COMPUTATIONAL MECHANICS 2018
34th conference with international participation
Srní
October 31 - November 2, 2018

Tramway front end design safe for pedestrian

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This paper is focused on the field of rail vehicles passive safety. The really intensive research was dedicated to the safety tram front end design in last two years. The main point of this research is to reduce the severity of the consequences of a collision between tramway and pedestrian.

The collision of pedestrian and tramway is complicated problem. Some interesting researches were published early before the interest of European rail industry. The work has tended to a new tram safety systems, proposal from the pedestrian, passenger and driver points of view. [1] Today the most interesting researches were published by the "Technical Agency for ropeways and Guided Transport Systems" [2]. This is connected with the preparation of a new regulation. The collision scenario is based on statistical research and moreover the local research in Czech Republic is in the agreement with these statistics. The statistic of accidents is important for the definition of boundary conditions. The testing collision scenario consists of the tramway with the initial velocity equalling to 20 km/h, the initial position of the pedestrian with respect to the front-end of tram. The monitored value of the pedestrian is HIC (Head Injury Criterion) with its maximum threshold value equal to1000. The research is more focused on the tram design and less on the road (which can also produce several injuries by secondary impact of pedestrian). However, this is not a case of this research and it cannot be solved by the tramway producers. The result of pedestrian collision is most influent by geometry and material of the tram front-end.

For assessment of influence of tram geometry, it is necessary to investigate in the numerical simulations with different shapes of tram face. To avoid some unpredictable stochastic phenomena, it would be best to provide simulations with maximum number of possible geometries. One possible approach is to simplify the tram front-end design to the discreet description. The tram face can be divided to the finite number of linear flats with the finite number of positions [3]. Each flat has its own stiffness, damping and slope (inclination angle) definition. This approach is not as perfect as continuous reality, because the number of variants increase rapidly (1), but it can evaluate the safety of most geometries, where some of them are quite unpredictable.

$$V'(r,n) = n^r = 5^4 = 625 \quad , \tag{1}$$

where the constant **n** is number of bodies and **r** is number of possible positions for each body. From this simple formula (1) it is obvious then the computations cannot be provided manually although this approach leads to the fast rigid body simulations.

With advantages of numerical software Virtual Performance Solution and its module Pam-Crash (which allows implement the python code to the input file), the simulation with next partition can be prepared. The main input file (*.pc) contains the minimum necessary settings and python variables for the geometry definition. This input file consists of another include

files (*.inc) with Multibody systems definitions (Human body model Virthuman, the ground definition, and the tram front-end design). The last include file contains python code which can create the simply Multibody model of tram face with basic trigonometry transformations (with known python variables defined in main input file) at the start of simulation.

This definition of simulation allows us to use another code for creating and running all possible variants of tram design. The first fast solution was prepared in Matlab which runs specific multibody computations on Linux based cluster through shell bash script (*.sh). The Matlab was selected cause its suitable and known possibilities to format text correctly and readable for Pam-Crash (close to Fortran syntax). Probably this work could be done with Linux shell script only (with significant effort) in the future. Although the multibody is not much suitable for parallelization, solving more of multibody simulations allows very simply parallelism. Each simulation can run in separate thread or node of cluster. This approach allows solver to finish optimization process in hours instead of days (on one CPU). The results of many simulations can be finally post-processed with Visual viewer scripts (*.tpl).

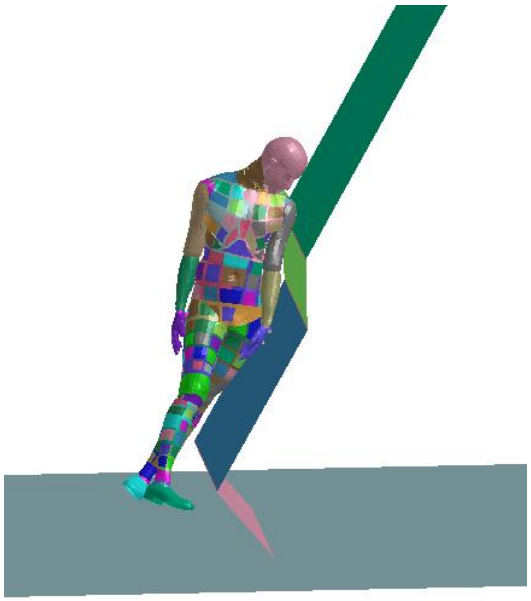

Fig. 1. The Multibody simulation of pedestrian collision with variable tram shape

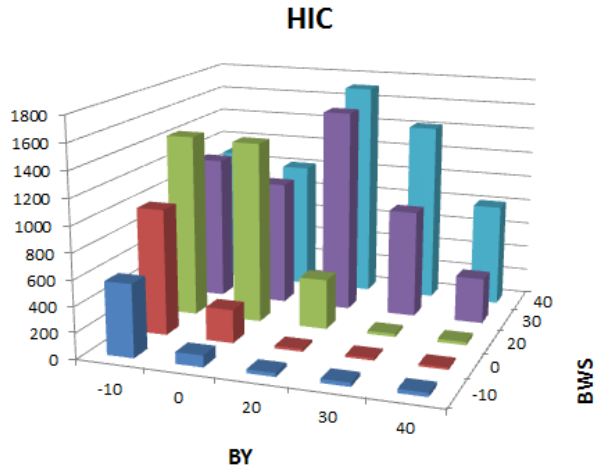

Fig. 2. The influence of two variable angles on the Head Injury Criterion value

Acknowledgements

The work has been supported by the project TRIO FV20441 „Výzkum a vývoj bezpečného čela tramvaje" provided by the Ministry of Industry and Trade of Czech Republic.

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