The 3rd International Conference on
″Computational Mechanics
and Virtual Engineering″
COMEC 2009
29 – 30 OCTOBER 2009, Brasov, Romania

THE CAR COLLISION SPEED DETERMINATION THROUGH THE DECOMPOSITION OF THE RETROSPECTIVE MOTION

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Abstract: *At the International Conference „Computational Mechanics and Virtual Engineering" I will attend with a proper method for automobile collision speed determination through the decomposition of the retrospectively motion. Starting from the post-impact motion, retrospectively from the place where the automobile stop, determine the speed on the law of energy conservation. Follows the sequence itself on the same principle by forming a system of two equations with two unknown, by resolution which retains the actual (positive) value, followed by motion before the collision which is solved by classical formula according traces of braking.*

1. INTRODUCTION

The determination of impact speed will be based on the decomposition of the movement of both cars in the following steps:
- Movement after collision;
- Collision itself;
- Motion before collision.

2. MOVEMENT AFTER COLLISION

To define the elements of movement in all three steps, we use the distances recorded in the paperwork of research on the spot, with a sketch of the accident site, the existing evidence in the file and photographies, which will be introduced in system of equations, which defines the law of energy conservation, as follows:

$$\frac{m_1 \times u_1^2}{2} = m_1 \times g \times f_{max} \times S_{10}$$

$$\frac{m_2 \times u_2^2}{2} = m_2 \times g \times f_{max} \times S_{20}$$

in which:
m_1 = mass of car nr. 1, where we add weight of the vehicle´s load, in kg;
m_2 = mass of car nr. 2, where we add weight of the vehicle´s load, in kg;
u_1 = speed of car nr.1 after the collision, in m/s;
u_2 = speed of car nr.2 after the collision, in m/s;
g = 9,81 m/s^2, the gravitional acceleration;
f_{max} = maximal road aherence adhesion from the road type;
S_{10} = movement distance after collision of the car nr.1, in m, from the case file;
S_{20} = movement distance after collision of the car nr.2, in m, from the case file;
Returning to the equation system mentioned above, by entering the data and making the necessary simplifications, resulting after impact velocities

$$u_1 = \sqrt{2 \times g \times f_{max} \times S_{10}} \quad [\text{m/s}]$$

$$u_2 = \sqrt{2 \times g \times f_{max} \times S_{20}} \quad [\text{m/s}]$$

3. THE COLLISION ITSELF

Because the collision between two cars is semi-elasic to plastic, we will apply the principle of kinetic energy conservation found by using a two equation system with two unknown values: v_1 and v_2 as following:

$$\begin{cases} \frac{m_1 * v_1^2}{2} + \frac{m_2 * v_2^2}{2} = \frac{m_2 * u_2^2}{2} + \frac{m_1 * u_1^2}{2} + w_1 + w_2 \\ k = \frac{u_2 - u_1}{v_1 - v_2} \end{cases}$$

in which we know:
u_1, u_2 after collision velocities;
k = coefficient of restitution = 0.13 - 0.25 range for speeds in 40 - 60 km/h and 0.1 - 0.3 for higher speeds;
$W_1$and W_2 - energy consumed by deformation of the two vehicles.
To proceed, the following trick will be used: we divide the terms of the first equation with m_1 and then reduce them by ½. From the second equation we extract v_1, making both equations take the following form:

$$\begin{cases} v_1^2 + \frac{m_2 * v_2^2}{m_1} = \frac{m_2 * u_2^2}{m_1} + u_1^2 + \frac{w_1}{2 * m_1} + \frac{w_2}{2 * m_1} \\ v_1 = v_2 + \frac{u_2 - u_1}{k} \end{cases}$$

We introduce v_1 of the second equation in the first equation, obtaining a second degree equation with one unknown value, v_2:

$$v_2^2\left(1 + \frac{m_2}{m_1}\right) + 2 * v_2 * \frac{u_2 - u_1}{k} + \frac{u_2^2 - 2 * u_2 * u_1 + u_1^2}{k^2} -$$

$$- \frac{m_2 * u_2^2}{m_1} - u_1^2 - \frac{w_1}{2 * m_1} - \frac{w_2}{2 * m_1} = 0$$

This is solved by the well-known formula: $v_2 = \frac{-b \pm \sqrt{b^2 - 4 * a * c}}{2 * a}$, in which we only consider the real (positive) value.

The terms in the equation of degree two are:

$$a = 1 + \frac{m_2}{m_1}$$

$$b = 2 * \frac{u_2 - u_1}{k}$$

$$c = \frac{u_2^2 - 2 * u_2 * u_1 + u_1^2}{k^2} - \frac{m_2 * u_2^2}{m_1} - u_1^2 - \frac{w_1}{2 * m_1} - \frac{w_2}{2 * m_1}$$

Then we find the value of v_1 with the following formula: $v_1 = v_2 + \frac{u_2 - u_1}{k}$

4. MOTION BEFORE COLLISION

The initial speed of car no. 1, before the collision, will be determined using the following relation:

$$v_{o1} = 1{,}8 \times g \times t_3 \times f_{max} + \sqrt{26 \cdot g \cdot f_{red} \cdot S_1 + v_1^2}$$

where each value is known.
The same relation will be used to determine the speed of car nr.2, before collision.