

COBOD INTERNATIONAL

3D CONSTRUCTION PRINTING TECHNOLOGY

END TO END PROJECT CYCLE



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01

Project initiation

PURPOSE

Establish feasibility and define the right technology fit before committing to purchase

KEY ACTIVITIES

- Project brief — type, layout, budget
- Site assessment — topography, access, utilities
- Technology feasibility & printer selection

OUTPUT

Approved project brief and confirmed printer model & material system

02

Design phase

PURPOSE

Produce construction-ready drawings optimised for 3D printing

KEY ACTIVITIES

- Architectural design within machine boundary
- Structural design — wall system, loads, foundation
- MEP routing & working drawings

OUTPUT

Complete permit-ready working drawings

03

Permitting

PURPOSE

Obtain legal approval to proceed with construction

KEY ACTIVITIES

- Review local building codes & structural requirements
- Prepare material assessment report
- Submit construction permit application

OUTPUT

Approved construction permit

04

Model prep & site preparation

PURPOSE

Convert design to G-code and prepare the site for printing

KEY ACTIVITIES

- 3D CAD modelling
- Foundation excavation & casting
- Embedded MEP inlets & site levelling for printer installation

OUTPUT

foundation and site complete with printer installed

05

3D printing

PURPOSE

Print the primary wall structure and integrate structural reinforcement

KEY ACTIVITIES

- G-code & Dry run before printing
- Wall printing with bonding agent & wall binders
- First fix of electrical conduits .
Rebar cage insertion & column/beam casting

OUTPUT

Completed printed walls with structural columns & beams cast

06

Horizontal structure

PURPOSE

Add slabs, beams, and roof on the printed walls.

KEY ACTIVITIES

- Select slab/roof system — RCC, steel, precast or 3D-printed
- Install roof for single-storey buildings
- Cast or install intermediate slabs for multi-storey

OUTPUT

Enclosed building with complete floor/roof structure

07

Post-print finishing

PURPOSE

Complete all fit-out work to make the building habitable

KEY ACTIVITIES

- Final fix of Electrical conduits, insulation & wall plastering
- Doors, windows & flooring installation
- Sanitary, mechanical & interior fit-out

OUTPUT

Fully finished, move-in ready interior

08

Completion

PURPOSE

Formally close the project and hand over to the owner

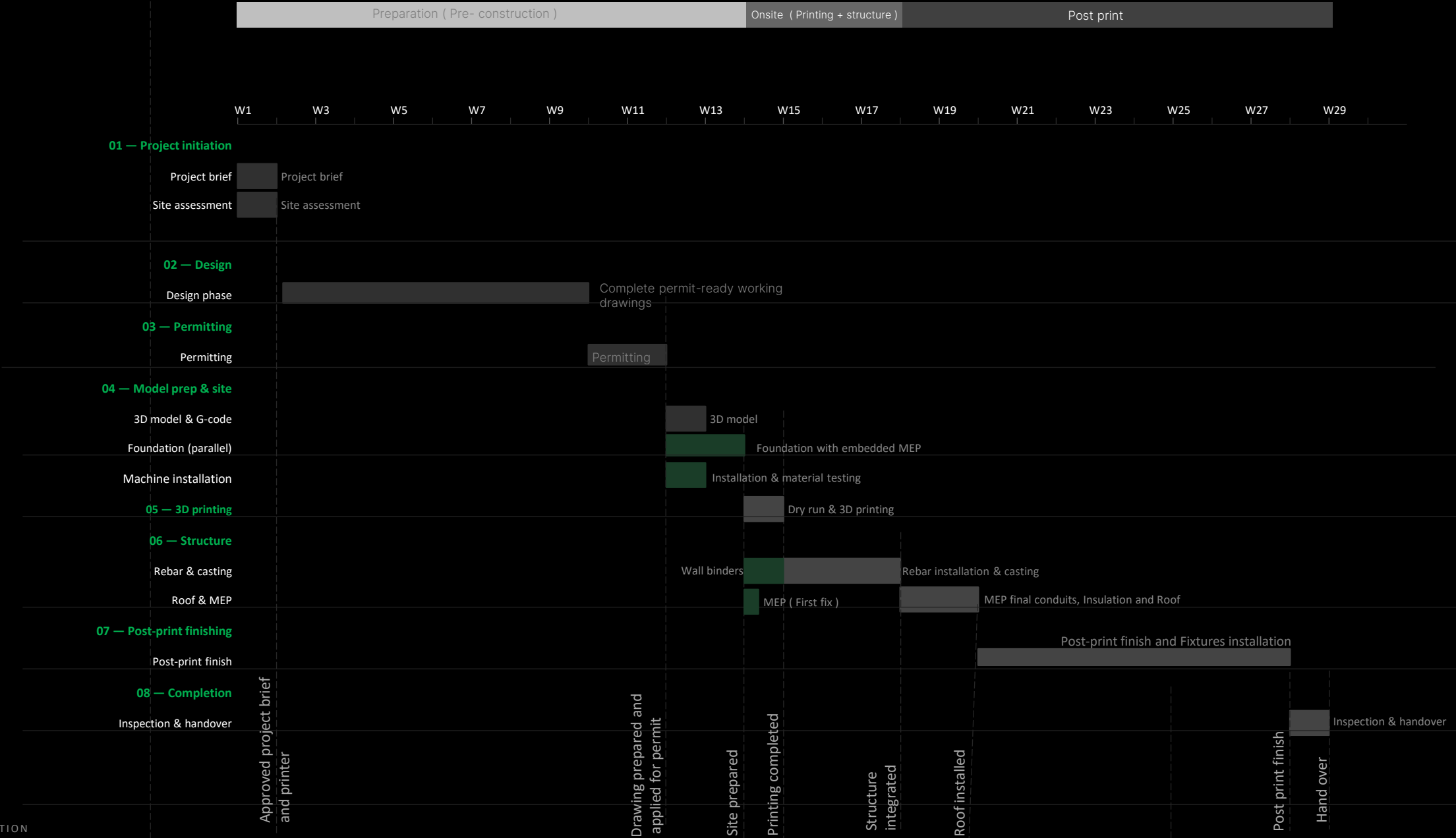
KEY ACTIVITIES

- As-built drawing preparation
- Site inspection & authority approval
- Key handover to client

OUTPUT

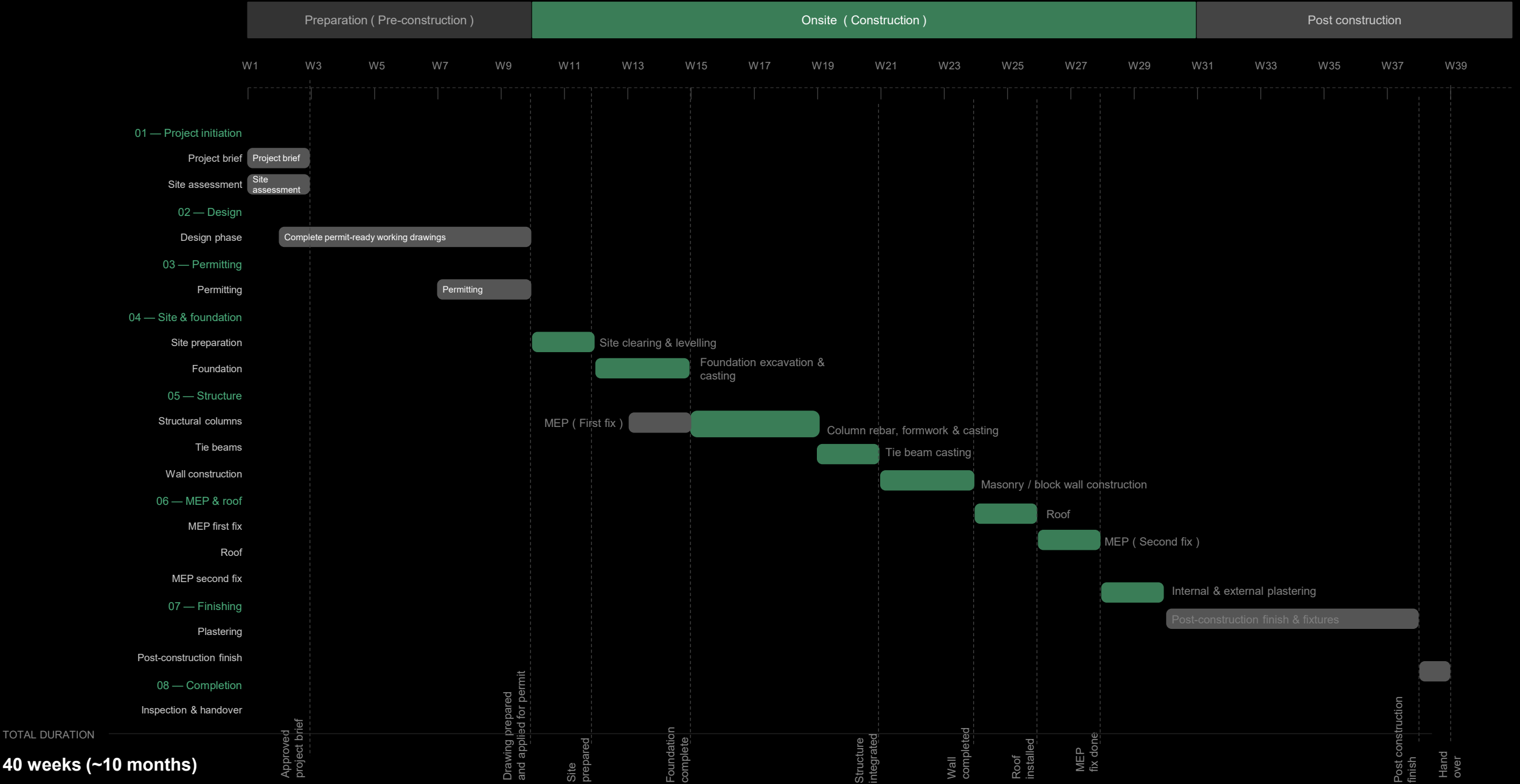
Signed-off building & key handover complete

END-TO-END TIMELINE — TYPICAL PROJECT (100 SQM HOUSE)



TOTAL DURATION
27 weeks (~6.75 months)

END-TO-END TIMELINE — CONVENTIONAL CONSTRUCTION (100 sqm HOUSE)



Time Efficiency: 3DCP vs Conventional

1. Speed

3D concrete printing outperforms conventional construction in two key areas. Conventionally, structural columns need formwork that must be fabricated, assembled, and struck after every pour, a labour intensive cycle repeated at each column. In 3DCP, the printed walls act as permanent formwork, and the open cavity left during printing takes rebar and cast concrete directly, eliminating separate formwork entirely. Speed follows the same pattern. Masonry crews work at human pace and need curing breaks between lifts to prevent settlement, while the printer runs continuously under automated control, completing the full wall structure in a fraction of the time with consistent quality.

2. Parallel Phase Execution

3D concrete printing enables multiple construction phases to run simultaneously. For example, MEP first-fix conduit embedding and column formwork preparation can be carried out in parallel with the printing process itself. In conventional construction, each phase must be fully completed before the next can begin — structural columns cannot start until the foundation is done, walls cannot start until the columns are cast, and so on. This sequential dependency significantly extends the overall project timeline.

3. Plastering is Optional

Conventional masonry walls require plastering on both internal and external surfaces to achieve a finished appearance and protect the wall — adding several weeks to the schedule along with additional material and labour costs. In 3DCP, the printed surface finish is significantly smoother and more consistent, making plastering optional rather than mandatory..



01. Project Initiation

PURPOSE

Determining project feasibility and readiness before committing to 3D concrete printing.

This phase determines whether 3D concrete printing is the right fit for the project. It is a decision-making stage that involves selecting the appropriate machine size and configuration if a printer is yet to be purchased or preparing the project brief and timeline if one is already available.

KEY ACTIVITIES

- Project brief — type, layout, budget
- Site assessment — topography, access, utilities
- Technology feasibility & printer selection

OUTPUT

Approved project brief and confirmed printer model & material system



1. Project Initiation			
1.1	Introduction to project		Project owner
	1.1.1	Project brief (Residential / Commercial / Warehouse / infrastructure / Institutional)	
	1.1.2	Project layout (Single unit / multi unit / low rise / mid rise / high rise)	
	1.1.3	Project budget	
1.2	Site assessment		Project owner
	1.2.1	Site details (Flat / Contour / Multi level) / Proposed area	
	1.2.2	Site accessibility	
	1.2.3	Site logistics (Minimum setback for operation / Boom loader)	
	1.2.4	Electrical and water supply	

** Stage 01 and 02 are before consulting COBOD team



1. Project Initiation

1.3	Technology feasibility		COBOD Team / Customer
	1.3.1	Technology acceptance in the country	Customer
	1.3.2	Local regulation (Helps to chose right machine size)	Customer
	1.3.3	Building analysis and machine recommendation for initial study	COBOD Team
1.4	Printer selection		
	1.4.1	Based on feasibility study (BOD2/BOD3/BOD XL/Infinity)	COBOD Team
	1.4.2	Configuration based on single / multiunit development.	COBOD Team
	1.4.2	Material - Mortar / Concrete (MDS) / Concrete (RMC)	COBOD Team / Customer

** Customer can initiate the purchase from this point



02. Design phase

PURPOSE

Produce construction-ready drawings optimized for 3D printing

3D concrete printing has geometric and dimensional constraints — not every wall shape or structural system in conventional construction translates directly to a printed build, and this phase translates the architectural vision into drawings specifically optimized for the printer's capabilities. Unlike traditional construction where complex forms demand expensive and time-consuming formwork, 3D printing makes unconventional geometry accessible — rounded corners, surface-integrated patterns, and organic wall profiles are no harder to print than a straight wall, opening design possibilities that would be prohibitive to build conventionally. For structures larger than the printer's working envelope, multiple print sections are required, and this must be carefully incorporated into the design — architectural elements, openings, and surface features must be planned around the connection points between sections to ensure seamless visual and structural continuity across the joins.

KEY ACTIVITIES

- Architectural design within machine boundary
- Structural design — wall system, loads, foundation
- MEP routing & working drawings

OUTPUT

Complete permit-ready working drawings



2. Design phase				
2.1	Architectural design			
	2.1.1	Training for the Customer architect / printing team (Online)		COBOD
		2.1.1.1	How to design for 3D printing (Wall design / Opening / MEP / Structural integration)	
		2.1.1.2	Introduction to the machine and material.	
		2.1.1.3	Introduction to COBOD Slice	
	2.1.2	Designing based on the machine configuration		Architect
		2.1.2.1	A building within the machine's printable boundary area.	
		2.1.2.2	Multiple installation of printer (Footprint larger than printer area)	
		2.1.2.3	Hybrid printing (Onsite printing + prefab 3D printing)	
		2.1.2.4	Prefab 3D printing (volumetric / Panel)	



2. Design phase

2.2	Structural design			
	2.2.1	Material testing and load calculation		
		2.2.2.1	Sourcing material components for concrete	COBOD + Customer
		2.2.2.2	Strength assessment	Customer
		2.2.2.3	Load calculation	Customer / PE
	2.2.2	Identifying wall system		
		2.2.2.1	Load bearing / Non load bearing	Customer / PE
		2.2.2.2	Wall type (Single wall / Double wall / Sandwich wall / Wavy wall)	Customer / PE
		2.2.2.3	Column and beam layout	Customer / PE
		2.2.2.4	Foundation drawing based on site assessment	Customer / PE



2. Design phase

2.3	MEP planning			
	2.3.1	Electrical		
		2.3.1.1	Double wall – Through cavities	Architect
		2.3.1.2	Single wall - Wall-drilled conduits	Architect
	2.3.2	Plumbing		
		2.3.2.1	Foundation	Architect
	2.3.3	Mechanical		
		2.3.3.1	Ceiling	Architect / consultant
2.4	Completion of working drawing for submission			Architect

** Submission drawings are ready for submission (Construction permit)

2. DESIGN PHASE

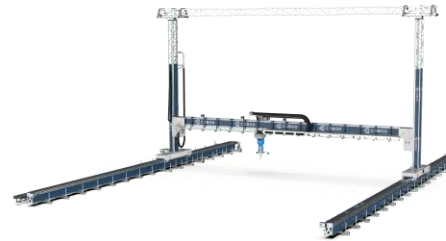
2.1 INTRODUCTION TO PRINTERS



BOD2

Best selling construction printer

A BOD2 printer is modular, allowing its size to be adjusted by adding or subtracting modules. Each module measures 2.5m. The printer operates on three main axes: X, Y, and Z. The X-axis caps at 5 modules, giving a printable width of 11.90 m. The Y-axis has no module limit, so length can extend indefinitely, but pairs of Z-axis supports must be placed at intervals along it to keep longer spans stable. The Z-axis caps at 4 modules for a printable height of 8.14 m, plus a further 1 m from the concrete foundation under each leg.



BOD3

Ideal for multi unit development

The X-axis is limited to 5 modules, enabling a printable width of 11.90m. Along the Y-axis, modules form a linear rail that supports a pair of Z-axes, allowing for unlimited printable length without requiring additional Z-axes. The Z-axis is limited to 4 modules, enabling a printable height of 8.20m



BOD XL

For high rise and large footprint

The BOD XL is a scaled version of the BOD2, with each module measuring 5 m instead of 2.5 m. Like the BOD2, it allows a maximum of 5 modules along the X-axis, giving a printable width of up to 24 m, unlimited modules along the Y-axis, and 4 modules along the Z-axis for a printable height of up to 18.30 m.

2. DESIGN PHASE

2.2 MATERIAL TYPES



MATERIAL DELIVERY SYSTEM

Best selling construction printer

D-fab concrete is designed to be mixed from locally sourced materials. It combines sand, aggregates, cement and water with a small proportion of additives, where the aggregates give high compressive strength of around 45 MPa and the additives make the mix 3D printable. Because the materials are sourced locally, it is the most reliable and affordable printable option available.



READY MIX CONCRETE

For high rise and large footprint

Ready-mix concrete is delivered to site by truck, already batched at the plant. The mix arrives with additives dosed on arrival or in-line at the pump to give it the printable characteristics, so no mixing plant is needed on site. It suits projects with good plant access and continuous printing, though it offers less control over the mix and leaves you dependent on delivery timing and the truck's working window.



READY MIX MORTAR

Ideal for multi unit development

Mortar is a ready-mix dry material combined with water in the right proportion to give a consistent printable mix. It is convenient, requiring little mixing, but costs 4–5 times more than COBOD D-fab concrete. Its small aggregates and high cement content make printed structures prone to heavy shrinkage and severe cracking.

2. DESIGN PHASE

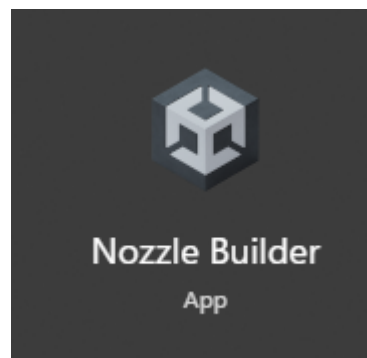
2.3 SUPPORTING SOFTWARES



COBOD SLICE

G-code generation

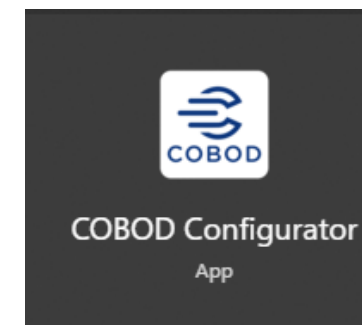
The slicer converts the 3D model into G-code. It slices the model into printable layers and generates the toolpath based on the print parameters, which the printer then reads and executes to build the structure.



NOZZLE BUILDER

Build nozzle sizes

A nozzle builder is a nozzle modelling software. It controls the dimensions of the nozzle, which in turn determine the layer dimensions. It offers different nozzle types, including round and rectangular, with or without a flap.



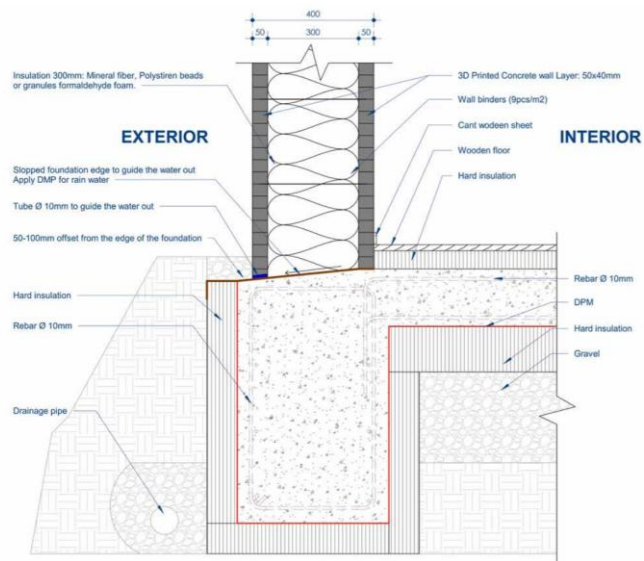
CONFIGURATOR

Simulate building

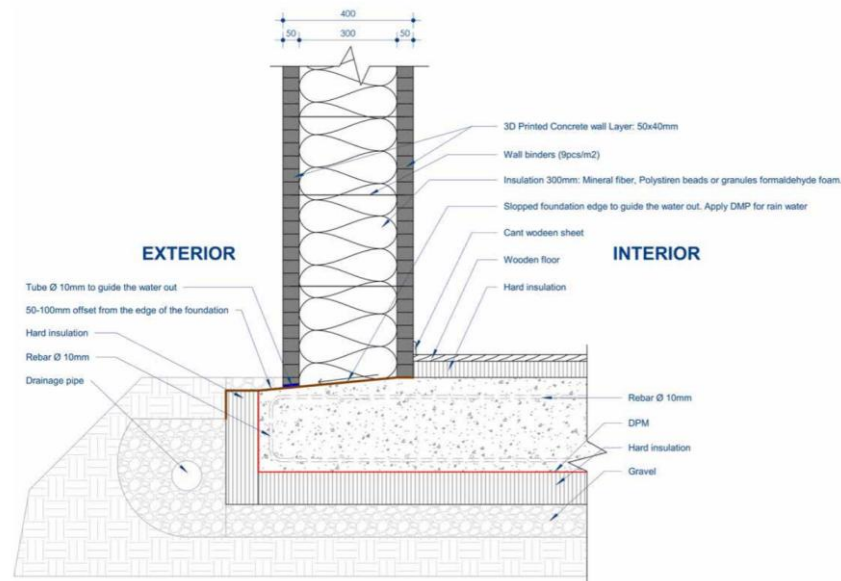
A configurator is a simulation software that displays the different printer models and lets you adjust the machine dimensions to understand the resulting printing bounding volume. It also allows 3D models to be imported and the print simulated at actual machine size.

2. DESIGN PHASE

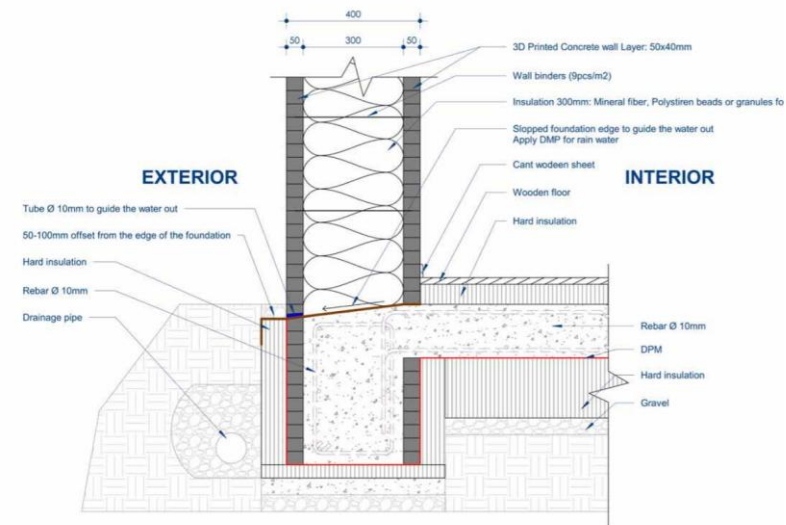
2.5 FOUNDATION



** detailed structural document is available on request.



** detailed structural document is available on request.



** detailed structural document is available on request.

PLINTH BEAM

Save material

A reinforced plinth beam runs under the printed wall, carrying the load into the ground along the wall line only. Since concrete is placed where it is needed, material use is low. The floor slab is built separately, with hard insulation and gravel laid within the plinth.

RAFT

For even load transfer

A continuous reinforced raft spreads the wall load evenly across the whole footprint, which suits weaker or variable soils. The slab, DPM, insulation and gravel layers are cast as one build-up, giving a level base and a single edge detail for the printed wall to sit on.

3D PRINTED SLAB

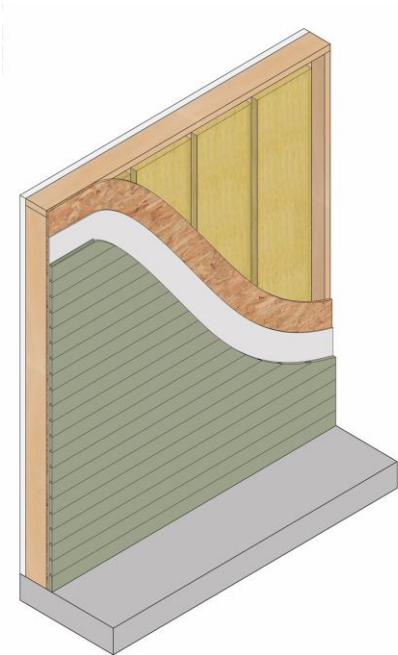
Fast and efficient

The foundation edge is printed as permanent formwork and filled with reinforced concrete, so the same printer forms both the base and the wall above. It removes conventional shuttering from the sequence, making the foundation fast and efficient to build with minimal formwork waste.

Foundation type is determined and constructed per local professional methods and recommendations. Selection depends mainly on soil conditions, structural load from building height and size, and building shape and size.

2. DESIGN PHASE

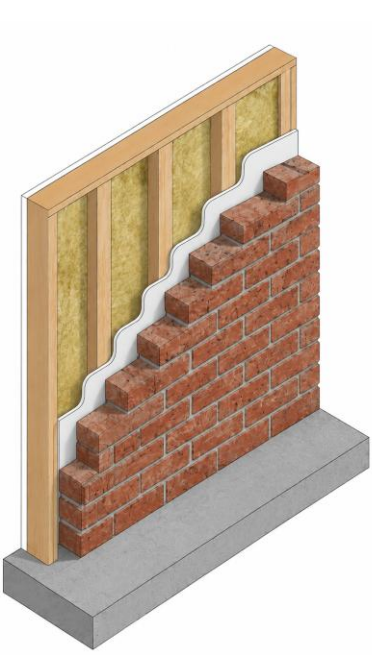
2.4 WALL TYPES



TIMBER FRAME

Light weight

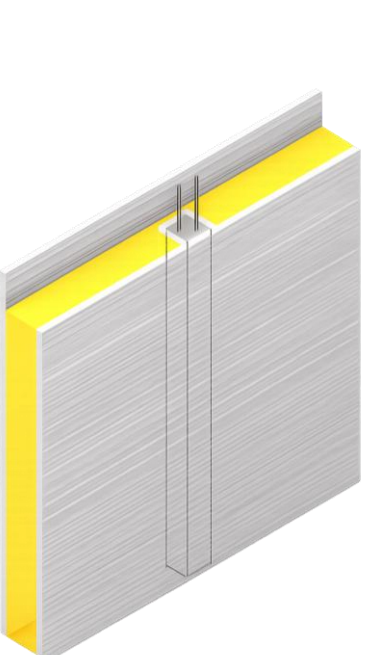
A load-bearing stud frame supports the wall, with insulation batts filling the cavities between studs. A breather membrane and rigid sheathing wrap the exterior, finished with horizontal timber cladding. The assembly is lightweight, quick to erect, and relies on multiple separate layers, each installed as its own trade operation.



BRICK WALL

Skilled labor

A timber stud frame with cavity insulation forms the inner leaf, separated by a membrane and ventilated cavity from an outer brick skin laid on the foundation. The brickwork provides weather protection and thermal mass, but requires skilled masonry, mortar curing time, and careful cavity detailing throughout.



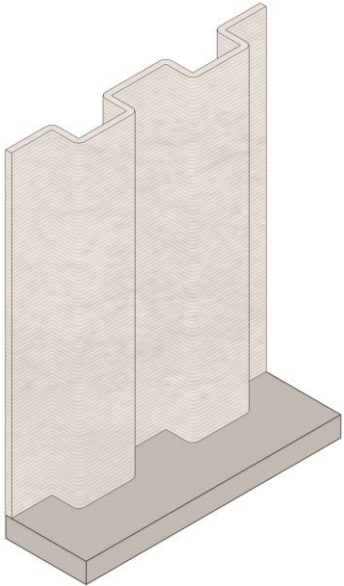
3D PRINTED

Fast and efficient

The wall is printed directly on the foundation as a continuous layered structure, with the printed shells acting as permanent formwork for insulation and cast concrete infill. Structural continuity carries straight through to the slab or beam above, removing separate framing, formwork, and cladding stages from the build sequence.

2. DESIGN PHASE

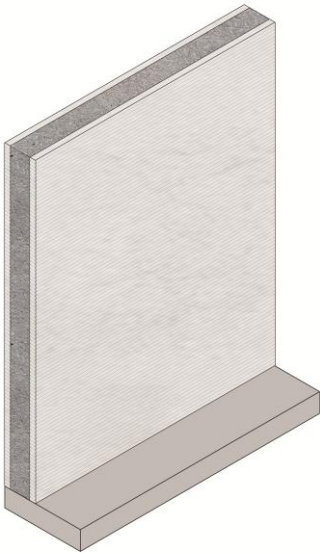
2.5 DIFFERENT TYPES OF 3DCP WALLS



SINGLE LAYER

internal

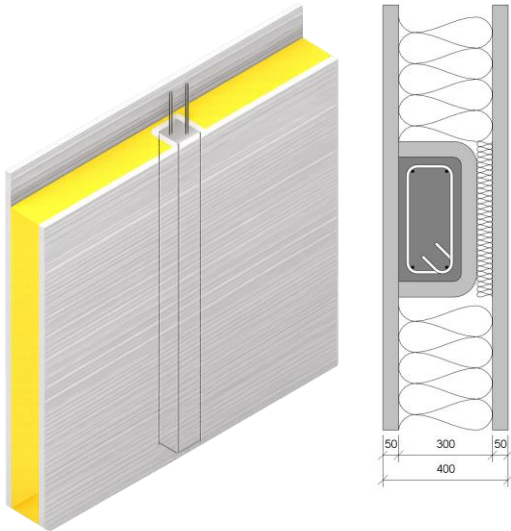
A single printed wall is printed in one sweep of the nozzle. The zigzag print path keeps the wall light and stable. Depending on the layer height and width, it can serve as an internal partition to a structural monolithic wall.



DOUBLE LAYER - POURED

Retaining wall

Two printed layers act as permanent formwork for concrete poured into the cavity between them. The poured core, with reinforcement, provides the structural capacity, while the printed faces give the finish. It replaces skilled masonry work and delivers a solid, load-bearing wall in a single operation.



DOUBLE LAYER - FRAME INTEGRATED

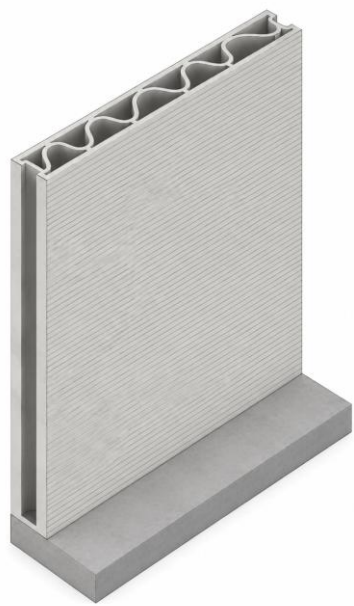
Widely used

Two printed layers with insulation in the cavity, tied into a structural frame of columns and beams. The frame carries the load, so the printed walls are non load-bearing and serve as envelope and finish. This lets the printer work alongside conventional structural systems, suiting multi-storey and higher-load buildings.

Each wall type has trade-offs; the right choice depends on design and local requirements. Key 3D printing considerations: load-bearing capacity, wall thickness, insulation, thermal bridging, layer height and width.

2. DESIGN PHASE

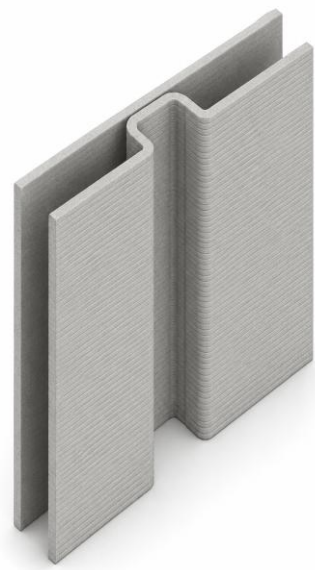
2.5 DIFFERENT TYPES OF 3DCP WALLS



DOUBLE WALL - INFILL

Structural without rebar

Two printed layers joined by a continuous wavy layer, printed in one pass. The internal cells are filled with insulation or lightweight infill, giving a finished wall with good thermal performance. The infill ties the face layers together and acts as a structural member.



DOUBLE WALL – OPEN FACE

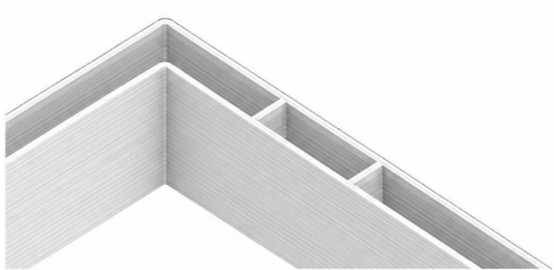
Efficient rebar installation

Two printed layers with one face left open for column integration. The open cavity stays accessible for placing reinforcement after printing and can be poured later. It gives the most flexibility on site for reinforcement installation and overlapping.

Each wall type has trade-offs; the right choice depends on design and local requirements. Key 3D printing considerations: load-bearing capacity, wall thickness, insulation, thermal bridging, layer height and width.

2. DESIGN PHASE

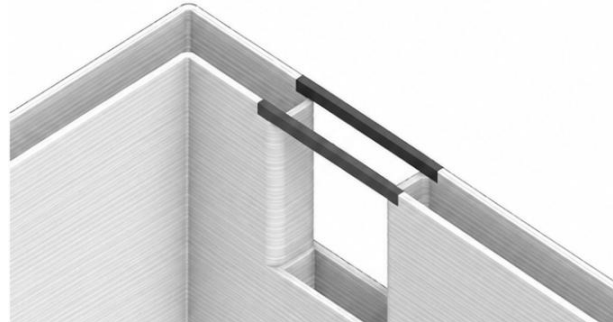
2.6 OPENINGS



SILL

Bridges to support

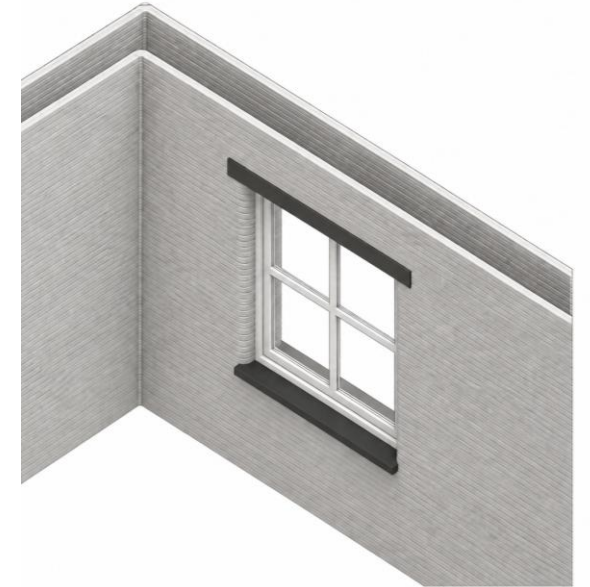
Printing runs continuously up to sill level, where the window opening begins. Internal cross bridges are printed along the way to support the layers above once the opening is printed with a turnaround. Instead of printed bridges, steel plates can also be used.



PLACEMENT OF LINTEL

Support wall above the span

Once the opening is complete, lintels are placed manually across the span, bearing on the wall either side. They carry the load over the opening and give the following layers a continuous surface to print on. The lintel can be steel, cast in situ, or prefabricated.



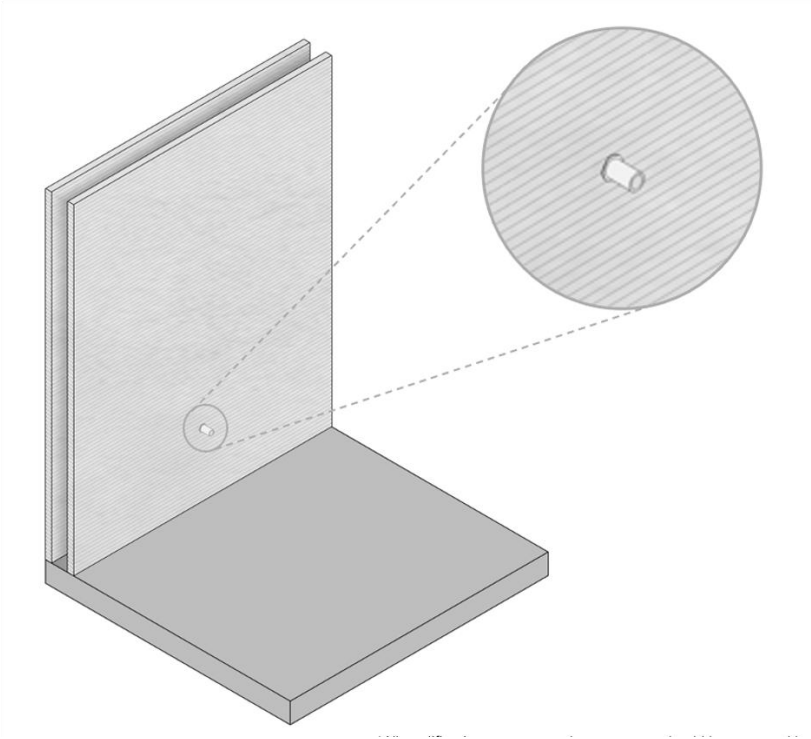
WALL ABOVE LINTEL

Complete the opening

Printing resumes directly over the lintel and the wall continues upward as a normal closed path. The opening is now fully formed, with the lintel transferring the load above it into the wall on both sides.

2. DESIGN PHASE

2.7 MEP SOCKETS



CORE DRILLED

No provision while printing needed

1.CORE DRILLED OPENING OPTION



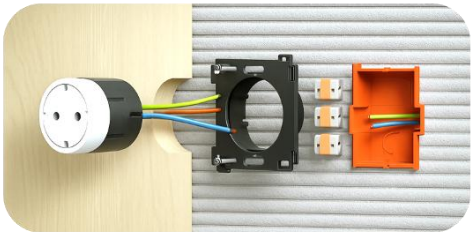
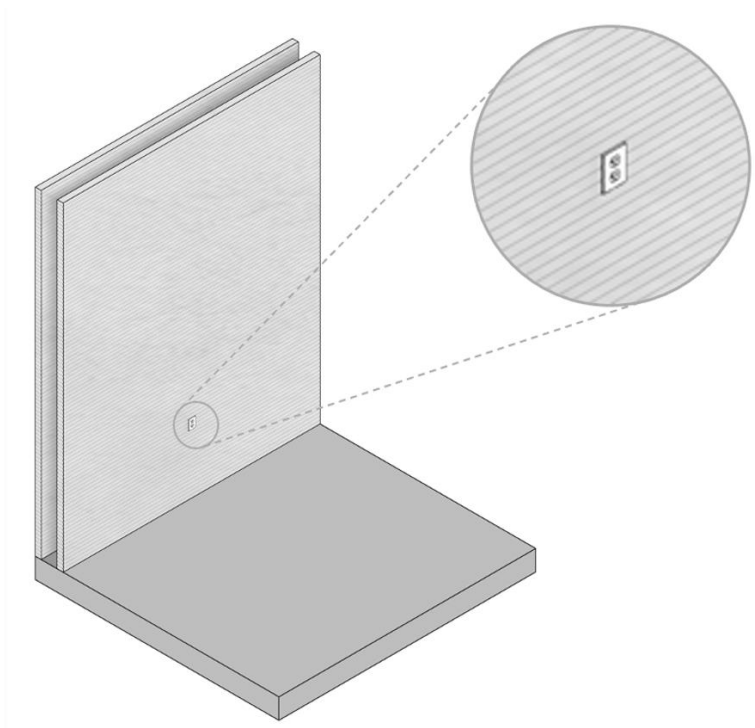
2. FRESH CUT OPENING – UNCOVERED VS COVERED



Holes for electrical sockets are core drilled after printing, so no provision is needed in the print path itself.

2. DESIGN PHASE

2.7 MEP SOCKETS



2.FRESH CUT OPENING – NO FINISH



3. FRESH CUT OPENING – TROWELED



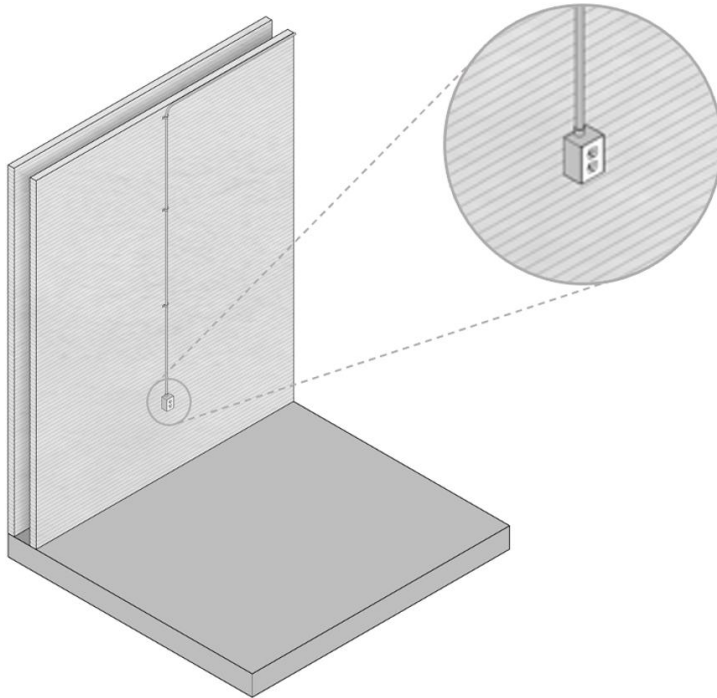
SOCKET PLACEMENT

During print

Socket boxes are placed during printing itself, embedded as the layers are laid, so no after work is needed once the wall is printed.

2. DESIGN PHASE

2.7 MEP SOCKETS



EXPOSED OUTLET WIRING



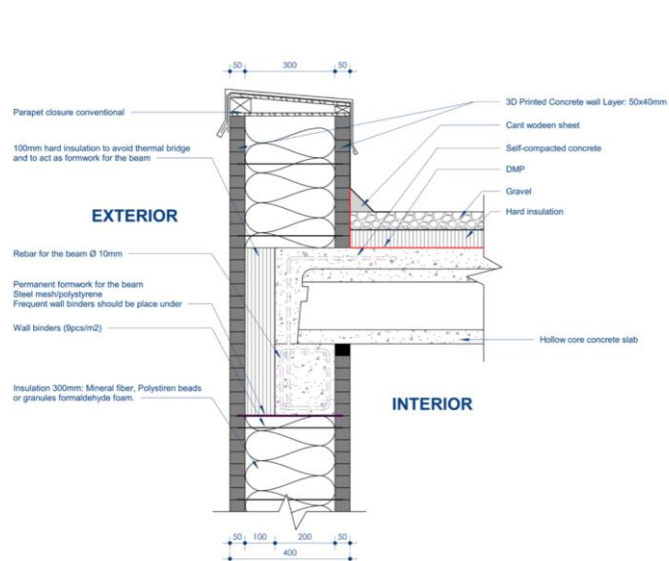
EXPOSED SOCKETS

Aesthetics not priority

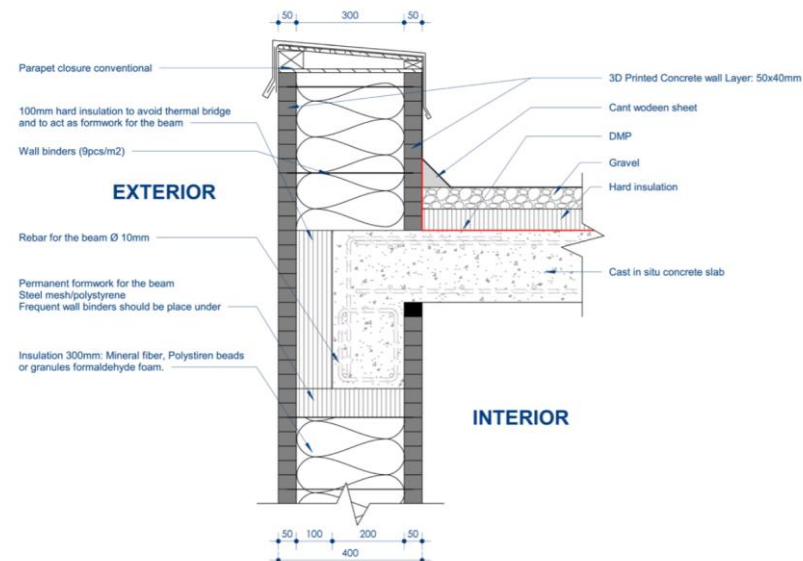
Outlets and conduits are surface mounted after the whole print is completed. This option is considered where aesthetics is not a priority, since the services remain visible on the wall face.

2. DESIGN PHASE

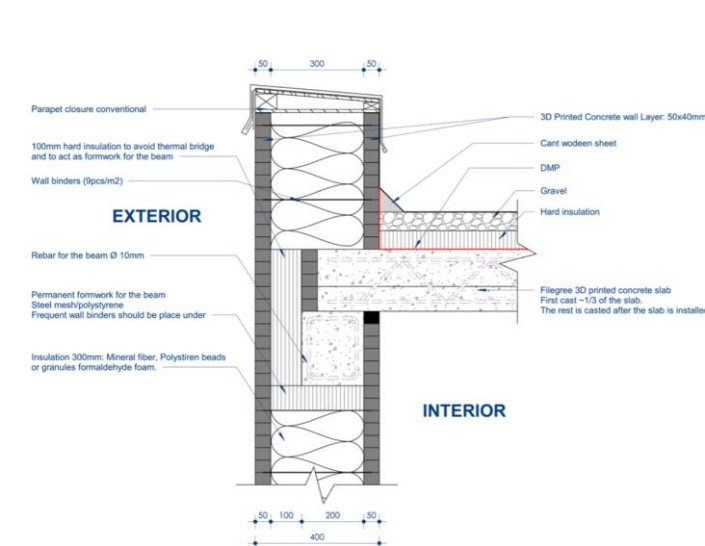
2.8 FLOOR SLAB/ ROOF SLAB



** detailed structural document is available on request.



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HOLLOW CORE

Light weight

Precast hollow core units bear on a ring beam formed inside the printed wall, with permanent formwork of steel mesh or polystyrene and wall binders placed beneath. A self-compacting concrete topping ties the units together. Erection is fast and spans are long, but craneage is needed on site.

CAST IN SITU

Regular shaped

The slab is cast in place and made continuous with the ring beam inside the wall, giving a fully monolithic connection between floor and printed wall. It handles irregular plans and openings easily, at the cost of temporary propping, shuttering and on-site curing time.

3D PRINTED

Fast and efficient

A filigree 3D printed slab is used as permanent formwork. Roughly one third is cast in the factory, with the remainder cast once the panels are installed and tied into the ring beam. It removes shuttering, cuts weight for handling, and keeps floor and wall in the same printed system.

precast suits regular plans with crane access, filigree suits complex plans, cast-in-situ suits small/regular shaped sites, and hollow core suits light roofs.



03. Permitting

PURPOSE

Obtain legal approval to proceed with construction

For load-bearing 3DCP walls, regulatory approval requires three layers of technical proof: a Material Test Report from an accredited lab confirming compressive strength, inter-layer bond strength, and durability across both print orientations; wall tie inside the printed layers documented as structural elements providing composite action, shear transfer, and buckling restraint.

For non-load-bearing 3DCP walls, the structural compliance burden falls entirely on the conventional frame design and material test report — the printed wall serves only as an outer shell, with all loads acting through the frame, and is treated no differently from any standard infill or cladding element. Foundation connection detailing proven adequate for both gravity and seismic overturning demands.

KEY ACTIVITIES

- Review local building codes & structural requirements
- Prepare material assessment report
- Submit construction permit application

OUTPUT

Approved construction permit



3. Permitting

3.1	Understanding local regulation. (Siemic / typhoon / tropical / winter)		
	3.1.1	Understanding the structural type and structural drawing prepared	PE
	3.1.2	Preparing drawing based on the building system and wall types	Architect
	3.1.3	Material assessment report	PE
	3.1.4	Construction permit submission	Architect + PE



04. Model and site preparation

PURPOSE

Prepare 3D model and site for printing with printer installed onsite.

A 3D concrete printer works from a 3D model rather than conventional 2D drawings, and that model must be prepared with maximum detail including openings, MEP sockets, column formworks, and all embedded elements defined before a single line of print path is generated. From this model, the toolpath is derived, dictating every movement of the printer head for efficient, uninterrupted printing.

In parallel, site preparation can proceed simultaneously with foundation work completed to drawing, MEP inlets cast into the foundation at precise locations to align with the cavities of the printed walls and the printer installed, calibrated, and troubleshot, so that when the model and toolpath are finalised, the site is ready to print without delay.

KEY ACTIVITIES

- 3D CAD modelling
- Foundation excavation & casting
- MEP integration & site levelling for printer installation

OUTPUT

Foundation and site complete with printer installed



4. CAD modelling and site preparation

4.1	CAD Modelling			
	4.1.1	3D modelling the geometry (3D printing works in 3D model not 2D)		Architect
	4.1.2	Slicing the model for statistics and layer time		Architect / Site Engineer
		4.1.2.1	Material and time estimate	
		4.1.2.2	Simulation of print before actual onsite print	
		4.1.2.3	G-code for printing.	
4.2	Ground excavation for foundation			
	4.2.1	Based on the soil type, foundation type is chosen		
		4.2.1.1	Raft foundation	

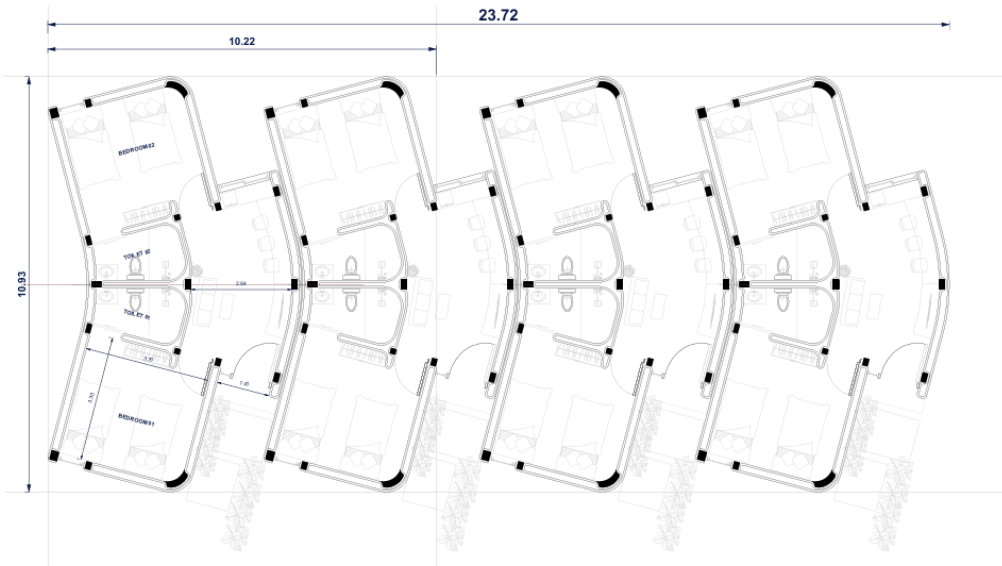


4. Site preparation and foundation

		4.2.1.2	Plinth beam	General contractor
		4.2.1.3	Foundation outline 3D printed and cast out later	PE
4.2	Casting foundation			General contractor
	4.2.1	For a non-load-bearing system, starter bars stick out from the foundation at every column position.		
4.3	MEP integration			General contractor
4.4	Site levelling for printer installation			General contractor
	4.4.1	BOD2 - Site compaction at every concrete foot position		
	4.4.2	BOD3 - Site compaction along the rail placement		

4. MODEL AND SITE PREPARATION

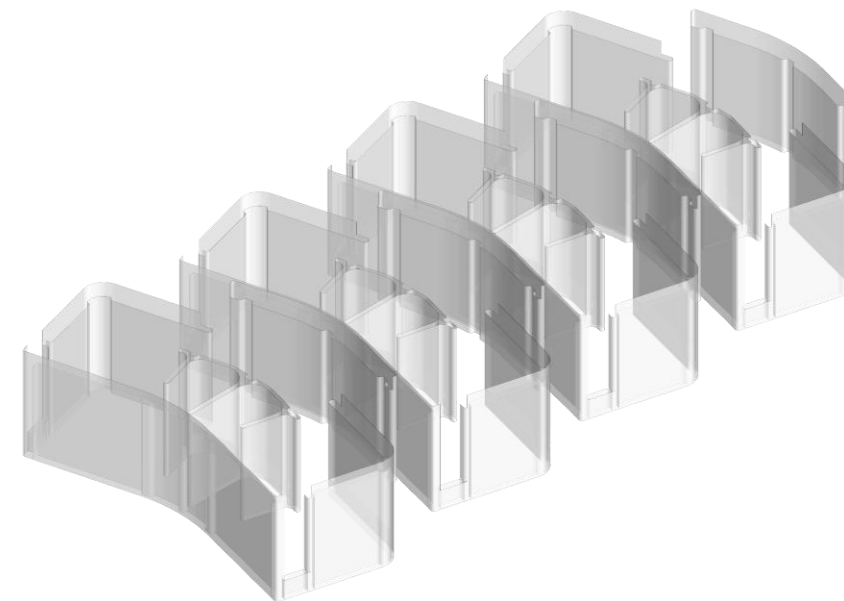
4.1 CAD MODELLING



COMPLETE FLOOR PLAN

Eco village- Indonesia

The floor plan is drawn by using the free-form capability of 3D printing, allowing curved and wavy walls. The layout is set within the printer's build envelope, with a clearance gap between wall sections to allow for relocation of the machine. Where these relocation points are anticipated in the design, the joints fall at deliberate positions and the result reads as intentional. Where they are not, the division lands mid-wall or in unplanned locations, and the break becomes visible in the finished building.



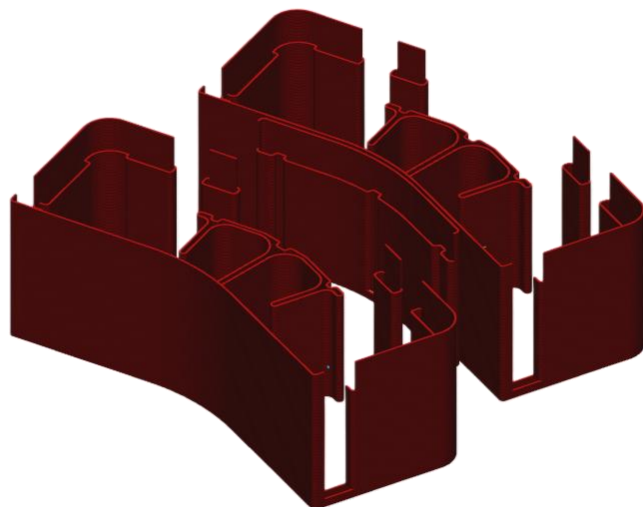
3D MODEL

Eco village- Indonesia

Based on the floor plan, a 3D model is prepared in any CAD software. This model is an exact replica of the final printed building and forms the direct input for slicing, so wall widths, cavities, and openings must be modelled as they are to be printed.

4. MODEL AND SITE PREPARATION

4.1 CAD MODELLING

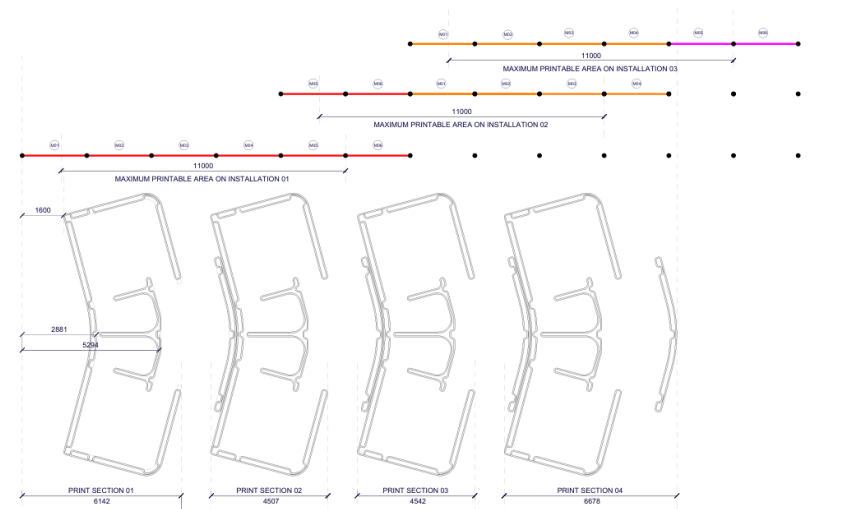


Summary
Total duration 1d 13h 41min 44s
Concrete volume 21,010.05 L
Distance & Time
Total travel 16,070.48 m
Print distance 10,505.02 m (1d 6h 21m 56s)
Rapid distance 5,565.46 m (7h 19m 48s)
Layer Information
Layer count 90
Z range 40 mm → 3,600 mm
Layer time (avg) 25m 7s
Layer time (min/max) 9m 31s / 29m 42s
Vertical buildup rate 0.1 m/h

SLICER SIMULATION AND GCODE

Eco village- Indonesia

The 3D model is sliced and the G-code is generated for the first installation. The statistics produced by the slicer give material quantities and estimated print duration, supporting planning of deliveries and team.



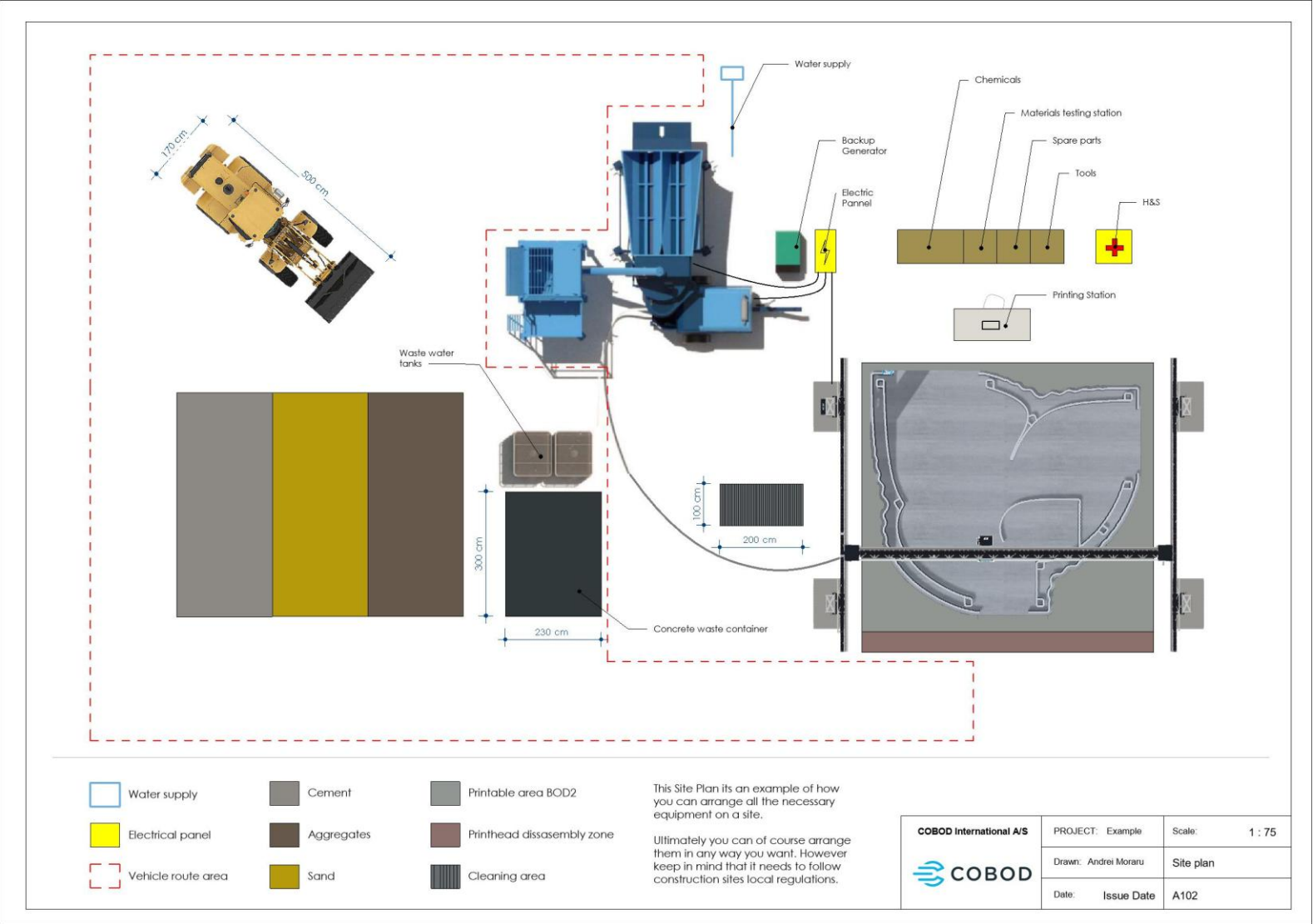
ONSITE INSTALLATION LAYOUT

Eco village- Indonesia

An installation layout is drawn so that rail movement is anticipated for each remaining section of the building. A precise layout ensures efficient machine positioning and allows the whole building to be completed with the minimum number of printer relocations.

4. MODEL AND SITE PREPARATION

4.2 INSTALLATION AND FOUNDATION



4. SITE PREPARATION

4.3 FOUNDATION AND EMBEDDED MEP



RAFT FOUNDATION

Emergent - USA

A raft is a single reinforced slab covering the whole building footprint, spreading wall loads evenly over weaker soil. It suits 3D printing by providing a flat, continuous, level datum for the first layer. Services and starter bars are cast in beforehand; surface flatness is critical, as deviations propagate upward.



PLINTH BEAM FOUNDATION

Eco village- Indonesia

A plinth beam is a reinforced concrete beam cast at ground level, tying isolated footings together and carrying the wall loads above. It resists differential settlement and blocks ground moisture from rising into printed walls.



PLINTH BEAM FOUNDATION

O-House _ Japan

The building rests on a strip foundation: a 300 mm embedded footing with a 200 mm reinforced concrete stem, 500 mm deep overall, carrying all vertical wall and structural loads and providing the required flexural and punching resistance. Beneath it, 49 columnar ground improvement elements (φ500 mm × 3.0 m) stiffen the weak soil and limit long-term settlement, rather than acting as load-bearing piles. COBOD International |35

4. SITE PREPARATION

4.2 FOUNDATION AND EMBEDDED MEP



RAFT FOUNDATION

Sunway_ Malaysia

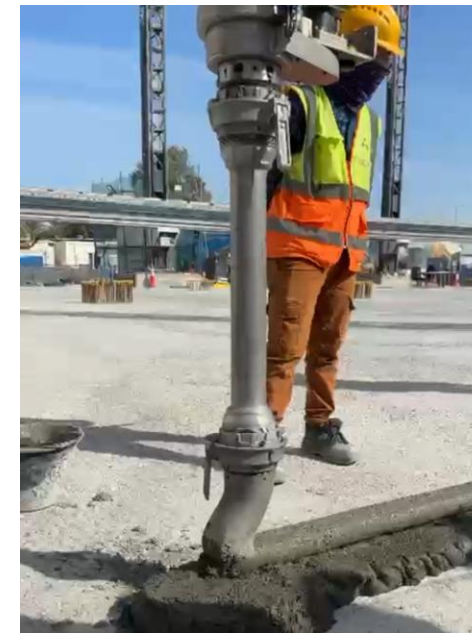
A raft is a single reinforced slab covering the whole building footprint, spreading wall loads evenly over weaker soil. It suits 3D printing by providing a flat, continuous, level datum for the first layer. Services and starter bars are cast in beforehand; surface flatness is critical, as deviations propagate upward.



STARTER BARS

Argos_ Columbia

Starter bars are vertical rebar dowels cast into the foundation and left protruding into the printed wall cavity. They provide structural continuity between foundation and wall, anchoring the printed structure against uplift and lateral loads, and are later tied into vertical columns.



EXTENSION NOZZLE

UCC_ Doha

Protruding starter bars obstruct the standard printhead. An extension nozzle increases the nozzle length so the printhead clears the exposed rebar while printing continues uninterrupted.



05. 3D printing

PURPOSE

Print the primary wall structure and integrate structural reinforcement

The COBOD slicer converts the 3D model into G-code which runs on the machine for a dry run first, printing without extruding material to verify that the toolpath is correctly positioned over the foundation and that no obstacles interfere with printer movement.

Once confirmed, material is pumped to the hopper and printing begins, with duration depending on the size of the structure. As printing progresses, wall ties must be placed between layers at every 9 to 12 square metres on double walls to hold the two shells together, lintels must be installed as the printer reaches opening heights, and electrical conduits must be fixed inside the wall cavities once reach the height.

Once printing is complete for the floor, reinforcement cages are installed and tied to the starter bars before columns are cast, and once cured, beams are completed if a traditional column and beam system is chosen, or alternatively precast frames are installed. Unlike conventional construction where the frame comes first, in 3D printing the walls are printed first and the frame is cast after, reversing the traditional sequence.

KEY ACTIVITIES

- G-code & dry run before printing
- Wall printing with bonding agent & wall binders
- First round of electrical conduits
- Rebar cage insertion & column/beam casting

OUTPUT

Completed printed walls with structural columns & beams cast



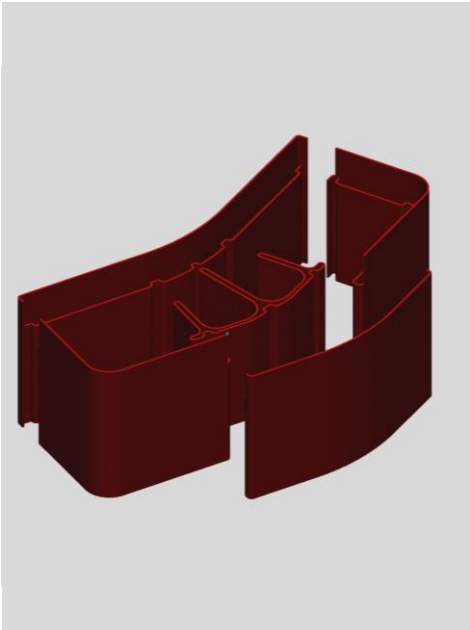
5. 3D Printing

5.1	Exporting G-code from the slicer		Machine operator / Site Engineer
	5.1.1	A G- code is exported from slicer with slice parameters assigned.	
5.2	Dry run		Machine operator
	5.2.1	Check toolpath before material extruding through nozzle	
	5.2.2	If any object exists, reconfigure toolpath.	
5.3	Printing walls		Machine operator
	5.3.1	Applying bonding agent	Site Engineer
	5.3.2	Wall binders at every 9 m2 wall area	Site Engineer

5. 3D Printing				
	5.3.3	Cavity for the column printed along with walls		
		5.3.3.1	Completely concealed to cavity	
		5.3.3.2	One side open for easy overlapping with cage	
		5.3.3.3	2 side open column	
5.4	Opening details			
	5.4.1	Integration of different type of lintel and printing on top (Cast in situ / steel plate / Precast RC)		
	5.4.2	No lintel. This area will covered with Cement board / ACP		
5.5	Rebar integration			
	5.5.1	A rebar cage is inserted into the column cavity, overlapping with the starter bars.		
5.6	Casting column and beams			

5. 3D PRINTING

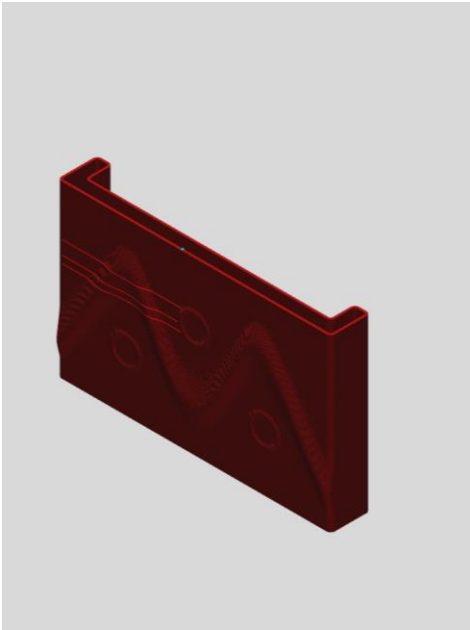
5.1 G- CODE GENERATION



ROW HOUSE
Eco village- Indonesia

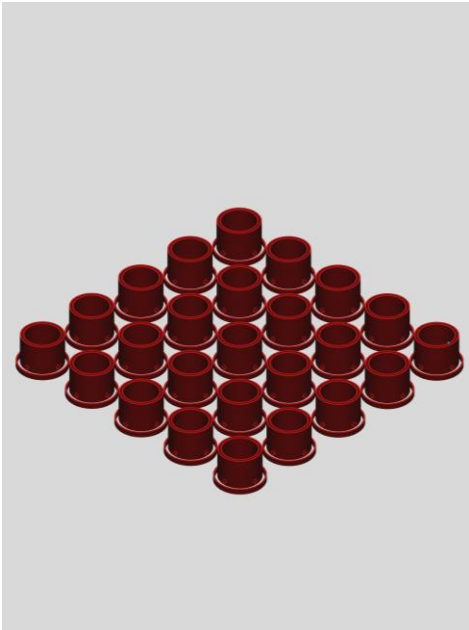
G-code is generated in COBOD Slice from the prepared model and the assigned print parameters. These parameters, including layer height and layer width, are set to ensure efficient and reliable printing. Shown here is the slicer simulation for a single-floor, 48 sqm house in Indonesia.

Output: print-ready G-code



DECORATIVE FREE-STANDING WALL
Nuqul_ Jordhan

This is the slicer output for a free-standing decorative wall with added patterns.



PREFAB 3DCP – 30 UNIT MANHOLE
Concept

This slicer outcome is for printing multiple prefab sections. With the slicer, the minimum and maximum layer time is ensured for proper layer-to-layer bonding.

5. 3D PRINTING

5.3 BONDING AGENT& DRY RUN



BONDING AGENT

Disaster Relief Housing - Malaysia

A bonding agent is an additive material applied onto the concrete base/foundation before printing begins. This ensures proper bonding between the freshly printed concrete and the foundation cast days prior.



DRY RUN

Emergent - USA

A dry run is a full execution of the print toolpath without extruding concrete. The nozzle traces the programmed G-code so the team can verify set-out position, wall alignment against the foundation, clearances around starter bars and formwork, and detect collisions or reach limits before any concrete is placed.



5. 3D PRINTING

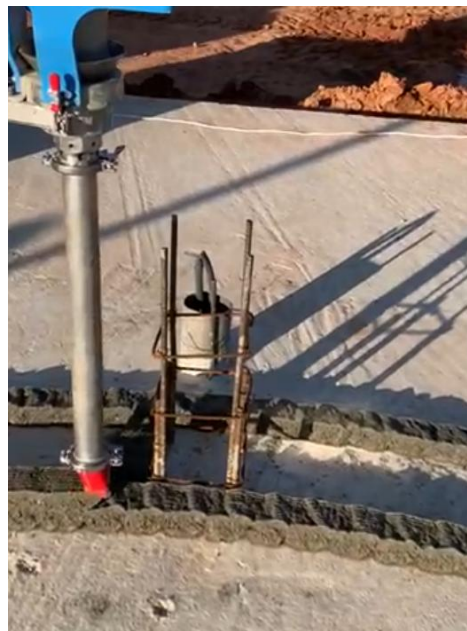
5.3 STARTER BARS AND TIE BEAMS



STARTER BAR

Argos_ Columbia

Starter bars are vertical rebar dowels cast into the foundation and left protruding into the printed wall cavity. They provide structural continuity between foundation and wall, anchoring the printed structure against uplift and lateral loads, and are later tied into vertical columns.



STARTER BAR

14 Tree - Africa

Protruding starter bars obstruct the standard printhead. An extension nozzle increases the nozzle length so the printhead clears the exposed rebar while printing continues uninterrupted.



TIE BEAM

Neom_ Saudi

Tie beams are reinforced concrete beams that connect the foundation to the columns and printed walls, locking them into a single rigid frame. They restrain differential settlement and lateral movement, transfer horizontal forces between footings, and provide a level, continuous base from which the printed walls rise.

5. 3D PRINTING

5.4 WALL TYPES



SINGLE WALL

Sunway_ Malaysia

Both external and internal walls are printed as a single 100 mm layer. The walls act as load-bearing elements, with no reinforced columns provided. Reinforcement bars are placed at every corner and wall intersection to ensure structural continuity and a sound connection between printed sections.



SINGLE WALL 150 MM

Water tank _ Abayan

A single wall is printed in one continuous pass, with widths ranging from 100 mm to 450 mm depending on the nozzle used. It suits partitions and non-cavity elements, where the full thickness is achieved directly without an internal infill pattern



100 MM DOUBLE EXTERIOR AND 100MM SINGLE INTERIOR

HTL_ Ireland

This wall type follows the Eurocode masonry approach (Eurocode 6, EN 1996), treating the printed section like conventional brickwork: each printed layer corresponds to a brick course in both width and height. External walls are printed as a double layer, internal walls as a single layer.

Each wall type has trade-offs; the right choice depends on design and local requirements. Key 3D printing considerations: load-bearing capacity, wall thickness, insulation, thermal bridging, layer height and width.

5. 3D PRINTING

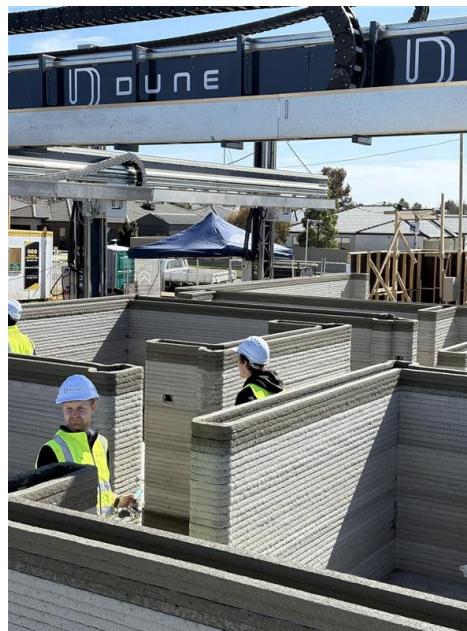
5.4 WALL TYPES



DOUBLE WALL

Emergent - USA

A cavity double wall is printed as two single layers separated by an open void, with no internal infill. The cavity is later filled with reinforcement and grout, insulation, or used to route services, allowing the wall's performance to be adjusted if needed.



DOUBLE WALL

Dune- Australia

A cavity double wall is printed as two single layers separated by an open void, with no internal infill. The cavity is later filled with reinforcement and grout, insulation, or used to route services, allowing the wall's performance to be adjusted if needed.



DOUBLE WALL - NO CAVITY

L&T _ India

A double wall with no cavity is printed as two adjacent layers deposited directly against each other, forming a solid section in a single pass. It gives greater thickness and stiffness than a single wall without the need for later filling.

5. 3D PRINTING

5.4 WALL TYPES



TRIPLE WALL

PERL_ Germany

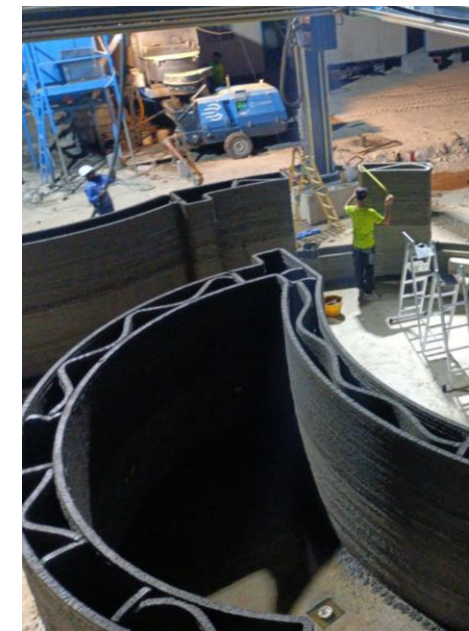
The external wall is printed as three layers forming two cavities: the outer cavity holds insulation, the inner cavity takes reinforcement and grout. This separates thermal and structural functions in one printed section. Internal walls are printed as a double layer with a single cavity.



450MM SINGLE WALL

GE_Wind tower base

A single-layer wall printed at 450 mm width, the widest single-layer section COBOD has printed to date. It was used as the base structure for a wind turbine tower.



DOUBLE WALL WITH INFILL

GU Tech - Oman

A double wall linked by an internal infill pattern in the cavity space, typically a zigzag or wave geometry. The infill braces the shells against buckling and shear, while the resulting cavities accommodate reinforcement, grout, insulation, or services.

5. 3D PRINTING

5.4 WALL BINDERS



C- TYPE

Argos_ Columbia

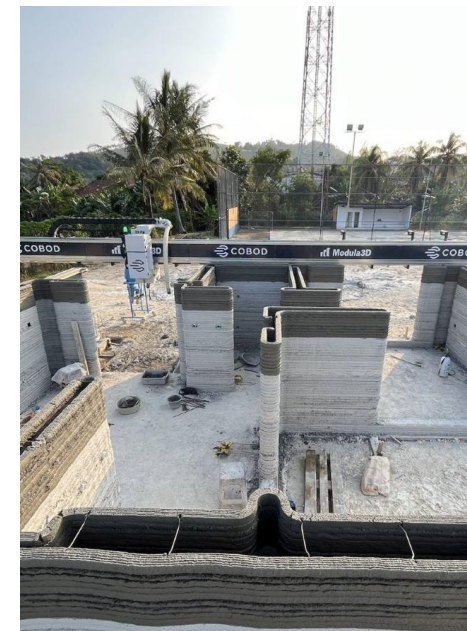
A C-type wall binder is a C-shaped reinforcement bar, minimum 4 mm diameter, placed at regular intervals to connect the external and internal layers of a double wall. It ties the two layers together, allowing them to act as a single structural unit.



EMBEDDED REINFORCEMENT CAGE

Argos_ Columbia

A prefabricated reinforcement cage is lowered into the cavity of the printed double wall. Longitudinal bars are linked by web members, tying the external and internal layers into a single composite section before grouting.



LINEAR TYPE

MTD_ Indonesia

Ties are transverse bars placed across the cavity, linking the external and internal printed layers. They resist the bursting pressure of the grout pour and transfer shear, so the wall acts as one composite section. A minimum of nine ties per square metre of wall area is provided.

5. 3D PRINTING

5.4 WALL BINDERS



LINEAR TYPE

14 Tree

Ties are transverse bars placed across the cavity, linking the external and internal printed layers. They resist the bursting pressure of the grout pour and transfer shear, so the wall acts as one composite section. A minimum of nine ties per square metre of wall area is provided.



5. 3D PRINTING

5.5 COLUMN INTEGRATION – FORM WORK PRINTING



OPEN COLUMN

Auditorium for Indocement- Indonesia

In this wall system, an open cavity is created while printing the inner layer, with one side left open. The size of the cavity corresponds to the size of the structural column. Once the full floor height is printed, the open side of the cavity allows for the overlapping of the starter bar with the rebar cage, and formwork is then placed to pour the concrete column.



FULLY CONCEALED COLUMN AND INFILL PATTERN

O- House - Japan

The wall is printed as two curved layers joined by a continuous wave infill, which braces the layers and forms closed cells along the wall. At structural positions, selected cells are enlarged into rectangular pockets that act as columns, reinforced and filled with concrete. The column is formed by the print itself, requiring no separate formwork.



FULLY CONCEALED COLUMN

Student housing - Denmark

The column is contained entirely within the printed wall thickness, leaving flushed wall on either face. Reinforcement bars are lowered into the cavity from above and tied manually through a service pocket formed below the column opening, or connected below the column opening, or connected using couplers. The cavity is then grouted, so the column reads as part of the wall.

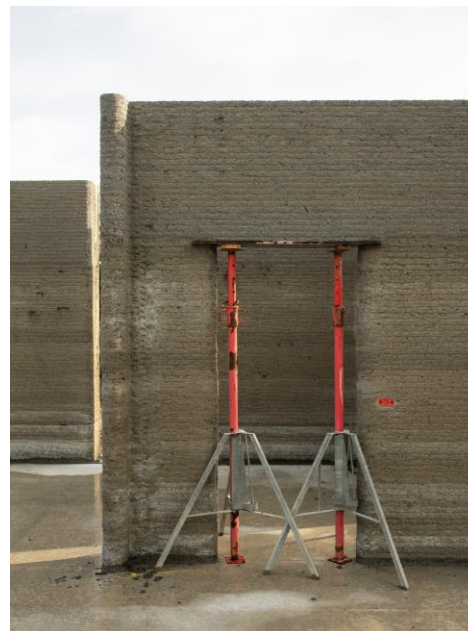
5. 3D PRINTING

5.6 OPENINGS



CAST IN SITU LINTEL

Eco village - Indonesia



CAST IN SITU LINTEL

Student housing - Denmark



CAST IN SITU LINTEL

Café_ Oman

Where an opening is too wide to be bridged by the print alone, the lintel is cast in place. Timber props and formwork are erected across the opening, reinforcement is placed, and concrete is poured to span between the printed walls. Once the lintel has gained strength, the props are struck and printing continues above.

5. 3D PRINTING

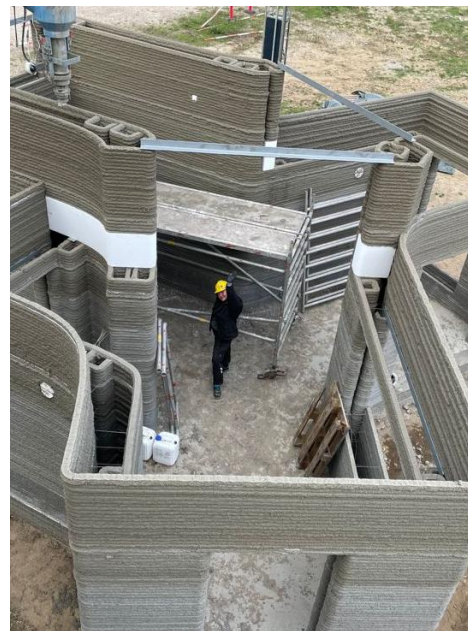
5.6 OPENINGS_ LINTELS



NO LINTEL – FULL HEIGHT WINDOWS

Hydrogen demonstration center - Oman

Openings are taken to the full height of the wall, so no printed section remains above them and no lintel is required. The window frame spans directly between the printed wall ends, removing the need for formwork, props, or prefabricated lintel elements.



STEEL LINTEL

Student housing - Denmark

A steel plate is placed across the opening as a prefabricated lintel, matched to the width of the printed layer. It spans between the printed walls and carries the layers above, allowing printing to continue directly over the opening without formwork, props, or a curing period.



NO LINTEL- ACP PANEL

Auditorium for Indocement- Indonesia

No lintel is used at the opening. Aluminium composite panels are fitted once printing is complete, closing and lining the head of the opening. The panels arrive pre-finished, so no plastering, rendering, or additional surface treatment is required afterwards.

5. 3D PRINTING

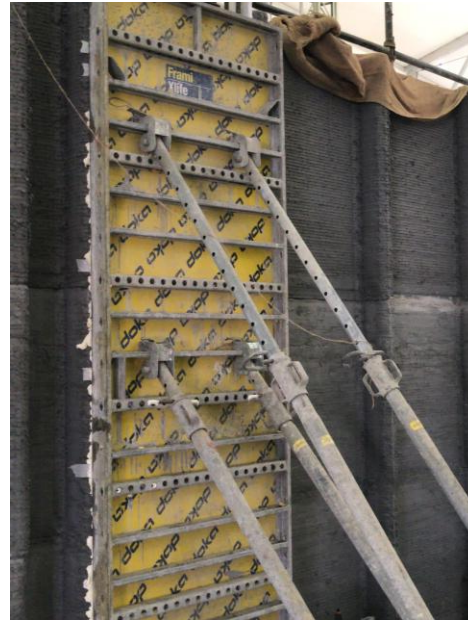
5.7 COLUMN CASTING



ONE SIDE OPEN

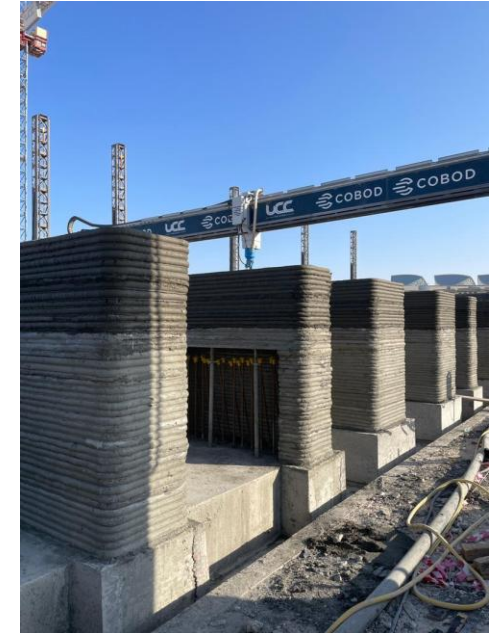
Eco village_ Indonesia

The column pocket is printed with one face left open, giving direct access for reinforcement. Once printing is complete, the vertical cage is inserted and lapped with the starter bars projecting from the foundation. Formwork is then fixed across the open face and concrete is poured to cast the column.



ONE SIDE OPEN

Emaar villa_ Dubai



CONCEALED COLUMN WITH ROOM FOR REBAR TIE

UCC School_Qatar

The column is concealed within the wall thickness, with a service room printed at its base. This opening gives access into the cavity so the inserted rebar cage can be manually lapped and tied to the starter bars projecting from the foundation. Once the connection is made, the pocket is closed and the column is cast.





06. Horizontal structure

PURPOSE

Add slabs, beams, and roof on the printed walls

The printer handles vertical walls, but floors, intermediate slabs, and the roof require a separate structural system, with selection and installation depending on the structural design and building type.

For multi-storey projects, printing pauses for the intermediate slab to be installed, after which printing resumes and continues for the upper floors.

KEY ACTIVITIES

- Select slab/roof system — RCC, steel, precast or 3D-printed
- Install roof for single-storey buildings
- Cast or install intermediate slabs for multi-storey

OUTPUT

Enclosed building with complete floor/roof structure



6. Horizontal structure

6.1	Single storied building		
	6.1.1	Roof (RCC / Steel / Wood / 3D printed Filigree / Precast)	
6.2	Multistorey building		
	6.2.1	intermediate slab (Precast slab / Cast in situ slab / steel deck / 3D printed half slab)	

6. HORIZONTAL STRUCTURE

6.1 SINGLE STORIED BUILDING / ROOF



WOODEN BEAM AND RAFTERS_ SLANTED

3DCP_ Denmark

Timber rafters are seated directly on top of the printed wall, bearing on the finished layer or on a levelling course. They are anchored to the wall using fixings cast into the grouted cavity or into the ring beam, then carry the roof structure above.



WOODEN BEAM AND RAFTERS

3DCP_ Denmark



WOODEN ROOF _ FLAT

3DCP_ Denmark

6. HORIZONTAL STRUCTURE

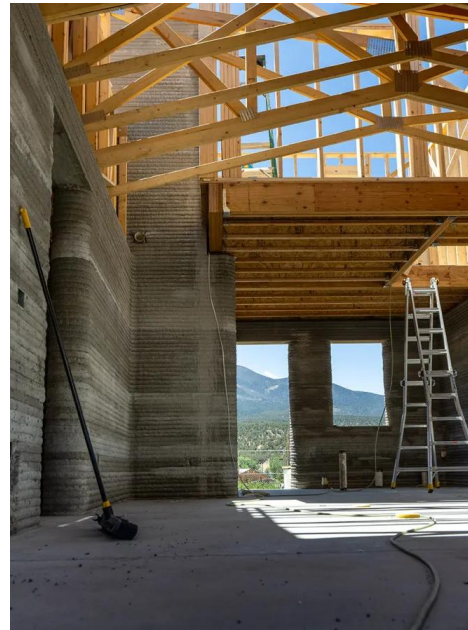
6.1 SINGLE STORIED BUILDING / ROOF



PITCH ROOF

Community house _ Ireland

Timber rafters are seated directly on top of the printed wall, bearing on the finished layer or on a levelling course. They are anchored to the wall using fixings cast into the grouted cavity or into the ring beam, then carry the roof structure above.



WOODEN RATERS



STEEL BEAMS

HTL-Ireland

A cold-formed steel frame is seated directly on top of the printed wall, with diagonal members bracing the assembly. The frame bears on the finished layer and is anchored to fixings set in the grouted cavity, then carries the roof deck above.

6. HORIZONTAL STRUCTURE

6.1 SINGLE STORIED BUILDING / ROOF



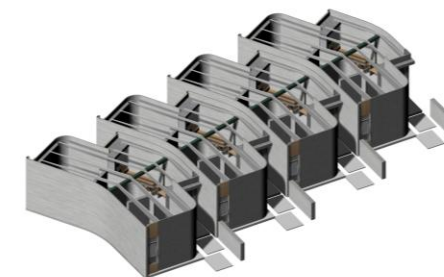
LGS TRUSS

Eco village_ Indonesia



LGS TRUSS

KA Bina_ Malaysia



LGS TRUSS

Eco village_ Indonesia

Light-gauge steel frames are seated directly on top of the printed wall, with diagonal members bracing the assembly. The frame bears on the finished layer and is anchored to fixings set in the grouted cavity, then carries the roof deck above.

6. HORIZONTAL STRUCTURE

6.1 SINGLE STORIED BUILDING / ROOF



WOODEN RAFTERS WITH THATCH

3DCP_

Timber rafters are seated on top of the printed wall and covered with a thatch finish. The assembly keeps the roof mass very low, reducing the seismic load transferred to the walls during an earthquake, and uses locally available materials that are simple to fix and replace.



PREFAB ROOF PANELS

PERI_ Germany

Prefabricated panels are lifted into place and seated directly on the printed wall, spanning between bearing points. Fabricated off site to the required size and finish, they shorten site time considerably, require no propping or curing, and are anchored to fixings set in the grouted cavity.

6. HORIZONTAL STRUCTURE

6.2 MULTI STORIED BUILDING / FLOOR SLAB



CAST IN SITU SLAB

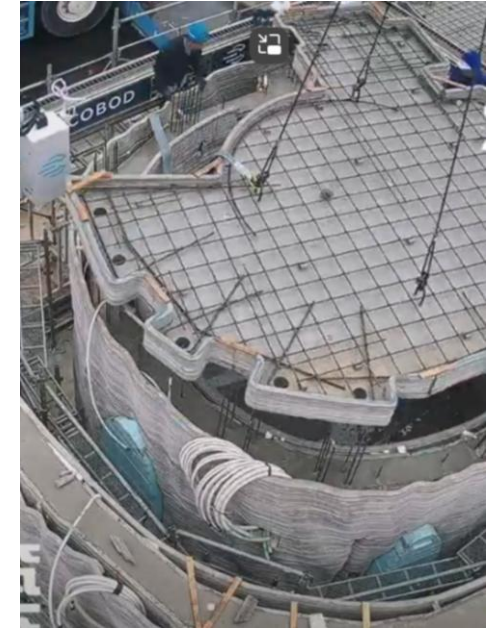
Dar Villa - Saudi

The slab is cast on site directly over the printed walls. Formwork and props are erected across the span, reinforcement is placed and lapped with bars projecting from the grouted wall cavity, and concrete is poured. This creates a monolithic connection between slab and wall, giving good diaphragm action, though it requires propping and a curing period before the next storey can be printed.



CAST IN SITU SLAB

Dar Villa - Saudi



3D PRINTED PREFAB SLAB

O- House - Japan

Formwork is printed in the shape of the slab, reinforcement is placed inside, and concrete is poured to half the slab depth. The resulting half slab is cured, lifted, and seated on the printed walls. The remaining depth is then poured in situ, bonding the units together and to the walls to form a continuous, monolithic slab.

6. HORIZONTAL STRUCTURE

6.2 MULTI STORIED BUILDING / FLOOR SLAB



PREFAB 3D PRINTED SLAB

O- House - Japan

Formwork is printed in the shape of the slab, reinforcement is placed inside, and concrete is poured to half the slab depth. The resulting half slab is cured, lifted, and seated on the printed walls. The remaining depth is then poured in situ, bonding the units together and to the walls to form a continuous, monolithic slab.



PREFAB – FILIGREE SLAB

RUPP - Germany



STEEL JOIST

HTL_ Ireland

Steel joists are lifted into position and seated on the top of the printed wall, bearing across both printed layers. Each unit is levelled and aligned before fixing, so the deck above sits true. The joists span between walls and carry the floor or roof structure.



07. Post print finish

PURPOSE

Complete all fit-out work to make the building habitable

This phase covers all fit-out work that turns a structural shell into a habitable space, including electrical and plumbing fixtures, doors, windows, flooring, insulation, wall plastering, and all mechanical and sanitary installations.

KEY ACTIVITIES

- Electrical conduits, insulation & wall plastering
- Doors, windows & flooring installation
- Sanitary, mechanical & interior fit-out

OUTPUT

Fully finished, move-in ready interior



7. Post print finish		
7.1	Completion of electrical conduit work	
7.2	Insulation filling	
7.3	Wall finish (Untreated / plastering / painting)	
7.4	Doors and windows installation	
7.5	Flooring	
7.6	Toilet fixtures	
7.7	Electrical and mechanical fixtures	
7.8	Interior and furniture layout	

7.POST PRINT FINISH

7.1 WALL FINISH



RETAINING TEXTURE

Student housing_ Denmark

The printed layer lines are left exposed as the finished surface, with no plaster or render applied. The ribbed texture becomes the architectural expression of the interior, removing a wet trade from the programme and shortening the finishing period.



PRINTED - ROUND NOZZLE

O-House_ Japan



PLASTER FINISH

14 Tree

The printed surface is plastered over its full area, concealing the layer lines and producing a smooth, conventional wall finish. The ribbed print profile gives a strong mechanical key for the plaster, though the added wet trade extends the finishing programme.

7.POST PRINT FINISH

7.1 WALL FINISH



PLASTER FINISH- INTERIOR

HTL_ Ireland

Internal walls are plastered to a smooth finish, concealing the printed layer lines. The ribbed print profile gives a strong mechanical key for the plaster, allowing a conventional flat surface ready for paint or tiling.



PRINTED - ROUND NOZZLE

Havlar_ Portugal

A round nozzle produces a pronounced sausage profile on each layer, giving a soft, rounded ribbed surface. The result suits interiors intended to read as true to material, where the printing process itself is left visible as the finish character rather than being concealed.



ROUND NOZZLE

Havlar_ Portugal

7.POST PRINT FINISH

7.1 WALL FINISH



PAINTED

Amber café _ Thailand

Paint is applied directly onto the printed layers without plaster or filler. The layer profile remains visible through the coating, retaining the printed texture while providing colour, sealing the surface, and improving cleanability.



PAINTED - ROUND NOZZLE



ROUND NOZZLE

7.POST PRINT FINISH

7.1 WALL FINISH



PANELLED

Lviv school

Laminated timber panels are fixed to the printed wall on battens or a light framing system, with the void behind used to run services or insulation. The panels arrive pre-finished, so no wet trades are required, and they provide a warm, tactile surface that contrasts with the exposed printed texture elsewhere.



HYBRID WALL FINISH

Dar_ Saudi arabia

Selected surfaces are plastered while others are left with the printed texture exposed. This allows smooth, flat finishes where they are needed, such as wet areas or feature walls, while retaining the printed expression elsewhere and limiting the extent of wet finishing work on site.



HYBRID FINISH

14 Tree

7.POST PRINT FINISH

7.1 OPENINGS



WOODEN FRAME

Student housing_ Denmark



WOODEN FRAME

Student housing_ Denmark



WOODEN FRAME

Kamp C

Timber sub-frames are fixed into the printed opening to receive the window or door. The frame is packed and anchored to the printed layers, taking up the tolerance of the printed edge and providing a straight, true fixing surface. It also gives a clean junction between the ribbed printed wall and the glazing.

7.POST PRINT FINISH

7.2 OPENINGS



UPVC FRAMES

O-House _ Japan



UPVC FRAMES

PERI_ France

UPVC frames are fixed directly into the printed opening, packed and anchored to the printed layers. The packing takes up the tolerance of the printed edge and holds the frame square, while the sealed junction between frame and wall provides a weathertight, maintenance-free perimeter.

7.POST PRINT FINISH

7.3 FLOORING



TILE FLOOR

Eco village_ Indonesia

Tiles are laid over the slab in the conventional way, using a screed or levelling layer to correct any deviation carried through from the printed structure. Wall junctions are trimmed with skirting or a coved edge, closing the gap between the flat floor and the ribbed printed wall face.



PARAQUET FLOORING

Hospital_ Thailand

Parquet is laid over the slab on a levelling screed or underlay, which corrects any deviation carried through from the printed structure. The timber finish warms the interior against the grey printed walls, and an expansion gap is left at the perimeter, covered by skirting at the wall junction.



FINISH RC FLOORING

Kamp C

The slab is finished as the final floor surface, power-floated or polished and sealed rather than covered. This removes a finishing trade entirely and keeps the material palette consistent with the exposed printed walls, giving a continuous concrete surface from floor to wall.



7.POST PRINT FINISH

7.3 FLOORING



POLISHED CONCRETE FINISH

O-House Japan

The slab is ground back and polished to expose the aggregate, producing a mosaic or terrazzo-like surface. Aggregate colour and size can be selected to control the pattern. The finish is then sealed, giving a durable, low-maintenance floor that requires no separate covering.



POLISHED CONCRETE FINISH

O-House Japan

7.POST PRINT FINISH

7.4 FIXTURES



PLUMBING

O-House_ Japan

Supply pipework is routed through the wall cavity during printing, so no chasing or surface conduit is needed afterwards. Fixture positions are set out in the model in advance, with fixing points formed in the printed layers. The fittings mount directly onto the exposed printed surface, leaving the wall texture intact.



ELECTRICAL

PERI_ Germany

Electric conduits run through the cavities, and the switches are installed on the finished wall after plastering is completed.



FIXTURES

O-House_ Japan

Plumbing pipes run through the cavities, and the plumbing fixtures are installed on the finished wall printing is completed.





08. Handover

PURPOSE

Formally close the project and hand over to the owner

The final phase formally closes the construction process and transfers ownership and responsibility to the client. As-built drawings document what was actually constructed, authorities conduct a final site inspection, and the project is legally and contractually handed over. At the end of this stage, the building belongs to the owner.

KEY ACTIVITIES

- As-built drawing preparation
- Site inspection & authority approval
- Key handover to client

OUTPUT

Signed-off building & key handover complete



8. Completion		
8.1	Completion drawing preparation	
8.2	Site inspection and approval	
8.3	Key handover	

Modification

PURPOSE

Adapt the completed building to new needs, safely and compliantly

This stage covers any change made after handover — internal layout changes, new openings in printed walls, extensions, or system upgrades. Each change is checked against the as-built drawings for structural impact, approved where the local code requires it, and recorded so the building's documentation stays accurate for future works.

KEY ACTIVITIES

- As-built review & structural impact check
- Modification design & authority approval
- Execution of works and as-built record update

OUTPUT

Approved modification completed & documentation updated

Modification

1	Addition / Extension of a Wall to an Existing 3D-Printed Wall	
2	Cutting an Opening in a 3D-Printed Wall	

CUTTING AN OPENING IN A 3D-PRINTED WALL

DOORS



EXISTING WALL

Framed wall

A 3D printed wall with the RCC column-and-beam frame concealed within it. The frame carries all structural loads; the printed layers act purely as non-load-bearing, insulated infill.



OPENING CUT

Door/window

The printed infill is cut away to form the new door opening. Because the printed layers carry no load, removing this section does not affect the building's structural stability.



LINTEL INSTALLED

RC/ Steel

A lintel is set across the opening to support the printed wall above and transfer its weight to the reveals, and the door frame is fitted beneath.



INFILL ABOVE

Brick / Prefab 3D printed

The panel above the lintel is closed with either brickwork or a prefabricated 3D printed panel, with insulation reinstated continuously and both faces sealed before finishing.

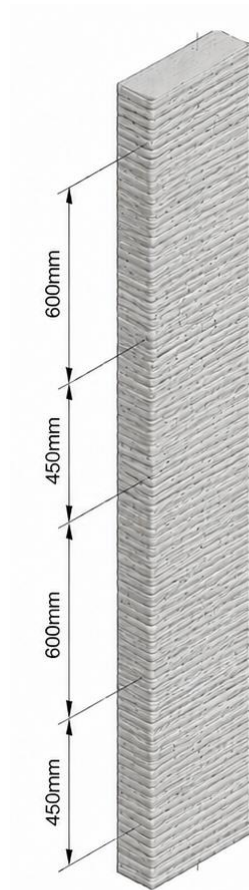


Figure 1
Fixing holes



Figure 2
Installation of wall ties

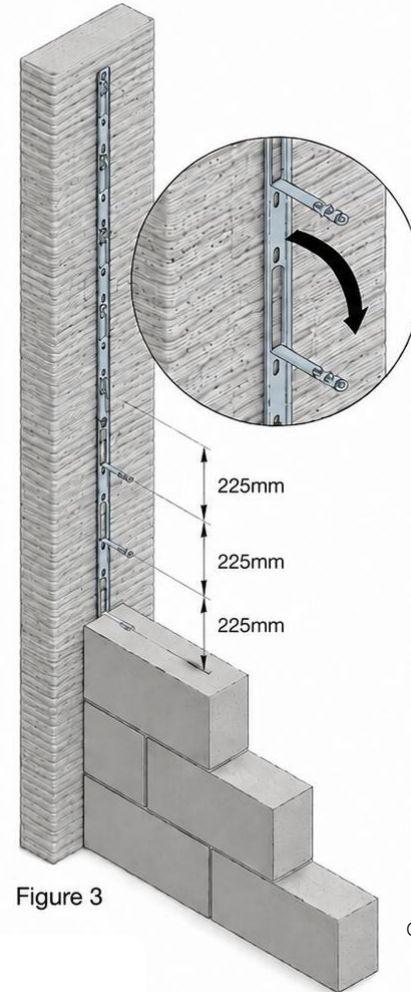


Figure 3

Overlapping brick wall and 3D printed wall using wall ties

** Reference : Ancon QuickStart wall starters

Grind the printed face flat, then fix the starter strip with resin anchors into the print's solid wall or the frame column. Fold ties every 225mm into the brick bed joints, seal the junction, carry insulation continuously across it. New brickwork needs its own foundation.

COBOD INTERNATIONAL

3D CONSTRUCTION PRINTING TECHNOLOGY

END TO END PROJECT CYCLE

