NEW ENERGY ABSORBING MATERIALS AND THEIR USE IN PERSONAL PROTECTIVE EQUIPMENT

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WARNING

This presentation contains videos that some audiences may find disturbing.
Why do we need PPE?
Why do we need PPE?

The video is adopted from Instagram @mx___passion.
Why do we need PPE?
Why do we need to improve PPE?
Why do we need to improve PPE?

The video is adopted from youtube.com.
Why do we need to improve PPE?
The video is adopted from Instagram @street.bikes.

Why do we need to improve PPE?
How to realize that a protective device is good?
How to realize that a protective device is good?

The picture is adopted from www.bikebandit.com/
How to realize that a protective device is good?
How to realize that a protective device is good?
How to realize that a protective device is good?
What has been done?

- Head protection:
  - Realistic material characterization for FE based injury criteria.
  - Partial optimization of helmet.
  - New materials for new generation of helmets.

- Neck Protection:
  - Assessment of a neck protective device.
Head and Neck PPE

The pictures are adopted from www.dainese.com/
Realistic material characterization for FE based injury criteria
Uniaxial Test.

EPS Compressive Stress-Strain [Ro=17 Kg/m^3]

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Realistic material characterization
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Partial optimization of helmet
Optimization of the chin bar to mitigate the risk of BSF

- MATLAB

- Fixed nodes

- 3.5 m/s

- Sorting Data for 343 lay-ups

- Optimized Chin Bar [27% reduction of neck axial load]

- Pass ECE Criteria [HIC & PLA]?

- Rigid Anvil
New materials for new generation of helmets: More reliable helmets
Lattice Structures

Struts and braces are 0.2 µm in diameter. Total size of the lattice is about 10 µm.
Lattice Structures

The video is adopted from http://cen.acs.org.
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Lattice structures for helmet’s liner

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Lattice structures for helmet’s liner

- **EPS liner**
- **Hierarchical lattice liner**

- **Resultant acceleration [g]**
- **Time [ms]**

![Graph showing acceleration vs. time for EPS and hierarchical lattice liners.](image-url)
Lattice structures for helmet’s liner

Rotational acceleration [Krad/S²]

Time [ms]

- EPS liner
- Hierarchical lattice liner
Lattice structures for helmet’s liner
Lattice structures for helmet’s liner

$t=5$ ms  $t=10$ ms  $t=15$ ms
Lattice structures for helmet’s liner

Eff. stress [MPa]

- t=5 ms
- t=10 ms
- t=15 ms
Lattice structures for helmet’s liner
New materials for new generation of helmets: Lighter helmets
SPCETRA for outer shell of helmets
SPCETRA for outer shell of helmets
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Assessment of a neck protective device
Assessment of a neck protective device
Assessment of a neck protective device

With brace

Without brace

5 ms 10 ms 15 ms 20 ms 25 ms 30 ms 35 ms 40 ms
Conclusions

- **Head protection:**
  - Realistic material characterization provides experimental data for further FE analyses of helmet oblique impacts.
  - The developed approach could be adopted by manufacturers and experimental study will be the next step of this work.
  - Hierarchical lattice structures could reduce the risk of head injuries. The optimization of the lattice will be the next step.

- **Neck Protection:**
  - According to our result, such devices may increase the risk of cervical injuries, therefore design of such a device needs more researches on mechanisms of neck injury mitigation and developing a standard for design of such devices is crucial.
Journal papers:

- S. Farajzadeh Khosroshahi, S. Tsampas, U. Galvanetto, “Feasibility study of using a hierarchical lattice struructure as the helmet liner”, [Manuscript].

Conference presentations and proceedings:


Others:

THANKS FOR YOUR ATTENTION