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SAFETY ELEMENTS AT THE ROAD AND RAILWAY TRAFFIC CONFLICT POINTS

ABSTRACT

The work analyses the conflict points between road and railway traffic as points of collision. The growing frequency of both transport modes meeting at the same level results in the growing danger at these points resulting in turn in traffic accidents at collision points requiring therefore implementation of protection measures.

Since misreading of traffic signs, unadjusted driving of road vehicles, passage of road vehicles when the barrier is lowered, and inattention of motorists and pedestrians are the most frequent causes of traffic accidents at railroad crossings, adequate and economically optimal solutions need to be found.

By solving the above-mentioned problems, using the signal and safety as well as construction measures, the authors suggest solutions which would increase traffic safety at railroad crossings.

KEY WORDS

railroad crossings, traffic safety, conflict points

1. INTRODUCTION

At-grade crossings of road and railway lines as conflicting points of road and railway traffic represent a source of continuous danger for the safety of traffic participants.

The degree of danger increases by the increase of traffic frequency, inadequate protection of the railroad crossing, and under the influence of weather conditions.

The complexity of solving safety problems is also increased by the simultaneous participation of several traffic participants. Their different approach to solving this problem results from the number of emergency cases at a railroad crossing compared to the total number of traffic accidents, primarily in road traffic. Since the number of accidents at railroad crossings is negligible, this problem has been considered with less attention.

The best solutions, from the aspect of traffic safety, are the grade-separated railroad crossings. However, due to high costs of their design, the justification of such investments is always analysed and less expensive solutions applied.

Systemic solving of the railroad crossing problem is often slow, due to the great number of rules that form the standardised framework for such operation.

2. METHODS OF SOLVING SAFETY PROBLEMS AT RAILROAD CROSSINGS

Railroad crossings are protected by:

- marking the crossing by traffic signs insuring the visibility triangle from the road to the railway,
- construction of signalling and safety devices at crossings,
- designing railroad crossings in two levels.

2.1. Visibility Triangle as Element of Satisfactory Visibility from Road to Railway Line

If the railroad crossing is marked by traffic signs, and the visibility from road to the railway line is satisfactory, the at-grade railroad crossing can be considered as protected.

The prescribed visibility is determined by space limited triangle of visibility (marked by points ABC in Figure 1). The visibility starts at point B (in Figure 1) of the triangle of visibility, which is located in the cen-

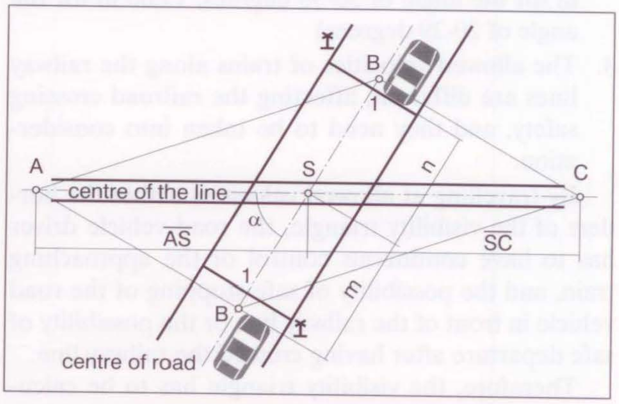

Figure 1 - Visibility triangle at railroad crossings

tre of the road carriageway and aligned with the traffic signs ("STOP" or "St. Andrew's Cross"). At that point the road vehicle is obliged to stop. Looking from that point to the left and to the right along the railway line, the driver should be able to see points (A and C) of the visibility triangle that are located in the centre of the railway track. These are the points at which the driver, looking from the halted road vehicle has to be able to observe the railway vehicle on the railway line.

For safe crossing of the road vehicle across the at-grade railway line, at the moment of train passage through the railroad crossing, the vehicle needs to be outside the railway line area, i.e. it should have already passed the boundary line (line 1 in Figure 1).

In accordance with the regulations regarding criteria, procedures, methods of determining and protecting the railway and the road (Official Gazette No. 32, 1994), it is not possible to determine unambiguously for all railroad crossings the dimensions of the visibility triangle, since there is a number of variables that influence the size of the triangle.

The regulations start from certain facts. However, these facts contain a number of variables.

1. Before crossing the railway line road vehicles must stop. The stopping point is aligned with the traffic sign, "St. Andrew's Cross" located at a distance of 3 to 10 meters from the railway line. The distance of the vehicle stopping point is a variable and it influences substantially the form and the size of the visibility triangle.
2. The halted road vehicles in front of the traffic sign have to start moving again. This requires different periods of time, which makes it also a variable.
3. After start-up, the road vehicle travels at uniform acceleration until reaching the velocity of V=5 km/h. However, the distance a vehicle has to pass in order to exit from the railway line area depends on the angle of the railroad crossing and varies from 3.5 m to 17 m. (it amounts to: 3.50 m for the angle of 80-90 degrees, 4.50 m for the angle of 70-79 degrees, 5.50 m for the angle of 60-69 degrees, 6.50 m for the angle of 50-59 degrees, 11,00 m for the angle of 30-39 degrees, 17,00 m for the angle of 20-29 degrees)
4. The allowed velocities of trains along the railway lines are different, affecting the railroad crossing safety, and they need to be taken into consideration.

By travelling at allowed velocities within the borders of the visibility triangle, the road vehicle driver has to have continuous control of the approaching train, and the possibility of safe stopping of the road vehicle in front of the railway line or the possibility of safe departure after having crossed the railway line.

Therefore, the visibility triangle has to be calculated for each railroad crossing separately. The distance of the intersection of the centres of the road and railway lines (point S) up to the end points of the visibility triangle (points A and C) due to the variables, needs to be calculated for every railroad crossing individually according to the expression:

$$AS = SC = V_v \cdot t$$

where:

V_v – maximum allowed velocity on the railway line,

t – overall required time for the road vehicle of the maximum allowed length to start after stopping (from point B) and to leave the railway line area with its rear part (to cross the line 1 on the opposite side of the railway line).

The crossing time of the road vehicle across the railway line contains a number of variables and is calculated according to the expression:

$$t = \frac{V_c}{a} + \frac{m+n+d-s}{V_c}$$

where:

V_c – velocity of the road vehicle on the railroad crossing (V_c = 5 km/h),

a – constant acceleration of the road vehicle (from the moment of starting in front of the sign „STOP“ until the moment of reaching the velocity of 5 km/h

m – distance of the traffic sign at which the car has stopped from the centre of the railway line (measured according to the centre of the road)

n – distance of the border of the railway line area (line 1) from the centre of the line (measured according to the centre of the road)

d – maximum allowed length of the road vehicles

s – path travelled by the vehicle after starting (from point B) until reaching velocity V_c.

The ground area within the visibility triangle should not contain any barriers such as movable or fixed structures or high vegetation. Urban plans and location and building permits should insure visibility in this area, although this has been neglected many times.

Often the unfavourable position of railroad crossings regarding configuration of the terrain (railway line in a curve or a cutting) along with the influence of severe weather conditions (night, fog) results in reduced visibility at railroad crossings and significantly affects traffic safety.

3. CLASSIFICATION OF RAILROAD CROSSINGS

In order to determine the optimal method of protecting the traffic, the crossings need to be classified first, regarding the handled road and railway traffic.

For classification of the crossings, traffic has to be recorded that is handled during one hour of peak load exerted on the respective crossing.

A factor of the traffic volume at a crossing can be obtained from the coefficient K, which is determined by the ratio of the total crossing occupancy time T_z by all vehicles and the difference of counting time T_m and the time the crossing is closed because of railway traffic $T_ž$ (available time for road traffic).

$$K = \frac{T_z}{T_m - T_ž}$$

The occupancy time of the crossing by road traffic can be empirically obtained out of the number of road traffic participants and the time required by each of them to pass the crossing, provided there is maximum traffic during the counting time, i.e.:

$$T_Z = 12.5 \cdot P(1+v) \quad [sec]$$

Variable P is obtained by summing up all the individual road traffic participants during one period of counting T_M, and regarding characteristics it is converted to the unit "passenger vehicle", i.e.:

$$P = n_p + 1.2 \cdot n_t + 1.7 \cdot n_š + 3.5 \cdot n_z + 0.2 \cdot n_b + 0.1 \cdot n_{pj}$$

where:

- n_p – number of passenger cars and motorcycles
- n_t – number of commercial vehicles and buses
- $n_š$ – number of commercial vehicles with trailers and articulated buses
- n_z – number of horse-drawn vehicles,
- n_b – number of bicycles and mopeds
- n_{pj} – number of pedestrians.

Factor v, during the occupancy period of the crossing by road traffic is empirically determined in the following way:

- for every meter of length of the road crossing in excess of 8.5 m, the factor v increases by 0.03;
- for a secondary road with low traffic volume, the factor v increases by 0.1;
- for several secondary roads with low traffic volume, the factor v increases by 0.25;
- for one or more secondary roads with the same traffic as the main road, the factor v increases by 0.4.

The time available for road traffic is in fact the occupancy period of the crossing by railway vehicles. Thus, for railroad crossings with normal railway traffic one can assume that a train occupies the railroad crossing approximately for 60 seconds on the average, which yields:

$$T_Z = 60 \cdot N \quad [sec]$$

where:

N – number of trains and shunting runs during counting, i.e. on the average during twelve hours of peak traffic.

The load coefficient K, according to previous expressions, looks as follows:

$$K = \frac{12.5 \cdot P \cdot (1+v)}{3600 - 60 \cdot N}$$

When the coefficient K equals one or is greater than one, then the crossing is considered as the one with higher volume of traffic. In case when K ranges between 0.5 and 1 - this is considered as moderate traffic volume. Low traffic volume at a crossing is characterised by the coefficient value less than 0.5.

According to this classification the method and level of protection, i.e. of technical equipment, is determined.

In order to determine the method and level of railroad crossing protection, the conditions of movement for road vehicles and for trains along the railway line at the moment of possible collision have to be set.

Due to the specific characteristics of railway traffic, the time and place of informing road traffic participants about approaching the railroad crossing have to be determined. Considered as the marginal case is the last moment in time when the road vehicle is exactly at the distance of the stopping path from the place of safe stopping in front of the border of the free profile of the railway line. This stopping limit must be marked by a suitable traffic sign. The position of the sign should be considered as the limit, since the road vehicle driver has no more time for safe stopping, including the response time.

4. CONCLUSION

It may be concluded that special attention needs to be paid to the railroad crossings as collision points between road and railway traffic. Regardless of the crossing classification, an obligatory visibility triangle needs to be always provided from the road to the railway line as minimum safety at the point of a possible emergency event.

Since insuring visibility triangles often raises proprietary problems due to many involved in the procedure, such solutions are often delayed and alternative solutions tend to be implemented with more or less success.

SAŽETAK

U radu se analiziraju mjesta sučeljavanja cestovnoga i željezničkog prometa kao kolizione točke. Povećanje frekvencije obje vrste prometa, koji se sučeljavaju u istoj razini, dovodi do povećanja opasnosti na tim mjestima, što rezultira prometnim nezgodama na kolizionim točkama, te je potrebno reagirati zaštitnim mjerama.

Kako su najčešći uzroci prometnih nezgoda na cestovnim prijelazima: nepoštivanje cestovnih prometnih znakova, neprilagođenje vožnje cestovnih vozila, prolaz cestovnih vozila ispod

spuštenih branika, te nepažnja vozača cestovnih vozila i pješaka nužno je pronaći adekvatna i ekonomski optimalna rješenja.

Rješavajući navedene probleme, koristeći se signalno-sigurnosnim i građevinskim mjerama autori predlažu rješenja za povećanje sigurnosti prometa na cestovnim prijelazima preko željezničke pruge.

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