions—ultimately strengthening the entire national construction sector. The responsible execution of strategic infrastructure investments will yield tangible benefits for the Polish economy. There are well-documented cases of successful implementations of new railway track structures, which initially were used only locally but, thanks to positive operational experiences and high quality, later gained international recognition and became a standard solution for high-speed rail lines. A similar process can unfold in Poland. We have the technological and engineering potential to develop our own solutions for HSR and, following the example of other countries, to promote them at the European level. As TINES, we fully meet all regulatory requirements for speeds exceeding 250 km/h (see Illustration 3). The only thing the industry lacks is hands-on experience in delivering such projects. However, every company that boasts such expertise

today once had its first opportunity. Let us work together to develop the know-how and competencies of Polish enterprises.

Source materials

- [1] Sikora R., 'Kierunkowy program rozwoju linii kolejowych dużych prędkości w Polsce', *Przegląd Kolejowy* 1995, nr 2.
- [2] Railway Investments of CPK, www.cpk.pl, dostęp 21.02.2025 r.
- [3] Report No 3996-A/11, 'Opinia dotycząca blokowych podpór szynowych w otulinie – system EBS – w podwójnym połączeniu torów na stacji Warszawa Lotnisko Chopina – Aneks', Railway Research Institute, Department of Railway Infrastructure and Transport, Warsaw, June 2014, p. 5.
- [4] Pawlik M., Raczyński J., 'Aktualny stan wdrażania interoperacyjności na kolejach Unii Europejskiej', *TTS Technika Transportu Szynowego*, 2009 r., 4-5, pp. 39-40.
- [5] PN-EN 13481-5+A1:2017-04 Railway Applications – Track – Performance Requirements for Fastening Systems – Part 5: Fastening Systems for Ballastless Track with Rail Fastened to a Slab or Embedded in a Rail Channel.
- [6] PN-EN 13481-5:2022-12 Railway Applications – Track – Performance Requirements for Fastening Systems – Part 5: Fastening Systems for Ballastless Tracks.
- [7] Commission Regulation (EU) No 1299/2014 of 18 November 2014 on the technical specifications for interoperability relating to the 'infrastructure' subsystem of the rail system in the European Union (OJ L 356 12.12.2014, p. 1).
- [8] Report No 004250, 'Opinia Techniczna – system przytwierdzenia – system TINES® EBS', Railway Research Institute, Department of Railway Infrastructure and Transport, 19 December 2024, p. 8.
- [9] IK/CZT/027/2024/V01, 'Bezterminowy Certyfikat Zgodności Typu dla typu budowli system przytwierdzenia typu TINES® EBS', Railway Research Institute, Centre for Quality and Certification, 20 December 2024, p. 1.
- [10] IK.001224/12, 'Standardy Techniczne. Szczegółowe warunki techniczne dla budowy infrastruktury kolejowej Centralnego Portu Komunikacyjnego. Wytyczne projektowania. Tom I.2 Droga szynowa – konstrukcja obiektów budowlanych, Wersja 3.0.0.', finalised on 26 September 2023, published on 15 January 2024.
- [11] Commission Regulation (EU) No 1303/2014 of 18 November 2014 concerning the technical specification for interoperability relating to 'safety in railway tunnels' of the rail system of the European Union (OJ L 356, 12.12.2014, p. 394).
- [12] Technical Dialogue Forum between CPK and the Railway Industry, www.cpk.pl, accessed on 21 February 2025.