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Analysis of the consequences for the occupant of the overturned vehicle

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Abstract: *The following study analyzes the severity of injuries suffered by an occupant of a rolled-over vehicle when trying to escape. In order to have some realistic results, 2 experiments were made. The first experiment was effectuated by the help of a so-called pendulum stand where we simulated 3 cases with the dummy holding itself with one hand, with 2 hands, and ten without hands, while releasing the seatbelt. Then the second experiment was a much more realistic one where we used the rollover stand in order to see what exactly happens with the dummy in a real vehicle. Then the data was analyzed and compared.*

Keywords: *rollover, occupant, dummy, experiment, analyzes*

1. INTRODUCTION

The study discusses the alarming increase in the number of cars in Romania and the lack of corresponding infrastructure modernization, which has led to a rise in road accidents. To gauge road safety, the number of fatal accidents and those resulting in serious injuries is a critical metric. The European Road Safety Observatory highlights the impact of fatal accidents, where for each fatality, at least five people sustain severe injuries or injuries with lifelong consequences. Analyzing data from hospitals and police databases is a crucial means of understanding the scope and nature of these accidents.

In 2021, Europe experienced an average of 44 fatalities in accidents per 1 million people, marking a 5% increase from 2020 but a 13% decrease from 2019. Sweden and Malta were identified as the two "safest" European countries, with 18 and 17 deaths per 1 million people, respectively. In contrast, Romania tops the list with an alarming average of 93 deaths per 1 million people, well above the European average.

Additionally, the text notes the issue of rollover accidents, with limited recent statistics available (the most recent data dating back to 2006). The number of these incidents has gained significance, particularly due to the increasing popularity of vehicles with a higher center of gravity, such as SUVs

and MPVs. These vehicles are more susceptible to instability and rollovers, adding to the concerns surrounding road safety.

2. TECHNICAL REQUIREMENTS

An accident is considered a rollover type, if the vehicle turns on its side or top, in any minute of the impact. Statistics, made by the IIHS (Insurance Institut for Highway Safety) state that in 2020 30% of the total fatal accidents were rollover type. The IIHS has data since 1978, and the conclusion is that the percentage of deaths caused by rollover accidents is between 27-36%. When analyzing, there are 4 phases that can be considered: Pre-roll phase, Point of no return, First phase of roll, and Rolling phase.

2.1. Objectives

The main objectives of this study are the determination of NIC (neck injury criteria) and HIC (head injury criteria) values for the occupant who is trying to escape from a rolled-over car.

2.2. Methodology

The methodology used for this experiment consists of the 2 simulations, the pendulum type test and the rolled-over vehicle test. For this, the following tools were used:

- Pendulum test stand
- Rolled over vehicle stand
- High-speed camera
- Test dummy
- PIC DAQ tool
- Lighting devices
- Specified software

The experiment was conducted in accordance with the scenario, and a test run was conducted to ensure that all systems and apparatus were operating properly. Before the simulation: the experimental stand was set up, the dummy was positioned in each test stand's initial starting position, the device for recording the dummy's accelerations as well as the recording video camera were both initialized, the signal for releasing the dummy from the belt was given, and the impact between the occupant's head and the roof of the corresponding vehicle of the stand was performed. After impact: the camera recording was stopped, acceleration recorder was switched off, photographs were taken.

The first experiment stays in collecting data about the injuries, when the dummy is supported by 1 and 2 hands, and then without hands while opening the seatbelt.

The second experiment stays in collecting data about injuries when the dummy is placed in a car, which is really on its top, and it is using the required method for escaping from a car, which means supporting itself with its legs on the windshield of the car while releasing the seatbelt.

Fig. 2.1. The dummy position after the pendulum type tests

Fig. 2.2. The dummy in final position after the rolled over vehicle type tests

Using the PIC DAQ tool we managed to compare data from the experiments:

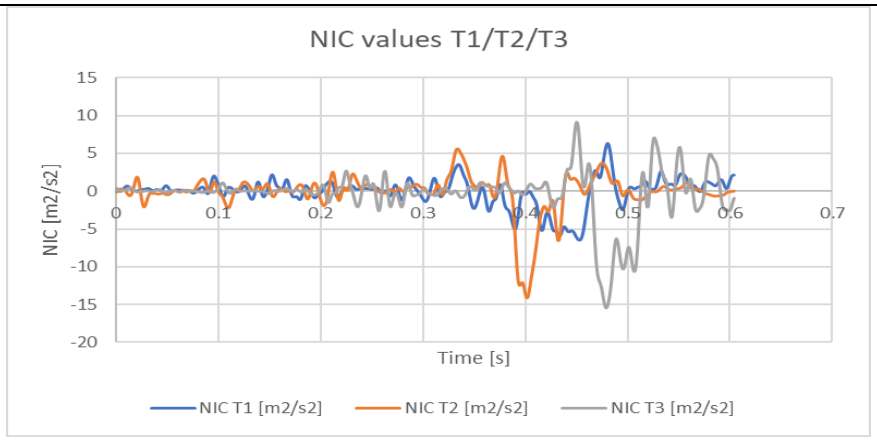

Fig.2.3. Values for neck injury from the pendulum test

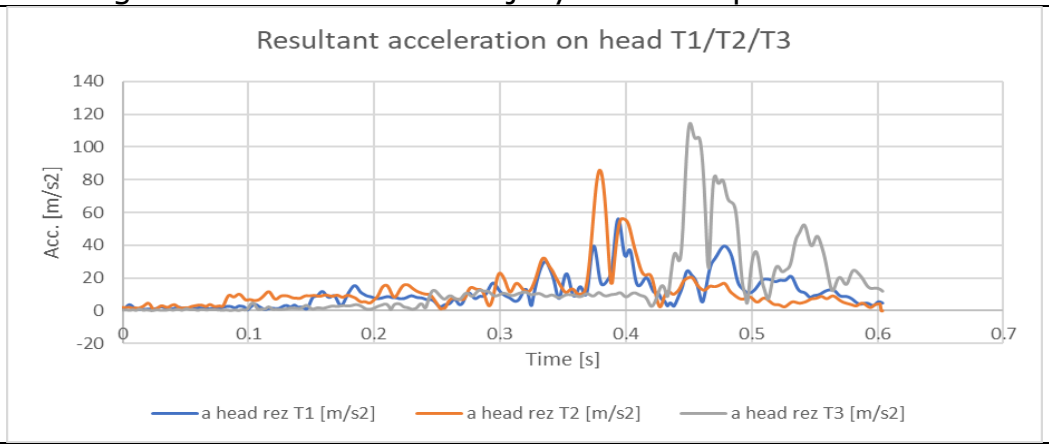

Fig.2.4.Resultant acceleration on the head

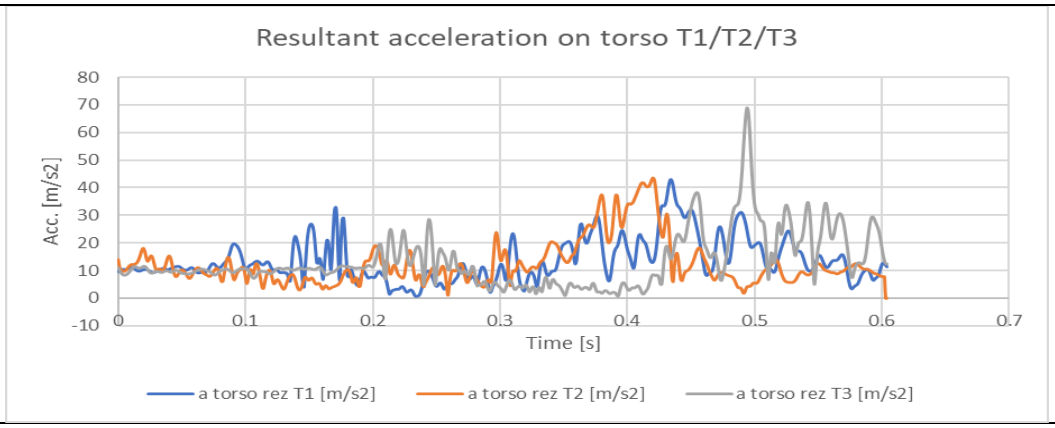

Fig.2.5.Resultant acceleration on the torso

Comparing the values:

	T1	T2	T3
NIC MAX	6.274	5.592	9.126
NIC MIN	-6.484	-14.112	-15.441

Acc. res.max head	56.135	85.908	114.50
Acc. res.max torso	42.986	43.545	68.946

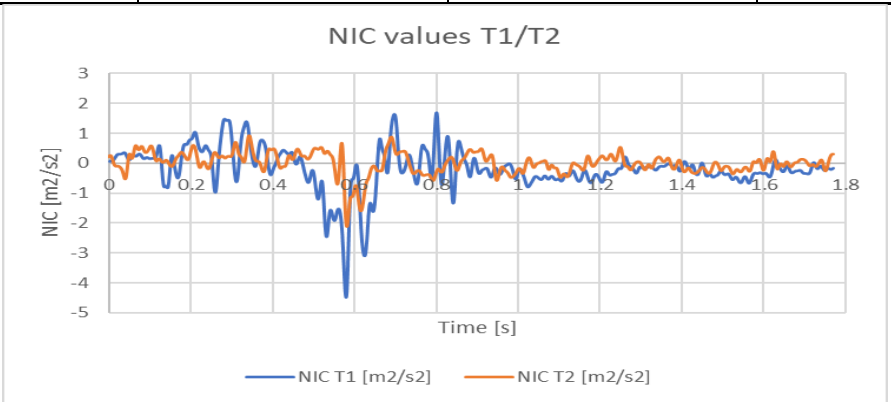

Fig.2.6. Values for neck injury criteria from the rollover test

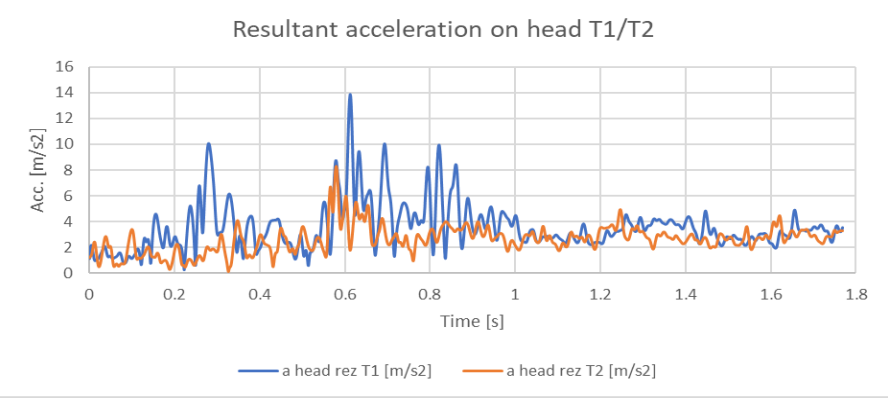

Fig.2.7. Resultant acceletarion on head

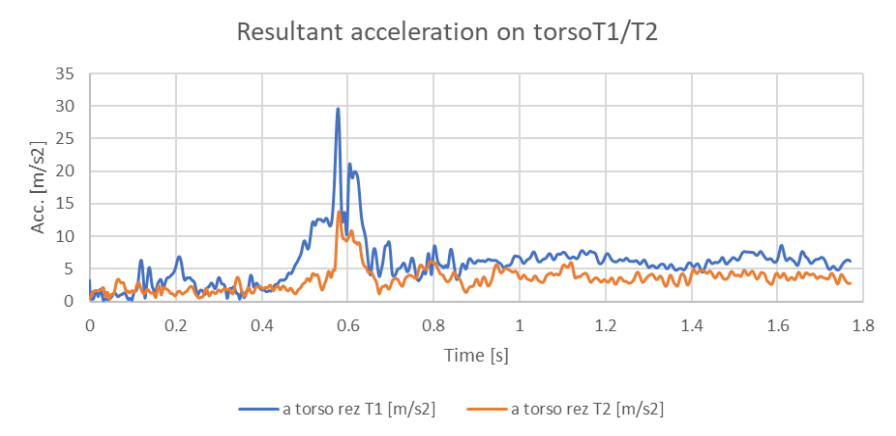

Fig.2.8. Resultant acceleration on the torso

3. CONCLUSIONS

	T1	T2	Delta load reduction
NIC MAX	1.70	0.938	55%
NIC MIN	-4.474	-2.124	47%
Acc. res.max head	13.883	8.271	60%
Acc. res.max torso	29.576	13.915	47%

Following analysis of the video data, it was concluded that a simple unbuckling of the seat belt can cause a fall and support the occupant in the head only. Due to the fact that the phenomenon could not be analyzed in detail for the determination of the stress values, a microanalysis of the movement and stresses occurring at the moment of the occupant's head falling from the roof onto a dedicated stand, in which the dummy was positioned hanging at the same level as in the case of the rollover on the stand with the body in relation to a considered surface of the roof, was carried out.

The dummy was equipped with triaxial acceleration sensors and head- and thorax-mounted reticules for video analysis. Following the sampling results, occupant stress parameters were determined and measured at the time of head support in the ceiling only by neck stress without other support.

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