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Professional paper

DETERMINING THE DANGER THRESHOLD OF INTERSECTION TRAFFIC ACCIDENTS

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Abstract

Summary: Accidents at intersections where the traffic is regulated with traffic signals are an everyday occurrence despite the right of way being clearly and unequivocally determined by a traffic sign. The problem is further complicated when one of the two participants is moving at an illegal speed. Hence, the question arises, of whether speed of movement can be imposed as a factor in creating danger, or whether the dangerous situation is the result of not respecting the right of way.
This paper will analyze the methodology of determining the danger threshold of intersection traffic accidents where traffic is regulated by traffic signals, and thus the procedure for determining dangerous traffic signals. In doing so, traffic situations at a four-way intersection will be covered, where both drivers maintain their direction of movement, and the driver who moves along the street with the right of way drives the vehicle at an illegal speed.

Keywords: Dangerous situation, danger threshold, traffic accident, speed.

Introduction

Traffic accidents are negative phenomena in the traffic system, which are usually the result of disobeying traffic rules and regulations. It is an indisputable fact that traffic accidents occur due to the mistakes of drivers, and one of the questions posed to experts in the field of traffic is: what omissions were made by the participants in a certain traffic accident, what connection do these omissions have with the occurrence of the traffic accident, under which circumstances the traffic accident could be avoided, etc.
The question often asked is whether the driver who was traveling at an illegal speed and took part in a traffic accident can be the participant who created the dangerous traffic situation and under what circumstances.
When discussing dangerous traffic situations, it is necessary to know what a dangerous situation is, so taking into account that there is no universally accepted definition of the term dangerous situation, what would most closely correspond to the definition of a dangerous situation can be formulated in the following way:
A dangerous traffic situation is any change in road conditions that requires the reaction of at least one participant to prevent a traffic accident.
The term *situation* refers to a set of circumstances regarding speeds, distances and the manner of movement of the traffic participant.
Intersection traffic accidents are particularly interesting, as one of the drivers joins the main street from a side street, and the other driver, who is moving along the street with the right of

way, drives the vehicle at an illegal speed. In such traffic accidents, it is necessary to answer which is the key omission, that is, which of the two participants created the dangerous traffic situation. Is the cause of the accident the failure to respect the right of way, or the movement of one of the participants in it at an illegal speed?
In order to answer the aforementioned question, it is necessary to introduce the term *danger threshold*, that is, the threshold distance between two vehicles through which it can be determined which of the two participants created the dangerous traffic situation.

Determining the danger threshold at an intersection

Movement speed can be imposed as one of the essential factors in creating a dangerous traffic situation. In a specific traffic accident, where one of the two participants joins the main street from a side street, and the other participant moves at an illegal speed, the question arises as to what the limit distance between the two vehicles is, to which the reason for the occurrence of a traffic accident will be non-compliance of the right of way, and which is the distance after which the speed of movement will be imposed as a factor in creating the danger.
Let's consider a case where there was a collision between vehicle 1 and vehicle 2, in a situation where the driver of vehicle 1 joins a road with the right of way, on which vehicle 2 encounters from his left side. At the same time, the driver of vehicle 2 is moving at illegal speed $V_2 \rangle V_{doz}$. In such a case, the question arises whether the driver of vehicle 2 can be the cause of the dangerous traffic situation, that is, in which case the dangerous traffic situation was created by the driver of vehicle 1, and in which case the driver of vehicle 2, who moves with illegal speed is the participant who created the dangerous traffic situation. To answer this question, it is necessary to determine the threshold of danger (S_{pr-op}).

The danger thresholdт (S_{pr-op}) in a situation where vehicle 1, joining from a secondary road and is moving in the same direction as vehicle 2, coming from its left side, represents the minimum distance at which vehicle 2 should be in relation to vehicle 1 for the driver of vehicle 1 to be able to safely join the street that vehicle 2 is moving on, without causing the driver of vehicle 2 to change the previous mode of movement (not to cause him to react by braking and/or shifting). If vehicle 2, which is moving at a higher speed than the maximum allowed, was at a greater distance from the danger threshold (S_{pr-op}), then, the dangerous traffic situation is created by the driver of vehicle 2 who is moving at an illegal speed. Otherwise, the dangerous traffic situation is created by the driver of vehicle 1 who started to join, in a situation where the conditions for safely entering the road on which vehicle 2 is moving were not met, i.e. the dangerous situation is the result of disregarding the right of way from the driver's side of vehicle 1.
In order for the driver of vehicle 1 not to cause the driver of vehicle 2 to react by braking, it is necessary for him, in the phase of joining the road with the right of way, to develop the speed with which vehicle 2 is moving, that is, in the last case, the maximum allowed. The required distance and the time it takes the driver of vehicle 1 from a stationary state to develop the maximum permitted speed of movement is:

$$S_{dnV1} = \frac{V_{doz}^2}{2 \cdot a_{V1}} \quad , \quad t_{dnV1} = \frac{V_{doz}}{a_{V1}}$$

During this time t_{dnV1}, vehicle 2, with the maximum permitted speed of movement, will cover a distance of:

$$S_{dnV2} = V_{doz} \cdot t_{dnV1} = V_{doz} \cdot \frac{V_{doz}}{a_{V1}} = \frac{V_{doz}^2}{a_{V1}}$$

Lastly, the danger threshold in this case can be determined as follows:

$$S_{pr-op} = S_{dnV2} - S_{dnV1} = \frac{V_{doz}^2}{a_{V1}} - \frac{V_{doz}^2}{2 \cdot a_{V1}}$$

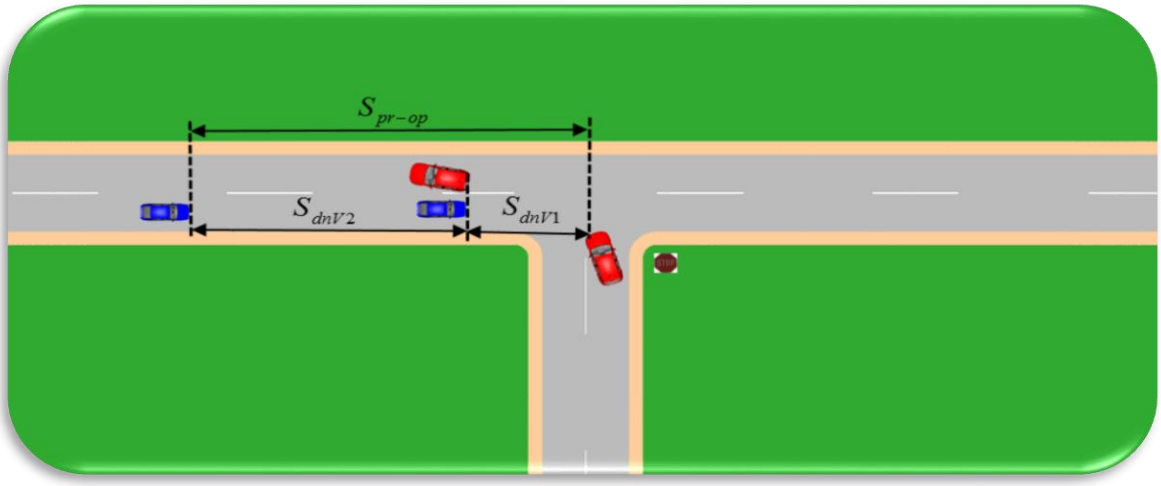
$$S_{pr-op} = \frac{V_{doz}^2}{2 \cdot a_{V1}}$$

Table 1. Values for the danger threshold under different conditions.

Ordinal number	Maximum allowed speed (V_{doz})	Maximum acceleration of vehicle 1 (a_{V1})	Danger threshold (S_{pr-op})
1	30 *km/h*	1,0 m/s^2	34,7 *m*
		1,5 m/s^2	23,1 *m*
		2,0 m/s^2	17,4 *m*
2	40 *km/h*	1,0 m/s^2	61,7 *m*
		1,5 m/s^2	41,2 *m*
		2,0 m/s^2	30,9 *m*
3	50 *km/h*	1,0 m/s^2	96,5 *m*
		1,5 m/s^2	64,3 *m*
		2,0 m/s^2	48,2 *m*
4	60 *km/h*	1,0 m/s^2	138,9 *m*
		1,5 m/s^2	92,6 *m*
		2,0 m/s^2	69,4 *m*
5	80 *km/h*	1,0 m/s^2	246,9 *m*
		1,5 m/s^2	164,6 *m*
		2,0 m/s^2	123,5 *m*

Source: Produced by the paper authors.

Table 1 gives the values for the danger threshold (S_{pr-op}) for a different value of the maximum permissible movement speed (V_{doz}) and a different value of maximum acceleration (a_{V1}) that can be developed by vehicle 1, which joins the road with the right of way.



Drawing 1. Danger threshold when turning from a side road, where both vehicles are moving in opposite directions.
Source: Produced by the paper authors.

Let us consider a case where a collision between vehicle 1 and vehicle 2 has occurred, in a situation where the driver of vehicle 1 joins a road with the right of way, after which vehicle 2 encounters him from his left side (see drawing 1). Meanwhile, the driver of vehicle 2 is moving at an illegal speed $V_2 \rangle V_{doz}$. And in this case, the question is posed: in which case was the dangerous traffic situation created by the driver of vehicle 1, and in which case is the driver of vehicle 2, who moves at an illegal speed, the participant who created the dangerous traffic situation?

The danger threshold (S_{pr-op}) in a situation where vehicle 1, joining from a side road and moving in the opposite direction of vehicle 2, coming from its left side, represents the minimum distance at which vehicle 2 should be in relation to vehicle 1, so that the driver of vehicle 1 can safely leave the lane on which vehicle 2 is moving, without causing the driver of vehicle 2 to change the previous mode of movement (not causing him to react by braking and/or moving in left or right).
In order for the driver of vehicle 1 not to cause the driver of vehicle 2 to react by braking, it is necessary for him to leave the lane on which vehicle 2 is moving during the phase of joining the road with right-of-way. The required distance to travel for vehicle 1 to leave the lane on which vehicle 2 is moving depends on the width characteristics of the thoroughfare on which vehicle 2 is moving, and the geometrical-technical characteristics of the intersection.
In such a case, the time it takes for the driver of vehicle 1, from a stationary state, to leave the lane on which vehicle 2 is approaching from his left side, amounts to:

$$t_{dnV1} = \sqrt{\frac{2 \cdot S_{dnV1}}{a_{V1}}}$$

During this time t_{dnV1}, vehicle 2, with the maximum permitted speed of movement, will cover a distance of:

$$S_{dnV2} = V_{doz} \cdot t_{dnV1} = V_{doz} \cdot \sqrt{\frac{2 \cdot S_{dnV1}}{a_{V1}}}$$

Lastly, the danger threshold in this case can be determined as follows:

$$S_{pr-op} = S_{dnV2} + S_{dnV1} = V_{doz} \cdot \sqrt{\frac{2 \cdot S_{dnV1}}{a_{V1}}} + S_{dnV1}$$

In Table 2, the values for the danger threshold (S_{pr-op}) are given, for different values of the maximum permissible speed (V_{doz}), the distance traveled by vehicle 1 to completely leave the lane on which vehicle 2 is moving, and different values of the maximum acceleration (a_{V1}) that can be developed by vehicle 1, which joins the carriageway with the right of way.

Table 2. Values for the danger threshold under different conditions

Ordinal number	Maximum allowed speed (V_{doz})	Distance to be covered by vehicle 1 (S_{dnV1})	Maximum acceleration of vehicle 1 (a_{V1})	Danger threshold (S_{pr-op})
1	30 *km/h*	10 *m*	1,5 m/s^2	40,4 *m*
			2,0 m/s^2	36,4 *m*
		12 *m*	1,5 m/s^2	45,3 *m*
			2,0 m/s^2	40,9 *m*
		15 *m*	1,5 m/s^2	52,3 *m*
			2,0 m/s^2	47,3 *m*
		10 *m*	1,5 m/s^2	50,6 *m*

2	40 *km/h*		2,0 m/s^2	45,1 *m*
		12 *m*	1,5 m/s^2	56,4 *m*
			2,0 m/s^2	50,5 *m*
		15 *m*	1,5 m/s^2	64,7 *m*
			2,0 m/s^2	58,0 *m*
3	50 *km/h*	10 *m*	1,5 m/s^2	60,7 *m*
			2,0 m/s^2	53,9 *m*
		12 *m*	1,5 m/s^2	67,6 *m*
			2,0 m/s^2	60,1 *m*
		15 *m*	1,5 m/s^2	77,1 *m*
			2,0 m/s^2	68,8 *m*
4	60 *km/h*	10 *m*	1,5 m/s^2	70,9 *m*
			2,0 m/s^2	62,7 *m*
		12 *m*	1,5 m/s^2	78,7 *m*
			2,0 m/s^2	69,7 *m*
		15 *m*	1,5 m/s^2	89,5 *m*
			2,0 m/s^2	79,5 *m*

Source: Produced by the paper authors.

Conclusion

In a situation where it is necessary to answer the question of whether the speed of movement can be the creator of the dangerous traffic situation, it is necessary to carefully carry out the time-space analysis, by correctly determining the disposition of the participants in certain characteristic moments before the contact between vehicles.
Through comparison of these calculated distances with the danger threshold, which was covered in this paper, it will be possible to draw a conclusion with regards to which of the two drivers created the dangerous traffic situation.
When discussing danger threshold determination, it is necessary to point out that there are a number of other situations it can be applied to, such as cases of changing traffic lanes, semi-circular turns, etc.

References

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