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BARRIERS AND HALF-BARRIERS - VIOLATION AT LEVEL CROSSINGS: A CASE STUDY OF DRIVERS BEHAVIOUR IN CROATIA

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Abstract

This study investigates accidents at active level crossings (LCs) in Croatia (A.1.3., by ERA classification) equipped with barriers or half-barriers and warning automatic devices (light and sound signalling). Statistical data were collected to identify the number of yearly broken barriers and half-barriers, causes, consequences, time, location and spatial distribution of accidents. Only collisions with barriers and half-barriers were analysed. Although active LC protection systems effectively prevent accidents due to road user errors, there are many broken barriers or half barriers at the LCs (378 in 2020, 435 in 2019), which indicate risky driving behaviour of LC users. The results of the analysis show a declining trend. Still, as the high number of barriers or half-barriers at the LCs were in most cases broken just before the train was approaching, for which they were lowered, this could have led to severe accidents. Based on this, we can assume that the most significant focus of accident prevention and improving safety at LCs in the future need to be on human behaviour.

Keywords: safety, level-crossings, risky driving, violation, half-barriers/barriers breakage

1 Introduction

A level crossing (LC) is a point of intersection of a railway or industrial track and a road at the same level, which may include a crossing with a pedestrian and bicycle path or other paths intended for the passage of people, animals, vehicles, or machinery [1]. As an intersection of road and rail infrastructure and road and rail traffic, LC represents a traffic point with a high risk of accidents. There are 1,499 level crossings at the railway network in the Republic of Croatia [2]. Accidents at level crossings are one of the most significant contributors to the overall number of accidents on railways. Out of all railway accidents in 2020 in Croatia, 44 % occurred on LCs. There are approximately 150.000 level crossings in the European Union, of which 51 % are active. In 2018, 1.721 significant accidents happened in railway transport or railway and road combined transport systems with material damage estimated at 383 million euros [3]. On the railway network in Croatia, only 39 % of all LCs have active protection [2]. At an active level crossing, its users are protected from an oncoming train or are warned by activating devices when crossing the level crossing is not safe for the LC users. Protection using physical devices includes barriers or half-barriers and protective fences. Warning using built-in equipment at level crossings include visible devices (lights) and sound devices (bells, trumpets, sirens, etc.) [1]. Active protection means the highest LC protection.

Despite the highest safety protection, many accidents occur on active LCs. While most of the accidents involve people going around the gates or mistakenly turning onto the railway tracks, there are many crashes into the barriers and half-barriers. Most recent data suggest that the total numbers of broken barriers and half barriers at LCs are dropping annually, but the number remains high, as well as the material damage. The study's primary purpose is to investigate and in detail analyse accidents at active level crossings in Croatia equipped with barriers or half-barriers and warning automatic devices (light and sound signalling). After an overview of research papers dealing with traffic safety at LCs in chapter Background, a data about the accidents characteristics such as location and spatial distribution, date and time, causes and consequences are analysed in chapters Data and Results. According to collected data, suggest possible measures for improving the current situation, influencing human behaviour in the future, and decreasing the number of collisions are proposed in chapter Discussion and conclusion.

2 Background

Collisions of vehicles and barriers and half-barriers on level crossings which causes broken barriers and half-barriers are a huge problem. In most cases, broken barriers and half-barriers result from drivers' non-compliance with traffic regulations and human behaviour. Although the consequences of this problem are mostly material damage, any breakage of barriers or half-barriers could lead to a more serious accident. An analysis of accidents in Great Britain between 1949 and 2009 showed that the first half of that period reduced accidents by 64 %. It is believed that this was caused by the implementation of more active level crossing [4]. In Germany, an evaluation of 51 level crossings accidents was conducted. The data results have shown that 41 % of accidents happened at level crossing equipped with half-barriers. The conclusion was that half-barriers alone don't provide necessary accidents prevention and safety at level crossings [5]. Another accidents analysis was done in Finland by comparing accidents at passive and active level crossings between 1991 and 2011. Data have shown significantly more accidents at the passive level crossing [6]. A study done by Czech researchers [7] reflects the dangers of level crossings equipped with barriers. It is emphasised that barriers are easily broken while many road users are unaware of this. In France, accidents with automatic level crossing were analysed using different factors like the type of transport mode, geographical region, and traffic moment. The research goal was to improve safety at level crossings [8]. Based on the analysis of different characteristics of the level crossing (type of crossing, type of barrier, warning device, and traffic volume), it was concluded that full barriers offer more protection than half barriers [9]. The risky behaviour of car drivers at the level crossing often contributes to the long waiting time. The results can be a zigzag driving between level crossing barriers. This usually happens at level crossing equipped with two half-barriers [10]. Barriers have long been used as a safety measure at a level crossing, and new technology has increased their lifespan and production costs. The research [11] explores the problem of implementing new technology and identifying critical components for the modernisation of barriers at level crossings. Appling Value Analysis as an innovative approach, it was possible to identify critical components, regarding the value of the mechanisms, obsolescence and new solutions, aiming to modernise the level crossing barrier systems, always ensuring the safe fail mode. Although there is numerous international research on the accidents on a level crossing, including both passive and active protected level crossing, there is still a lack of research primarily dedicated to the problem of collision of vehicles and barriers and half-barriers.

3 Data

This study is based on two data sources: a database from the Ministry of the Interior [12] and the infrastructure manager HZ Infrastructure [2]. The infrastructure manager database of the HZ Infrastructure covers many parameters for accidents analysis in detail. In this research, data about the number of barrier and half-barrier fractures, month, date and time, location, the railway tracks category, frequencies of the fractures at the same barrier/half-barrier, causes and consequences of barrier/ half-barrier fractures are included. Data from 2014 to 2020 are analysed. This period is chosen as the data collection methodology in HZ Infrastructure is consistent from 2014, and the last published statistical data is from 2020.

4 Results

Any barrier and half-barrier breakage are an incident that represents an avoided accident and a potential injury or threat to the life of a LC road user. During the seven years from 2014 to 2020, there were 3,200 half-barrier/barrier breakages at level crossings in Croatia. The half-barrier/barrier breakages (Figure 1) show a declining trend, although annual figures are still high. In 2014, there were 469 half-barrier/barrier breakages at level crossings in Croatia, followed by 501 in 2015, 447 in 2016, 525 in 2017, 452 in 2018, 435 in 2019 and 378 in 2020.

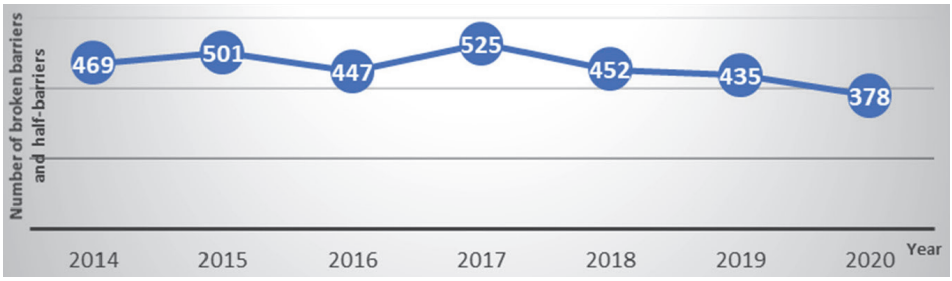

Figure 1 Number of barrier/half-barrier fractures (2014 – 2020)

Since the half-barriers/barriers at LCs were broken immediately before passing the train for which they were lowered, every half-barrier/barrier breakage could have led to an accident. The spatial distribution of barrier/half-barrier fractures (Figure 2) shows the highest concentration of fractures in the gravitational area of Zagreb, where it is also the highest concentration LCs and of railway traffic.

Figure 3 shows the monthly distribution of half-barrier/barrier breakages at level crossings in Croatia. The most significant number of half-barrier/barrier breakages occurred during July (11.3 %), followed by August and October (10.3 %). The lowest breakages occurred in the winter period, in January (6.3 %) and in November and December (6.5 %).

Time distribution for 24 hours a day (Figure 4) shows that the peak is from 12:00 to 13:00. The lowest number of barrier/half-barrier fractures (less than 2 %) is from 23:00 to 5:00. Regarding the railway tracks category (Figure 5), the most fractures with 65.3 % occur on main lines (M), 23.5 % on the regional lines (R) and 11.2 % on the local lines (L).

Figure 2 Spatial distribution of barrier/half-barrier fractures (2014 – 2020)

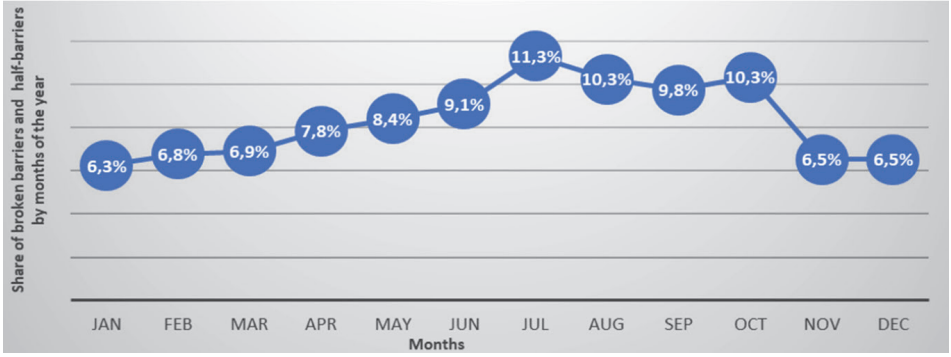

Figure 3 Monthly distribution of barrier/half-barrier fractures (2014 – 2020)

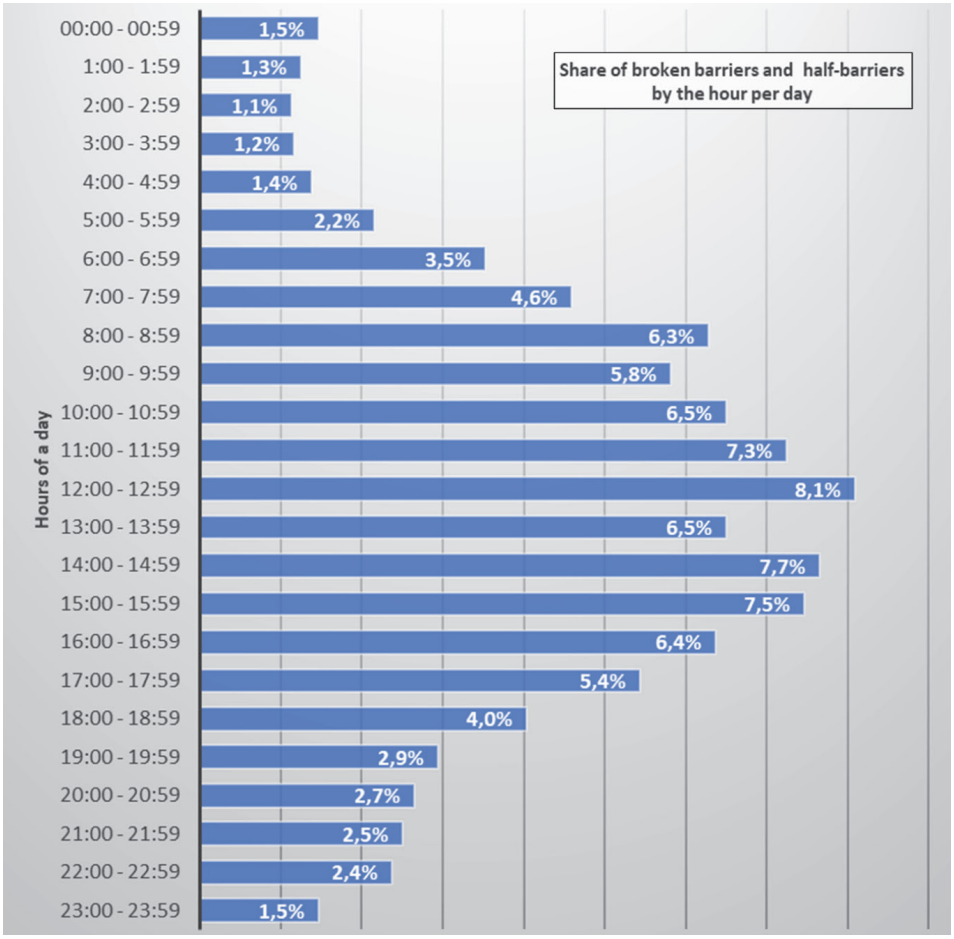

Figure 4 4-hours distribution of barrier/half-barrier fractures (2014 – 2020)

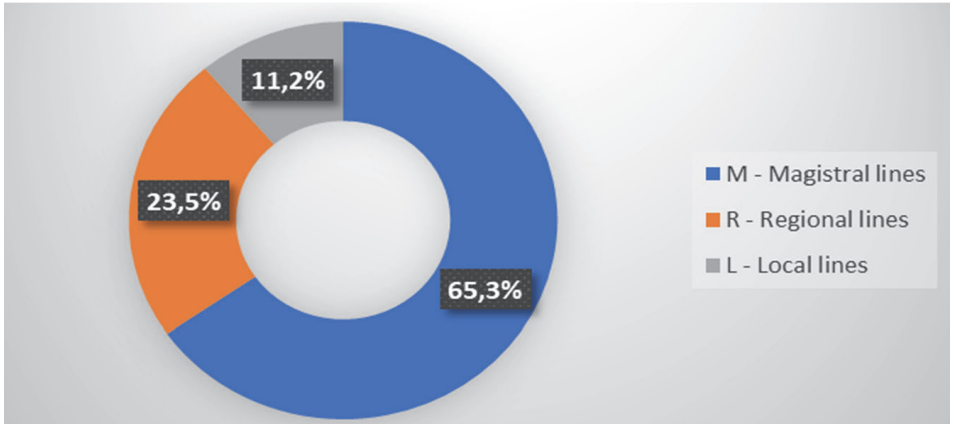

Figure 5 Distribution of barrier/half-barrier fractures by the railway tracks category (2014 – 2020)

An in-depth analysis of the barrier/half-barrier fractures indicates that fractures do not occur at all LCs but stand out critically where fractures occur several times a year. Figure 6 shows the most enormous number barrier/half-barrier fractures on the same LC in one year. The LC with the highest number of barrier/half-barrier fractures is LC named “Petra Kresimira” (652+783) on the railway line Zagreb Gk – Rijeka (M202), located in the city of Rijeka. From 2014 to 2020, 68 collisions occurred at that LC. Additionally, the most fractures occurred on that LC in 2015 (14 fractures), 2016 (8 fractures) and 2020 (8 fractures). The second extremely critical with a total of 62 fractures in the same period is LC named “Kolodvor Dugo Selo” (444+802) on the railway line Zagreb Gk - Dugo Selo (M102). There were 14 fractures in 2014 and 12 fractures in 2018.

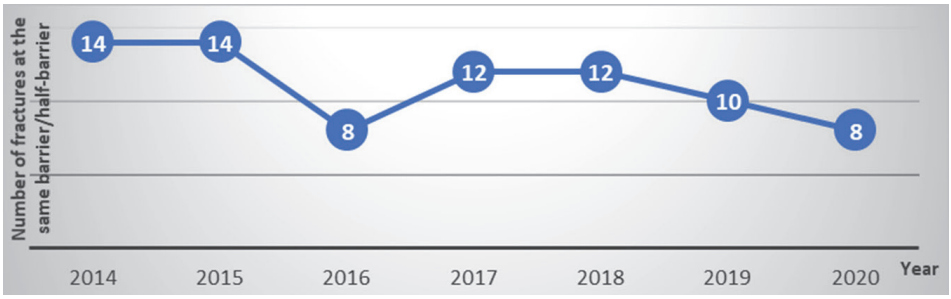

Figure 6 Number of fractures at the same barrier/half-barrier (2014 – 2020)

Causes of barrier/half-barrier fractures are categorised in four main categories: unidentified LC user, identified LC user (known data about LC user and vehicle), extreme weather conditions (primarily strong wind) and infrastructure manager error (Figure 7). In 93.4 % of cases, human behaviour is the cause of the barrier/half-barrier fractures (74.5 % unidentified and 18.9 % identified), followed by 6.3 % of weather conditions and only in a 0.3 % error of the infrastructure manager. It is worrying a high percentage of unidentified LC users left the incident scene without reporting any damage. The main consequences of barrier/half-barrier fractures are material damage on railway infrastructure, material damage on LC users’ vehicles and passenger and freight train delays. From 2014 to 2020, material damages to the railway infrastructure HZ Infrastructure were calculated due to half-barrier breakage in 3.958.094,31 HRK. HZ Infrastructure recorded 14,165 minutes of passenger and freight train delays during this period. Material damage on LC users’ vehicles. Data on material damage to LC users’ vehicles have not been recorded, and it isn’t easy to estimate it. Material damages to HZ Infrastructure due to half-barrier breakage per year is estimated at HRK 0.5 million [2].

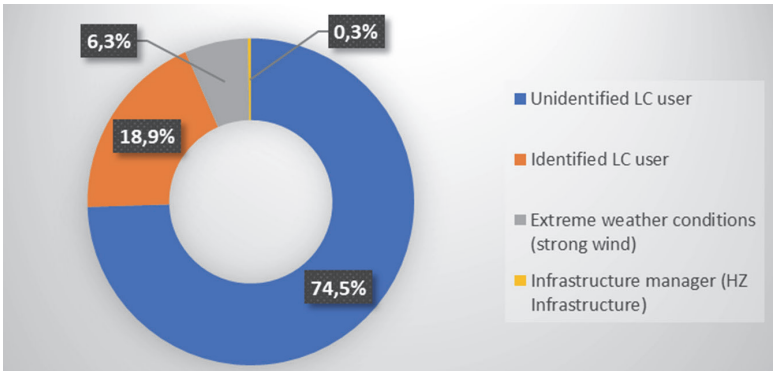

Figure 7 Causes of barrier/half-barrier fractures (2014 – 2020)

5 Discussion and conclusion

As the main cause of incidents and accidents is the human error of road users, many studies try to explain the reasons of driver behaviour to find appropriate measures to reduce them and education tools and training methodology. This study investigated data about the number of barrier and half barrier fractures, a monthly distribution of their fractures, time distribution during the day, spatial distribution, distribution by the railway tracks category, frequencies of the fractures at the same barrier and half barrier, causes and consequences of barrier and half barrier fractures. Data on the number of barrier/half-barrier fractures on the LCs is one of the leading indicators of traffic unculture in the Republic of Croatia. Although the number of breakages is decreasing yearly, there are still many bypasses and non-compliance with traffic rules by drivers of road motor vehicles, which can lead to severe consequences. Data on the barrier/half-barrier fractures only partially show the state of the driver's traffic culture because there is no information on intentional bypassing of the half-barrier in places where there was no damage or breakage. In addition to fractures, many LC failures due to the theft of copper parts are also significant. It is a huge problem, especially since no existence of CCTV on any LC could partially discourage perpetrators. Future research should include an in-depth analysis of the causes of crashes with barriers and half-barriers, i.e., investigating the reasons for drivers' risky behaviour on LCs to propose optimal safety measures. Risk reduction measures have to take into account all the LC users. Technology advancements will continue to reduce the risks associated with LCs. The concept of self-driving or autonomous road vehicles is becoming a reality. It is expected that they will be capable of connecting to the environment in which they operate, including LCs. With future development, it can be expected that the LCs vehicles would be able to communicate directly with approaching vehicles and warn drivers that a train is approaching. Maybe even take control of a road vehicle and safely bring it to a stop before reaching the crossing. The human factor, which is now the leading cause of accidents and incidents, would thus be reduced to a minimum. Until that distant future, current safety measures should educate and change patterns of risk behaviour of LC users.

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