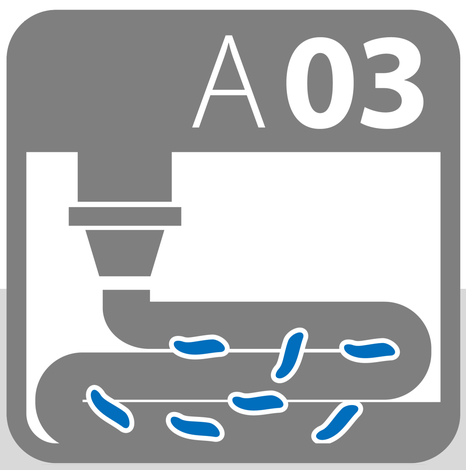

Extrusion of Near-Nozzle Mixed Concrete - Individually Graded in Density and in Rate of 3D Fibre Reinforcement

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Summary

The gradation of material properties in concrete extrusion represents a particular challenge. Therefore, an innovative near-nozzle mixing system is being developed in A03 which enables immediate gradation of the fibre content and the density ranging from normal to lightweight concrete. Furthermore, in combination with insertion of vertical reinforcement over several layers a 3D transmission of tensile and flexural forces in the structure can be achieved. Thus, material properties, such as thermal conductivity and strength, can be precisely adjusted in the component.

Objectives

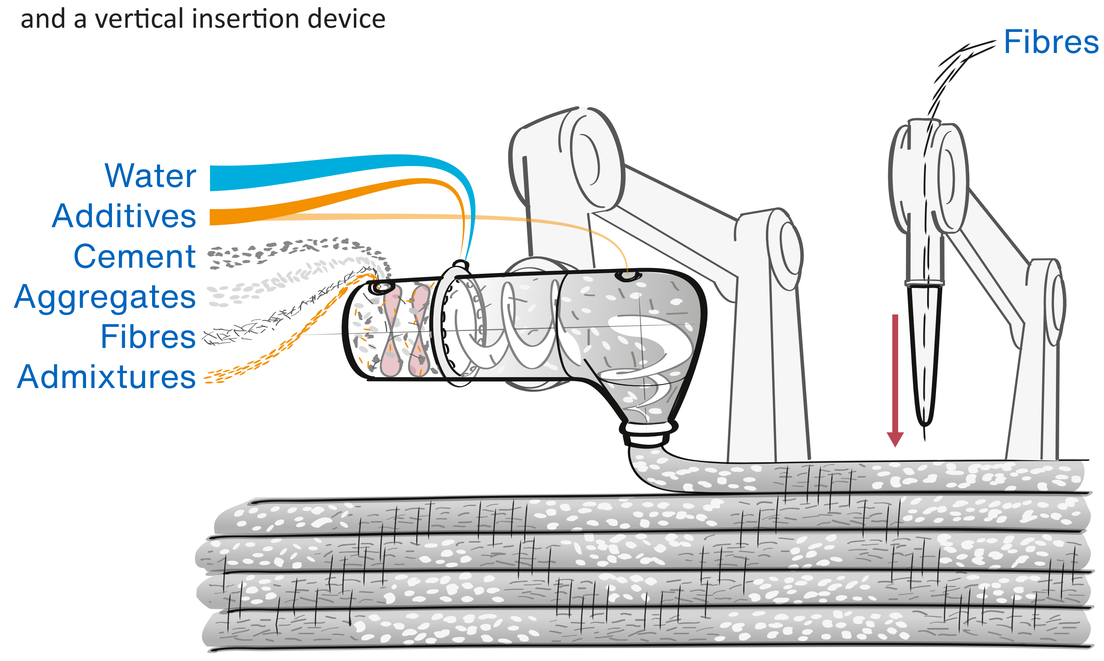
- Local control of material properties in a building component by graded extrusion
- Gradation in fibre content and density according to the required function, e.g. structural or insulating
- Insertion of reinforcement elements for enhanced flexural tensile strength
- Increased layer bonding by insertion of vertical reinforcement

Research Questions

- How fast can gradation take place with near-nozzle mixing?
- What freedom in material design does near-nozzle mixing allow?
- In which direction has reinforcement to be applied for maximum load bearing?
- How far can the anisotropy, induced by the layer-by-layer extrusion and the fibre alignment, be reduced by the insertion of vertical reinforcement?

Concept

- Combination of a near-nozzle mixing device and a vertical insertion device

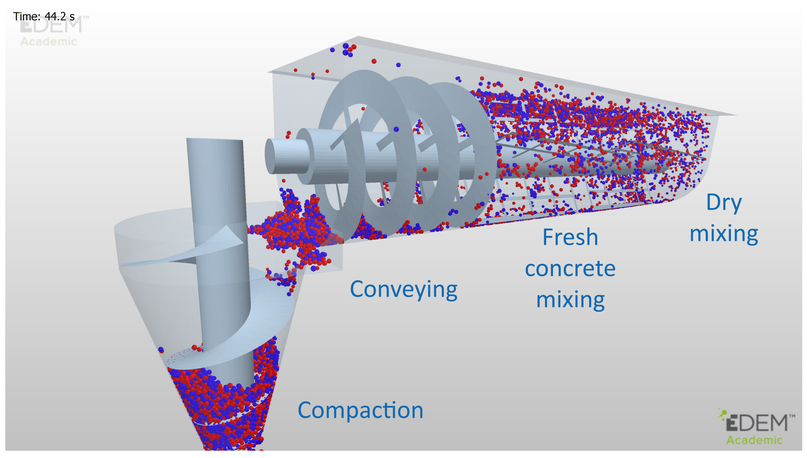


Preliminary Work

Initial tests on gradation, reinforcement and modelling of a near-nozzle mixing device were carried out to complement existing know-how from previous projects and to investigate the feasibility of the approach.

- In an ongoing research project extrudable lightweight concrete mixtures were developed for a standard extrusion device with pumping system. Based on this, challenges and possibilities for the extrusion of lightweight concrete could be derived. In particular, the pumpability over greater distances poses a challenge for light aggregates due to the pressure that occurs. In general, however, good thermal conductivities and strengths can be achieved.
- Preliminary tests were executed to increase the strength of building components by implementation of reinforcement

- The flexural tensile strength of test specimen was improved by up to 650 % by inlaid steel rebars and up to 175 % by inserted rebars. The lower effectiveness of the inserted reinforcement could be due to insufficient bond. If the rheology for improving the connection between reinforcement and concrete is developed accordingly, a great potential of this technique can be expected.



- Preliminary tests show that DEM modelling of mixing, transportation and extrusion of concrete strands combined with virtual prototyping on basis of 3D-CAD is suitable to plan and engineer the machine.
- Comparing various auger shafts, paddle screws in open design show a high degree of mixing of solids over very short distances.
- For fluidisation, a ring nozzle shows a very good efficiency with little installation space.
- Belt screws have better mixing properties, while solid screws can achieve higher transport capacity.