SECURITY ON THE ROAD-RAILWAY INTERSECTIONS IN POLISH STATE RAILWAYS

Andrzej Surowiecki[1], Artur Duchaczek[2], Michał Zieliński[3]

ABSTRACT

In the paper, the conditions of using of two-planes road-railway crossings is presented. There were discussed the on the Polish State Railways obligatory classification of one-plane road-railway crossings and the conditions of attachment to the particular categories. Technical guidelines of one-planes railway crossings (in the range of: geometrical arrangement of road and track, visibility at the crossing and pavement) are described. Safety of traffic installations on the one-planes crossings are presented. In the conclusions the actions undertaking by Polish State Railways for security on the railway crossings improvement are discussed.

Key words: Road-railway intersections, Polish State Railways, traffic security.

STRESZCZENIE

Przedstawiono wybrane zagadnienia przepisów ogólnych, znajdujących się w Rozporządzeniu MTiGM, dotyczące warunków technicznych, jakim powinny odpowiadać skrzyżowania linii kolejowych z drogami publicznymi i ich usytuowanie. Omówiono kryteria klasyfikacji skrzyżowań linii kolejowych z drogami samochodowymi. Przedyskutowano wymagania techniczne w zakresie projektowania oraz budowy przejazdów i przejść dla pieszych. uwagę skupiono na ocenie jakości technicznej stosowanych na PKP PLK S.A. konstrukcji nawierzchni na przejazdach kolejowych oraz funkcjonowaniu systemów bezpieczeństwa ruchu, A także o wymaganiach technicznych dla skrzyżowań dwupoziomowych.

Słowa kluczowe: Skrzyżowania dróg kolejowych z drogami publicznymi, warunki techniczne, bezpieczeństwo.

1) Andrzej Surowiecki, assoc. prof. PhD, Gen. T. Kościuszko Military Academy of Land Forces, Faculty of Security Affairs, Department of Safety Engineering, P. Czajkowskiego Street 109, 51-150 Wrocław, Poland, e-mail: andrzejsurowiecki3@wp.pl

2) Artur Duchaczek, Ing. PhD, Gen. T. Kościuszko Military Academy of Land Forces, Faculty of Management, P. Czajkowskiego Street 109, 51-150 Wrocław, Poland, e-mail: aduchaczek@wp.pl

3) Michał Zieliński, M.Sc. Eng., Wrocław University of Environmental and Life Sciences, Institute of Building, pl. Grunwaldzki 24 50-363 Wrocław Poland; e-mail: michal.zielinski@up.wroc.pl

1 THE CRITERIA OF CLASSIFICATION OF ROAD-RAILWAY CROSSINGS

In Poland is obligatory the Minister of Transport Regulation, which defines the technical conditions to be met by the railway crossing highway [4]. This Regulation produces the possibility of building a one level crossings and a traffic protection. Crossings on the one level are called railway crossings. Polish railways (PKP PLK S.A.) crossings were divided according to the technical equipment and safety devices into categories [3]:

1) Category A: public use crossings with barriers on the entire width of the road and the self-acting traffic lights. Rail employee service is used when crossing the road to cut more than two main tracks. Travel speed train reaches 160 km/h.
2) Category B: the public crossings with barriers (half the width of the road) and the self-acting traffic lights. This category includes the intersections of railway lines, for which there is speed over 140 km/h.
3) Category C: crossings for public use without barriers, with automatic traffic lights or traffic actuated by the rail employee. This category includes the intersections of railway lines, for which there is speed $120 \leq v \leq 140$ km/h.
4) Category D: the public crossings without barriers and without automatic traffic light. On the road is just a "Stop" sign. This category includes the intersections were visibility is ensured and speed on the railway line does not exceed 120 km/h.
5) Category E: the public crossings for pedestrians,
6) Category F: use non-public railway crossings.

The crossings division into categories of traffic security is determined by: category railway line, road class, traffic intensity by rail and road, conditions of visibility, terrain and strategic considerations. Categories A, B, C are crossings guarded by technical devices. At crossings D, E and F (called unguarded) security is provided by an appropriately located road sings [2].

The intersections of these selection criteria is the most controversial measure of traffic, the traffic intensity. This criterion is expressed analytically (measurably) the product of the so-called IR motion. IR parameter is treated as a measure of the collision. IR value is calculated as the product of the intensity of road traffic and rail during the day. Classical criterions, based on the IR traffic product are: unguarded crossings by $IR \leq 20\,000$, guarded crossings by $20\,000 < IR \leq 50\,000$ and flyover crossings by $IR > 60\,000$.

However, the practice shows that the changes over the years, the nature of the two types of traffic, that is to say the intensity and structure.

The method of calculating by the railways PKP PLK S.A. arbitrarily adopted the motion product IR, which determines the category of railway crossing does not take into account [5]:

- non-uniform road and rail traffic,
- speed vehicles,
- the travel time on the railway crossing, which is a dangerous zone,
- waiting times of road vehicles, the crossing is occupied by a train,

- interruptions of the railway traffic in order to discharge the queue of vehicles waiting,
- time of occupy space of intersection of vehicles both type traffic.

It is therefore usual to verify the traffic assessment by the relevant researches and propose new developments in this field [2].

2 THE TECHNICAL REQUIREMENTS FOR THE PLANNING OF ROAD-RAILWAY INTERSECTIONS

In Poland, on the land transport network is over 18 000 road-railway crossings located, at an average of 1300 m [2]. 65 % from this number of intersections is unattended. With operations in Poland statistics show that over 90 % of accidents are caused by road users. Over 30 % of accidents occur at crossings guarded, almost 60 % of the unguarded crossings [2].

A significant increase in road traffic in Poland means that the existing method of securing a number of level crossings is insufficient. We should also mention the problem of traffic safety improvement costs: the cost of one set of self-assembly of signaling can reach more then 240 000 EUR. In the absence of measures to upgrade traffic security systems, placed on the crossings for rail vehicles the speed limit to 20 km/h [4].

The most effective way to reduce the number of accidents is to reduce to a minimum the number of one level crossings and replacing them with viaducts. This trend is observed in Poland and abroad. Specific solutions are proposed flyovers unified, simple in construction, access roads and technology implementation.

According to the technical guidelines in force in Poland [4] two-level railway crossings of public roads are used, for example, in the case of:

- construction of a new railway line or road,
- a railway line crosses the highway or road speed traffic road,
- on the railway line force speed over 160 km/h,
- the total time of closing crossing for road vehicles is more than 12 hours a day,
- there are favorable conditions for field and construction of two-level crossing is justified on grounds of economic or military.

Traffic safety in the surrounding road-railway crossing depends largely on the visibility of crossing from a public road. Visibility must be maintained regardless of the type of traffic security, which is applied to the crossing. Due to the need to ensure adequate visibility and reduce the section of road pavement in the intersection of the railway tracks, the most appropriate is the design of the intersection at 90° angle. According to the Regulation [4], the angle of the axis of the road crossing with the axis of the railway track should be at least 60°. For commuting to railway crossings should provide adequate horizontal and vertical visibility in accordance with the rules governing the design of roads and streets. On the crossing and within 20 meters from the crossing prohibits the placing ads, posters and other items that could limit visibility.

When designing the new sections of railway lines to avoid excessive number of crossings. It is recommended to perform a single crossing at a distance of at least 3 km of railway lines. When designing a new way, to meet the requirements of the longitudinal section of the access roads to the junction with the railway line. For example: both sides of the railway crossing, at a length of at least 26 m formation line of road should be located in the level or at the longitudinal slope of $i_p \leq 0{,}25$ %.

There are also specific conditions that must be followed [3]:

- in the case of construction or reconstruction of the crossing, in which the railway track is run in a straight line, and the road in the horizontal circular arc,
- in the case of construction of a new crossing, in which the road is located in a straight line, a single-track railway line or multi-track is located in the horizontal circular arc.

Railway crossings with the public roads should be properly designed and constructed so that it eliminated the harmful effects of vibration and noise in buildings located near the intersection [3, 5].

3 EXAMPLES OF PAVEMENT STRUCTURES USED AT RAILROAD CROSSINGS IN POLAND

Type of road surface on the crossing and access roads to the intersections should be like on the road. This does not include the section of the track area between the toll gates [3]. In this zone, use a surface consisting of elements: concrete blocks or prefabricated panels or another alternative solutions.

In the width of level railway crossing do not perform of changes of a superstructure construction [3]. Should be used welded rails.

On the Polish Railways (Polish State Railway-PKP PLK S.A.) are used for different types of surfaces crossings. But in recent years (after the Poland accession to the European Union) are built into modern structures. The basic materials for the construction of modern pavements are: concrete, rubber and rubber-like materials. More and more often used in paving unconventional materials, such as polyethylene, epoxy, plastic coated steel and elastomers. The designer of modern surfaces draws attention to improving the sustainability of road-rail crossings pavement and provide comfort driving of motor-cars.

This classic type of surface of one-level crossings, used for more than 50 years is the construction of *CBP* [3]. It consists of a large-scale prefabricated two-way reinforced concrete slabs with dimensions: 0,63 m x 3,0 m (outer plate) and 1,3 m x 3,0 m (inner plate). Surface is designed to crossings on single-track lines and more than single-track, the straight track sections and horizontal curves with a radius of $R \geq 800$ m. *CBP* design is suitable for rails 60E1 and 49E1 type and fastening rails to the sleepers K (classic) and type SB (elastic).

CBP design advantages: a small number of elements, ensuring quick and easy installation, competitive price compared to other solutions.

CBP construction defects: in the process of operation are changes in the position of plates (lack of stability), because the panels are not permanently connected to the track.

A much better solution is to design a Mirosław type, used for more than 25 years. Application: for mounting on road crossings of single track railway lines and multi-track on straight sections and horizontal curves of radius R ≥ 300 m. Mirosław construction can be used for rails 60E1 and 49E1 type and fastening rails to the sleepers K and SB.

Components of Mirosław construction:

- prefabricated reinforced concrete slabs, interior and exterior,
- beams supporting internal and external,
- elastomeric dampers (rubber or polyurethane),
- strips of rubber cushioning and sealing.

Mirosław design advantages: surface is connected to the tracks in a sustainable manner, as small plates are elastically suspended on rails feet. As a result, the vertical position of the rail slabs does not change during operation. Installation and removal of slabs is easy. Replacing a part does not affect the position of the neighboring elements. The price is competitive.

Mirosław design faults: the external panels are joined to the support beam using screws. Moreover, is it necessary to realize continuous footing thickness 0,2-0,3 m below the supporting beams.

Modern surface at the railway crossings in Poland is STRAIL structure, consisting of rubber plates. Application: single-track railway lines and multi-track, 60E1 and 49E1 type rails, wooden or pre-stressed concrete sleepers, rail attachment type K or SB, straight sections of track or horizontal curves R ≥ 800 m.

Basic components: rubber plates internal and external, elements connecting plates, concrete curbs, shock absorber cushions. Two-layer boards are: outer layer with a thickness of 7-8 mm is made of high quality rubber, the inner layer is made of a mixture of the curing.

Advantages: panels made of recycled materials, efficient noise reduction, the ability to build in a number of variants.

Defects: wear and tear of shock absorbers, delamination of the plates, difficult to control the position of the plates. The high price belong to the disadvantage.

In addition, there are, and are used in Poland hybrid solutions, combining the advantages of the system Mirosław at the system STRAIL. For example, the reinforced concrete plate with the upper layer of rubber.

Drainage of railway crossings is performed on general principles, applicable to lines and railway stations. Drainage system is realized as follows [3]: suitable drop of the railway subgrade, filter layer and installing drainage pipes.

4 PROBLEMS OF SAFETY AT ROAD-RAILWAY CROSSINGS

The most important condition, which should meet the newly built, upgraded (modernized) and existing rail-road crossings is the safety of the users. Statistics show that the minimum numbers of accidents occur at crossings unguarded and not equipped with protective devices (category F). However, these crossings have minimal motor-car traffic and trains, which run with limited speed. A small number of accidents recorded also at one-level crossings of category A, which are best protected. Most accidents at one-level crossings are observed in category B and C.

In recent years, in 1000 category B crossings there were about 25 accidents per year. When surveyed, in 1000 crossings in category C were 40-45 accidents per year.

The principal activities of the company PKP PLK S.A. to improving safety at rail-road crossings are [5]:

- reducing the number of crossings unguarded (categories D and F), and expanding the number of crossings in category B and C,
- equipment crossings category A signalling approach, self-acting light signalling and acoustic signalling and industrial television,
- works to improve the visibility of crossings from road (works are concerned most of all categories of crossings).

Used on Poland Railways Crossing self-acting signalling systems are composed of:

- control system,
- connector of warning system W1 (relating to signalling devices ans barrages closure),
- circuit breaker of warning system W2 (relating to signalling devices and barrages opening).

Location of connector of warning system results with condition: $t_{car} \leq t_{train}$, where: t_{car} – journey time of car across the intersection, t_{train} - journey time of high speed train, calculated from location place of connector system to the intersection.

Considering the extreme value of condition $t_{car} \leq t_{train}$, receives the relationship (fig. 1) [1]:

$$\frac{L_1}{v_{min,car}} = \frac{L_2}{v_{max,train}} \tag{1}$$

where:

L_1 – length of danger zone for motor-car,

$v_{min,car}$ – minimum speed of motor-car,

L_2 – distance of W1 connector system from intersection,

$v_{max,train}$ – speed limit of train.

Length of danger zone for motor-car L_1 [1]:

$$L_1 = p + 2f + d + d' \tag{2}$$

where:

p – length of car,

f – horizontal dimension of railway transit-gauge measured from the railway track symmetry axis,

d – distance of signalling device from edge of railway transit-gauge,

d’ – motor-car additional distance from signalling device.

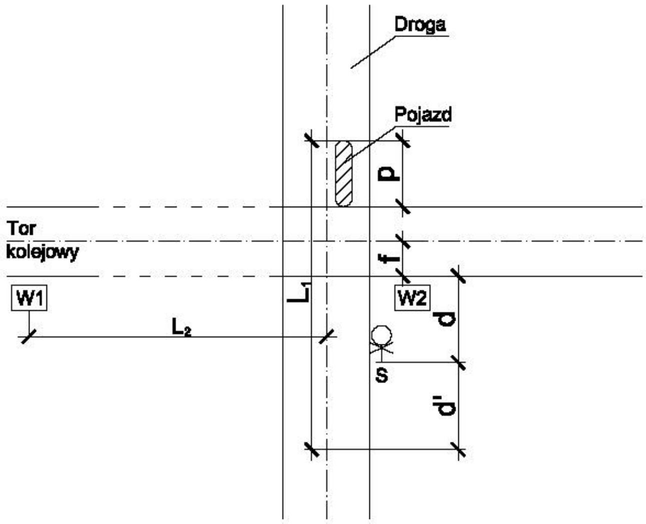

Figure 1 Scheme of installations of crossing self-acting signalling in Poland [1].(Explanation is in text given)

5 CONCLUSIONS

The only fully effective way to improve the situation at road-rail crossings in Poland (PKP PLK S.A.) is to reduce the number of intersections in one-level crossing and construction of two-level crossings as viaducts or tunnels.

Currently, the railways PKP PLK S.A. one of the basic conditions for determining the category of the crossing is to move the product of IR, which are determining the impact of road traffic and rail. It operates in a determined values not included in the structure of random of crossing load. Measure of safety of traffic should be the probability of a collision P_{coll}. Only solution to a probabilistic model of traffic at the intersection of theory queuing methods allows the calculation of the parameter P_{coll}. In the deterministic model, an estimate of the probability P_{coll} is the index of inaccessibility of crossing for road traffic I_{inac}, presented in [2].

It is necessity to use (in extreme cases) specific speed limit thresholds on some roads with one-level railway crossings [5].

For particularly dangerous crossings it would be beneficial to install industrial television. These crossings should be marked boards, informing about the number of accidents that have occurred there.

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Článok recenzovali dvaja nezávislí recenzenti