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WARP SPEED BUS BODY DURING ROLLOVER

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ABSTRACT

Overturning the bus is the most dangerous type of road traffic accident, because in the case of "folding" body window frames remaining living space in the passenger compartment is considerably reduced. This leads to serious injury and even death of passengers. In Russia, the new buses pass certification tests, which assess the strength of the body structure. However, indicators that assess Traumatic bus passengers do not have to date. The paper proposes a new indicator that can solve this problem.

Keywords: passive safety, body deformity, trauma car, bus.

1. INTRODUCTION

The level of passive safety of vehicles, ie, reducing the severity of injury to the driver and passengers in a traffic accident (TA), is usually characterized by a shock-strength properties of the body, and the probability of its fire. Accordingly, the shock-strength properties can be assessed by the following indicators: vehicle deformation, human congestion and vehicle, likely the person throwing out of the car.

The level of passive safety bus rollover currently evaluated only two indicators:

a) A deformation of the bus body.
b) the probability of throwing a person out of the bus.

Control indicator "Deformation of the body of the bus" is carried out by the state. However, the verification of this indicator is carried out only in respect of new buses, which for "Approval of a vehicle type", must pass certification tests of the UNECE Regulation number 66 [1]. No verification procedures of this index for the buses in service is not provided.

In the second case for buses, there are no criteria for checking the indicator "The probability of throwing a man." There are rules of UNECE №11 with respect to latches and door retention components, but they apply only to vehicles of category M1, N1, and do not apply for buses [2]. On 01.03.2010 in the RF Government Resolution "On the seat belts" [3] has been added to the item: "The buses used to transport passengers in intercity, seating should be equipped with safety belts." Thus, the problem of retaining a passenger in the cabin of the bus in the event of an accident solved only Seat passengers carried between the settlements at a distance of more than 50 km. The other passengers are not protected by anything.

2. MAIN PART

Let us examine whether there is a relationship between the index of "deformation of the body of the bus" and a decrease in the probability of the severity of passenger injury in an accident. When evaluating this indicator nor the deformation, it is not considered any speed. According to UNECE Regulation №66 estimated the strength of the upper part of the body structure at offset window frames in the passenger compartment. However, it is clear that the severity of injury of passengers will significantly depend on the rate of deformation of the body.

Forensic experts [4] by car trauma understand "mechanical injuries caused by external or internal moving parts of the vehicle (ATS), as well as appearing in the fall from a moving ATS". This road trauma are divided:

a) Collision - the clash with a person moving exchanges.
b) Moving wheels ATS person.
c) Loss of a moving human exchanges.
d) Injury of man within the ATS.
e) Compression of the body between the ATS and other items.
f) Combination injury.
g) Atypical injury.

The basis of this classification put conditions for the occurrence of damage in different circumstances of accidents.

Despite the fact that the accident is very fleeting, every case of automobile injury occurs in cycles and consists of multiple, consecutive, short phases. Each phase corresponds to a specific injury mechanism of formation damage. Consider the most common injury resulting from the rollover bus (Table-1) [4].

Thus, the rollover bus road trauma in victims may arise from the impact and body tremors, and compression of the friction body. However, the number of phases, and, consequently, the degree of damage of each of these mechanisms may vary depending on the characteristics of the particular case [5].

Table-1. Types of automobile injury, injury phase and mechanism of injury.

Types of car injury	Phase injury	The mechanism of formation damage
Loss of human motion ATS	1. Body Collision with parts of the ATS. 2. The fall on the ground. 3. Slip on the ground.	1. Blow parts of ATS. 2. Blow on the ground and body shaking. 3. The friction on the ground.
Injury of man within ATS	1. Body Collision with parts of the ATS. 2. The body .Press prevailing due to deformation of the body parts, assemblies and units ATS.	1. Shock and body shaking. 2. Compression.

If the tipping formed a strong deformation of ATS, the affected body may be further squeezed bumped down parts of the body.

Table-2 shows the mechanisms of injury and the phases inside the bus. [6]

Table-2. Phases of injury and mechanism of injury on the body by the action of the internal parts of the bus passengers.

Body collisions with the internal parts of the bus	Compression of the body between the established parts of the passenger cabin of the bus
Damage from impact	Damage by crushing
Local	Local
Distant	Distant

All events inside the car when the accident takes place very quickly, within a fraction of seconds. To see this, we calculate the time spent on the deformation of the body of the bus during the test of the complete vehicle rollover. [1]

For this we use the known results of the test bus LIAZ-5256 rollover. [7] These data suggest that the pillars deformation at 1.25 m above the floor shall not exceed 0.3 m. On this basis, form the circuit for determining the time of deformation of the body (Figure-1).

Knowing the radius indicated on H_1 chart = 1.99 m and arc length $l_{1,99}$ = 0,3 m, find the angle β', characterizing displacement of the of gravity to the end of the strain:

$$\beta' = \frac{l_{1,99}}{H_1}, \quad (1)$$

$$l' = \beta' \cdot H, \quad (2)$$

$$t_{\text{деф..}} = \frac{T \cdot l'}{2 \cdot \pi \cdot \text{H}} = \beta' \cdot \sqrt{\frac{H}{g}}, \quad (3)$$

Where g = 9,81 м/с^2 - acceleration of gravity;

l' – arc length Nm radius, angle β'.

Substituting numerical values, calculation perform unknown quantities (Figure-1).

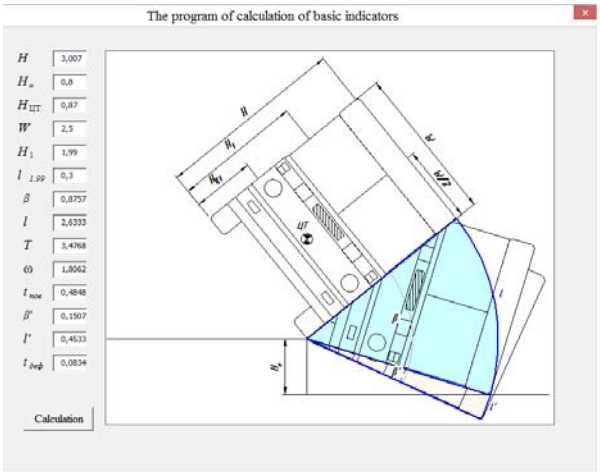

Figure-1. Scheme of deformation of the bus body and calculated data.

Thus, the time spent on the deformation of the body of the bus LIAZ-5256, is only 0.0834 seconds.

Consider the mechanism of injury to the passenger.

In accordance with the Table-2 at the beginning of a bus rollover body of a man inside the passenger cabin, will face with the bodies of other passengers, seats, window frames, windows and other parts of the interior of the passenger compartment and the body of the bus.

At the moment of impact on the bearing surface of the bus body is deformed and there is compression of the body. Moreover, in this case, the body will be affected:

- inside the cabin: in other bodies of passengers and their baggage, loose or torn equipment;
- the outside: the reference road surface, cuvette, etc. upon impact with the roof of the body will cause deformation of the roof and window frames, which will squeeze the body of passengers, in the cabin.

The higher the strain rate, the more intensively the load will act on the body.

Consider, by which the speed dependent deformation, i.e. change in the volume of the passenger compartment at a time - $\Delta V / t$, m^3 / s.

The proposed parameter $\Delta V / t$ depends largely on the strength of the body of the bus. On the strength of the body affects the layout, the location of the power unit, construction material and sidewalls, weight and size parameters, conditions and period of operation, mileage, etc.

Thus, the higher the strength of the body, the lower strain rate.

Consequently, the authors of the proposed measure the rate of deformation of the rollover will be directly characterize the severity of injuries of passengers in case of accident.

Consider the quantitative value of this indicator.

Time bus body deformation was calculated using the formula (3). Define the change in volume of the passenger compartment during rollover. To do this, we calculate the volume of the cabin before and after the accident.

Prior to the accident the passenger compartment volume V_1:

$$V_1 = V_A - V_т - V_{ob} - V_{bag}, \quad (4)$$

Where

V_A = the total volume of the passenger compartment, m^3;

$V_т$ = interior volume occupied by the driver and passengers, m^3;

V_{ob} = the volume of equipment installed in the passenger compartment, m^3 (air ducts, luggage racks, seats, handrails, etc.);

V_{bag} - interior volume occupied m^3 luggage.

After the accident the passenger compartment volume V_2:

$$V_2 = V_1 - \Delta V, \quad (5)$$

Where ΔV = the required change in volume, m^3.

We calculate these amounts for the bus LIAZ-5256.

To find the complete interior volume VA, m^3, we will consider it a rectangular parallelepiped, so that we obtain:

$$V_A = L \cdot W \cdot H_{pot}, \quad (6)$$

Where

L = overall bus length, m;

H_{pot} = the height of the roof of a body, m.

Substituting numerical values:

$$V_A = 11{,}4 \cdot 2{,}5 \cdot 2{,}105 = 60.$$

For example, the bus LIAZ-5256 has a capacity of 110 passengers. Each passenger, in accordance with [8] can have up to 0,064 m3 of hand luggage. Therefore, the amount of interior lyase busy luggage V_{bag} =7,04 m^3.

The volume of the passenger is determined by the condition of the passenger body weight 68 kg, the body of the driver of 75 kg, the adult human body density $1070 kg/m^3$ [9]. Consequently, $V_T = 0{,}063 m^3$, $V_T = 0{,}07 m^3$. On the bus, the total volume of passengers and the driver will be 7.08 m^3.

Body volume of equipment, depending on the type of seat, cabin heaters and taking into account the space occupied by the engine compartment and wheel arches, is about $V_{ob..} = 7 m^3$.

The volume of the bus before the accident the passenger compartment V_1, m^3 is equal to:

$$V_1 = 60 - 7{,}08 - 7 - 7{,}04 = 38{,}88.$$

As a result, tipping the bus LiAZ 5256 [7] volume of the body of the bus is reduced to $V_2 = 30{,}34\ m^3$. (Figure-2).

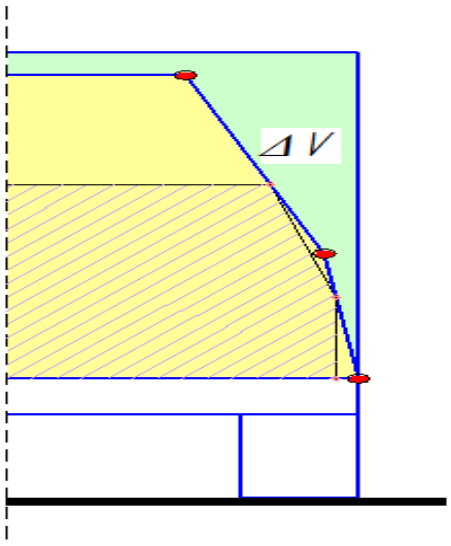

Figure-2. Change the volume of the passenger cabin of the bus after the accident.

Hence the change in volume was:

$\Delta V = 38,88 - 30,34 = 8,54\ m^3$.

Thus, the decrease in volume of the body of the bus LIAZ-5256 to 8.54 m^3 happen in 0.08 seconds. The quantitative value of $\Delta V/t$ figure was 102.9 m^3/s.

Next, we define the criteria for index of deformation speed rollover.

Consider the following options for the strain rate:

When $\Delta V = 0$. The passenger compartment is not deformed. Thus there will be no load on the outside (no deformation of the body). A mechanism for passenger injury occurs due to shock received when falling and crushing other passengers bodies, their baggage, loose or torn equipment. This may lead to easy and moderate injury.

When $\Delta V = V_1/2$. The volume of the passenger compartment to the accident halved. In the initial stage of the accident injuries of passengers will be similar to the mechanism of injury when $\Delta V = 0$. In the final stage of this will lead to compression of the passengers of the bus body structural elements. It should be borne in mind that compression will occur within 0.1 s, which in fact would be a blow. This can lead to serious injury and death.

Consider the effect of a time warp. In this case, the following options:

a) When $t \rightarrow 0$ parameter $\Delta V / t \rightarrow \infty$.
b) For $0 < t < 1$ parameter $\Delta V / t$ increases by an order.
c) At $t = 1$ parameter $\Delta V / t = \Delta V$.
d) At $t > 1$ $\Delta V / t$ parameter decreases with increasing t.
e) At $t = \Delta V$ parameter $\Delta V / t = 1$.

3. CONCLUSIONS

Summarizing the study, we can conclude that in order to reduce the severity of passenger injury from tip-over is necessary:

a) Have sufficient body strength coach, to strive for the condition $\Delta V = 0$.

b) When designing a passenger bus interior designers must take into account the supply of V_1.

c) The process of deformation of the body of the bus need to "stretch" the time from 1 sec. and more.

To meet these requirements is possible to use a number of devices that will enhance the structural strength of the bus body during a rollover. A description of such devices is presented in [10-14].

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