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THE EVALUATION OF KINEMATIC MEASURES WHICH CHARACTERIZE THE VEHICLE-PEDESTRIAN ACCIDENTS

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Abstract: *This paper evaluates the kinematic measures of a vehicle-pedestrian accident in its various stages from the physical and mathematical point of view. The parameters resulting from the primary research of the accident scene and the testimonial evidence are taken into account when evaluating the kinematic measures which characterize such an accident. Thus, by the reconstruction of car accidents with pedestrians it shall be determined: the time that passed from the beginning of the pedestrian's projection to the pedestrian's fall on the ground; the distance covered by the pedestrian from the beginning of his/her projection on the ground; the horizontal and vertical components of the pedestrian's speed at the fall on ground; the resulting speed with which the pedestrian's body starts moving after the fall on the ground; the distance on which the pedestrian's body slides on the roadway; the distance on which the pedestrian is projected from the initial contact to the moment he/she stopped on the roadway, etc.*

The study considers various longitudinal inclinations of the road, various inclination of the pedestrian's trajectory, various impact speeds and various pedestrians (male/female - 5%; 50%; 95%), the vehicle being one with advanced motor (car).

The results obtained are graphic results which offer the possibility of revealing various stages of the accident. The numerical model developed can be applied to the reconstruction of vehical-pedestrian accidents in order to establish their dynamics occurance and, at the same time the influence of various factors which contribute to the evolution of such accidents.

The computerized analysis with its advantages (reduction of calculation time, simulation of various accident situations, etc.) becomes a useful and necessary tool for the technical experts and engineers who carry on their activity in the field of reconstruction of car accidents and development of car security systems. Given the complexity of the numerical models developed, the use of the computerized analysis in the reconstruction of car accidents can be a trsutful tool used by specialists.

Key words: *vehicle, pedestrian, car accident, kinematic measures*

1. INTRODUCTION

In order to evaluate the kinematic measures of a frontal collision with rolling of the pedestrian, it is necessary to reconstruct the accident starting from the data made available from the scene of the accident or/and established by the testimonial evidence. Among the measures that have to be identified from the scene of the accident, it is worth mentioning: the distance that the pedestrian was projected from the initial contact to the moment to the pedestrian reached the ground, the distance covered by the pedestrian by sliding on the roadway, the distance between the final position of the pedestrian and that of the vehicle, etc. In general, in the reconstruction of the accident it is important to know the initial speed of the vehicle in order to compare it to the maximum legal speed in that place or in order to evaluate the possibilities of avoiding the accident, these representing important elements in establishing the culpability of the parties [7].

In order to clarify such car accidents, the following aspects are extremely important [4, 7, 12]: the inclination of the pedestrian's trajectory towards the axis of the road; the speed of the pedestrian when crossing the road; if the pedestrian maintains the same speed when crossing the road; if the crossing of the road takes place with stops or changes of direction of the pedestrian. From the point of view of the energetic consumption, the movement of a pedestrian in crossing the road can be classified in [5, 6, 7, 10]: slow walk, quiet walk, fast walk, slow run and fast run. The speed within each category is influenced by a multitude of factors, among which the most important being the age, sex, physiological state, locomotors deficiencies, objects carried, etc.

As it results from the impact theory, when a collision between two bodies of different weight takes place, the most affected body will be the one with the lower weight. Thus, in vehicle-pedestrian collisions, the most important is the way pedestrians react during the collision. In this type of collision the pedestrian describes as result of the impact a trajectory (made of three stages - *contact, flight, sliding)*, which depends on the pedestrian's height, the type of car body (especially the length of the car's bonnet) and the speed of the vehicle [2, 4, 7, 12, 16].

During the *contact* stage between the vehicle and the pedestrian, the pedestrian's legs are hit by the bumper, and when an adult pedestrian is involved, the head hits the back part of the bonnet or even the windscreen (if the bonnet is short or the impact speed is high). During this stage, for the study it is important to consider, first of all, the duration of the contact stage, respectively the road covered during this duration because by increasing the duration of the contact stage, the stresses which the injured person has to face are diminished.

The second stage of the pedestrian's trajectory after the impact is the *flying* in the air stage, when the body of the injured person has higher speed than that of the vehicle (the vehicle usually being already braked), and the pedestrian's trajectory is determined by the mechanics laws regrading the thrown away bodies. During this stage it is important to know the duration of the stage and the trajectory covered. These elements determine the speed of the body when it reaches the ground.

When landing, the body suffers a new impact (secondary collision), in this case the stresses could be bigger than in the case of the impact with the car body because of the rigidity of the land.

During the victim's *sliding* on the falling area stage, the body of the injured person slides and rolls over under the action of an inertia force until its kinetic energy will fully turn into mechanic work of the friction force and eventually in potential energy. There are fewer stresses during this stage than during the impact stage. However, there can be some serious injuries during this stage, too because of hitting some obstacles, sliding, or because of the danger of getting in the way of other vehicles.

In the case of vehicle-pedestrian accidents [2, 4, 5, 7, 12] it is necessary to analyze the casualty ratio of a great number of elements (the geometrical and weight ratio of the victim and the vehicle; the speed of the vehicle; the longitudinal inclination, the nature and state of the road, etc.)

An extremely important factor for the movement made by the pedestrian and, at the same time, for the severity of the injuries suffered is the place of the first contact between the vehicle and the victim. This place is determined, on the one hand, by the geometrical characteristics of the frontal part of the vehicle and, on the other hand, by the anthropometric dimensions of the pedestrian [12].

In the case of a vehicle-pedestrian collision, once the difference between the height of the adult pedestrian's center of gravity and the distance from the ground at the impact area (the contact) increases, the pedestrian's movement of rotation accentuates, this being responsible for the serious injuries of the head [12, 16]. When the height of the pedestrian's center of gravity is shorter than the distance from the ground at the impact area, there is a danger of running over the pedestrian (situation specific to trucks, buses, etc.).

The vehicle-pedestrian collisions take place in most cases by hitting the pedestrian with the frontal part of the vehicle, the pedestrian being laterally situated to the vehicle [4, 7]. As a result of the impact, the pedestrian may move as follows [4]: pushed towards the front of the vehicle; projected forward, thrown on the bonnet and projected forward; rolled on the bonnet; rolled on the roof of the car.

The various vehicle-pedestrian impact situations are revealed through physical-mathematical models. In order to evaluate the kinematic measures of the vehicle-pedestrian collision, it has been developed a model of numerical calculation which takes into account the physical phenomena that take place during such a car accident and which allows the user to obtain results with graphical interpretation.

2. THE NUMERICAL EVALUATION METHOD

2.1 Stages of the vehicle-pedestrian collision

The model of numerical calculation developed in the programme MathCAD is based on the physical phenomena during the consecutive stages of the *collision between the frontal part of a vehicle and a pedestrian laterally situated to the vehicle* (Fig. 1) [2, 7].

It has been considered the general case when the road is inclination with the angle α and the vehicle hits the pedestrian with the speed v_a, and then, runs with a constant speed v_{a0} on a distance S_1, and then, it brakes and stops at the end of the distance S_2 (Fig. 1) [2, 7].

The contact with the pedestrian takes place at the time t=0, when the vehicle runs with the speed v_a. After the time t=0, the pedestrian is taken on the bonnet of the vehicle and it occurs a secondary impact with the windscreen, this is when its speed reaches the value v_{p0}, and the vehicle reduces its speed at v_{a0}; at the same time, the center of gravity of the pedestrian's body changes the position to the height h and moves in the forwarding direction of the vehicle with the distance S_L. From this moment, the pedestrian's projection begins on a parabolic trajectory inclination with the angle δ in relation to the road; this inclination is due, on the one hand to the initial movement of the body after being taken on the bonnet of the vehicle, and on the other hand, to the obliquity of the windscreen. This situation refers only to advanced engine for vehicles which produce the initial rotation of the pedestrian; where it is a typical frontal projection (with trucks), ($S_L = 0$) and there is no secondary impact [2, 7].

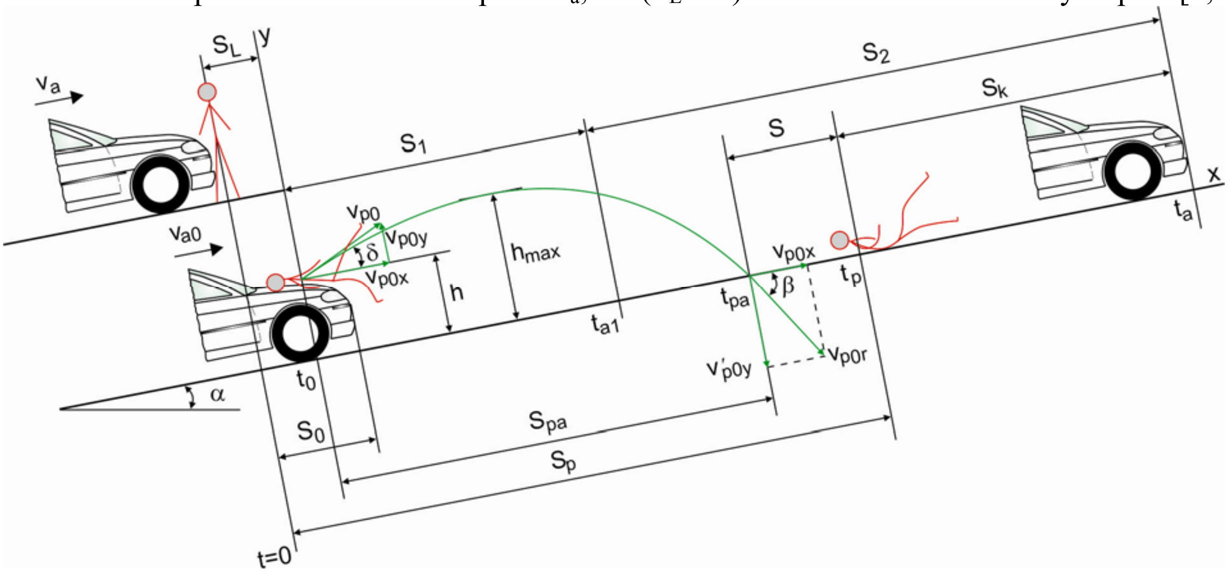

Fig. 1. General scheme of the vehicle-pedestrian impact.

2.2 Notations used in the model of calculation

There are a series of variables in the model of calculation, as follows:

- i - characterizes the longitudinal inclination of the road (i = 1…4), (α_i = 0°; 2°; 4°; 6°), and respectively the initial inclination of the pedestrian's trajectory (δ_i = 3°; 6°; 9°; 12°);
- j - characterizes the height of the center of gravity h_j and the weight m_{p_j} of the pedestrian [1, 3, 8, 12],
  - j = 1 - male pedestrian, 5% (h_1 = 0.993 m; m_{p_1} = 66.21 kg);
  - j = 2 - male pedestrian, 50% (h_2 = 1.102 m; m_{p_2} = 80.50 kg);

- j = 3 - male pedestrian, 95% (h_3 = 1.168 m; m_{p_3} = 96.41 kg);
- j = 4 - female pedestrian, 5% (h_4 = 0.907 m; m_{p_4} = 49.44 kg);
- j = 5 - female pedestrian, 50% (h_5 = 0.985 m; m_{p_5} = 59.85 kg);
- j = 6 - female pedestrian, 95% (h_6 = 1.107 m; m_{p_6} = 72.43 kg);
  - male/female 5% - the anthropometric dimensions are smaller than those of the 95% of the adult male/female population;
  - male/female 50% - the anthropometric dimensions represent the average of the adult male/female population;
  - male/female 95% - the anthropometric dimensions are bigger than those of the 95% of the adult male/female population;

- u - characterizes the speed of the vehicle ($v_{a_u} = 30 \ldots 60\ \text{km/h}$).

In order to make it easier to follow the model, the measures and notations which characterize the vehicle-pedestrian impact are defined in table 1 (Fig. 1).

Table 1

Measures and notations used in the numerical model

Measure	Notation	U.M
- distance covered by the vehicle during the contact with the pedestrian	S_0	m
- distance covered by the vehicle with constant speed after hitting the pedestrian	S_1	m
- distance covered by the braked vehicle with constant deceleration	S_2	m
- distance covered by the beginning of the projection to the fall on the roadway	S_{pa}	m
- distance covered by the pedestrian by sliding on the roadway	S	m
- distance between the final position of the pedestrian and the vehicle	S_k	m
- distance covered by the pedestrian's body from the initial contact to the beginning of the projection	S_L	m
- the distance the pedestrian was projected on from the moment of the initial contact to the stop on the roadway	S_p	m
- the medium coefficient of friction between the tires of the vehicle and the roadway on the distance S_2	f_a	-
- the medium coefficient of friction between the pedestrian's body and the roadway	f_p	-
- the gravitational acceleration	g	m/s^2
- the height of the pedestrian's center of gravity at the beginning of the projection	h	m
- the maximum height of the pedestrian's trajectory	h_{max}	m
- the weight of the vehicle	m_a	kg
- the weight of the pedestrian	m_p	kg
- the duration of the contact between the pedestrian and the vehicle	t_0	s
- the time that passed between the beginning of the pedestrian's projection and the fall on the roadway	t_{pa}	s
- the time that passed between the initial contact and the stop of the vehicle	t_a	s
- the duration the vehicle ran with a constant speed after hitting the pedestrian	t_{a1}	s
- the total time of the pedestrian's movement from the initial contact to the stop	t_p	s
- the time that passed between the initial contact and the moment when the pedestrian was projected on the roadway	t_{p1}	s
- the time corresponding to covering the distance S by the pedestrian after getting on the roadway, rolling and sliding on the roadway with a braked movement	t_{ps}	s
- the initial speed of the vehicle	v_a	m/s
- the speed of the vehicle at the beginning of the pedestrian's projection	v_{a0}	m/s
- the speed of the pedestrian after separating from the vehicle	v_{p0}	m/s
- the speed of the pedestrian at the beginning of his/her sliding on the roadway	v_{p0r}	m/s
- the angle between the pedestrian's trajectory from the beginning of the projection and the roadway	δ	degree
- the angle between the pedestrian's trajectory from the moment the pedestrian reached the ground and the road	β	degree
- the angle of longitudinal inclination of the road	α	degree
- the report between the tangential impulse ($m_p \cdot v_{p0x}$) and the vertical impulse ($m_p \cdot v'_{p0y}$) of the forces developed when the pedestrian's body fell on the roadway	μ	-

- the ratio between the pedestrian's speed v_{p0} and the speed of the vehicle v_{a0} at the time of separation	ρ_v	-

If in the numerical model a certain measure (M) is necessary to be used and this measure varies between a minimal value (M_{min}) and a maximum one (M_{max}), considering a variable k which reveals values of the measure considered between ($M_{min}\ldots M_{max}$), a generally valid relation for the model of calculation developed is defined as follows [13]:

$$M_k = M_{min} + (k-1)\cdot\frac{M_{max}-M_{min}}{10}, \ k = 1...11.$$

2.3 Possibilities to evaluate the kinematic measures of the vehicle-pedestrian collision

In order to define the equations of the pedestrian's movements it is taken into account an orthogonal coordinate system with the axis x situated on the road plan in the direction of the vehicle in the position corresponding to the beginning of the pedestrian's projection on a parabolic trajectory, inclination with the angle δ in relation to the roadway and the axis y perpendicular to the surface of the road (Fig. 1) [2, 7]; this position being considered as reference for the time scale.

After the moment t_0, on a duration t_{pa}, the pedestrian moves independently in relation to the vehicle after a parabolic trajectory which crosses the roadway under an angle β. As in most of the cases the speed v_{p0} is under 60 km/h [7], the air resistance is neglected, this is when it is considered that v_{p0} keeps its value unchanged until the pedestrian's contact with the roadway. As follows, the pedestrian rolls over and slides on the roadway with a braked movement, with a coefficient f_p, and stops after a distance S which is covered in time t_{ps}.

The vehicle is running after the initial impact with a constant speed v_{a0} on the distance S_1 when the time t_{a1} passes and then it starts braking with the coefficient f_a and stops at the end of the time t_a after running the distance S_2 [7].

The coefficient of friction (adherence) between the tires of the vehicle and the roadway depends on the nature and state of the road [7, 15].

As the impact force situated at the level of the hitting area passes only rarely through the center of gravity of the pedestrian's body, the pedestrian performs both a translation motion and a rotational motion at the same time. Taking into consideration the reduced balance of the energy which produces the rotation and taking into consideration the equation of impulses conservation only for translation ($v_{a0}\cdot(m_a+m_p)=m_a\cdot v_a$), it can be obtained the speed of the vehicle at the beginning of the pedestrian's projection with the following relation [2, 4, 7]:

$$v_{a0} = \frac{m_a}{m_a+m_p}\cdot v_a, \ \text{[km/h]}. \quad (1)$$

Knowing the speed of the vehicle at the beginning of the pedestrian's projection, it can be determined the speed of the pedestrian after separating from the vehicle with the following relation [2, 7]:

$$v_{p0} = \rho_v \cdot v_{a0}, \ \text{[km/h]} \quad (2)$$

In most frontal collision situations where the rolling of the pedestrian takes place, $\rho_v = 1$ [2, 7].

If the resistance of the air is neglected during the pedestrian's projection process, the pedestrian's trajectory is a parabolic one with void horizontal deceleration and uniform vertical acceleration g. Under these circumstances, the distance S_{pa} can be determined by the relation [2, 7]:

$$S_{pa} = v_{p0}\cdot t_{pa}\cdot\cos\delta - \frac{1}{2}\cdot g\cdot t_{pa}^2\cdot\sin\alpha, \ \text{[m]} \quad (3)$$

The time t_{pa} consists in the duration of lifting the body with the speed ($v_{p0}\cdot\sin\delta$) until it reaches the height $\left(\frac{v_{p0}^2\cdot\sin^2\delta}{2\cdot g\cdot\cos\alpha}\right)$ and the duration of its descent from this height to the roadway, that is [2, 7]:

$$t_{pa} = \frac{v_{p0}\cdot\sin\delta}{g\cdot\cos\alpha} + \frac{\sqrt{(v_{p0}\cdot\sin\delta)^2 + 2\cdot g\cdot h\cdot\cos\alpha}}{g\cdot\cos\alpha}, \ \text{[s]} \quad (4)$$

At the time of the pedestrian's contact with the road, the speed v_{p0} has the components v_{p0x} - on the roadway and v'_{p0y} - perpendicular on the roadway [2, 7]:

$$\begin{cases} v_{p0x} = v_{p0}\cdot\cos\delta - g\cdot t_{pa}\cdot\sin\alpha \\ v'_{p0y} = v_{p0}\cdot\sin\delta - g\cdot t_{pa}\cdot\cos\alpha \end{cases}, \ \text{[km/h]}. \quad (5)$$

The resulting speed v_{p0r}, which is the speed the pedestrian's body starts moving on the roadway after the pedestrian falls on the ground, is determined by taking into account the fact that the pedestrian's collision with the road is without bounce, and according to the principle of impulse preservation ($m_p \cdot v_{p0r} = m_p \cdot v_{p0x} + \mu \cdot m_p \cdot v'_{p0y}$), the following relation is obtained [2, 7]:

$$v_{p0r} = v_{p0x} + \mu \cdot v'_{p0y}, \text{ [km/h]}, \quad (6)$$

where $\mu = -f_p$.

The angle β between the pedestrian's trajectory and the roadway is determined according to the speeds v_{p0x} and v'_{p0y} [7]:

$$\beta = arctg \frac{v'_{p0y}}{v_{p0x}}, \text{ [degree]} \quad (7)$$

The distance S on which the pedestrian's body slides on the roadway, can be determined by the relation [2, 7]:

$$S = \frac{v^2_{p0r}}{2 \cdot g \cdot (f_p \cdot \cos\alpha + \sin\alpha)}, \text{ [m]} \quad (8)$$

The friction coefficient f_p between the pedestrian and the roadway is a coefficient of resistance at forwarding, as besides the friction with the road there are also rollings; the energetic losses given to internal organs rupture, breaking of the bones or/and tearing off the clothes are highly important in estimating f_p.

The distance that the pedestrian was projected from the initial contact to the stop on the roadway is given by the relation [2, 7]:

$$S_p = S_L + S_{pa} + S, \text{ [m]}, \quad (9)$$

in which $S_L \cong h/2$.

The maximum height h_{max} of the pedestrian's trajectory (Fig. 1) can be determined by the relation [7]:

$$h_{max} = h + \frac{v^2_{p0} \cdot \sin^2\delta}{2 \cdot g \cdot \cos\alpha}, \text{ [m]} \quad (10)$$

3. RESULTS OBTAINED

Results with graphical interpretation of the kinematic measures which characterize the vehicle-pedestrian collisions can be obtained based on the calculation method.

As an example, in the numerical calculation model, it has been taken into account the following entry data: the vehicle involved in the accident is climbing a dry asphalt concrete with a longitudinal inclination α_i; the speed of the vehicle v_{a_u}; the height of the center of gravity h_j and the weight m_{p_j} of the pedestrian; the initial inclination of the pedestrian's trajectory δ_i.

Based on the entry data, taking into account the physical phenomena during the consecutive stages of the vehicle-pedestrian collision (Fig. 1) and using the numerical calculation model developed in the MathCAD software, results regarding the variation are obtained:

- the time that passed between the beginning of the pedestrian's projection and his/her fall on the ground, depending on the speed impact (Fig. 2, Table 2);

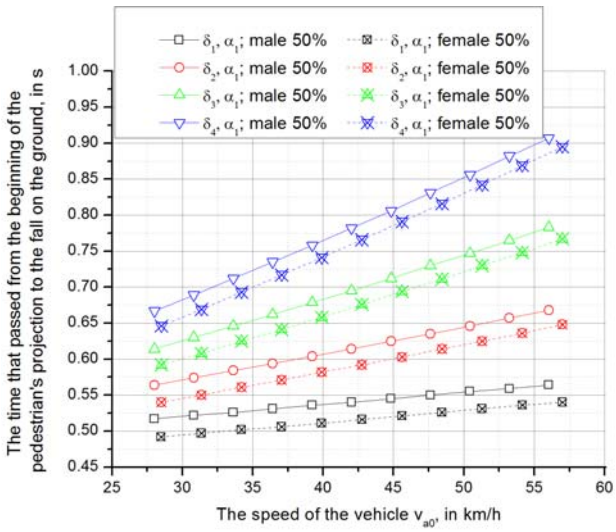

Fig. 2. Variation of time that passed from the beginning of the pedestrian's (male/female 50%) projection to the fall on the ground, depending on the speed impact when there is a constant longitudinal inclination of the road and various inclination of the trajectory δ_ι.

- the distance covered by the pedestrian from the beginning of his/her projection to the fall on the ground, depending on the impact speed (Fig. 3, Fig. 4);
- the resulting speed with which the pedestrian's body starts moving after falling on the ground, depending on the impact speed (Fig 5);
- the difference between the resulting speed v_{p0r}, with which the pedestrian's body starts

moving on the roadway after the pedestrian falls on the ground and the pedestrian's speed v_{p0} after separating from the vehicle when there are various inclination of the pedestrian's trajectory δ_i and various longitudinal inclination of the road α_i (Fig. 6);

- the distance on which the pedestrian's body slides on the roadway, depending on the resulting speed with which the pedestrian's body starts moving on the roadway after falling on the ground (Fig. 7);
- the distance that the pedestrian was projected from the initial contact to the stop on the roadway depending on the impact speed (Fig. 8) etc.

Table 2

Variation of the time that passed between the beginning of the pedestrian's projection and the pedestrian's fall on the ground in % when there are various inclination of the pedestrian's trajectory δ_i and various longitudinal inclination of the road α_i by comparing the male pedestrian 50% and the female pedestrian 50%

Pedestrian / δ, α	male		female	
	5%	95%	5%	95%
δ_1, α_1	-4.222035	+2.422204	-3.328637	+5.019373
δ_1, α_2	-4.253531	+2.387357	-3.344482	+4.981517
δ_1, α_3	-4.215653	+2.384951	-3.377309	+5.030783
δ_1, α_4	-4.225352	+2.397720	-3.354408	+5.040393
δ_2, α_1	-3.414634	+1.892092	-2.698559	+4.124502
δ_2, α_2	-3.443180	+1.876755	-2.682403	+4.107909
δ_2, α_3	-3.453365	+1.889020	-2.694840	+4.149441
δ_2, α_4	-3.475700	+1.855670	-2.704354	+4.110008
δ_3, α_1	-2.727391	+1.422419	-2.107383	+3.248322
δ_3, α_2	-2.777778	+1.369327	-2.093117	+3.260432
δ_3, α_3	-2.773799	+1.367366	-2.103712	+3.269463
δ_3, α_4	-2.743466	+1.417241	-2.112864	+3.276277
δ_4, α_1	-2.121739	+0.997101	-1.598579	+2.569568
δ_4, α_1	-2.143685	+0.984936	-1.609658	+2.580187
δ_4, α_1	-2.140708	+0.960426	-1.595933	+2.577137
δ_4, α_1	-2.147806	+0.993072	-1.615566	+2.570755

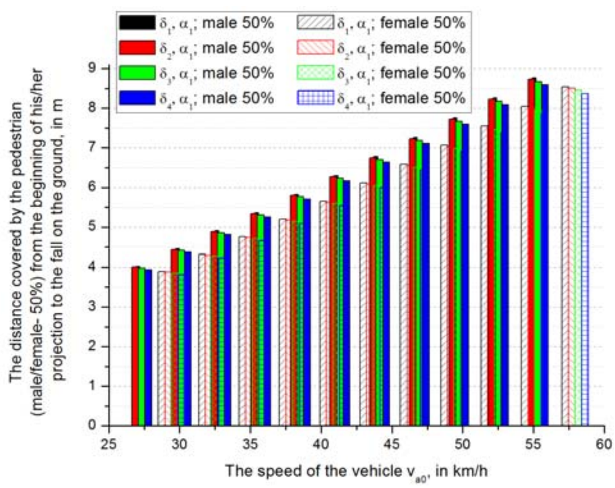

Fig. 3. Variation of the distance covered by the pedestrian (male/female 50%) from the beginning of his/her projection to the fall on the ground, depending on the impact speed when there is a constant longitudinal inclination of the road α_1 and various inclination of the trajectory δ_i.

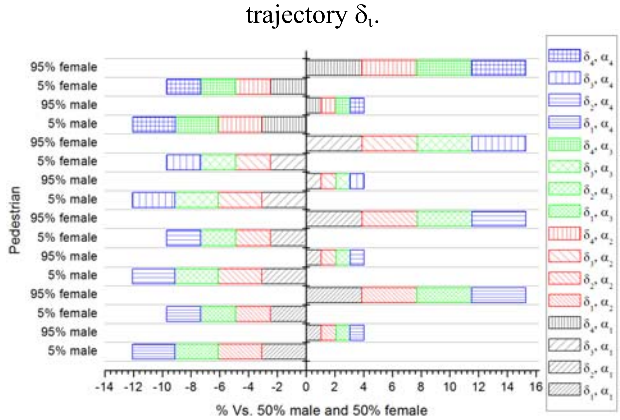

Fig. 4. Variation of the distance covered by the pedestrian from the beginning of his/her projection to the fall on the ground in % when there are various inclination of the pedestrian's trajectory δ_i and various longitudinal inclination of the road α_i, comparing the male pedestrian 50% and the female 50%.

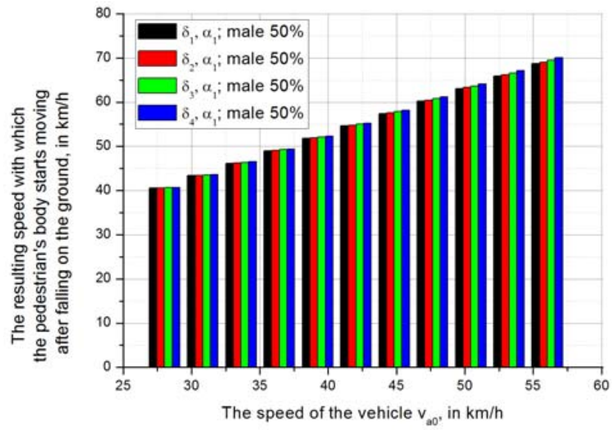

Fig. 5. Variation of the resulting speed with which the pedestrian's body starts moving after falling on the ground, depending on the impact speed, when there is a constant longitudinal inclination of the road α_1 and various inclination of the trajectory δ_i.

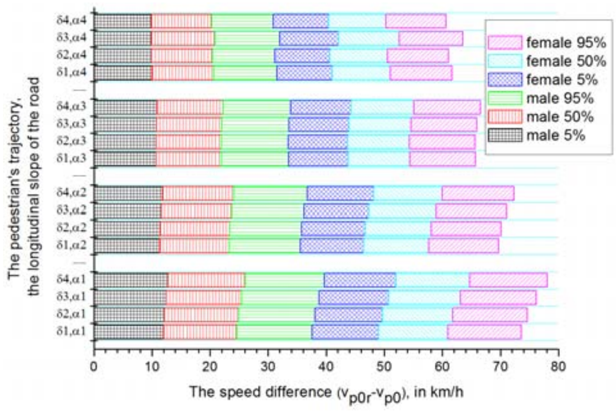

Fig. 6. The speed difference (v_{p0r}-v_{po}) when there are various inclination of the pedestrian's trajectory δ_i and various longitudinal inclination of the road α_i.

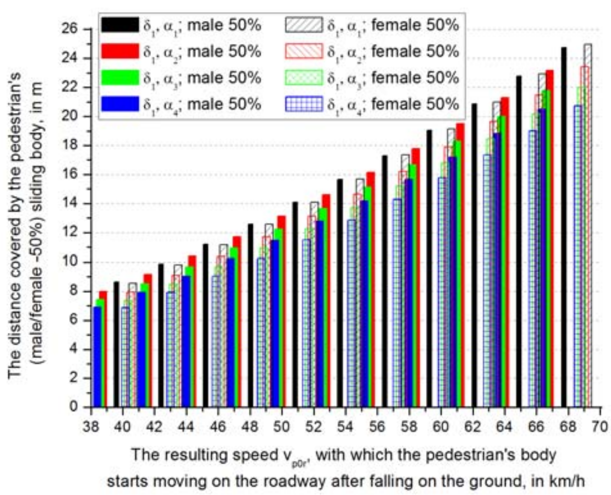

Fig. 7. The distance covered by the pedestrian's (male/female 50%) body sliding on the roadway when there is a constant inclination of the pedestrian's trajectory δ_1 and various longitudinal inclination of the road α_i.

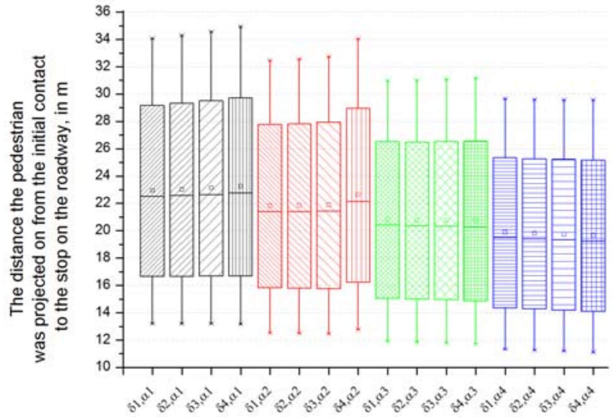

Fig. 8. The distance the pedestrian (male 50%) was projected on from the initial contact to the stop on the roadway when there are various inclination of the pedestrian's trajectory δ_i and various longitudinal inclination of the road α_i.

4. CONCLUSIONS

The numerical model developed in order to evaluate the kinematic measures which characterize the vehicle-pedestrian accidents allows changing the entry data, taking into account the impact conditions and obtaining results with graphical interpretation. This can be applied to the settlement of the vehicle-pedestrian accidents in order to establish the dynamic of their production and the influence of various factors that contribute to their evolution.

The results obtained follow, in general, the evolution in time of the kinematic measures that characterize the vehicle-pedestrian accidents and they can be presented synthetically in tables or graphics.

Taking into account the variables considered, the results can be observed comparatively considering the pedestrians studied, the situations of their trajectory inclination, the situations of longitudinal inclination of the road, etc. Besides the results presented, the computation algorithm allows obtaining other results like:

- the duration of the pedestrian's contact with the vehicle;
- the distance covered by the vehicle during the contact with the pedestrian, depending on the impact speed;

- the time that passed between the beginning of the pedestrian's projection and the moment the maximum height was reached;
- the maximum height of the pedestrian's trajectory;
- the angle between the pedestrian's trajectory and the roadway at the fall on the ground;
- the time that passed between the initial contact and the pedestrian's projection on the roadway;
- the total time of the pedestrian's movement from the initial contact to the stop;
- the time the vehicle ran with a constant speed after hitting the pedestrian;
- the distance covered by the braked vehicle with constant deceleration;
- the time that passed between the initial contact and the stop of the vehicle;
- the distance between the final position of the pedestrian and the vehicle, etc.

The numerical model developed can also be adapted to the situation in which for the reconstruction of the accident it is wanted to be determined the initial speed of the vehicle in order to compare it to the maximum speed limit for that area or in order to analyse the possibilities of avoiding the accident. Thus, the initial speed of the vehicle can be determined by taking into account the different pieces of evidence from the scene of the accident (the distance the pedestrian was projected on S_p; the distance the pedestrian slided on S; the distance between the final positions of the vehicle and the pedestrian S_k; the distance S_1 on which the vehicle ran with a constant speed, etc.).

Using the computerised analysis with all its advantages (reduction of projection times, simulation of various functioning conditions, large applicability in fields of interests, etc.) becomes useful and necessary tool to contemporary engineers who carry on their activity in fields such as projection, construction, development and safety of vehicles; it has to be emphasied the fact that using the computerized analysis is not enough and it is not necessary in issuing some final considerations, but due to the complexity of the numerical models develeped at the present time, it can be a trustful tool used by the specialists.

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EVALUAREA MĂRIMILOR CINEMATICE CARE CARACTERIZEAZĂ ACCIDENTELE RUTIERE DE TIP AUTOVEHICUL-PIETON

Rezumat: În lucrare se evaluează, din punct de vedere fizico-matematic, mărimile cinematice ale unui accident rutier de tip autovehicul-pieton, în diferite etape ale acestuia. La evaluarea mărimilor cinematice care caracterizează un asemenea accident, se ţine seama de parametrii rezultaţi din cercetarea primară a locului faptei, respectiv din probele testimoniale. Astfel, prin reconstituirea accidentelor rutiere cu pietoni se caută să se determine: timpul scurs din momentul începerii proiectării pietonului până la căderea lui pe sol; distanţa parcursă de pieton din momentul începerii proiectării până la căderea pe sol; componentele pe orizontală şi verticală a vitezei pietonului în momentul căderii acestuia pe sol; viteza rezultantă cu care începe să se deplaseze corpul pietonului după căderea pe sol; distanţa pe care alunecă corpul pietonului pe carosabil; distanţa de proiectare a pietonului din momentul contactului iniţial până la oprirea pe carosabil etc.

În studiu sunt luate diferite înclinări longitudinale ale drumului, diferite înclinări ale traiectoriei pietonului, diferite viteze de impact şi diferiţi pietoni (bărbat/femeie - 5%; 50%; 95%), autovehiculul considerat fiind cu motorul avansat (autoturism). Rezultatele obţinute sunt sub formă grafică şi oferă posibilitatea surprinderii diverselor etape ale accidentului. Modelul numeric dezvoltat poate fi aplicat la reconstrucţia accidentelor rutiere de tip autovehicul-pieton, pentru a stabili dinamica producerii acestora şi totodată influenţa diferiţilor factori care concură la evoluţia unor astfel de accidente.

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 siguranţă ale autovehiculelor. Datorită complexităţii modelelor numerice dezvoltate, utilizarea analizei computerizate în reconstrucţia accidentelor rutiere poate fi un instrument de încredere utilizat de către specialişti.

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