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LEVEL CROSSINGS AT RAILWAYS

Abstract

The intersection of railways with other roads can be designed in different ways, according to the needs, conditions, possibilities and regulations. Level or grade crossing is one of the solutions used in civil engineering. These areas pose inherent hazards to train operations, as they do to motor vehicles, non-motorized vehicles and pedestrians. Generally, new crossings (particularly on mainline tracks) should not be permitted unless no other viable alternatives exist. Even in those instances, consideration should be given to closing one or more existing crossings. When there is no other alternative, provisions must be made to ensure that the roadway approaches and crossing surface are suitable for all traffic, that sufficient warning is provided of the approach of trains, and that management of the this type of intersection is coordinated with other intersections involving nearby roads. Various types of level crossing structures and equipment can be used, each providing different technical and safety design. This paper shows different approaches and regulations used throughout the world and various types of level crossing structures and systems.

Key words

Railways, roads, intersection, level crossing, crossing structures

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1. INTRODUCTION

The intersection of railways with roads can be done in two ways:

- Level crossing (single level) – where the railway superstructure needs to be constructed so that the road vehicles or pedestrians and cyclists can cross (figure 1);

Figure 1. Example of a level crossing in the Netherlands (Dutch Safety Board, Level crossing safety - a hazardous intersection of interests, 2018)

- Level/grade separation (two or multiple levels) – this type of intersections are usually made with bridge structures such us underpasses or overpasses (figure 2). The location of the bridge should be economical, safe and technically justified solution. Tunnels are also used for level separation, but these structures are often more expensive and difficult to construct. The benefits of grade separation include zero possibility of train-vehicle collisions, reduced traffic congestion and the removal of the requirement to sound a horn as a train approaches the crossing.

Figure 2. Example of a bridge overpass in the city of Skopje, 2017

The choice of the type of intersection depends from the state regulations, needs, conditions, possibilities and the type of transport infrastructure. From a safety aspect, the solutions on two or multiple levels (level separation) are better and in some cases mandatory.

2. RAILWAY LEVEL CROSSING

Level crossings or single level intersections are designed in order to allow crossing for both trains and road vehicles. This is achieved by constructing the road pavement in level with the rail head. These crossings are arranged in order to eliminate any damaging impacts from the road vehicles to the rails and the railway in general. Apart from the structure and technical properties, a certain degree of safety must be guaranteed. The construction of level crossings is legally restricted and controlled with technical regulations.

2.1. GEOMETRIC CHARACTERISTICS AND COMPONENTS OF LEVEL CROSSINGS

The crossing surface (travel way) width is usually equal to the road width, but no smaller than 3,0 m (5,0 m) depending on the daily traffic and safety equipment (figure 3). The road width should be the same with the crossing surface, 20,0 m before and after the crossing. At pedestrian crossings, the width of the surface should not be less than 1,0 m (1,2 m). For pedestrians and cyclists the recommended shared crossing width should be minimum 2,4 m.

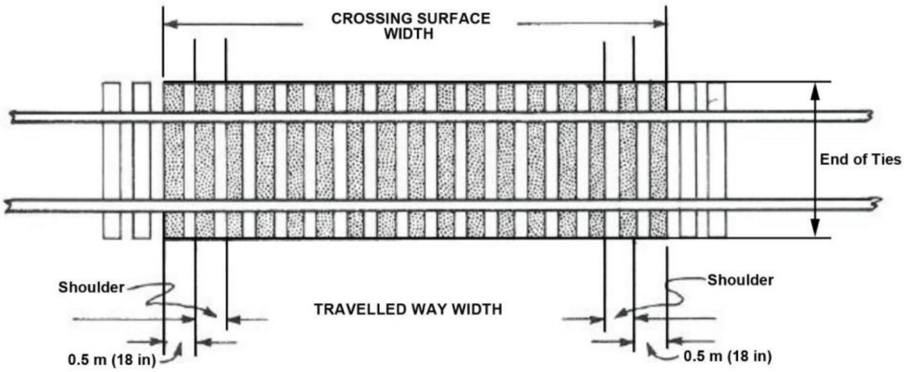


Figure 3. Crossing surface width (Transport Canada, Grade Crossing – Handbook, 2019)

The road pavement has to be at the same level with the rail head in horizontal, in length of at least 3,0 m from both sides of the railway axis. The longitudinal gradient of the road should be 2,0 % for 10,0 m (5,0 m for sidewalks) from the crossing (nearest rail).

Generally, the components of level crossings include:

- Crossing surface – area between and outside the rails, which can be designed with different materials;
- Guard (safety) rails – elements that are not required with the newer level crossing systems;
- Signal and safety equipment – vertical and horizontal road signs, flashing-light signals, audible warnings and gates (with manual or automatic regulation).

2.2. LEVEL CROSSING SAFETY

From a safety aspect, level crossings can be divided into two groups (figure 4):

- Active (protected) crossings – where dynamic signals and equipment are used (flashing-light signals, audible warnings and gates);
- Passive (unprotected) crossings – where static signals are used (vertical and horizontal road signs).

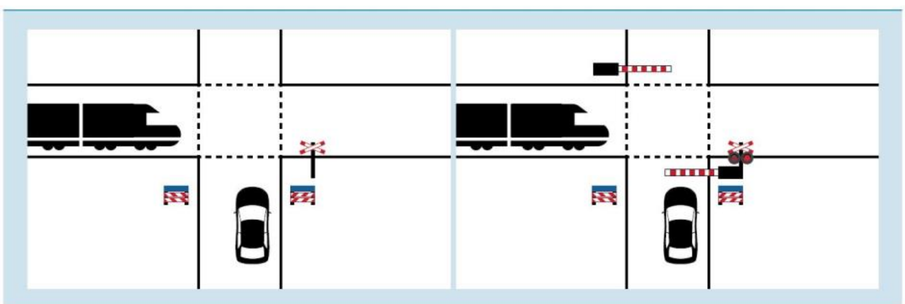
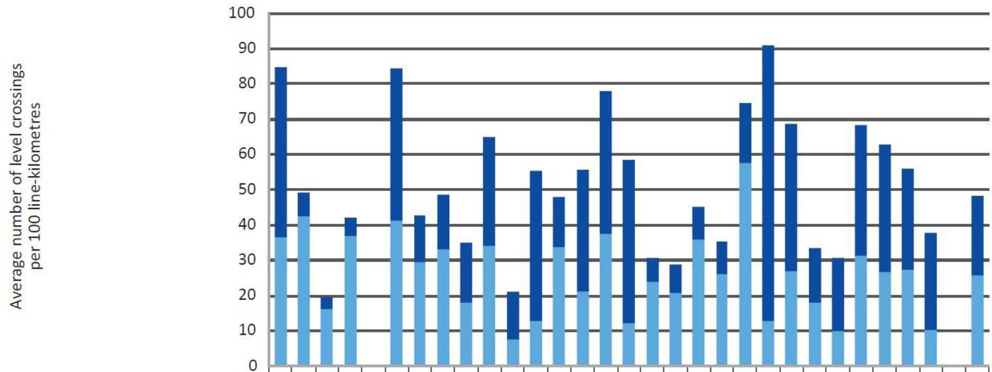


Figure 4. Schematic description of active (right) and passive (left) level crossing (Dutch Safety Board, Level crossing safety - a hazardous intersection of interests, 2018)

There were 108.196 level crossings in the EU Member States in 2014. On average, there are just under five level crossings per 10 line-kilometres in the EU, with active level crossings representing just under 53 % of all level crossings (figure 5). From 2012 – 2016 the average number of accidents per year is around 500, which represents near 30 % of all railway accidents.



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Passive level crossings per 100 line-km	48	6.7	3.6	5.1	0	43	13	16	17	31	14	43	14	34	41	46	6.7	8.3	9.1	9	17	78	42	15	21	37	36	29	28		23
Active level crossings per 100 line-km	36	42	16	37	0	41	30	33	18	34	7.6	13	34	21	37	12	24	21	36	26	57	13	27	18	10	31	27	27	10		26

Figure 5. Number of active and passive level crossings per 100 line-kilometres in some European countries (European Union Agency for Railways, Railway Safety in the European Union, 2017)

In Macedonia there are total of 252 level crossings, of which 151 are passive and 101 active. Montenegro has 39 level crossings or 15 passive and 24 active crossings. In Serbia there are total of 2133 level crossings, of which 1594 are passive and 539 active. Croatia has 1518 crossings or 924 passive and 594 active level crossings. In Bulgaria there are 783 level crossings, of which 137 are passive and 646 active.

3. TYPES OF LEVEL CROSSINGS

The types of level crossings and their structure vary in the world. According to the material used as a crossing surface, there are crossings with rock, wood, asphalt, concrete and rubber.

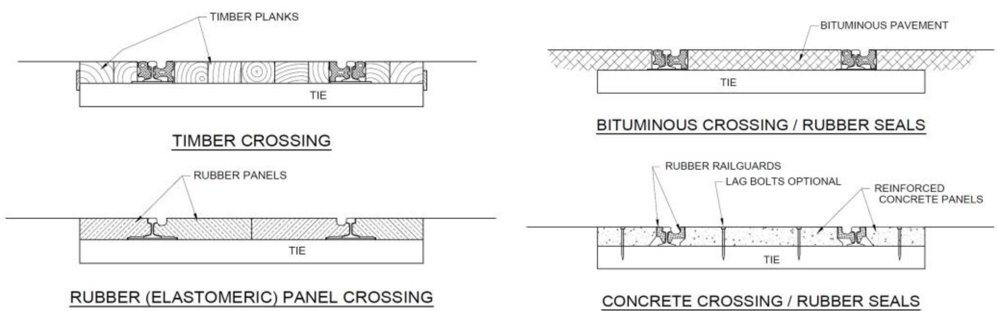

Figure 6. Example of different types of level crossing surfaces (Railway crossings & utilities chapter, Geometric Design Guidelines for B.C. Roads, 2019)

In the early days, sand, gravel and granite cubes where used for this purpose. In this region, some of these types of level crossings still exist. Wooden panels (beams or ties) or combination of wooden panels with asphalt or concrete (figure 7) can be used for crossings with low daily traffic or pedestrian/bike crossings.

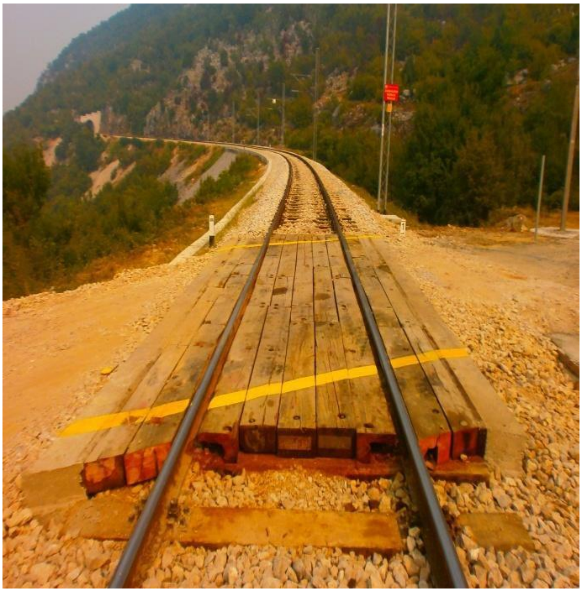

Figure 7. Construction of a crossing with wooden and concrete elements in Montenegro (Level crossing analysis at railway lines in management of Railway infrastructure Montenegro, 2017)

Asphalt, is very often used as a crossing surface. This material can be also combined with wood or rubber, in dependence with the daily traffic. Compared to the crossings with prefabricated materials, the construction and maintenance of asphalt crossings is more difficult and demanding.

One of the newer approaches for level crossing surfaces are concrete (figure 8) and rubber prefabricated elements (panels). These materials are characterised with great load capacity, durability, easy construction, low maintenance costs.

Figure 8. Example of a crossing with concrete panels in the USA (Highway-Rail Grade Crossing Surface Material Performance, NURail Research Project, 2010)

An additional advantage of the rubber panels is the noise reduction and the ability to be recycled. Rubber panels are usually combined with concrete and steel (aluminium) elements (figure 9).

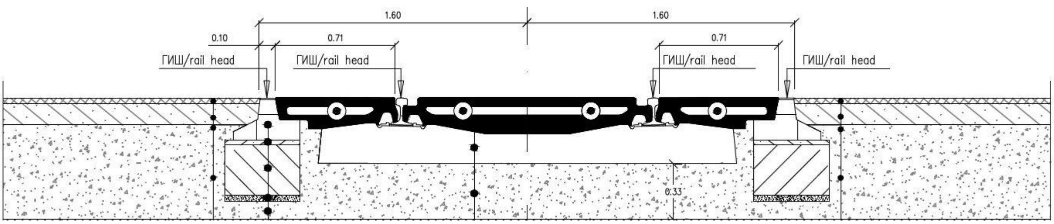

Figure 9. Cross section of a crossing with rubber panels in Macedonia (Railway line Bitola - Kremenica)

Crossings surfaces that are in bad condition, can cause decreased safety and damage to both railway and road vehicles i.e. making them very inefficient. The Balkan region in general, has a lot of old and inefficient level crossings and some of them have high daily traffic. This causes problems and discomfort for the everyday road users. The implementation of newer systems (e.g. prefabricated elements) can benefit the overall infrastructure near these crossings. In 2017 in Macedonia, there were only seven level crossings with rubber panels in the entire railway system.

4. CONCLUSION

Level crossings represent complex structures for both roads and railways. If not designed and constructed properly, these areas can cause great problems related to vehicle and infrastructure damage, accidents, increased costs and maintenance. The overall quality and safety of the level crossings is linked with the crossing surface and the signal and safety equipment. The Balkan region is characterised with significant number of old crossings that represent a serious safety and financial problem. The future development and improvement of the railway system, should consider the newest systems and solutions for these areas. The data about geometric design, safety equipment and types of level crossings show in this paper, give an overview and a guideline for solutions that should be more often used in this region.

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