

COBOD INTERNATIONAL

3D CONSTRUCTION PRINTING TECHNOLOGY

COBOD CONNECT March 14th 2024



The event will be recorded.

Use the Q&A feature to ask questions during presentations, followed by a brief Q&A session after each.



WELCOME & INTRODUCTION

Welcome to our COBOD Connect Event!

Join us for our biannual meeting to celebrate our joint accomplishments and discover the latest innovations at COBOD.

We'll dive into customer projects and introduce our new products. Interactive sessions and demos await, along with the chance to discuss your ideas with peers.

Prepare for an insightful and productive session ahead!

COBOD Participants



Henrik Lund-Nielsen
Founder & General Manager



Jakob Jørgensen
Co-Founder & CTO



Zoë A. C. Knudsen
Head of Products & Communication

Guest Speakers



AGENDA

Timing*	Topic	Presenter
09.00 - 09.15	State of the Union	Henrik Lund-Nielsen
09.15 - 09.25	KA Bina	Azrul Esfandy
09.25 - 09.45	Advancements and Further Developments	Henrik Lund-Nielsen
09.45 - 10.05	PERI 3D Construction	Chikaeze Ugwu
10.05 - 10.25	Innovations and New Applications	Jakob Jørgensen
10.25 - 10.45	Harcourt Technologies Ltd (HTL)	Jandre Oosthuizen
10.45 - 11.00	Q&A	Henrik Lund-Nielsen

*Central European Time (CET)

Contents

- I State of the Union**
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- III Innovations and New Applications
 - ▶ Water tanks
 - ▶ RMC solution
- IV Q&A

REFLECTING ON THE RECENT TRENDS

INDUSTRY TRENDS AND CUSTOMER ACHIEVEMENTS

As predicted last time, we are seeing a movement away from the traditional focus on single-story residential projects to embrace larger and more diverse projects. Our different customers have really advanced to more ambitious applications:

► Multi Story Residential Development

- Dar Al Arkan's **smart home villa** spans three floors and 345m² (3,715 SF) and is the **tallest 3D printed building in the world**. Showcasing the adaptability of 3D printing in **high-end residential construction**.
- Nidus3D's **first North American 3 stories apartment complex**
- PERI's **social housing**, 3 stories apartment project

► Public Amenities

- Europe's first 3D-printed public building, a **football clubhouse** with two floors and 330m² (3,550 SF), indicates the potential for **recreational and communal spaces**.
- Printed Farms almost 1.000 m2 **horse staples**
- The Lviv 3D-printed school, with its substantial area of 370m² (3,982 SF), demonstrates the technology's expansion into **large-scale educational facilities**.

► Offices & Institutional

- L&T's **three stories army offices**, with 1.256 the world's largest 3D printed building
- Siam Cement Group's **two stories medical center**
- L&T's **post office**

► Industrial Facilities

- PERI's Heidelberg **data center**, standing as Europe's largest 3D-printed structure at nearly 600m² (6,600 SF), reinforces the technology's use in **commercial projects**.



COBOD IN 2024

Official BOD3 launch – 6 orders already recieved

- ▶ We are excited to announce that the official launch of BOD3 is very approaching soon.

BOD3 Infinity Development – First 2 orders received

- ▶ The BOD3 Infinity, currently in its prototype phase, is set to transform large-scale construction printing. You can use the printer as a two Z-axis BOD3 or with a small initial investment convert it into a one Z-axis warehouse/shell structure printer. No printer has this kind of flexibility.

Printhead 2.0 is being developed and ready at the end of the year

- ▶ **Separate Components:** With the separation of mixing arms and extruder screw, operators can now achieve finer control, resulting in a more consistent and manageable concrete mix.
- ▶ **Integrated Cleaning System:** The new cleaning feature is integrated directly into the printhead, facilitating a quicker and more efficient maintenance routine.
- ▶ **Additive Spraying System:** This innovation enables a more homogeneous mix, improving the overall quality of the material output.

Fire Resilience Testing

- ▶ Our valued customer, KA Bina, has completed a 2-hour fire resistance test on a 3D printed wall with our D.fab technology.



KA BINA

Contents

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Sustainable construction through 3D printing;

**Cases on large scale, materials saving
3D construction printing of critical
infrastructure**

March 2024



FOR CONCRETE CONSTRUCTION, IN-SITU FORMWORK AND PRECAST HAVE BEEN THE DOMINANT CONSTRUCTION METHODS IN THE PAST

Pre-cast concrete



Description Concrete that is cast and cured in molds in a controlled environment, such as a factory or a plant, and then transported and assembled at the construction site.

Includes molds and extrusion-based concrete.

Cast-in-place (in-situ) concrete



Concrete that is poured and cured in shuttering built at the construction site.

Includes form-work, tilt-up, and slip-forming.

THE HISTORIC CONCRETING METHODS OF THE PAST, CANNOT DELIVER THE SUSTAINABLE CONSTRUCTION REQUIRED TODAY

DUE TO THE INHERENT RESTRICTIONS OF THESE METHODS FOR LOTS OF APPLICATIONS THESE METHODS CANNOT DELIVER THE MOST SUSTAINABLE AND MATERIALS SAVING SOLUTION

Inherent restriction	Restrictive details	In-situ Formwork	Precast	Consequences	Examples / cases
Transport restrictions	Typically max 4,5m diameter due to road widths and height of bridges	n.a.	X	Suboptimal solutions	- Windmill towers maxing out at 80-100m - Water sewage tanks with small diameter needs to be made much taller (instead of wider) , leading to excessive excavation activity and cost
	Must have integral reinforcement to be able to lift the concrete structure from the mold and transport it	n.a.	X	Excessive use of materials as materials are placed where really not needed	- Precast wall elements - Standard wall elements for warehouses
Mold restrictions	Cannot make too complex molds / concrete structures	X	X	Excessive additional cost and/or Excessive use of materials	- Precast seahives; coastal barriers - In situ wall elements
	Difficult to make other geometries than straight and rectangular	X	X	Excessive use of materials to compensate for weak contribution from the geometry to the strength of the construction	- Rectangular caisson, instead of caissons with rounded ends towards the water pressure - Conical bottom part of windmill tower instead of trumpet shape, which reduces the foundation from a massive foundation to a strip foundation
	Cannot vary concrete thickness in the mold	X	X	Excessive use of materials as materials are placed where really not needed	Water, biogas and other liquid tanks, with same wall thickness all the way, despite the fact that large thickness only need for bottom part

3D PRINTING UNLOCKS INTELLIGENT SOLUTIONS TO ADDRESS LIMITATIONS OF EXISTING METHODS – SUSTAINABLE CONSTRUCTION

Standardized solutions with pre-cast and in-situ concrete

Transport, mold and design restrictions leading to inefficient, suboptimal solutions and excessive use of materials



Sustainable construction – via 3D construction printing

The design freedom of 3D printing allows for designs where, there is maximum structural support from the geometry and therefore much less need for concrete and reinforcement

Leading to significant materials, co2 and cost savings

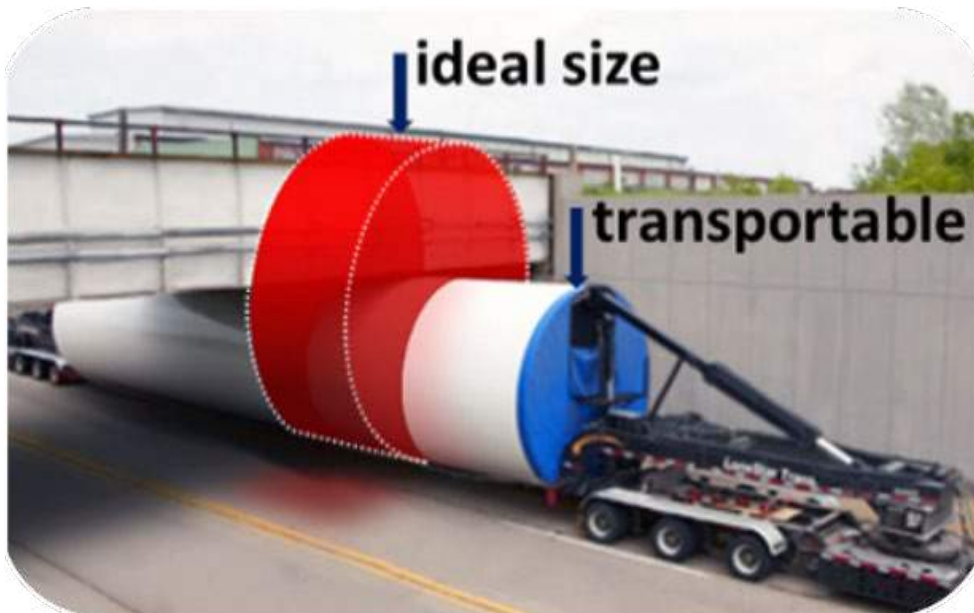


WHY 3D PRINT WIND TURBINE TOWERS ?

Because the 3d construction printing technology can deliver the tower heights present solutions cannot

Towers are conical meaning the base is wider than the top. The taller we want to go the wider the base will be. We want to go beyond 80-100m, but impossible/too expensive now.

**Present situation: Steel towers and elements
concrete towers**



World's first 3D printed wind turbine tower, 2019

Scope:

- ▶ Concrete: 100 tons (hollow)
- ▶ Reinforcement: none

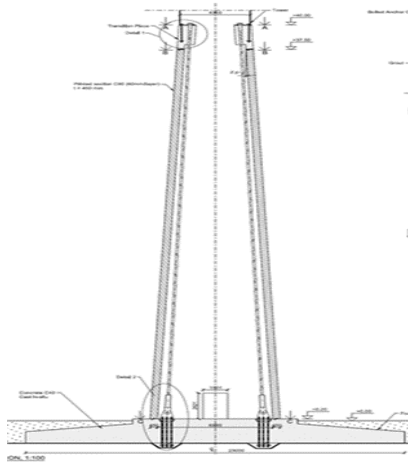
Printing time: 3 weeks;
second time: 3 days



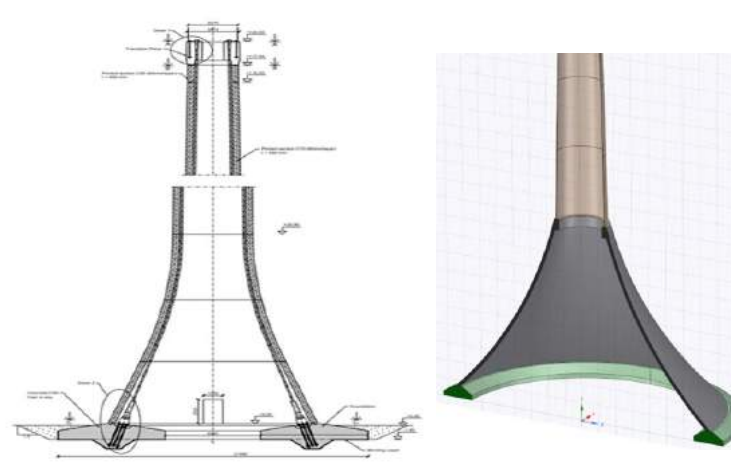
10 m

NOT ONLY CAN WE PRINT TALLER TOWERS, WE CAN ALSO SAVE ON THE MATERIALS

Traditional cone-shaped design



3DCP wider trumpet-shape



40% saving on materials for foundation



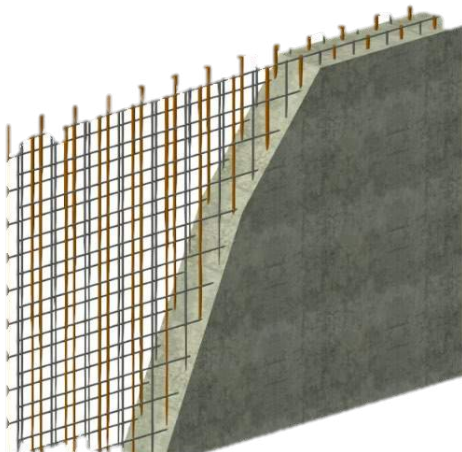
Logic

Wide diameter means that the foundation can be made as a strip foundation instead of being massive, **leading to a 40% saving in the amount of concrete and reinforcement used for the foundation.**

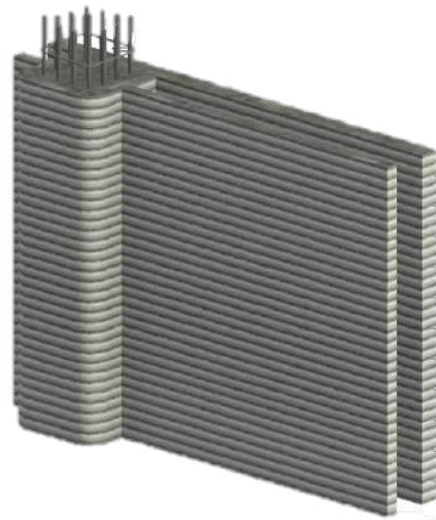
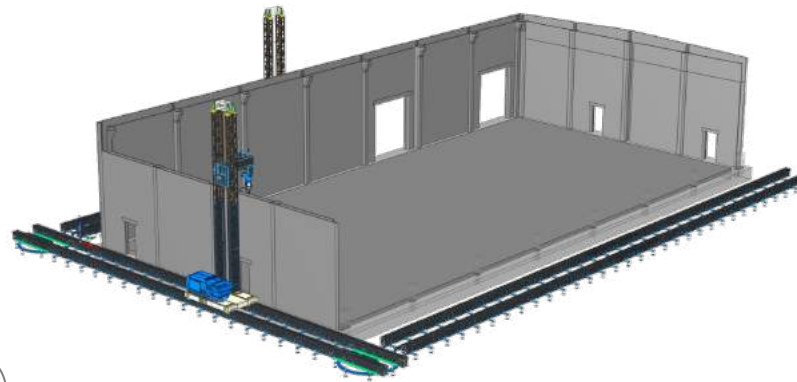
The trumpet shape cannot be made with precast and in situ casting solutions, **as the mold would be too complex.**

STANDARD WALL ELEMENTS

Conventional warehouse / data center



3D printed warehouse / data center



Description

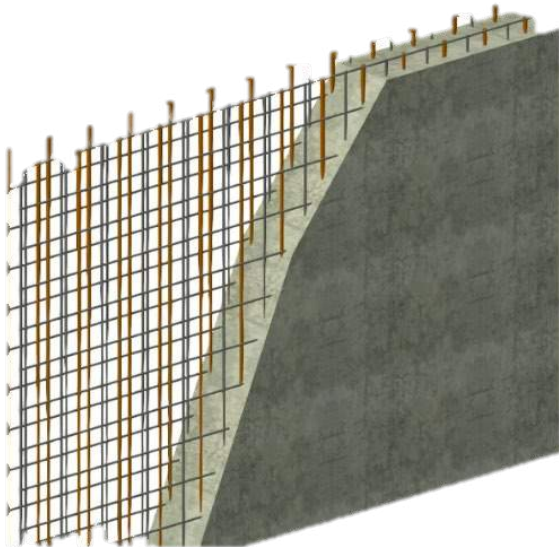
Together with Rambøll COBOD has conducted a study on a 5,000 m² 3D printed warehouse at 330 x 160 ft (100 x 50 m)..

The study concluded that 3D printing can make such large structures using unreinforced walls with reinforced columns (precast and in situ casting **cannot make such as it requires a too complex mold**)

The study also compared the materials consumptions related to the two ways of making the wall elements for the warehouse.

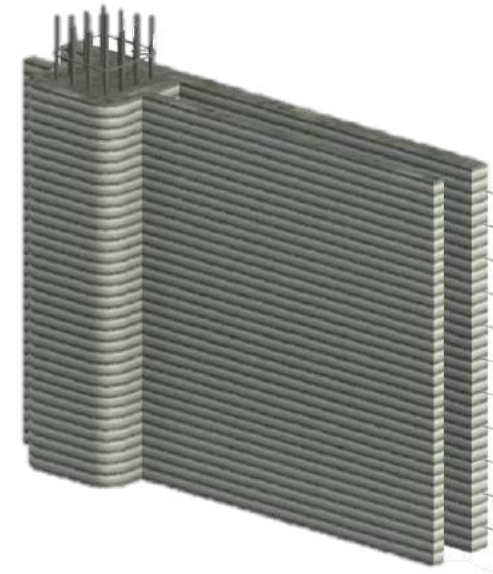
STANDARD WALL ELEMENTS; 31%-50% MATERIALS REDUCTION VERIFIED IN RAMBØLL STUDY FOR A 5.000 M2 WAREHOUSE

Traditional reinforced wall, e.g., pre-cast or in-situ



Same strength

3D construction printing wall element with columns



Concrete, m3

800 m3

50% reduction

400 m3

Rebar, tons

80 t

31% reduction

55 t



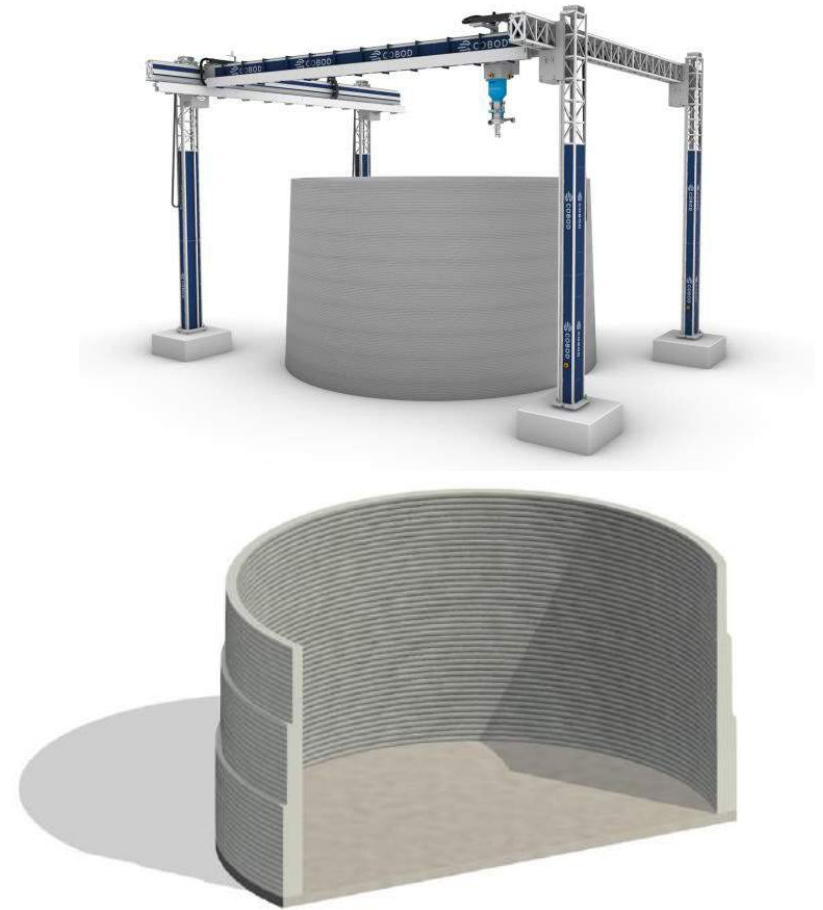
PERI 3D CONSTRUCTION

Contents

- I State of the Union
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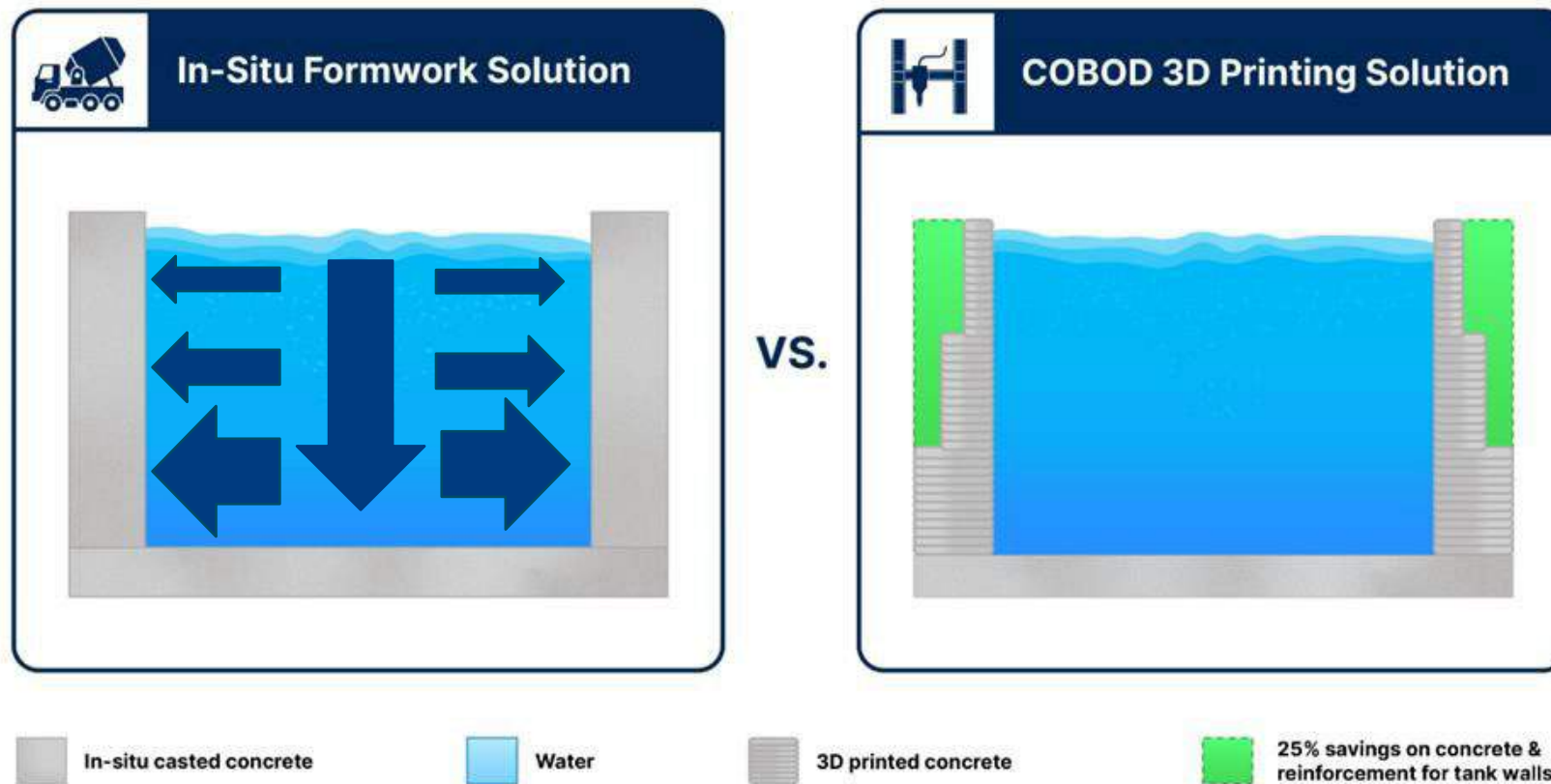
3D PRINTED WATER TANKS

3D PRINTED LARGE WATER TANKS (1/3)



3D PRINTED LARGE WATER TANKS (2/3)

3D Printing **Enables 25% Savings** on **Concrete & Reinforcement** Used for the Tank Walls in **Water Tanks**



 Pressure from the water

Logic

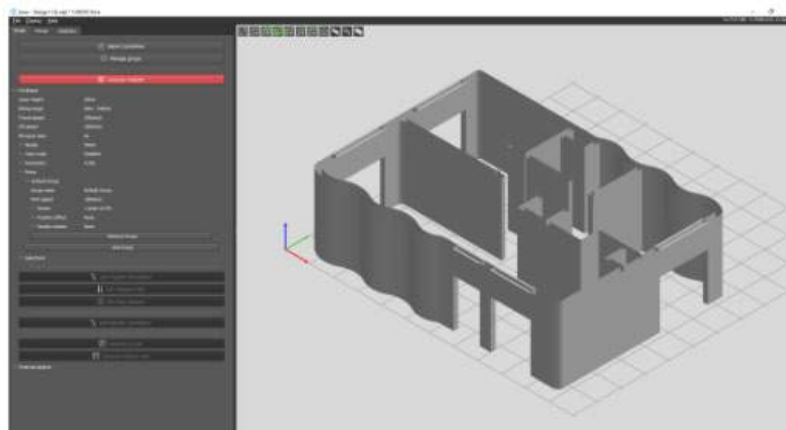
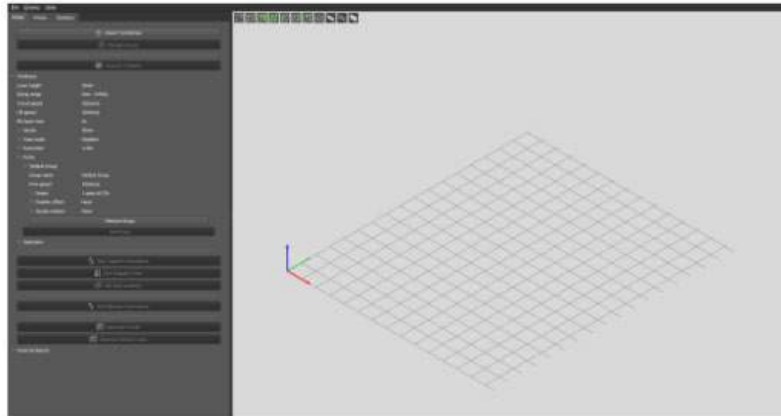
As the pressure from the water is decreasing with height, it makes no sense to make the walls with the same thickness all the way up.

With in-situ formwork it is not possible to vary the wall thickness, but with 3D construction printing technology it is.

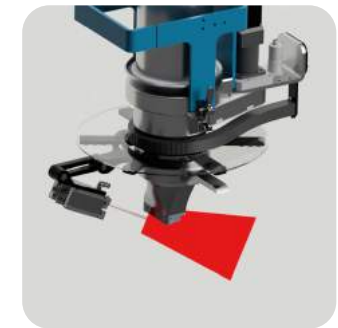
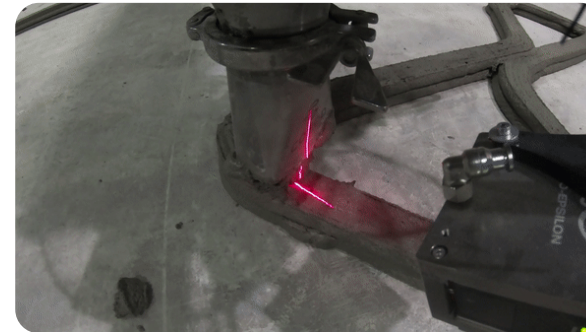
The tanks were reinforced by 3D printing concrete, which contained macro fibers.

3D PRINTED LARGE WATER TANKS (3/3)

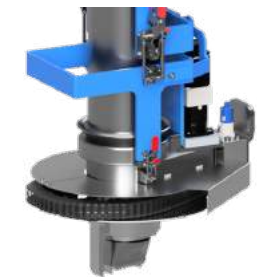
COBOD Slice: New Slicer features introduces additional benefits and new methods for 3D printing



NAP/ACE Laser: Scanning the "bulge" in front of the printhead to automate extrusion control



Misting & Sprays: Misting fluids to the layers while printing



READY-MIX CONCRETE (RMC) SOLUTION

3D PRINTING USING RMC

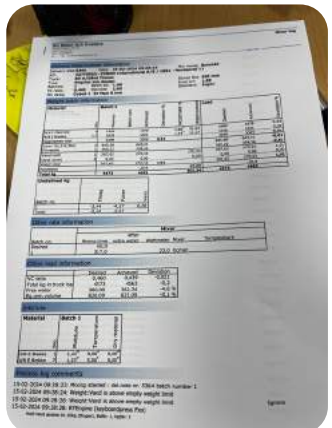
- ▶ Save time on site prep and cleaning -> increase overall productivity
- ▶ Get certified concrete from the local plant
- ▶ Increase productivity (m³/hour of concrete)
- ▶ Less equipment to maintain and ship between sites



RMC PROCESS

Concrete plant:

Get technical data sheets from plant
send D.fab alpha / Accelerator
Ask them to provide certification + cubes for testing



On site:

Check mix at arrival, adjust with D.fab Alpha
Add Alpha to truck every 20-30 minutes



PROCEDURE

- ▶ Confirm with COBOD if you want to use RMC
- ▶ We will work with you and your local plant to find the right recipe
- ▶ Training and Standard Operational Procedure (SOP) will be supplied from COBOD
- ▶ Print



MIX DESIGN AND STRENGTH

	Test 1 (kg/m3)	Test 2 (kg/m3)
Cement (CEM 1 52,5 R)	320	320
Fly ash	180	180
Total water	190	195
D.Fab Alpha	8,5	8,5
D.Fab Beta	0,5-1,5	0,5-1,5
Sand (0-4 mm)	777	770
Gravel (2-8 mm)	793	788
CEMEX ISOXEL 5450	3,75	4,5
CEMEX ISOXEL 899	3,75	4,5

Compressive strength (MPa)	Test 1	Test 2
7 days	28,5	31,57
28 days estimate	37	41



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