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MAIN FACTORS INFLUENCING AN ACCIDENT RATE AT LEVEL CROSSINGS OF ŽSR

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Abstract: *The paper deals with analysis of the main factors having impact on safety of level crossings operated at the Slovak Railways (ŽSR). Considering a number of victims of traffic accidents, level crossings belong to places with the highest accident rate at the railway. Based on analysis of statistic data some conclusions are presented discussing what is contribution of level crossing systems to the whole safety, what impact of organizational measures on secondary safety is and how improper behaviour of road traffic participants contributes to accident rate.*

Key words: *safety, level crossing, statistics, analysis, organizational measures.*

INTRODUCTION

One of the main factors in the process of risk analysis and definition of safety requirements for railway level crossing systems is identification of hazards and their consequences. Identification of hazards may be realized either on the base of theoretical considerations and analyses or on the base of analysis of accident events and actual practical experience from operation of similar safety-related systems, however practically used approaches are mostly based on both.

RESULTS OF STATISTIC EVALUATION OF ACCIDENT EVENTS AT LEVEL CROSSINGS OF THE ŽSR

At present the total length of railway network in SR is 3661 km with 2322 level crossings being operated there. There are about 97% of relay-based systems and 3% of electronic systems. Level crossings (LCs) are built at the lines with the maximum train speed up to 120 km per hour. At present, building of LCs at the corridor lines having the maximum allowed speed 160 km per hour is allowed in exceptional and justified cases only. For the sake of enabling comparison, the Table 1 shows the way of equipping LCs in 1995 and 2006.

Table1 Statistic data on numbers of LCs at the ŽSR in 1995 and 2006

	1995	2006
Total number of level crossings at the ŽSR	2500	2351
Unprotected LCs	1385	1251
Protected LCs	1115	1100
Manual (mechanical) LCs	154	124
Automatic LCs – without barriers	440	451
Automatic LCs – with barriers	521	525

Automatic LCs without barriers operated at the ŽSR inform road traffic participants about an approaching train during the warning period (two red cross-flashing lights, situated side by side). In addition, in the basic state so called active signalling is also used. It is represented by one white flashing light, that informs about the fact there is no railway vehicle in LC area that could endanger traffic operation at the LC. However, this signal does not release road traffic participants from liability to become sure that no railway vehicle is really approaching the LC.

The speed limit for road traffic participants at Slovak LCs is 50 $km \cdot h^{-1}$ provided that the active signalling is being given, otherwise the speed limit is 30 $km \cdot h^{-1}$.

In 2006 the active signalling was installed at:

♦285 LCs (i.e. 54% out of all automatic LC systems with barriers);

♦312 LCs (i.e. 69% out of all automatic LC systems without barriers).

Official data sources can be used to get the following kinds of information:

♦ A kind of LC system installed at the LC where an accident event occurred;

♦ Category of line where an accident event occurred;

♦ Cause of an accident event;

♦ Consequences of an accident event.

Obtained statistic data is distributed according to causes of an accident event origin in such a way that causes cover the whole hazard space. The following causes are considered:

♦ H_{LC} – failure of LC system (hazardous functioning of the LC system, e.g. no warning activity when a railway vehicle is approaching the LC);

♦ H_{DER} – derailment of the railway vehicle at the LC (due to driftwood, downfallen load, ...);

♦ H_{OS} – failure of operating staff (e.g. when an equipment was out of order);

♦ H_{PRV} – failure of the person driving a railway vehicle;

Table 2 Numbers of accident events at LCs of the Slovak Railways (ŽSR)

	Unprotected LCs	Manual (mechanical) LC systems	Automatic LC systems – without barriers	Automatic LC systems – with barriers	LCs Totally
1995	26	5	24	12	67
1996	40	3	29	9	81
1997	38	2	30	11	81
1998	43	5	27	27	102
1999	34	1	30	12	77
2000	35	0	47	2	84
2001	30	0	20	17	67
2002	32	0	30	13	75
2003	17	0	14	9	40
2004	27	0	26	6	59
2005	35	1	27	8	71
2006	22	0	33	3	58

Table 3 Numbers of fatalities at railway LCs and Slovak roads

	Unprotected LCs	Manual (mechanical) LC	Automatic LC systems – without	Automatic LC systems – with	LCs Totally	Roads Totally
1995	0	0	3	0	3	698
1996	4	0	4	0	8	640
1997	2	0	8	4	14	828
1998	3	0	8	1	12	860
1999	3	0	5	0	8	671
2000	5	0	3	1	9	628
2001	4	0	6	3	13	614
2002	6	0	8	0	14	610
2003	1	0	4	0	5	645
2004	7	0	1	2	10	603
2005	3	0	3	1	7	560
2006	1	0	7	4	12	579

♦H_{RTP} – failure of a road traffic participant; (Note: from the viewpoint of consequence analysis it would be interesting to know if a road vehicle crashed into the railway vehicle or vice-versa; the way of collision has a significant effect on accident consequences);

♦H_{MS} – failure of the maintenance staff.

Even though accidents at railway LCs represent only a little part of all accidents that happened in road transport in the Slovak Republic (Table 2), they are usually associated with damages to human health (Table 3). Therefore it is necessary to deal with causes of these accidents in order to propose such measures that enable to reduce their numbers (under acceptable economic conditions).

Results from accident event analysis performed in relation to the cause and death consequences for the period 1995-2006 (automatic LC systems) are shown in Table 4.

The given statistic data indicates that numbers of fatalities at railway LCs represent ca 2% of all fatalities in road transport (Table 3). In addition, 859 out of total 862 accident events were caused by failure of road traffic participants, 2 were caused by failure of maintenance staff and only 1 was caused by failure of the LC system (Tables 2 and 4). Fatality rate at LCs (victims were always road users) does not change significantly during the analyzed period and oscillates along the value 10 fatalities per year (see Fig. 1).

It is very difficult to evaluate this parameter since it is influenced by different factors whose changes are unknown (e.g. traffic intensity, passive safety of road vehicles, etc.).

Table 4 Analysis of accident events at LCs equipped with automatic LC systems

Automatic LC systems	**Year**	**Cause**						
		H_{LC}	**H_{DER}**	**H_{OS}**	**H_{PRV}**	**H_{RTP}**	**H_{MS}**	**Σ H**
Accident event / consequence [number / death]	1995	0	0	0	0	36/3	0	**36/3**
	1996	0	0	0	0	38/4	0	**38/4**
	1997	0	0	2/0	0	39/12	0	**41/12**
	1998	1/0	0	0	0	53/9	0	**54/9**
	1999	0	0	0	0	42/5	0	**42/5**
	2000	0	0	0	0	49/4	0	**49/4**
	2001	0	0	0	0	37/9	0	**37/9**
	2002	0	0	0	0	43/8	0	**43/8**
	2003	0	0	0	0	23/4	0	**23/4**
	2004	0	0	0	0	32/3	0	**32/3**
	2005	0	0	0	0	35/4	0	**35/4**
	2006	0	0	0	0	36/11	0	**36/11**

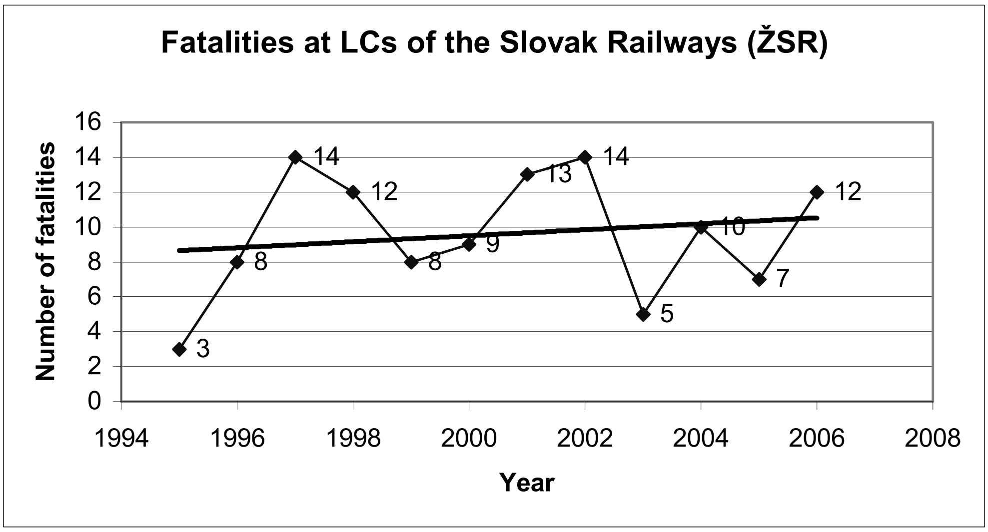

Fig. 1 Fatalities at Slovak LCs during the period 1995-2006

It will be worth to define unambiguous rules for collecting of statistic data and its processing, followed by definition of requirements for safety integrity. Ambiguity exists, for example in the fact, that some methods used for risk analysis are function-oriented, that is a set of safety-related functions is defined and risk is being estimated or calculated for each such a function, and consequently measures are being proposed to minimize risk to the required level. The problem consists in the fact that the list of such functions is not exactly defined but created by the analyst. In consequences of this approach the same procedure may finally bring a different safety level. It seems that from this point of view it is better to base analysis on consideration of the whole risk associated with the system.

CONCLUSIONS

The following facts result from the performed analysis of available statistic data:

♦ Failures of LC systems represent only little contribution to accident events occurred at LCs;

♦ Accident events at LCs are mostly caused by road traffic participants who do not respect traffic regulations;

♦ The number of accident events at LCs equipped with automatic LC systems with barriers is significantly lower than number of accidents at LCs equipped with LC systems without barriers;

♦ Least number of accidents occurred at LCs equipped with manually (mechanically) operated LC systems – it is caused by permanent presence of operating staff at the LC who is responsible for safety at the LC, and by existence of mechanical barriers that protect road vehicle drivers and pedestrians from entering the hazardous zone.

Safety at the railway LCs can be increased by:

♦ Reduction of the organization measures and substituting them with technical measures (e.g. installing of the LC system with barriers);

♦ Increase of availability of the LC system – in that case organizational measures will be extended to the traffic staff of railways too.

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ОСНОВНИ ФАКТОРИ, ВЛИЯЕЩИ ВЪРХУ БРОЯ НА КАТАСТРОФИТЕ ПРИ ПРЕЛЕЗИТЕ В СЛОВАШКИТЕ ЖЕЛЕЗНИЦИ

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Резюме: *Докладът анализира основните фактори, оказващи влияние върху безопасността на прелезите в Словашките железници (ŽSR). Като се вземат пред вид жертвите, прелезите са едни от местата с най-висок брой на инциденти в железниците. На базата на анализа на статистически данни са направени заключения, които дискутират значението на прелезите за общата безопасност, въздействието на организационните мерки върху безопасността и ролята на неправилното поведение на участниците в движението за повишаване на броя на катастрофите.*

Ключови думиs: *безопасност,прелези, статистика, анали, организационни мерки.*