Additive Manufacturing in Construction
1st funding period: The Challenge of Large Scale

AMC TRR277

C03 Integration of Passive and Active Functions in Additively Manufactured Construction Elements

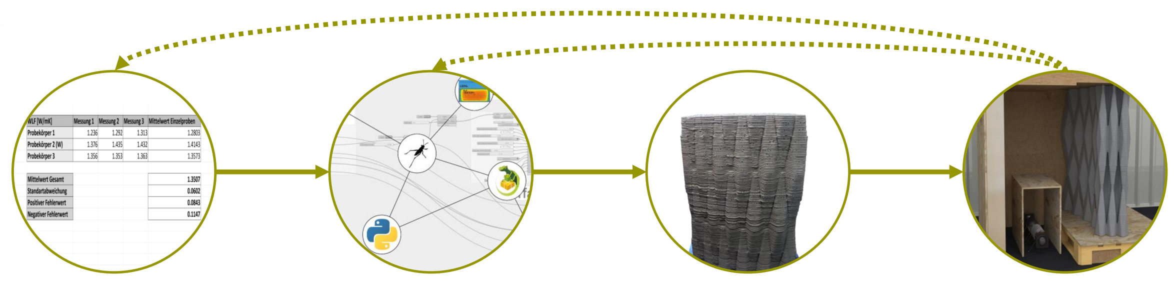
Prof. Dipl.-Ing. Thomas Auer
M.Sc. David Briels
M.Sc. Ahmad Saleem Nouman

Chair of Building Technology and Climate Responsive Design, TUM

Project summary

AM enables highly differentiated building elements, directly integrating and enhancing passive and active functions (building physics and building services). The project is thereby aiming for reduced embodied and operational carbon emissions and improving indoor air quality and thermal comfort.

Workflow



Main outcome of 1st funding period

Thermal Optimization of AM wall elements
- Performance criteria and measured material characteristics (A01, A02, A03)
- Workflow for simulation-based parametric design optimization
- Parametric studies for monolithic AM elements (U-value: 0.2 – 0.6 W/m²K)
- Validation via in-situ heat flux measurements (deviation +25 %)

Thermal load-shifting of AM murocaust
- Transient simulation of thermal load-shifting potential of AM murocaust

Electric Wire Heating Integration
- Reduce hydronic systems, enable CO_2-driven load management and control local thermal user comfort

Acoustics of AM elements
- Simulation workflow for effect of AM elements on sound dispersion

Key collaboration in 1st funding period

- **A01** Monolithic SCA façade element with cell structure and blow-in insulation
- **A02** Selective binding of lightweight aggregates (foamed clay) for thermally enhanced monolithic elements
- **A03** Concrete extrusion of cellular structure with lightweight material and graded material properties
- **A04** Thermally activated ribbed slab and hollow-core column for ventilation
- **A05** Combination of fibre reinforcement with integration of electric wire heating
- **C01** Combined 2D and 3D heat flux simulations
- **C04** Automated path-planning for thermally enhanced geometries and simulation-based parametric design

Project status

Heat flux measurements

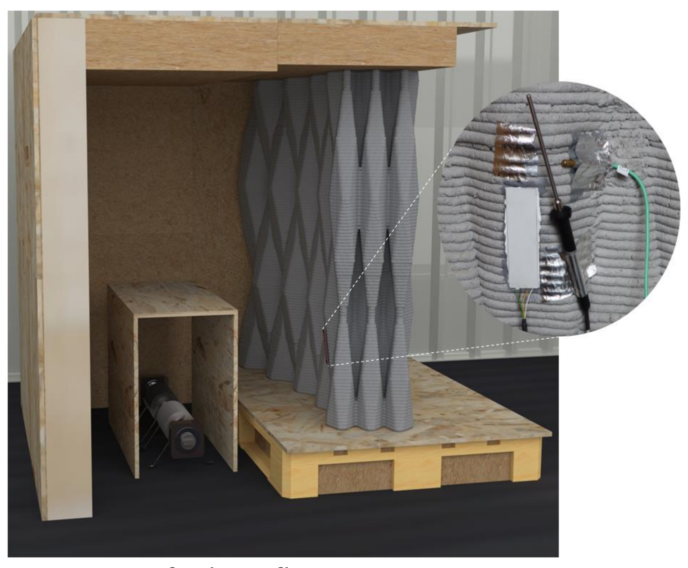


Fig 1: Setup for heat flux measurements on an innovative cellular solid prototype (u-value: 0.75 – 1.37 W/m²K

Thermal load-shifting

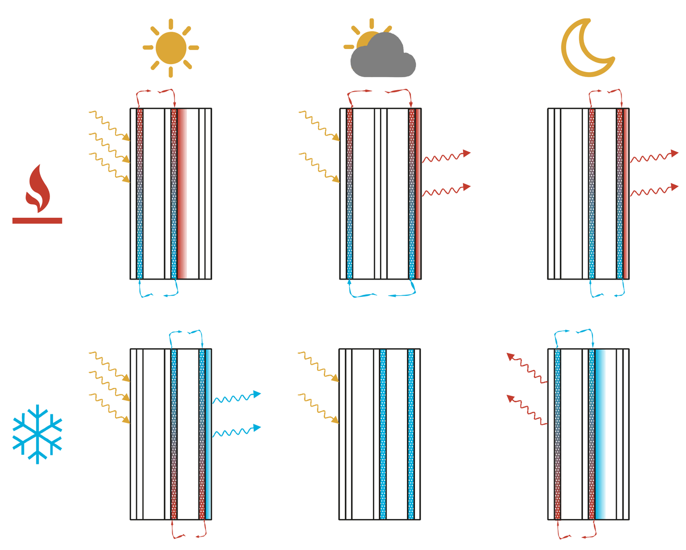


Fig 2: Thermal load-shifting cases of an AM murocaust façade illustrated in a vertical section.

Acoustic simulations

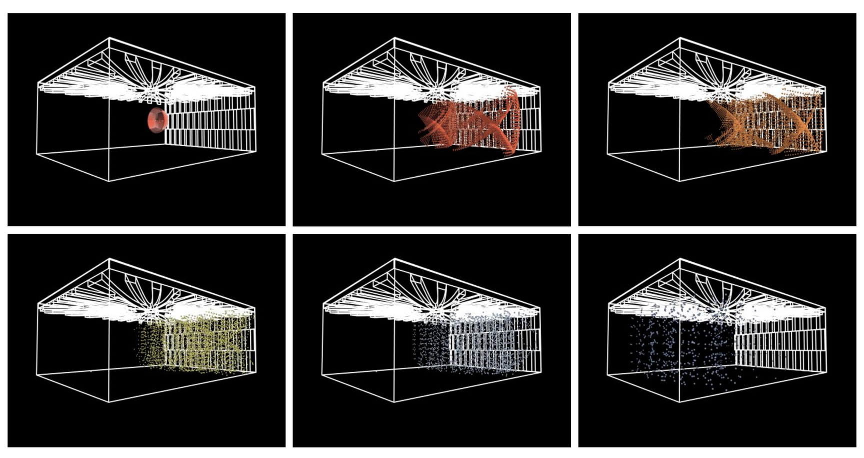


Fig 3: AM elements shaping sound dispersion: Insights from acoustics simulations at room level.

2D heat flux simulations

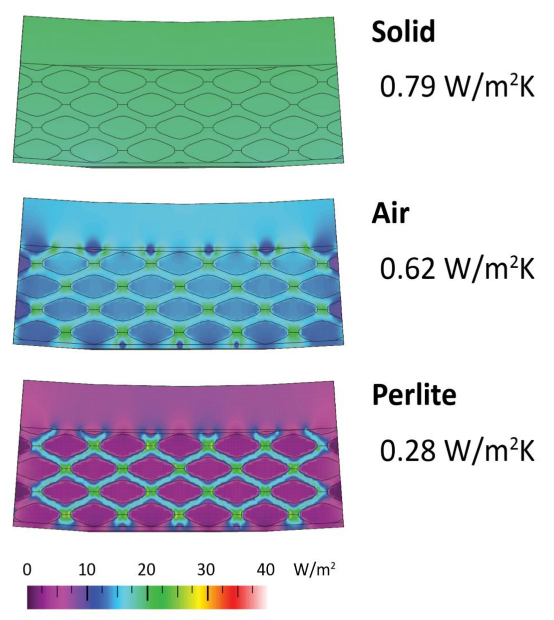


Fig 4: Comparing 2D heat flux simulations of a SCA façade element: solid vs. air-filled vs. insulation-filled.

Use cases for functional integration

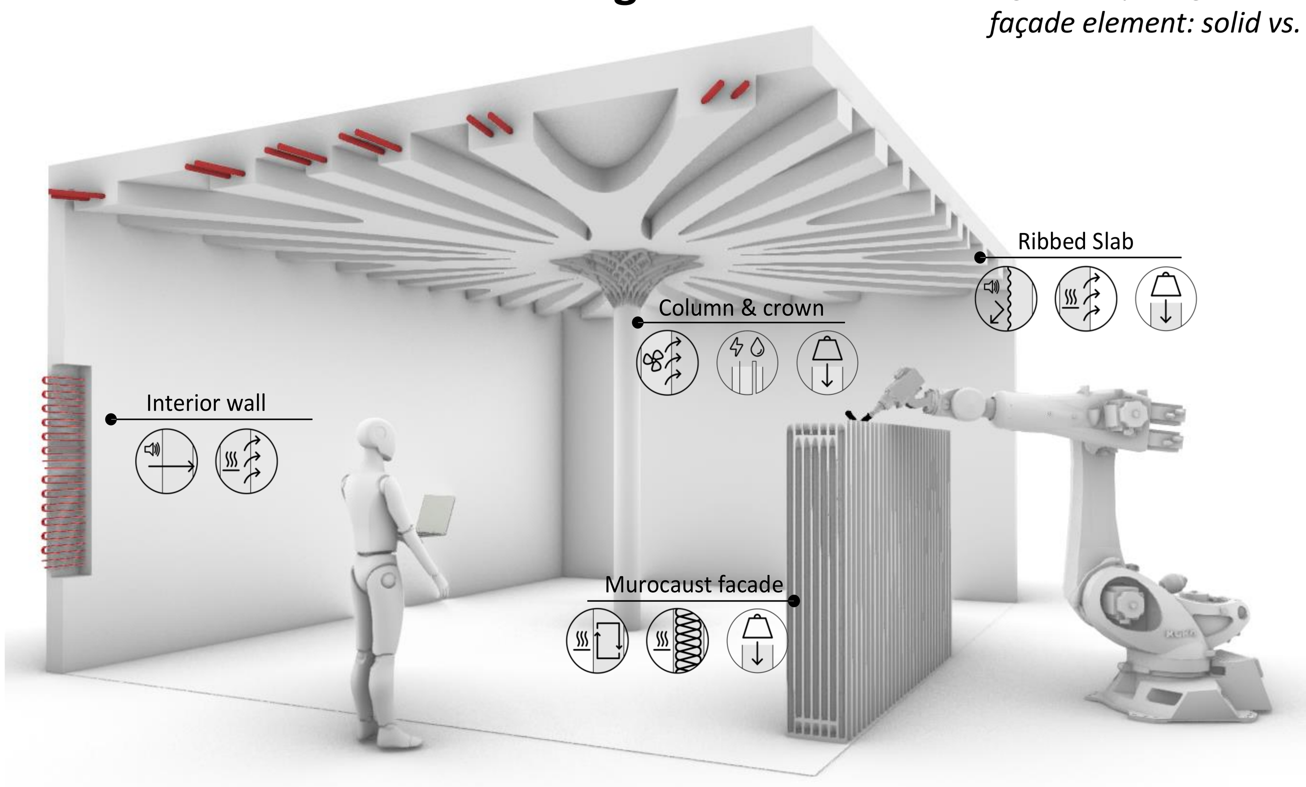


Fig 5: Integrating passive and active functions in AM building elements: Unlocking new possibilities.

Large Scale Demonstrators

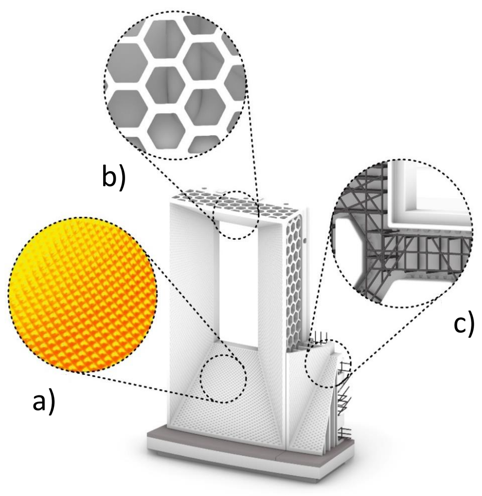


Fig 6: SCA façade element with functional hybridization

Breuer x AM
- Insulating zone (b) with cell structure filled with blow-in insulation material (perlite)
- Enhanced thermal insulation performance with U-value = 0.28 W/m²K (- 75 % - solid)

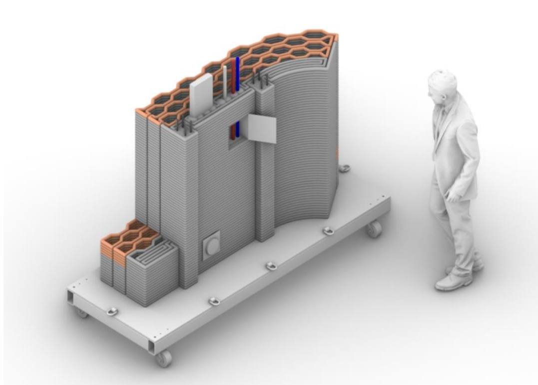


Fig 7: Extruded façade element with material gradation

Marriage of two Materials
- Insulating zone (red) with lightweight material and cell structure (U-value = 0.84 W/m²K)
- Integrated building services (ventilation, piping, revision)

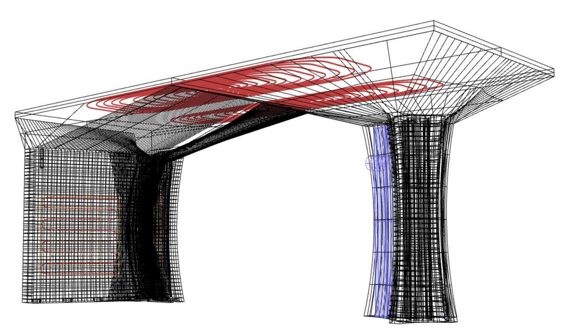


Fig 8: Multiple active installations

Shelltonics
- Localised thermal activation in wall and ceiling
- Ventilation through hollow-core column to minimise piping

Fig 9: Monolithic SPI blocks with lightweight aggregates

Blox
- Encapsulated, unbound lightweight aggregates (foamed clay)
- Graded cellular structure for functional hybridization (U-value = 0.3 – 0.6 W/m²K)

Funded by
DFG Deutsche Forschungsgemeinschaft
German Research Foundation

Technische Universität Braunschweig
Technical University of Munich TUM