Geopolymer materials in 3D printing techniques

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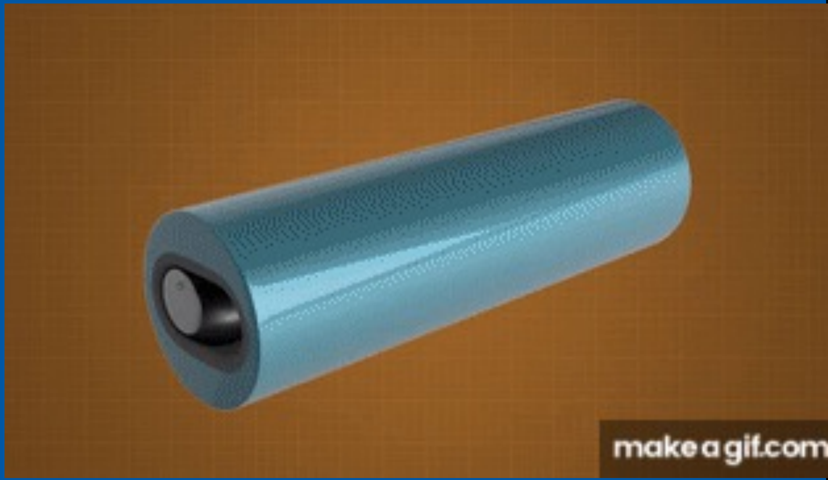
09 July 2024 16th Geopolymer Camp, Saint-Quentin – France

Past extrusion material:

Screw extrusion



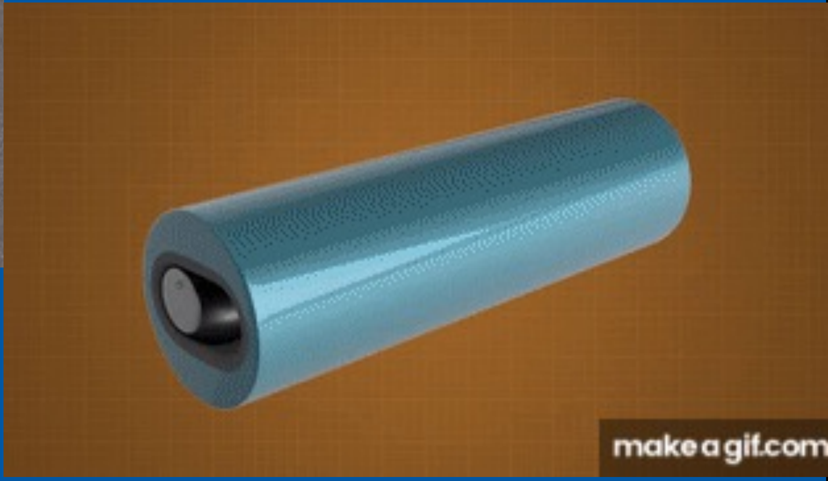
Extrusion with a syringe

Stator pump

Past extrusion material:

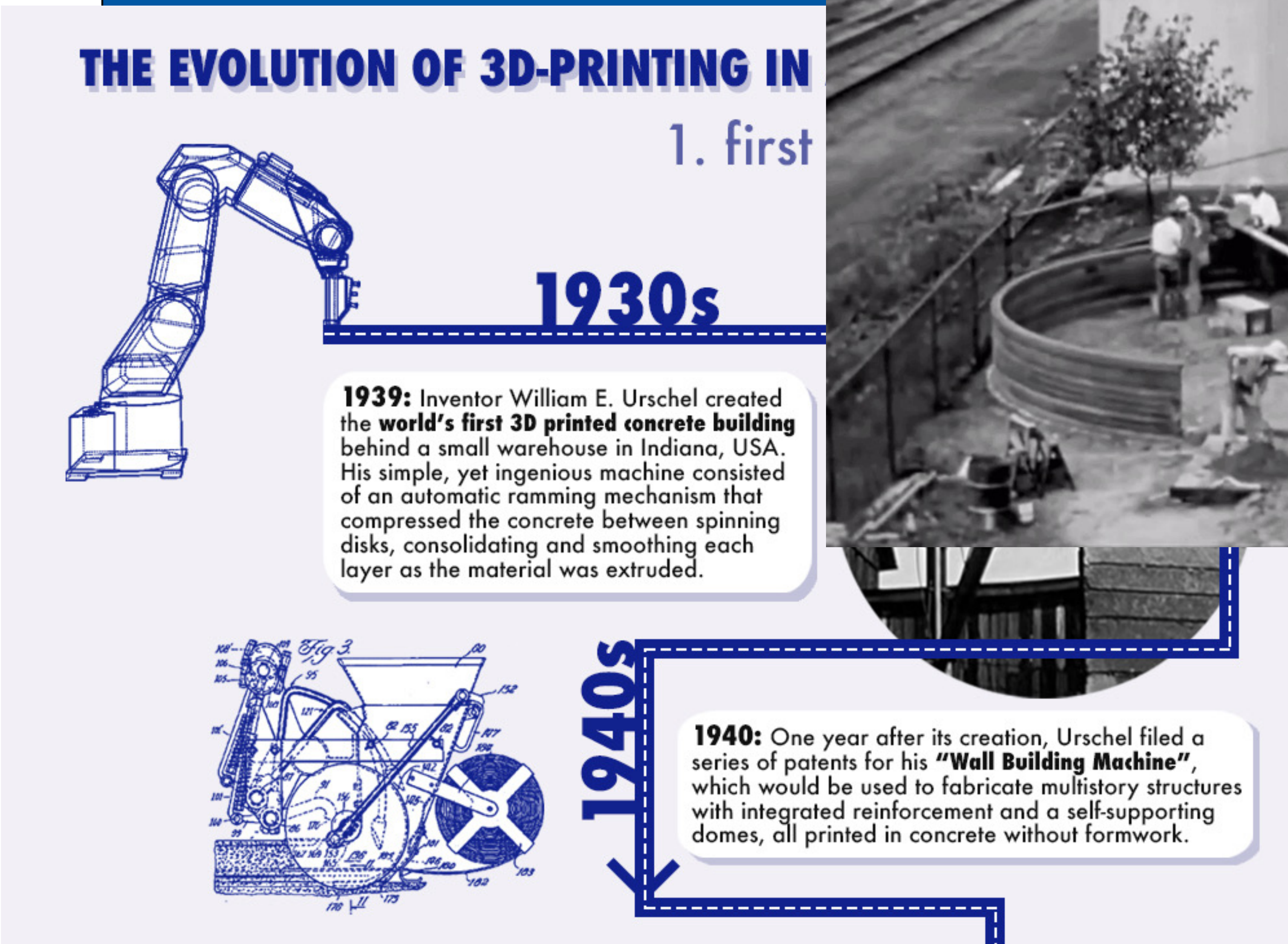
Extrusion with a syringe

Screw extrusion



Stator pump

The Evolution of 3D Printing in Architecture:



https://www.archdaily.com/1005043/infographic-the-evolution-of-3d-printing-in-architecture-since-1939

The Evolution of 3D Pr

4. first architec

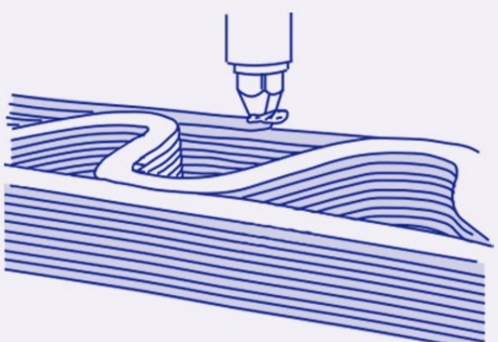
2000s

2004: Italian engineer Enrico Dini developed the D-Shape 3D printer, which employs a **binder jetting technique to create large-scale structures** using a mixture of sand and inorganic binding materials. This marked an important step towards printing architectural elements.

FUN FACT

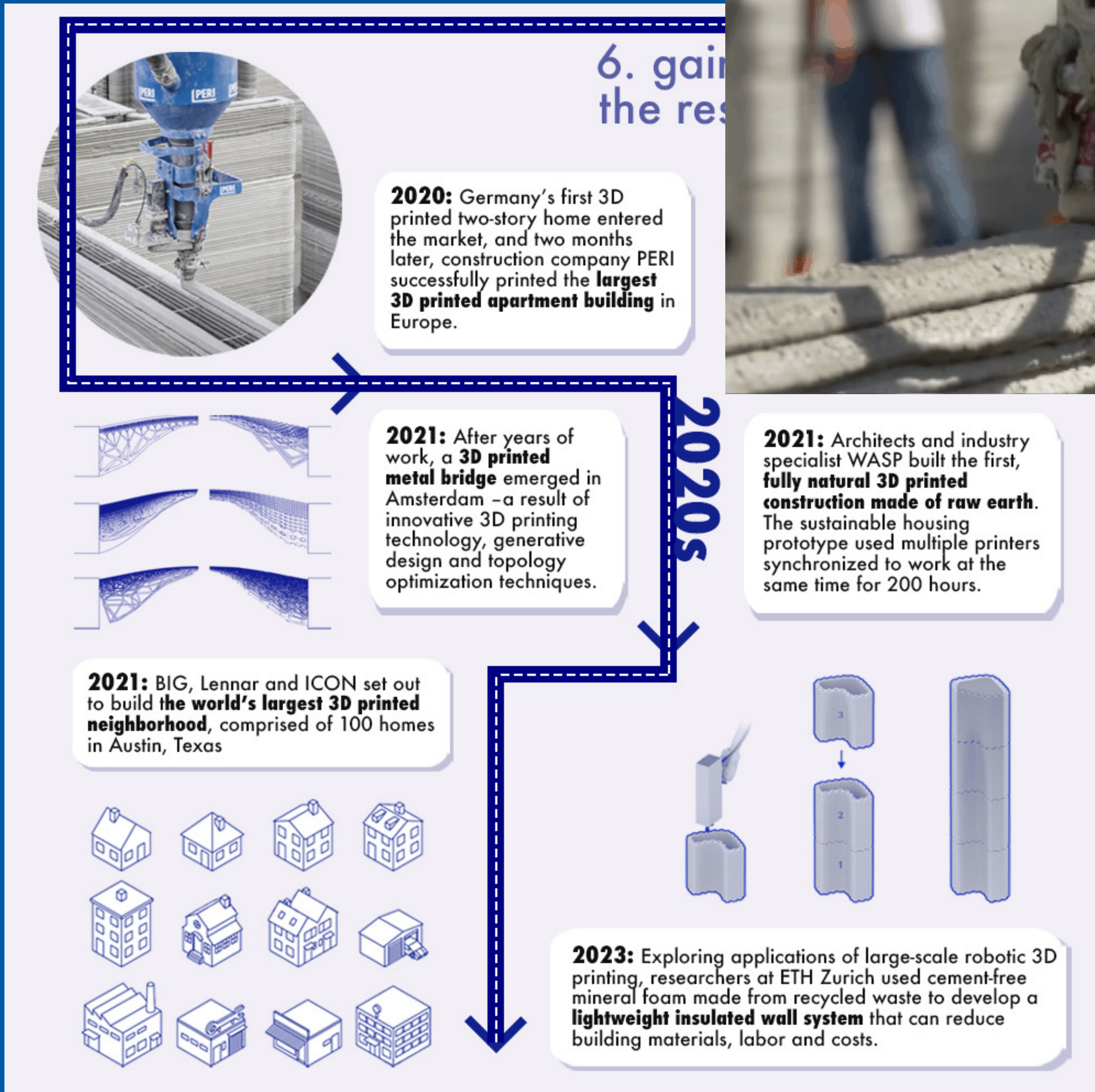
Gaudí's Sagrada Familia uses complex 3D printed prototypes to accelerate the construction process

2006: MIT researchers created a **large, highly controllable robotic arm** able to print from concrete to recycled plastic using a conventional construction nozzle. This same year, the first **Selective Layer Synthesis (SLS)** machine was made available; basically, materials could be melted during the process, enabling the manufacture of industrial parts made from various materials.



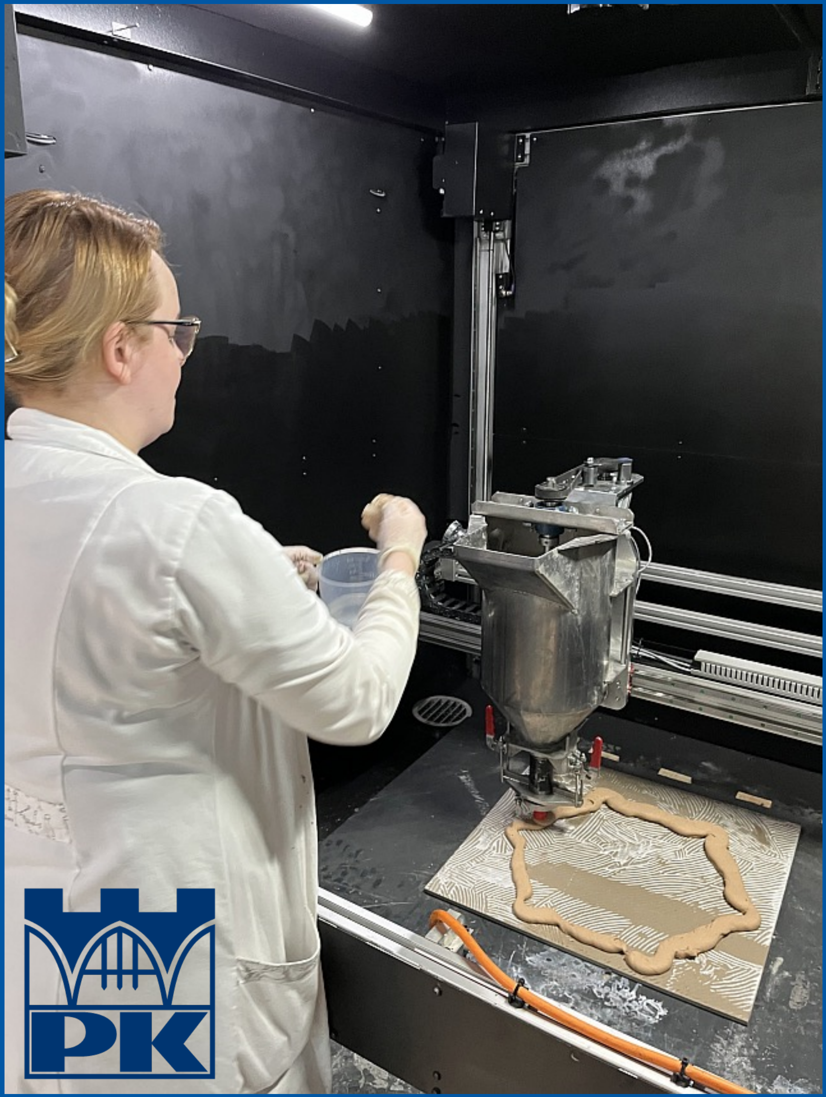
2009: More researchers and companies began experimenting with **3D printing concrete**, opening new possibilities for architectural applications due to the material's structural capabilities.

The Evolution of 3D Printing in Architecture:



Binder Jetting

Mixing & applying

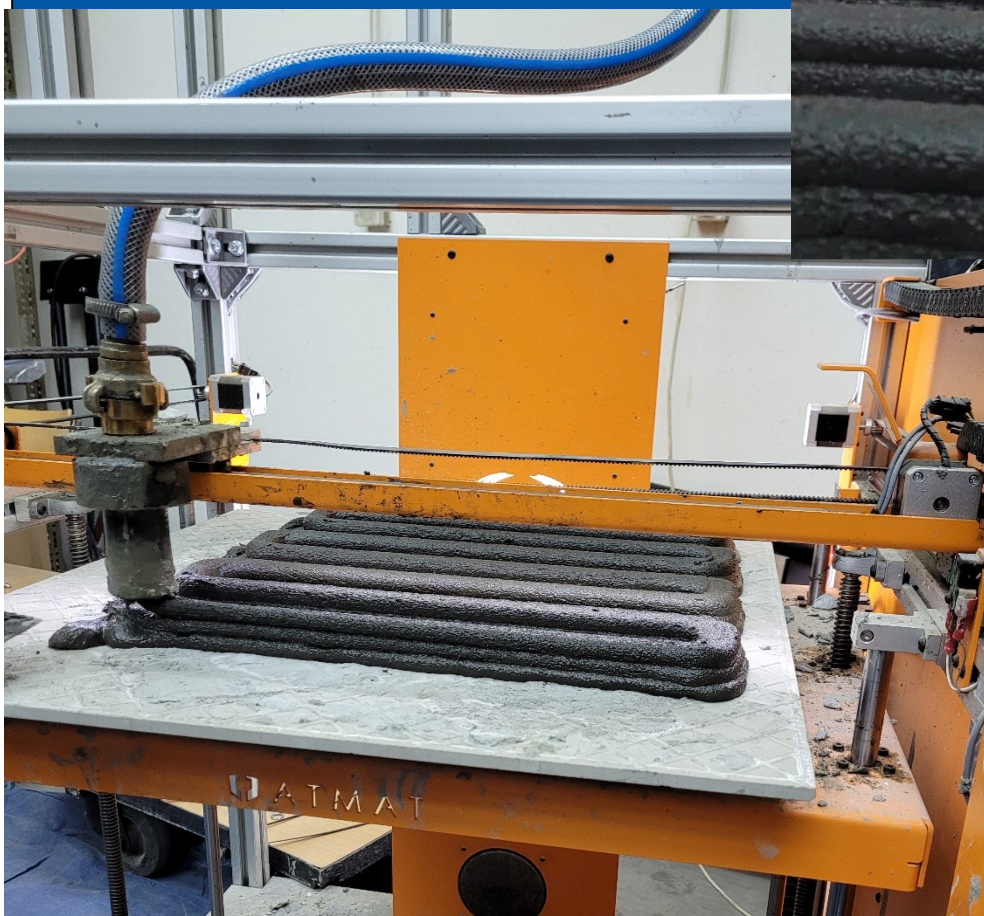


Sample devices

Small-Scale concrete 3D printer.

Sample devices

Typical print parameters:
Material feeding speed – 2 [dm^3/min]
Print speed – 300 [mm/s]
Layer height 10 [mm]



The dimensions of the printer's worktable are 460 x 460 x 40 mm. When printing from the tested material, a nozzle with a diameter of Ø20 mm was used.

Sample devices

Sample devices

Sample devices

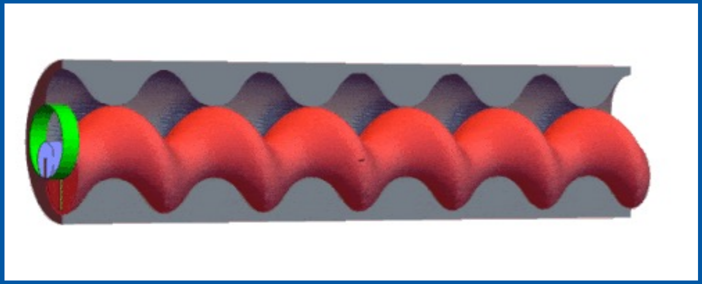
Sample devices

Sample devices

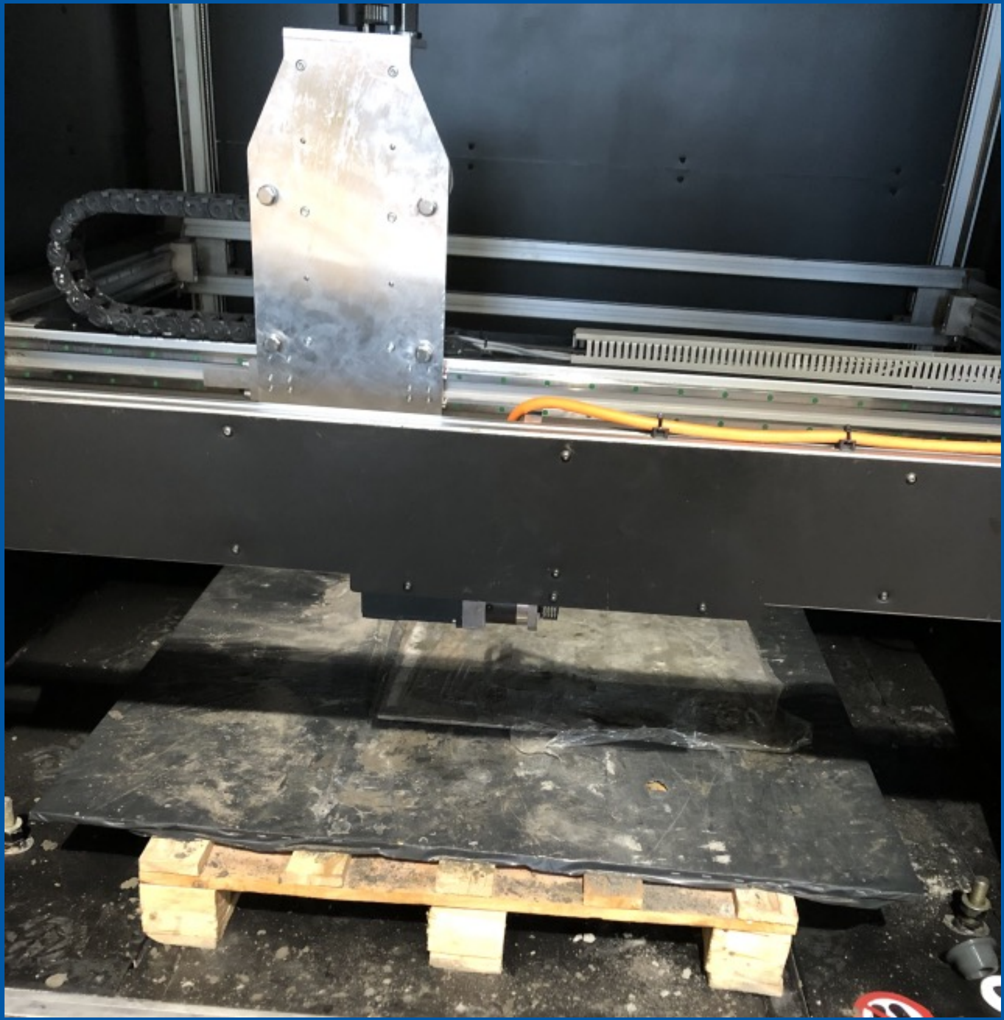
Sample devices

Sample devices

stator pump



Sample devices



Sample devices

Sample devices

Problems with 3D printing

- Too dry
- Too moist
- oo slo
- o fast
- ers

Problems with 3D printing

- Too dry
- Too moist
- You are printing too slowly

Flow not adapted to
he printing speed

Problems with 3D printing

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Problems with 3D printing

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Flow not adapted to the printing speed

- Unconnected layers

Problems with 3D printing

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- Too moist
- You are printing too slowly
- You're printing too fast
- Unconnected layers
- Dries too slowly
- Corosion

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Flow not adapted to the printing speed

[3D-Printed House Construction Time-Lapse]

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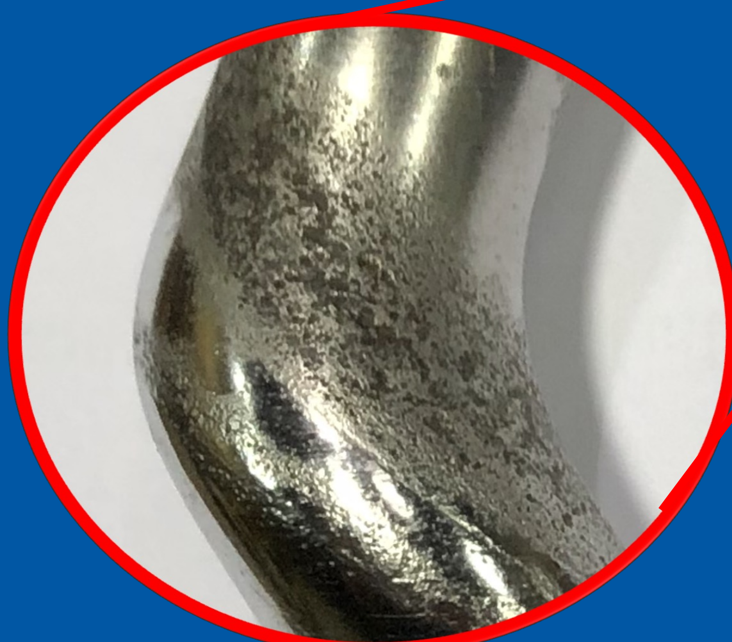

stator pump

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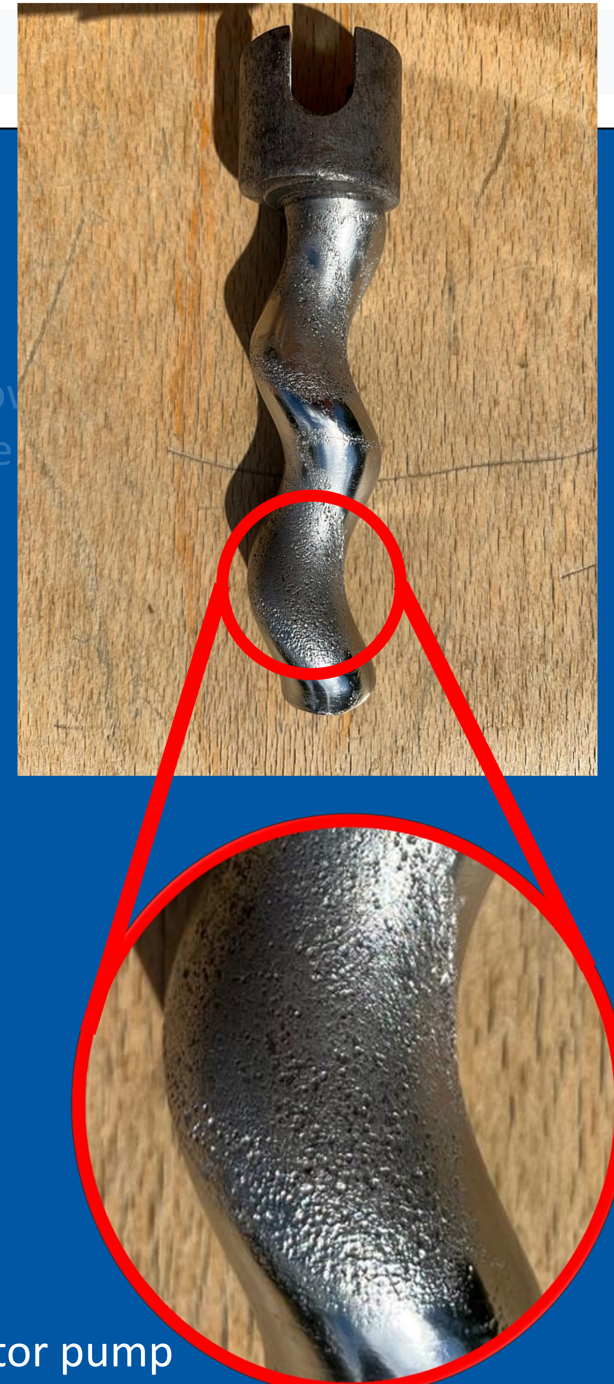

stator pump

Projects

	Project: Development of 3D printing technology for construction and facade prefabricated elements made of concrete composites and geopolymers (PRINTGEOHOUSE)
Amount and sources of funding	National (Polish) /EU—Polish National Centre for Research and Development in Poland. Total project: ca. 1 784 050.00 EUR Co-financing: ca. 806 342.38 EUR Coordinators: Prof. Janusz Mikuła, Prof. Marek Hebda, CUT
Duration	01/01/2019-31/12/2021
Consortium	Cracow University of Technology CKBM Sp. z o. o. Sp. K. (Company)
Raw mat.	Metakaolin, fly-ash
Technology	Laboratory (testing materials): modified WASP 2040; Scale-up: Large-format printer (ATMAT)
Planned product	Components for production of residential house on place)

Fundusze Europejskie Inteligentny Rozwój

Rzeczpospolita Polska

NCBR Narodowe Centrum Badań i Rozwoju

Unia Europejska Europejski Fundusz Rozwoju Regionalnego

Projects

	Project: Smart Geopolymers (SMART-G)
Amount and sources of funding	EU: ERA-MIN 2 (Call 2019), TOPIC 4. Recycling and Re-use of End-of-Life products Total project: 1 085 926 EUR (Coordinator: Prof. Hubert Rahier, VUB) CUT: 116 250 EUR (Coordinator CUT: Prof. Izabela Hager)
Duration	01/12/2020-31/11/2023
Consortium	Lider: VUB – Vrije Universiteit Brussel, Belgium Partners: Portugal: University of Aveiro Greece: MNLT Innovations GP, IESL/FORTH, Mytilineos S.A. Poland: Cracow University of Technology, PBP Łęgprzem Sp. z o.o, Poland Belgium: ResourceFull
Raw mat.	Industrial waste, red mud, CDW, etc.
Technology	Extrusion – ATMAT company
Planned	Tunnel

ERA-MIN 2

NCBR
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Projects

	Project: Development of lunar regolith simulant for 3D printing in Binder Jetting technology
Amount and sources of funding	PL: National Science Center Poland, MINIATURA V Total project: 6 000 EUR Coordinator: PhD Eng. Barbara Kozub
Duration	02/12/2021-01/12/2022
Consortium	CUT
Raw mat.	Regolith
Technology	Manual trials (binder Jetting)
Product	Regolith

NARODOWE CENTRUM NAUKI

MINIATURA

Korniejenko, K.; Pławecka, K.; Kozub, B. An Overview for Modern Energy-Efficient Solutions for Lunar and Martian Habitats Made Based on Geopolymers Composites and 3D Printing Technology. *Energies* 2022, *15*, 9322. https://doi.org/10.3390/en15249322

Projects

	Project: Development of geopolymer composites as a material for protection of hazardous wrecks and other critical underwater structures against corrosion (MAR-WRECK)
Amount and sources of funding	EU: M-ERA.NET 3 CALL 2021, Call Topic: High performance composites Total project: 1 141 860 EUR (Coordinator: PhD Thomas Grab) CUT: 275 000 EUR (Coordinator CUT: PhD Kinga Korniejenko)
Duration	01/06/2022-31/05/2025
Consortium	Lider: Technische Universität Bergakademie Freiberg, Germany Partners: Cracow University of Technology, Poland HIBRID Sp. z o.o, Poland Technical University of Liberec, Czech Republic
Raw mat.	Ashes, tailings, construction waste, etc.
Technology	Extrusion and binder jetting
Planned	Material for underwater applications

MAR-WRECK

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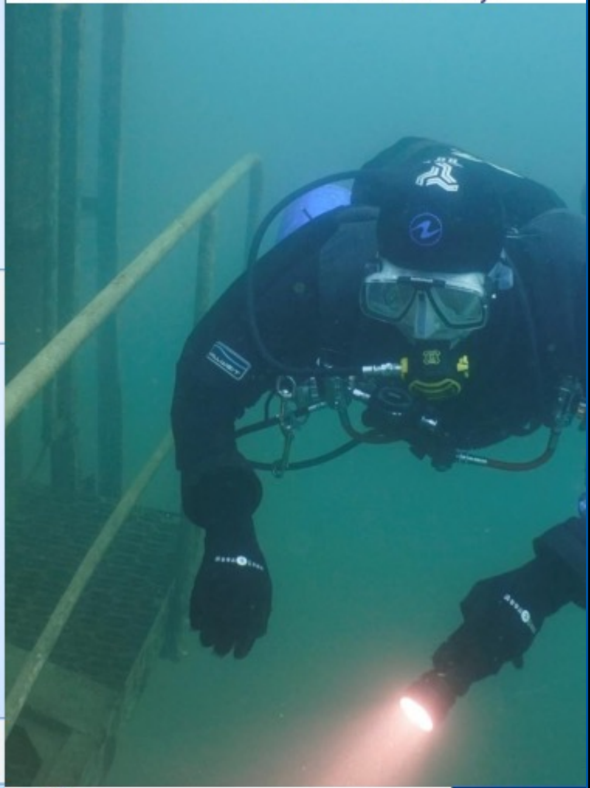
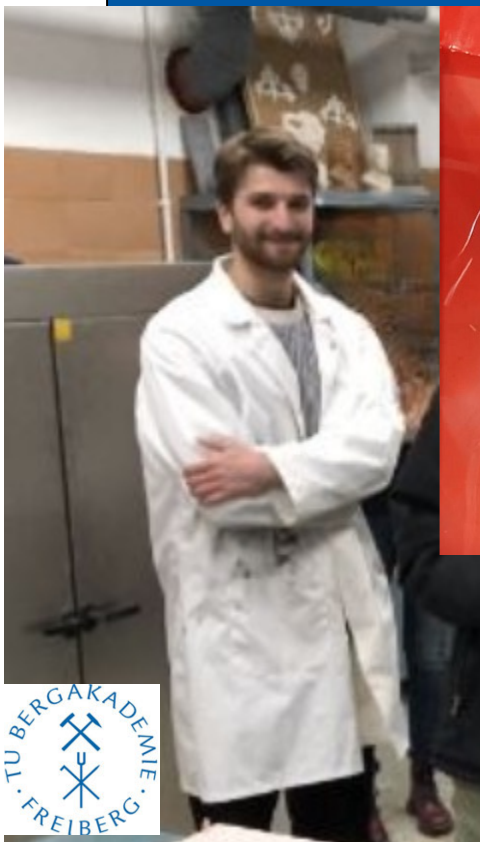
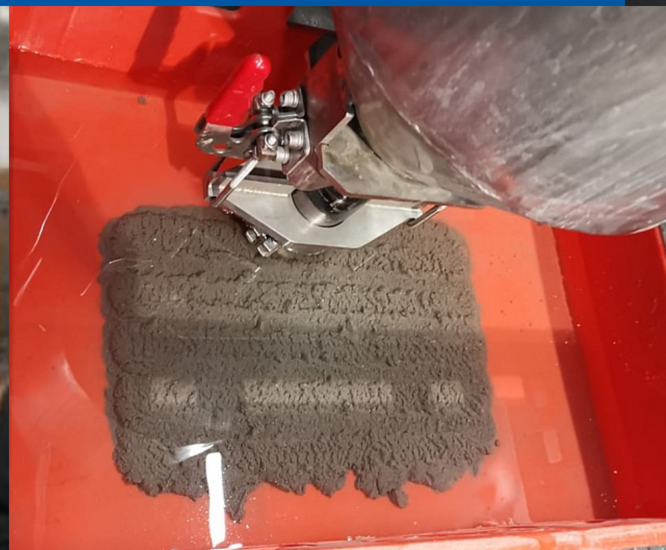


M-ERA.NET

Projects





Thank you for your attention

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