TRAFFIC ACCIDENTS WITH INVOLVEMENT OF PEDESTRIANS. CASE STUDIES

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INTRODUCTION

Methods for the speed determination of the pedestrian, as well as of the vehicle at the moment of impact with the victim have obtained a fairly large spread for the situations when on the spot inspections do not record the presence of the braking traces and of the categories of signs which generally allow a direct establishment of the victim position in the moment of its hitting by the front part of the vehicle. Other types of traces (pieces of damaged machinery parts, biological traces, signs of the contact created upon the impact) are also analyzed, allowing the quantification of the collision magnitude. On the other hand, their relative arrangement on the under question road segment, together with the stop position of the vehicle after the collision, may provide in some cases the required elements for the establishment of the kinematical parameters mentioned above (the speed on the impact and the projection distance), through the use of empirical relationships together with those of Newtonian mechanics.

1. DETERMINATION OF THE PROBABLE VEHICLE SPEED AND OF THE PLACE OF IMPACT

There aren't particular problems in a situation when on the spot were found traces printed by the tires of the vehicle during the braking process and the place of impact is indicated either by the presence of the certain traces coming from the projection of the fixed objects by a reduced contact with the victim's body (hat, keys, etc.), either by the presence of biological traces (frequently dynamic traces of blood − drops), either by the rubbing traces printed on the carriageable by the footwear soles objects. It is considered an issue approach that is typical for the situations when such signs are missing.

1.1. Basic objectives

The two objectives that are in question (the establishment of the moving speed of the vehicle and the place of impact), frequently required in the framework of the traffic accident criminal expertise, can be treated in many cases at the same time, starting from the fact that the distance of the victim projection is dependent mainly on the speed of the vehicle at the moment of impact. Production method of a road traffic event with involvement of pedestrian is subsequently materialized through the existence of some material evidences. In what follows will be taken into consideration four categories of traces, namely:

− biological traces that materialize the rest position of the victim;

− traces derived from the projection of the glass shards that belong to damaged assemblies (windshield /headlights);

− signs of contact created on the vehicle body upon the impact;

− the stop position of the vehicle after the braking process.

1.2. Concepts applied to the methodology

Approached methodology is based on the use, according to the available data provided by the on the spot research, of the only two of the sample material evidences referred to above. It is clear that in case you have three or even all four listed items, the reached degree of certainty is higher. Their creation and arrangement at the accident site will take place via dynamic action, common element being the speed of the vehicle at the moment of impact. Possible situations will be illustrated through practical cases, chosen according to the types of signs that were found on the spot. Road events where the rest relative position of the vehicle and of the pedestrian are known.

An event with pedestrian involvement can be divided into three phases: phase of switch, flight phase and the phase of tumbling and slipping of the victim on the surface on which it is projected. Upon the collision, the pedestrian acquires the speed of the vehicle, describing in the flight phase a parabolic trajectory which differ depending on the position of the point of impact in relation with the pedestrian center of mass. Relative position of these two points determines or not the existence of the rotation component around the center of mass.

Following the impact, the pedestrian may remain in the rest position on the surface of falling behind or in front of the vehicle frontal plane in its stop position (at the limit − in the frontal plane of the vehicle).

First case is characteristic for the situations when the impact speed is very high. The impact velocity is higher than 55-60 km/h and the vehicle is not decelerated or is braked with less intensity, in cases of collision with the extreme parts of the frontal plane of the vehicle body. In the latest case (impact with slipping), the design distances are much reduced in relation with the situation of the impact with the middle part of the vehicle body (total impact), being ascertained a reduction by up to 45% of the projected distance. On the other hand, the amplitude of the side projection will increase.

The second case is specific for the impacts at speeds up to 50 km/h, either the car is braked vigorously at the moment of impact, whether it is braked vigorously immediately after the impact and the victim is taken on the hood, case when there may be significant distances between the car frontal plane and the position of rest of the victim in front of it.

Studies conducted both in real cases and as a result of the mannequins usage that reproduce the size and consistency of the human body, resulted in the establishment of several empirical formulas that show the relationship between the speed at the moment of impact and the projection distance of the victim for situations in which pedestrian is hit by the front plane of the car in the middle part of it (Stcherbatcheff, Searle, Kühnel, Barzeley, Appel, etc.). Some of these relations reveal for certain arrangements of deceleration a less projection distance of the pedestrian than it is required to stop the vehicle from the speed of impact. In these cases it is possible to establish simultaneously the projection distance of the victim, and therefore, by default, the place of impact, and the speed at the moment of impact on the basis of a system of equations.

Road events when are known relative arrangements of the first fragments that belong to the smashed windshield or headlights and of the pedestrian after the projection.

In practice are frequently encountered situations when the stopping position of the vehicle is not known because the driver changed it from various reasons (transportation of victims, not to stop the traffic, etc), or this position does not exist, as long as the driver did not stop at the site of the accident.

Road events when are known relative arrangements of the first fragments that belong to the smashed windshield or headlights and of the vehicle after stopping.

The characteristic of this situation is the lack of biological traces (static traces of blood) which mark the last position of the victim, subsequently transported to hospital. The case will be illustrated by a situation from the expertise practice that have other elements also, but which, in this case, will be used only as a check for the proposed methodology.

Road events which require to estimate the impact speed based on car deformations.

An important category of evidences that fit the estimation of the velocity on impact are the traces of crash contact. The estimation of the impact velocity can be achieved through a comparative analysis, having access to a database which includes damaged vehicles for which are known the impact speed based on the measures made using others types of tracks (breaking traces, projection distances, etc.). This analysis is based also on the other cues offered by the practice in this area. Thus, we refer to the certain stages between which can be made first estimations.

For lower speeds, up to 15 km/h, in most cases there is no plastic deformation of the car to be found, the most common signs in these cases being traces of dust delamination or, optionally, a lamp breakage.

For a speed of about 20-35 km/h, deformations are with reduced amplitude and are located generally on certain singular body parts (bumper or engine hood in the frontal part). Characteristic for these remaining deformations is their location on the frontal side which mark an impact which not involves, in many cases, taking of the victim by the engine hood, the pedestrian being projected forward. For impact speeds of around 35-45 km/h, the adult pedestrian generally doesn't have contact with the car windshield or its breakage not occurs (Figure 1).

Figure 1. Impact at speed of around 20-35 km/h.

At the speeds above 40 km/h, the victim is taken on the engine hood. Windshield breakage, in its lower section, takes place for the speeds of 45-60 km/h (Figure 2).

Figure 2. Impact at speeds of approx. 45-60 km/h.

At the speeds of about 60-70 km/h, windshield breakage takes place at a higher rate. At higher speeds, crashes touch also vehicle pillars in their upper side, or the car flag. At the speeds above 75 km/h, the vehicle may pass under the strongly accelerated pedestrian. He may fall behind the vehicle on the carriageable or, in many cases, remain in contact with the body of the vehicle, entered partially in the passenger compartment.

This category of signs is in the most majority of the cases at the disposal of the expert through the judicial photos, in such a way that the determinations of the previous sections should be in conjunction with the deformation analysis. But there are situations where the estimation of the moving velocity of the vehicle on the basis of the damages amplitude may constitute the point of departure in subsequent determinations. The methodology is characteristic for the situations when it isn't known the stop position of the vehicle or the regime of deceleration until stopping and either the position in which were found the fragments derived from the smashed windshield or headlights.

2. DETERMINATION OF THE PEDESTRIAN POSITION AND SPEED AT THE MOMENT OF IMPACT

In case of traffic accidents with pedestrian involvement, the method for the determination of the speed and movement direction of the pedestrian is based on the testimonial evidence, by the choice of speed values from the specialized literature on the basis of the age and sex of the involved pedestrian. This was proved to be a good method under conditions when most of the testimonies match each other, but there are many situations where statements are contradictory or there are no witnesses or survivors. In this circumstance, it is absolutely necessary to consider the speed and trajectory of the pedestrian based on the traces remained after the impact and on the injuries suffered by him.

There are plenty of variables that affect the event of a collision between a motor vehicle and a pedestrian, making it a very complex equation. Further reference is made for a part of the aspects that occur in the accidents with pedestrian involvement, being confined only on those that have a direct connection to the proposed calculation method.

2.1. Calculation parameters

In a collision with a pedestrian, for the same value of the collision speed (40 km/h), it can be proved that the way it takes the pedestrian and the places of impact with his different parts of the body differ from one vehicle type to another, depending on its frontal shape and the relative position of the pedestrian towards the longitudinal axis of the vehicle.

Besides the frontal shape of the vehicle, the pedestrian height has a particular importance in the analysis of the traces left on the windshield after the collision (Figure 3). The damages suffered by the vehicle overlapped with the height of the pedestrian may provide clues for an approximate evaluation of the speed of impact, the pedestrian's direction, his speed and post-crushing trajectory.

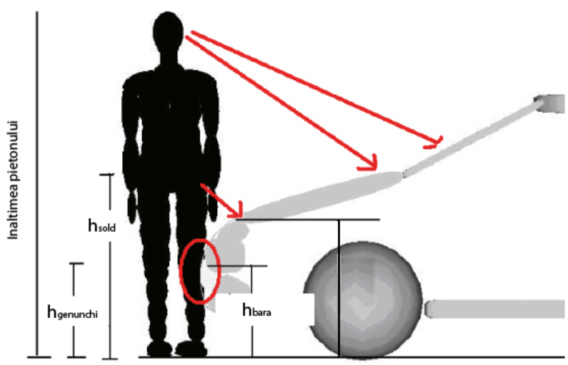

Figure 3. Typical places of contact between pedestrian and motor vehicle.

The time passed between the impact between different parts of the pedestrian body and the vehicle body, represents an important element by which can be done the determination of the pedestrian's relative speed towards the vehicle one.

Some specific studies over the kinematic impact between the pedestrian and vehicle shows that for the same impact velocity the type of the car and its frontal shape influence significantly the pedestrian movement and the time on which his hip, shoulder and head hit the front part of the vehicle.

2.2. Methodology application

According to the received data, person B. M. was moving on a street towards the town center driving a car brand Subaru Justy.

Around ---- o'clock, according to his own words, he observed belatedly a pedestrian engaged in crossing the street from the left to right behind some other cars moving in the opposite direction. The pedestrian, ignoring the red light of the semaphore, began to cross the street on the crosswalk among the vehicles that were circulating in the direction of Central Square and entered on the other direction of movement. At that moment he was hit by the front-right side of the Subaru vehicle. Proceeded to the analysis of the possibilities to avoid the accident, analytically was determined the speed of the pedestrian compared to the vehicle one. The distance between the place of impact of the hip and head was measured according to the images made on the spot by police, resulting a value of approx. 30 cm (Figure 4).

Figure 4. Distance between pedestrian hip and head places of impact.

Also, taking into account the lower class of the car and considering that the impact speed was around 40 km/h, was deduced the time between the hip impact and the head impact with the car, being of approx. 100 ms.

Substituting the data in the formula, we get:

$$\boldsymbol{V_p = 3,6 \cdot \frac{d_{S-C}}{T_{S-C}} = 3,6 \cdot \frac{0,3}{0,1} = 10,8 \approx \approx 11\ [{}^{km}/_{h}]} \quad (1)$$

where:

$d_{S-C} = 0{,}3\ m$ represent the distance between the place of impact of the hip and the place of impact of the head with the car;

$T_{S-C} = 0{,}1\ s$ is the time passed between the hip impact and the head impact with the car.

The travel speed of the pedestrian thus calculated shall be in accordance with the testimonial evidence properly administered and are within the limits given by the literature.

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