Research for the prevention of legal violation type of level crossing accidents

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SUMMARY

In this study, we define “legal violation type of level crossing accident” as a collision between a train and automobile in which the automobile enters level crossing area after crossing alarm is sounded, where level crossing is equipped with crossing alarm and barriers (category 1 level crossing)”. We have analyzed the cause and discuss effective measures.

As a result, for accidents that occur with automobiles entering area before lowering of barrier, we confirmed that the obstacle detection device is significantly effective, that it is effective to lower the barrier on the entry side before the barrier on the exit side and that way of escaping for a trapped vehicle is not known.

Furthermore, for accidents caused by oversight, we confirmed that the causes of oversight differ in case of accidents occurring in cases of level crossing entry before or after lowering of barrier.

In addition, for accidents caused by deliberate entry, we confirmed that people who caused the accidents were either quite young or elderly, and the entry motivation is different in each case.

1. INTRODUCTION

JR-East has reduced the number of collision accidents between railway vehicles and automobiles at level crossings through several countermeasures such as installing "obstacle detection device" which notifies the train driver with an alarm when a trapped automobile is detected in a level crossing. This countermeasure is considered effective if a automobile is trapped within a level crossing before the crossing alarm is activated; however, the effect could be limited if it is trapped after the activation of the crossing alarm as the train may be approaching.

We analyze the cause and discuss effective measures about legal violation type of level crossing accident.

2. NUMBER OF VIOLATION TYPE LEVEL CROSSING ACCIDENT

In the 10 years from 2001 to 2010, 260 train and car collisions at JR-East category 1 level crossings have occurred. Through in-house analysis of the accident report, it is estimated that 104 (about 40%) of those were of the violation type.

3. THE ANALYSIS OF VIOLATION TYPE LEVEL CROSSING ACCIDENT

In order to analyze the cause of the 104 accidents, we classified accidents by error pattern of entry into the level crossing, reason of entry, and entry timing (entry before or after the barrier is completely lowered).

3-1. Error pattern of entry into level crossing

Accidents resulting from human-error patterns of entry were classified into the following three:

- Oversight : Entry due to unawareness of the level crossing itself, or alarm or barrier
- Intentional : Deliberate entry in spite of awareness
- Negligence : Entry due to driving error

3-2. Reason of entry

Accidents were classified according to reason of entry. (Refer to table for details of classification.)

3-3. Entry timing

Accidents were classified entry timing.

- Before lowering : Entry before barrier is completely lowered
- After lowering : Entry after barrier is completely lowered

The following table shows a summary of violation-type level crossing accidents according to the above classifications.

Table 1 - Summary of violation-type level crossing accidents

Error pattern	Entry cause	Entry timing		Sum total
		Before lowering	After lowering	
Oversight	With consciousness	10	[2] 9	19
	Sleepiness	2	8	10
	Subtotal	12	17	29
Intentional	Judged crossing was possible.	18	[3] 5	23
	Escape from police	0	1	1
	Subtotal	18	6	24
Negligence	Driving error	0	15	15
Unknown	-	7	29	36
Sum total	-	[1] 37	67	104

We analyzed and examined countermeasures regarding accidents which occur with automobiles entering before lowering of barrier [1], and accidents caused by oversight which occur with automobiles entering after lowering of barrier [2] and intentional entry which occurs with automobiles entering after lowering of barrier [3], to find possible measures for the railway operators, such as improvement of level crossing facilities.

4. ANALYSIS OF ACCIDENTS WHICH OCCUR WITH AUTOMOBILES ENTERING BEFORE LOWERING OF BARRIER

4-1.Effectiveness of the obstacle detection device

We analysed the effectiveness of the obstacle detection device described above for accidents that occur with automobiles entering before lowering of barrier. The relation between the existence of the obstacle detection device and the accident number is shown in Fig. 1.

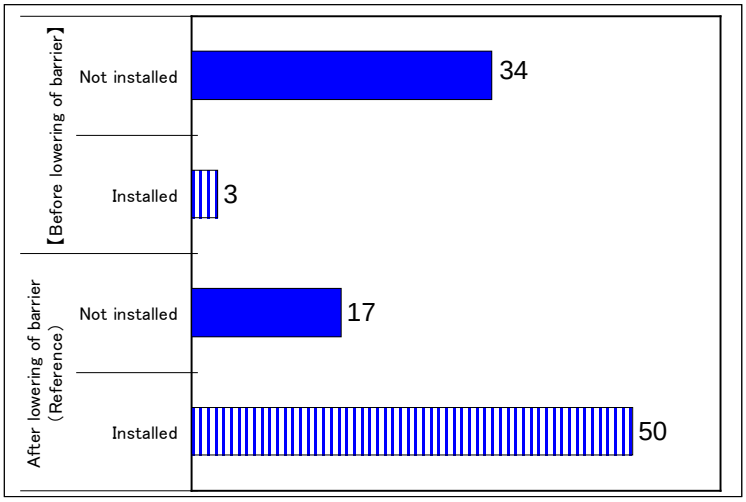

Figure 1: The relation between existence of obstacle detection device and accident number

Obstacle detection devices are not installed in 92% (34/37) of the level crossings at which the accident occurred. On the other hand, there are many level crossing accidents occurring after lowering of barrier despite the existence of an obstacle detection device. (It is considered to be because obstacle detection devices tend to be installed with priority on heavily-travelled level crossings, etc.) A significant relationship was recognized upon investigating the significance of the existence of the obstacle detection device before/after lowering of barrier ($p<.01$). As a result, we confirmed that the obstacle detection device is significantly effective against accidents that occur with automobiles entering before lowering of barrier.

4-2.Cause of inability to escape from a level crossing

On the other hand, when automobiles enter a level crossing before lowering of barrier, it should be able to escape, since there is usually a time margin before a train arrives. In the case of one set of barriers (one barrier installed on each side of the level crossing), the level crossing alarm is sounded with a time margin of 35 seconds or more before train passage. In the case of two sets of barriers (two barriers installed on each side of level crossing), the time margin is greater. As a result, so, we investigated reasons that a vehicle could not escape before the train reached the level crossing, and the attempted methods of escape. The result of analysis regarding events occurring after entering level crossing is shown in Fig. 2.

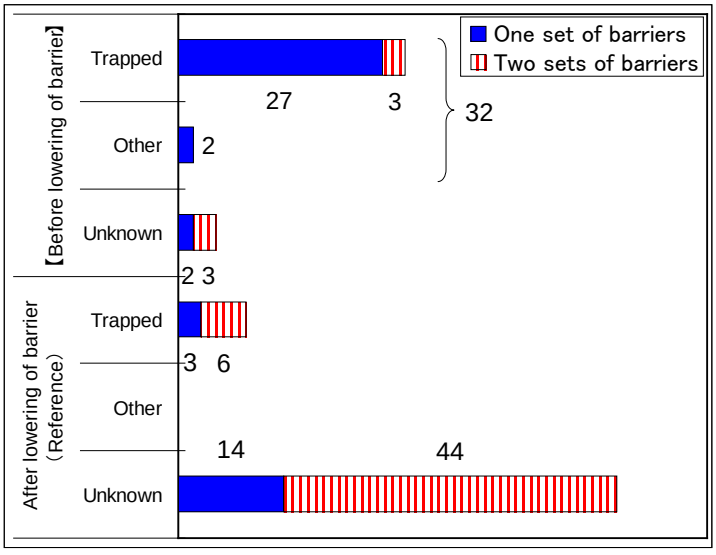

Figure 2: Cause of inability to escape from level crossing

94% of all accidents (30/32) occurred with trapped vehicles, and 90% of those (27/30) occurred where one set of barriers lowered simultaneously. In the case of two sets of barriers, accidents are less likely to occur than with one set of barriers, because the barrier on the entry side is lowered before that on the exit side. On the other hand, many level crossing accidents occur after lowering of barrier in the case of two sets of barriers. (It is considered to because two sets of barriers tend to be installed with priority on heavily-travelled level crossings, etc.)

As a result, we confirmed that it is effective to lower the barrier on the entry side before the barrier on the exit side.

4-3.Example of driver's action from time of vehicle trapped to accident

Rail companies have published the following as a recommended way for the escape of an trapped vehicle: “do not stop vehicle but keep going forward, allowing car bonnet to push up barrier to escape.” However, according to analysis of accidents with trapped automobile, the unsuitable actions were taken, for example “driver gets out of car on foot to raise barrier by hand (12)”, “driver leaves car in level crossing and escapes(5)” . In other words, proper escape methods are not known. As a result, we confirmed that it is required to reinforce common knowledge of how to properly escape from a level crossing.

5. ANALYSIS OF ACCIDENTS CAUSED BY OVERSIGHT

Ten accidents were caused by oversight before the barrier was lowered and nine afterwards. We analyzed the characteristics of level crossing accidents caused by oversight.

Table 2 - Characteristics of level crossing accidents caused by oversight

	Oversight-type		Other types
	Before lowering	After lowing	
Average width of road (m)	4.22	7.11	5.31
Average length of crossing (m)	9.37	7.39	9.36
Average number of trains per day	100.8	72.6	88.7
Average number of automobiles per day	1372	3302	1515
Average axes angle (deg)	75.4	75.1	77.2
Average visibility (m)	119.0	121.1	128.4

Typical examples of crossings at which each type of accident occurred are shown in Fig. 3.

Before lowering of barrier case

After lowering of barrier case

Figure 3: Typical examples of crossings at which accidents caused by oversight occur

The average width of road at which accidents occur before lowering of barrier is significantly narrow. On the other hand, the average width of road at which accidents occur after lowering of barrier is significantly wide and average length of crossing significantly short. However, neither number of trains per day, number of automobiles per day, axes angle, or visibility made any significant difference.

When ten crossings at which accidents occurred before lowering of barrier are checked by photographs, they tend to be narrow and small, and so it is assumed that almost all drivers are familiar with local geography. Therefore there is high possibility of oversight of level crossing alarm rather than the crossing itself.[1] As a result, we confirmed that the improvement in visibility of alarm would be effective, in addition to measures mentioned in chapter 4.

When nine crossings at which accidents occurred after lowering of barrier are checked by photographs, they are generally wide and large. At a wide level crossing, since the speed of automobiles is comparatively high, driver's kinetic vision tends to decline. Furthermore, the visibility of the alarm at level crossing decreases. Therefore there is high possibility of oversight of the level crossing itself or the alarm. Because the effect of the obstacle detection device is limited after lowering of barrier, it is very important to improve visibility of the level crossing itself, alarms, barriers, etc.

6. ANALYSIS OF ACCIDENTS CAUSED BY DELIBERATE ENTRY

Eighteen accidents were caused by deliberate entry after the barrier was lowered and five accidents before. We analyzed the characteristics of level crossings for accidents caused by deliberate entry before lowering of barrier. As a result, average visibility (81m) is significantly shorter ($p<.05$) than other level crossings (127 m). Therefore, it is guessed that it was difficult for the vehicle to stop before the level crossing at high speed and it passed through the level crossing. In addition, neither width of road, length of crossing, number of trains per day, number of automobiles per day, or axes angle made any significant difference.

On the other hand, analysis results of five accidents caused by deliberate entry after lowering of barrier are described as reference because the respective reasons of entry are ambiguous, as shown below.

- Noticed lowering of barrier, but was in a hurry. (1)
- Disregarded alarm, broke through barrier and entered level crossing. (2)
- Entered level crossing by force. (2)

We analyzed the characteristics at level crossings of accidents caused by deliberate entry after lowering of barrier. As a result, the average width of road (9.34m) is significantly shorter (*p<.01*) than other level crossings (5.31m). In addition, neither length of crossing, number of trains per day, number of automobiles per day, axes angle, or visibility made any significant difference.

We also analyzed the characteristics of the drivers of the five accidents caused by deliberate entry. As a result, we confirmed that those who caused three accidents were quite young (20, 20, 30 years old) and two accidents by those who were much older (73, 84 years old). Sample photos of the level crossings where these accidents occurred are seen in Fig.4.

・Elderly drivers case

・Young drivers case

Figure 4: Level crossings where accidents caused by deliberate entry after lowering of barrier occurred.

When five crossings at which the accidents caused by deliberate entry after lowering of barrier occurred are checked by photographs, they are generally wide, and so vehicle speed tends to increase.

[1] JAPAN RAILWAY ELECTRICAL ENGINEERING ASSOCIATION (1994) "Research on analytical survey of accidents in level crossing and visibility improvement of level crossing"

Elderly drivers are reported to have delayed response in stopping and steering, narrowed range of visibility and decrease in kinetic vision.[2] Moreover, it has been reported that there is a psychological tendency to believe that "the train will not come". Since it is not conceivable that elderly drivers would intentionally violate law and pass after lowering of barrier, it is possible "although they noticed alarm and would have entered before lowering of barrier, they did after lowering of barrier as a result “due to the above-mentioned elderly driver’s tendency. In these cases, the measures for visibility improvement at a crossing or alarm would probably be effective.

On the other hand, it has been reported that young drivers tend to speed and drive impulsively. For this reason, it is also considered that it was difficult to stop before the level crossing at high speed and they passed through the level crossing at the wide crossing shown in Fig. 4 where a vehicle can gain speed. In these cases, countermeasures such as some form of surveillance to serve as an inhibition to entry may be effective.

Regarding accidents caused by deliberate entry after lowering of barrier, we need to acquire still more detailed data and analyze it again in the future.

7. CONCLUSIONS

We analyzed 104 violation type level crossing accidents and the following conclusions were obtained.

- Obstacle detection devices are significantly effective against accidents that occur with automobiles entering before lowering of barrier,
- 94% of accidents occurred with trapped vehicles, and 90% of those occurred at level crossings where one set of barriers lower simultaneously**.**
- It is effective to lower the barrier on the entry side before the barrier on the exit side and to strengthen common knowledge of cautionary measures at level crossings.
- Causes of oversight differ, whether an accident occurring in a case of level crossing entry either before or after the barrier is lowered, it is very important to improve visibility of the level crossing itself, alarm, barriers, etc.

[2] Japan Traffic Safety Association (2010) “People-friendly safe drive”