COBOD Training L1

Module 1.1

Modelling for 3DCP

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COBOD

INFORMATION DISCLAIMER

TIMELINE
3D PRINTING CONSTRUCTION
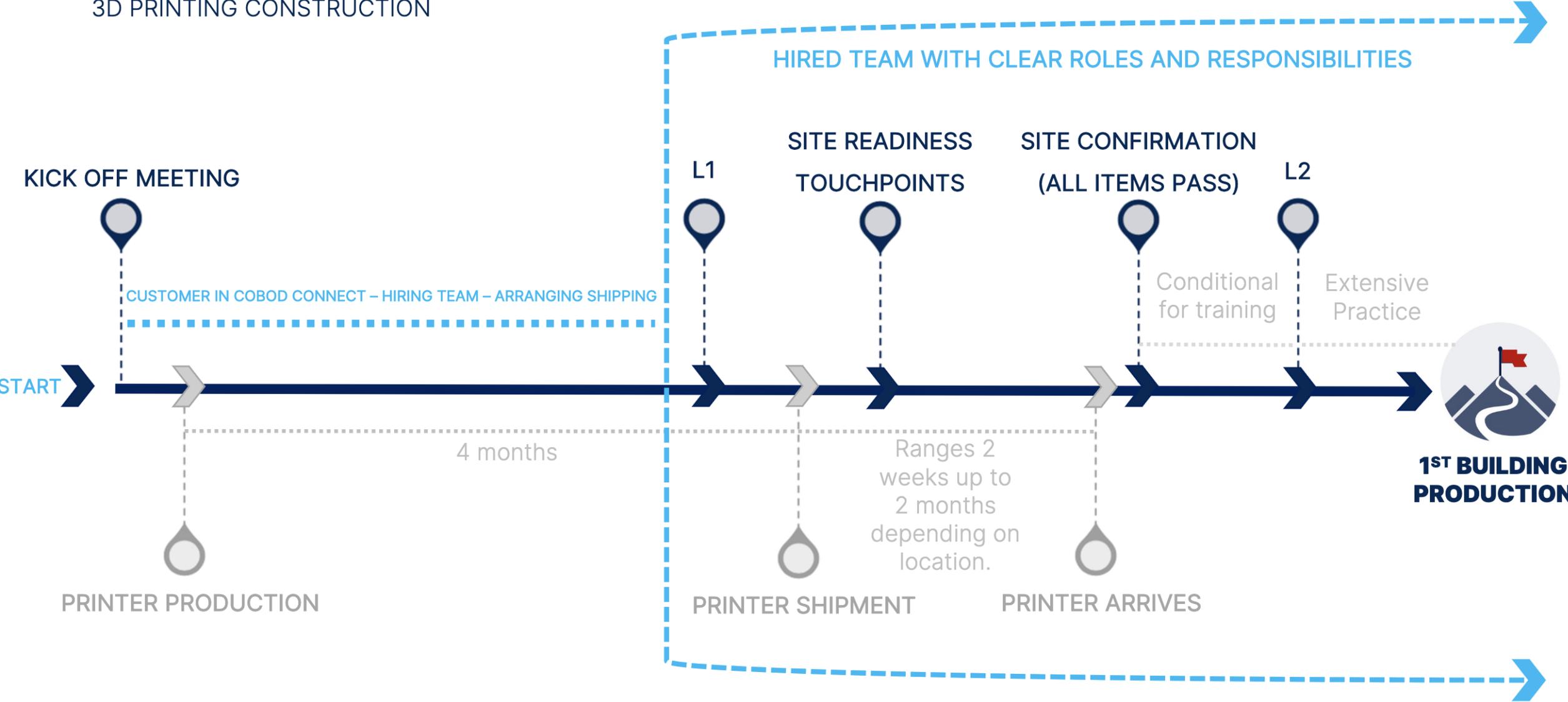
COBOD

HIRED TEAM WITH CLEAR ROLES AND RESPONSIBILITIES

KICK OFF MEETING

L1

SITE READINESS TOUCHPOINTS

SITE CONFIRMATION (ALL ITEMS PASS)

L2

Conditional for training

Extensive Practice

CUSTOMER IN COBOD CONNECT – HIRING TEAM – ARRANGING SHIPPING

START

4 months

Ranges 2 weeks up to 2 months depending on location.

PRINTER PRODUCTION

PRINTER SHIPMENT

PRINTER ARRIVES

1ST BUILDING PRODUCTION

AGENDA AND OBJECTIVES

COBOD CONFIGURATOR

www.cobod.com/configurator/

COBOD CONNECT – LIBRARY AND RESOURCES

https://connect.cobod.com/

WARRANTY DISCLAIMER

It is important to read and understand the following concepts about your product warranty:

• Warranty covers 14 months from the date the shipment departs COBOD's production facilities.
• Warranty covers free replacement of defective or missing mechanical and electrical parts.
• Warranty covers online remote support to install the parts and shipping of the parts.
• Warranty does not cover consumables or wearable parts.
• Alterations or external additions made to the equipment that are not approved by COBOD R&D technical board prior to being implemented will void warranty. Such changes include (but are not limited to):
    • Printer system changes.
    • Changes to the material delivery system or hose management.
    • Removal or covering of COBOD logos, branding stickers and other trademarks on the equipment.
    • Tampering, removal or changes to original safety elements, classification stickers or signs on the equipment.
• Failure to maintain the equipment according to the maintenance guidelines will void warranty.
• Failure to operate the equipment according to the operational guidelines will void warranty.
• In addition to the loss of warranty, modifying equipment against the manufacturer's advice is not recommended as this could generate serious safety hazards for users.
• Operation with materials not suitable for use with the COBOD -equipment will void warranty. Ask COBOD if there is any doubt about the suitability of the materials.
• The responsibility to provide sufficient documentation in the form of incident reports and/or maintenance evidence lies with the owner of the equipment.

COBOD's technical team will assess each case to determine if warranty is applicable based on the information provided above.

DOCUMENTATION THAT SUPPORT THIS MODULE

1. STANDARD OPERATIONAL PROCEDURE – MODELLING AND SLICING

2. STANDARD OPERATIONAL PROCEDURE – BOD2

3. WC1 – CONSTRUCTION DETAILS

4. DESIGN EXAMPLES
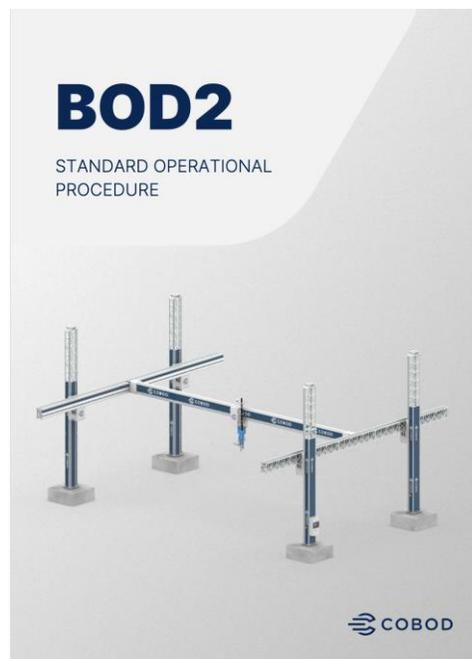
SYSTEM OVERVIEW
BOD 2 - 3D PRINTER

Hose Management System (HMS)

Printer System

Material Delivery System (MDS)

Printable area (PA)

COBOD
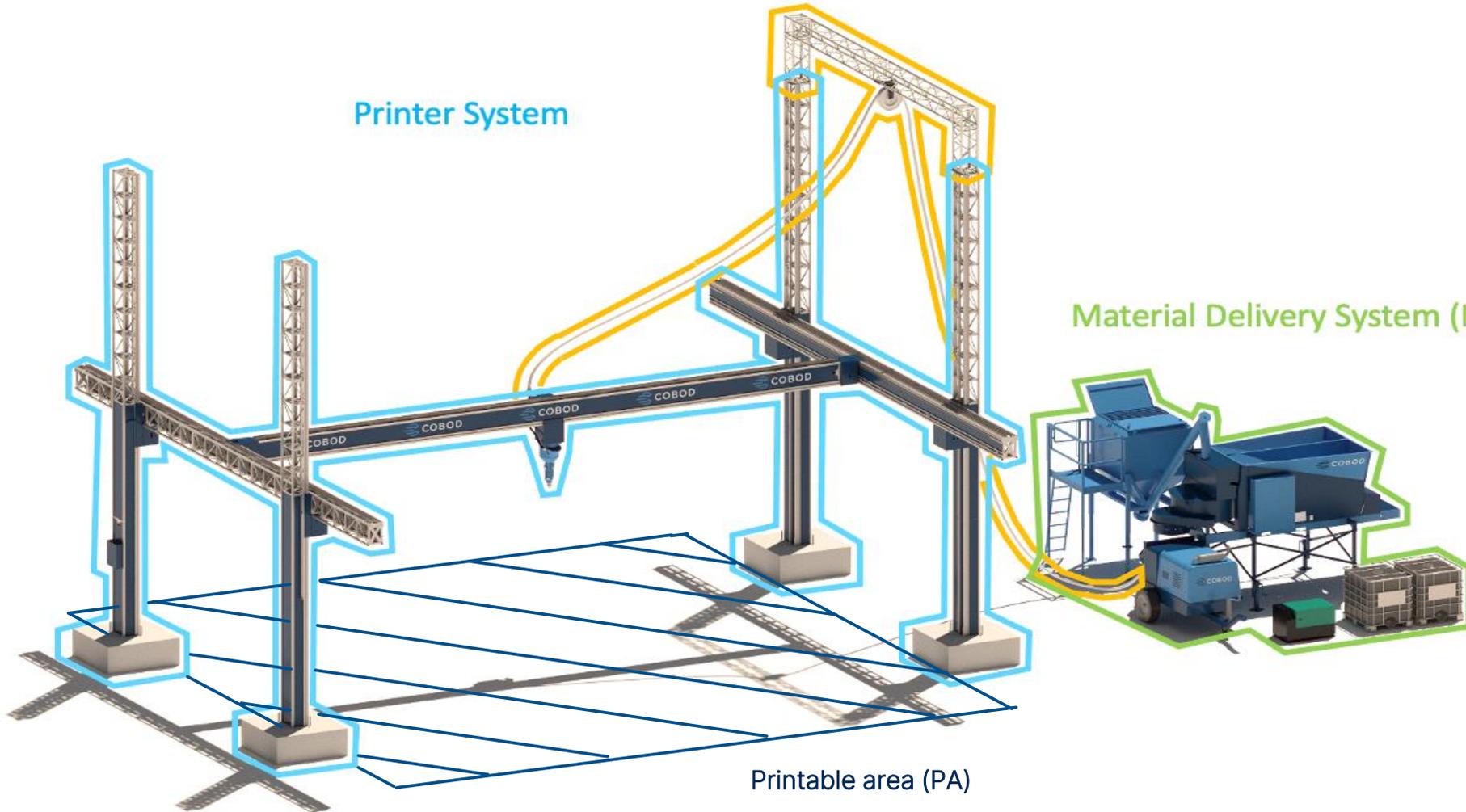
Printer System
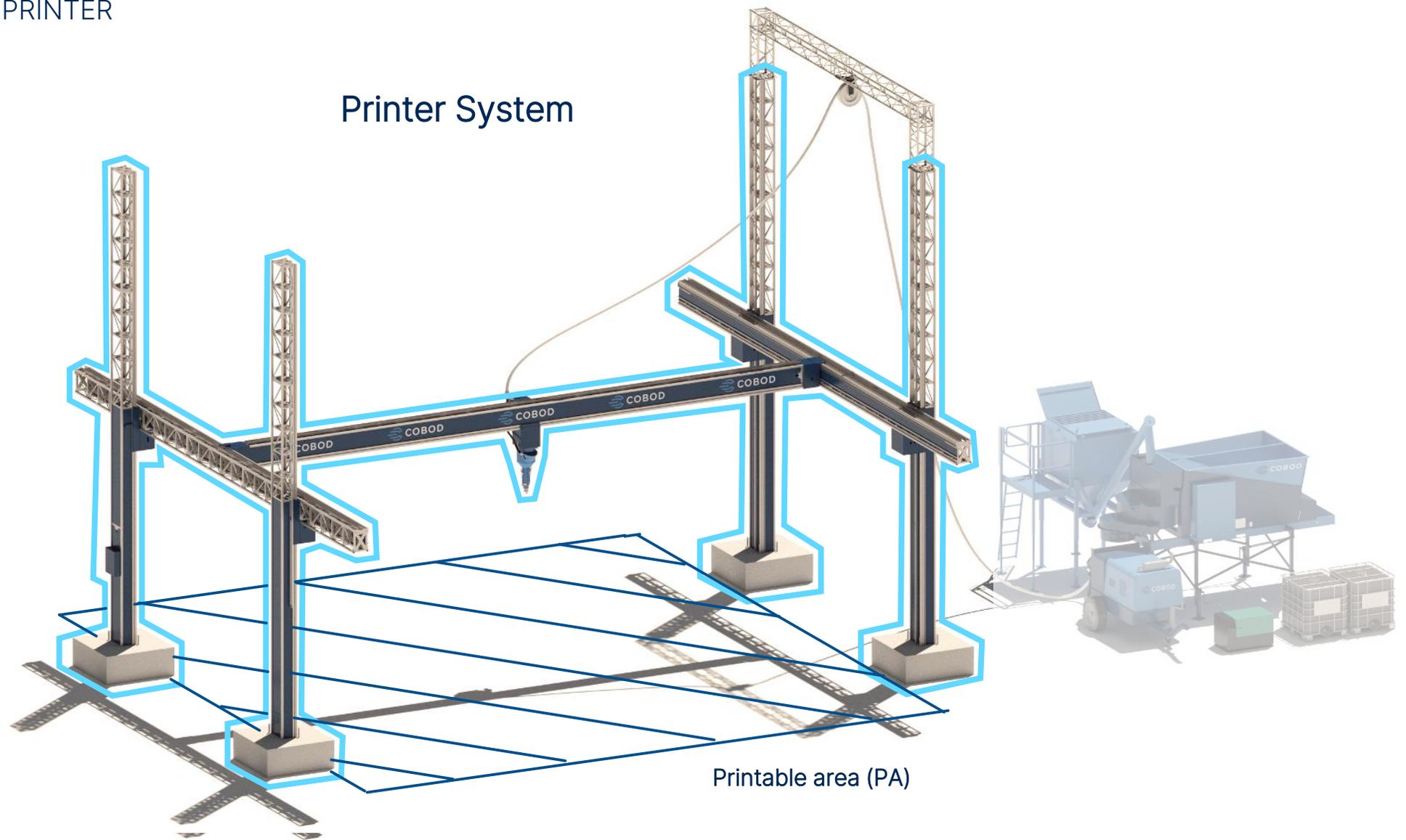
Printable area (PA)

MODELING IN THE OVERALL 3DCP PROCESS DIAGRAM

WEEK PROGRESS

COBOD

Converting a 3D/ BIM model int a 3D printable file.
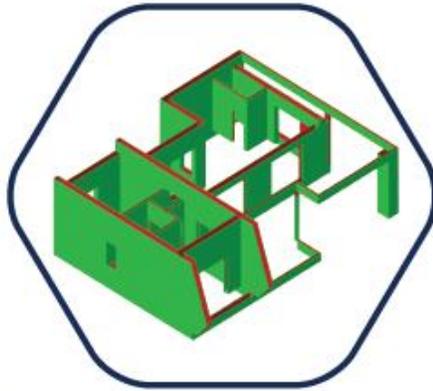
Slicing the geometry and DIGITAL RUN.

BOD2 Installation, Operation and DRY RUN.

3DCP Materials.

Material Delivery System and HMS.

LAYER AS THE 3DCP UNIT

LAYER PARTS

LAYER SPECIFICATIONS

Layer specifications such as centerlines, height and width (that create high or low resolution, high or low production) can vary depending on the design criteria, however, it is important to decide such parameters when you start designing a 3DCP building as they will significantly impact look, operation and quality control of your product.

Basic dimensions
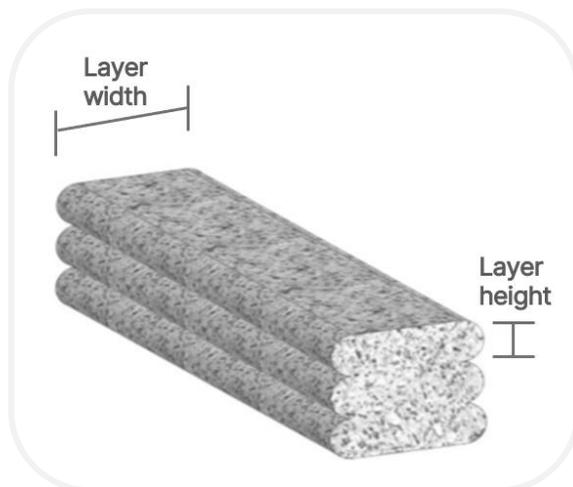
End and start parameters

Resolution

Layer width

Layer height

End of layer pull

Start of layer drop
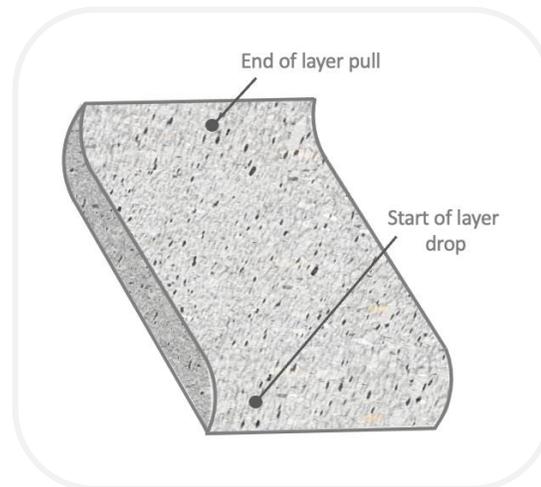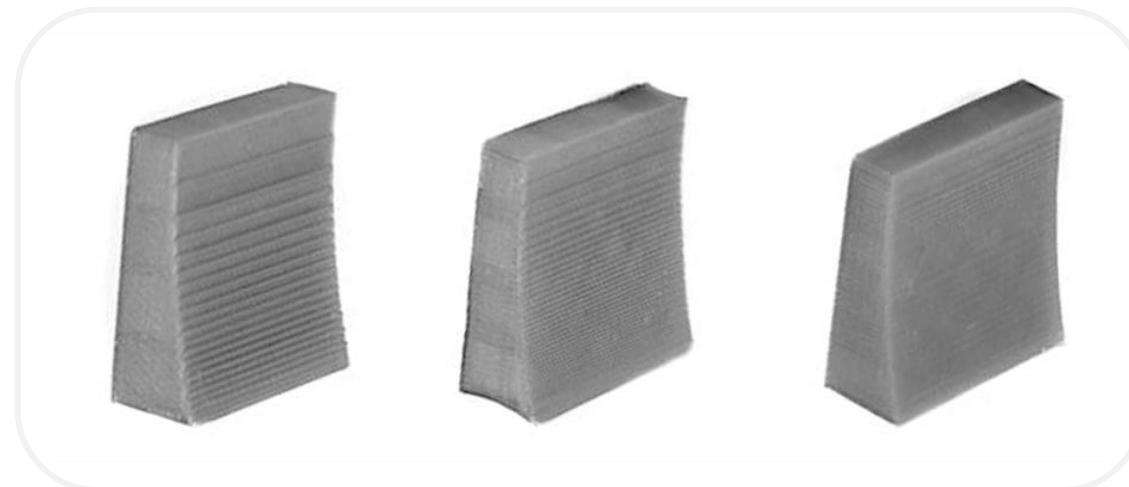
CORNERS

A 3D printer cannot make 90 degrees sharp corners, which is why when you are modeling, the corners must have a fillet.

The radius of the fillet must be greater or equal to your layer width. For example, if you have a wall which is 50mm, then the radius of your corner fillet must be equal or greater than 50mm, or as a reference, the radius of the corners is equal to the width of your nozzle.

Grey area representing the desired final shape of the 3D printed path.

Dashed line representing where the surface should be drawn.

50 mm 3D printed wall
=
50 mm radius of surface corner
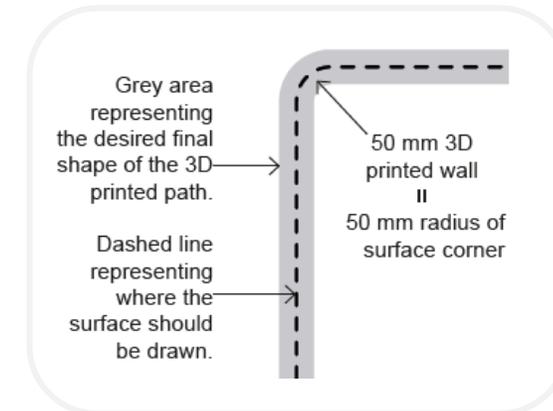
CHOOSING THE RIGHT NOZZLE

MODELING CONSIDERATIONS SECTION

A nozzle is the mechanical end part of the 3d printer where material comes out and it is directly related with your wall design.

It is important to understand the different types of nozzles that exist, and the role nozzles play in design, quality control and operation to ensure a smooth printing experience.

Your 3D printer comes with steel nozzles varying in size. For mortar printheads the default dimensions are 50x20 mm (width x length) and for HT (high throughput) printheads the dimensions are 50x40 mm and 80x30 mm (width x length).

Flaps can be attached to the nozzle on either one or both sides. The flaps help to ensure achieving the intended layer width and gives a better surface quality overall. See picture of nozzle without (left) and with flaps (right) to the right.

Nozzle with flaps

Nozzle without flaps

Flap Options

Flap length

Generally speaking, you should know:

- Type of nozzle (round or square).
- Material of your nozzle (stainless steel or plastic).
- Dimensions, connections, front and back sides.
- If you will be using 2 flaps, 1 flap or none.

FLAP USE
LAYER SPECIFICATIONS

Using or not using flaps has direct implications in your project and printing extrusion control.

Implications are related to inventory, health and esthetic look.

When flaps are not used a rounder layer edge is formed and creates pockets that might collect dust or mold overtime as well as pockets for insects while consuming more material in the process. A higher extrusion control will also be needed from your printer operator.

Using flaps will maintain the shape better while consuming less material providing a more uniform look.

Different sizes of flaps are included in your product to address different scenarios, inserting the dimensions of the flap you choose will be an important step during the slicing process.

You can choose to use a flap in both sides (internal and external) or only external. Not paying attention to the internal flap during printer travels might result in accidental wall cut during operations.

Nozzle without flaps
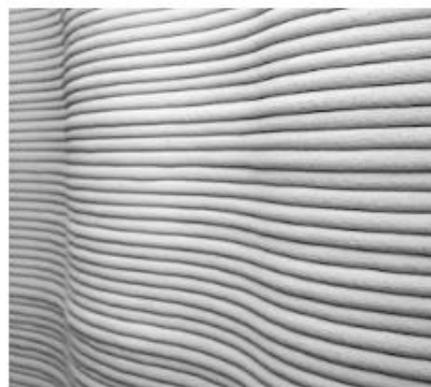
Round edges

Nozzle with flaps

Flat edges

CENTERLINES

LAYER SPECIFICATIONS

A centerline is a theoretical surface or plane representing the center of each 3D printed element. This surface is then imported into COBOD Slicer where it will be divided into individual horizontal layers, which will act as toolpaths for the 3D printer to deposit material layer by layer.

A centerline runs exactly through the middle of the nozzle as seen in the pictures.

The start and end point of a centerline is defined exactly in the middle of the circle from the top of the nozzle.

Nozzle without flaps

Centerline in nozzle
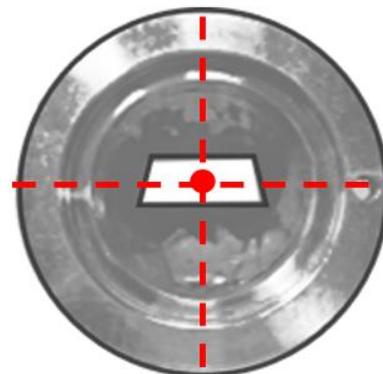
Centerline in reference to edges

Front view

Centerline
Nozzle
3DCP Material

Top view

Nozzle
Centerline
3DCP Material
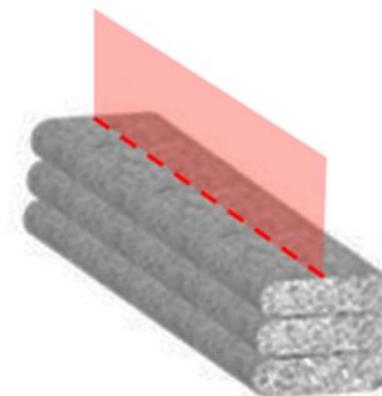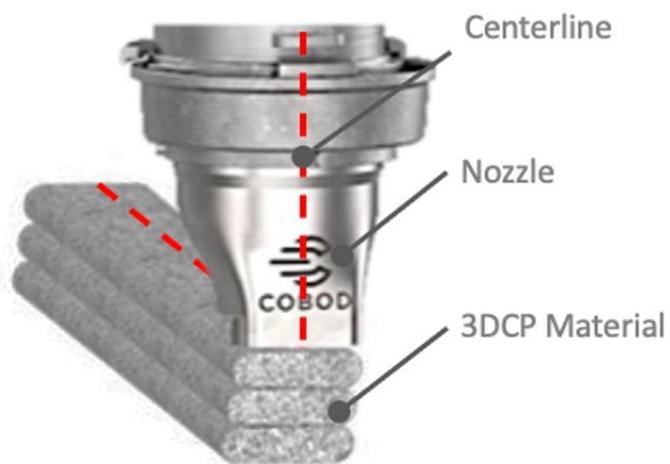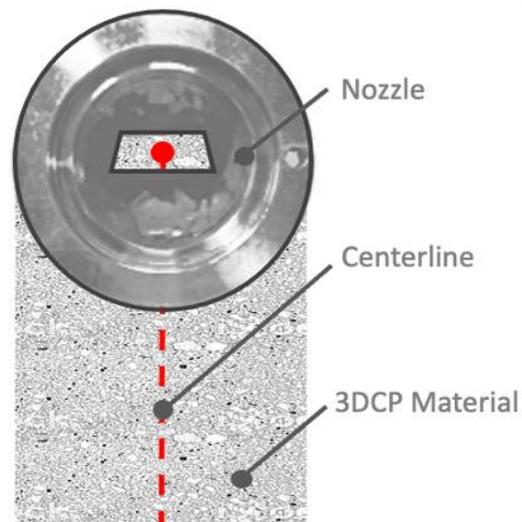
Centerline in COBOD Slice

Centerline
Surface
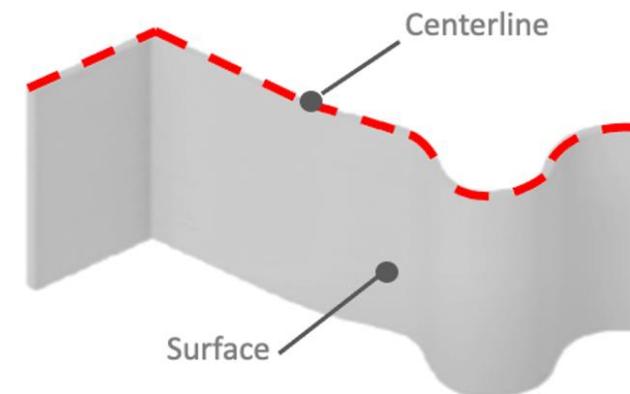
LAYER TIME
LAYER SPECIFICATIONS

Good layer bonding, but **too much slump resulting in sunken layers,** and the need to compensate with more extrusion

TOO FAST ❌

Steady layer width and even layers, but **very poor layer adhesion resulting in poor strength and durability**

TOO SLOW ❌

Steady layer width and good layer bonding

OPTIMAL ✅

LAYER TIME EXAMPLES

LAYER SPECIFICATIONS

	Case 1	Case 2	Case 3
Print speed	300 mm/sec	100 mm/sec	85 mm/sec
Layer time	2 min 60s	5 min	8 min 40s
Conclusion	Too fast ❌	Too fast ❌	Optimal ✔️
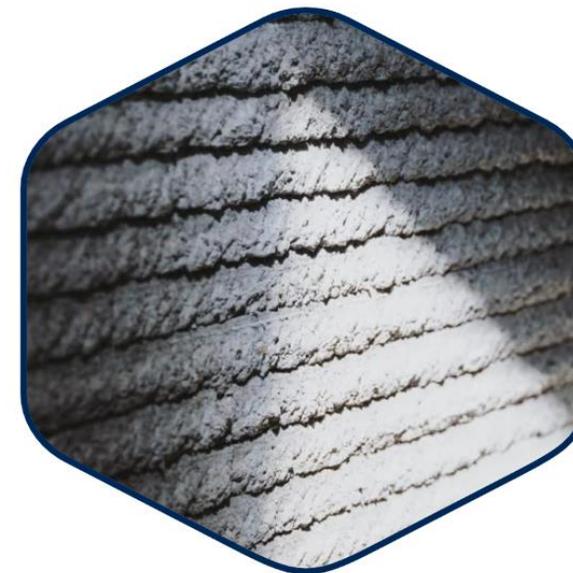
The following factors will affect your layer time:

- ❖ Weather conditions
- ❖ Material performance
- ❖ Geometry size
- ❖ Desired resolution
- ❖ Geometry complexity
- ❖ Printer operator performance

KEY PERFORMANCE INDICATORS (KPIs) FOR MODELING

KEY PERFORMANCE INDICATORS

1 3DCP LOGISTICS	2 MODELING CONSIDERATIONS	3 STRUCTURAL CONSIDERATIONS

Definition: 3DCP logistics is the optimization of your printable units, site planning and printing time in accordance with the volume output of material per hour.
Measurement unit: X m3 of material/h

Definition: The modeling considerations are the key elements which will make your design 3D printable, including printable area, wall design, and openings.
Measurement unit: YES/NO

Definition: Structural considerations are the key elements which will be approved by your structural engineer in order to obtain the building permit. These will include foundation, column and slabs.
Measurement unit: YES/NO

- Project management
- Site plan optimization
- Utilities needed
- Tools needed
- Trained crew

- Poor planning
- No site plan
- Tools missing
- Crew is not trained, no clarity in roles

- Less junctions
- No thermal bridges
- Defining details
- Openings considerations according to layer height
- Flaps/no flaps

- Many junctions
- Many small pieces
- Not understanding your nozzle
- Radius for corners is less than the width of the nozzle

- Regulation compliance
- Structural details
- Structural drawings approved
- Overlap reinforcement for columns

- Structural elements are not well planned and ready.
- Foundation slab is equal to the footprint of the building
- Printer is not aligned with foundation

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1
3DCP LOGISITICS

3DCP CONSTRUCTION PHASES

3DCP LOGISTICS SECTION

DESIGN AND ENGINEERING

- Creating architectural model (BIM/CAD model)
- Adjust the model according to 3D printing techniques
- Prepare necessary drawings for Building Permit
- Create construction drawings
- Create the construction schedule and cost calculations
- Create centerlines
- Export STEP file

SITE PREPARATIONS

- Prepare the site according to the recommendations for 3DCP
- Initial excavation/grounding
- Cast slab and/or prepare for printing the formwork for the foundation slab
- Place concrete basis
- Install the printer
- Install the MDS and Batch plant

FINISHING

- Insulate the walls.
- Add windows/doors.
- Add post printing finishes (if needed)
- Optional plastering the interior walls
- Cast the slab or install the roof
- Arrange the landscape.

1   **2**   **3**   **4**   **5**

SLICING THE GEOMETRY

- Import STEP file in COBOD Slice
- Adjust all necessary parameters
- Test the printing file in the Slicer
- Adjust and test again until you are satisfied with the result
- Generate g-codes for different horizontal sections of the geometry

PRINTING

- Print top or full foundation formwork
- Install all necessary MEP
- Add reinforcement and cast
- 3D print vertical structures (walls, column's formwork)
- 3D print until the top of window/door
- Add lintels
- Continue 3D printing until you reach the top of the slab/roof
- Dissasembly BOD2

BEFORE PRINTING   **PRINTING**   **AFTER PRINTING**
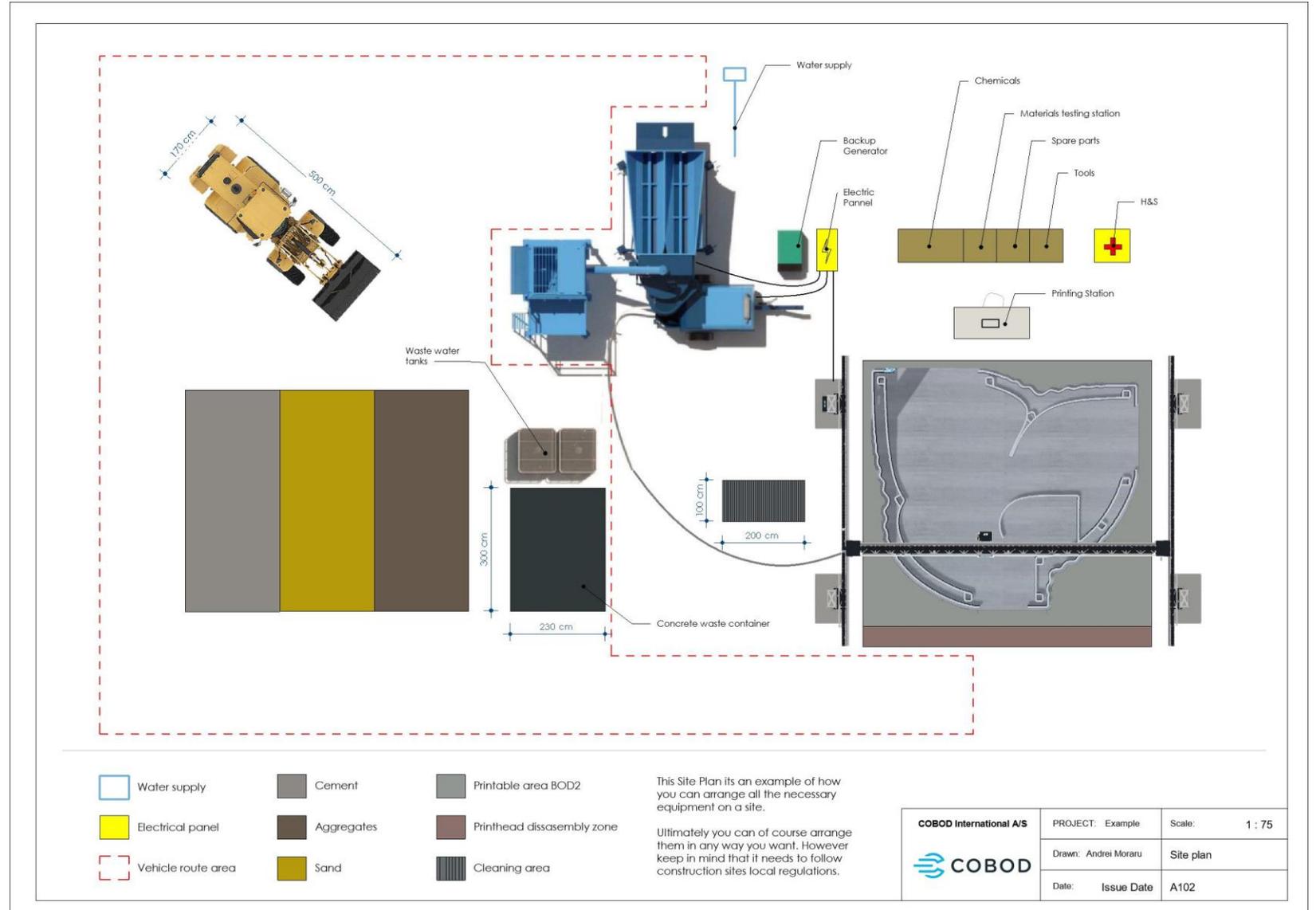
SITE OPTIMIZATION
3DCP LOGISTICS SECTION

One of the most important factors in 3DCP logistics is the Site optimization.

You want to set-up your site in the best way possible to prevent issues that might occur, or (in case your building is bigger than the printable area and your build is projected to be printed in segments) you must consider printer movements when you plan the arrangement of the equipment on site.

In the image you can see an example on how to arrange the equipment on site to avoid accidents and to have clear visibility from the control station of what is happening when a building is being printed.


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Water supply

Chemicals

Materials testing station

Spare parts

Tools

H&S

Backup Generator

Electric Pannel

Printing Station

Waste water tanks

170 cm

500 cm

300 cm

100 cm

200 cm

230 cm

Concrete waste container

Water supply	Cement	Printable area BOD2
Electrical panel	Aggregates	Printhead dissasembly zone
Vehicle route area	Sand	Cleaning area

This Site Plan its an example of how you can arrange all the necessary equipment on a site.

Ultimately you can of course arrange them in any way you want. However keep in mind that it needs to follow construction sites local regulations.

COBOD International A/S	PROJECT: Example	Scale:	1 : 75
COBOD	Drawn: Andrei Moraru	Site plan	
	Date: Issue Date	A102	

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2
MODELING CONSIDERATIONS

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CONTINUOUS LOOPS

MODELING CONSIDERATIONS SECTION

Continuous loops allows you to 3D print faster, more stable structurally and to get a better surface quality as you will not have too often the seams of start/end of a layer.
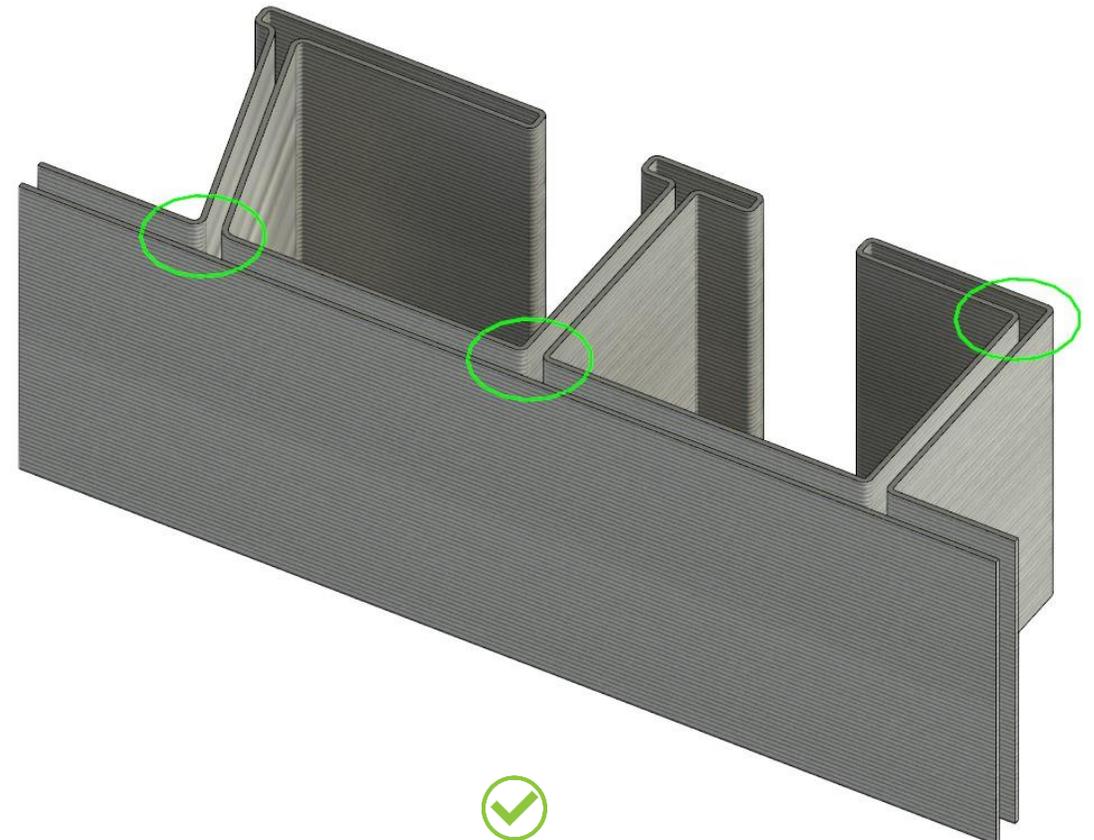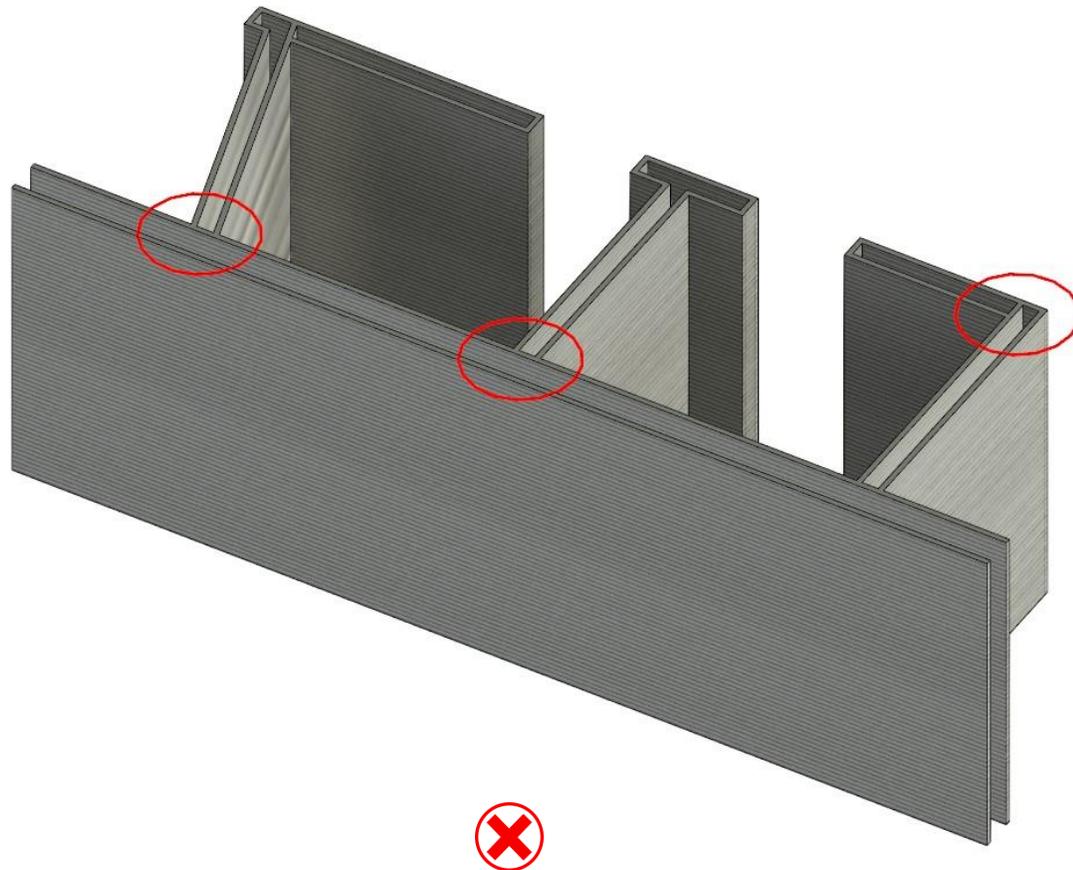
AREAS OF YOUR PRINTER

MODELING CONSIDERATIONS

1. **Installation area:**

   The minimum three-dimensional volumetric space required by the printer.

   Its maximum outer dimensions.

2. **Printing area:**

   The maximum printing area. This area is the same as operational area, excluding space for cleaning and maintenance operations.

3. **Cleaning area:**

   An area reserved for cleaning and maintenance. This area is needed to allow the X-axis to move down to ground level.

   Can be anywhere inside the print area. By aligning openings (doors, windows etc.) it is possible to have the cleaning area anywhere inside the operational area.

4. **Operational area:**

   The maximum three-dimensional space of which the printer can move.
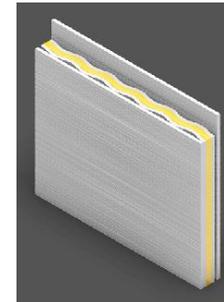
COBOD
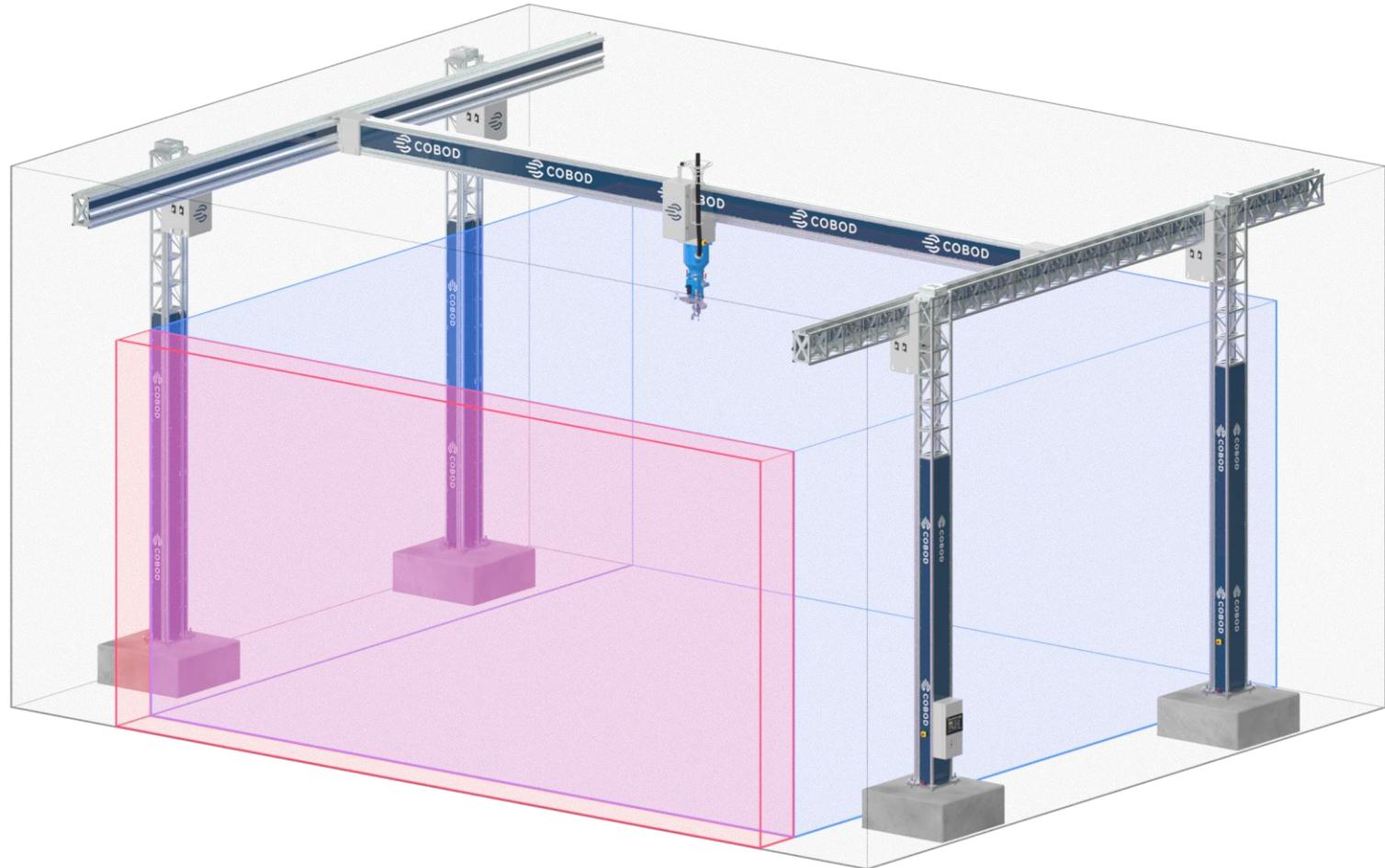
WALL TYPES

MODELING CONSIDERATIONS

3D printing offers almost unlimited opportunities for how you can model the walls. In this section, five different types of walls are illustrated. Further details about this walls can be found in the Design manual document.
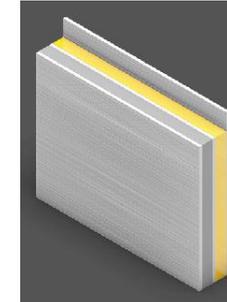
These walls can be combined or altered as desired.

There are various advantages and disadvantages for each wall type, and the choice will depend on the overall design and local building regulations.
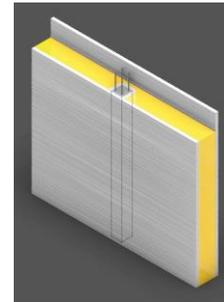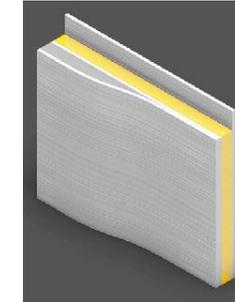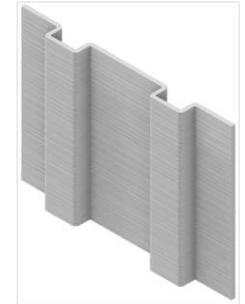

| Hollow wall with integrated column | "Snake wall" | Double wall or "Sandwich wall" | Bespoke double wall | Single wall |

Factors to take into consideration when modeling the 3D printed walls:

1. Wall type (loadbearing / non-loadbearing)
2. Wall thickness
3. Insulation layer according to building regulations
4. Avoid thermal bridges if necessary, depending on the building regulations
5. Layer height
6. Layer width

Centerline

Layer height
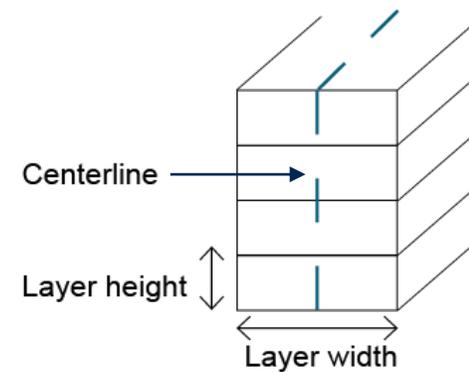
Layer width

Layer height and width of the 3D printed layer can vary depending on the design criterias.

The most common dimensions are layer height = 20 mm and layer width = 50 mm.
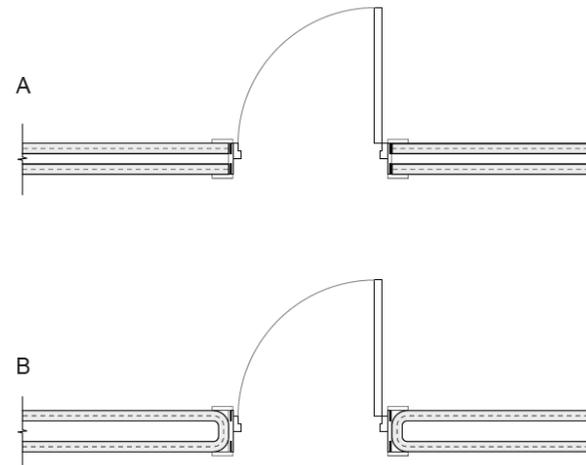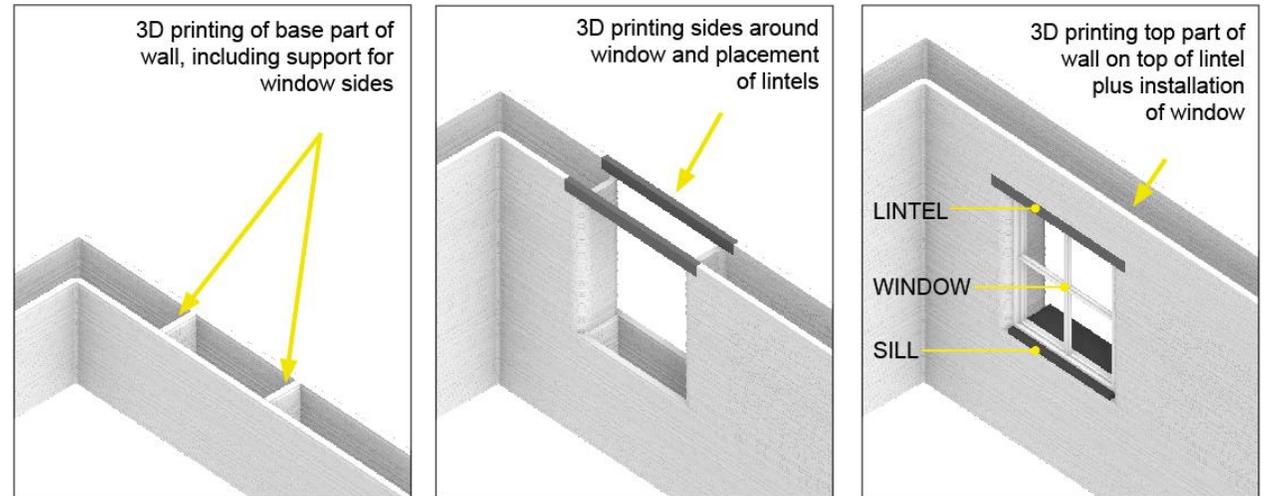
OPENINGS

MODELING CNSIDERATIONS

Voids for both windows and doors should be subtracted from the modelled surfaces. Underlaying walls should be created also as a part of the surfaces to support the 3D printed walls around the window.

After the walls around the window are printed, there are several way to install the lintel. This applies for both windows, doors or other openings.

If a floor to ceiling windows is desired, there will naturally be no need for underlaying support in the form of 3D printed walls. Therefore, the void can be created in similarity with a door opening. In this way, your building will be printed faster.

Factors to be defined in the design phase before implementing any type of door/window into your project are:

1. Wall thickness and type
2. Avoiding thermal bridges or not
3. Window span and height
4. Window support type: steel plate or 3D printed supports
5. Frame location: towards interior or exterior
6. Window side supports
7. Lintel design

3D printing of base part of wall, including support for window sides

3D printing sides around window and placement of lintels

3D printing top part of wall on top of lintel plus installation of window

LINTEL

WINDOW

SILL

A

B

MODELING CONSIDERATIONS

9. OPENINGS (WINDOWS/DOORS)

Window / door detail for avoiding a cold bridge.
At every external wall opening, the printed layers are ending with a U-shaped edge towards the cavity wall. A minimum gap of 5-10cm is required between the two edges to prevent a thermal bridge.
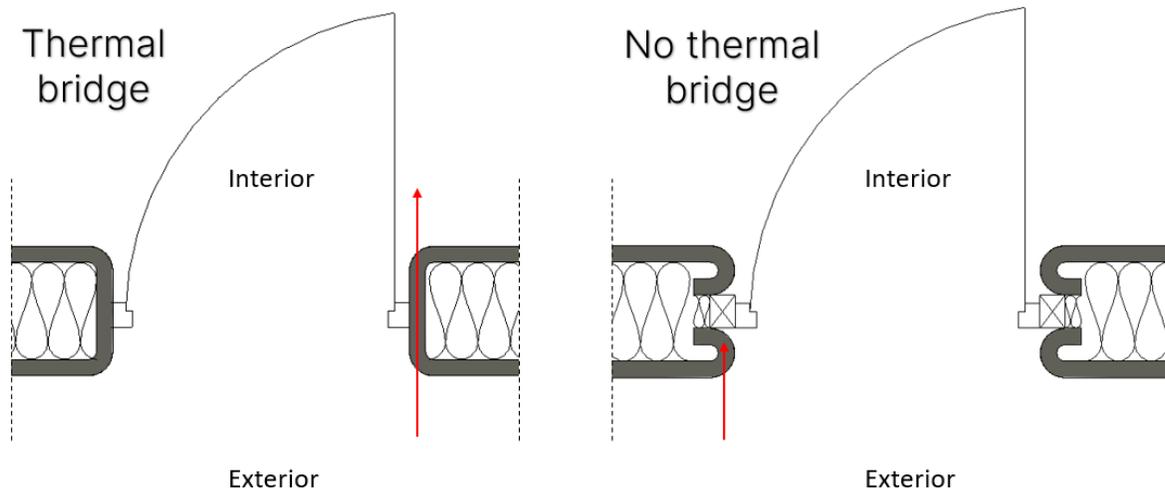
Window Detail from Hostelbro Project – 3D printed House

MODELING CONSIDERATIONS

10. OPENINGS (MEP)

- The necessary voids for the electrical sockets can be included and planned in the CAD file. This will automatically eliminate the need to drill or cut holes in the 3D printed walls, allowing various installations.
- The necessary voids can be cut after the wall is finished; however, we do not recommend this, at it will require heavy machinery and the walls are more prone to crack.
- The necessary voids can be cut right after the print while the material is still wet. This way you can create a clean void for MEP.

The wires can be placed on the inside both external and internal walls if it is designed as double wall.

The main plumbing work will be done while working with the foundation. A complete water piping network must be placed before casting the foundation, leaving pipes sticking out in the cavity wall, similar case to wiring.

Voids for water outlets, cleanout valves can be included in the planned CAD file, or manually removing wet material. Other options are also possible as in having the wiring and plumbing under the roof/slab and covered by the false ceiling.
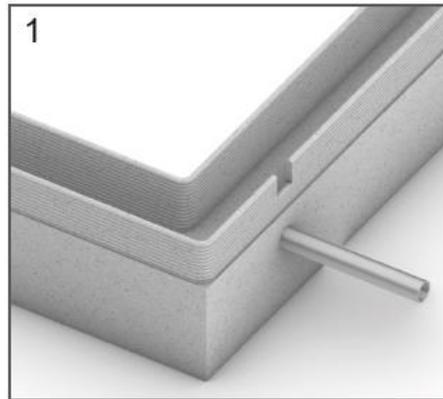
The main water line is placed in the foundation before casting.
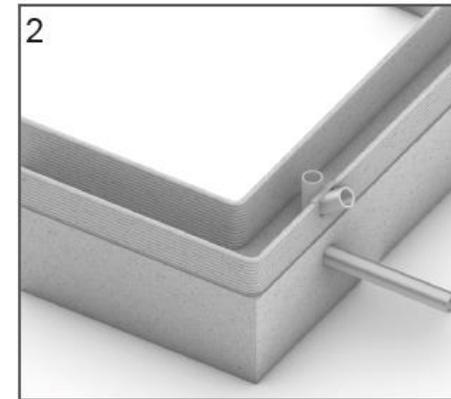
A void for plumbing is designed in the CAD file for easier installation.
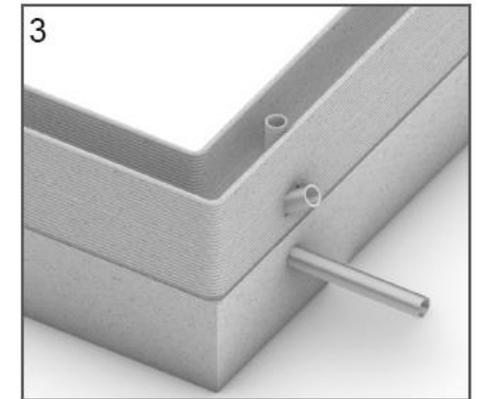
The bifurcated pipes from the primary lines are placed in between the walls.

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3
STRUCTURAL CONSIDERATIONS

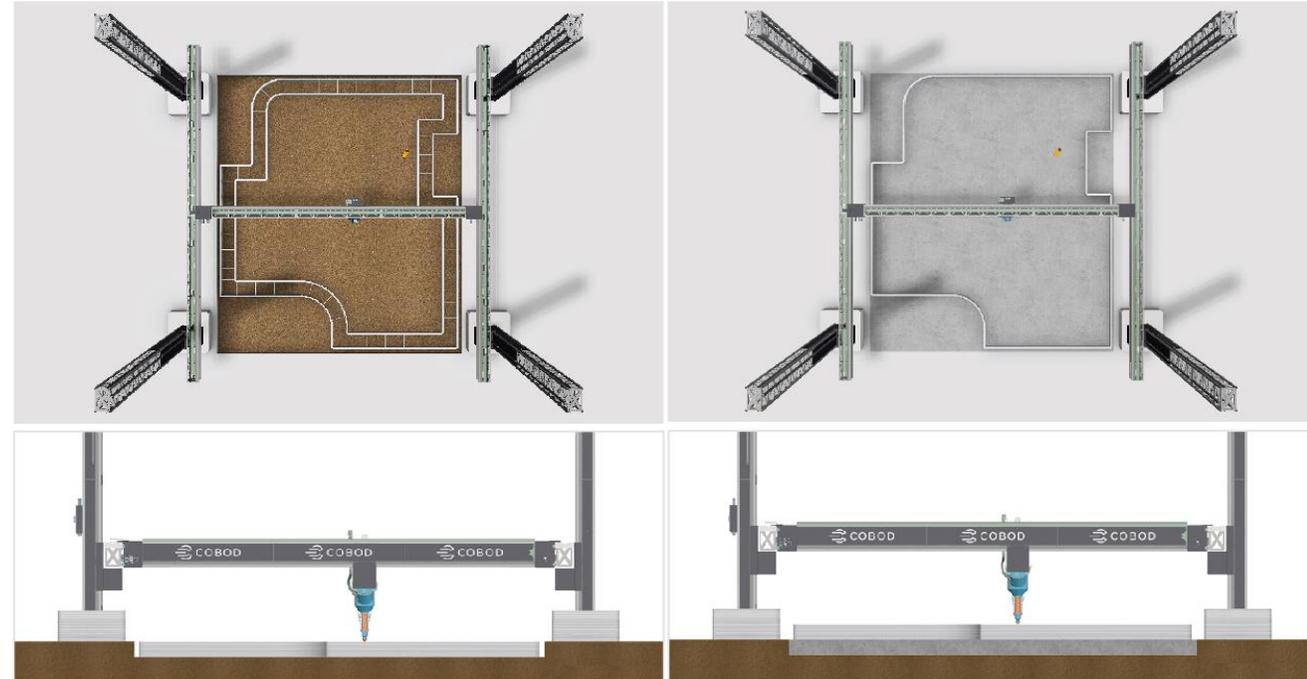# STRUCTURAL CONSIDERATIONS

1. FOUNDATION

We highly recommend using the 3D printer to print the outline border of at least the top part of the foundation, both for orthogonal and more complex shapes. **3D printing the outline of the foundation will make printing the vertical structures a lot easier.** It will also eliminate the need for creating complex formwork to cast the foundation. Then simply pour conventional concrete after 2 days to finish your foundation.

In case manual work is chosen for the foundation, we recommend to build the foundation at least 5-10cm bigger on all sides than the printed geometry. This will avoid any misalignment between the foundation slab and the printable file.

For the top part of the foundation, waterproofing and insulation (if required by the local building code) should be implemented before casting the slab. The figure shows the plumbing pipe sticking out of the base foundation and the 3D printed top part.

As seen in the figure besides, the 3D printer can be installed on concrete feet. This will increase the printable height area. The use of concrete feet will typically add 60cm of printing height.

3D printing a plinth beam foundation directly on the leveled ground.

Base foundation size limited to just fit the shape of the building with 5-10cm tolerance. The top part of the foundation is printed by the 3D printer.

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STRUCTURAL CONSIDERATIONS

1. FOUNDATION

Left drawing — PLINTH FOUNDATION CONNECTION

400
50 | 300 | 50

Insulation 300mm: Mineral fiber, Polystiren beads or granules formaldehyde foam.

3D Printed Concrete wall Layer: 50x40mm

Wall binders (9pcs/m2)

Cant wodeen sheet

Wooden floor

Hard insulation

EXTERIOR

INTERIOR

Slopped foundation edge to guide the water out
Apply DMP for rain water

Tube Ø 10mm to guide the water out

50-100mm offset from the edge of the foundation

Hard insulation

Rebar Ø 10mm

Rebar Ø 10mm

DPM

Hard insulation

Gravel

Drainage pipe

REVISIONS:

A   18.April.23   Changes to reinforcement

DESCRIPTION

Casted foundation connection with 3D printed concrete double wall.

Use cases:
- 1,2,3 story house
- Warehouse

ASSEMBLY

- Earth excavation and leveling the soil
- Place gravel under the slab
- Place hard insulation
- Place DPM
- Place the reiforcement for the plinth and slab
- Cast the foundation and slab
- Make the sloped edge 30 min after pouring the concrete
- Place DMP tarp as shown in the drawing) brown line)
- After 1-2 days of curing, the 3D printed walls process can start

PLINTH FOUNDATION CONNECTION

COMPANY	ADDRESS	DRAWN BY:	SCALE:	DRAWING NO.:
COBOD INTERNATIONAL A/S	Skudehavnsvej 17A 2150 Nordhavn Denmark +45 9290 9066 info@cobod.com	Andrei Moraru Architectural Technologist	1:5 (milimiters)	WC1_F01_C_D01
			DATE: 14.April.2022	**REVISED BY** ZM

Right drawing — PLINTH FOUNDATION CONNECTION WITH COLUMN

400
50 | 250 | 100

3D Printed concrete formwork for the column 50mm

Rebar Ø 20mm overlapped 600mm

50mm insulation to avoid thermal bridge

3D Printed Concrete wall Layer: 50x40mm

Self compacted concrete

Cant wodeen sheet

Wooden floor

Hard insulation

EXTERIOR

INTERIOR

50-100mm offset from the edge of the foundation

Hard insulation

Rebar Ø 10mm

Drainage pipe

Rebar Ø 10mm

DPM

Hard insulation

Gravel

REVISIONS:

A   18.April.23   Changes to reinforcement

DESCRIPTION

Casted foundation connection with 3D printed concrete double wall.

Use cases:
- 1,2,3 story house
- Warehouse

ASSEMBLY

- Earth excavation and leveling the soil
- Place gravel under the slab
- Place hard insulation
- Place DPM
- Place the reiforcement for the plinth and slab
- Leave Rebar sticking out of the foundation 60cm
- Cast the foundation and slab
- Make the sloped edge 30 min after pouring the concrete
- Place DMP tarp as shown in the drawing) brown line)
- After 1-2 days of curing, the 3D printed

PLINTH FOUNDATION CONNECTION WITH COLUMN

COMPANY	ADDRESS	DRAWN BY:	SCALE:	DRAWING NO.:
COBOD INTERNATIONAL A/S	Skudehavnsvej 17A 2150 Nordhavn Denmark +45 9290 9066 info@cobod.com	Andrei Moraru Architectural Technologist	1:5 (milimiters)	WC01_B01_C1_D01
			DATE: 14.April.2022	**REVISED BY** ZM

High-quality images + more drawings are available in Doc. – WC1 Construction Details
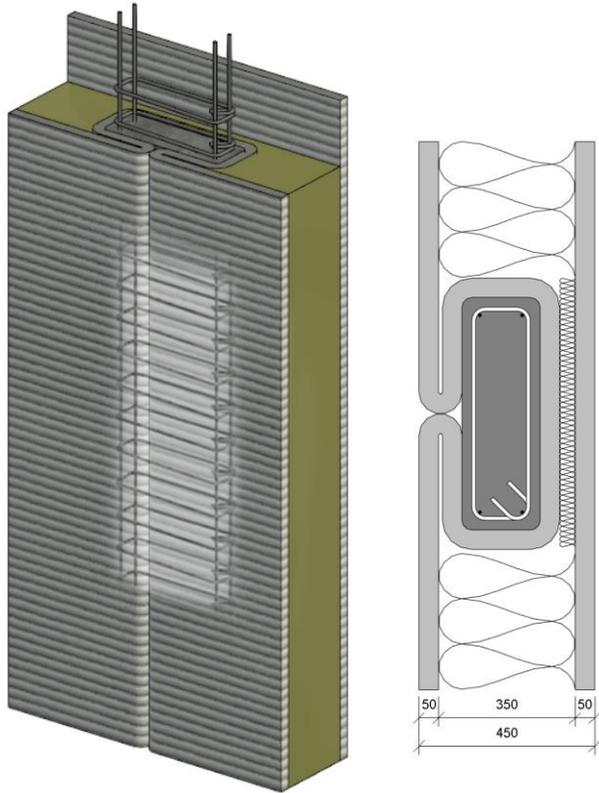
COBOD

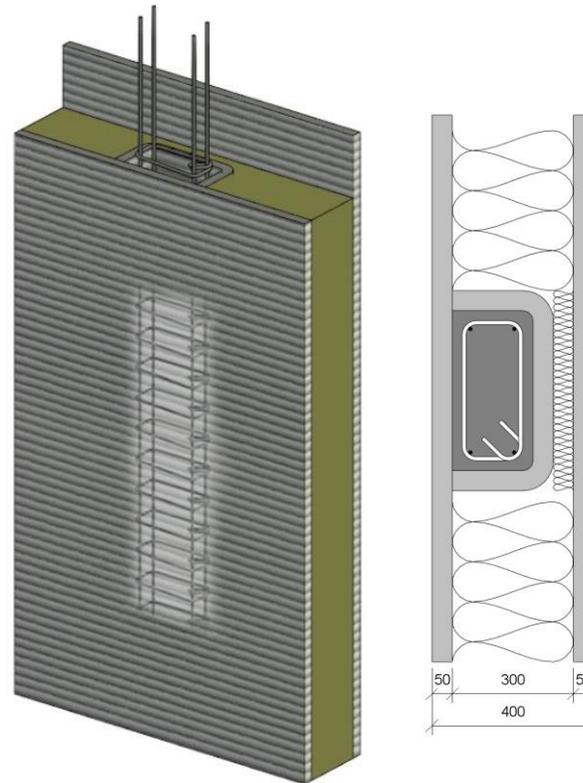# STRUCTURAL CONSIDERATIONS

2. COLUMNS

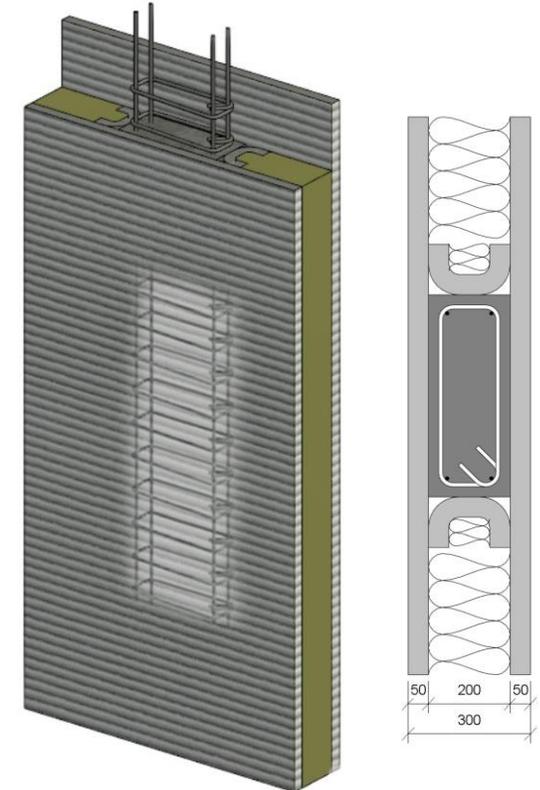3D printing offers a lot of opportunities and free modeling on how you can print the columns formwork.

Basically, the 3D printer is creating the outer shell of the column, in which you add after the rebar, the cage and fill with normal concrete.

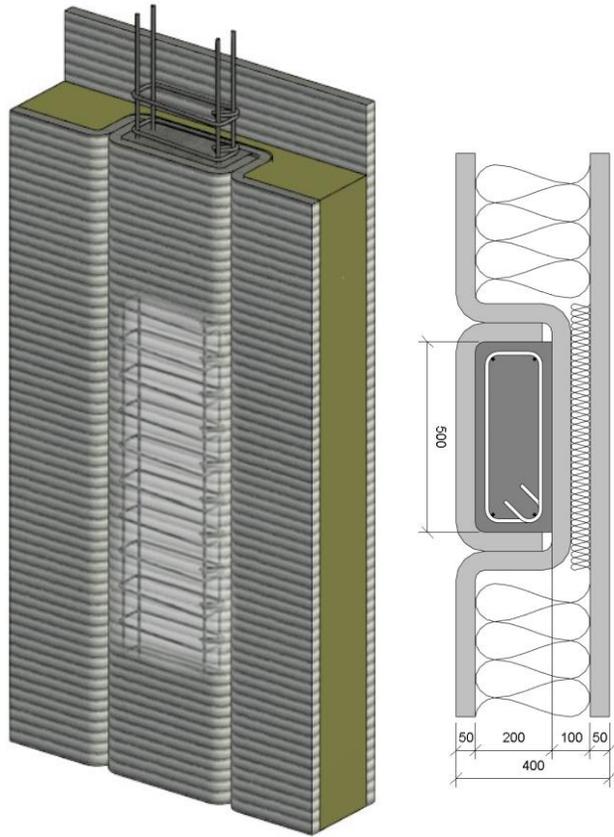450mm wall with column
integrated in the cavity.

400mm wall with column
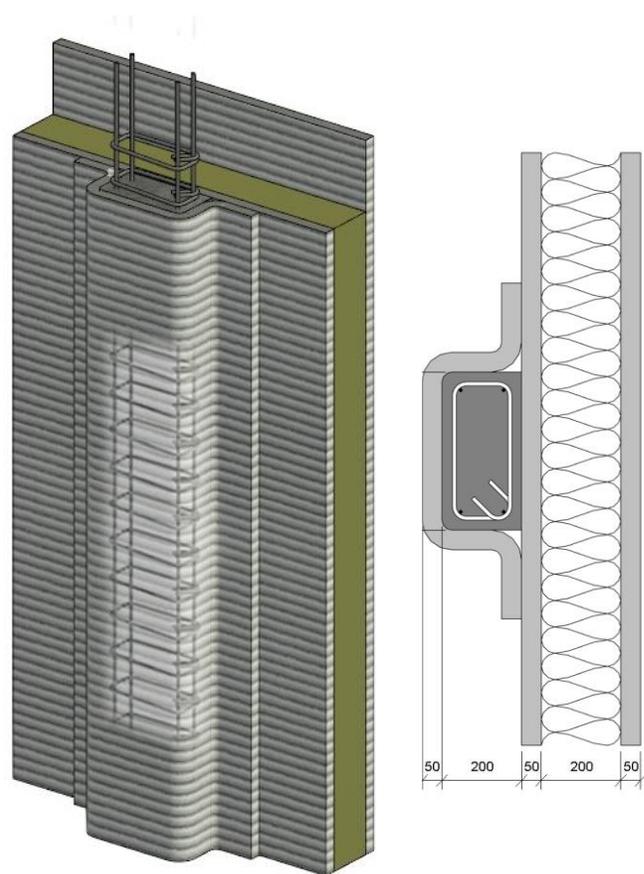integrated in the cavity.

300mm wall with column
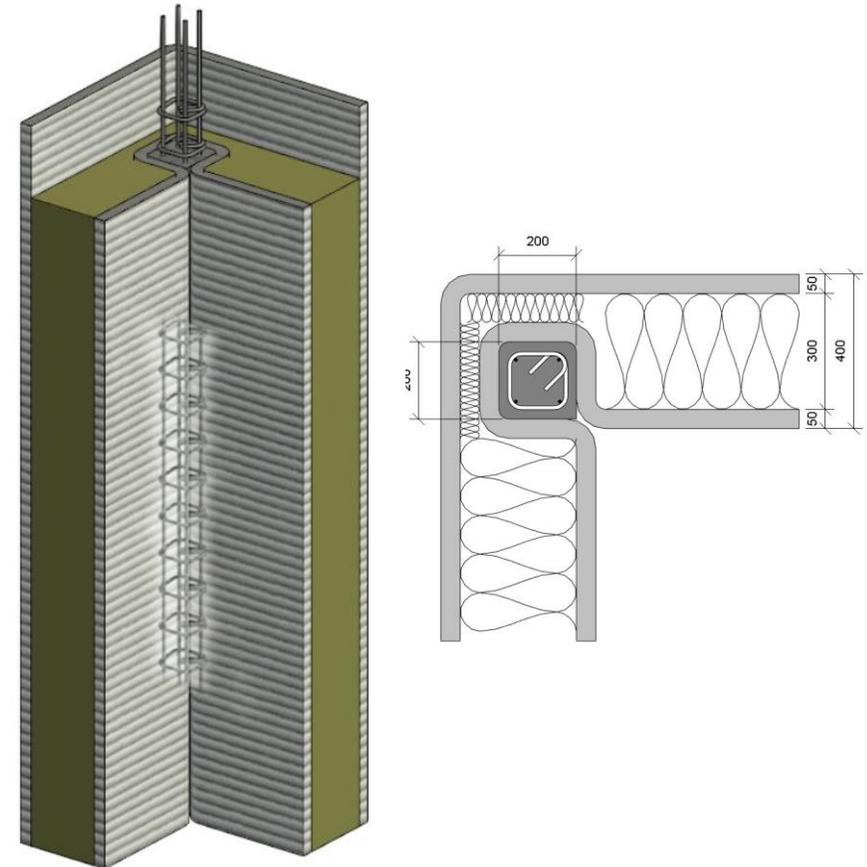integrated in the cavity.

STRUCTURAL CONSIDERATIONS

2. COLUMNS

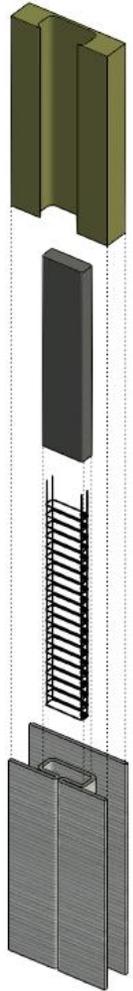400mm wall with column integrated in the cavity.

300mm wall with column on the inside.

300mm wall with column integrated in the corner

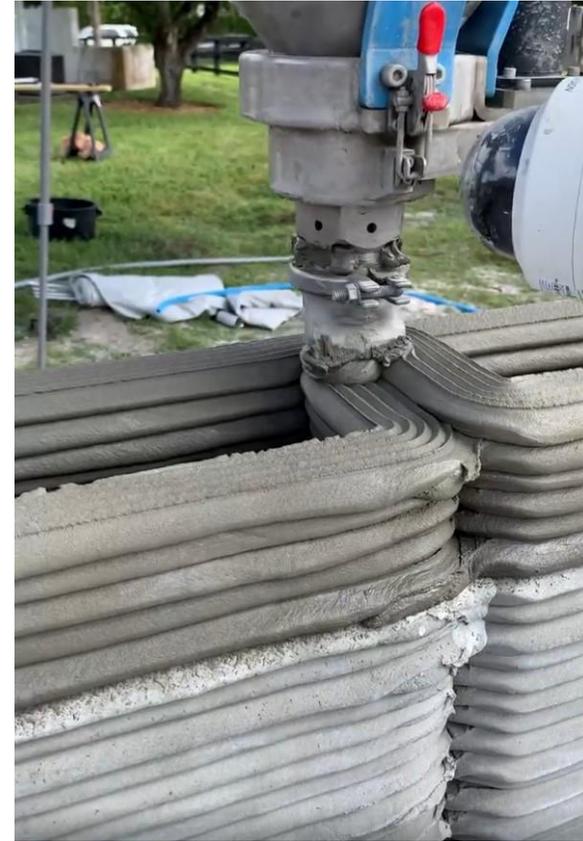# STRUCTURAL CONSIDERATIONS

2. COLUMNS

Insulate the wall.

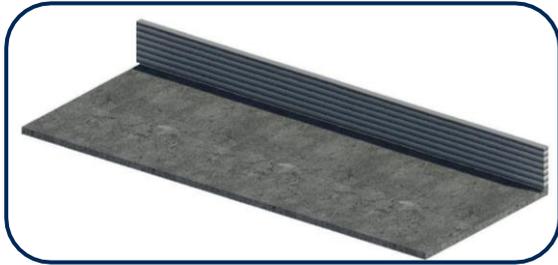Cast with conventional concrete.

Insert reinforcement cage.
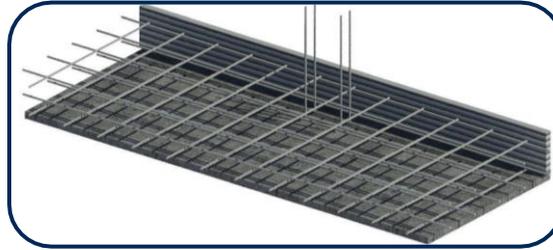
3D printing the formwork for the
column and the walls.
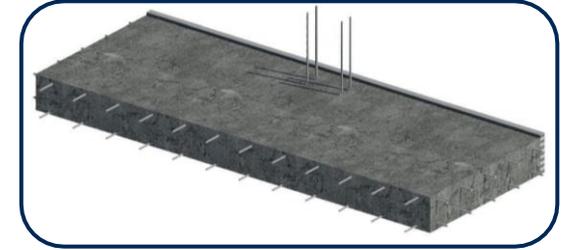
STRUCTURAL CONSIDERATIONS
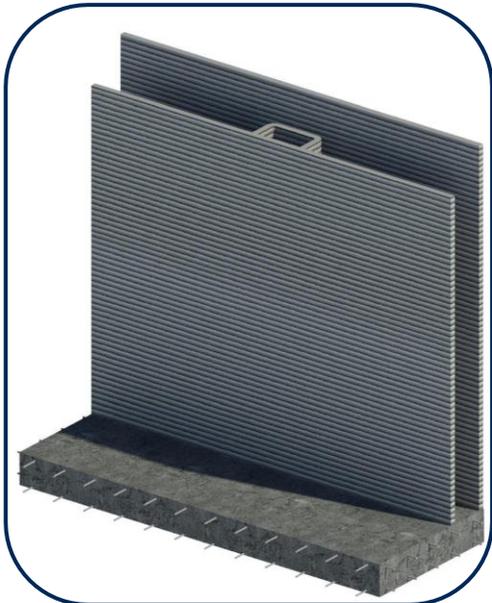
2. COLUMNS – FROM FOUNDATION TO THE SLAB/ROOF
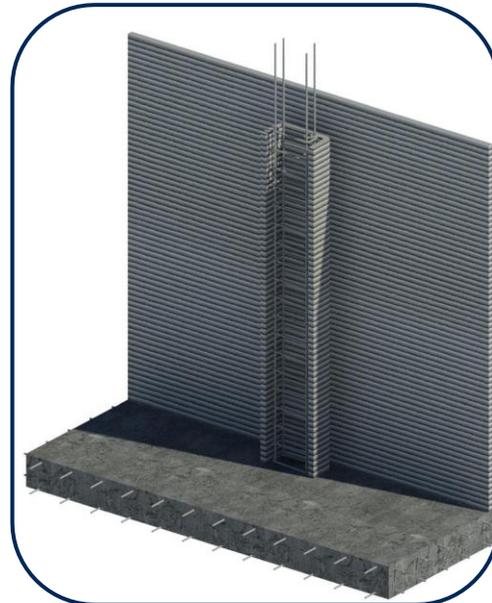

3D print formwork for foundation
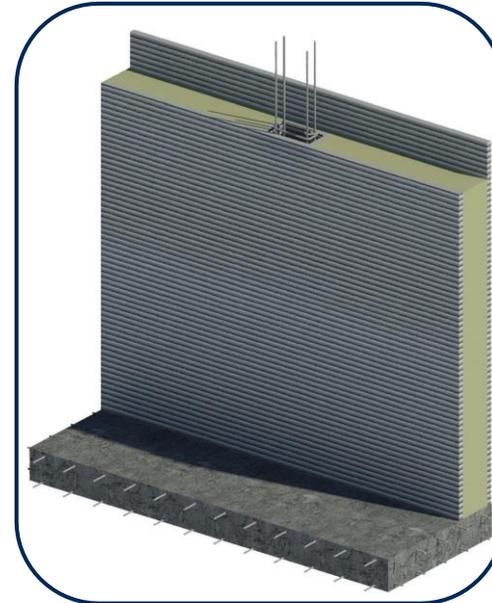

Add reinforcement
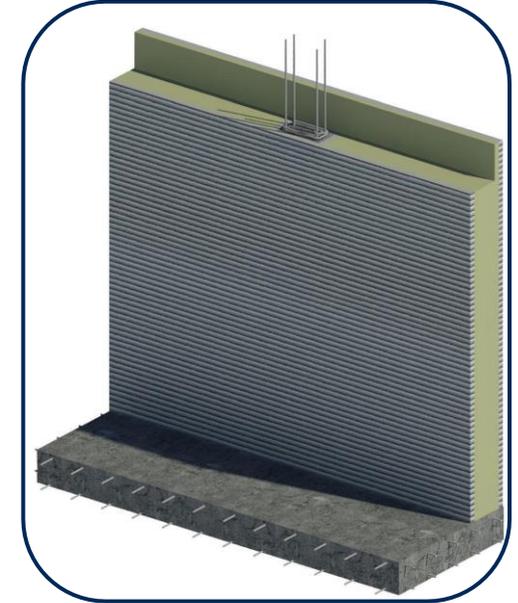

Cast the foundation

3D print the walls and column's formwork

Insert the reinforcement cage
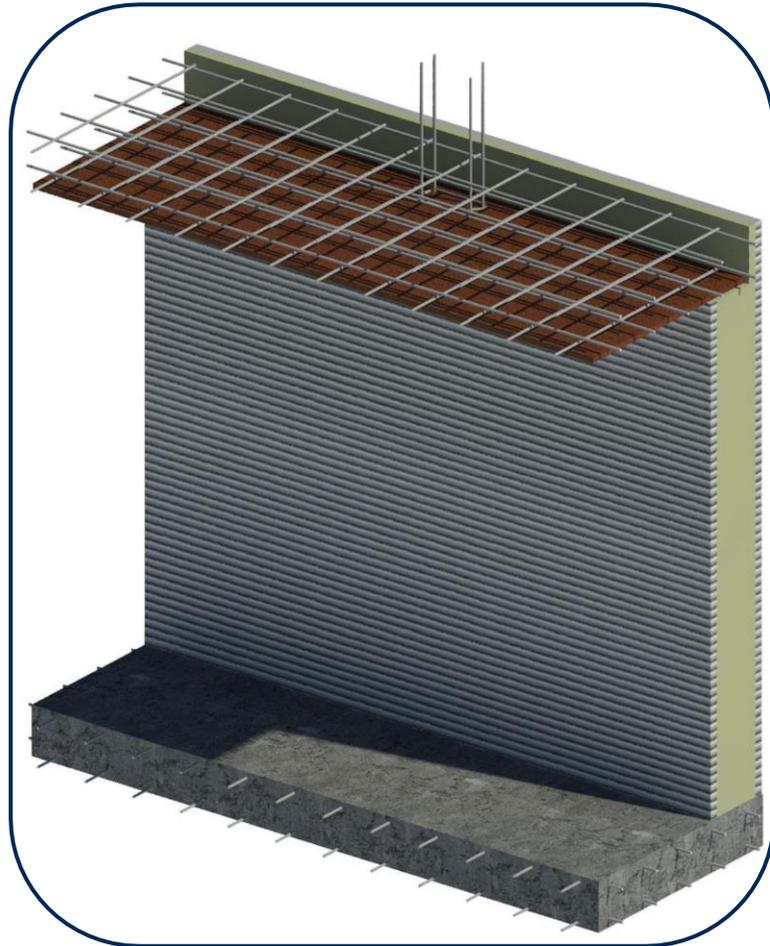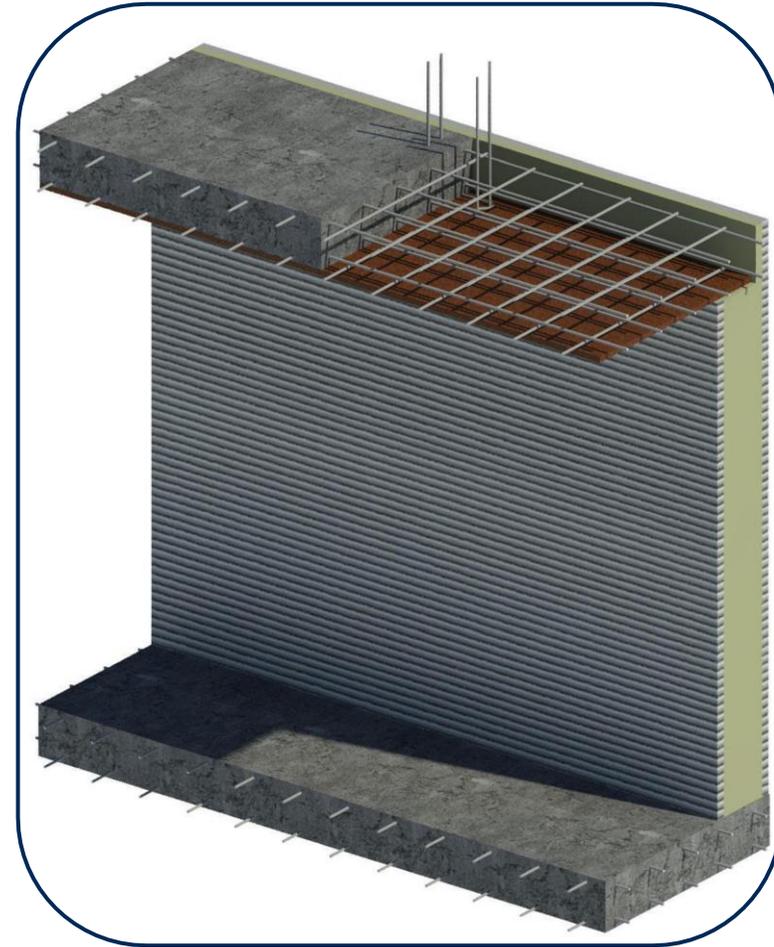

Insulate the wall

Insulate the outer shell

STRUCTURAL CONSIDERATIONS

2. COLUMNS

- Add support formwork for casting the slab
  - Add reinforcement

- Cast the slab together with the columns

STRUCTURAL CONSIDERATIONS

3. REINFORCEMENT CONNECTION

Reinforcement can be connected to the foundation by leaving rebar sticking out of the foundation.
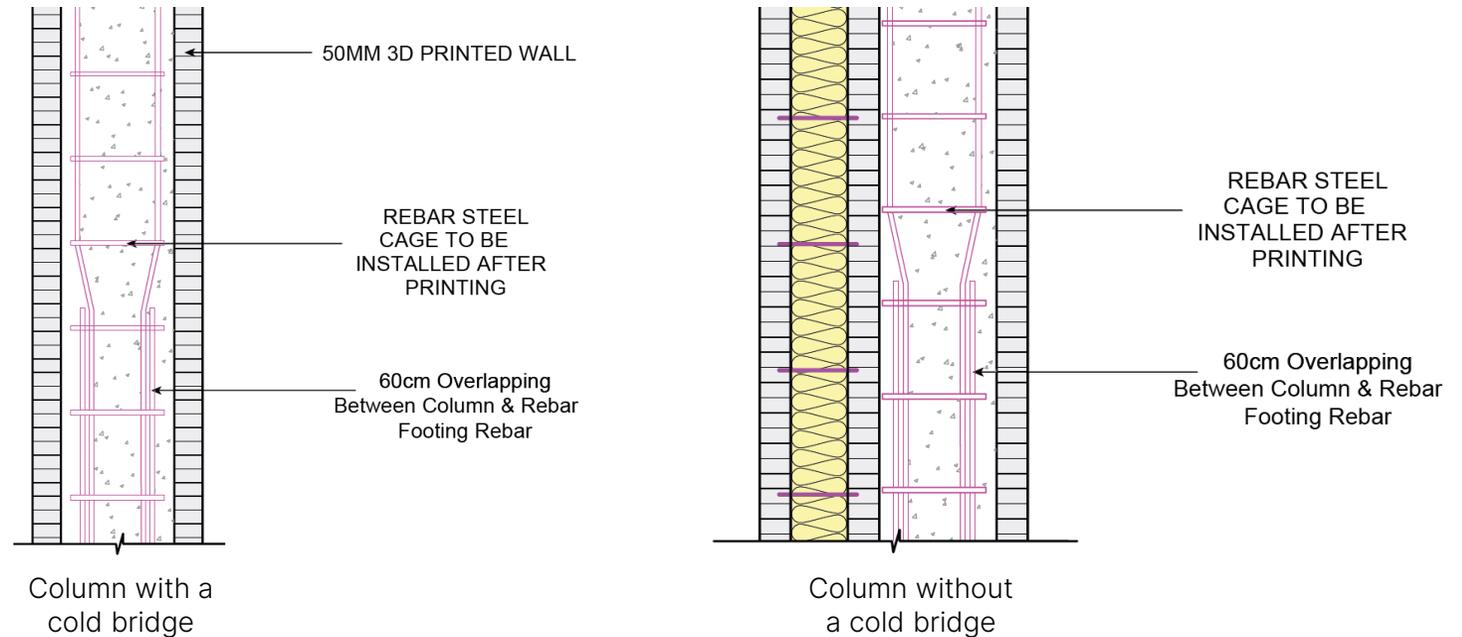
Then the printer can deposit the layers around the rebar, creating the necessary formwork for the column.

Next step is to insert the reinforcement cage from the top and overlap it with the rebar connected to the foundation

The overlap is approximately 20 x diameter of the vertical rebar. For example, in these details, the vertical rebar's diameter is 3cm x 20 = 60cm

It is recommended use this technique of connecting reinforcement in the columns, however you have to consider the inner side of 3D printed formwork which will not be perfect if you don't have a flap, ending up to be a formwork thicker than the one in the drawing.

Therefore, is recommended to make the interior of the columns 3-5cm bigger, for inserting smoother the reinforcement cage.

50MM 3D PRINTED WALL

REBAR STEEL CAGE TO BE INSTALLED AFTER PRINTING

60cm Overlapping Between Column & Rebar Footing Rebar

Column with a cold bridge

REBAR STEEL CAGE TO BE INSTALLED AFTER PRINTING

60cm Overlapping Between Column & Rebar Footing Rebar

Column without a cold bridge

STRUCTURAL CONSIDERATIONS

3. REINFORCEMENT CONNECTION

1

2

3

3D print around column rebar up risers using extension nozzle. Leaving a small opening for rebar connecting.
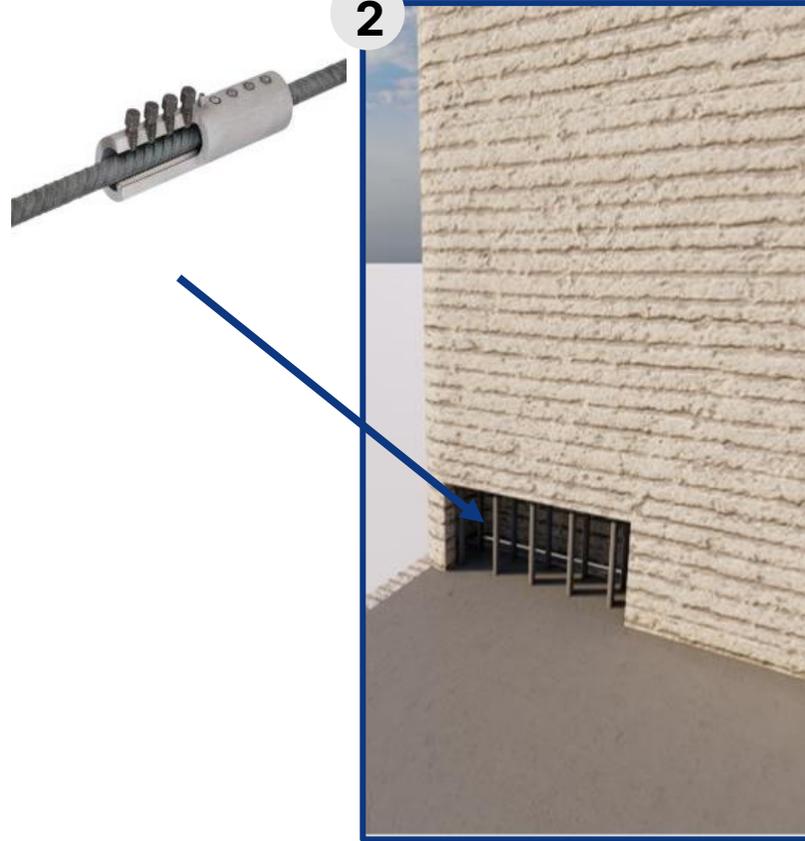
Insert column rebar from top of the wall, use rebar coupler to connect column rebar with rebar up risers.
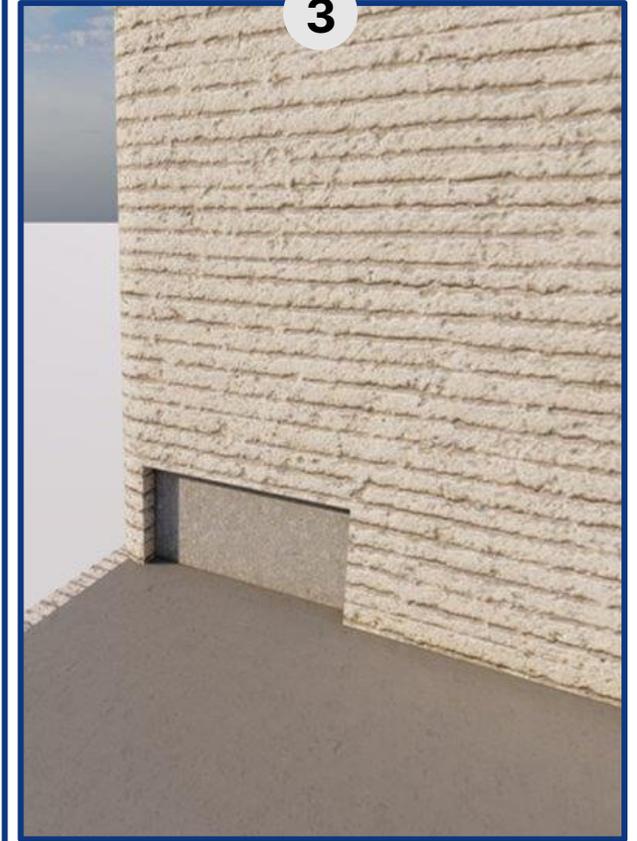
Use temporary formwork for the opening and cast concrete in column.

COBOD

STRUCTURAL CONSIDERATION

4. SLAB CONNECTION

There are different types of slabs that can be used in 3DCP, these types of slabs can be used in floors as well as in roof structures.

1. Cast in situ RCC.
2. Precast slabs (hollow core, double T, etc.
3. Filigree slabs (recommended when the shape of the building is complex. These slabs can be 3D printed.
4. Steel or wooden decks.

STRUCTURAL CONSIDERATIONS

4. SLAB CONNECTION

Cast in situ slabs, or prefabricated elements can be connected to 3D printed walls similarly with conventional techniques.

For cast in situ beams, a permanent formwork is placed on top of the 3D printed layers with ½ overlap, then the printer can continue to 3D print the walls.

Insert the reinforcement cage with spacers and cast it.

Create the formwork for the casted slab or in case of prefabricated hollwcore slabs, just rest them on the beams, then continue with the second floor.

REVISIONS:

A   18.April.23   Changes to reinforcement
-
-
-
-
-

DESCRIPTION

Casted foundation connection with 3D printed concrete double wall.

Use cases:
• 1,2,3 story house
• Warehouse

ASSEMBLY

• 3D print the inner leaf and the column's formwork until the bottom of the slab
• 3D print the outter leaf until the top of the deck, to act as formwork for casting
• Place hard insulation to avoid a thermal bridge on the side.
• Add reinforcement to connect the column to the slab and cast the rest
• Continue 3D printing the paraper
• Finish the roof conventionally

Drawing labels:

Parapet closure conventional
Wall binders (9pcs/m2)
100mm hard insulation to avoid thermal bridge and to act as formwork for the beam
Rebar for the beam Ø 10mm
3D Printed column formwork 50mm
Insulation for avoiding a thermal bridge

3D Printed Concrete wall Layer: 50x40mm
Cant wodeen sheet
Self-compacted concrete
DMP
Gravel
Hard insulation
Hollow core concrete slab

EXTERIOR
INTERIOR

50 | 300 | 50
50 | 100 | 200 | 50
400

PARAPET ROOF CONNECTION WITH HOLLOW-CORE DECK AND COLUMN

COMPANY
COBOD INTERNATIONAL A/S

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2150 Nordhavn
Denmark +45 9290 9066
info@cobod.com

DRAWN BY:
Andrei Moraru
Architectural Technologist

SCALE:
1:5 (milimiters)

DATE:
14.April.2022

DRAWING NO.:
WC01_B02_C1_D01

REVISED BY
ZM

COBOD

STRUCTURAL CONSIDERATIONS

5. ROOF CONNECTION

Roofs and slabs are very much similar with conventional construction, they follow the same principles of connecting the rebars from foundation to the roof.

Continue 3D printing the parapet and apply the roof finishes.

This is an example of 3D printed slab called filigree concrete slab with 3D printed formwork.

REVISIONS:

A 18.April.23   Changes to reinforcement

DESCRIPTION

Casted foundation connection with 3D printed concrete double wall.

Use cases:
- 1,2,3 story house
- Warehouse

ASSEMBLY
- 3D print the inner leaf and the column's formwork until the bottom of the slab
- 3D print the outter leaf until the top of the deck, to act as formwork for casting
- Place hard insulation to avoid a thermal bridge on the side.
- Add the Filigree slab and connect it to the column
- Cast the rest of the filigree slab
- Continue 3D printing the paraper
- Finish the roof conventionally

Drawing labels:
- Parapet closure conventional
- 100mm hard insulation to avoid thermal bridge and to act as formwork for the beam
- Wall binders (9pcs/m2)
- EXTERIOR
- Rebar for the beam Ø 10mm
- 3D printed concrete formwork for the column
- Insulation 50mm to avoid a thermal bridge
- INTERIOR
- 3D Printed Concrete wall Layer: 50x40mm
- Cant wodeen sheet
- DMP
- Gravel
- Hard insulation
- Filigree 3D printed concrete slab First cast ~1/3 of the slab. The rest is casted after the slab is installe

Dimensions: 50 300 50 / 50 50 50 250 / 400

PARAPET ROOF CONNECTION WITH FILIGREE DECK AND COLUMN

COMPANY	**ADDRESS**	**DRAWN BY:**	**SCALE:**	**DRAWING NO.:**
COBOD INTERNATIONAL A/S	Skudehavnsvej 17A 2150 Nordhavn Denmark +45 9290 9066 info@cobod.com	Andrei Moraru Architectural Technologist	1:5 (milimiters) **DATE:** 14.April.2022	WC01_B02_C1_D07 **REVISED BY** ZM

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SPECIAL CONSIDERATIONS

COBOD

SPECIAL CONSIDERATIONS

1. PRINTING A GEOMETRY BIGGER THAN THE PRINTABLE AREA.

If your design is bigger than the printable area, you might consider splitting the building in 2-3 parts and print them individually.

In this case, you need to consider these movements of the printer when you are designing your building.

For this project, it was decided to have floor to ceiling windows in order to join perfectly the 3 3D printed sections.

There is a lot of design freedom on how to cover those gaps: floor to ceiling windows, cast concrete, 3D print that section as a piece of wall and insert it in the gap, etc.

However, we recommend to design according to your printable area, and if you need to move the printer, design and model accordingly.

COBOD
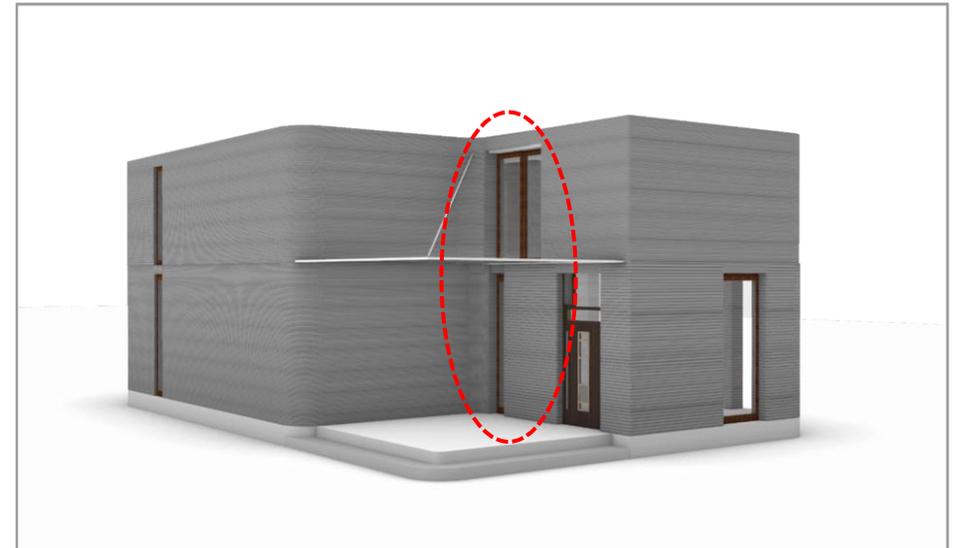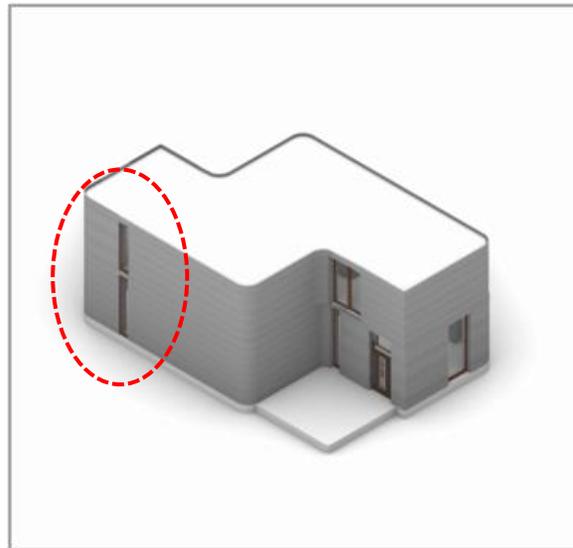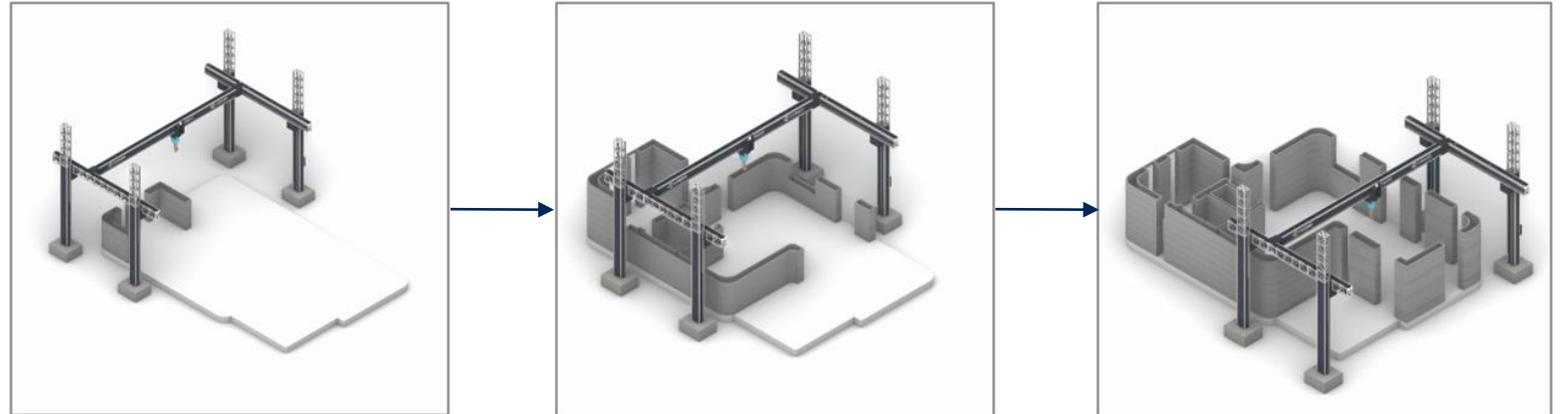
SPECIAL CONSIDERATIONS

2. 3D PRINTED FILIGREE ROOF SLAB

3D Print Formwork

Place Reinforcement

Cast the First 6-8cm

Place Roof Slabs on the Building

Cast the Last 12-14cm on Site

COBOD

CAD VS SLICER

INPUTS NEEDED FOR A GEOMETRY

Some inputs are exclusively done in the CAD software, and some are exclusively done in the COBOD Slice, it is important to understand what needs to be done in each so you can correct properly.

|	CAD	COBOD Slice
Walls	X	
Centerlines	X	
Layer Height		X
Location in space (XYZ)	X	
Layer Width		X
Print speed		X
Openings	X	
Solids	X	
Joining Centerlines	X	
Seams	X	X
Order of objects		X
Any other cuts in the walls (MEP)	X	
G-code		X

REVIT PLUG-IN

FAQ

1. How to download and install the Revit Plug-in?

Go on connect.cobod.com/software/revit-plugin and download the files + the manual on how to install and use it.

2. Can you export a step file from Revit? – YES

3. Can I use my own Revit Template? – No, use the provided template form COBOD Connect.

4. What type of objects can this Plug-in handle? - All geometries except walls created with spline, sloped surfaces or parametric design.

MODELLING IN AUTODESK REVIT

REVIT MODEL TURNED INTO STEP FILE WITH COBOD REVIT PLUG-IN

COBOD
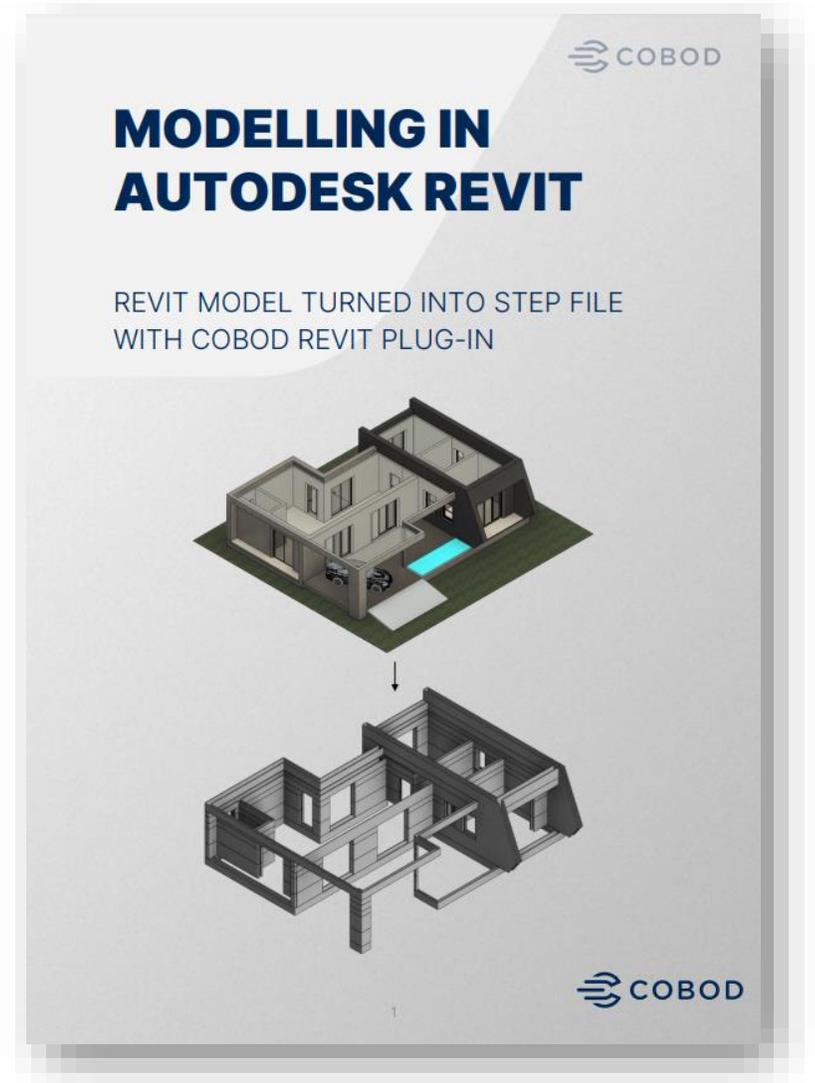
▶RECAP KPI

1 3DCP LOGISTICS	2 MODELING CONSIDERATIONS	3 STRUCTURAL CONSIDERATIONS

Definition: 3DCP logistics is the optimization of your printable units, site planning and printing time in accordance with the volume output of material per hour.
Measurement unit: X m3 of material/h

Definition: The modeling considerations are the key elements which will make your design 3D printable, including printable area, wall design, and openings.
Measurement unit: YES/NO

Definition: Structural considerations are the key elements which will be approved by your structural engineer in order to obtain the building permit. These will include foundation, column and slabs.
Measurement unit: YES/NO

- Project management
- Site plan optimization
- Utilities needed
- Tools needed
- Trained crew

- Poor planning
- No site plan
- Tools missing
- Crew is not trained, no clarity in roles

- Less junctions
- No thermal bridges
- Defining details
- Openings considerations according to layer height
- Flaps/no flaps

- Many junctions
- Many small pieces
- Not understanding your nozzle
- Radius for corners is less than the width of the nozzle

- Regulation compliance
- Structural details
- Structural drawings approved
- Overlap reinforcement for columns

- Structural elements are not well planned and ready.
- Foundation slab is equal to the footprint of the building
- Printer is not aligned with foundation

COBOD

MOST COMMON MODELING MISTAKES FOR BEGINNERS

Centerlines are not joined	Centerlines are joined	Solids are not modeled	Model is not at Z0	Radius of corners is too small	Foundation Does not have 5-10cm offset

The centerlines of closed loops must be joined in order to select the geometry in the Slicer as one object.

If the centerlines are not joined, the slicer will see them as separate objects.

The centerlines of unclosed loops must not be joined in order to select the geometry in the Slicer as one object.

If the centerlines are joined, the slicer will not see them as separate objects.

Solids must be modeled in the STEP file in order to be avoided by the Printhead. After you modelled them, make sure in the Slicer you add them as external objects.

Every geometry you want to be 3D printed, needs to be set at Z0, including the foundation formwork.

Keep the foundation under Z0 in your drawings, but not in the model for printing.

Creating a fillet for corners with a smaller radius than the width of the nozzle will create an imperfect corner after is 3D printed.

Make sure to create the fillet equal or grater than the width of the nozzle used for 3D printing.

If you cast the slab before, the foundation should have an offset of 5-10 cm on each side, after which the walls can be modelled on top.

This will prevent any misalignment between the walls, foundation and the printer.

Make sure you understand which centerlines need to be joined and which not.

CERTIFICATION TEST

▶ Link: https://www.flexiquiz.com/SC/N/eb7561f7-91c2-42cd-aa02-41f444f3e277
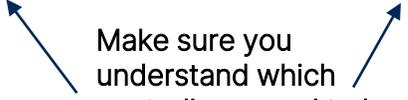
▶ Time limit: 20 minutes.

▶ Dynamic: All documents can be used as help.

▶ Approval: At least an 80% score to pass.

▶ Sequenced: Need to pass Level 1 test before proceeding to site training (Level 2).

COBOD

THANK YOU FOR YOUR ATTENTION!

COBOD