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

AMC TRR277

C06

Integration of Additive Manufacturing in the Construction Process

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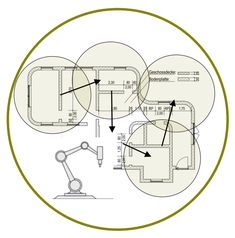
Project summary

The aim of this project is to investigate the integration of additive manufacturing in the construction process at the scale levels of component fabrication (using bi-directional flow of information between production and planning), building construction (in-situ printing) or component assembly on-site (using mixed reality besides others) and on the industry scale (e.g. integrated project delivery).

Main outcomes of 1st funding period

Closed loop Workflow for SC3DP



Fabrication strategies based on robotic systems

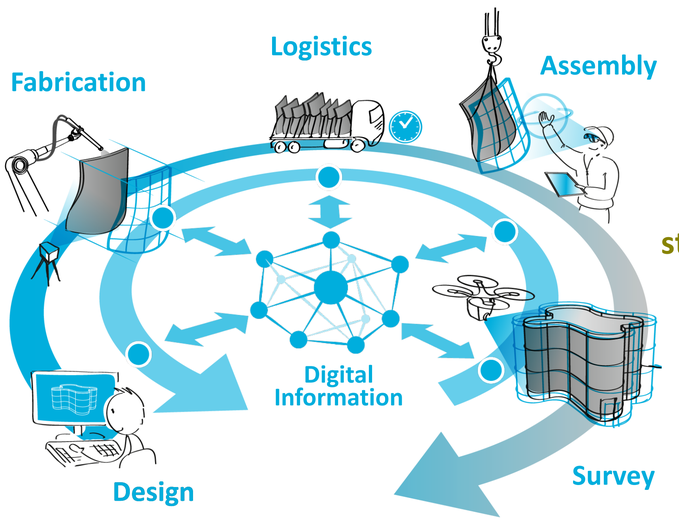
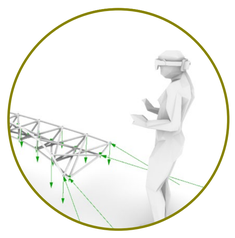
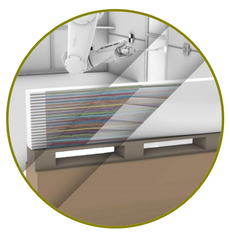


Fig 1: AM process chain and main outcomes



AR-based assembly strategies of AM components



Feedback loop for as-built data

Key collaborations in 1st funding period

A04 Process analysis and quality control, comparison of SC3DP to formwork-based fabrication

B05 Enhancing the robot pose estimation accuracy in the construction site

C04 Bi-directional data transformation between FIM and physical world; robotic systems for in situ use

C05 Investigating the quality of the joints for assembly

Project status

- A classification framework for robotic systems with four categories has been developed and the influence on the production process was analysed [26]
- An automated workflow for quality control with automated surface finishing was investigated and proto-typically implemented [20]
- In close collaboration with C05, various specimens are realized and measured to investigate the quality of the joints for assembly [25]
- Together with C04, methods to feed back detailed as-printed information into the Fabrication Information Model (FIM) have been developed [25]
- Ongoing investigating of AM impact on planning/execution (CD Breuer x AM)

Large scale demonstrator

Shelltonics (A04): Holographic enrichment of real objects with the results from planning and simulation

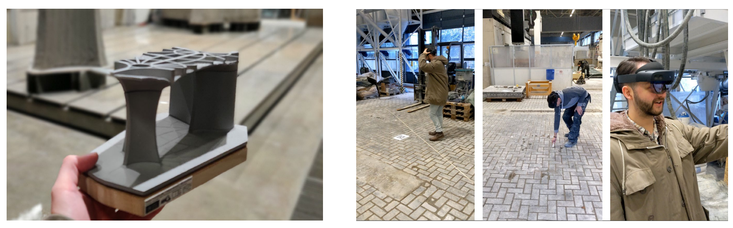


Fig 2: Shelltonics model

Knitecrete Bridge (A05): Automatic pin detection, quality control

Fig. 3: Knitecrete Bridge

Workflow

- Automated quality control with subsequent automated surface finishing
- Investigation of the process steps with a subsequent productivity analysis

Process analysis

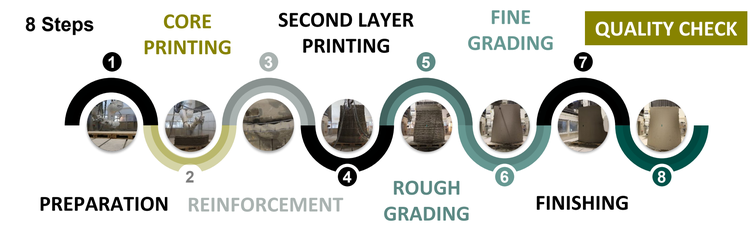


Fig. 4: Process Chain for Shotcrete 3D Printing

Geometric quality control

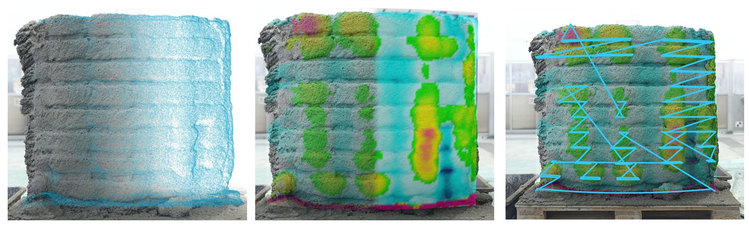


Fig. 5: Deviation of as-planned & as-built with path planning for surface improvement

Closed loop workflow

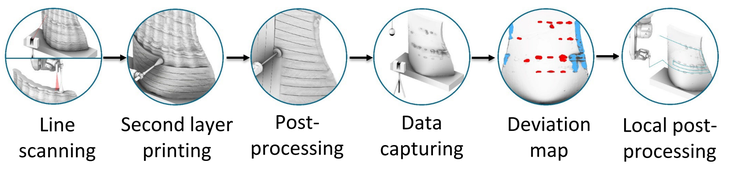


Fig. 6: Automated detection of manufacturing artefacts and local path planning to improve surface quality

Transferring as-built information back to BIM

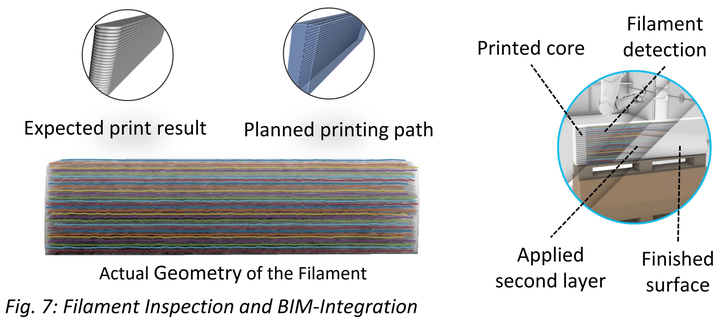


Fig. 7: Filament Inspection and BIM-Integration

Production time against conventional construction

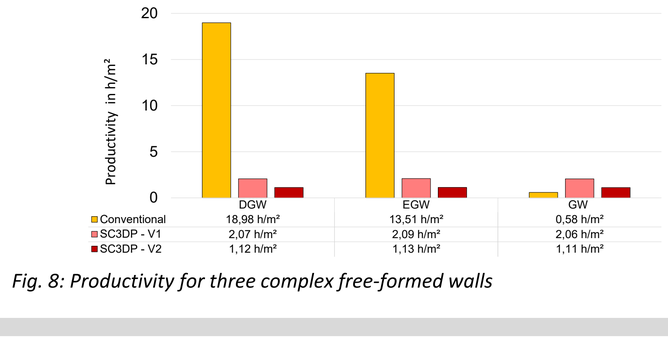


Fig. 8: Productivity for three complex free-formed walls

Conclusion

- By leveraging the bidirectional information exchange framework, the project explored the integration of additive manufacturing in construction at three scales
- Consequently, the project aimed to enable continuous quality control through seamless digitization and additive manufacturing from design to fabrication to assembly

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