

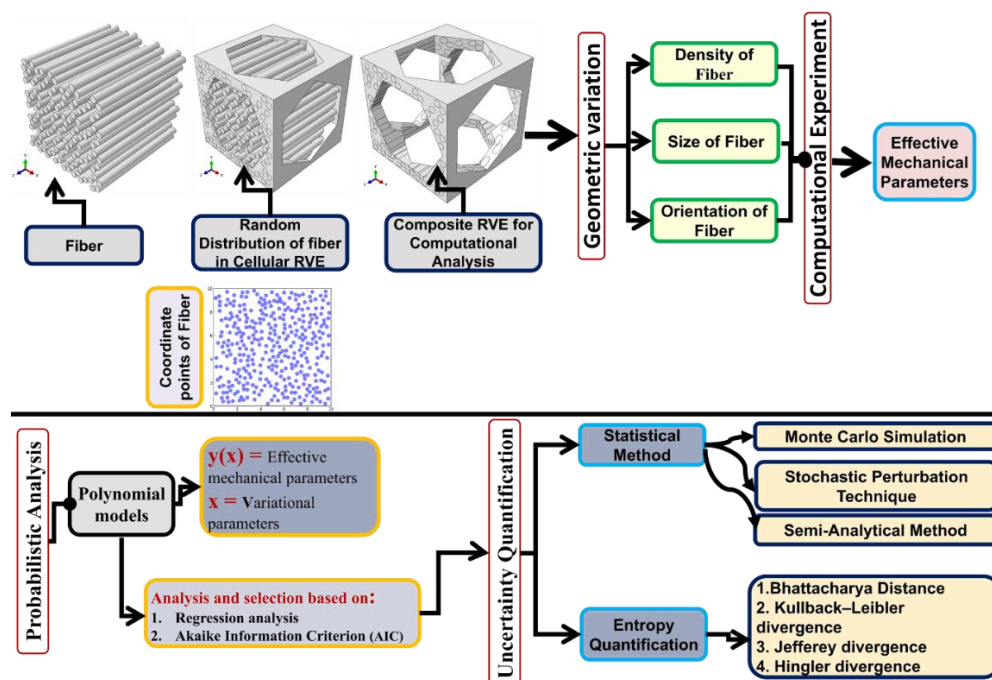
## Mechanical response of the cellular material with incorporation of Fiber

Safdar Iqbal, and Marcin Kamiński

The mechanical performance of cellular materials can be significantly improved by incorporating a reinforcing material to form a composite cellular structure. In this study, fibers were embedded within the representative volume element (RVE) of a cellular material to develop a fiber-reinforced composite architecture. A numerical homogenization approach based on the finite element method was employed to determine the effective mechanical parameters of the composite cellular material. To evaluate the influence of uncertainties in material properties and structural response, a polynomial response model was developed and used for uncertainty propagation. Three probabilistic methods: Monte Carlo simulation, the stochastic perturbation technique, and the semi-analytical method were implemented and compared in terms of their ability to predict the probabilistic characteristics of the effective mechanical response. Furthermore, information-theoretic measures, including the Bhattacharyya distance, Kullback–Leibler divergence, Jeffrey’s divergence, and Hellinger distance, were employed to quantify the similarity and divergence among the probability distributions obtained from the different probabilistic approaches. The proposed computational framework provides an efficient and reliable methodology for predicting the effective mechanical properties and quantifying the associated uncertainties of fiber-reinforced composite cellular materials, thereby contributing to the design and reliability assessment of advanced lightweight engineering structures.

**Keywords:** Cellular material; fibers; numerical analysis: mechanical property; probabilistic analysis

### Graphical Abstract:



**First Author:** Safdar Iqbal

**Affiliation:** *Department of Structural Mechanics, Faculty of Civil Engineering, Architecture and Environmental Engineering, Lodz University of Technology, Al. Politechniki 6, 93-590 Lodz, Poland*

**e-mail:** [safdar.iqbal@dokt.p.lodz](mailto:safdar.iqbal@dokt.p.lodz)

**Second Author:** Marcin Kamiński

**Affiliation:** *Department of Structural Mechanics, Faculty of Civil Engineering, Architecture and Environmental Engineering, Lodz University of Technology, Al. Politechniki 6, 93-590 Lodz, Poland*

**e-mail:** [marcin.kaminski@p.lodz.pl](mailto:marcin.kaminski@p.lodz.pl)