Institute for
Structural Analysis

TECHNISCHE
UNIVERSITÄT
DRESDEN

Univ.-Prof. Dr.-Ing. habil. M. Kaliske

MASTER'S THESIS 2018

MASTER OF SCIENCE

Implementation of the Neumann-type boundary conditions within a decoupled thermo-elastic homogenization framework

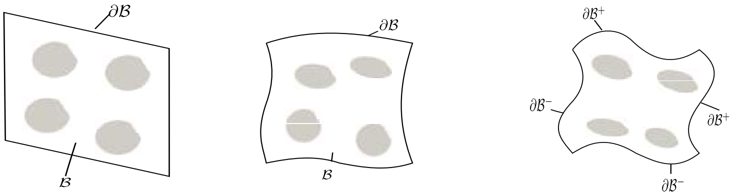
Tom Thomas

born on 13.03.1994 in India

since 2016 Technische Universität Dresden

2012 – 2016 St. Josephs College of Engineering and Technology, Kerala, India

Boundary conditions of the proposed decoupled homogenization method



$\dot{\boldsymbol{x}} = \dot{\overline{\boldsymbol{F}}}\boldsymbol{X} \;\forall\; \boldsymbol{X} \in \partial\mathcal{B}_0$

$\dot{\theta} = \dot{\overline{\theta}} \;\forall\; \boldsymbol{X} \in \partial\mathcal{B}_0$

Dirichlet-type BC

$\boldsymbol{T} = \overline{\boldsymbol{P}}\boldsymbol{N} \forall \boldsymbol{X} \in \partial\mathcal{B}_0$

$\theta = \overline{\theta} \;\forall\; \boldsymbol{X} \in \partial\mathcal{B}_0$

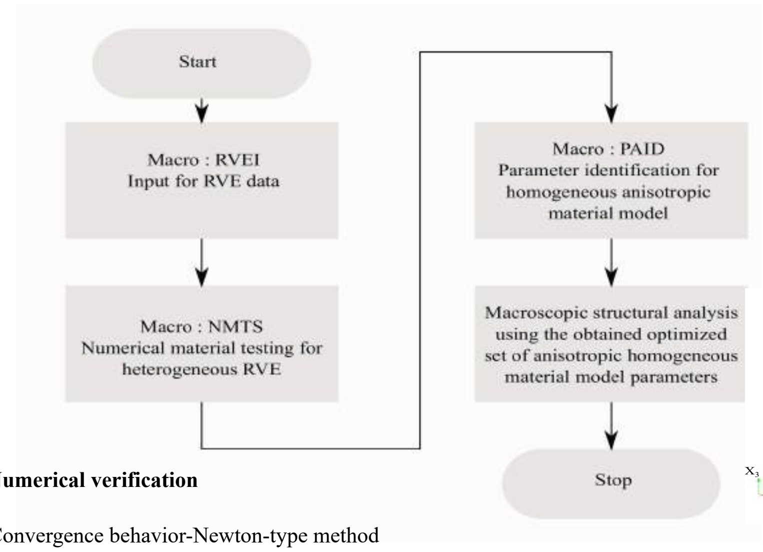
Neumann-type BC

$[\![\dot{\boldsymbol{x}}]\!] = \dot{\overline{\boldsymbol{F}}}[\![\boldsymbol{X}]\!] \forall \boldsymbol{X}^+ \in \partial\mathcal{B}_0^+ \wedge \boldsymbol{X}^- \in \partial\mathcal{B}_0^-$

$\dot{\theta} = \dot{\overline{\theta}} \;\forall\; \boldsymbol{X}^+ \in \partial\mathcal{B}_0^+ \;\wedge\; \boldsymbol{X}^- \in \partial\mathcal{B}_0^-$

Periodic-type BC

Algorithm for the FE^2 method



Homogenization quantities

$$\overline{\boldsymbol{F}} = \frac{1}{V}\int_{\mathcal{B}_0} \boldsymbol{F}\,\mathrm{d}V_0$$

$$\overline{\boldsymbol{P}} = \frac{1}{V}\int_{\mathcal{B}_0} \boldsymbol{P}\,\mathrm{d}V_0$$

$$\overline{\theta} = \frac{1}{v}\int_{\mathcal{B}_t} \theta\,\mathrm{d}v$$

Step 3: PAID macro

-Optimization of the identified material parameter

-Optimizer -Omni-optimizer (IIT Kanpur)

Specifications of the UTBC at the RVE boundary

-Normal forces are added to the boundary nodes of RVE

$$\boldsymbol{f}_b = \boldsymbol{T}_b \mathrm{d}A_0 = \overline{\boldsymbol{P}}\boldsymbol{N}_b \mathrm{d}A_0$$

-Mass-type pertubation vector and matrix

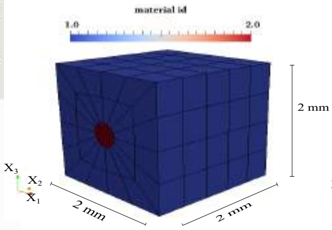
$$\boldsymbol{R}^I_{\gamma i} = \int_{\partial\mathcal{B}_0^E} \boldsymbol{N}^I \gamma \boldsymbol{N}^J \boldsymbol{u}_i^J \mathrm{d}V_0$$

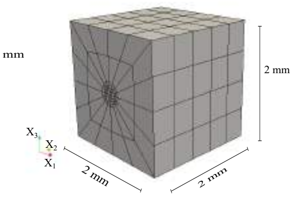
$$\boldsymbol{M}^{IJ}_{\gamma ij} = \int_{\partial\mathcal{B}_0^E} \boldsymbol{N}^I \gamma \delta_{ij} \boldsymbol{N}^J \mathrm{d}V_0$$

Example

Fiber reinforced RVE

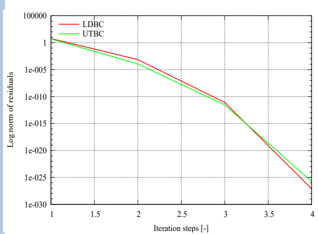
Homogeneous RVE



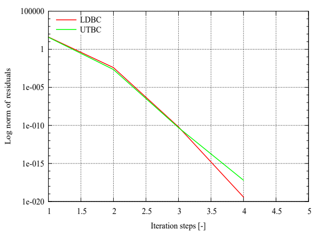


Numerical verification

-Convergence behavior-Newton-type method



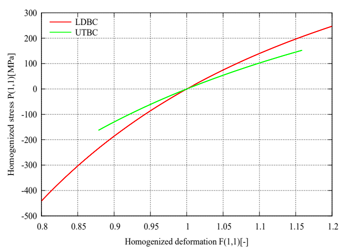
Homogeneous RVE



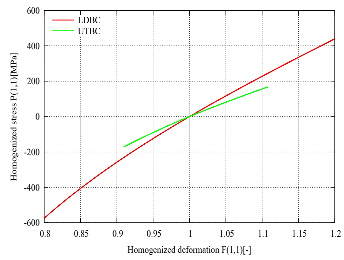
Heterogeneous RVE

Validation

Stress-Strain graph

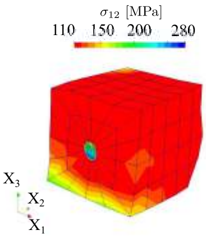


Heterogeneous RVE

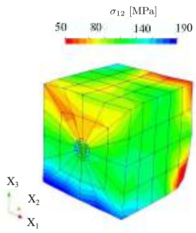


Homogeneous RVE

CauchyStress distribution-UTBC

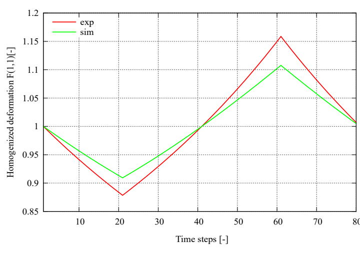


Heterogeneous RVE

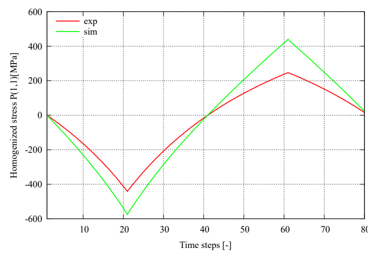


Homogeneous RVE

Comparison of NMTS and PAID for the obtained homogenized quantities



Heterogeneous RVE



Homogeneous RVE

SUPERVISORS

Univ.-Prof. Dr.-Ing. habil. M. Kaliske | Prof. Dr.-Ing. Wolfgang Graf

Dr.-Ing Robert Fleischhauer