Developing structurally optimised concrete components: Additive manufacturing using a powder bed

About this project

SupLeichtAF

Developing structurally optimised concrete components: Additive manufacturing using a powder bed

Markets:

Material: Others (Compressible concrete)

This project is funded by the Technology Transfer Programme Leichtbau (TTP LB) of the Federal Ministry of Economics and Energy.

Technology Transfer Program Leichtbau

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Context

The construction industry faces the challenge of reducing resource consumption and CO# emissions, particularly in the case of cement-based building materials. At the same time, the demand for customised components is growing. Conventional manufacturing processes are reaching their limits in this regard: complex geometries require elaborate formwork and result in material wastage during production and processing.

Additive manufacturing processes offer new possibilities in this regard. The powder bed process, in particular, allows for virtually unrestricted shaping. In this process, dry powder is applied layer by layer and locally solidified using an activator fluid. Unbound material remains in the powder bed as a support structure and can be reused. This makes it possible to produce even delicate geometries, overhangs and cavities, which can only be achieved to a limited extent using the extrusion process, in which concrete or mortar is applied layer by layer through a nozzle.

However, the technology has so far only been of limited use for cement-bound materials. Printed components often fail to achieve the mechanical properties required for load-bearing applications. Furthermore, there is a lack of suitable design approaches and reliable process parameters. This is where the SupLeichtAF project comes in: it combines numerical optimisation methods with additive manufacturing to develop material-efficient and load-bearing lightweight structures.

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Purpose

The team is developing a resource-efficient construction method for additively manufactured lightweight components made from cement-bound materials. To this end, it is further developing powder-bed technology for use in the construction industry and testing it using a demonstration structure.

The focus is on the production of topologically optimised components. Using numerical methods, the researchers are devising geometries that use material only where it is required for load-bearing capacity, stiffness or building physics requirements. The aim is to significantly reduce material consumption whilst maintaining the necessary functions of the components.

To this end, the project partners are investigating suitable dry mortar formulations, process parameters and post-processing steps for 3D printing in a powder bed. In addition, they are developing design concepts and digital models to mathematically verify the load-bearing behaviour and service life of the components. Through the material-efficient design of the structures and the reuse of surplus powder, the team also aims to reduce CO# emissions and waste.

The demonstration structure demonstrates the potential of powder-bed 3D printing for the production of complex, structurally optimised concrete components.

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Procedure

The project team initially develops suitable binder systems and dry mortar mixtures for powder bed additive manufacturing. It analyses the flow properties, wettability, workability and strength of the printed materials and adapts the mixtures to the requirements of the printing process.

In parallel, the partners develop numerical methods for topology optimisation to design material-efficient, high-performance structures. The methods consider both mechanical requirements and manufacturing constraints, such as powder removal and the joining of individual components.

Building on this, the researchers optimise the powder bed process by investigating layer build-up, activator addition and key process parameters. They mechanically test printed reference components and use the results to refine digital simulation models. The project team also evaluates the durability of the materials under different environmental conditions.

Finally, the partners develop a design concept for additively manufactured lightweight structural elements, create digital structural models, manufacture individual components using the powder bed process and assemble them into a demonstration structure to verify the technical feasibility of the developed construction method.

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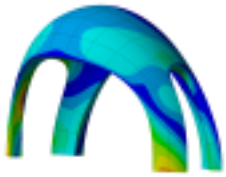


Funding duration:

Funding sign:	03LB3031	**Funding amount:**	EUR 860 thousand

Final report

Further websites

foerderportal.bund.de/foekat/jsp/SucheAction.do?actionMode=view&fkz=03LB3031A - SupLeichtAF featured in the federal government's funding catalogue

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Project coordination

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Lightweighting classification

	Realisation
Offer	
Products	
Services & consulting	

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Lightweighting classification

	Realisation
Field of technology	
Design & layout Lightweight design	✓
Functional integration	
Measuring and testing technology	
Modelling and simulation Structural mechanics	✓
Plant construction & automation	
Recycling technologies	
Manufacturing process	
Additive manufacturing 3D printing	✓
Coating (surface engineering)	
Fibre composite technology	
Forming	
Joining	
Material property alteration	
Primary forming	
Processing and separating	
Textile technology	

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Lightweighting classification

	Realisation
Material	
Biogenic materials	
Cellular materials (foam materials)	
Composites	
Fibres	
Functional materials	
Metals	
Plastics	
Structural ceramics Others (Compressible concrete)	✓
(Technical) textiles	