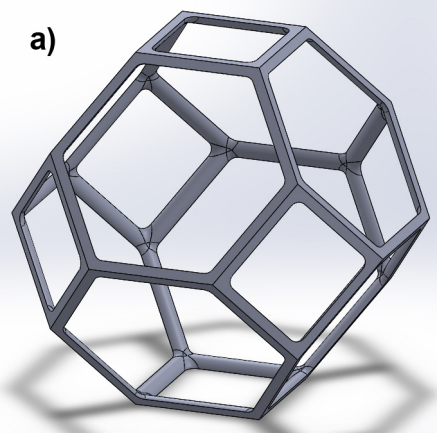
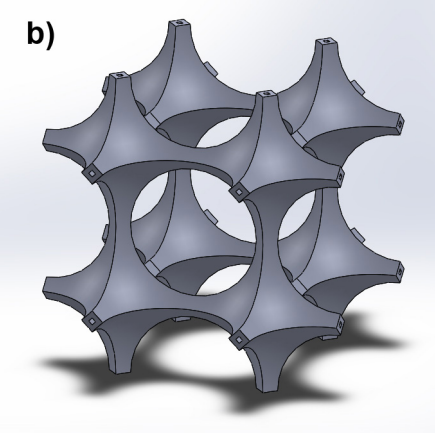
# INTELLIGENT CONTROL SYSTEM FOR CONTINUOUS CASTING BASED ON WATER FLOW CONTROL IN THE SECONDARY COOLING

## Goal of the project:

This project deals with the development of metamaterial structures composed tessellations of mainly two types of open cells: truncated hexahedron tessellation (the Kelvin structure, a) and hollow sphere tessellation (b). The structures will be modelled using computer aided design software and their mechanical properties will be evaluated using finite element analysis software. When the desired geometries will be developed, the CAD file will be exported to a rapid prototyping machine for manufacturing.




## Short description of the project:

This project addresses a subject in the field of innovative materials and it deals with the design and manufacturing of structures composed of engineered materials whose properties are not found in nature (metamaterials). The metamaterials proposed for this project will consist of cellular polymeric lattices, whose properties will be controlled through geometric parameter manipulation (strut thickness, cell size and shape). The main applications of these structures will be as cushioning and protective layers meant to absorb the deformations and impact energy of personal protective equipment. The project has two main stages. The first stage consists of the design and simulation of the structures in order to determine the optimal parameters in terms of mechanical properties. The second stage of the project will deal with the manufacturing of the structures through rapid prototyping and the experimental determination of their mechanical characteristics. The comparison between the estimated and experimentally determined properties will validate the designs of the structures, allowing for complex geometry modelling for actual safety equipment applications.

## Project implemented by

Politehnica University Timișoara

## Implementation period:

1.5.2018 – 30.4.2020

## Main activities:

O1. Literature survey concerning metamaterial structures and additive rapid prototyping techniques.
- A1.1. Literature study concerning mechanical metamaterial structures
- A1.2. Literature study concerning rapid prototyping techniques for polymers

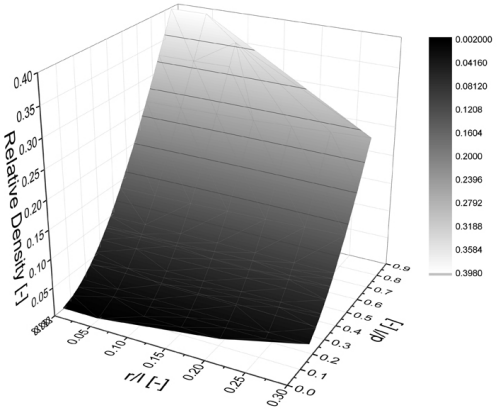
O2. Development of parametrical metamaterial structures
- A2.1. Design of metamaterial structures based on Kelvin cells
- A2.2. Design of metamaterial structures with hollow sphere cells

O3. Numerical evaluation of the mechanical properties of the developed metamaterial structures
- A3.1. Determination of the mechanical properties of the polymers used in rapid prototyping
- A3.2. Evaluation of the static mechanical properties of the developed structures
- A3.3. Evaluation of the impact and energy absorption properties of the developed structures
- A3.4. Optimization of metamaterial structures

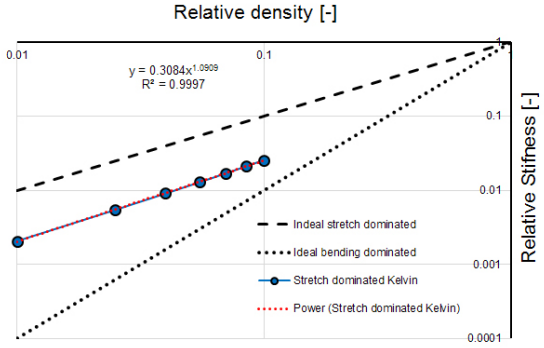
04. Manufacturing of metamaterial structures
    A4.1. Parameter adjustment for structure manufacturing through rapid prototyping
    A4.2. Manufacturing of designed structures through additive rapid prototyping
05. Experimental determination of the mechanical characteristics of the manufactured structures
    A5.1. Elaboration of static tests in compression on the manufactured structures
    A5.2. Elaboration of static tests in bending on the manufactured structures
    A5.3. Elaboration of fatigue tests in compression on the manufactured structures
    A5.4. Elaboration of impact tests on the manufactured structures
06. Structure validation and product component design
    A6.1. Comparison of results and simulation optimization
    A6.2. Design of safety equipment components based on metamaterial structures
    A6.3. Numerical analysis of the designed components' behavior in impact applications

## Results:

After the first year of implementation, several structures were generated, and the variation of relative stiffness with the structure parameters was investigated.




The geometries were imported into a finite element analysis software and the relative stiffness and relative strength variation with relative density was determined.
Partial results were published in an article entitled " A parametric study of the mechanical properties of open-cell Kelvin structures" and presented at the international conference AMS18




## Applicability and transferability of the results:

The results obtained from this project can be implemented in safety equipment, for various types of industries, such as civil engineering (helmets), sports (protective equipment such as helmets, shin guards, padding), automotive (motorcycle suits) and defense (body and vehicle armor)

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## Research Center

1. Laboratorul Ștefan Nădășan, Politehnica University Timișoara
2. Medical Engineering Research Center, Politehnica University Timișoara
3. ICER - Research Institute for Renewable Energy, Politehnica University Timișoara

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