



RAILWAY CROSSINGS - SOME EXPERIENCES FROM THE PRACTICE OF RECONSTRUCTED CROSSINGS

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Abstract

Level crossings (Rail-road crossings and pedestrian crossings) are places where rail and road traffic meet directly. As such, they represent points of high risk where accidents often occur with serious consequences in the form of human casualties and material damage. Rail-road crossings and pedestrian crossings over the railway at level are not a problem and the subject of solving only the section of the railway, but the very safety of traffic at these points depends significantly on the construction-traffic solution of the road in the immediate vicinity of the railway crossing. A big problem is the fact that there are a large number of railway-road crossings which, according to the regulations, would have to be built out of grade. However, due to the high costs of such solution, transport infrastructure managers often resort to other ways of securing railway-road crossings. The paper presents some examples of good and bad practice in the location, construction and level of security of railway-road and pedestrian crossings on the reconstructed railway network in Croatia. A comparison was made of some safety-technical solutions and technical means at our railway and road crossings of the European Union, as well as a comparison of the effectiveness of certain measures with regard to the behaviour of road users.

Keywords: railway-road crossing, safety, road, railway, signalling

1 Introduction

Level crossings (Rail-road crossings (ŽCP) and pedestrian crossings (PP)) are places of direct conflict between rail and road traffic and rail and pedestrian/bicycle traffic. Since these are the collision points of two line systems, of which the train always has priority, from a security point of view they represent high-risk traffic points where conflict situations often occur, sometimes with the most serious consequences. Statistical data show that in more than 90% of conflict cases, the main cause lies in negligent road motor vehicle drivers and pedestrians.

In order to avoid such events, railway-road crossings must be secured with an appropriate level of insurance, not only to protect the crossings from possible material damage or unwanted consequences for human health, but also to prevent violations of traffic regulations.

2 Definitions and description of railway-road crossing

A rail-road crossing is a place where a railway line or an industrial track and a road cross at the same level, it may also include a crossing with a pedestrian and bicycle path or other roads intended for the passage of people, animals, vehicles or machines [1]. It follows from this that the railway-road crossing is the place where rail and road traffic meet, so from the point of view of safety it represents a potential point of high risk. In order to ensure the smooth flow of traffic, railway-road crossings must be properly secured.

The basic division of insurance of rail-road crossings includes passive and active insurance. Active security of rail-road crossings is considered to be any security method that reacts by changing its state (light-sound or protection) when a railway vehicle approaches. Passive security is considered to be any crossing that is equipped with any warning sign, devices or other protective equipment that is permanent and does not change depending on any traffic situation.

2.1 Legal regulations on railway-road crossings

The legal regulation related to railway-road crossings in the Republic of Croatia is described in [2-8]. Depending on the type of roads, the category of railways and other roads, the intensity of traffic on railways and other roads, topographical and urban conditions, the crossing of a railway line with other roads is carried out as [4]:

- crossing out of level,
- crossing in the same level

Even though the solution of a level crossing (overpass, underpass,) represents a significant financial item in the investment, the crossing of the railway line and the road must be performed outside the level in cases as prescribed by the Ordinance [4]. According to some authors, rail-road level crossings are complex systems that involve interaction between several different types of land transport users, including train drivers, signalling personnel, pedestrians, cyclists, motorcyclists, car drivers and others [9]. As for the conditions for the execution of rail-road level crossings, they are also prescribed in the Ordinance [4].

2.2 Classification of rail-road crossings

Depending on the method of securing, there are two main types of rail-road level crossings: passive and active. Passive crossings are often only equipped with warning signs, “Andrew’s Cross”, possibly also the B02 “Stop” sign and road markings. At these crossings, the road user in principle decides for himself when it is safe to cross. Active rail-road crossings are additionally equipped with barriers (bumpers, semi-bumpers) and warning systems such as light and sound signals or at least only light and sound signals. On some of them, there is also a protection system on the side of the railway line, which does not allow a train to pass through the crossing (ŽCP) if it is not fully protected (secured), i.e. without users in the crossing area.

After the reconstruction of the section of the railway line R201, on the Žejinci ŽCP, due to the failure of the half-bumper (it did not lower when the train came upon it), the trains were stopped before they came upon the crossing, and after the train driver made sure that the road crossing was free, he could continue to start the train and pass the crossing.

3 The situation at railway-road crossings in the Croatia

3.1 Basic terms about safety in railway traffic

In railway traffic, a safety situation represents an unwanted, unintentional or unexpected situation, event or sequence of such events that result in any damage, regardless of the amount of damage. Extraordinary events are divided into four basic categories: serious accidents, accidents, incidents and avoided accidents [10].

A serious accident is an extraordinary situation in the event of a collision or derailment of a train in which at least one person is killed and/or five or more persons are physically injured, and/or material damage to the infrastructure or the environment exceeds two million euros.

An accident is an unwanted or unintentional sudden event or sequence of such events (collision, derailment, accident on crossings (ŽCP or PP)), which has harmful consequences in railway traffic such as human casualties and material damage that can be estimated at a value of up to two million euros.

According to HŽI data [11], not a single railway-road crossing in Croatia, out of 1494 of them, is unsecured, so at least minimum safety is ensured at all of them, depending on the level of the crossing itself.

Deaths caused by road-rail crossing accidents, according to data from the EU (Eurostat), account for a small percentage (1%) of all road-related deaths, but account for a large percentage (~30%) of rail-related deaths. Accidents at level crossings often lead to serious or even fatal injuries to users of level crossings, because the train is massive and heavy, travels relatively fast and has no way to avoid them (long stopping distance). Although the number of accidents and, consequently, victims, decreases annually by 3% to 4%, there is room for further improvement of safety on the crossings.

3.2 State of security at railway-road crossings

In the Republic of Croatia, there are a total of 1,494 level crossings, of which 818 pedestrian crossings are secured with signs (passive), 586 pedestrian crossings are secured with devices (active), 66 pedestrian crossings (PP) are secured with road signs and 24 pedestrian crossings are secured with devices. In the last few years, the number of road crossings has been decreasing, as some are raised, some are closed and reduced to neighbouring ones, and some are completely abolished. The level of safety depends on the category of railway and road, the permitted speed, the terrain conditions and the local circumstances at the crossing.

According to HŽI safety reports [12], it is evident that in recent years the number of serious accidents or accidents is decreasing. It was also established that the largest number of accidents occur at protected (active) crossings, and that an increased number of broken and damaged bumpers/bumpers was registered (442 in 2022). This represents significant material damage for the manager, and at the same time speaks of the arrogance and lack of traffic culture of a certain number of drivers.

4 Technical solutions for securing railway and road crossings in the Croatia and comparison with solutions in the EU

Passively secured railway-road crossings, compared to active ones, only give road vehicle drivers the information that a rail-road crossing is located there. Drivers do not receive information about whether a train is approaching, they have to see for themselves. The purpose of road signs is to attract attention at the rail-road crossing and show the existence of the crossing to road users. In this marking, the most commonly used sign for marking the rail-road crossing is A37 “Andrew’s Cross” (single, double, depending on the number of tracks), and the sign B02 “Stop” is most often next to it. If the crossing is over two or more tracks, it must also be provided with signal lights. In several EU countries there is a different form of the “Andrew’s Cross” sign (Figure 1).



Figure 1 a) Marking of crossing with A37 and B02 signs in Croatia; b) some EU countries

Approaching a rail-road crossing that is not secured by bumpers or half-bumpers is indicated by the sign A35 “Approaching a road crossing over a railway line without bumpers or half-bumpers”. At this type of crossing, a sign “Road-railway crossing warning” is placed at a certain distance, according to which the train driver must announce the approaching train to the road traffic participants before approaching the crossing.

It is essential to ensure the prescribed visibility from the road to the railway and from the railway to the road on the passive crossing. The prescribed visibility from the road to the railway line is achieved when the participants in road traffic in front of the rail-road crossing on both sides of the railway line have an unobstructed view from the vehicle to one side and the other at a distance that enables timely spotting of the oncoming train or railway vehicle, in order to safely crossing the railway line. The prescribed visibility from the road to the railway line is determined in relation to the permitted infrastructure speed on the part of the railway line where the rail-road crossing is located [11].

Analysis of the current situation shows that at many railway-road crossings, the triangle of visibility from the road to the railway or from the railway to the road or even from both positions is not ensured. The most common obstacles to the visor are vegetation along the railway or road, the crossing house or unfavourable geometrical elements of the road in relation to the railway (Figure 2).

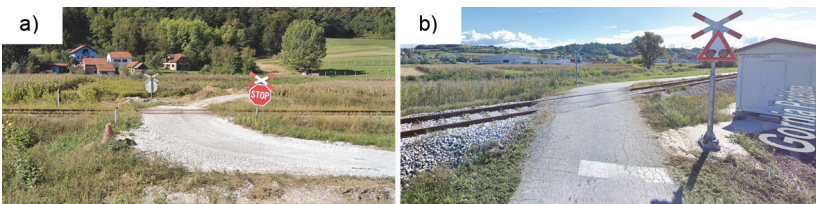


Figure 2 a) Passively secured railway-road crossing, b) obscured field of vision by the crossing box at the active transition

Active security of road crossings includes all those that warn road traffic participants about the approaching train. These are crossings secured by signal lights, bumpers, semi-bumpers and other obstacles, i.e. electrical and mechanical devices.

Signal lights in Croatia have the form of two alternately flashing red lights mounted on a triangular signal base on a pole. Along with the lights, a device for giving sound signals and the sign A37 (“Andrew’s Cross”, possibly also B02) are mounted. The shape of the signal light and the sign “Andrew’s Cross” in some EU countries differ, and some are shown in Figure 1b). Bumpers and half-bumpers serve as a physical blockade of road traffic when a train encounters a rail-road crossing (Figures 4 and 5). The bumpers/half-bumpers are coated with retro-reflective material along their entire length and have a flashing signal lamp.

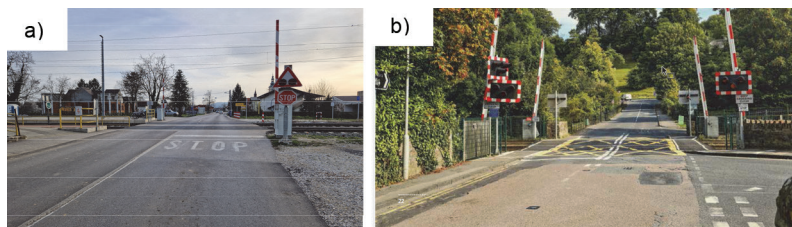


Figure 3 a) Crossing on the double-track railway M101 actively secured with half-barriers and other signalling (light and sound). Road elements are good, b) Crossing provided with half-bumpers and additional horizontal signalling at the crossing itself plus light and sound (British Railways) [13]



Figure 4 Crossing secured with bumpers plus light-sound, pedestrian crossing levelled by a guardrail (British Railways) [13]

Solving the safety problem of railway-road and pedestrian crossings over the railway (ŽCPs and PPs) is determined by the Transport Development Strategy of the Republic of Croatia 2017-2030. as one of the measures to increase the safety level of rail and road traffic.

The program for solving rail-road and pedestrian crossings over the railway for the period from 2023 to 2027 establishes a list of priorities for solving ŽCPs and PPs over the railway, and includes crossings that are in the process of being solved, crossings that are included in the project applications for which funds are secured, as well as those that are not covered by existing investment programs, and it is necessary to secure them. The purpose of the Program is to improve the level of security of crossings and to establish additional measures aimed at increasing the level of safety of railway and road traffic. Analyzing and comparing the safety methods on crossings in some EU countries, it can be concluded that the safety methods for passive and active crossings are similar, with the fact that some countries have more additional equipment for monitoring the situation at the crossing and additional safety. The traffic signals are basically the same (stop sign, Andrew’s cross, light signs) with slightly different shapes. Somewhere there are two red lights on a triangular, somewhere on a square base, somewhere the cross is turned horizontally, somewhere vertically. In all countries, half-bumpers are used, with the fact that in Germany and England they are performed as bumpers (two half-bumpers on each side that are lowered alternately).

In Germany and Austria, pedestrian crossings do not always have passing fences, they are larger under the regime of the main half-bumper or have their own half-bumper. In England, in addition to two flashing red lights, there is also a flashing orange one, the half-bumpers have a suspended net underneath, and the area of the railroad tracks around the crossing is fenced off, making it completely impossible to pull over and cross the tracks. The area of the crossing itself is marked with additional horizontal signalling. In Austria, a large number of passive crossings have a light-sound signal. In Italy and Hungary, the physical separation of the roadway (separation island) is performed in some places in front of the crossing and the half-bumper. In Italy, along with light and sound signalling (one light signal), a “propeller” is performed on the crossing, which rotates when the half-bumper is lowered and thus attracts the attention of the driver that he is approaching the crossing. The situation in Slovenia is similar to that in Croatia (part of the former railway system). Some possibilities for insuring railway crossings in some EU countries are shown in Figure 5.



Figure 5 Ways of insurance in some EU countries, in order: England, Hungary, Austria, Austria, Italy, Italy, Germany

5 Examples of implemented security measures for railway-road crossings on reconstructed railway sections in the Croatia

When reconstructing sections of railways in Croatia, crossings are also arranged (partially construction and most often passive safety are converted into active safety or existing active safety is supplemented with bumpers, cameras,...). The analysis of the situation revealed a problem in these reconstructions, that the road part of the crossing, primarily in height, is not arranged in accordance with the regulations, so some very problematic solutions were implemented. Levelling breaks are inappropriate and often in combination with transverse falls lead to increased side impacts, swaying of large vehicles or bouncing of passenger vehicles. This is probably the result of the insufficient length of the road section. The designers of the railway section most often solve the approaches to the crossings and fit them into the existing conditions, mostly in the zone of the construction plot of the railway, which is usually too short. In such a space, it is not possible to “stack” the necessary elements of the grade, especially if the section of the railway line is in a bend and with overhangs (problematic are the max longitudinal slopes of the grade, the relationship of the longitudinal slopes of the road edges to the slopes of the grade, rounding, wind drift zones according to the longitudinal slope of the railway, etc.). Furthermore, at some crossings, new roads were constructed parallel to the railway at a distance of approx. 5-6 m and then connected to the crossing before the crossing itself. Often there are no floor plan elements for turning a certain category of vehicle onto the crossing itself. A traffic jam is created in front of and in the crossing itself in order to let vehicles from that road pass. These vehicles, in order to be able to enter the crossing, usually have to occupy both traffic lanes. Figures 6-9 show some examples of railway crossings on railway lines in Croatia.

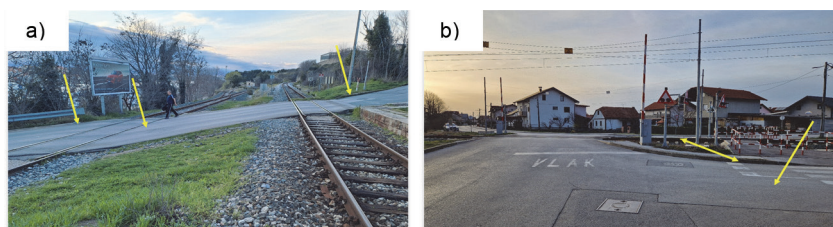


Figure 6 a) Crossing on M607 (L211) provided with bumpers without other measures (light and sound, pedestrian crossing fences). Very poor elements of the road level with “knife” positions, large longitudinal slope, b) Crossing on railway line R201, secured with half-bumpers, with light-sound measurement and camera, has pedestrian crossing fences. Good elements are the levelling of the road

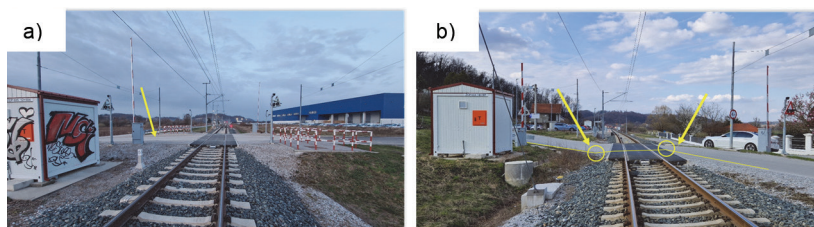


Figure 7 a) Crossing on the railway line R201, secured by half-bumpers, with light-sound measurement and camera, has pedestrian crossing fences. The levelling elements of the new road are well integrated, b) Crossing on railway line R201, secured by half-bumpers, with light-sound measurement and camera, does not have a pedestrian crossing fence even though it is located next to the stop. The elements of the road level are poorly integrated into the transition itself and the existing condition (big “jumps” when crossing)



Figure 8 The crossing on the L202 railway line, secured by half-bumpers, with a light-sound measure, has a pedestrian crossing fence. The elements of the road level are poorly integrated into the crossing itself and the existing condition (on a short stretch, up to the yellow dashed line, a greater height difference has been overcome, big “jumps” for BUS and trucks when crossing)

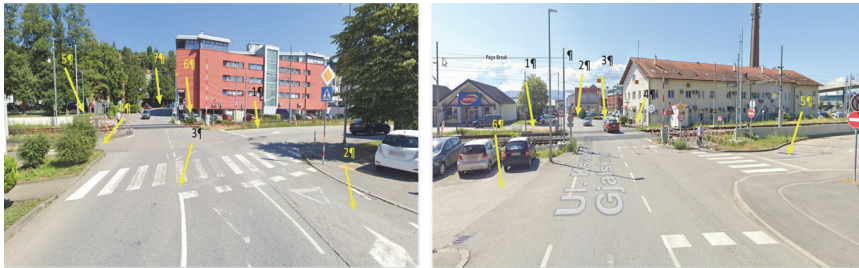


Figure 9 Crossing on the railway line R201/R106, secured by half-bumpers, with light-sound measurement, has a pedestrian crossing fence, located in a very complicated intersection, right next to the switch area. It is the only crossing in the whole city. A new street was built, the elements of the road level are poorly integrated into the crossing itself and the existing condition. There is no marked pedestrian crossing on the south side towards the passing fence, so pedestrians are brought directly onto the railway line

6 Conclusion

Railway-road crossings and pedestrian crossings are places where rail and road traffic meet directly. As such, they represent high-risk points where accidents with serious consequences often occur. An analysis of the newly reconstructed crossings shows in many locations an inappropriate solution to the geometry of the road part of the crossing itself, which, in addition to unpleasant driving over the crossing, leads to a safety hazard for road traffic or disruption of traffic flows. When designing reconstructions of the crossing, one should try to respect the prescribed geometry of the road part of the crossing so that, in a situation when it is not closed, it ensures the traffic of road vehicles in accordance with the intended speed without any consequences on safety or traffic flow.

Within the framework of the continuation of the implementation of the Program for solving rail-road and pedestrian crossings over the railway line for the next period, it is proposed to consider additional measures to improve safety on crossings. First of all, reduce passive transitions to an active phase, introduce additional training for participants, introduce some new innovative technical measures (rails, laser lighting of the crossing, cameras and radars, additional flashing lights to attract the driver’s attention, a light for marking the stop line, flashing road markers, painting the surface of the dangerous crossing zone, etc.), all with the aim of ensuring maximum traffic safety at railway and road crossings.

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