Introduction

Effective functioning of the transport system contributes to increasing the competitiveness of the economy. Efficient transport works by stimulating economic development of the state. In the coming period, the strategic mission is to strengthen the role of rail transport in an integrated transport system in Poland. Such an assumption The Ministry of Infrastructure and Development reported in [6]. For this purpose, the Polish State intends to take actions that have a positive impact on raising competitiveness of rail compared to other modes of transport. Competitive features are: travel time, travel comfort and safety level. The Ministry presented planned system of the railway network in 2020 with the permitted speed. Can be seen in its an overall increase in speed limits.

The development of railways in Poland related to development of bridge infrastructure and the adaptation of existing objects to the new criteria under the conditions of usability and capacity.

In the paper authors perform an analysis existing documents and standards used in the design of railway bridges and railway roads. In the work was discussed the possibility of introducing facilities for Polish high-speed rail. In particular, the authors discuss dynamic factors that affect the structure.

Technical requirements for railway bridges construction

Stresses in the structure of the bridge caused by the static load increase or decrease under the influence of moving vehicles. Taking into account it is necessary in the design of the construction. There are some differences between Polish [7] standards and Eurocode [8].

The vast majority of railway bridges in Poland was designed by Polish standards [7]. Should be noted that it does not state standards which are designed for high-speed railways. In particular, in dynamic impact field. Polish Standard [7] recommends the use of dynamic factor. It should be noted that in the present situation and the demand is a sufficient condition. However, in the context of high-speed railways it might not be sufficient.

The EC [8] provides a number of factors influencing dynamic behavior: the speed of traffic across the bridge, the span L of the element and the influence line length for deflection of the element being considered, the mass of the structure, the natural frequencies of the whole structure and relevant elements of the structure and the associated mode shapes (eigenforms) along the line of the track, the number of axles, axle loads and the spacing of axles, the damping of the structure, vertical irregularities in the track, the unsprung/sprung mass and suspension characteristics of the vehicle, the presence of regularly spaced supports of the deck slab or track (cross girders, sleepers etc.), vehicle imperfections (wheel flats, out of round wheels, suspension defects etc.), the dynamic characteristics of the track (ballast, sleepers, track components etc.). All this factors are taken into account in EC [8]. The EC [8] gives also requirement for a static or dynamic analysis. It is shown in Figure 1.  

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where:

\( V \) – the Maximum Line Speed at the Site [km/h]

\( L \) – the span length [m]

\( n_0 \) – the first natural bending frequency of the bridge loaded by permanent actions [Hz]

\( n_t \) – the first natural torsional frequency of the bridge [Hz]

\( \frac{v}{n_0} \text{lim} \) – is given as a function of \( \frac{v}{n_0} \text{lim} \) in annex F.

The most important difference in the approach presented in the Polish Standard [6] and Eurocode [7] are requirements for dynamic analysis. Considering the inclusion of the object to the high-speed rail line, that has been designed by Polish standards should be subject to re-evaluation of the dynamic feature in accordance with Fig. 1.

**Requirements of PKP PLK on the railway foundation in railway bridge**

In addition to the requirements of both the Polish standard as well as European standards for construction, stability and capacity of railway bridges, PKP PLK also sets its own requirements to be met by surface built for civil engineering structures. These requirements are specified in three documents: the Decree of the Minister of Transport and Maritime Economy on the technical conditions to be met by railway buildings and their location (the Official Gazette Number 151), Technical conditions for railway engineering objects (the Id-2) and Standards Technical: Volume III: Bridge Objects (the ST: Volume III).
The Official Gazette Number 151

This regulation requires that the construction and location of engineering objects ensure the proper maintenance gradeline of the track, in accordance with the shaping of the way. Railway foundation applied on an object should be adapted to the structure of these objects. If the railway track is laid on the ballast, track construction for civil engineering structures should be the same as the outside of the property, with the ballast trough should provide the opportunity to carry out the works mechanized equipment. The resilience of the track on the object and its surroundings should be close, and the change of elasticity should take place in a fluently [1]. The document also defines the maximum size of the track axis offset relative to the axis spans that do not require analysis of the project, which is 35 mm. Railway track on bridge structures with a span of more than 30 m should be placed on each span with bilateral elevation of the center span corresponding to the design elevation span. On the objects that do not have a such an elevation, elevation of the track should be performed by the choice of appropriate materials. The Regulation also specifies the conditions under which the object should apply compensatory instruments to be placed on movable bearings in accordance with the technical design object. Another condition laid down in [1] is the need for of the check rails. Check rail should be used to counteract the effects of the derailment of rolling stock, and stiffen the structure of the object. Check rail should be put on the entire length of the object, the inside of the track with old rails, sections of steel or other construction, completed part of the curve with a length of 10–15 m from the axis of the support span on the beachhead.

Instructions Id-2: Technical requirements for railway engineering objects

Instructions Id-2 beyond the requirements set out in the Official Gazette Number 151 more rigorously defines the maximum horizontal displacement axis of the track in relation to the axis of the span, which, according to this document should not exceed 30 mm. If this value is exceeded should be performed additional analysis of the construction work. This instruction does not permit the use in bridge structures rail joints, on bridges should be installed contactless track. The conditions under which the track should be put contactless are also clearly defined. If the project requires routing turnouts on the engineering object, such a solution is possible only in conjunction with ballasted track. However, this solution requires the consent of PKP PLK SA and must be taken into account in the calculation of the structure.

Standards Technical: Volume III: Bridge Objects

This document defines the detailed the technical conditions for modernization and construction of the railway line to speeds less than 200 km/h (for rolling stock) and 250 km/h (for tilting rolling stock). According to this document on new and modernized engineering objects and renewed through the exchange spans should be used on the track with sleepers and ballasted. The distance from this requirement is permitted only in the case of objects, on which the speed does not exceed 120 km/h. In this case, it is required that the width of the trough of ballast into a single track railway is not less than 4.40 m and a depth of not less than 0.75 m below the top surface of the rail head. Between the ballast and slab span bridge is recommended to use vibration isolating materials. Other requirements contained in this document are analogous to those required in the instruction Id-2.

The materials used today on the railway bridge structures

The choice of construction of railway foundation at a bridge object depends on largely on the structure of this object, and the type of surface outside the object. Currently on the exploited objects in PKP lines used for the following types of construction of the railway foundation:

- timber bridge sleepers,
- on the sleepers and ballasted,
- with direct fastening of rails to the construction of the object.
On the network of lines of PKP PLK is allowed to use three types of wooden bridge sleepers [2], as listed below cross-sectional dimensions that do not require additional calculations stability-strength at an axial spacing not exceeding 70 cm:

- **type I** – minimum length of 250 cm, the maximum spacing between centers for the side or main girders 1900 mm,
- **type II** – minimum length of 270 cm, the maximum spacing between centers for the side or main girders 2100 mm,
- **type III** – minimum length of 300 cm, the maximum spacing between centers for the side or main girders 2400 mm.

In Fig. 2 presents the basic types of wooden bridge sleepers used on the lines of PKP PLK S.A.

![Fig. 2. The basic types of wooden bridge sleepers](Source: own)

With this type of solution of railway foundation, all wooden bridge sleepers must be supported via centering pads. If the object is operated until the exchange of wooden bridge sleepers, acceptable is to support wooden bridge sleepers in belts upper stringers or beams of the upper without centering pads. On the objects with the track laid out on the wooden bridge sleepers whose length exceeds 60 m, is required to use the rail type of 60E1, while other objects rails not lighter than the 49E1.

![Fig. 3 Concrete sleeper type PS-94M.](Source: Technical sheet prestressed concrete sleepers type PS-94M)
On the new and modernized of engineering objects of engineering and renewed through the exchange of spans is required on the track sleepers and ballasted. A derogation from the foregoing requires approval by the PKP PLK. When using this type of construction of railway foundation used concrete sleepers or (rarely) steel sleepers. The most frequently used are concrete sleepers type PS-94M. Sleeper PS-94M is a type of concrect bridge sleeper (with check rail) adapted to the track width of 1435mm. It is produced in two versions: for rails type 60E1 and 49E1, using the elastic fastenings of rail to the sleeper type SB 3. If the project requires the application of check rails, it is executed in this case in the form of a third rail fastened to the sleeper using a screw. Sleepers are placed of ballasted with the fraction of 31.5–50 mm, with a thickness of 30–35 cm.

In Fig. 3 you can see a diagram of the concrete sleeper type PS-94M with installed check rail.

**Prospects for the use of new railway foundation for the bridge structures**

In the future, on the lines of PKP PLK in order to fit the infrastructure to European standards is planned to build high-speed railways. Typical exploitation parameters such conditions are: speed – up to 160 km/h, axle load – up to 22.5 tons, the emphasis on mb – 8 t/m.

An example of the railway foundation that meets these parameters is the railway foundation types Rheda 2000®. This system can be applied to a speed of 300-350 km/h, with a maximum superelevation of 180 mm. The components of the non ballast railway foundation type Rheda 2000 ® system are: rails, di-block concrete sleepers with trussed girders, flexible fastening of rail, concrete bearing layer and earthy foundation made of unreinforced concrete lean [5]. Due to the design of the vertical deformation of the surface on the bridges is performed by using the expansion joint, this is done through the use of the individual segments with a length of 4–8 m, which is poured on plate batch bridge and separated from the bridge by a separating layer. If the object is necessary to use the check rail is being implemented in a steel guide elements, respectively, adapted to the width of the nursery.

The Fig. 4 shows the schematic the di-block sleeper of system type Rheda 2000 with the check rail.

The advantages of the system Rheda 2000 ®, among others, to optimize the cost and reliability of the structure through the use of high-quality precast sleepers. By using prefabricated elements reaches a high precision track geometry. The installation process is easy and flexible for both manual and automatic method of building the track.

**Conclusions**

The work led to the following conclusions:

- the construction of the railway foundation, which will meet the performance requirements for high-speed rail requires additionally development of modern technical diagnostics and create models of typical types of degradation objects.
- there is a number of differences between the guidelines for the design bridges according to Polish Standards [7] and EC [8]. It should be taken into account in the case of changes in exploitation of railway bridges.
Abstract

In the paper authors made the review and assessment of the state on the lines operated by PKP PLK railway bridges in Poland. Presents possibilities of the changing the construction of track structure which can significantly affect the quality of the basic parameters of the track. Describes the types of track that can be applied to improve the quality of driving and adjusting it to a higher speed. In this part of the work authors describe the technical requirements for railway bridges. It is shown discussion about basic normative requirements which must be met both the engineering objects and railway track in those objects. Discusses the differences related to the design of buildings according to Polish and Eurocode standards. Have also described the Polish requirements which must be met to railway truck on the railway bridge.

Keywords: railway bridges, modernization, no ballast railway track

MOSTY KOLEJOWE - OCENA ISTNIEJĄCYCH OBIETków I MOŻLIWOŚCI MODERNIZACJI

Streszczenie

W pracy autorzy dokonali oceny stanu technicznego obiektów na liniach obsługiwanych przez PKP PLK. Szczególnej analizie zostały poddane mosty kolejowe. Przedstawiono możliwości zmian, które mogą znacząco wpłynąć na jakość podstawowych parametrów tychże obiektów. W pracy przedstawiono typy torów, które mogą być stosowane w celu poprawy jakości jazdy i dostosowanie jej do kolei wyższej prędkości.

Słowa kluczowe: most kolejowy, modernizacja, transport kolejowy

References