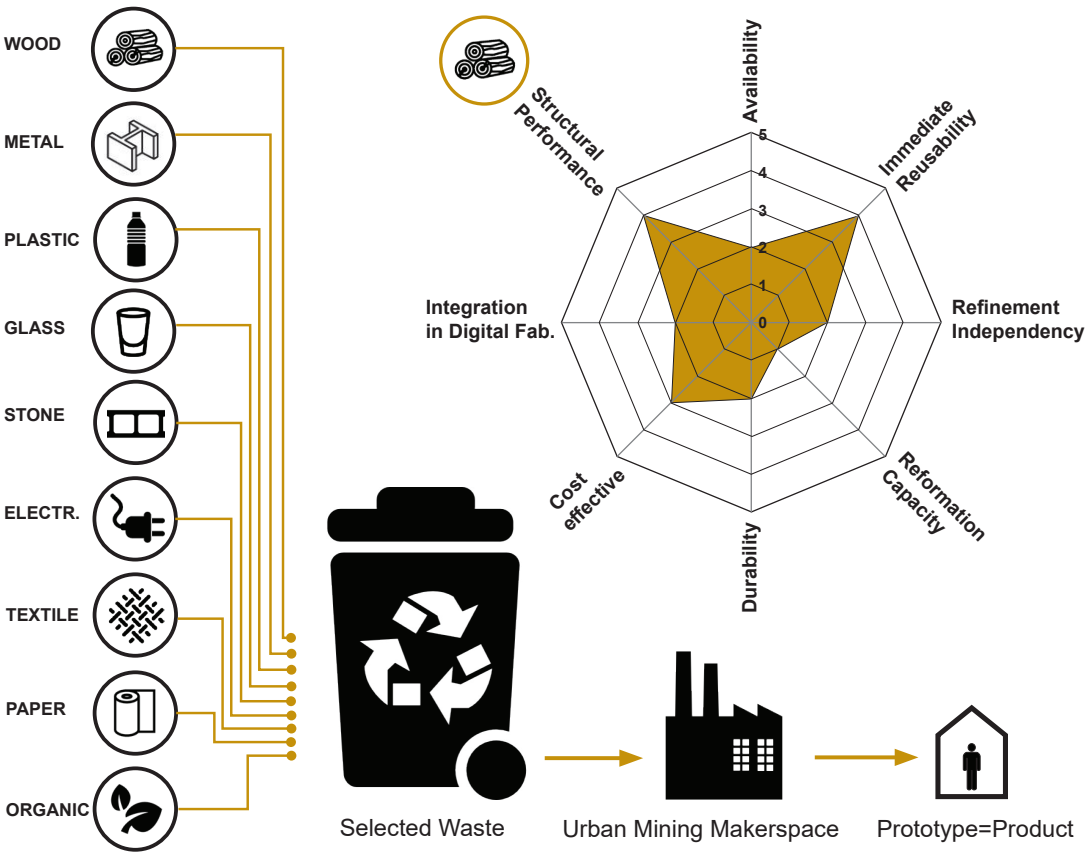
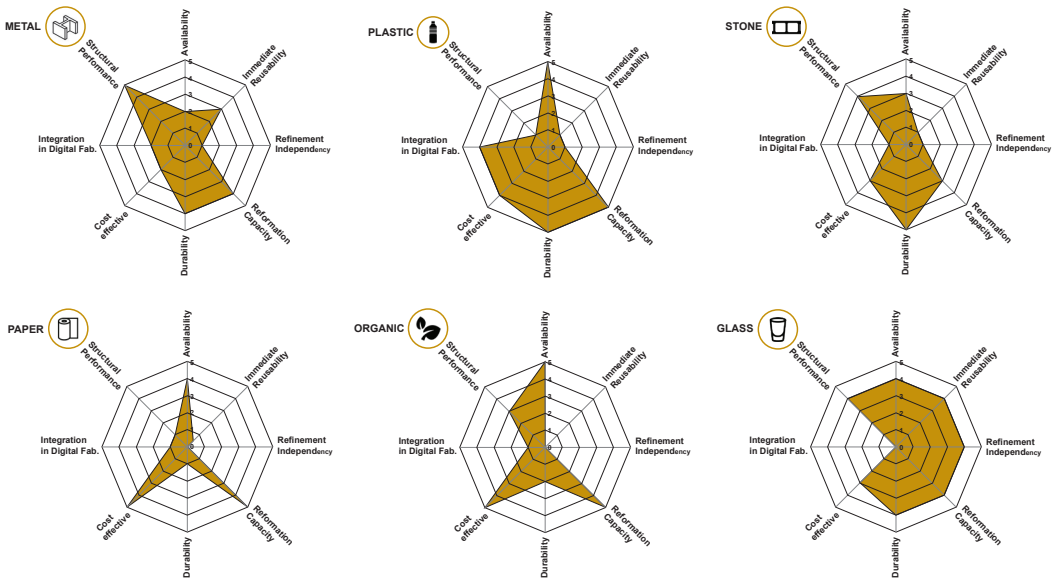
reFAB
UrbanMining MakerSpace

Objective

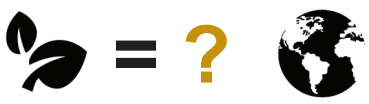
ReFab is an Urban Mining Makerspace, intended to be implemented in the area of Marineterrein in Amsterdam.
Objective of the project is the design of a generic, local-based manufacturing facility, ReFab, which is constructed from salvaged materials and operates through collective effort and interactive cultivation in the employment of refuse as raw material input in advanced production processes. These disposed elements can, if elaborated in proper manner, comprise an integral part of the raw material reserve in a perpetual loop of an advanced manufacturing practice. A transcending process that allows disused materials to become again part of the city life, by offering affordable products and elementary infrastructure that respond to the community's needs, and simultaneously the self-efficiency, development and replication of this autonomous spatial configuration into an adaptive network.

General overview & integration of refuse as raw material input in digital fabrication





Problem

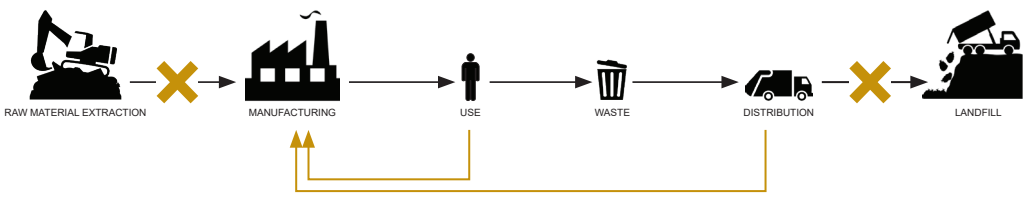


- **Pollution**
- **Raw Material Scarcity**
- **Essential Needs in Elementary Infrastructure**

Cities consume **75%** of the world's resources

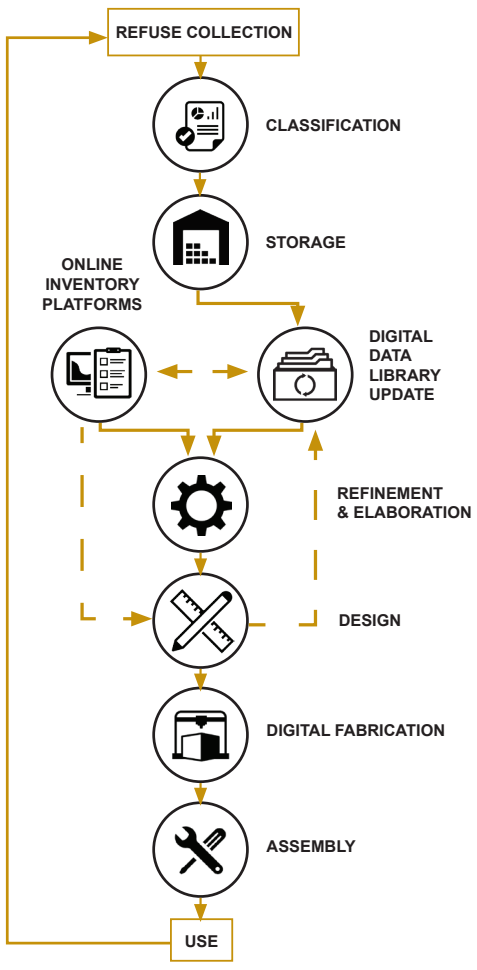
Construction sector is responsible for **45%** of the planet's raw material consumption

Urban Metabolism

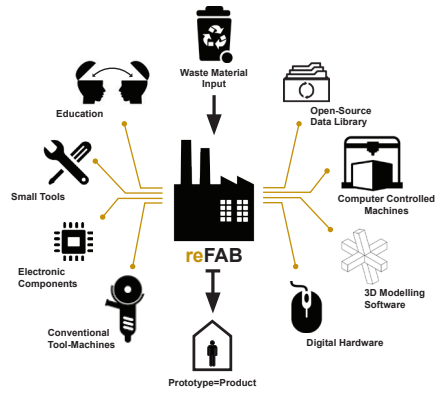


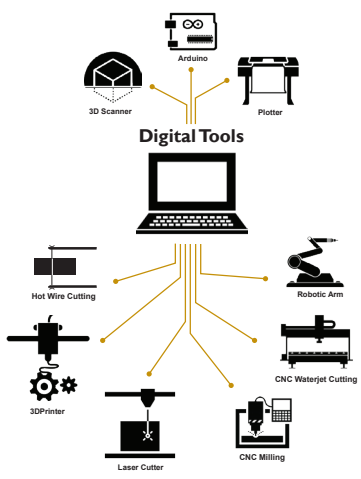
Linear Mentality of Production: Extract, Manufacture, Consume, Discard
Circular Mentality of Production: Reduce, Reuse, Recycle, Recover

Operating Process

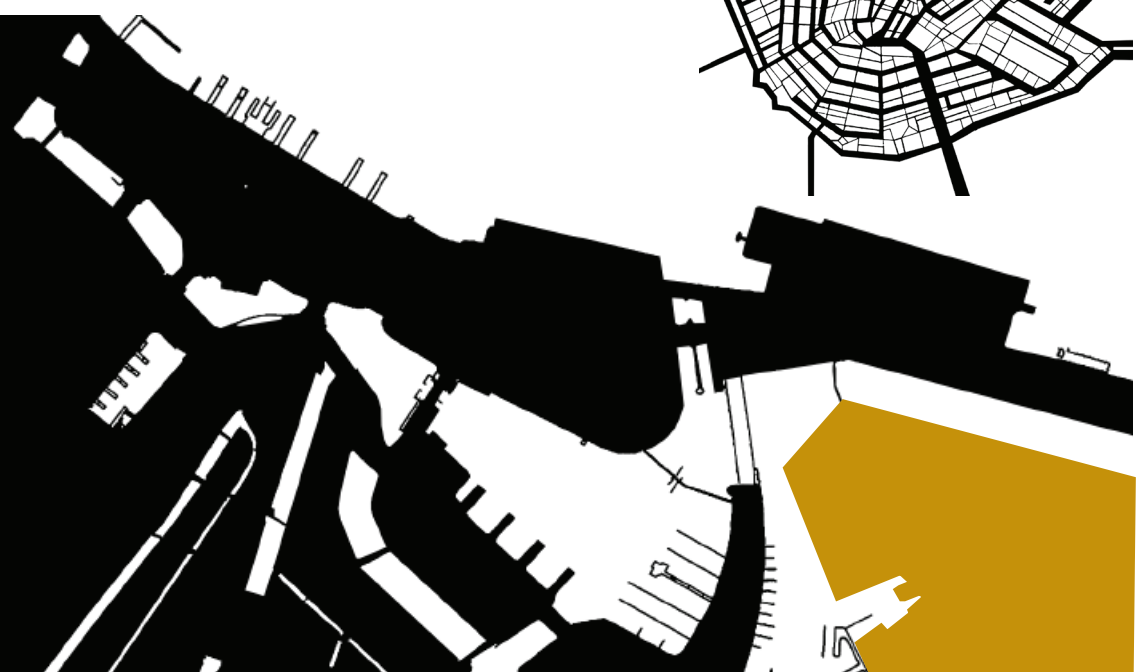


Operational Components

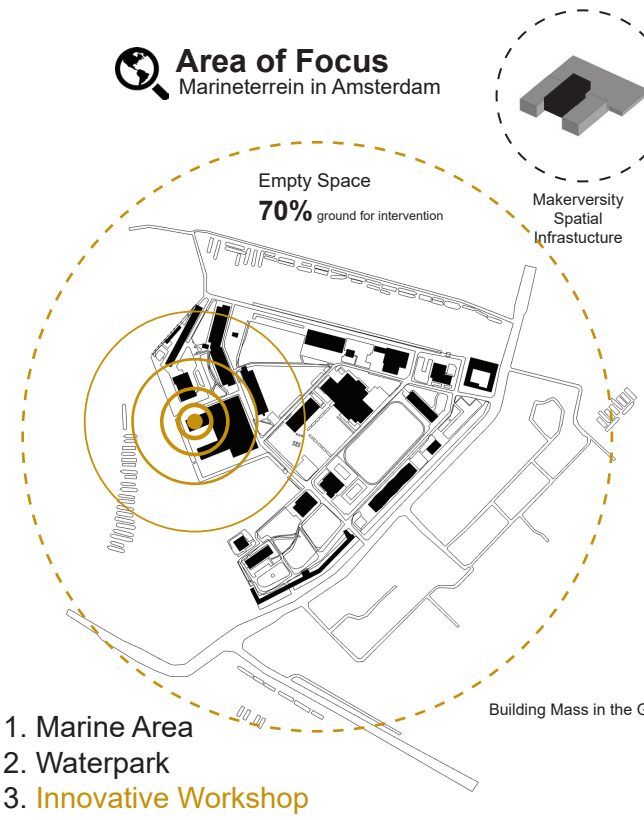




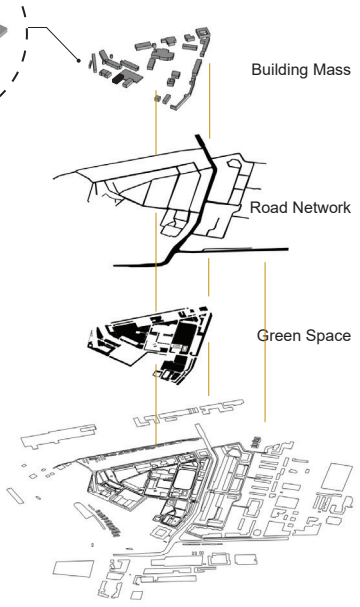
Marineterrein
Amsterdam



Area of Focus
Marineterrein in Amsterdam

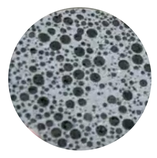


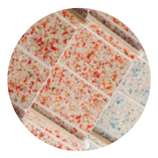
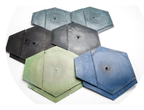
Site of Implementation
Operational Supporting Framework



Building Mass in the General Area of Investigation & Location of Interest

1. Marine Area
2. Waterpark
3. Innovative Workshop

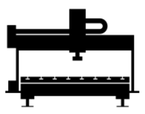
	 ECOR	 Paper Waste Brick	 Bagasse Particle Board	 Newspaper Wood	 Bitublock	 Fly Ash Cement	 Self-Healing Concrete	 Clay & Slag Brick	 Stonecycling Brick
Developed by	Noble Environmental Technologies	Spain's University of Jaen	Universities of India	Vij5 and Mieke Meijer	Dr. John Forth	UNKN	Bacterial Mineral Precipitation, TUDelft	TNO, Delft	Tom van Soest
Waste Origin	cardboard, newspaper, office paper, discarded wood chips, residual agricultural fibers including Bovine Processed Fiber (BPF), kenaf, oat, coffee, coconut, and other waste fibers	paper waste and by-products of the paper industry and waste water purification	sugar mills by-product	newspapers	recycled glass, incinerated sewage sludge ash (ISSA), quarry fines, MSW Incinerator bottom ash (MSWI BA), construction and demolition waste and other recycled aggregate	fine powder which is a byproduct from burning pulverized coal in electric generation power plants, a residue left at the end of the coal combustion process	construction market and micro-organisms laboratory development	clay material and slag deriving from the ferronickel production industry	demolition sites
Composition	100% Bio-based material converted from waste cellulose fiber, pressure, and heat	paper waste and waste from water purification, mixed in a ceramic blend(clay) and pressurized	bagasse fiber residual pulp from sugarcane	Newspaper and a type of adhesive (UNKN)	mix of coarse, fine and filler particles, ratios dependent on the feedstock material and desired product properties	fly ash and Blast Furnace Slag (BFS) mixed with lime and water it forms a compound similar to Portland cement	concrete in addition to microfibers and calcium carbonate precipitating micro-organisms	geopolymers from metakaolin, slag, NaOH and waterglass	pulverized recycled building materials (not provided composition)
Application	interior, furnishings, signage, displays, packaging, consumer products, artwork, storage, shelving etc.	conventional building construction	core material for laminated floors, replacing high-density and expensive wood fiberboard	panelling, furniture and interior equipment	load and non-load bearing construction units such as concrete and clay based building blocks	loadbearing construction and all building purposes	ideal for sewer, underground retainers for hazardous waste etc. building purposes	loadbearing construction and all building purposes	both interior and exterior applications on building construction
Waste Comp. Availab.	●●●●●	●●●●●	●●●●○	●●●●●	●●●●●	●●●○○	●●○○○	●●○○○	●●○○○
% Waste Composite	●●●●●	●●●○○	●●●●○	●●●○○	●●●●●	●●○○○	●○○○○	●●○○○	●●○○○
Manufact. Facility	●●●○○	●●○○○	●●●●●	●●●●○	●●○○○	●●○○○	●○○○○	●●○○○	●●○○○
Structural Efficiency	●●●○○	●●○○○	●○○○○	●●●○○	●●●●○	●●●●○	●●●○○	●●●●○	●●●○○
Thermal Insulation	●●●○○	●●●●○	●●●○○	●●●●○	●●○○○	●●●○○	●●●○○	●●○○○	●●●○○
Acoustic Insulation	●●○○○	●●●○○	●●○○○	●●○○○	●●●○○	●●●○○	●●●○○	●●○○○	●●●○○
Fire Resistance	●●●○○	●●●●●	●●○○○	●●○○○	●●●○○	●●●●○	●●●●○	●●●●○	●●●○○
Waterproof Efficiency	●●●●○	●●●●○	●○○○○	●●●●○	●●●○○	●●●●●	●●●●●	●●●●●	●●●●●
Cost Effective	●●●○○	●●●●○	●●●●○	●●●○○	●●●○○	●○○○○	●○○○○	●●○○○	●●○○○
Optimiz. Potential	UNKN	optimized through alternative, green products as sewage sludge, brewing by-products, olive, producing biodiesel etc.	mix with pMDI resin as a bonding agent and wax as dimensional stabilizer for laminated floor and furniture applications	UNKN	possible future changes due to product quality protocols may make current potential waste inputs more attractive	optimum amount of fly ash varies not only with application, but also with composition and proportions in the mixture	development of capsules with properties to survive the mixing process and release the healing agent	concerning durability description accelerated tests are required to estimate the material behaviour in its lifecycle	UNKN
Additional Estimation of the Product	+ no toxic adhesives, additives, formaldehyde, or other sources of off-gassing + bonds well with virtually any adhesive, coating, treatment, laminate or veneers + 75% lighter than conventional panels	+ requires less time of baking than conventional bricks - poor in mechanical strength - adhesion and forming difficulties following the production procedure	+ manufacturing process on a commercial scale + substitute for wood + lightweight	+ resemble the aesthetics of real wood	+ low carbon footprint and high recycled content generate price advantages + the adaptable process conditions appears highly suited to a wide range of wastes and the more inconsistent nature of waste characteristics - Heavy metals may be present in some of the aggregate wastes.	+ contains various heavy metals and toxic elements which are usually allowed to disperse in the atmosphere or is dumped in a landfill - Fly ash is a pozzolanic material, expensive replacement for Portland cement	+ self-repairs cracks in concrete structures + substantial savings, especially in steel reinforced concrete	+ utilizes by-products + low condensation in CO_2 - early stage of research - cost related uncertainty	+ meet today's industry requirements and can be used for both the interior and exterior of buildings + produced from various types of waste, and combined in different ways to create new colours, textures, shapes and sizes

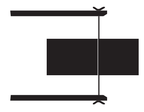
	 Saw Dust & Rice Husk Building Brick	 Rice Husk Ash Concrete (RHA)	 Fungi-brick	 Recycled Glass Brick	 Replast Brick	 Beverage Carton Brick	 Polli-Brick	 'Pretty Plastic' Tile	 Plastic Bag Brick
Developed by	UNKN	India	Mycologist Philip Ross	Japan's GRC, Beecycle, Kingston	Byfusion	ReWall	Miniwiz	Materia	Carter Zufelt, Wasted
Waste Origin	fine powder which is a byproduct from burning pulverized coal in electric generation power plants, a residue left at the end of the coal combustion process	by-product of burning the outer shell of the paddy that comes out as a waste product during milling of rice	corn stalks, hemp, and mycelium grow into solid objects in about five days with no added energy (can be composted at the end of the installation)	hydro-thermally solidified materials from breaking down glass waste into sand grade	all kinds of plastic from landfills and recycling facilities	beverage carton packages from landfills	plastic bottles from landfills and recycling facilities	locals who separate their waste, through WASTED and through visitors, who can bring plastic instead of a ticket when entering FabCity	milk containers, tupperware, oil/shampoo/detergent bottles, and mainly plastic bags
Composition	cast from fluorogypsum binder/plaster using saw dust, rice husk and exfoliated vermiculite	rice ash as admixture for concrete	chopped-up corn stalks, hemp, and mycelium	30-70% pozzotive glass replacing sand as admixture to cement	mix of shreded unsorted plastics	shreded and pressed material of 100% benerage cartons (paper, polyethylene and aluminum)	mechanically recycled plastic of type PET from drinking bottles	sorted, washed, grinded and moulded recycled plastic of type PET, HDPE and PE	plastic bags of type HDPE
Application	bricks, flooring tiles and plastering	special concrete mixes, high performance concrete, high strength, low permeability concrete	interior and exterior application on building construction	bricks, tile blocks, floor materials, outdoor furniture	interior and exterior application on building construction	initially intended for interior clading, but also various exterior applications	panelling, interior and exterior application on building construction	panelling slates and tiles, interior and exterior application	brick for interior and exterior application
Waste Comp. Availab.	●●●○○	●●●●○	●●●●○	●●●○○	●●●●●	●●●●●	●●●●●	●●●●○	●●●●●
% Waste Composite	●●●○○	●●○○○	●●●●○	●●○○○	●●●●●	●●●●●	●●●●●	○○○○○	●●●●●
Manufact. Facility	●●○○○	●●●○○	●●●○○	●●●○○	●●●●●	●●○○○	●●○○○	●●○○○	●●●●●
Structural Efficiency	●●●●○	●●●●●	●●●●●	●●●●○	●●●●○	●●○○○	●●●○○	●●●○○	●●●●○
Thermal Insulation	●●●●○	●●●●○	●●●●○	●●○○○	●●●○○	●●○○○	●●●●○	●●○○○	●●○○○
Acoustic Insulation	●●●○○	●●○○○	●●○○○	●●○○○	●●●○○	●●●○○	●●●○○	●●○○○	●●○○○
Fire Resistance	●●●○○	●●●●○	●●●●○	●●●○○	●●○○○	●●○○○	●●●○○	●●○○○	●●○○○
Waterproof Efficiency	●●●●○	●●●●○	●●●●●	●●●●○	●●●●●	●●●●●	●●●●●	●●●●●	●●●●○
Cost Effective	●●●○○	●●●○○	●●●●○	●●●○○	●●●●○	●●●●○	●○○○○	●○○○○	●●●●○
Optimiz. Potential	further studies on fire resistance and standardization, also addition of waste lime sludge may add economy	study on applications of RHA as repair mortars, coatings and soil stabilization	dial in different material properties of the bricks by changing variables, tune the material for permanent structures	integral pigment can be applied to the mix to further enhance the brick, by offering more design possibilities	improvement of product's production method and appearance for promotion reasons	UNKN	UNKN	UNKN	further ways of interlocking process and moulding shapes in regard to the need of assembly
Additional Estimation of the Product	+ lightweght + FG binder is cheaper than the lime and cement binders	+ carbon neutral green product + reduces the consumption of cement due to blending + considered a class apart from all other mineral admixtures due to its unique microstructure and the resultant benefits in concrete and its multi various application possibilities	+ 100% organic and compostable + stronger, pound for pound, than concrete + super-strong, water-, mold- and fire-resistant + grown and formed into just about any shape	+ artificial super-light aggregate + approximately 95% of coal Btu energy equivalent is saved + endless aesthetic possibilities	+ requires no adhesives + LEED certification + 95% lower greenhouse emissions (GHG) compared to concrete block + flexibility in shape - in some cases need additional support - appearance	+ no additional adhesives + waterproof due to its initial intended production reason - low mechanical strength	+ the 3D strong self-interlocking structure without chemical adhesives + translucent + 1/5 of standard curtain wall systems + lightweight + UV protection + scratch-resistant and easy to clean - process economically efficient in mass manufactured on-site	+ chemical resistant + lightweight + scratch resistance - moderate UV resistance - not renewable	+ HDPE has a high strength-to-density ratio, is widely accessible, and can be found in an abundance of colors + very simple production process - not yet applied and tested in building constructuion

The evaluation of the properties of each recovered material composite has been made with main criteria in accord to its application potential, in comparison with the other recycled products, and in regard to the evaluation of data provided from their developer, eco-friendly carriers and general web resources

Digital Fabrication Technologies

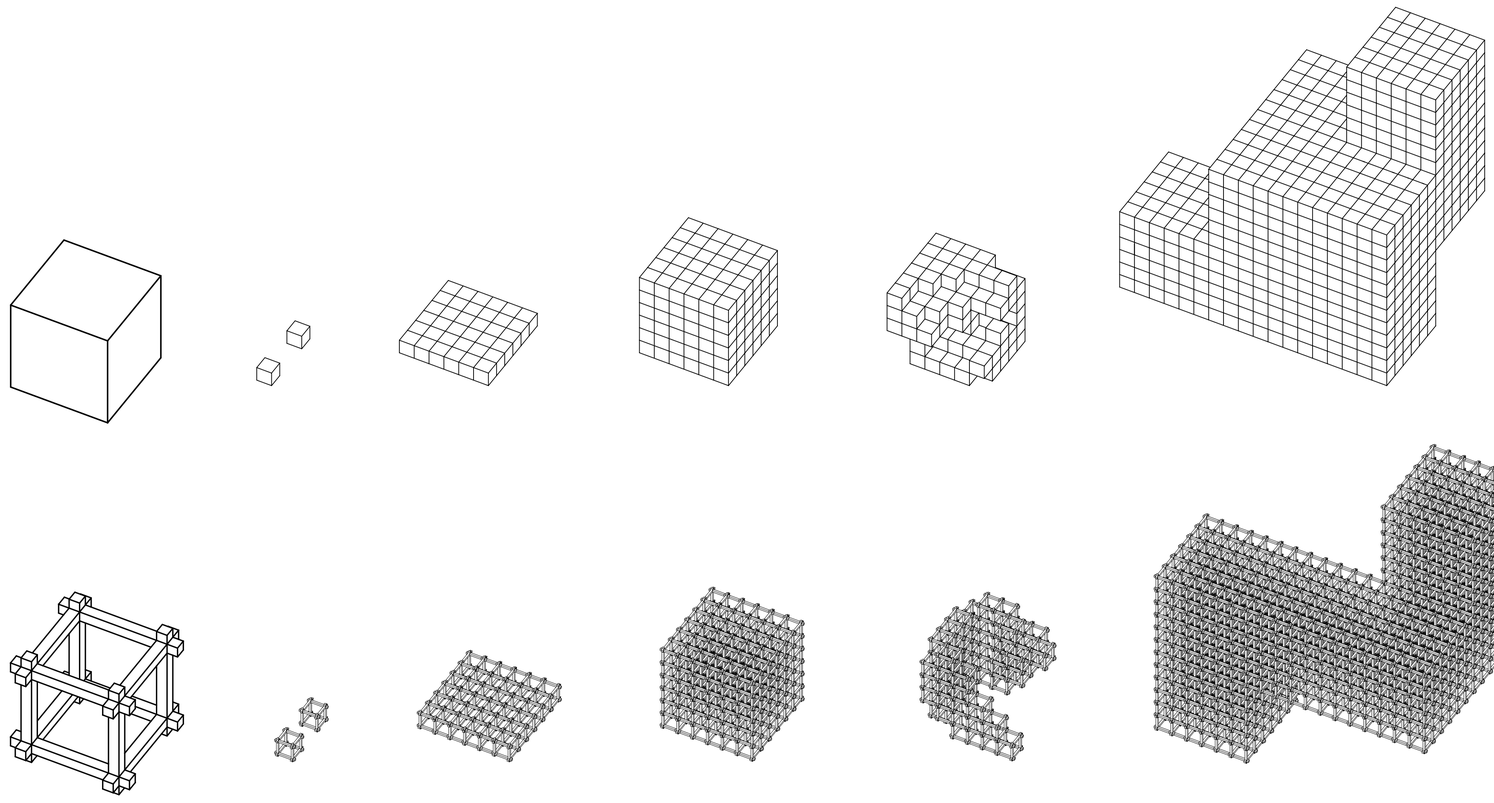
Overview & Evaluation



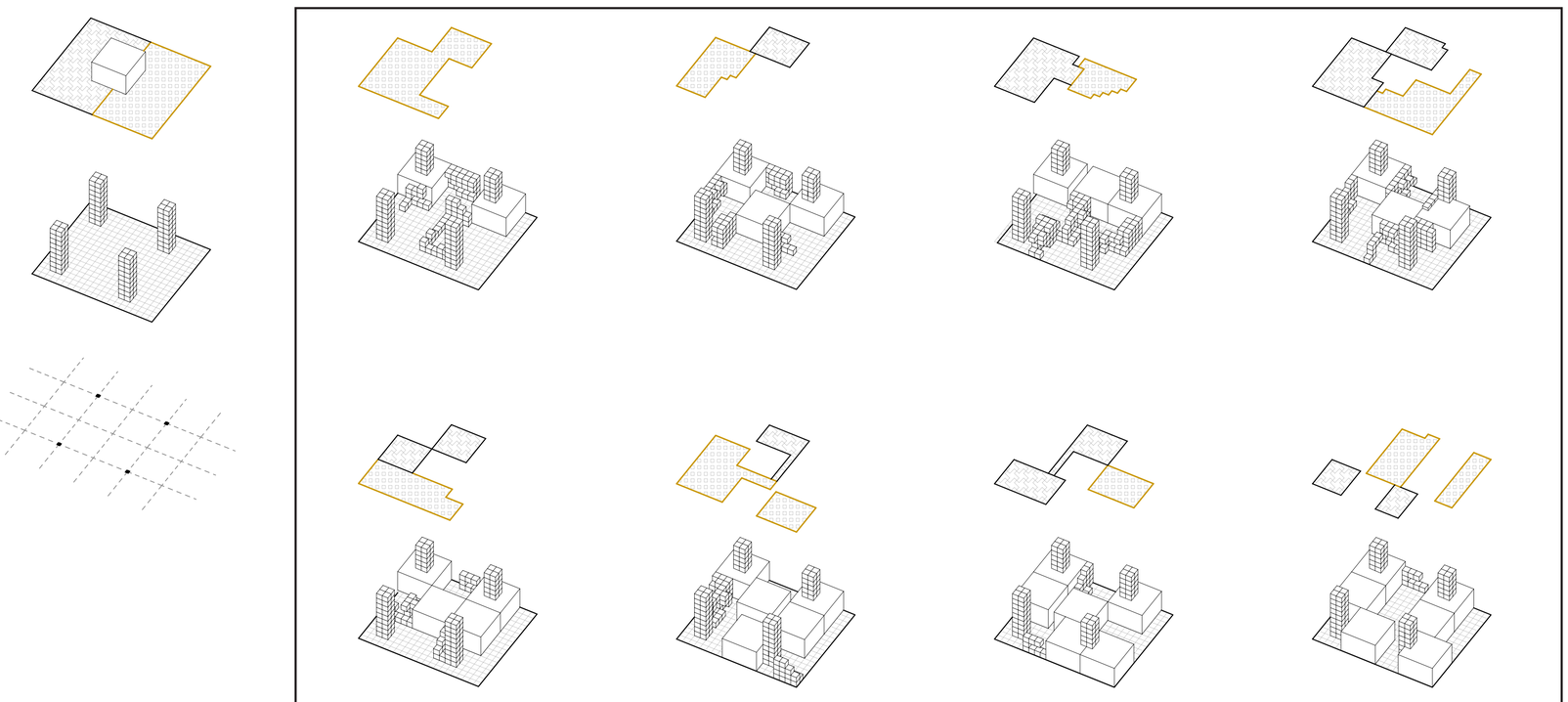


	3D Printing	CNC Laser Cutting	CNC Waterjet Cutting	CNC Milling	Hot Wire Cutting
Advantages	+ Waste plastic utilization + No waste are produced + No molds + Material variety + Form freedom	+ Precision + Demountable + Bearing structure ability + Engraving ability + Lightweight + Customization + No adhesives and joinery required	+ Demountable + Bearing structure ability + Customization + Thick material cutting ability	+ Demountable + Customization + Engraving + Software variety + No adhesives and joinery required	+ Form freedom + Customization + Large volume geometries + Lightweight
Disadvantages	- Not demountable - Not bearing	- Waste production - Energy consumtion - Speed - Limited size components	- Water consumtion - Speed - Waste production	- Waste production - Limited size components	- Difficulty in waste utilization - Not demountabe - Short material variety - Waste production - Not structural
Materials	• Plastic • Concrete • Ceramics • Aluminium	• Plywood • MDF • Metal • Plastic • Cardboard • Various depended on machine	• Wood • Plastic • Foam • Ceramics • Metal • Paper	• Wood • Metal [Various & Aluminium] • Cardboard	• Polystyrene • Styrodure
Waste Material Input	• Plastic [transformed through a melting and extrusion process to a new polymeric filament] • Ceramics	• Metal [transformed though melting process into a new sheet] • Plastic [transformed though melting process into a new sheet] • Wood [in the case of solid panel or by tramsforming wood in a by-product]	• Metal [transformed though melting process into a new sheet] • Plastic [transformed though melting process into a new sheet] • Wood [in the case of solid panel or by tramsforming wood in a by-product]	• Metal [transformed though melting process into a new sheet] • Wood [in the case of solid panel or by tramsforming wood in a by-product]	Rare cases of integrating a waste product
Energy Consumption	Depended on machinery and material	100kW	37kW & depending on pump	18kW	Depended on machinery and material
Material Thickness	Approx. 6x6m printing size	max. 400mm	max. 350mm	Approx. 250mm	Depended on the wire structure
Dig.Fabrication Speed	Depended on machinery and material	max. 300m/min	max. 35m/min	Approx. 10m/min	Depended on machinery and material
Finish Independency	● ● ○ ○ ○	● ● ● ● ○	● ● ● ● ●	◉ ○ ○ ○ ○	● ● ● ○ ○
Overall Production Speed	● ● ● ● ○	● ● ● ○ ○	● ● ○ ○ ○	● ○ ○ ○ ○	● ● ○ ○ ○
Waste Production	● ○ ○ ○ ○	● ● ● ● ○	● ● ● ● ○	● ● ● ● ○	● ● ● ● ○
Mat. Emb.Energy Economy	● ● ● ○ ○	● ○ ○ ○ ○	● ● ○ ○ ○	● ○ ○ ○ ○	● ● ○ ○ ○
Sustainability	● ● ● ● ○	● ● ● ○ ○	● ● ● ○ ○	● ● ● ○ ○	● ● ○ ○ ○
Material Variability	● ● ● ○ ○	● ● ● ● ○	● ● ● ● ○	● ● ● ● ○	● ○ ○ ○ ○
Waste Mat. Integration	● ● ● ● ○	● ● ○ ○ ○	● ● ○ ○ ○	● ○ ○ ○ ○	◉ ○ ○ ○ ○
Waste Pre-elab. Independ.	● ● ● ○ ○	● ● ○ ○ ○	● ● ○ ○ ○	● ● ○ ○ ○	◉ ○ ○ ○ ○
Product Recycling Capacity	● ● ● ○ ○	● ● ○ ○ ○	● ● ○ ○ ○	● ● ○ ○ ○	● ○ ○ ○ ○
Demountability	● ○ ○ ○ ○	● ● ● ● ●	● ● ● ● ●	● ● ● ● ●	● ● ○ ○ ○
	3D	**2D**	**2D**	**2D + 3D**	**2D + 3D**

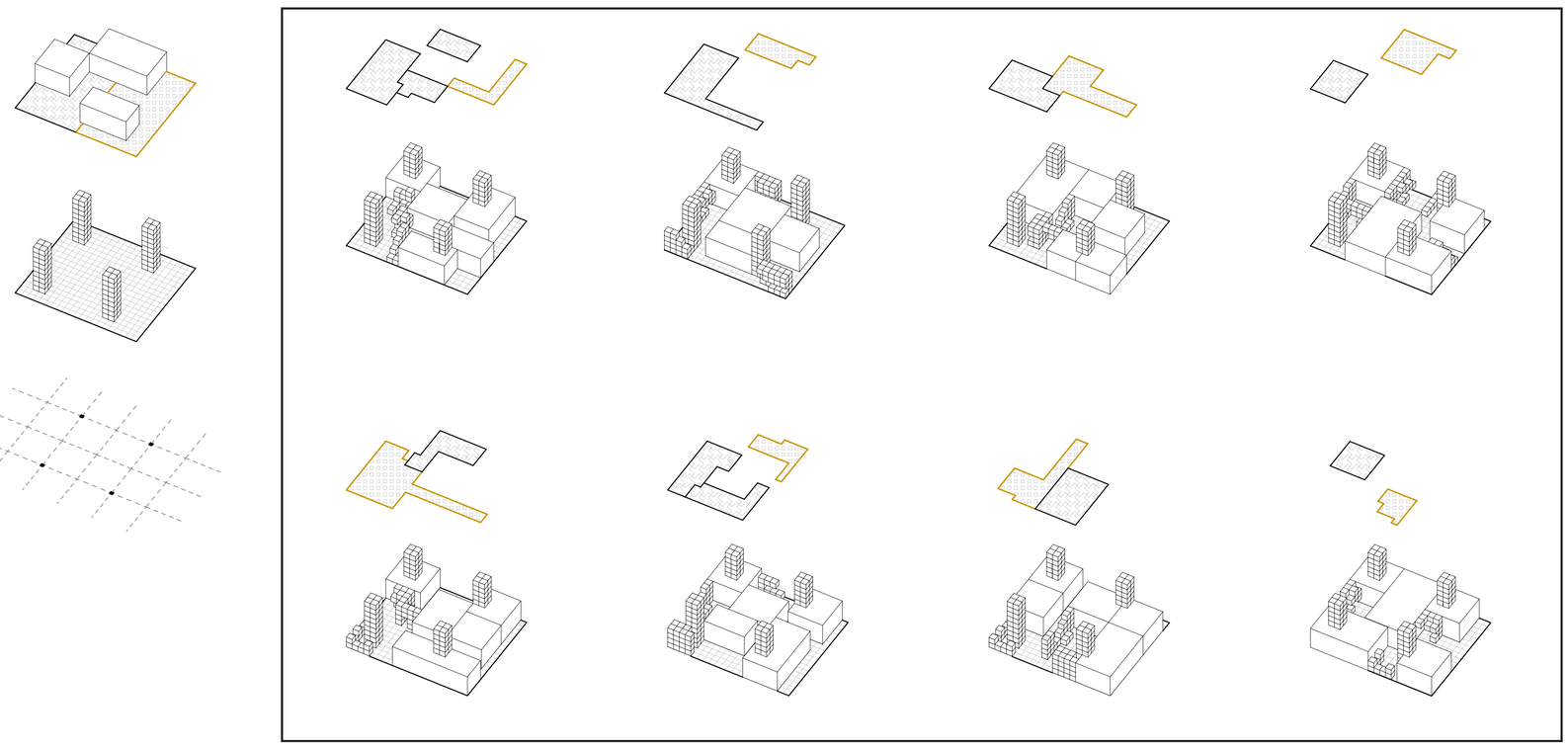
Modular Structural System Principle



6x6m² Workunits Spatial Development Potentials



Variable Size Workunits Spatial Development Potentials



Private Working Studios

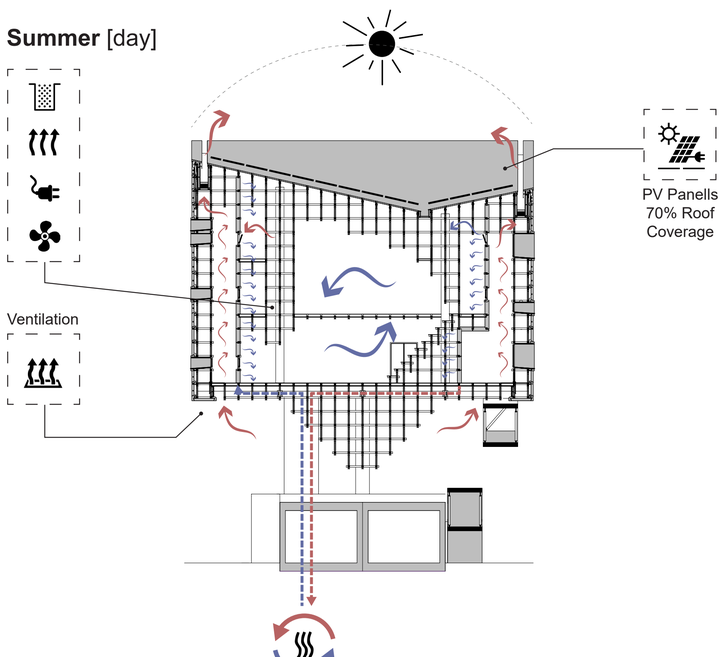
Technical Appliances Cores & Modular Components

Flexible Semi-Private Space

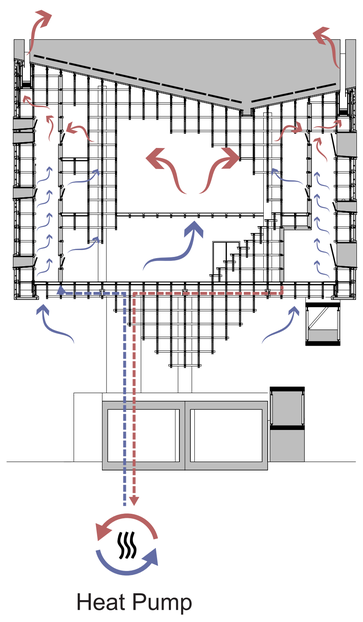
Flexible Shared Space

Climate Control Diagrams

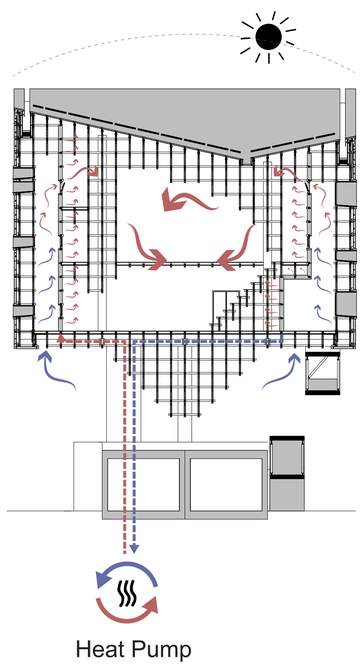
Summer [day]

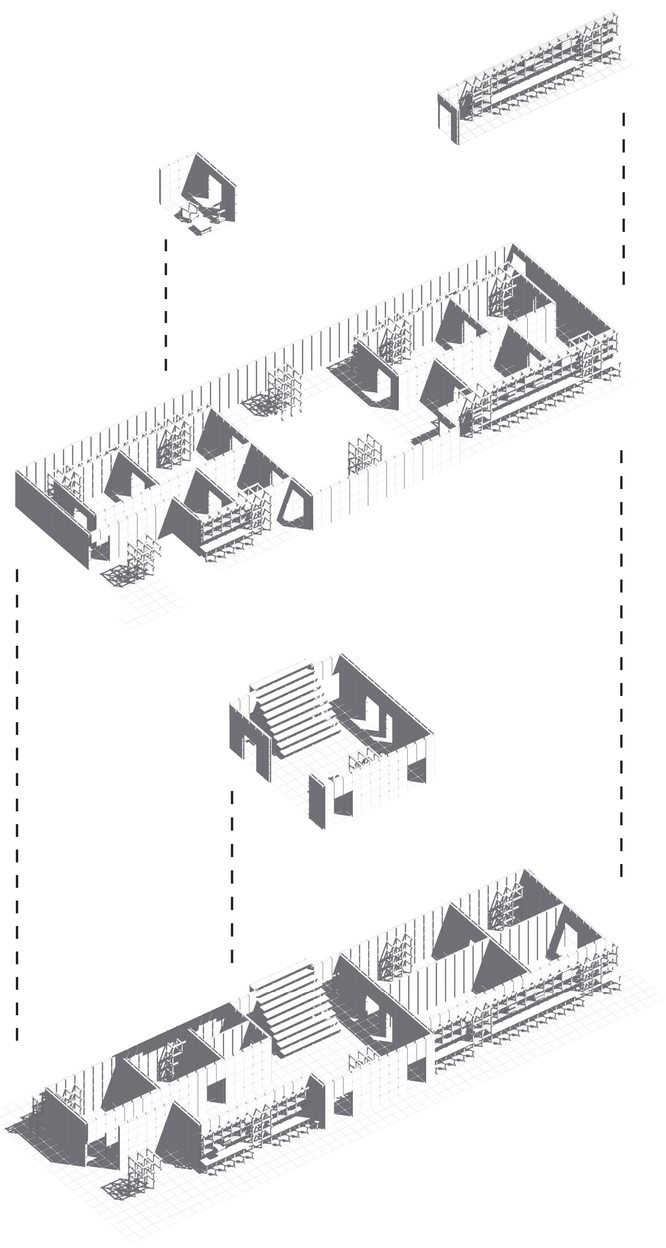


Summer [night]

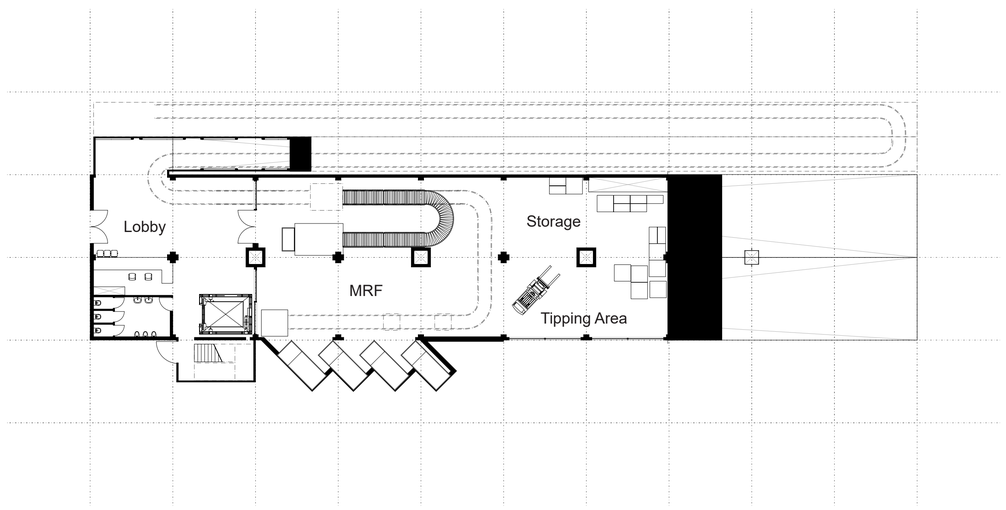


Winter

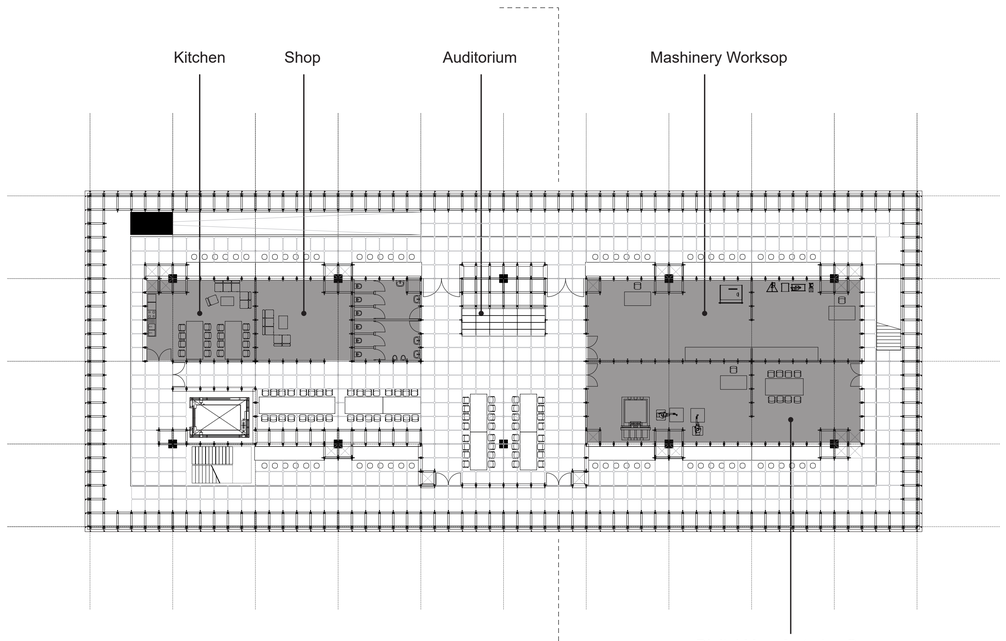




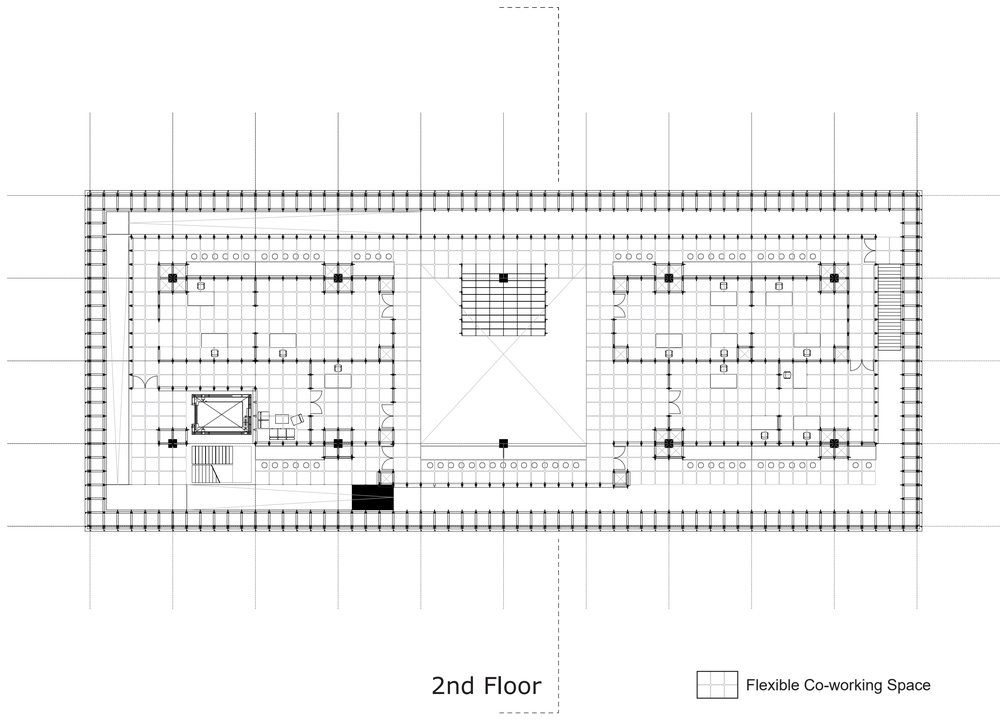
Floorplans



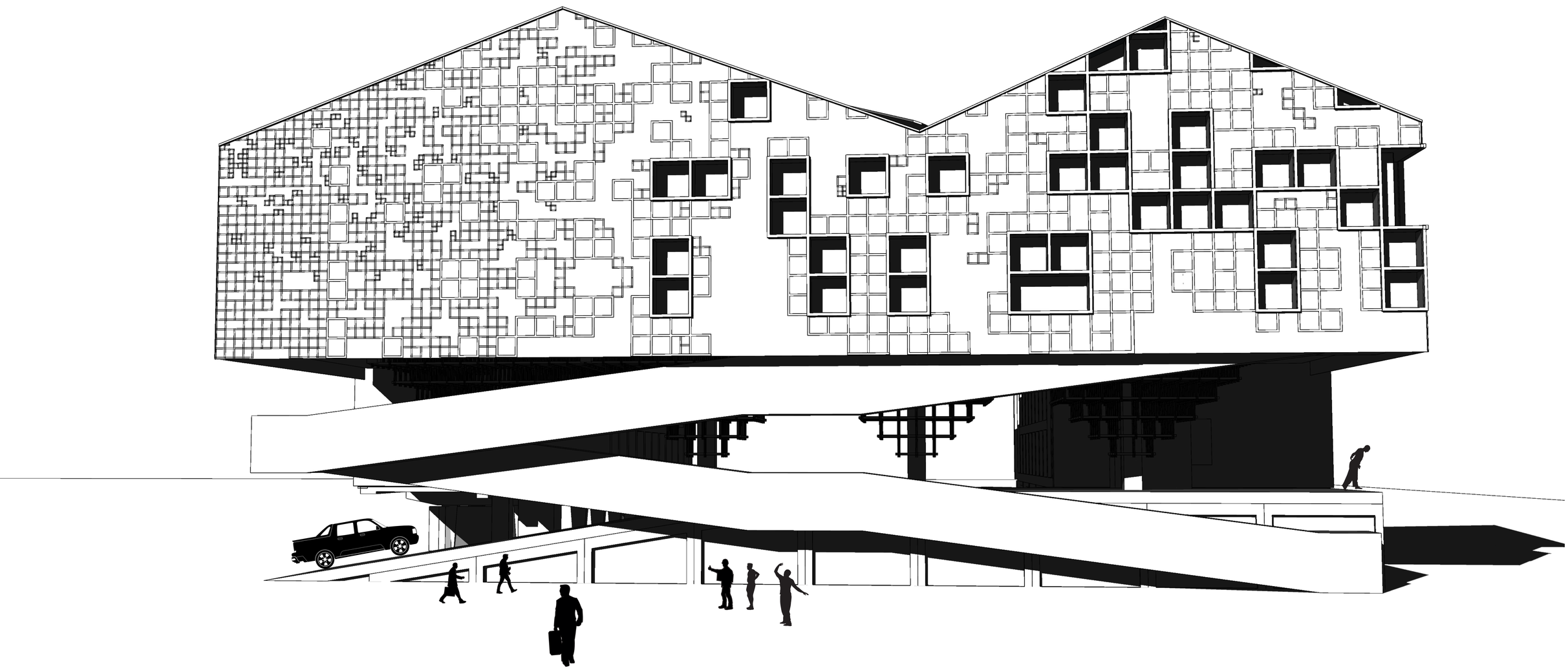
Ground Floor

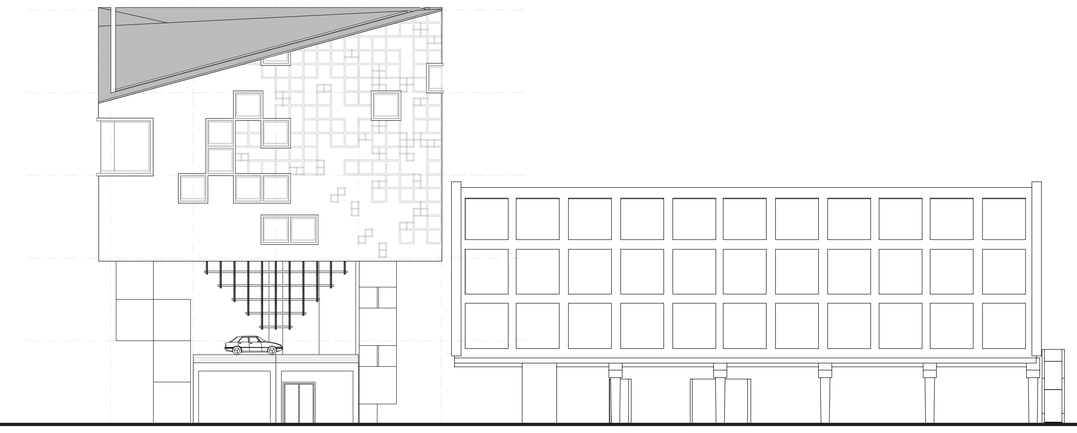


1st Floor



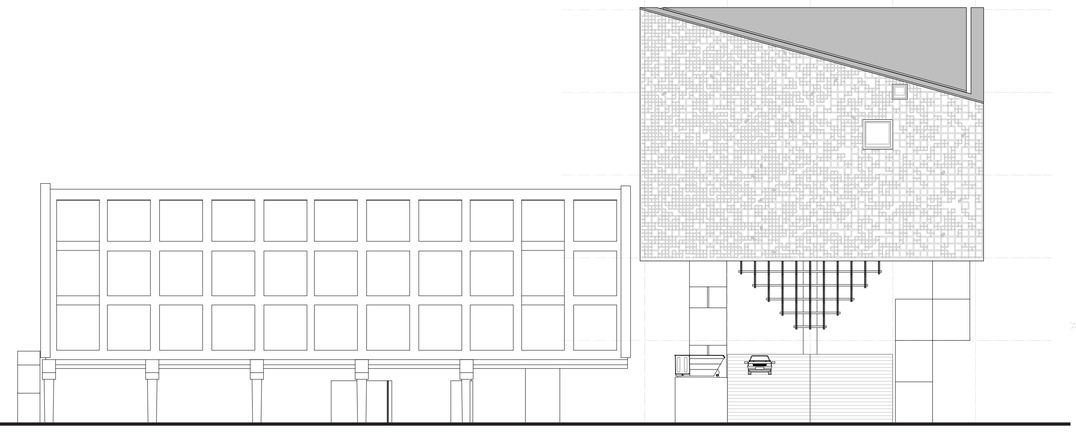
2nd Floor



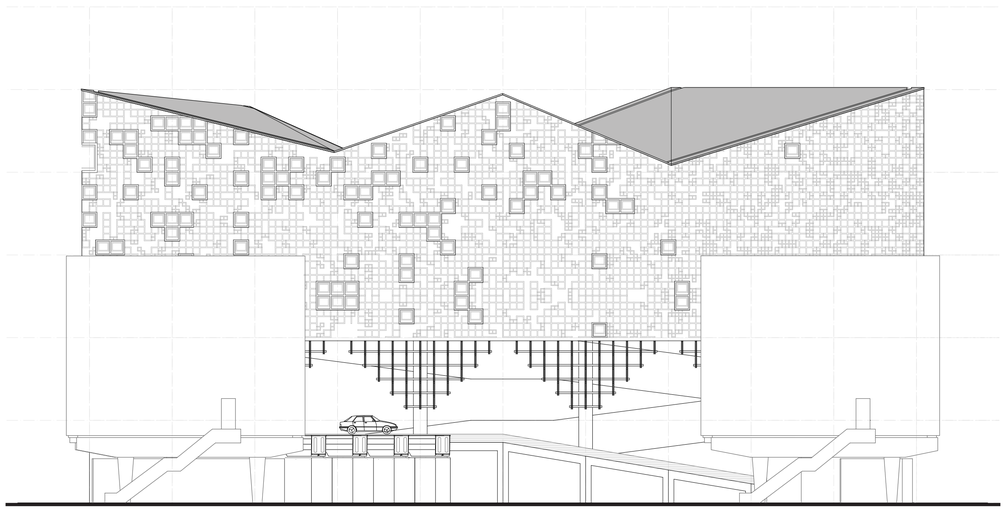


North-West Elevation

North-East Elevation



South-East Elevation



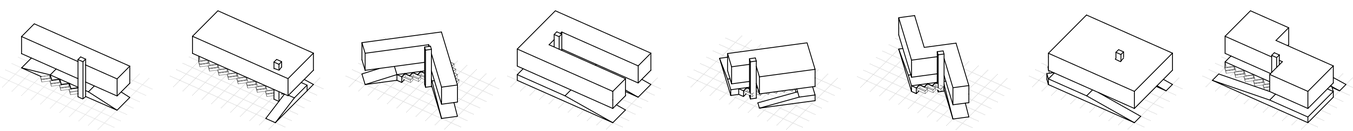
South-West Elevation

Shorting Platform Spatial Development Assesment

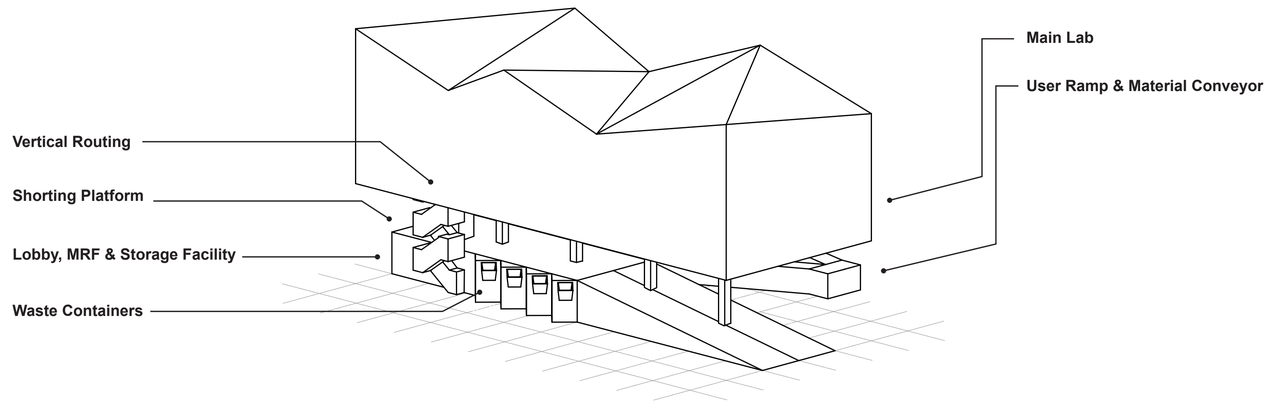
in plot of 2160m² available area & 6x6m Grid

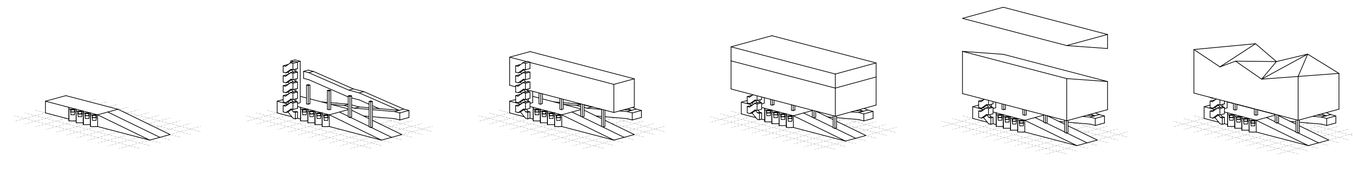
Overall Platform Area	720	1188	648	1584	648	648	1224	1728
MRF & Storage Area [m²]	288	864	288	864	468	216	864	1296
Waste container Capacity	8	8	11	6	12	7	8	10
Plot Coverage	33.33%	54.07%	30%	73.33%	30%	30%	56.66%	80%
Drivers Routing	●●●●●	●●○○○	●●●●○	●●●○○	●●○○○	●●○○○	●●●●○	●●○○○
Pedestrian Routing Capacity	●●●○○	●●●○○	●○○○○	●●●○○	●●○○○	●○○○○	●●●●○	●●●●○
Alternative Funcion Capacity	●●○○○	●●○○○	●●○○○	●●●○○	●●○○○	●●○○○	●●●●○	●●●●○

Vertical Grid Expansion



Program Requirements

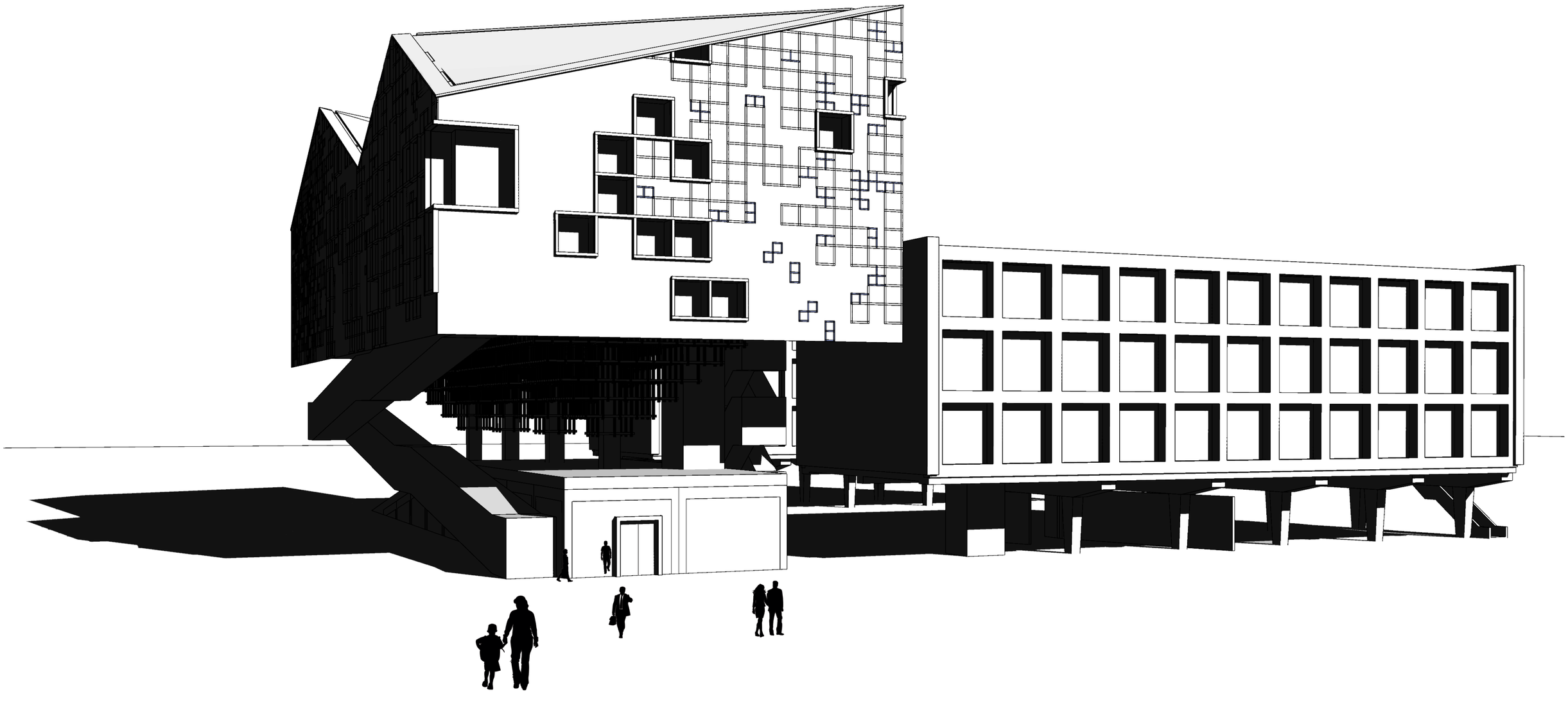




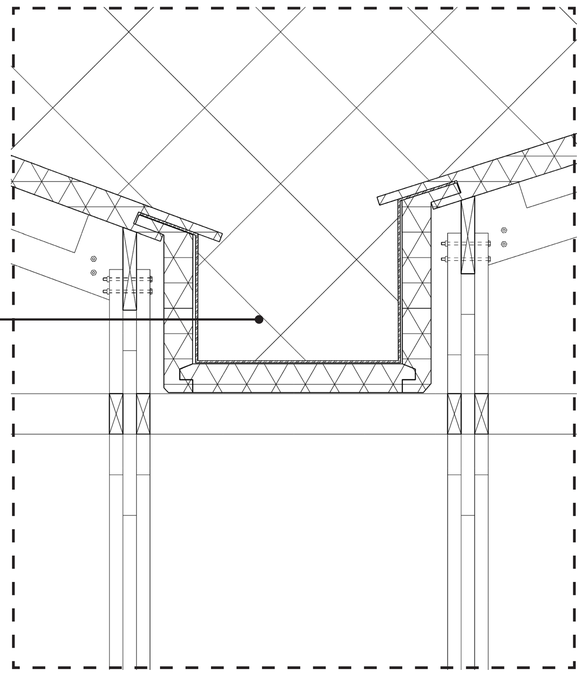
2nd &3rd Floor [1554m²]
- Workshops
- Offices
- Co-working Space

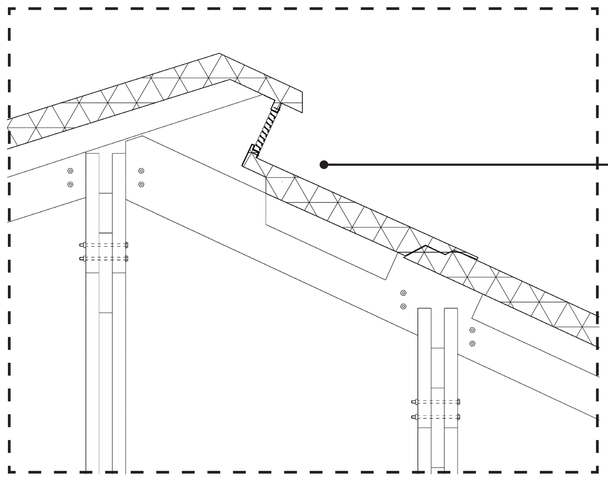
1st Floor Makerspace [972m²]
- Waste Elaboration & Rehabilitation Space
- Multipurpose Workshop Space
- Advanced Manufacturing Space
- Computer Room
- Offices
- Common area
- Auditorium
- Auxiliary Spaces

Ground Floor [504m²]
- MRF
- Storage facility
- Lobby



Gutter





Ventilation

Details

Second-Skin Facade Intermediate Space Qualities

Routing

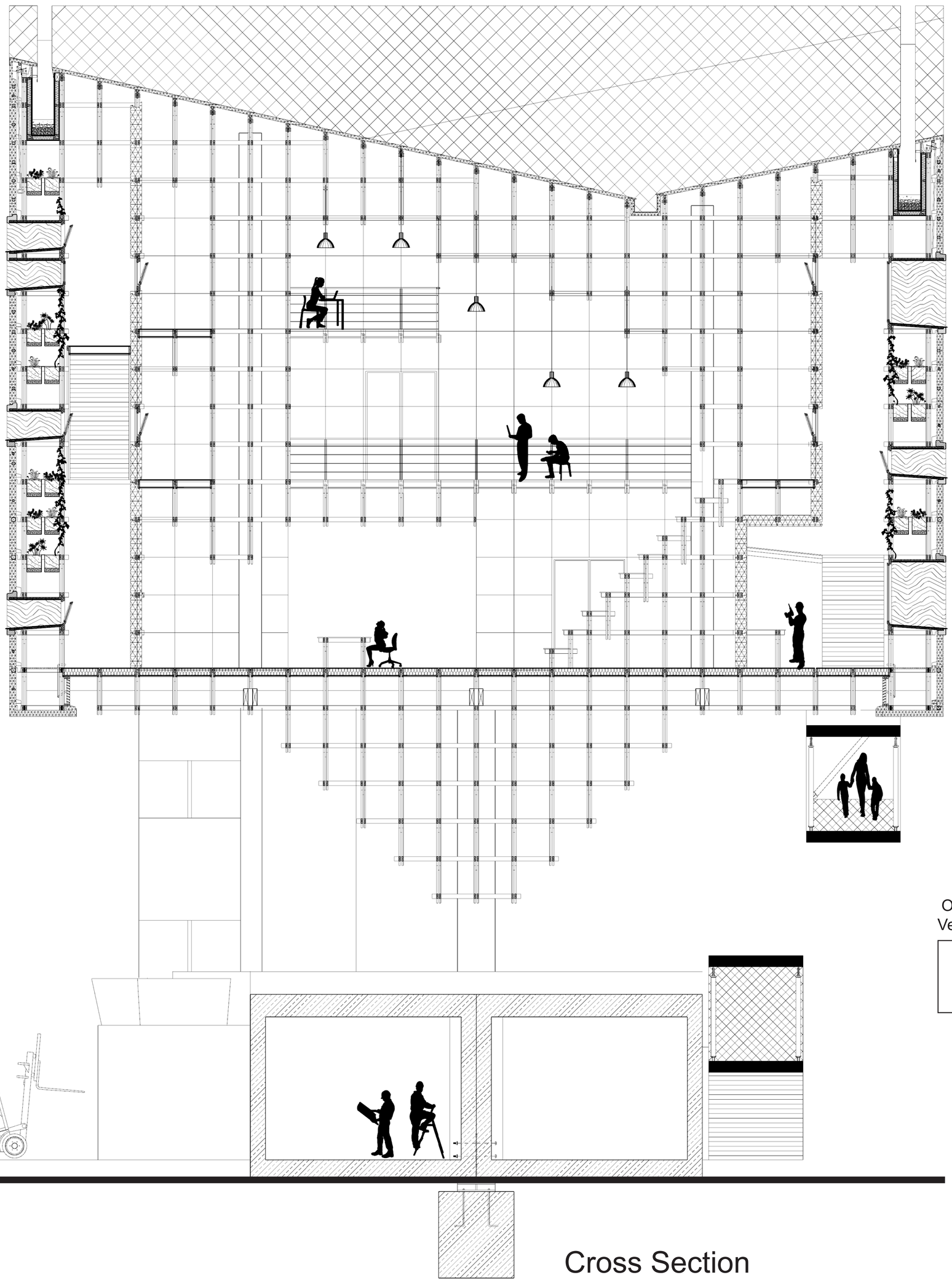
Ventilation

Making Space

Vegitation

Break

Climate Control

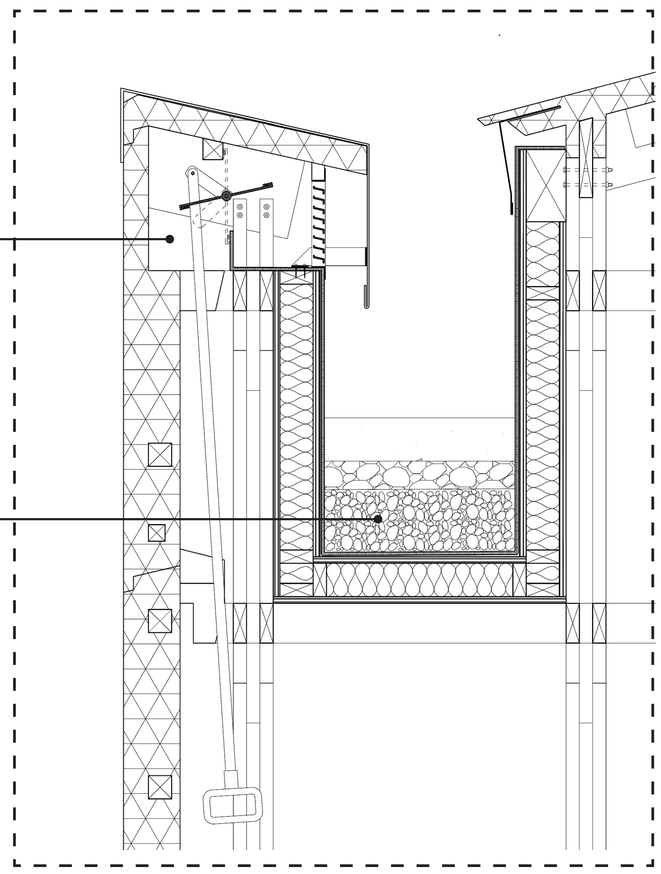


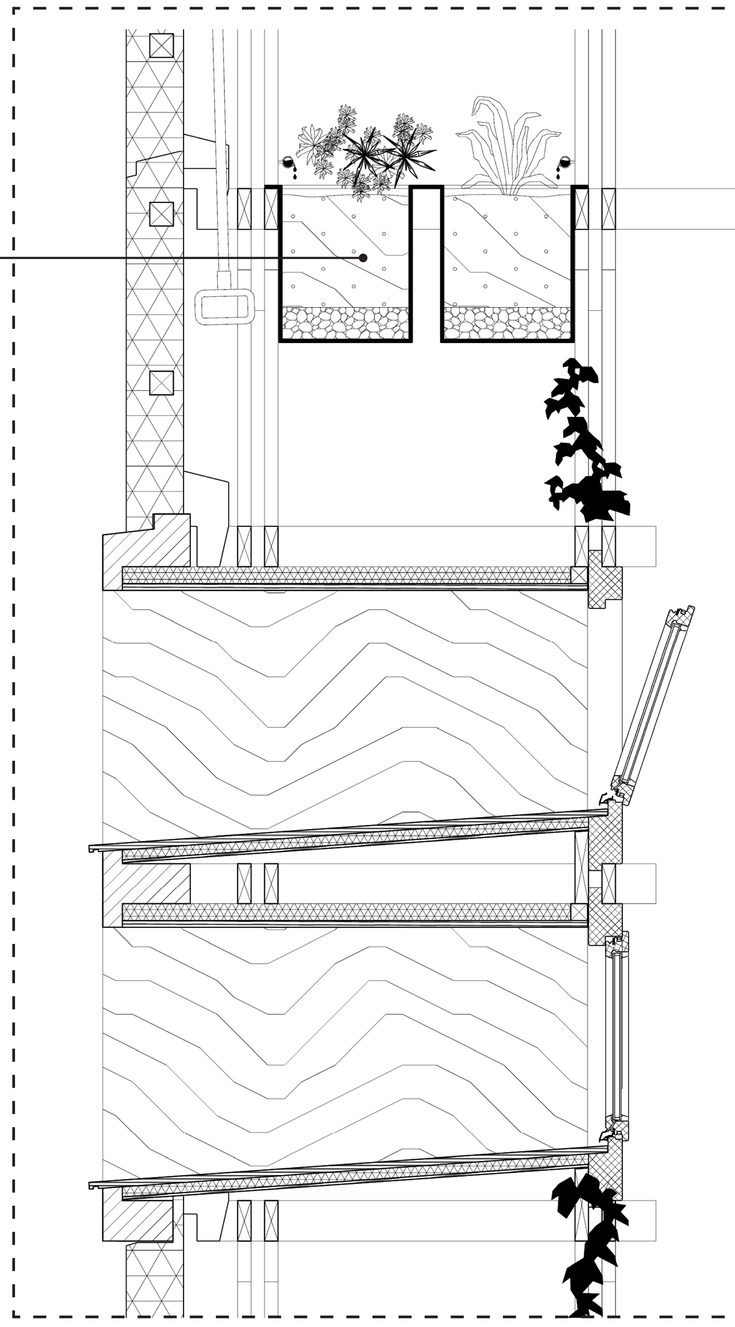
Cross Section

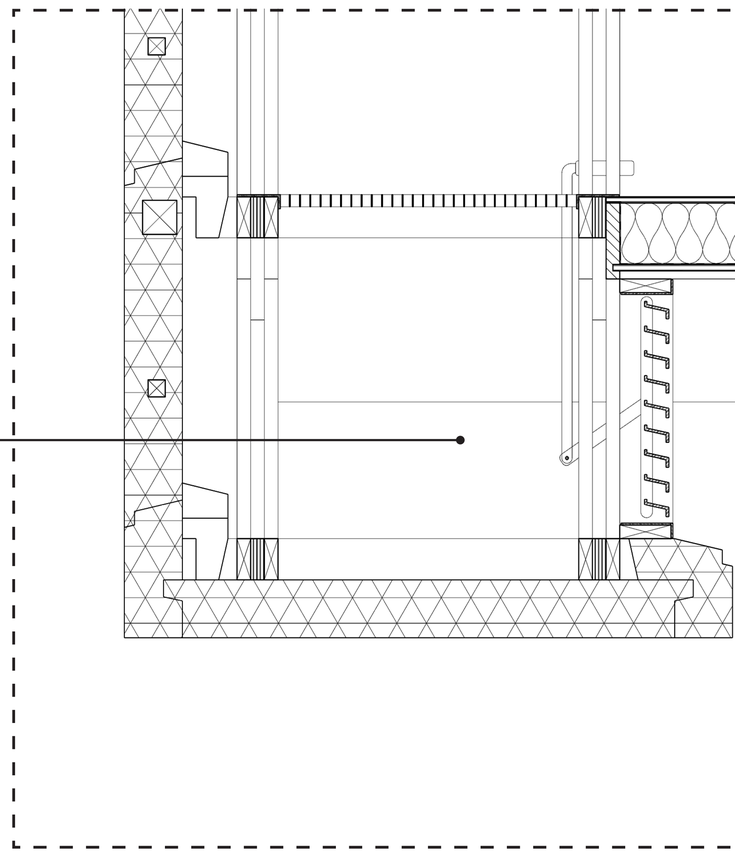
Operable Ventilation

Natural Water Filtration System

Vegitation

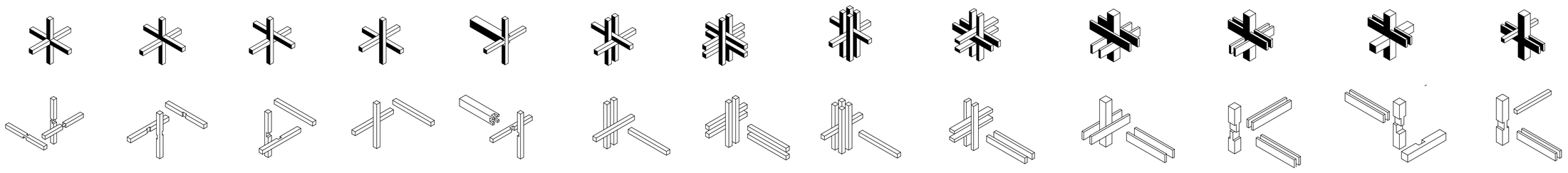






Operable Ventilation

Timber Joints in x,y,z Directions Study



Demountable Framework of Salvaged Timber Parameters

Fluctuating Life-cycle

Variable Dimensions

Interlocking Ability

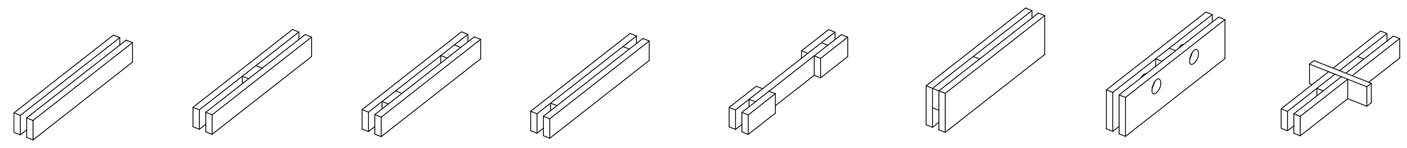
Fixings Minimization

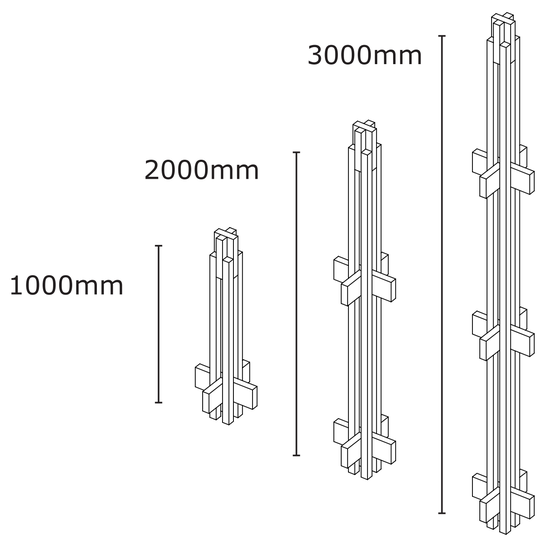
Variable Types & Quality

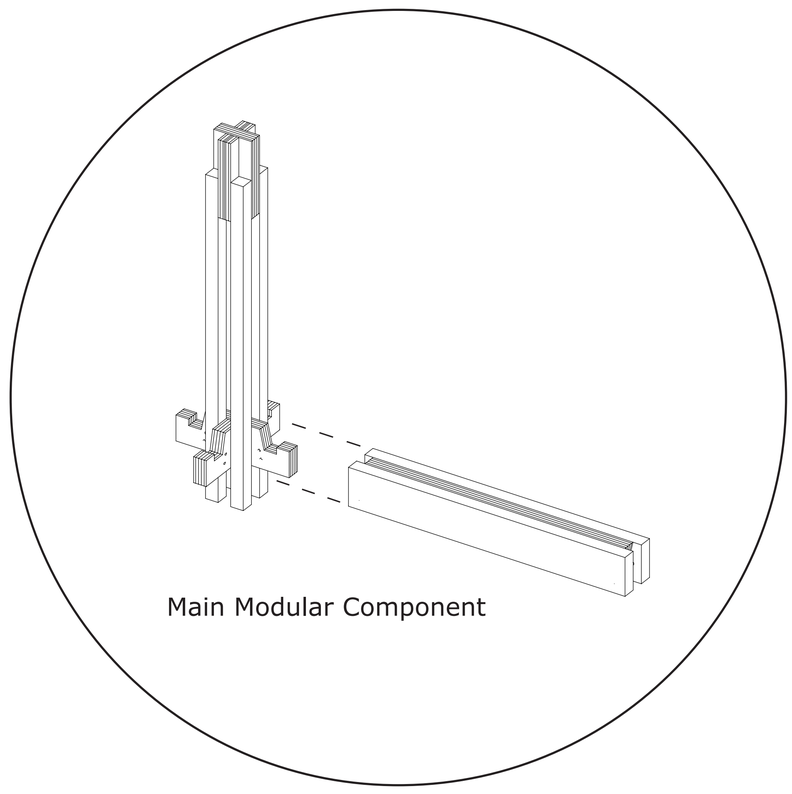
Robust Joinery

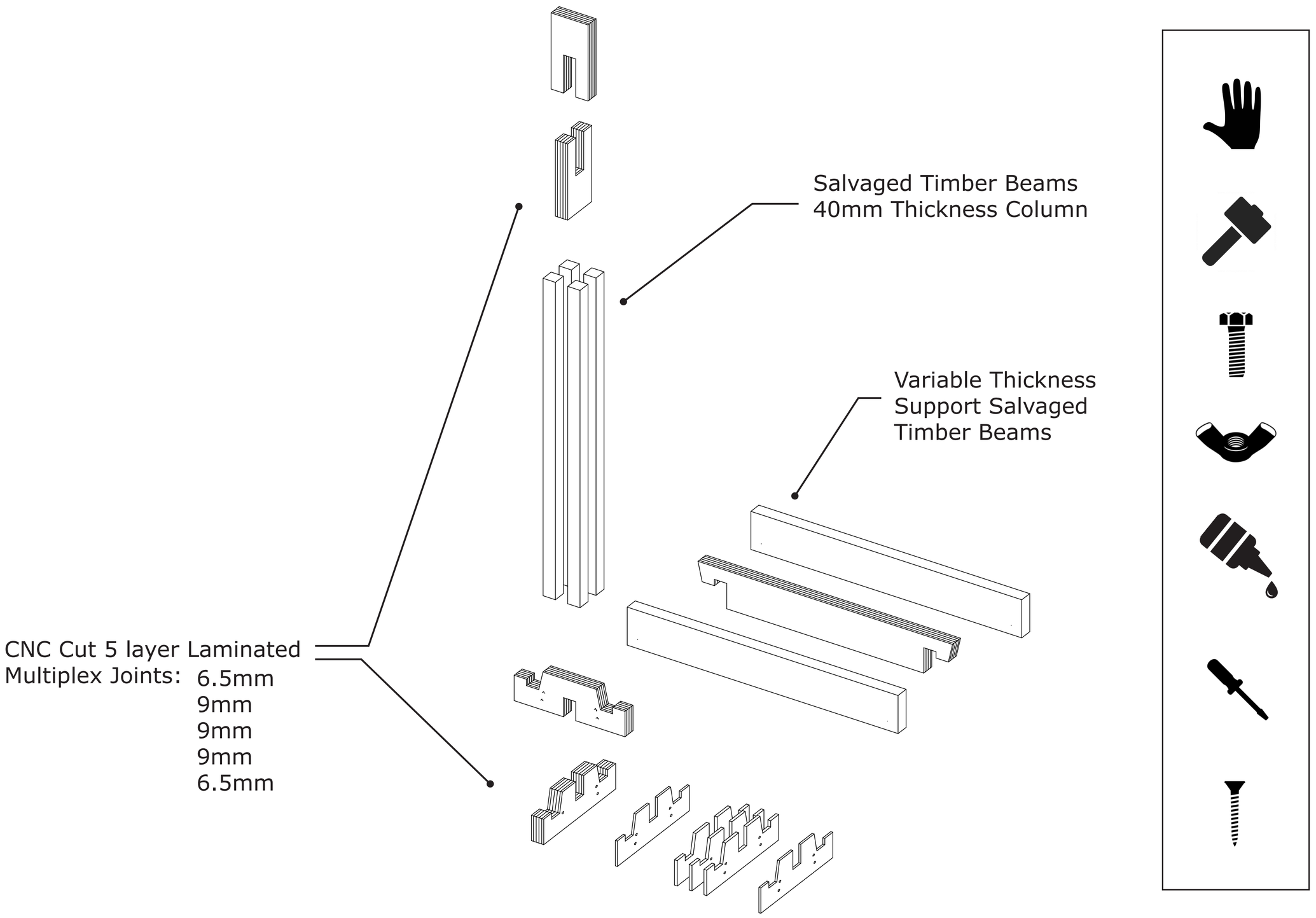
Plug-In Modular Function

Different Interlocking Beam Components

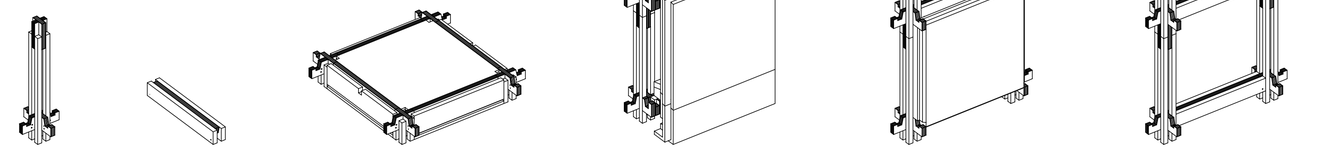








Modular System Building Elements



1. Main Component

2. Expansion Beam

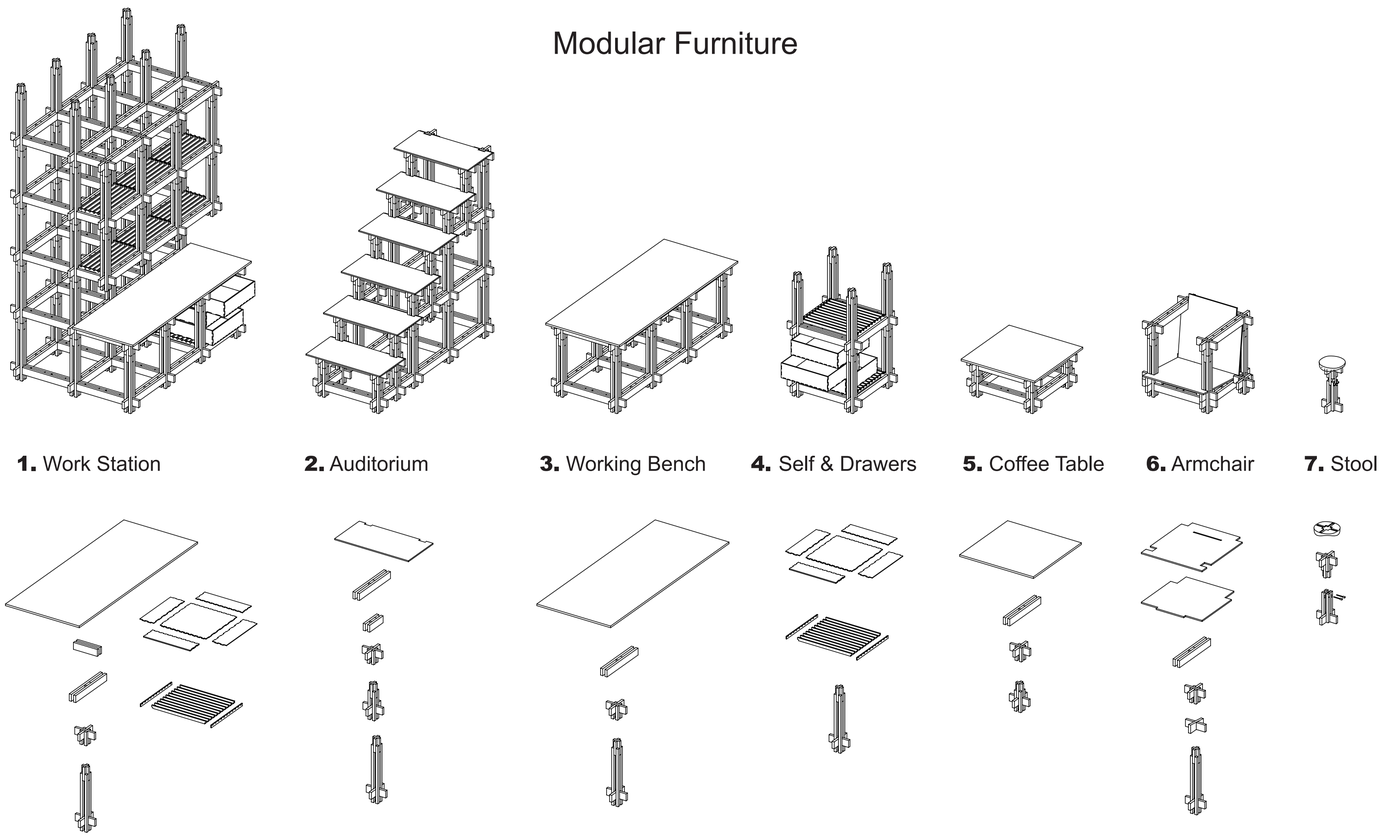
3. Floor Component

4. Exterior Facade Plastic Component

5. Interior Facade Component

6. Roof Connection

Modular Furniture



1. Work Station

2. Auditorium

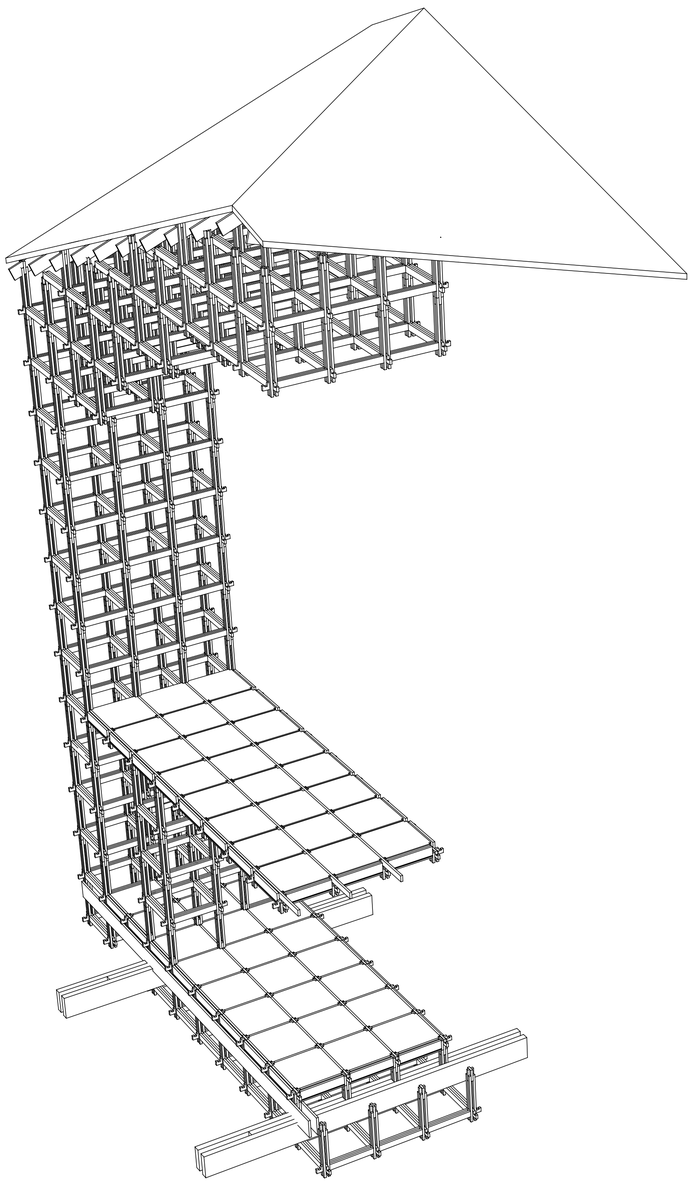
3. Working Bench

4. Self & Drawers

5. Coffee Table

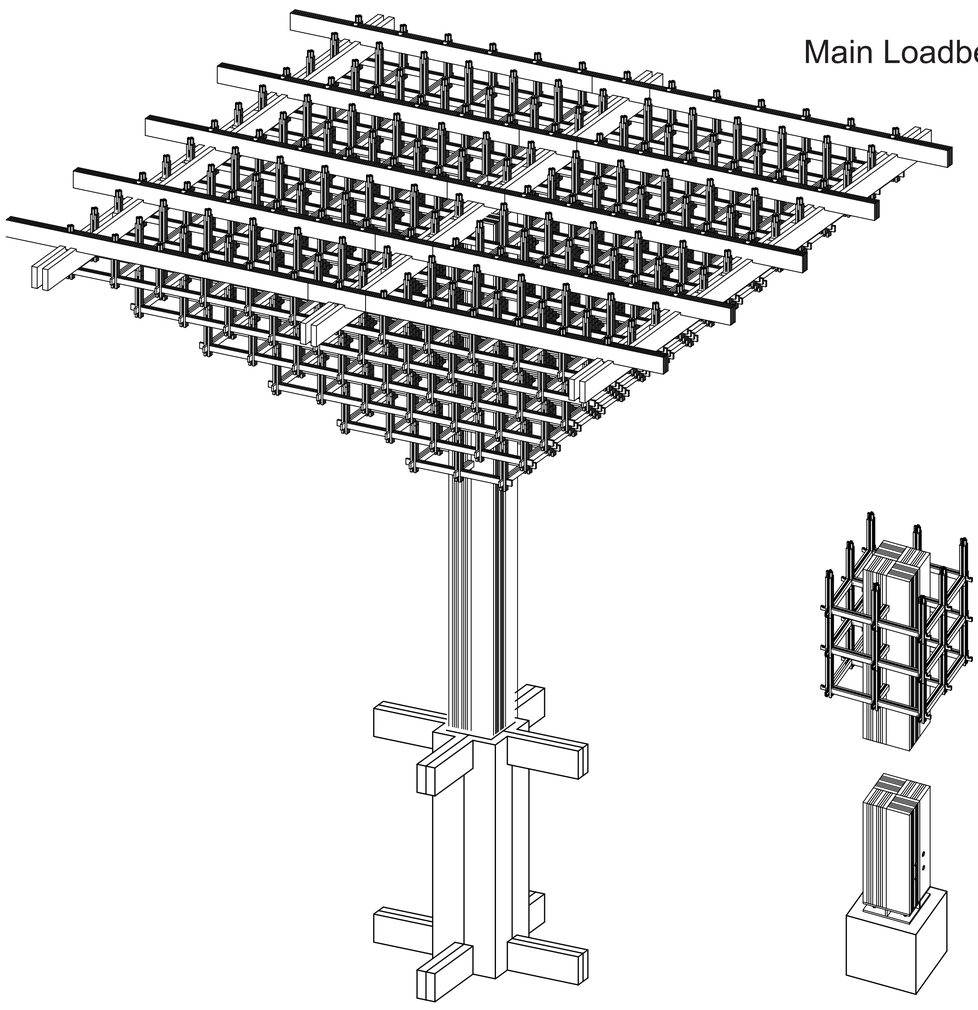
6. Armchair

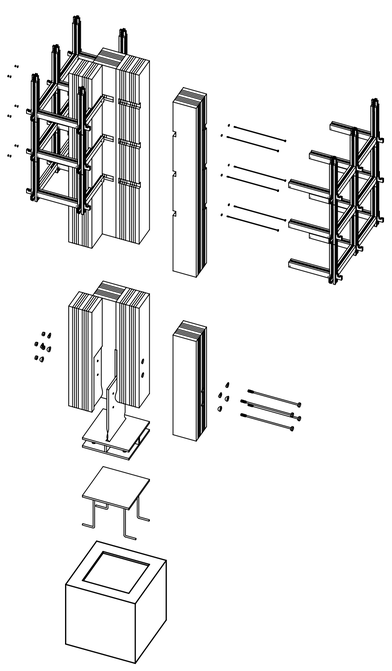
7. Stool



Floor Development Buliding Fragment

Main Loadbearing Column System

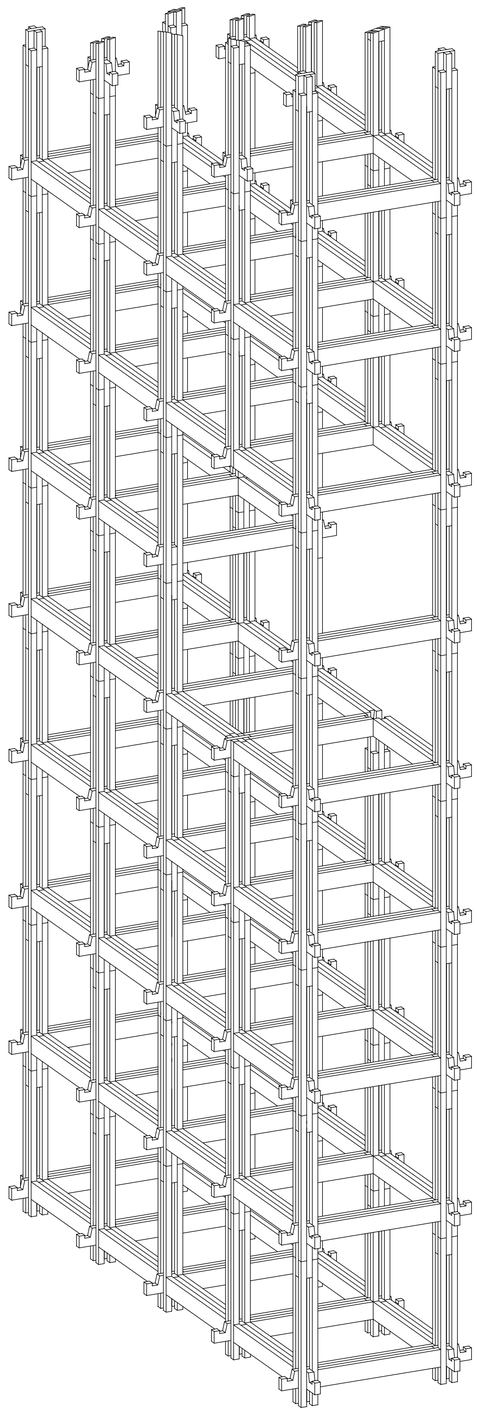


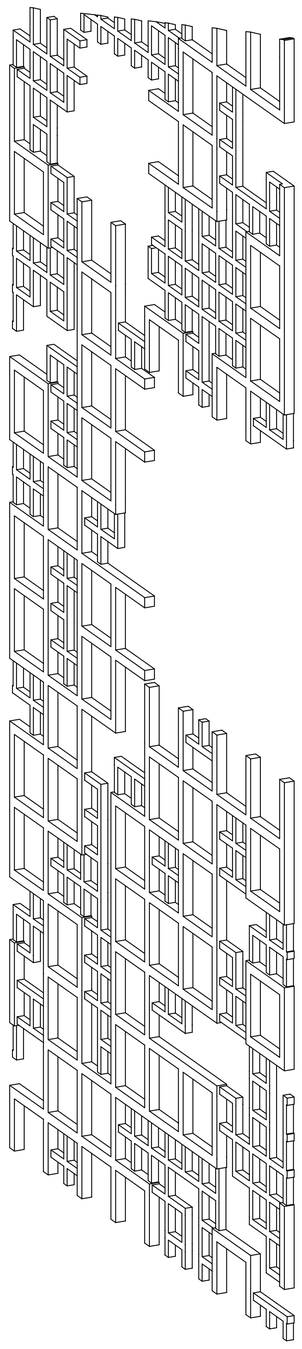


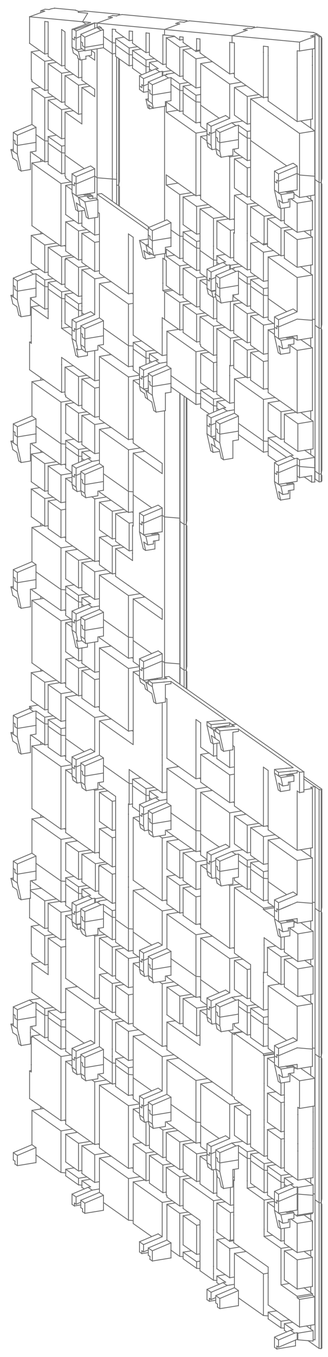
Concrete Support of Platforms Concrete Modular System

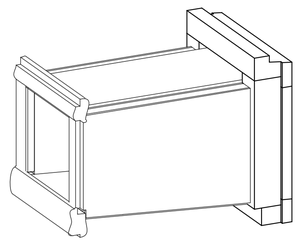
Foundation Detail

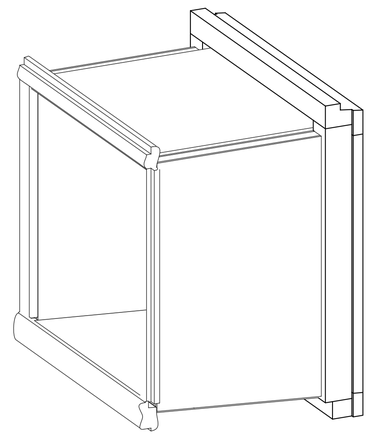
Bulding Fragment of South-East Facade

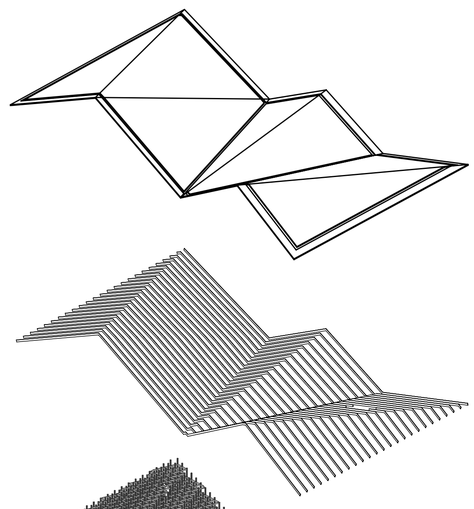












Plastic Roof Tiling

Timber Roof SupportingBeams

Timber Floor Formation

Timber Fluctuating Sealing

Timber Framework Facade Pattern

Exterior Facade Plastic Layer

Ramp-Routing

Timber columns 1000x1000mm

Concrete Modular Platform 6x6m

Vertical Routing

Shorting Containers