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# ASPECTS REGARDING THE NUMERICAL MODELLING OF PEDESTRIAN-VEHICLE ACCIDENTS WHEN BOTH PARTIES HAVE CONTINUOUS VISIBILITY OF EACH OTHER IN TRAFFIC

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***Abstract:*** *The paper evaluates from a physical and mathematical perspective the kinematic values of a traffic incident with continuous reciprocal visibility between a pedestrian and a vehicle in various stages of this incident. When evaluating the kinematic values that characterise such an incident one takes into account the parameters resulted from the initial research of the incident site, namely the testimonial evidence. By reconstructing the pedestrian traffic incidents one aims to determine: the vehicle's speed in various moments of the incident (the moment the incident danger occurred – the moment in which the pedestrian started to cross the road; the moment the braking marks are imprinted; the moment of the impact with the pedestrian); the distance between the vehicle and the pedestrian when the danger occurred; the length made by the pedestrian and the vehicle respectively from the moment the pedestrian stepped on the road and until they got hit by the vehicle; the time lapsed between the moment when the danger was noticed and the moment the pedestrian got hit; the time lapse for the driver's perception-reaction and the length made by the vehicle during this time; the analysis of all the possible variants for the incident to have been avoided.*

*The results obtained are in a graphic form and they provide the opportunity to observe various stages of the incident. The numerical model developed like this can be applied to solve a large number of traffic incidents of this type – pedestrian-vehicle – in order to establish the dynamics of such incidents and at the same time to establish the human factor involved in them.*

*The computerised analysis has several advantages–the reduction of the calculation time, the possibility to simulate various incident situations, etc.– and it becomes a useful and needed instrument for technical experts and engineers who reconstruct traffic incidents and develop safety systems on vehicles.*
***Key words***: *vehicle, pedestrian, traffic incident, reciprocal visibility, human factor, numerical modelling.*

## 1. INTRODUCTION

In Romania, from all the traffic incidents, about 18% are due to jay walking, about 8% due to drivers not letting pedestrians cross the street and about 5% are due to pedestrians being on the road [16, 22].

Crossing a road full of moving vehicles is a potential hazard for pedestrians, especially when this road is a highly used one, such is the case of roads crossing many towns and villages, where the number of pedestrians exposed to this hazard is higher than in the case of the roads outside towns or villages, because in the case of roads crossing through towns or villages we find many pedestrians starting to cross the road when they come out of the yard, an apartment building or from behind a stopped vehicle etc. [6, 9].

As a rule, the pedestrians will approach crossing the street in the direction that offers them the shortest route: that is perpendicular on the medial axis of the road. However, this is not always the case with under aged pedestrians. Usually, they cross the road so that they can get to groups of children or adults on the other side, not necessarily in a perpendicular direction. Other times, the crossing the street does not represent an aim, but it is the removal from a potential danger, as a self-defense mechanism, which, most of the times implies taking an oblique trajectory. Besides the pedestrians' trajectory against the axis of the road, there are several other aspects that assist in the clarification of traffic incidents [6, 8, 9]:

- the speed with which the pedestrians cross the road;
- whether the pedestrians maintain the same speed when crossing the road;
- whether crossing the road takes place with changes of direction or stops.

The moving speed of the pedestrians depend on the environmental conditions received, based on a temporary mental state, adapted to a specific behavioural situation. Clearly, if the pedestrians anticipate the possibility that they will be hit by a vehicle, they will adopt a higher speed when crossing the road. From an energy consumption point of view, the pedestrians' movement can be classified into: slow walk, casual walk, quick walk, brisk walk and brisk run [6, 8, 9, 15, 16]. In each case, the speed is influenced by a vast number of factors, among which are age, sex, physical shape, locomotor system deficiencies, items carried, etc. In order to identify the pedestrian various speeds, various specialised institutions from various countries have performed numerous experiments in various seasons, in places with various traffic intensities (street corners, pedestrian crossings, near big supermarkets) and in various weather conditions. The distances the pedestrians have crossed were between 4 and 9 m (the distances that are found most frequent in the case of traffic incidents with pedestrians involved), and the pedestrians have not been warned about these experiments, the age being established after timing them [6, 9, 15].

Crossing a road maintaining a constant speed and direction can be regarded as normal behaviour of pedestrians. However, there are also impredictible hesitant behaviours, most of them consisting in stops, turns around and moving in the opposite direction or taking a new direction [6, 8, 9, 16].

The complexity of reconstructing a traffic incident depends on the number and the nature of the factors influencing its production. In the case of pedestrian incidents, one must establish the evolution of their movements, speeds and directions. In what the drivers are concerned, one must establish their behaviour related to the attention paid, their reactions or their maneouvers that were still possible in order for them to avoid the incident [1, 5, 6, 7, 8, 9, 12, 15, 16, 21].

The evolution in time of the kinematic values that characterise a traffic incident can be captured using numerical calculus models, which are developed so that they can use as many variables possible to be encountered in traffic incidents and so the results can be synthetically presented either in tabular or graphic form. Unlike the tabular representations, the graphic ones provide an ampler overview, allowing us to take into account several causality relations, which is indispensable in the case of complex incidents [1, 5, 6, 9, 12, 13, 18].

## 2. THE NUMERICAL EVALUATION METHOD

The pedestrians are exposed to hazards when crossing the road and this leads them to choose the shortest distance most of the times, which is perpendicular to the road's direction (Fig. 1) [6, 9]. However, the common general framework of traffic incidents with pedestrians involved can be schematised (Fig. 2) [6, 9, 13] by representing the trajectories of both vehicles and pedestrians and placing them on a conventional road sector which contains all the basic elements that can be met in the vicinity. One must take into account the fact that most drivers involved in such incidents apply a combined maneouver to both avoid the pedestrian – which is usually a bypass turn immediately followed by a strong brake. Adopting the turn with one-two tenths of seconds before braking is the consequence of a lower reaction time to the turn than the braking [6, 8, 9].

When developing the numerical model for the impact incidents vehicle-pedestrian when both parties had good continuous visibility, one must take into account the general case of pedestrian incidents that has been rendered particular to the current researched situation – constant reciprocal visibility of both parties.

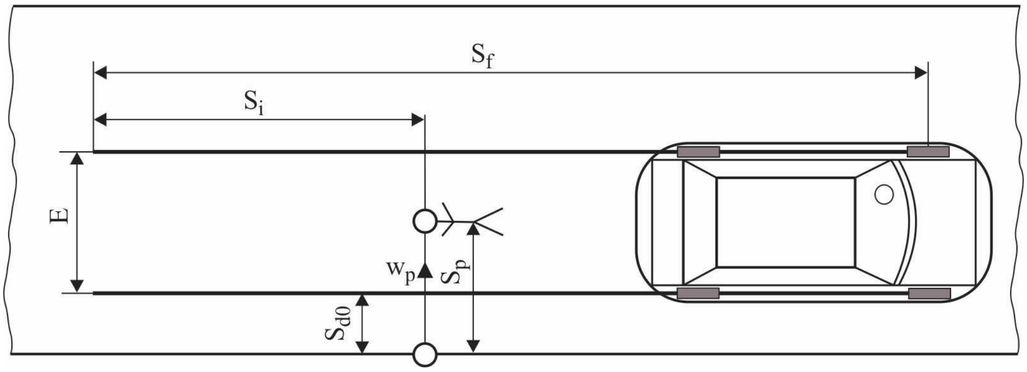


**Fig. 1.** Schematics of a pedestrian. E – the distance between the outer trace shape; $S_i$ – the distance covered by the vehicle from the moment it started braking with a constant deceleration up to the point it hits the pedestrian; $S_f$ – the length of the braking marks on the road; $S_{d0}$ – the distance between the right hand side edge of the sidewalk and the origin point of the braking marks imprinted by the right hand side wheels; $S_p$ – the distance covered by the pedestrian from the moment they started to cross the road until the moment of the impact; $w_p$ – the speed of the pedestrian when crossing the road.

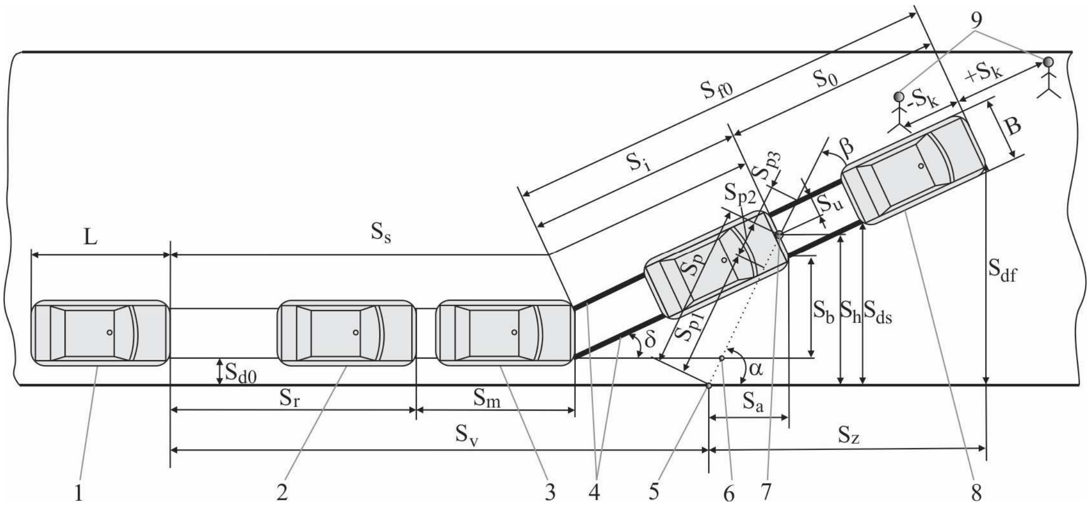


**Fig. 2.** General schematics for the reconstruction of incidents with pedestrians. 1 – the position of the vehicle at the initial moment of the danger of an incident; 2 – the position of the vehicle after the driver's perception-reaction time lapse; 3 – the position of the vehicle at the braking initial stage; 4 – raking marks; 5 – the pedestrian's position at the beginning of crossing the road; 6 – the pedestrian's trajectory when crossing; 7 – the pedestrian's position at the impact moment; 8 – the position of the vehicle stopped at the end of the braking marks; 9 – the victim's position after the incident.

The numerical algorithm using MathCAD is based on the values of the parameters resulted from the initial research of the incident place and from the testimonials found in the case file, such as (see Fig. 2) [6, 9, 13]:

- the distance $S_z$ measured parallel with the road, between the front of the stopped vehicle and the place where the pedestrian started to cross the road;
- the distance $S_{f0}$ from the initial place of the brake marks to the front of the stopped vehicle ($S_{f0} \cong S_f + C_f$, $C_f$ being the front console of the vehicle);
- the distances $S_{df}$ and $S_{ds}$ between the right hand side of the front and back of the stopped vehicle and the right hand side edge of the sidewalk;
- length $S_f$ a of the braking marks;
- the distance $S_{d0}$ between the right hand side edge of the sidewalk and the beginning of the braking mark done by the right side of the vehicle;
- length $L$ and the width $B$ of the vehicle;
- the distance $S_u$ between the impact print of the front of the vehicle and the left alignment of the body of the vehicle;
- according to the state and nature of the road we choose the adherence $\varphi$ and skidding $\varphi_s$ coefficients;

- time $t_m$ lapsed from the initial braking moment (when the driver stepped on the braking pedal) until the marking starts is chosen according to the brake manufacturing technique;
- speed $w_p$ and the pedestrian's trajectory inclination $\alpha$ will be deduced from testimonial evidence.

*Table 1*

**Parameters used in reconstruction of pedestrian traffic incidents**

| The size | Notation | M.U. |
|---|---|---|
| ❑ impact location to the front of the stopped vehicle | $S_0$ | m |
| ❑ impact location to the closest edge of the road | $S_h$ | m |
| ❑ location of the pedestrian when they started crossing the road, defined by the distance | $S_z$ | m |
| ❑ the distance covered by the pedestrian from the initial moment of crossing the road till the moment of the impact | $S_p$ | m |
| ❑ the pedestrian's mass | $m_p$ | kg |
| ❑ the mass of the vehicle | $m_v$ | kg |
| ❑ the speed of the vehicle in various moments of the incident | w | m/s |
| ❑ the speed of the vehicle at the moment of the danger of the incident (the moment when the pedestrian started to cross the road) | $w_v$ | m/s |
| ❑ the speed of the vehicle when it started to brake (braking marks) | $w_f$ | m/s |
| ❑ the speed of the vehicle in the initial impact moment with the pedestrian | $w_i$ | m/s |
| ❑ the speed of the vehicle when it became equal to the pedestrian's speed | $w_{vp}$ | m/s |
| ❑ the pedestrian's speed | $w_p$ | m/s |
| ❑ the time used for the pedestrian to cover distance $S_p$ | $t_p$ | s |
| ❑ the distance covered by the vehicle from the moment of braking with a constant deceleration until the moment of impact | $S_i$ | m |
| ❑ the distance covered by the vehicle in time $t_m$ corresponding to the increase in the deceleration and until its maximum value (wheels lock) | $S_m$ | m |
| ❑ the driver's reaction time | $t_r$ | s |
| ❑ the distance covered by the vehicle in time $t_r$ | $S_r$ | m |
| ❑ the distance between the vehicle and the pedestrian when this one started to cross the road | $S_v$ | m |
| ❑ the distance covered by the vehicle in the moment the pedestrian started to cross the road and until they got hit | $S_s$ | m |

The most frequent traffic incidents are the ones in which we know where the pedestrian started to cross the road (see Fig. 2). Table 1 defines the values and the notations [6, 9, 13] that characterise such incidents.

For reconstruction purposes, one chooses the initial landmark to which the kinematic values of the vehicle and the pedestrian are correlated. Preferably this landmark should be identical with the impact site of the vehicle with the pedestrian; a convention is made so that all values previous to this moment are marked with minus and all the ones that succeed it are marked with plus. With $S_1$ and $S_2$ we marked the distances where both the vehicle and the pedestrian were before the moment of impact. Thus we take into account the speed evolution of the vehicle and the distances $S_1$ and $S_2$ to which the vehicle and the pedestrian were at related to the impact point before and after the initial landmark [6, 9, 13].

When reconstructing pedestrian incidents we are interested especially in these elements:

- the speed of the vehicle in various moments of the incident (at the moment when the danger occurred – the moment the pedestrian started crossing the road; the moment of the braking markings; the impact moment), in order to check whether it was within legal limits or if it was adapted to the particular driving and traffic conditions;
- the distance $S_1$ to which the vehicle was situated in relation to the impact location;
- the distance $S_2$ between the pedestrian and the impact site (only for negative values of $t$);
- time $t_p$, needed to establish if there was enough to give the driver the opportunity to make evasive maneouvers;
- time $t_r$, needed to establish if the driver was paying attention or not;
- distance $S_r$ covered by the vehicle in time $t_r$;
- distance $S_s$, covered by the vehicle from the moment the pedestrian started crossing the road until the moment of impact, in order to establish if the driver made proper evasive maneouvers.

If we mark with $S$ the distance between the vehicle and the end of the braking marks at a random moment $t$, the kinematic values that are relevant for the reconstruction of the incident (for the limited value range S ≥ 0) are determined according to this variable *S* [6, 9, 13]. In order to convey graphically the speed variation of the vehicle and the distances covered by both the vehicle and the pedestrian in various moments of the incident, the numerical calculation model was developed in such a way that the kinematic values to be expressed according to the S variable so [1, 5, 6, 8, 9, 13, 18]:

$$w(S)=\begin{cases}\sqrt{2\cdot\varphi_S\cdot g\cdot S} & \text{if} \quad 0\le S<S_{f0}\\ \sqrt{w_f^2+2\cdot\varphi\cdot g\cdot(S-S_{f0})} & \text{if} \\ & S_{f0}<S<S_{f0}+S_m\\ w_v & \text{otherwise}\end{cases}, \quad (1)$$

where:

$$S_m=\frac{w_v^2-w_f^2}{2\cdot\varphi\cdot g}, \quad (2)$$

$w_v$ is the speed of the vehicle before braking, which can be expressed with the relation:

$$w_v=w_f+\frac{\varphi\cdot g\cdot t_m}{2}, \quad (3)$$

$w_f$ – the speed of the vehicle at the beginning of braking with a constant deceleration,

$$w_f=\sqrt{w_i^2+2\cdot\varphi_S\cdot g\cdot S_i}, \quad (4)$$

$w_i$ – the speed of the vehicle in the initial moment of the impact with the pedestrian, given by the relation:

$$w_i=\frac{m_v+m_p}{m_v}\cdot w_{vp}, \quad (5)$$

$w_{vp}$ – the speed of the vehicle in the moment its speed became equal to the pedestrian's speed, given by the relation:

$$w_{vp}=\sqrt{2\cdot\varphi_S\cdot g\cdot S_0}, \quad (6)$$

$$S_0=\frac{S_z-S_a}{\cos\delta}, \quad (7)$$

$\delta$ being the inclination of the braking markings (defined by the angle formed by the direction of the movement of the vehicle before initiating the turn and the braking marks) (see Fig. 2):

$$\delta=\arcsin\frac{S_{df}-S_{d0}}{S_{f0}}. \quad (8)$$

Time *t(S)*, specific to the distance *S* is determined with the relation [6, 9]:

$$t(S)=\begin{cases}\frac{\sqrt{2\cdot\varphi_s\cdot g\cdot(S_{f0}-S_i)}}{\varphi_s\cdot g}-\\ -\frac{\sqrt{2\cdot\varphi_s\cdot g\cdot S}}{\varphi_s\cdot g} \quad \text{if} \quad 0\le S<S_{f0}\\ \frac{\sqrt{2\cdot\varphi_s\cdot g\cdot(S_{f0}-S_i)}}{\varphi_s\cdot g}-\\ -\frac{\sqrt{w_f^2+2\cdot\varphi\cdot g\cdot(S-S_{f0})}}{\varphi_s\cdot g}+\\ +\frac{\frac{\varphi\cdot g\cdot t_m}{2}}{\varphi_s\cdot g}-t_m \quad \text{if}\\ \qquad S_{f0}<S<S_{f0}+S_m\\ \frac{\sqrt{2\cdot\varphi_s\cdot g\cdot(S_{f0}-S_i)}-w_f}{\varphi_s\cdot g}-\\ -t_m-\frac{S-(S_{f0}+S_m)}{w_v} \quad \text{otherwise}\end{cases}. \quad (9)$$

Distance $S_1(S)$ at which the vehicle is located in relation to the impact site is defined with the relation [6, 9]:

$$S_1(S)=S_{f0}-S_i-S. \quad (10)$$

Distance $S_2(S)$ between the pedestrian and the impact site [6, 9],

$$S_2(S)=\begin{cases}w_p\cdot\left[\begin{array}{l}\frac{\sqrt{2\cdot\varphi_s\cdot g\cdot(S_{f0}-S_i)}}{\varphi_s\cdot g}-\\ -\frac{w_f}{\varphi_s\cdot g}-t_m-\\ -\frac{S-(S_{f0}+S_m)}{w_v}\end{array}\right] \quad \text{if}\\ \qquad S\ge S_{f0}-S_i\\ 0 \quad \text{otherwise}\end{cases}. \quad (11)$$

Distance $S_p$, in m, which the pedestrian covered from the moment of crossing the road to the impact site is given by the relation (see Fig. 2) [6, 9]:

$$S_p=\frac{S_a}{\cos\alpha}, \quad (12)$$

and the time $t_p$, in s, in which they covered this distance is:

$$t_p=\frac{S_p}{w_p}, \text{ [s]}. \quad (13)$$

$S_a$, in m, is the projection of the segment $S_p$ along the direction of the road (see Fig. 2) [6, 9]:

$$S_a = \frac{S_{df} + (B - S_u) \cdot \cos\delta - S_z \cdot tg\delta}{tg\alpha - tg\delta}. \quad (14)$$

The impact site is characterised, apart from distance $S_0$ and the distance $S_h$, in m, (see Fig. 2) [6, 9]:

$$S_h = S_a \cdot tg\alpha. \quad (15)$$

The trajectories of the vehicle and the pedestrian are characterised by the angle $\beta = \alpha - \delta$ (see Fig. 2).

The distance $S_i$ was covered in time $t_{fi}$, in s, (see Fig. 2) [6, 9]:

$$t_{fi} = \frac{w_f - w_i}{\varphi_s \cdot g}, \text{ [s]}. \quad (16)$$

Time $t_r$ is the driver's reaction time in s and can be determined with the relation [6, 9]:

$$t_r = t_p - t_{fi} - t_m. \quad (17)$$

Distance $S_r$, in m, covered by the vehicle in time $t_r$, is given by the relation [6, 9]:

$$S_r = w_v \cdot t_r. \quad (18)$$

The moment the pedestrian started to cross the road, the vehicle was found at a distance $S_v$, in m, given by the expression [6, 9]:

$$S_v = (S_{f0} - S_0) \cdot \cos\delta + S_m + S_r - S_a. \quad (19)$$

From the moment the pedestrian started to cross the road until they got hit, the vehicle covered distance $S_s$, in m [6, 9]:

$$S_s = S_{f0} - S_0 + S_m + S_r. \quad (20)$$

With regards to *the analysis of the possibilities to avoid the incident*, we check if the vehicle could have been stopped by braking right at the impact site or before it or if the pedestrian deviated from the trajectory on which the vehicle was moving before it had managed to touch them with its front part. Thus, we can determine the total stopping distance $S_{te}$, if the vehicle moved with a speed $w_m$, a value that is around the legal speed value for that particular part of the road [6, 9]:

$$S_{te} = w_m \cdot t_r + \frac{w_m^2 - \left(w_m - \frac{\varphi \cdot g \cdot t_m}{2}\right)^2}{2 \cdot \varphi \cdot g} + \frac{\left(w_m - \frac{\varphi \cdot g \cdot t_m}{2}\right)^2}{2 \cdot \varphi_s \cdot g}. \quad (21)$$

If $S_{te} < S_s$, the incident could have been avoided, since the vehicle stopped before the impact site. If $S_{te} > S_s$, we determine the speed $w_{me}$ of the vehicle passing by the site where the pedestrian could have passed the moving trajectory of the vehicle [6, 9]:

$$w_{me} = \sqrt{2 \cdot \varphi_s \cdot g \cdot \left(S_{te} - S_s - \frac{S_u}{tg\beta}\right)}. \quad (22)$$

In this case, time $t_{se}$ is determined by the relation [6, 9]:

$$t_{se} = t_r + t_m + \frac{w_m - \frac{\varphi \cdot g \cdot t_m}{2} - w_{me}}{\varphi_s \cdot g}, \quad (23)$$

and time $t_{pe}$ with the relation [6, 9]:

$$t_{pe} = t_p + \frac{S_u}{w_p \cdot \sin\beta}. \quad (24)$$

If $t_{pe} \le t_{se}$, the incident could have been avoided, the pedestrian being away from the trajectory of the moving vehicle before it would have gotten to them.

## 3. OBTAINED RESULTS

The reconstruction of the incident is presented in a graphic form by which we can determine the dynamics of the incident. We can draw the curves for the speed *w(S)* and for the distances $S_1(S)$ and $S_2(S)$ according to the time *t(S)*. As an example, this is the case of a traffic incident which took place in a town and in which a vehicle hit a 55 year old male who was engaged in a brisk walk when crossing a horizontal road. Of the known parameters we mention: $m_p = 82$ kg; $m_v = 1285$ kg; $L = 4.238$ m; $B = 1.765$ m; $C_f = 0.881$ m; $S_{d0} = 2.2$ m; the distance between the outer shape from the exterior tracks, $E = 1.534$ m; $S_f = 31$ m; $S_{df} = 2.2$ m; $S_{ds} = 2.2$ m; $S_u = 0.75$ m; $S_z = 16$ m; $S = 1 \ldots 60$ m; according to the state and the cover of the road we choose the adherence and skidding coefficients $\varphi$ and $\varphi_s$ (dry asphaltic envelope: $\varphi = 0.75$; $\varphi_s \cong 0.8 \cdot \varphi$ [6, 9, 14, 15, 19, 20]); time $t_m$ lapsed from the initial braking moment (pushing down the brake pedal) until the braking marks are made is chosen according to the way in which the braking system was manufactured (if the vehicle has been equipped with braking limitators in a good condition:

$t_m = 0.2\ s$ [2, 3, 4, 6, 7, 8, 9, 10, 11, 17]); speed $w_p$ and the inclination $\alpha$ of the pedestrian's trajectory come out from the testimonial evidence ($w_p = 1.667\ m/s$ [6, 8, 9, 15]; $\alpha=90^0$).

Based on the imput data and using a numerical caculus model based on MathCAD, we obtain the graphic interpretation results of the kinematic values that characterise the vehicle-pedestrian collision types (Fig. 3).

Thus, the results show (see Fig. 3) that the vehicle, from an initial speed, before braking, of *74.66 km/h*, it ended at the impact moment with a pedestrian at a speed of *52.56 km/h*, and when the speed was equal to the pedestrian's, it was *49.41 km/h*. The driver had a reaction time of *0.81 s*, which is within recommended limits for situations that claim an imminent danger [3, 4, 5, 6, 7, 8, 9, 10, 11, 12], which reflects a normal behavious, they noticed the danger, started braking as soon as the pedestrian stepped into the road. From the moment when the pedestrian started to cross the road until the impact moment, the vehicle covered a distance of *34.74 m*, and the pedestrian *3.22 m* in *1.93 s*. After the impact, the vehicle covered another *16 m* in approx. *2.3 s*. The results graphically obtained (see Fig. 3) enable us, apart from checking the spped of the vehicle in various stages of the incident, to also evaluate the distance $S_1$ at which the vehicle is placed in relation to the impact site, respectively distance $S_2$ between the pedestrian and the impact site, which is directly influenced by the pedestrian's approach when crossing the road and their speed.

With regards to the analysis of the possibilities of avoiding the incident, taking into account the conditions under which the incident took place and the legal speed limit in that type of road (*50 km/h*), we notice that if the vehicle had run before braking with this speed, the incident could have been avoided, since the vehicle could have stopped before the impact site ($S_{te} < S_s$, $S_{te} = 27.31\ m$, $S_s = 34.73\ m$). In the case of vehicle speeds higher than *58 km/h*, $S_{te} > S_s$, but taking into account that the pedestrian, according to the initial data, was walking briskly, the accident would not have happened had the vehicle run with an initial speed of maximum *65 km/h*, where $t_{pe} = 2.37\ s$, $t_{se} = 2.39\ s$, thus $t_{pe} \leq t_{se}$, the pedestrian could have come out from the trajectory of the vehicle before it could hit them with the frontal part.

## 4. CONCLUSIONS

Applying the method we developed enables us to reconstruct pedestrian incidents as long as certain data from the impact site is known.

The numeric model we developed can be applied in solving traffic incidents with vehicle-pedestrian involvement to establish the dynamics of their occurrence and at the same time to analyse possibilities to avoid them in the first place. For the numerical calculations we need a relatively small amount of data which, generally is collected from any incident site. The results of the incident reconstructions and the ones that describe the temporal evolution of the kinematic values can be synthetically presented in a tabular or graphic form and, when needed, they can be graphically represtented so that they can offer a clearer temporal picture of the incident and its evolution.

The calculation model allows the change in the input data, taking into account other impact conditions, respectively obtaining graphic result interpretation that will highlight various factors that contribute to the evolution of pedestrian-vehicle type of incidents.

In this type of cases, the values that vary the most is the distance between the pedestrians and the impact site $S_2$, and this is due to the fact that the pedestrians' way of crossing the road and their speed vary from one pedestrian to another, according to their age, sex, etc.

A computerised analysis comes up with lots of advantages (modelling various impact conditions, taking into account several influencing factors at the same time, a reduced working time, etc.) and it becomes a useful and necessary instrument for the specialists that work to reconstruct traffic incidents or who work to develop vehicle safety systems.

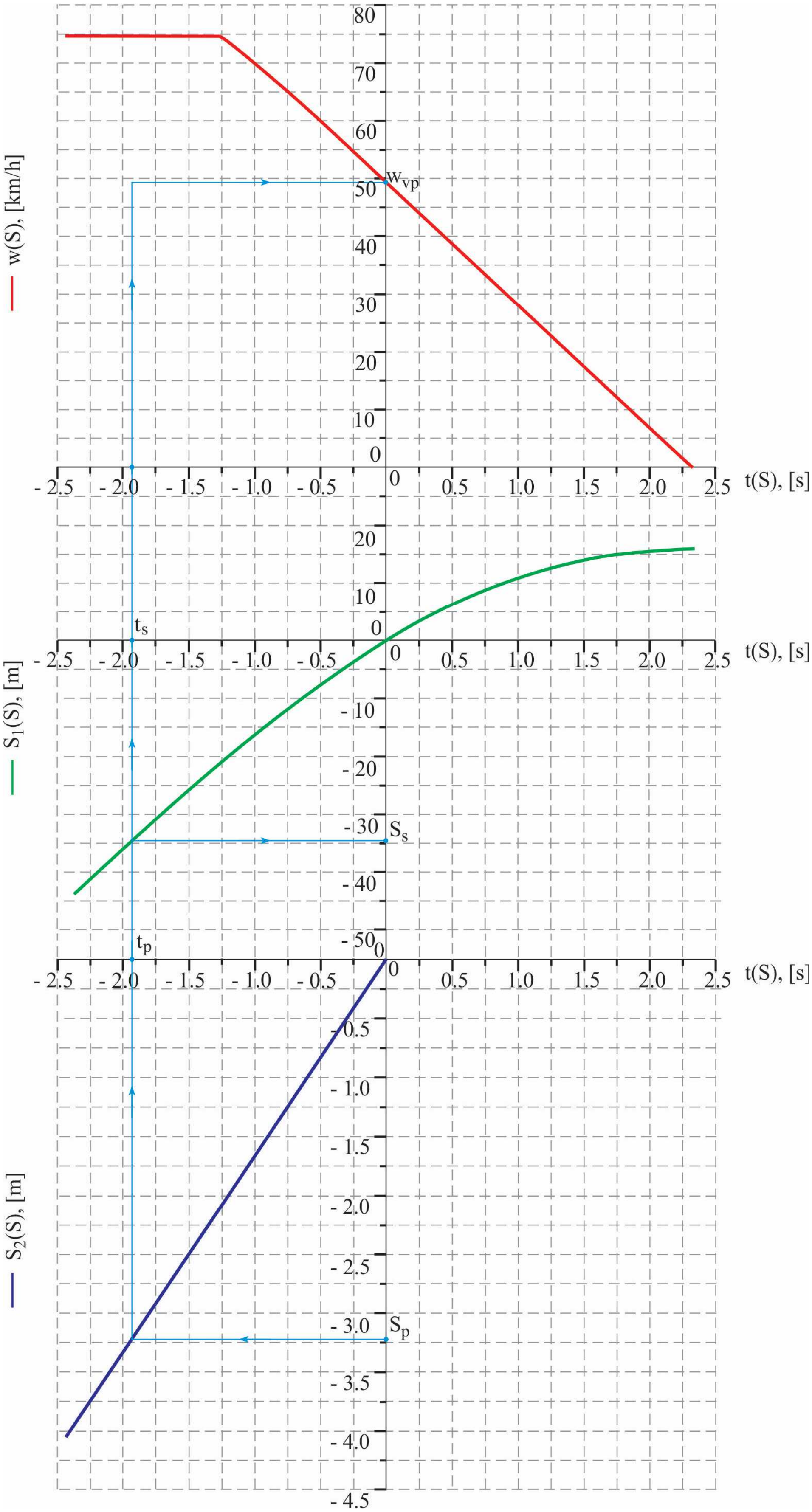


**Fig. 3.** Variation (w) of the vehicle speed and
the distance covered by the vehicle ($S_1$) and pedestrian ($S_2$) related to time.

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## ASPECTE CU PRIVIRE LA MODELAREA NUMERICĂ A ACCIDENTELOR DE TIP AUTOVEHICUL-PIETON, CU VIZIBILITATE RECIPROCĂ CONTINUĂ ÎNTRE PARTICIPANȚII LA TRAFIC

**Rezumat:** În lucrare se evaluează, din punct de vedere fizico-matematic, mărimile cinematice ale unui accident rutier cu vizibilitate reciprocă continuă între pieton-autovehicul, în diferite etape ale acestuia. La evaluarea mărimilor cinematice care caracterizează un asemenea accident se ține seama de parametrii rezultați din cercetarea primară a locului faptei, respectiv din probele testimoniale. Prin reconstituirea accidentelor cu pietoni se caută să se determine: viteza autovehiculului în diverse momente ale accidentului (în momentul apariţiei pericolului de accident - momentul în care pietonul a început traversarea părții carosabile; în momentul începerii imprimării urmelor de frânare; în momentul impactului cu pietonul); distanţa dintre autovehicul şi pieton în momentul apariţiei pericolului; distanţa parcursă de pieton, respectiv de autovehicul, din momentul în care pietonul a păşit pe carosabil până când acesta a fost lovit de autovehicul; timpul scurs între momentul sesizării pericolului de accident şi momentul lovirii pietonului; timpul de percepţie-reacţie al conducătorului auto și distanța parcursă de autovehicul în această perioadă; analiza posibilităţile de evitare a accidentului.

Rezultatele obținute sunt sub formă grafică și oferă posibilitatea surprinderii diverselor etape ale accidentului. Modelul numeric dezvoltat poate fi aplicat la soluționarea unui număr mare de cazuri de accidente rutiere, de tip autovehicul-pieton, pentru a stabili dinamica producerii acestora și totodată influența factorului uman implicat.

Utilizarea analizei computerizate, prin avantajele pe care le oferă (reducerea timpilor de calcul, simularea diferitelor situaţii de accident etc.) devine un instrument util şi necesar experţilor tehnici şi inginerilor care îşi desfăşoară activitatea în cadrul reconstituirii accidentelor rutiere şi dezvoltării sistemelor de siguranță ale autovehiculelor.

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