ANNALS OF THE FACULTY OF ENGINEERING HUNEDOARA
2003, Tome I, Fascicole 3

THE ESTIMATION OF THE FRONTAL IMPACT COLISSION SPEED WITH AN IMMOBILE OBSTACLE

Stancu FILIP, Cosmin BLEDEA,
Tiberiu Dimitrie BABEU

UNIVERSITATEA POLITEHNICA TIMISOARA,
FACULTATEA DE MECANICA

ABSTRACT

The paper presents a complex statistic analysis about the road events during 2002 and 2003 praising their reasons. In the framework of the paper, there are analyzed some theoretical considerations regarding the estimation of the impact speed when the impact with an immobile obstacle takes place. On the basis of the energy conservation law of the vehicle as well of the deformation force variation law, a differential equation is solved and it's solution is even the impact speed. The boundary conditions imposed that the deformation reach the maximum value when the vehicle stopped. The paper ends with a special case analysis performed as a technical expertise due after the frontal collision between a Honda Accord LX motorcar and an immobile obstacle.

KEYWORDS:
impact, traffic, motorcar, speed

1. Introduction

Last years, the road traffic in the Timis county presents a strongly traffic increasing, because of some reasons such as: the incresing of the number of cars, as well of the number of drivers, as well of the number of cars which passed through the county, especially the heavy traffic, the absence of the parking places, and the absence of a devious road around Timisoara, the stagnation of the urban equipments regarding the infrastructure of the road, the quality of the roads and not at last the high level of indiscipline of the drivers which are involved in the traffic.

Regarding the traffic events with serious consequences, a decreasing of the grave accidents but an increasing of their consequences (passing away persons) has been observed. For the last two years, the report is comparatively presented in the table 1 and figures 1, 2, 3 and 4.

TABLE 1

	Accidents	Passing away persons	Serious injured persons
2002	277	74	249
2003	249	72	234

Figure 1

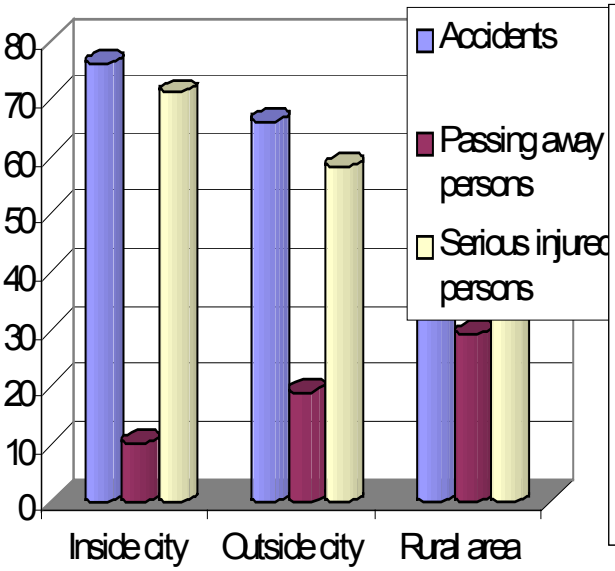
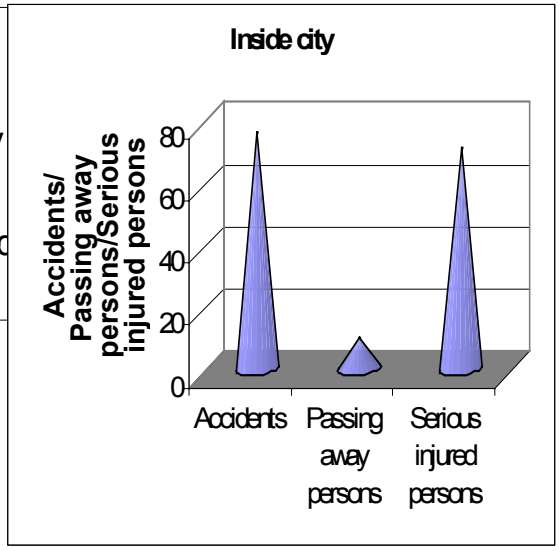


Figure 2



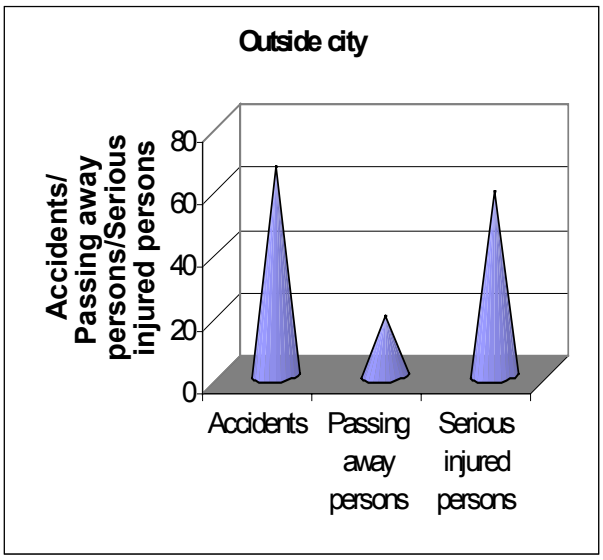


Figure 3

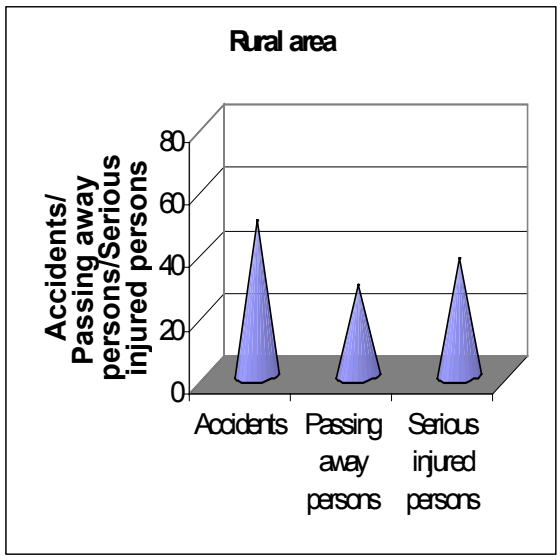


Figure 4

The analysis regarding the evolution of the accidents, in function of the place where that happened, emphasize that 41,98%,which means 76 accidents with 10 passing away persons and 71 serious injured persons, took place inside the cities;36,465,which means 66 accidents with 19 passing away persons and 58 serious injured persons took place outside the cities; and 27,075 which means 49 accidents with 29 passing away persons and 37 serious injured persons took place into the rural areas.

The analysis of the dynamics of the recorded events, for the period mentioned above, presents a worsening of their consequences going to an increasing of the number of the passing away persons because of the bad level of the emergency medical service.

Regarding the reasons, on the first place is considered to be the

ignorance of the legal speed limit or the non-adjustment of the speed with the road and traffic conditions (43 accidents-23 passing away persons-47 serious injured persons, which represents 27,92%); the non-observance of the traffic standards by the pedestrian people (34 accidents-10 passing away persons-25 serious injured persons, which represents 22,7%); than the absent-mindedness in the driving process(24 accidents-6 passing away persons-22 serious injured persons, which represents 15,58%); the ignorance of the right of way for vehicles (17 accidents-4 passing away persons-15 serious injured persons, which represents 11,3%); the ignorance of the right of way for pedestrian people (13 accidents-3 passing away persons-10 serious injured persons, which represents 8,44%); the ignorance of the no overtaking regulation (11 accidents-3 passing away persons-14 serious injured persons, which represents 7,14%).

Other reasons represent 7,29% from the total number of accidents. Because of the ignorance of the legal speed limit represents the primordial factor regarding the accidents with serious consequences, there are presented in the framework of the paper some theoretical considerations in order to estimate the frontal impact collision speed with an immobile obstacle. Also a case study is presented to estimate the dynamics of a traffic accident.

2. THEORETICAL CONSIDERATIONS

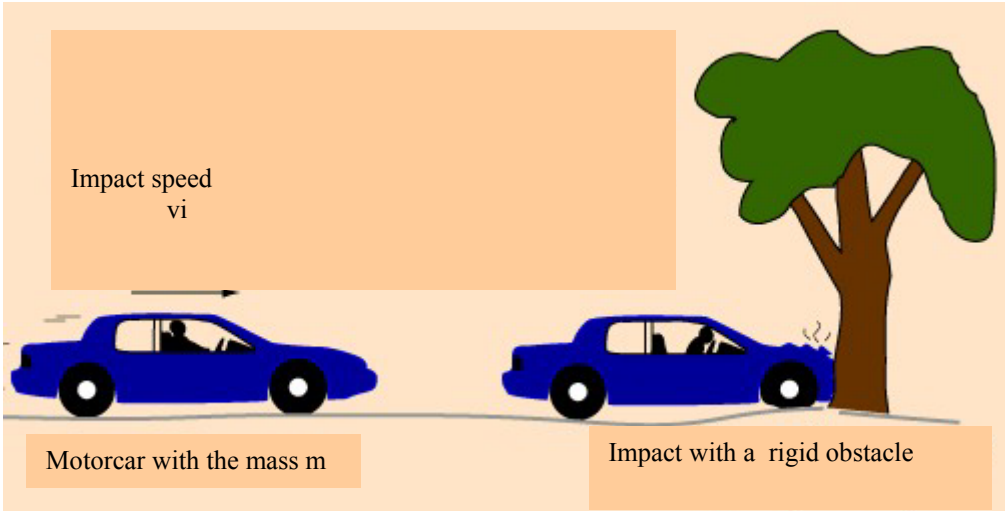


Figure 5

In accordance with the energy conservation principle for the frontal and backside collision, a deformation coefficient C[N/m] is defined. The experimentally measured coefficient followed the relation:

$$E_d = \frac{m \cdot v^2}{2} = \frac{C \cdot \delta^2}{2} \qquad (1)$$

where:
E_d - the deformation energy of the body of the car elements, [J]
V - the impact speed with an immobile obstacle, [m/s]

m - the mass of the motorcar, [kg]
δ - the residual deformation after the impact, [m]

The usual values of the coefficient C are as follows:

- 500…1500 KN/m for motorcars
- 4000…6000 KN/m for motor lorries in the cab area
- 12000…16000 KN/m for motor lorries in the chassis and protector bars areas
- 50000…60000 KN/m for motor lorries in the against-interlard structure areas

The superior boundary values of the C coefficient are typically of the low deformation domain respectively for the backside collisions. The values of the C coefficient increase when the mass of the motorcar also increases.

If the equality $F(\delta)=C$ is valid, where δ is the force variation function which produce the deformation, the expression of the energy is:

$$E_d = \int F(\delta) \cdot d\delta = \int C \cdot \delta \cdot d\delta \tag{2}$$

Admitting that during a frontal collision with a rigid obstacle, the coefficient C remain approximately constant, in accordance with the force equilibrium principal, the following equations there will be obtained:

$$m \cdot \frac{d^2\delta}{dt^2} = -C \cdot \delta \quad \Rightarrow \quad m \cdot \frac{d^2\delta}{dt^2} + C \cdot \delta = 0 \tag{3}$$

The differential equation (3) presents the solutions:

$$v_d = v_i \cdot \cos(\omega \cdot t) \tag{4}$$

$$\delta = \frac{v_i}{\omega} \cdot \sin(\omega \cdot t) \tag{5}$$

where v_d represents the motorcar speed for a certain moment t during the impact and v_I represents the initial impact speed, so:

$$\omega = \sqrt{\frac{C}{m}} \tag{6}$$

The deformation reach the maximum value when the motorcar stops (v_d=0),for the condition ω t = π/2, after the moment t_{max}:

$$t_{\max} = \frac{\pi}{2}\sqrt{\frac{m}{C}} \tag{7}$$

3. CASE STUDY

As a result of an expertise at the impact between a motorcar Honda Accord LX and a rigid obstacle, there have been measured a frontal deformation of δ=0,45 m (Figure 6). In accordance with [4], for the studied case, the C coefficient reach the value C=557KN/m, so:

$$\omega = \sqrt{\frac{C}{m}} = \sqrt{\frac{557 \cdot 10^3}{979}} = 23{,}85 \quad rad/s$$

$$t_{\max} = \frac{\pi}{2}\sqrt{\frac{m}{C}} = \frac{\pi}{2}\sqrt{\frac{979}{557 \cdot 10^3}} = 0{,}066 \quad s$$

Figure 6

There is presented in figure 6, an image of the motorcar Honda Accord LX after the impact.

In accordance with relation (5), the impact speed v_i reach the value:

$$v_i = \omega \cdot \delta = 23{,}85 \cdot 0{,}45 = 10{,}7325\ m/s = 38{,}637\ km/h$$

A breaking trace on the asphalt with a length of d_f=20 m has been measured, so the speed of the motorcar before the breaking process may be calculated with the relation:

$$v_0 = \sqrt{v_i^2 + 2 \cdot a_f \cdot d_f} \qquad (8)$$

where a_f represents the breaking acceleration, $a_f = g\ \square_l$, g = 9,81 m/s^2 is the gravitational acceleration and $\square_l$ is the coefficient of adherence.

So, the speed of the motorcar before the breaking process reach the value:

$$v_0 = \sqrt{10{,}7325^2 + 2 \cdot 9{,}81 \cdot 0{,}8 \cdot 20} = 20{,}71\ m/s = 74{,}57\ km/h$$

Taking into account that the accident has been produced inside the city, the maximum legal speed limit of 50 km/h has been exceeded.

4. CONCLUSIONS

The paper presents some theoretical aspects in order to estimate the impact speed for a frontal collision between a motorcar and an immobile obstacle. After the technical expertise of the damaged motor car, there is possible to estimate the speed in the moment of impact as well the speed before the breaking process. The theoretical aspects are used for a case study based on a real accident produced in the Timis county area.

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