Thesis Presentation

MSc in Architecture, Urbanism & Building Sciences
Building Technology Track

June 20th, 2022 - BK, TuDelft

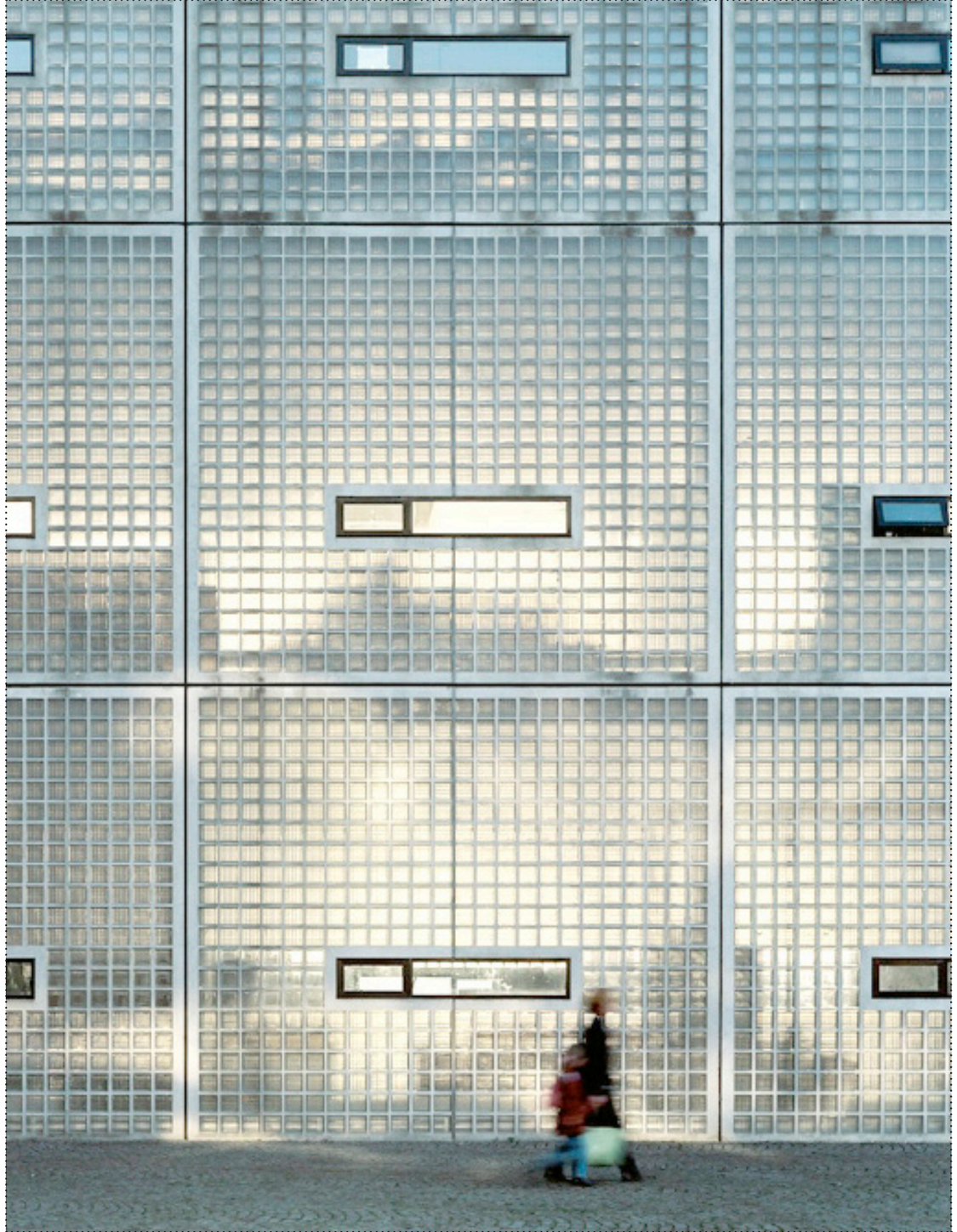
Anurag Sonar . 5201756

[The Glass Fortress, Thailand. Archsmith Architects]

[Qaammat Pavilion, Greenland. Konstantin Arkitekter]

Hollow Glass Block

[Clear-1919_8-Samba. Seves Glass Block]



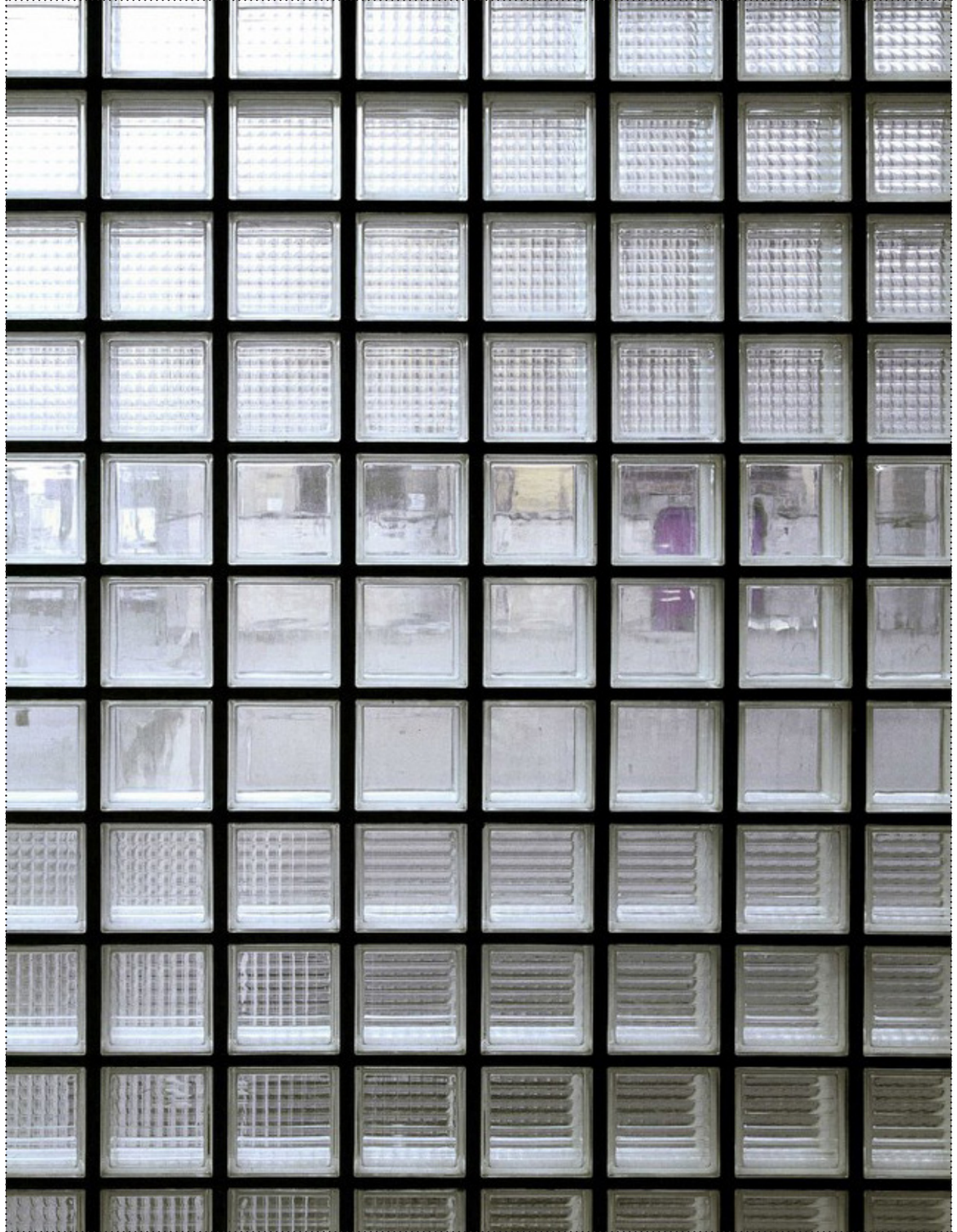
[Academy of Arts, Maastricht. Wiel Arets Architects]

Hollow Glass Block Characteristics

+

Thermal Performance

Sound Insulation



[Academy of Arts, Maastricht. Wiel Arets Architects]

Hollow Glass Block Characteristics

+

Thermal Performance

Sound Insulation

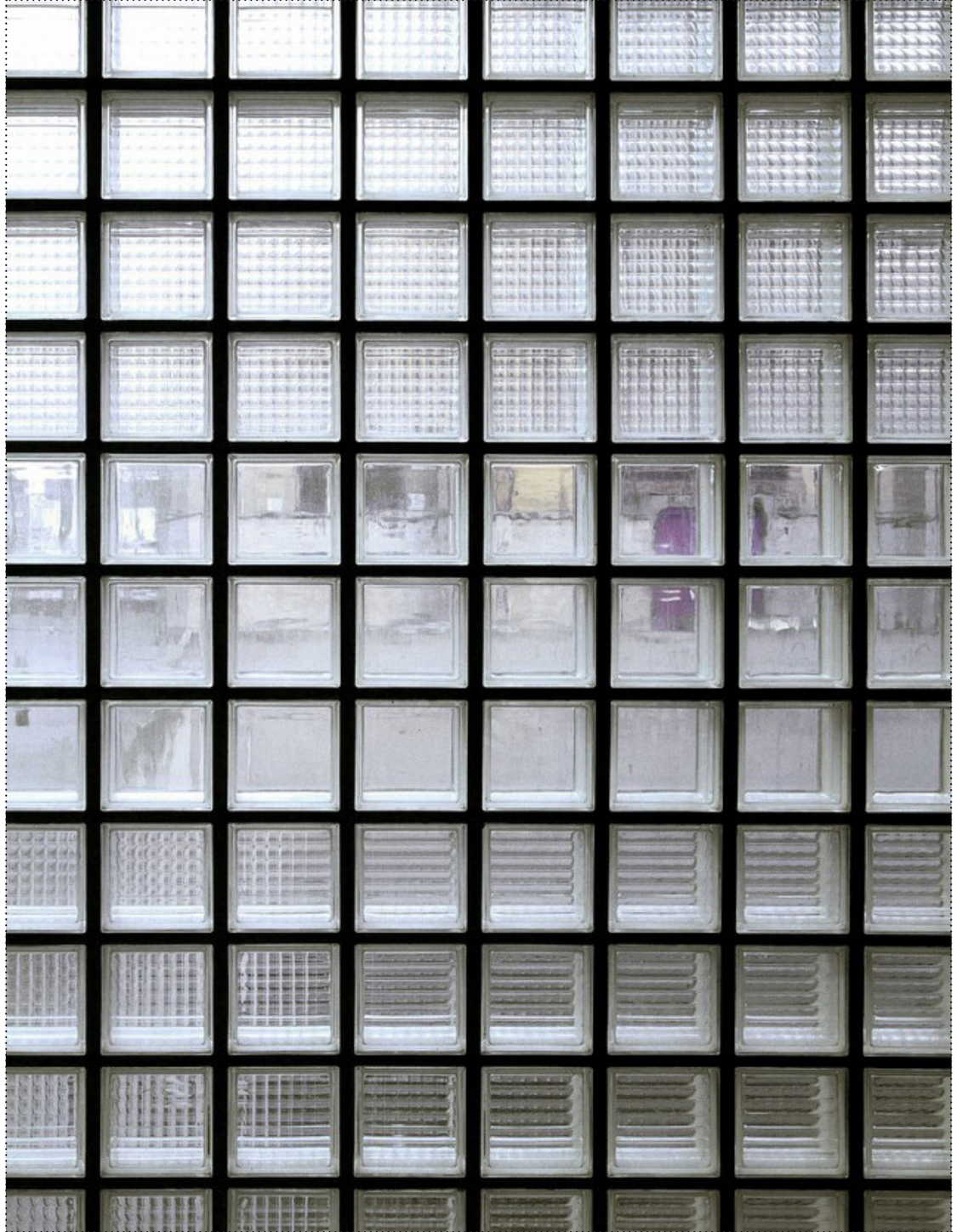
-

Non load-bearing

Compromised Transparency

Not replaceable

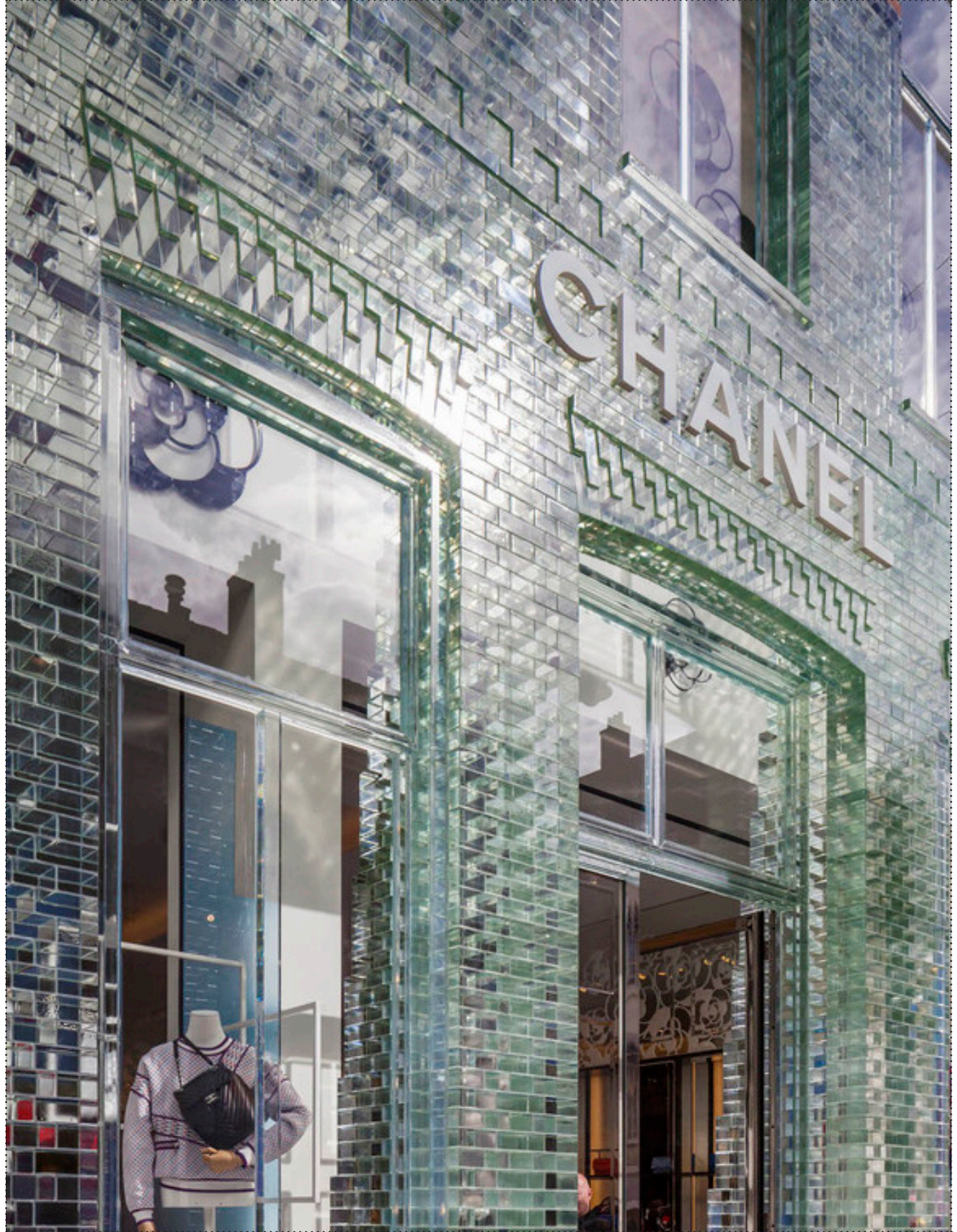
Not recyclable



[Academy of Arts, Maastricht. Wiel Arets Architects]

Solid Glass Block

[Poesia Arctic Crystal Natural. Absolute Brilliance Glass Blocks]



[The Crystal House, Amsterdam. MVRDV]

Solid Glass Block Characteristics

Load Bearing Capacity

+

High Transparency

Sound Insulation

[The Crystal House, Amsterdam. MVRDV]

Solid Glass Block Characteristics

Load Bearing Capacity

\+

High Transparency

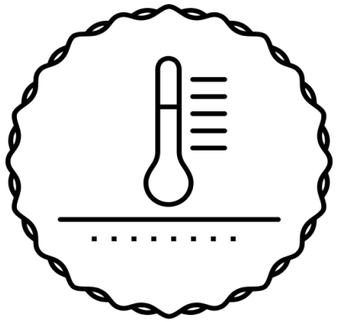
Sound Insulation

\-

Thermal Performance

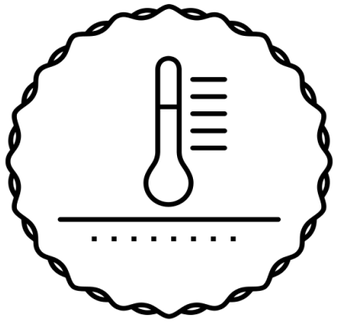
[The Crystal House, Amsterdam. MVRDV]

Compromise



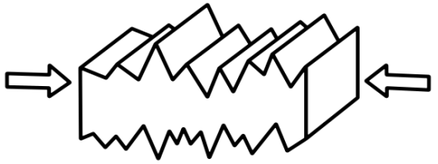
Thermal Performance

Compromise



Thermal Performance

or



Load Bearing Capacity

Glass block with the characteristics of both ?

Hybrid Glass Block

Hybrid Glass Block

Combination of **hollow** and **solid glass blocks** designed as a **single product** with **good thermal performance** and **load-bearing capacity**

- **Thermal Performance**
- **Structural Performance**

[Nathani. T, 2020 & Veden. M, 2019]

- Design development
- Manufacturing process
- Assembly system
- Recyclability

Product development of Hybrid Glass Blocks

Rethinking shape-manufacturing process-assembly system

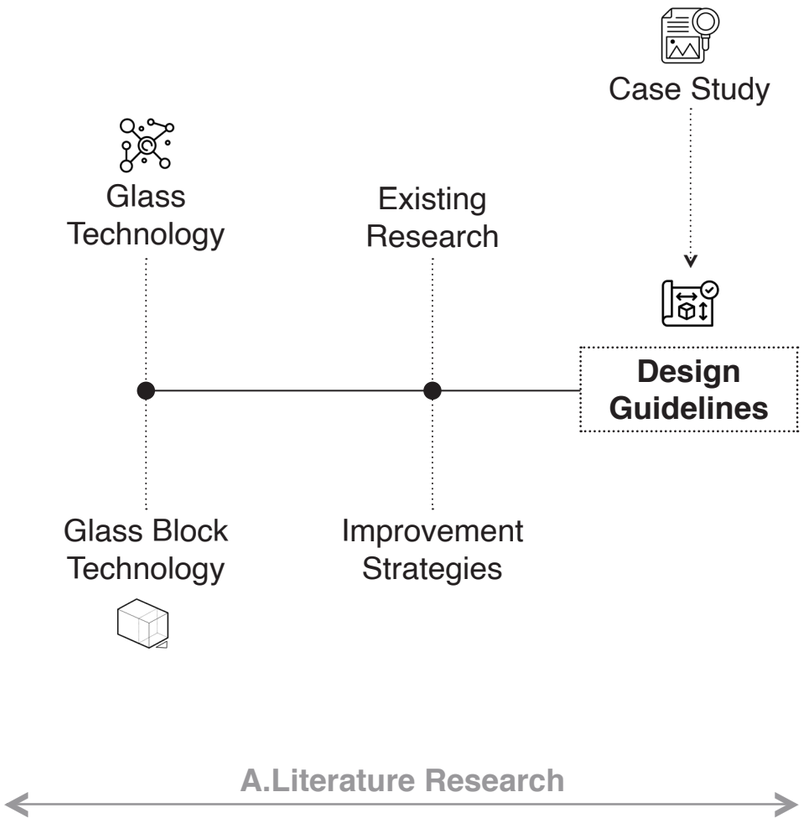
Main Research Question

What are the main **design considerations** and **challenges** in **designing** and **manufacturing** a hybrid glass block system that exhibits good **thermal** and **structural performance**?

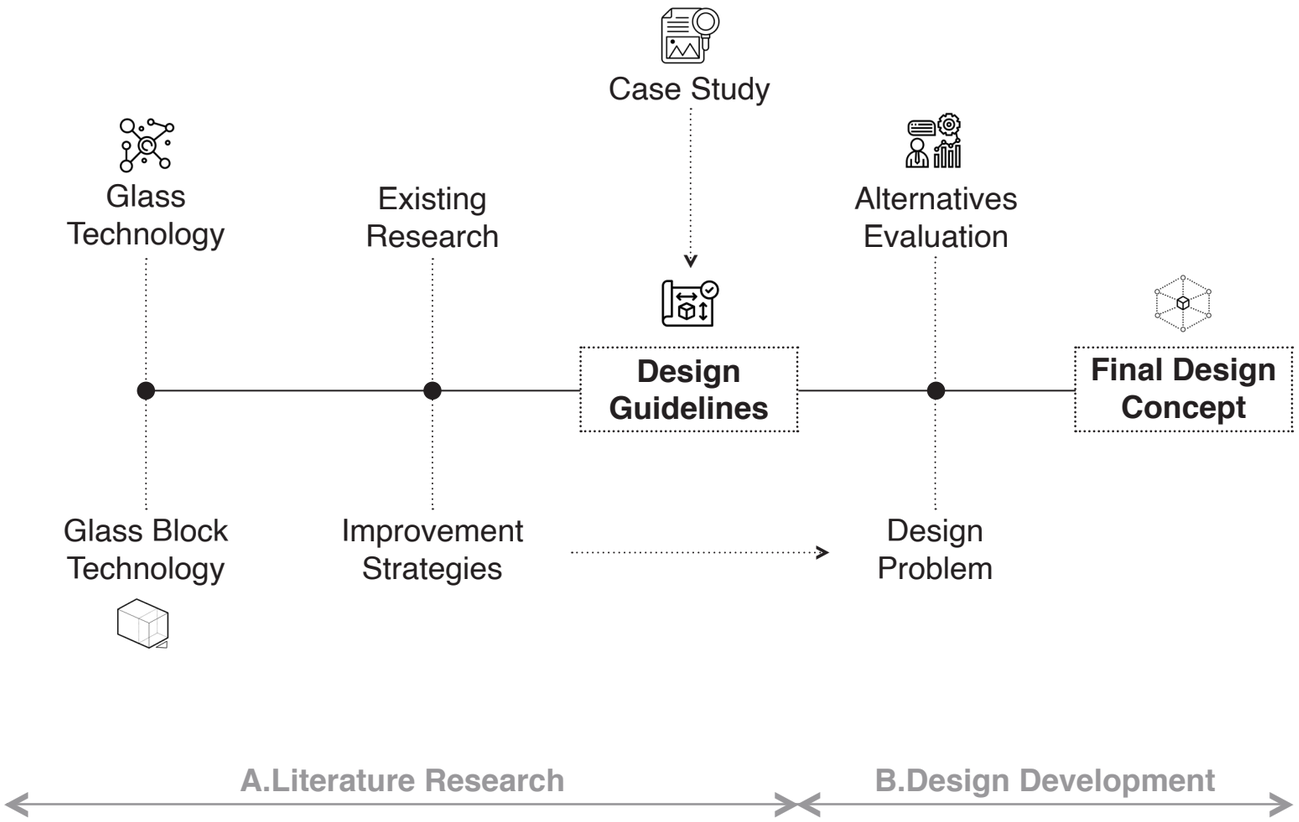
01

Research Methodology

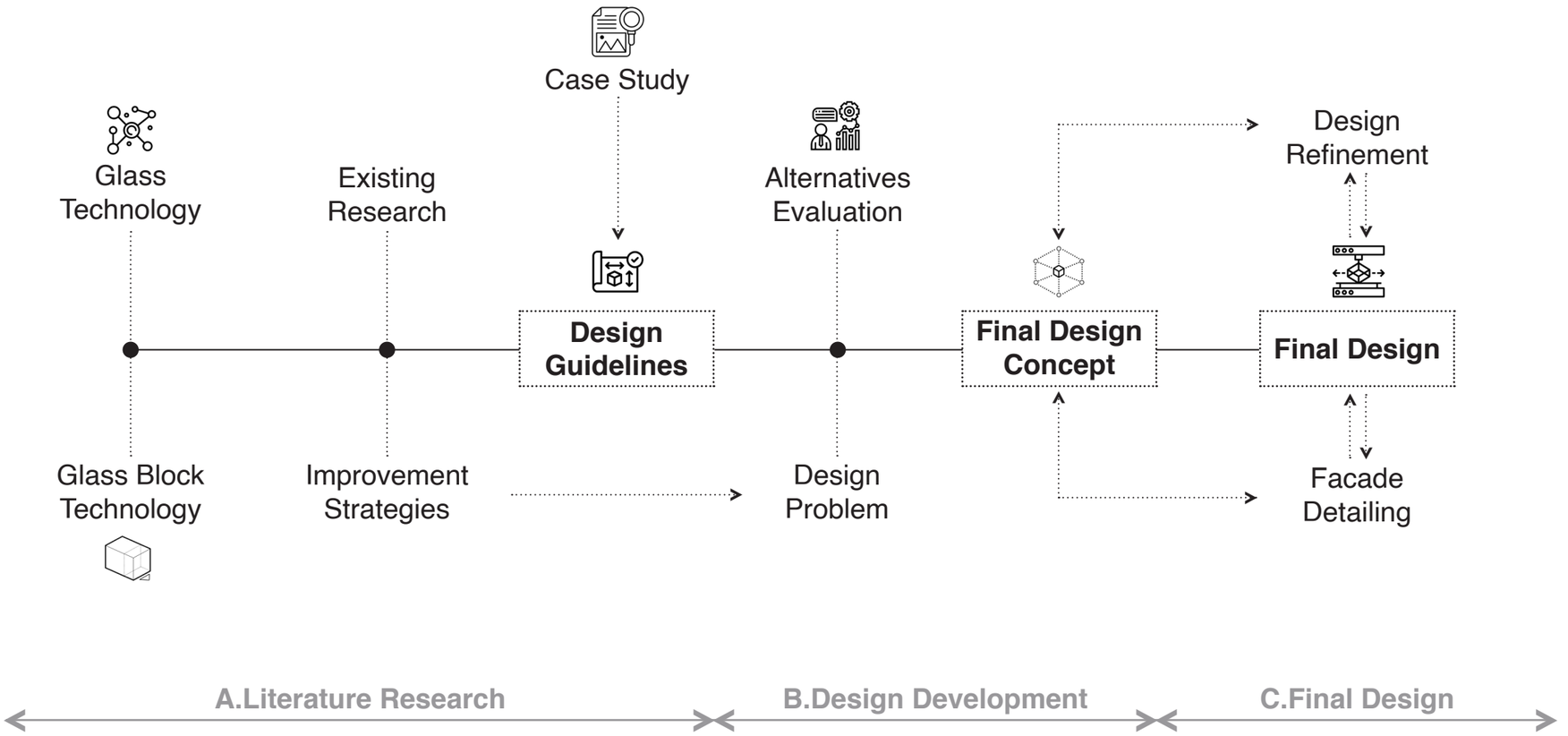
Research Methodology



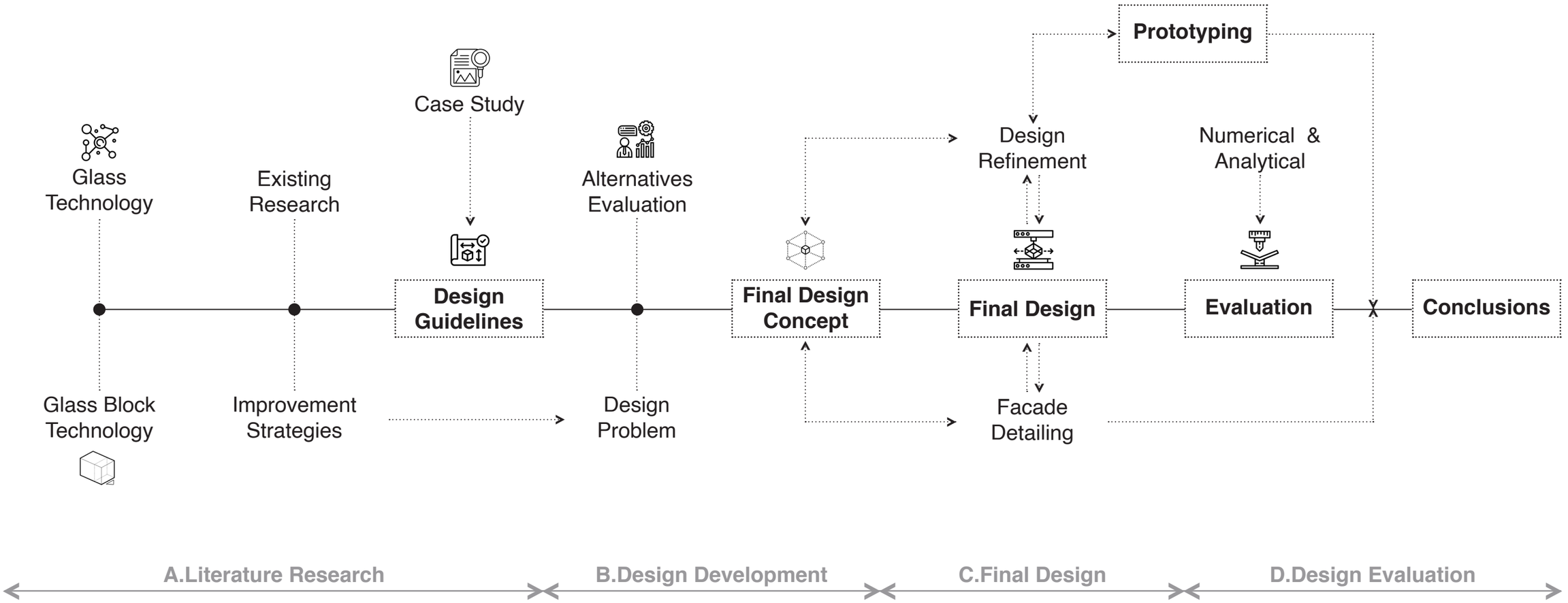
Research Methodology



Research Methodology



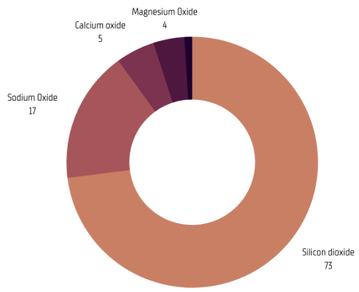
Research Methodology



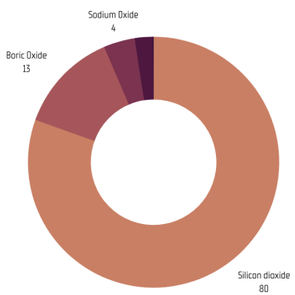
A

Literature Research

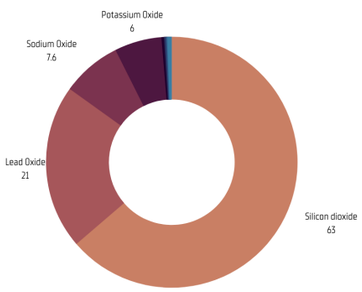
Material Composition



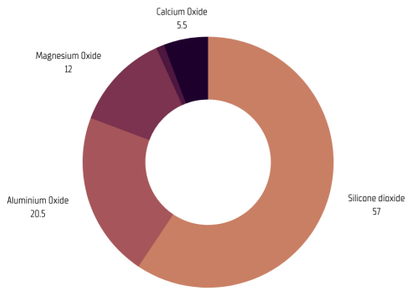
Soda-lime



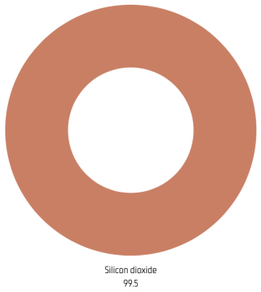
Borosilicate



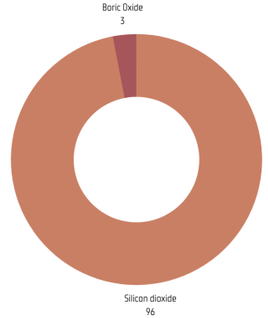
Lead Silicate



Aluminosilicate



Fused Silica



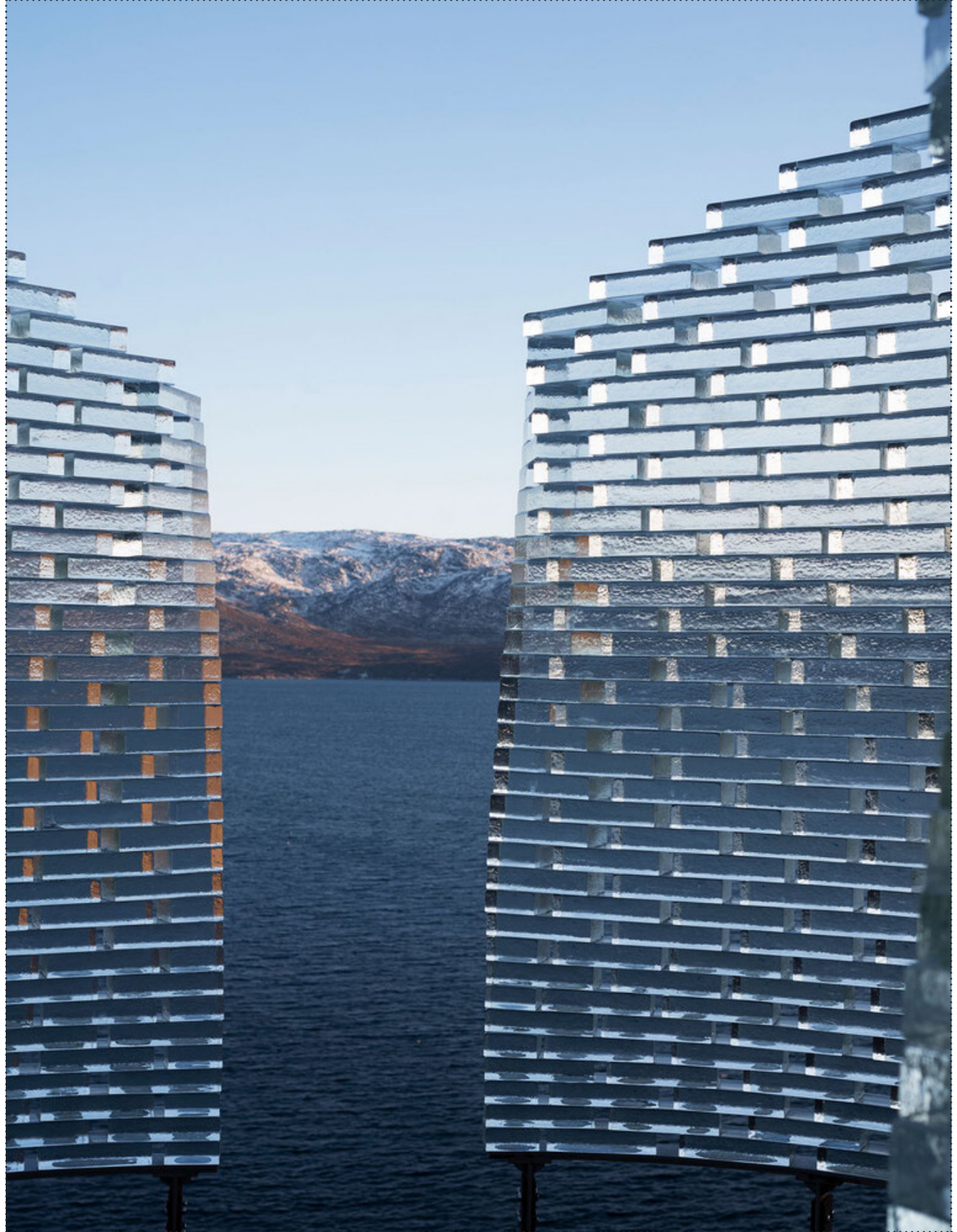
96% Silica

[Material Compositions & glass properties. Adapted Shand Armistead 1958]

Selected Glass Type

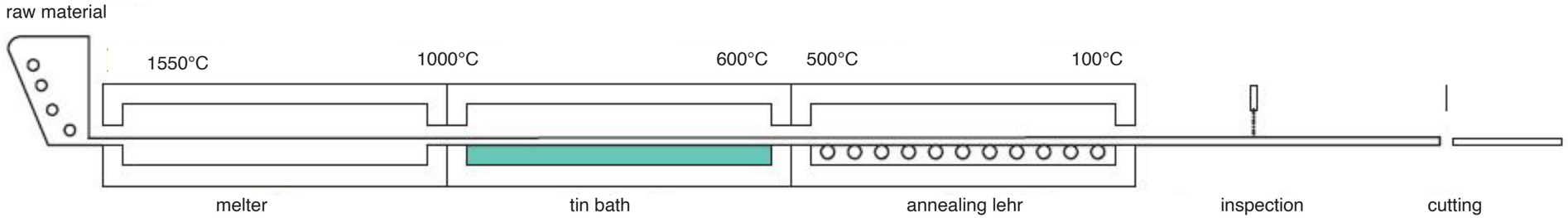
Borosilicate Glass

Low Thermal Expansion & annealing point, high thermal resistance, clear glass

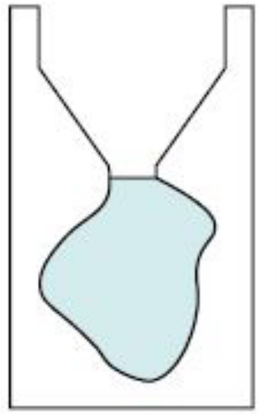


[Qaammat Pavilion, Greenland. Konstantin Arkitekter]

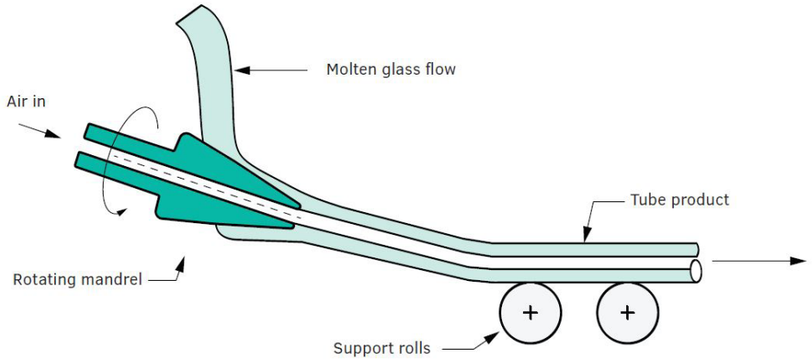
Manufacturing process



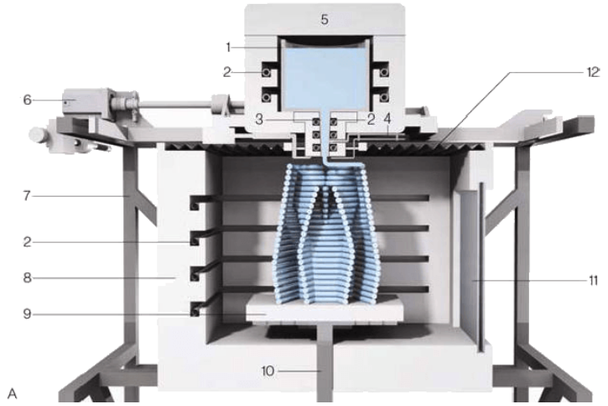
Float Method



Casting



Extruded Method



3D printing

[Worner, Oikonomopoulou. F, Velden. M, Klein. J]

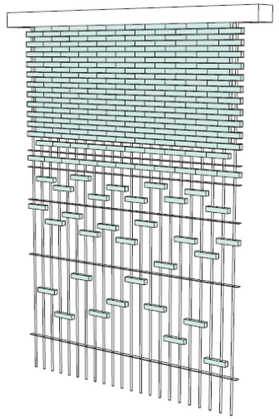
Selected Manufacturing process

Casting

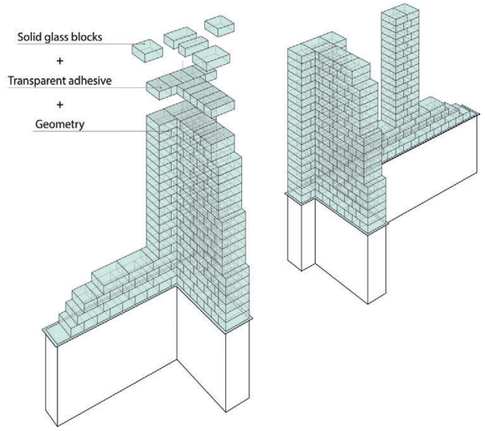
Smooth & transparent surface,
Freedom in shape & volume,
standard size - 20,000 [kgs]

[Casting of Soda-lime glass blocks at Poesia factory in Italy. Oikonomopoulou. F]

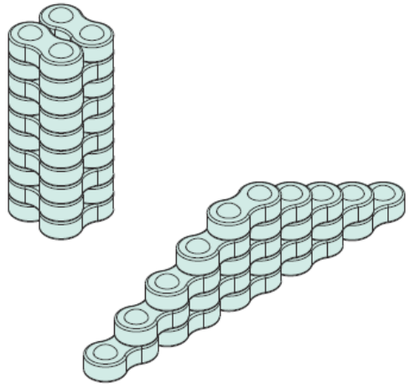
Assembly System



Metal Substructure



Adhesive



Dry - Interlocking

[Glass block installation methods. Oikonomopoulou. F]

Selected Assembly System

Dry - Interlocking

With Interlayer, Ease in assembly
and disassembly, recyclable

[Interlocking Cast glass components, Glass Transparency Group. Oikonomopoulou. F]

Selected Assembly System

Dry - Interlocking

With Interlayer, Ease in assembly
and disassembly, recyclable

Need for exploration

[Interlocking Cast glass components, Glass Transparency Group. Oikonomopoulou. F]

Material

- Lower themal exp. coeff.
- High thermal resistance
- High compressive & tensile strength
- Lower annealing temp.
- Resistance to thermal shocks
- Resistance to chemicals

Production

- Freedom of shape & volume
- Thickness limitation
- Rounding the edges
- High precision steel mould
- Mass production
- Less production energy & wastage
- Good optical quality

Assembly

- Dry stacked-Interlocking
- Ease in assembly
- Modular approach
- Minimise site activities
- Reversible Connections
- Design for redundancy
- Intermediate Interlayer
- Design for dissassembly

Application

- Minimise energy use
- Ease in maintenance
- Provide possibilities to adapt
- Ease in replaceability

End-of-life

- Consider durable materials in relation to life-span & reuse
- Design for dissassembly on all levels
- Maximise reusability & recyclability

Quality

- Production time in terms of standardisation
- Intergrate with building process
- Developemnt of scenarios for product use

Design Guidelines

Performance

15 - 25 [MPa]
Compressive Strength

1.6 - 2.2 [W/m2k]
Thermal Insulation

Design Guidelines

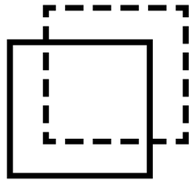
Performance

15 - 25 [MPa]
Compressive Strength

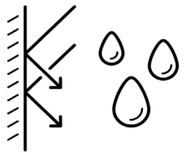
1.6 - 2.2 [W/m2k]
Thermal Insulation

Visual + Safety

40 - 50 [dB]
Sound Insulation



70 - 80 [%]
Light Transmission



45 [min UL]
Durability

Design Guidelines

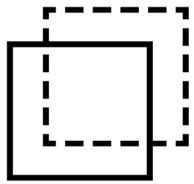
Performance

15 - 25 [MPa]
Compressive Strength

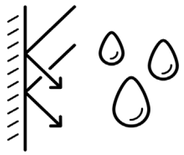
1.6 - 2.2 [W/m2k]
Thermal Insulation

Visual + Safety

40 - 50 [dB]
Sound Insulation

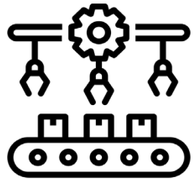


70 - 80 [%]
Light Transmission

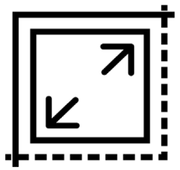


45 [min UL]
Durability

Standardisation



min. no. process
Ease in Manufacturing



10 - 15 [kg], max. 100 [mm] thk
Size & Weight

Design Guidelines

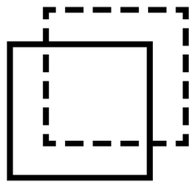
Performance

15 - 25 [MPa]
Compressive Strength

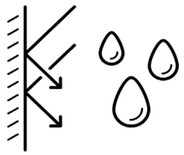
1.6 - 2.2 [W/m2k]
Thermal Insulation

Visual + Safety

40 - 50 [dB]
Sound Insulation

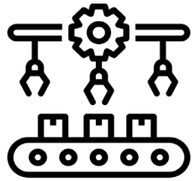


70 - 80 [%]
Light Transmission



45 [min UL]
Durability

Standardisation



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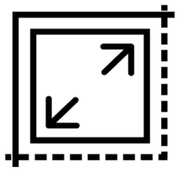
Ease in Manufacturing



10 - 15 [kg], max. 100 [mm] thk
Size & Weight

Sustainability

Reversible + Reusable
Recyclability

B

Design Develpoment

Academy of Arts, Maastricht

[Academy of Arts, Maastricht. Wiel Arets Architects]

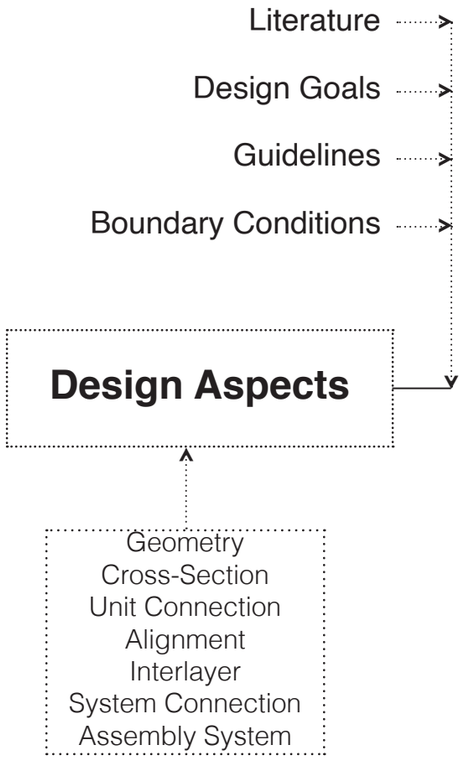
Academy of Arts, Maastricht

Maximise Transparency
Ease of Assembly
Design for Disassembly
Recylability

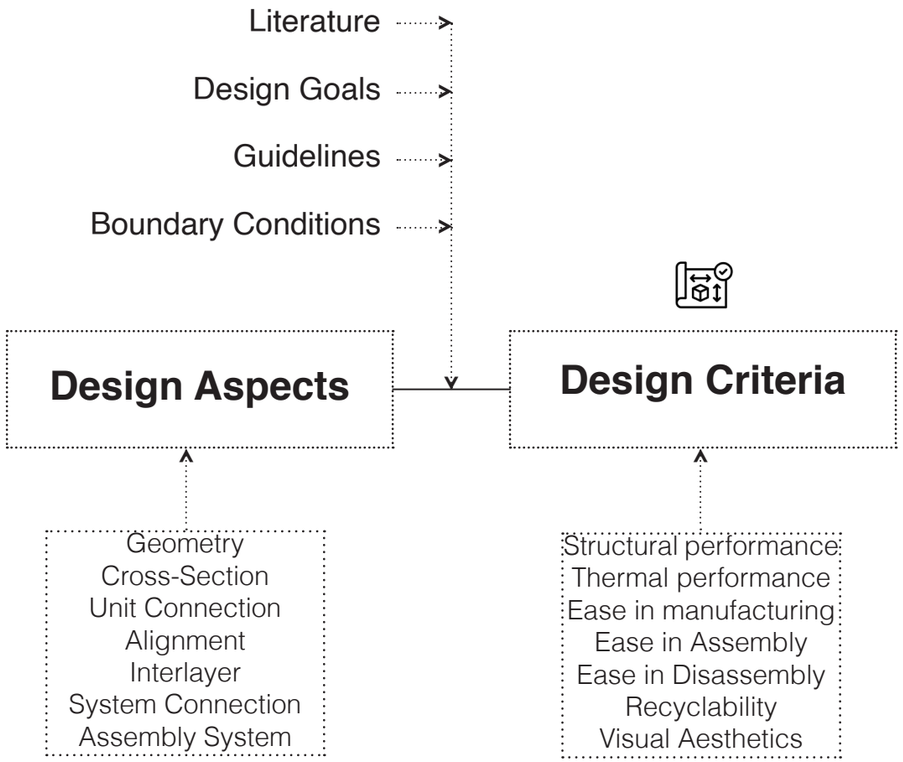
[Academy of Arts, Maastricht. Wiel Arets Architects]

To develop a **hybrid glass block system** with good **thermal** and **structural** performance, efficient **manufacturing** process, ease in **assembly-disassembly**, **recyclability** and visual **aesthetics**.

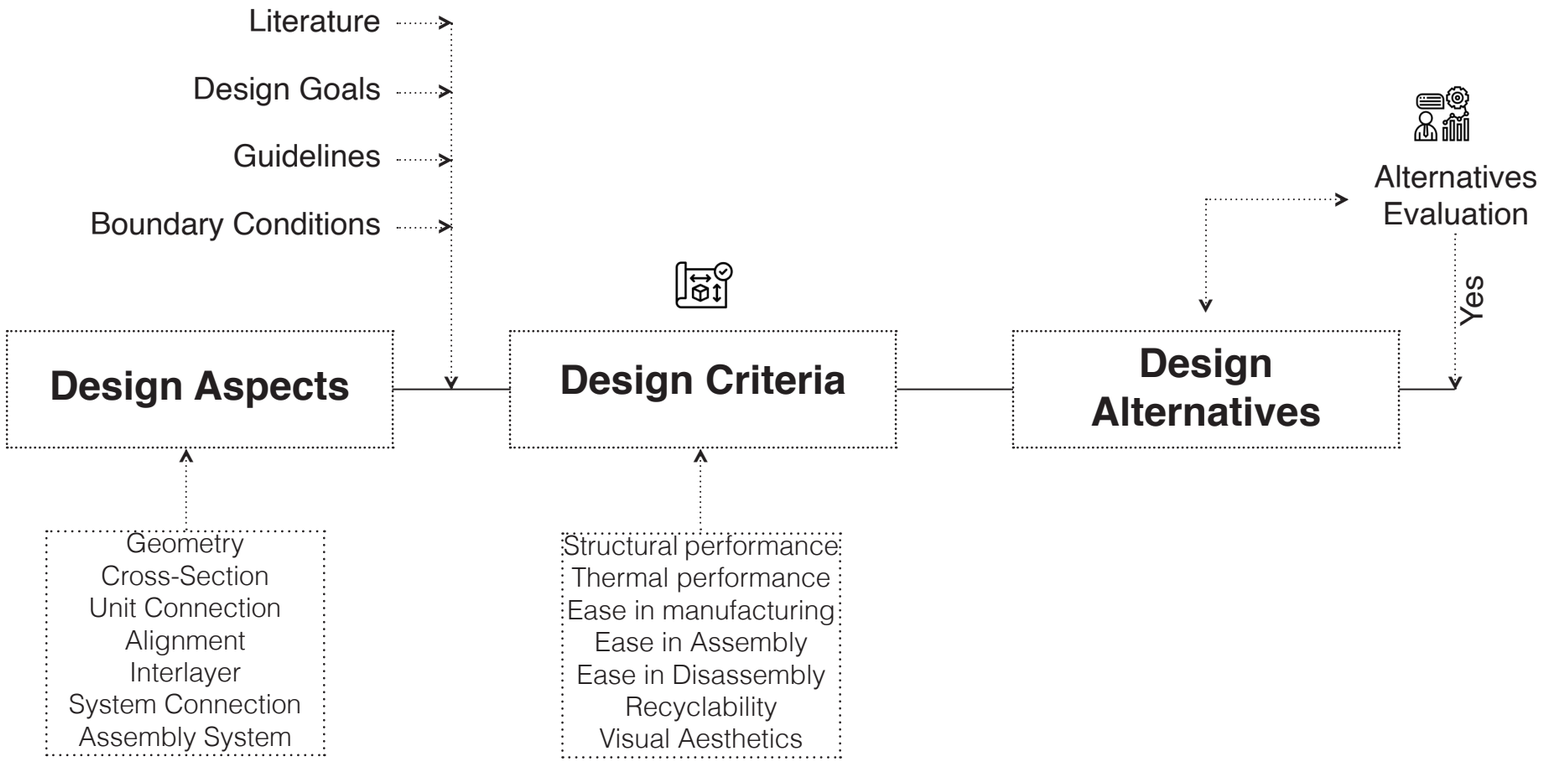
Design Methodology



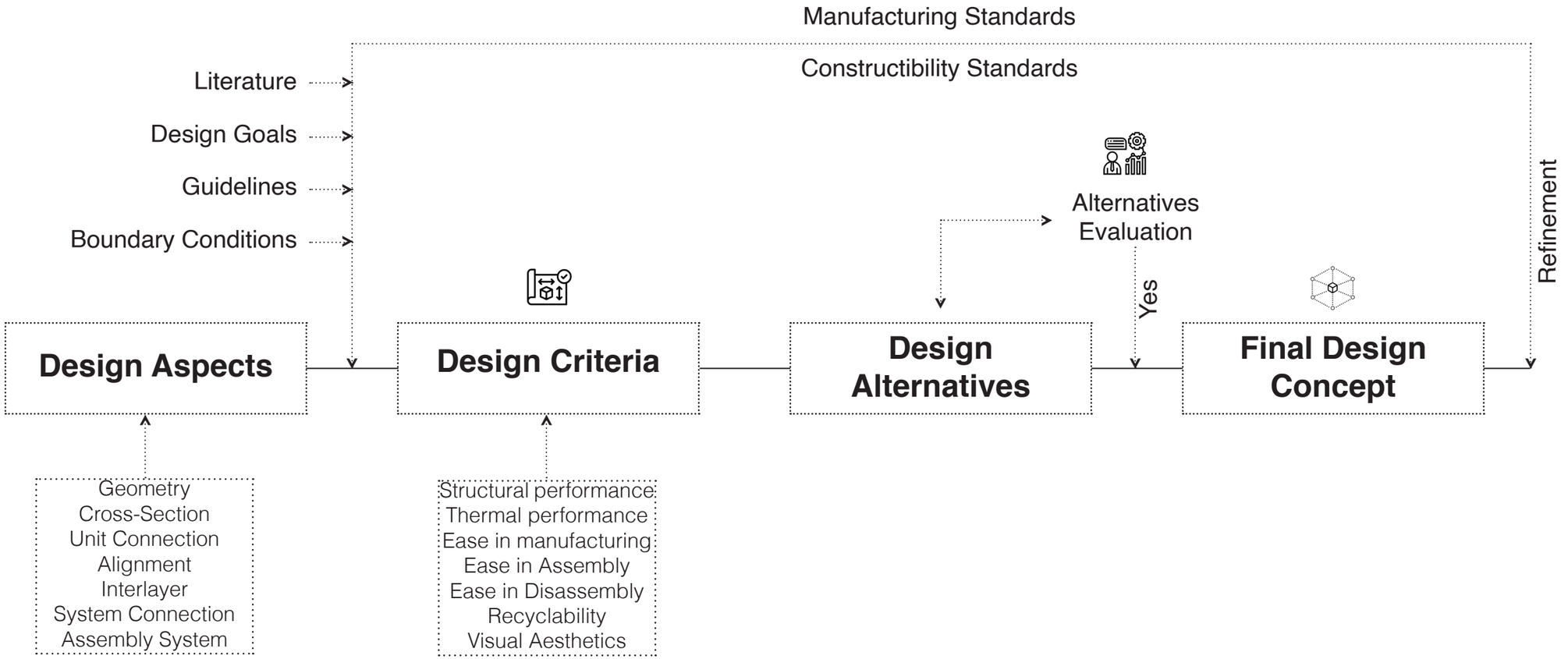
Design Methodology



Design Methodology



Design Methodology



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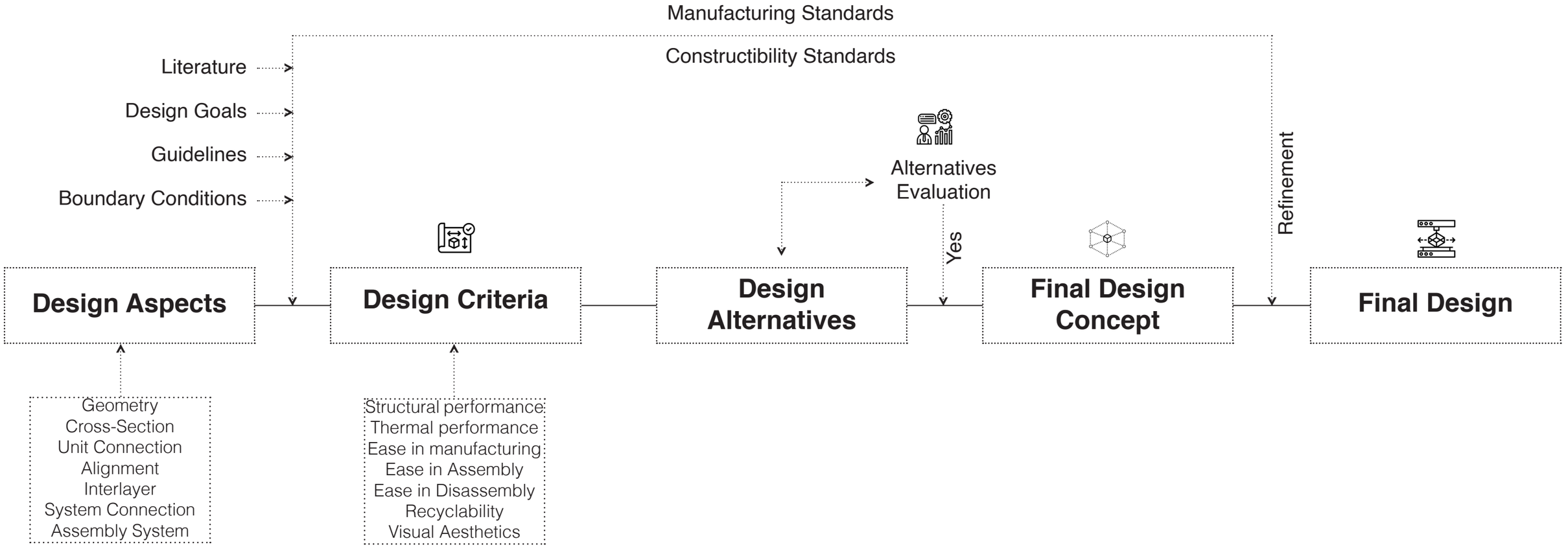
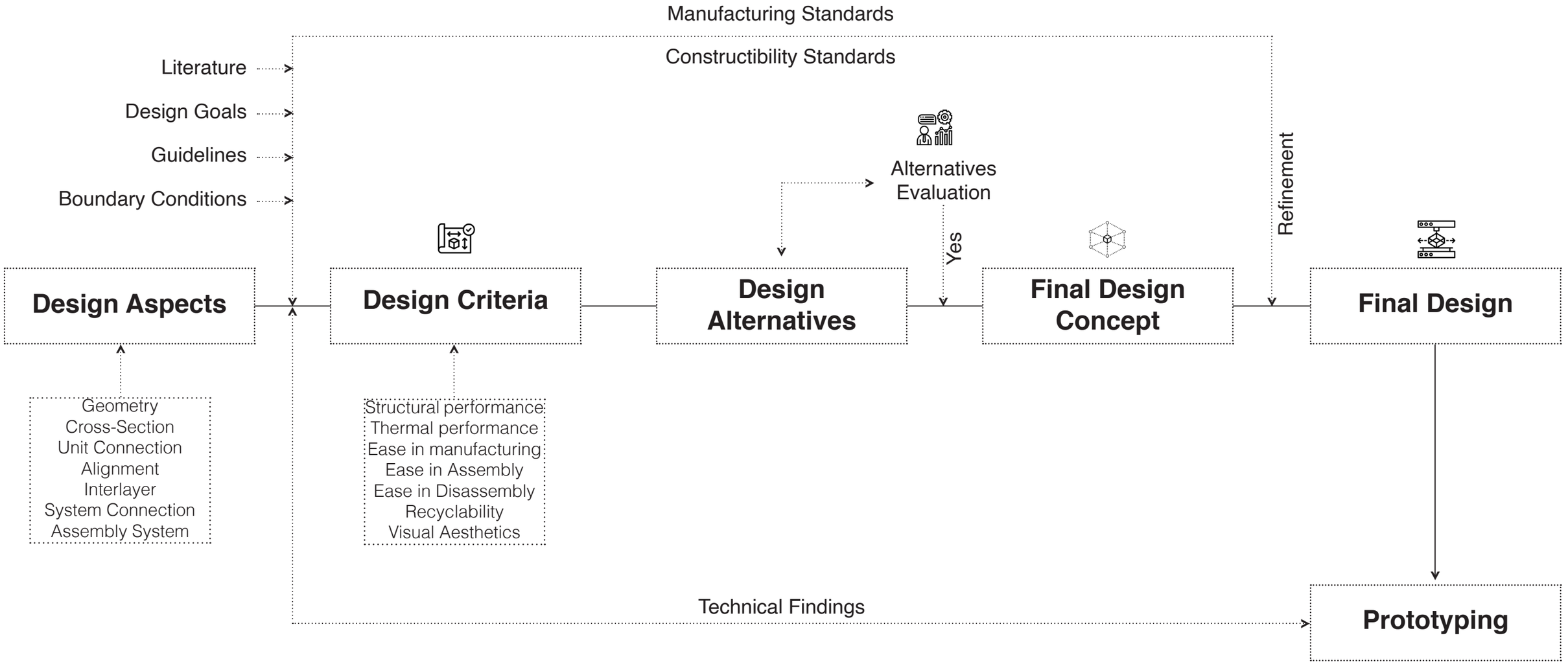
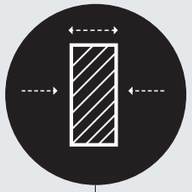


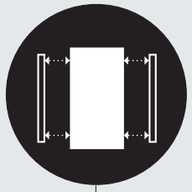
Design Methodology



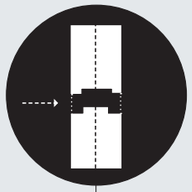
GEOMETRY



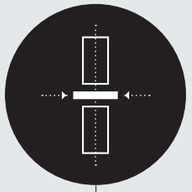
CROSS-SECTION



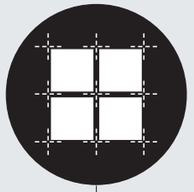
UNIT CONNECTION



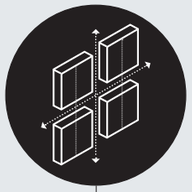
ALIGNMENT



INTERLAYER



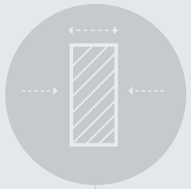
SYSTEM CONNECTION



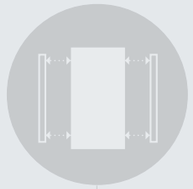
ASSEMBLY SYSTEM

Design Aspects

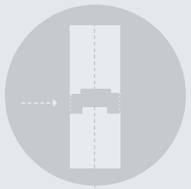
GEOMETRY



CROSS-SECTION



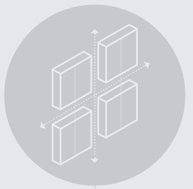
UNIT CONNECTION



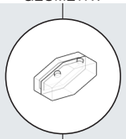
ALIGNMENT

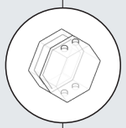
INTERLAYER

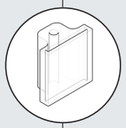
SYSTEM CONNECTION

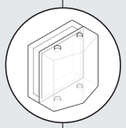


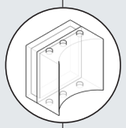
ASSEMBLY SYSTEM

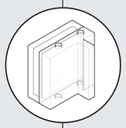


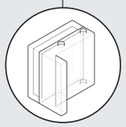








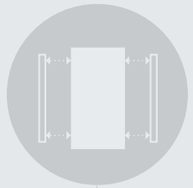




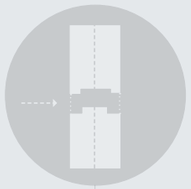
Design Alternatives

GEOMETRY

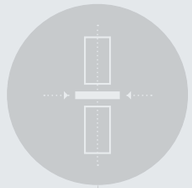
CROSS-SECTION



UNIT CONNECTION



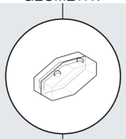
ALIGNMENT

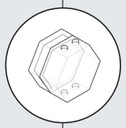


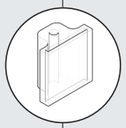
INTERLAYER

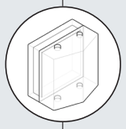
SYSTEM CONNECTION

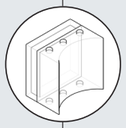
ASSEMBLY SYSTEM

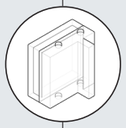


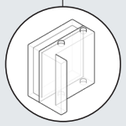




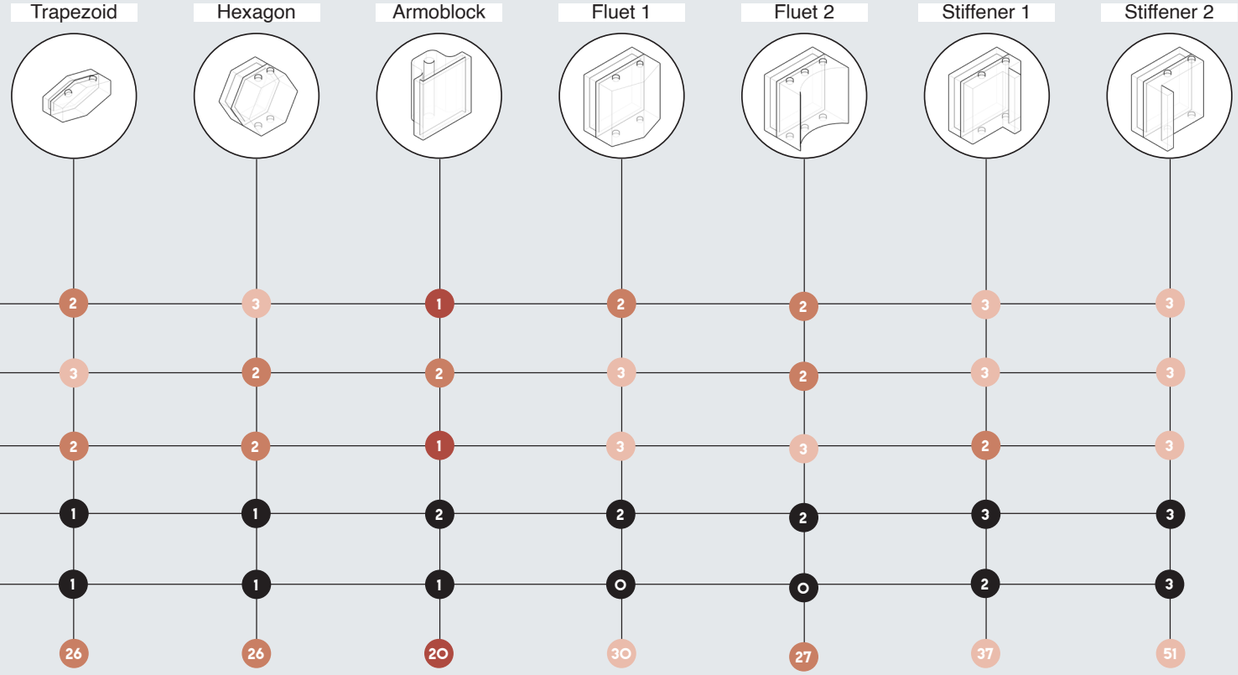




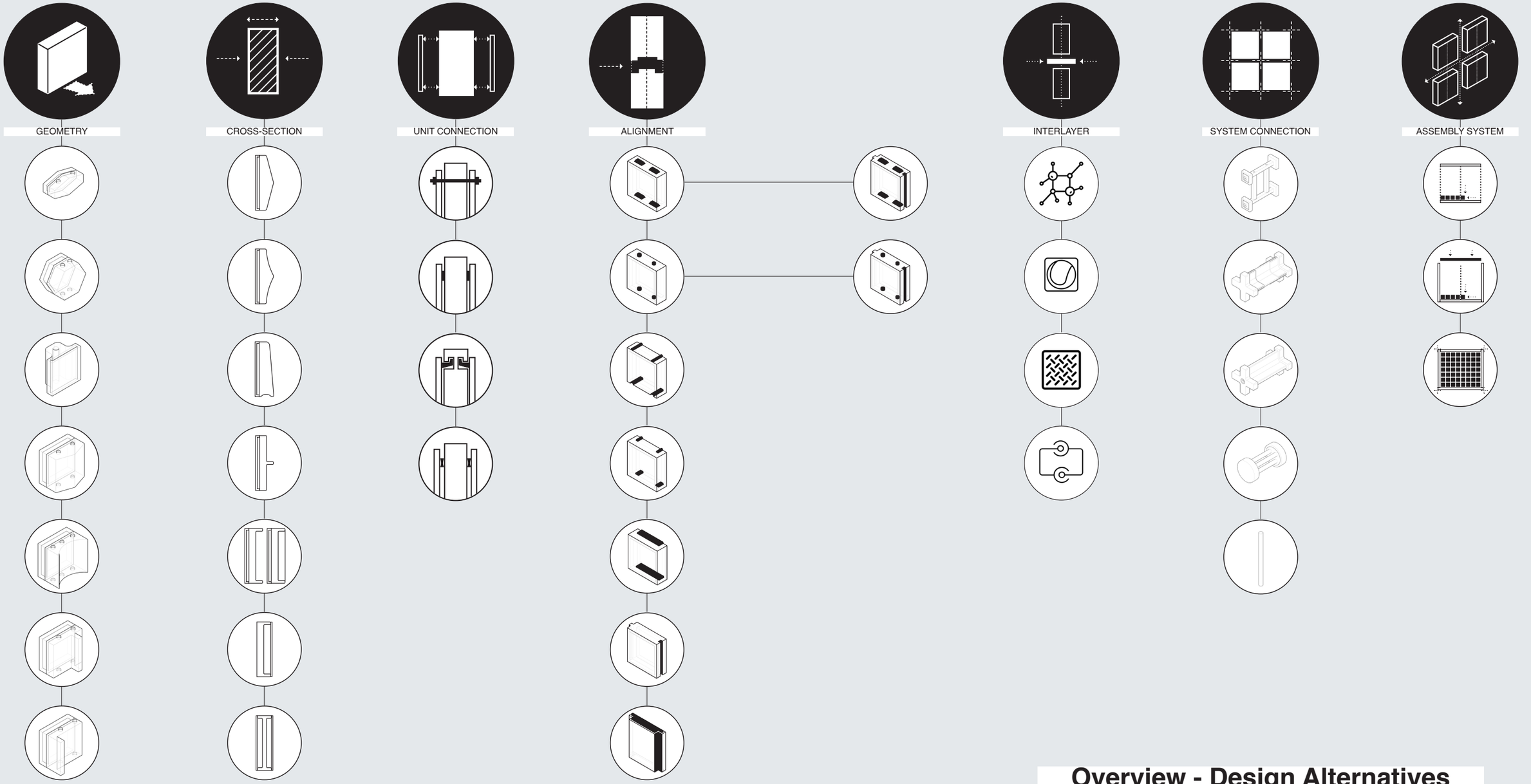




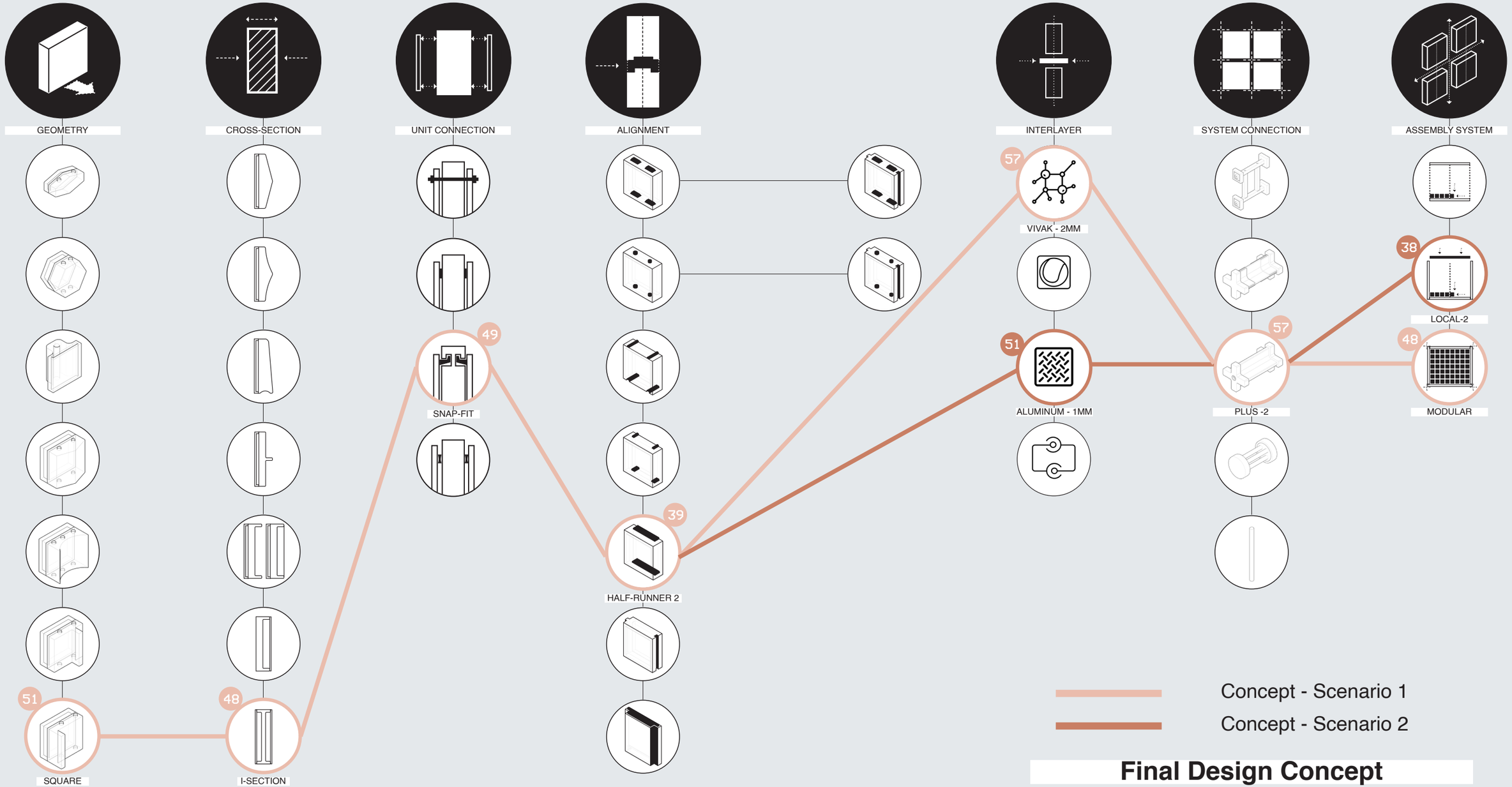
Geometry



Evaluation based on Criteria



Overview - Design Alternatives

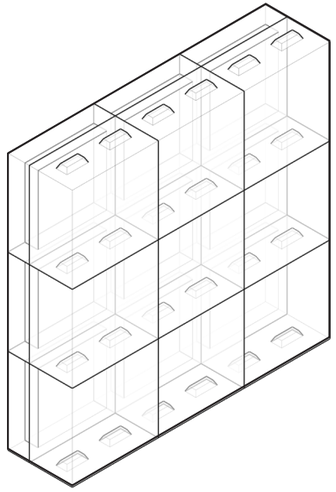


Final Design Concept

Key Decision

Alternate Stacking

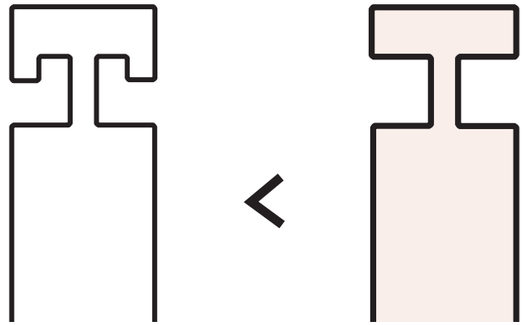
vs



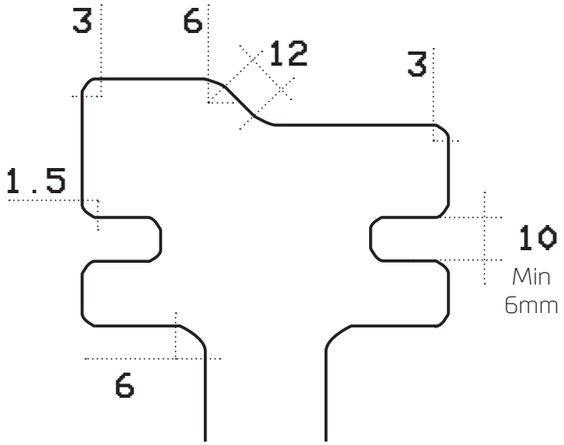
Vertical Stacking

[Academy of Arts, Maastricht. Wiel Arets Architects]

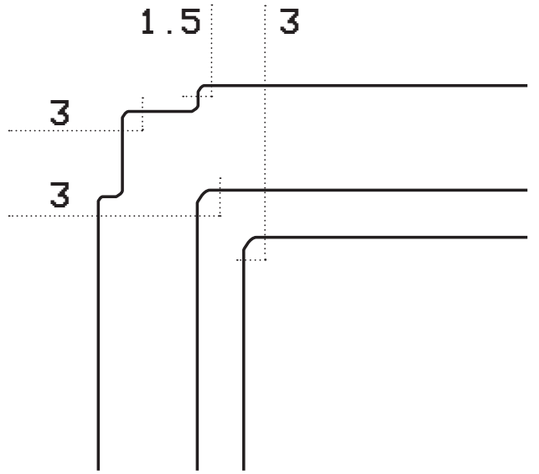
Design Refinement - CNC Milling & Casting Standards



Remove Undercuts



Rounded Edges

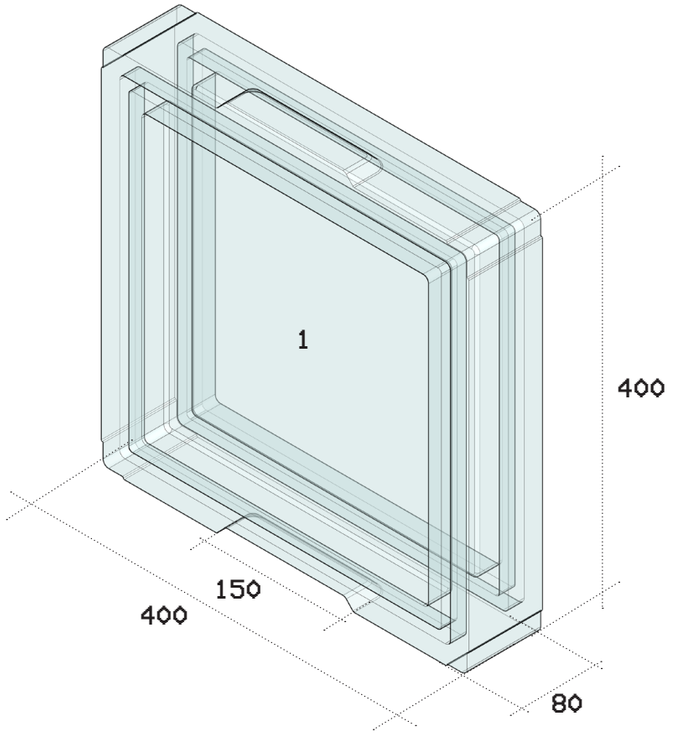


Rounded Corners

*All dimensions in mm

Final Design

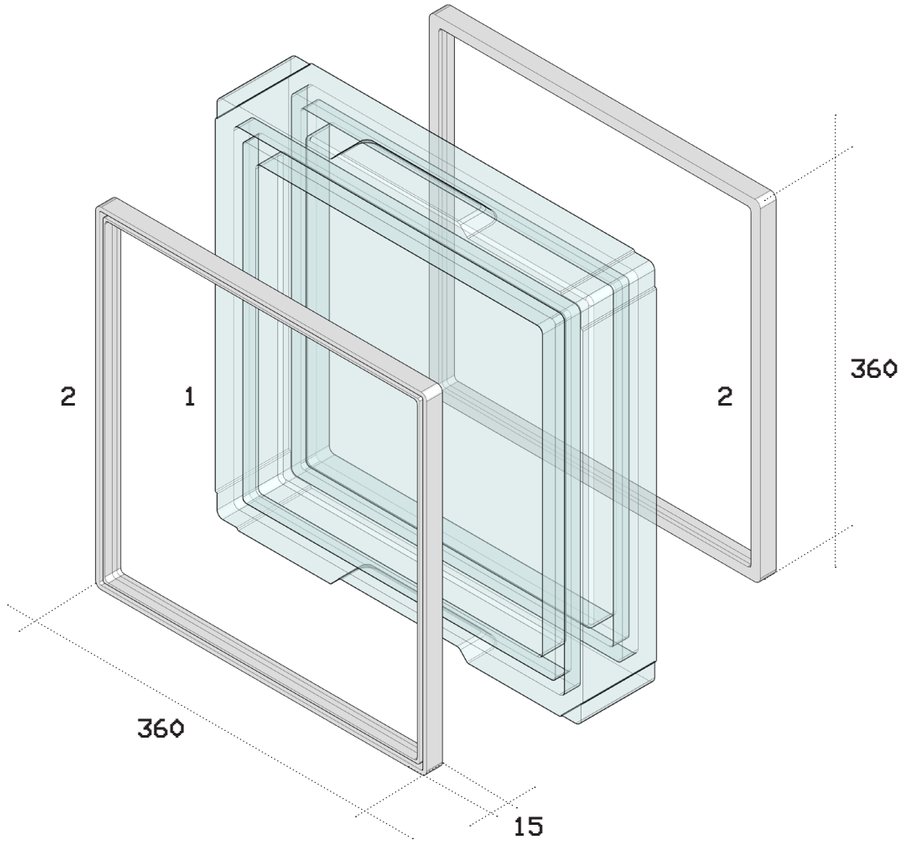
Unit Components



1 - Borosilicate Cast Glass component

*All dimensions in mm

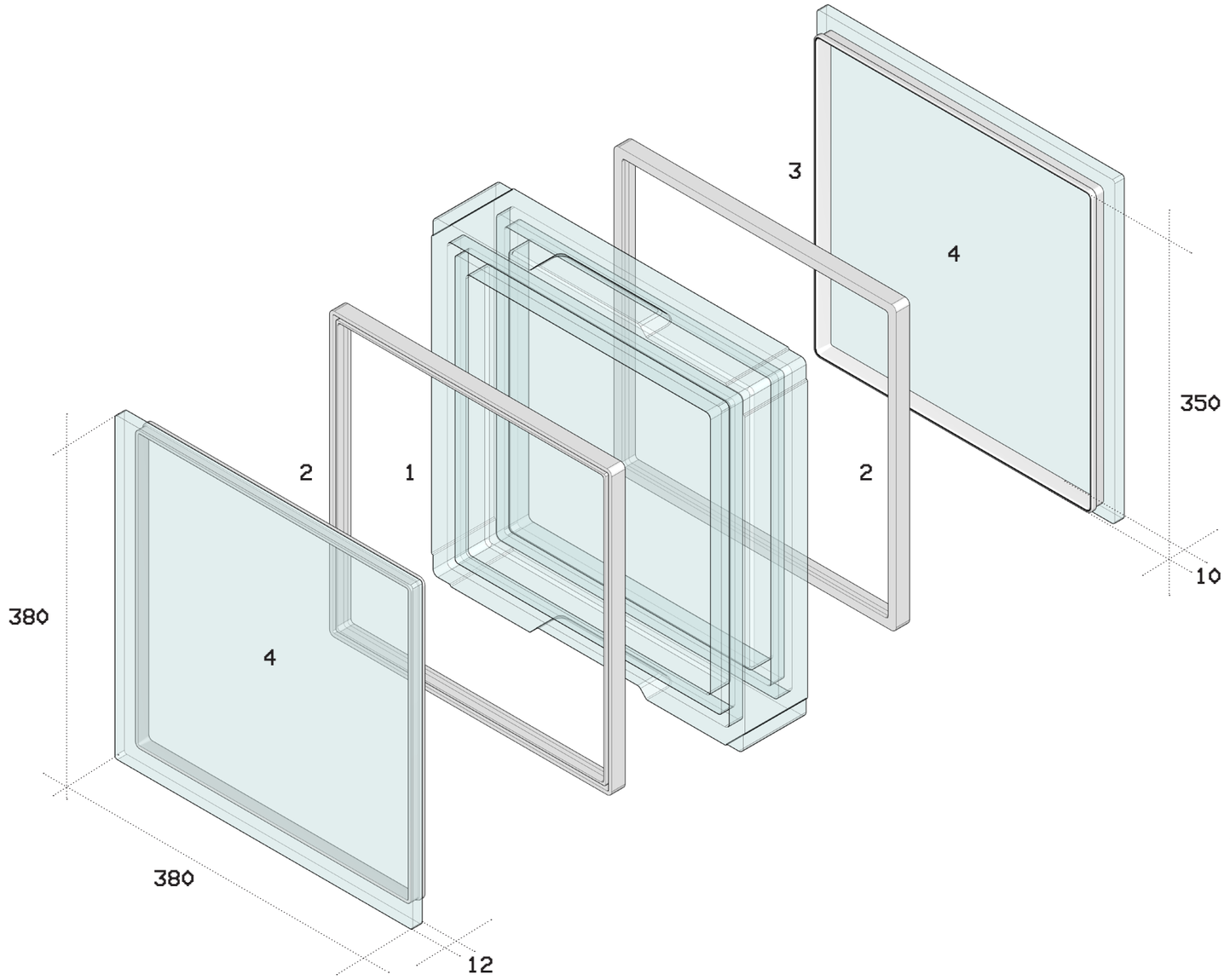
Unit Components



1 - Borosilicate Cast Glass component
2 - Snap Fit Profile

*All dimensions in mm

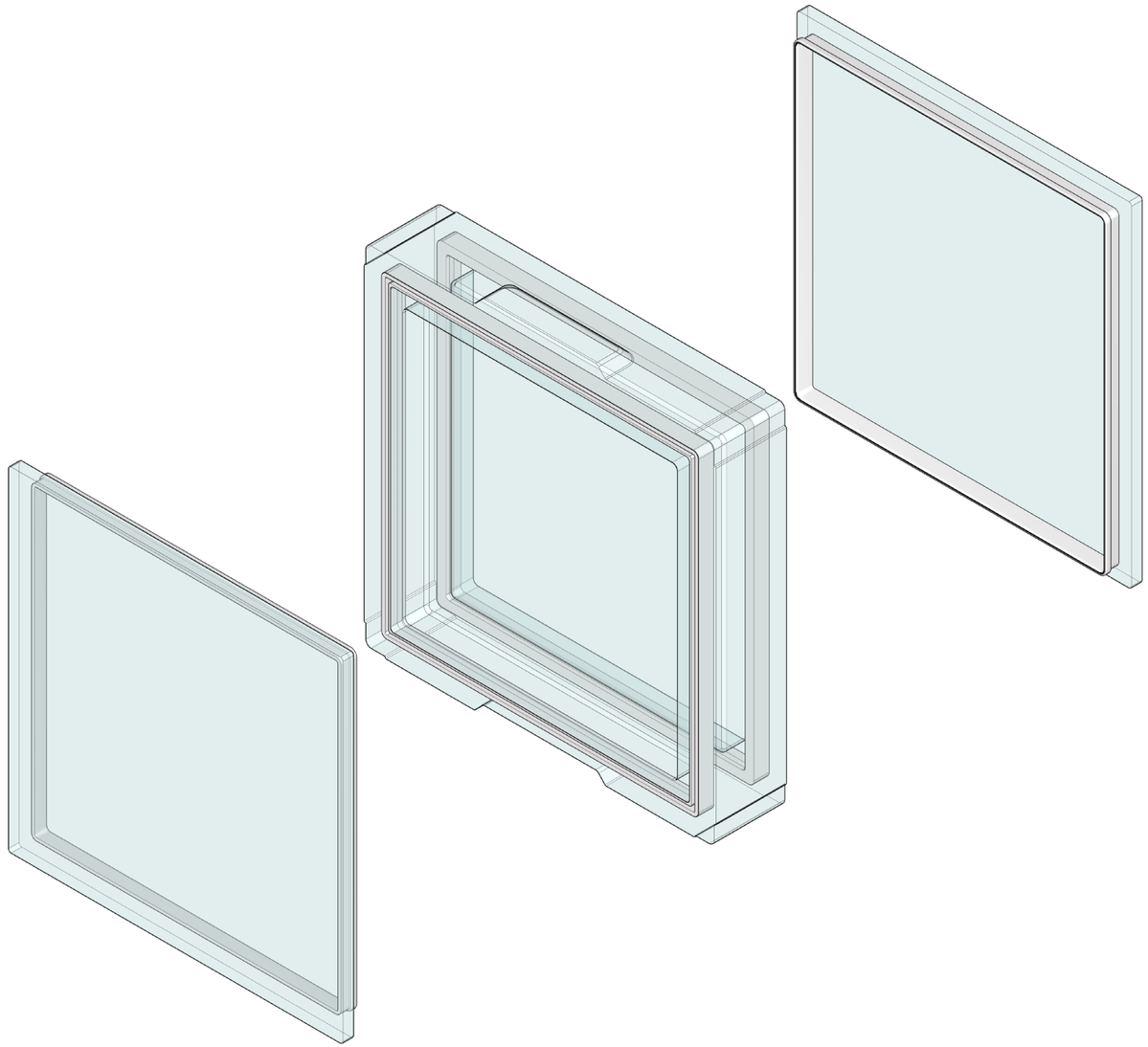
Unit Components



*All dimensions in mm

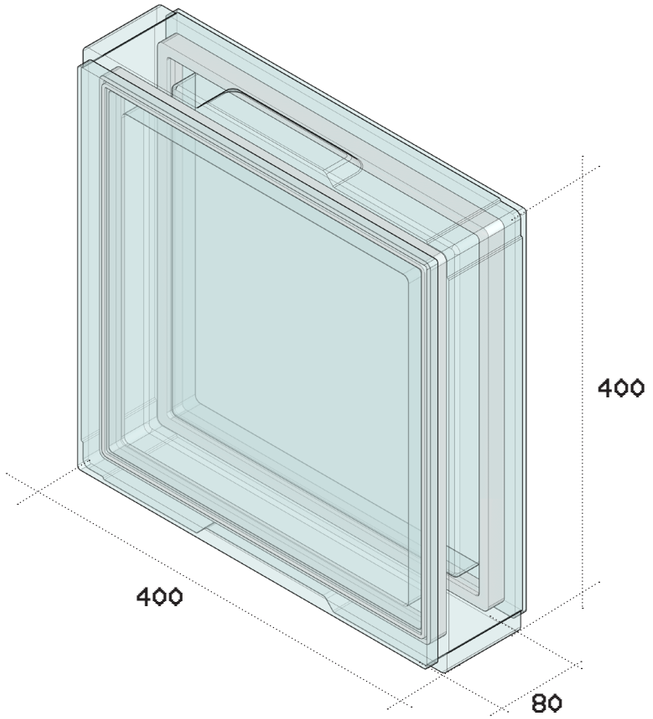
1 - Borosilicate Cast Glass component
2 - Snap Fit Profile
3 - Snap Fit insert
4 - Float Glass Panel

Unit Components



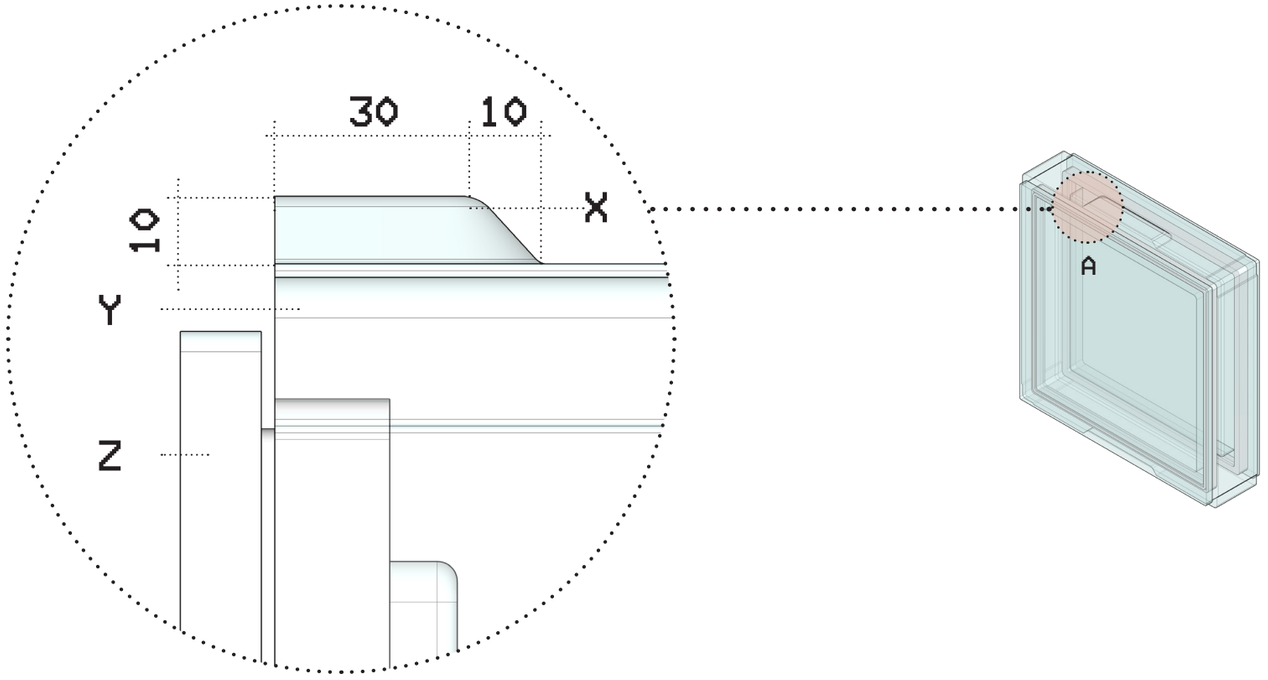
*All dimensions in mm

Hybrid Glass Block



*All dimensions in mm

Hybrid Glass Block - Details

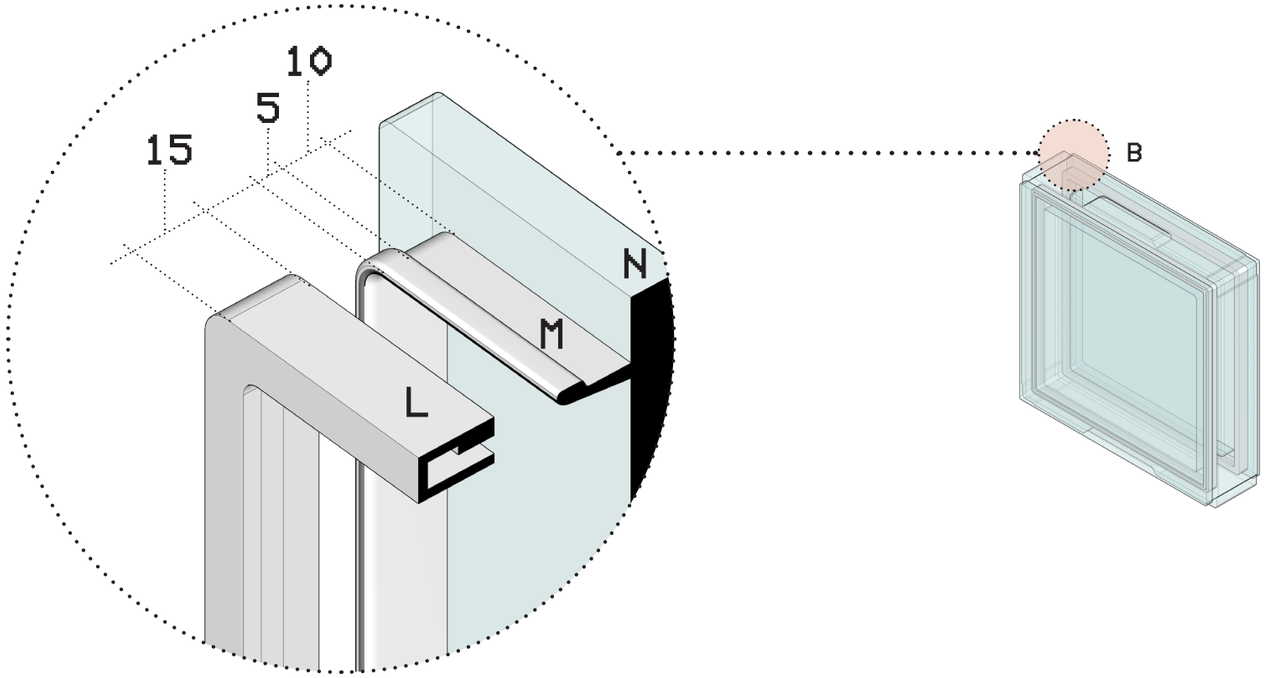


Alignment Detail: A

X - 3 mm Filleted edge
Y - Cast Glass Component
Z - Float Glass Panel

*All dimensions in mm

Hybrid Glass Block - Details

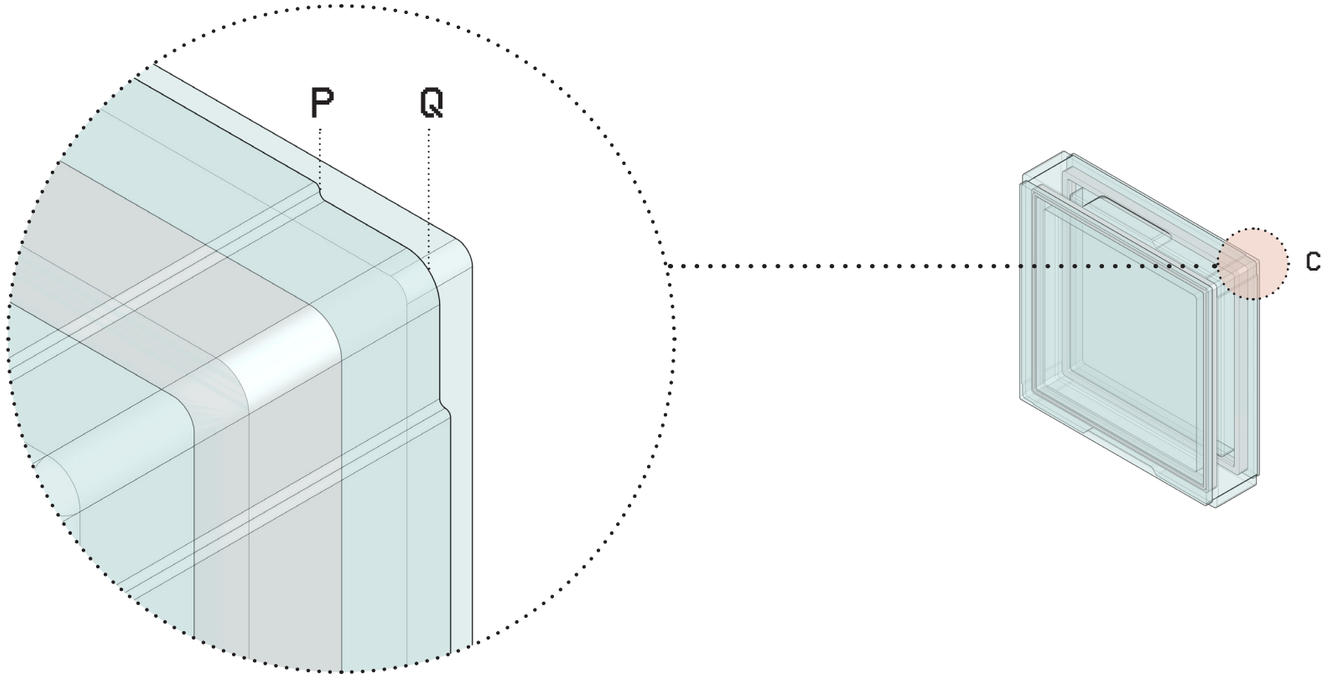


Snap-fit Detail: B

L - Female component
M - Male component
N - Float Glass Panel

*All dimensions in mm

Hybrid Glass Block - Details

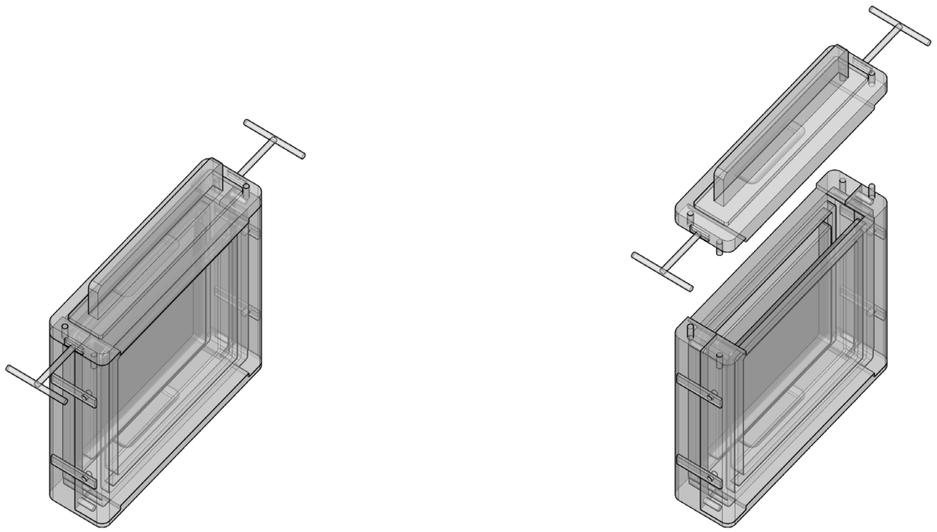


Corner Detail: C

P - 2 mm Filleted edge
Q - 6 mm Fileted edge

*All dimensions in mm

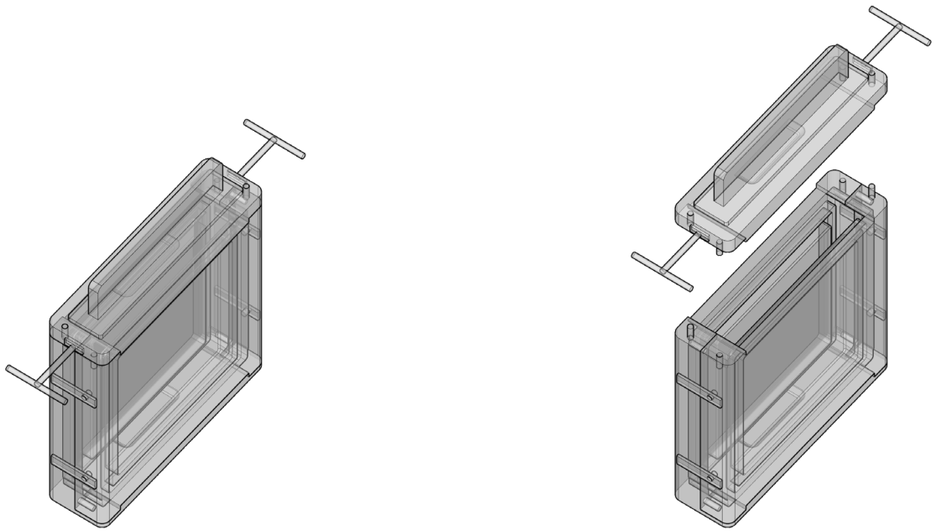
Mould Design



High Precision Steel Mould

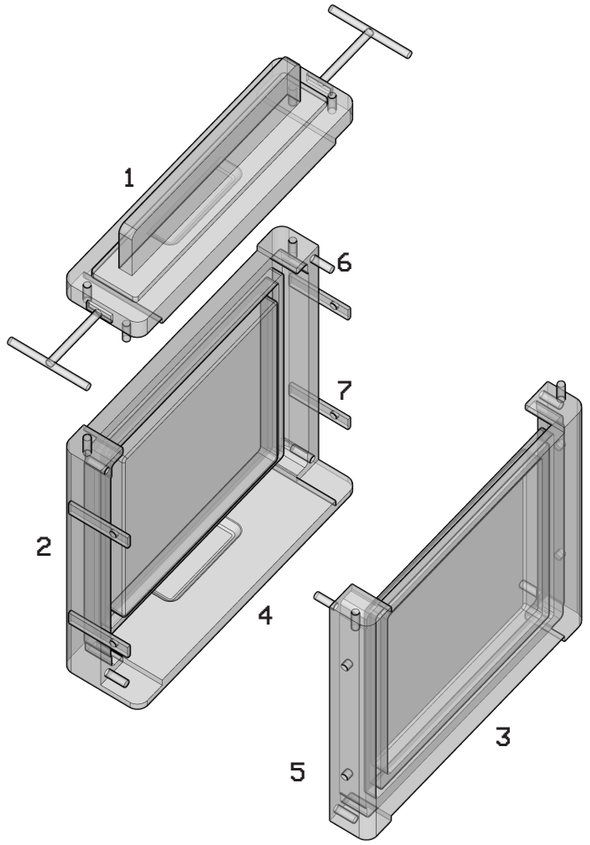
Geometry Casted Upside-down

Mould Design



High Precision Steel Mould

Geometry Casted Upside-down



Exploded View

1. Hydraulic Press
2. Steel Mould part 1
3. Steel Mould part 2
4. Base Plate
5. Air Vent
6. Alignment pin
7. Mould Lock

Kiln Casting

Prototyping
Explorative
Disposable Mould
Regulated Annealing

Prototyping

2 days

Silicone Mould

Made from pouring Silicone over foam block. Used for wax casting

Prototyping

2 days

1-2 days

Silicone Mould

Made from pouring Silicone over foam block. Used for wax casting

Wax Casting

Hot wax pour inside silicone mould. Used for crystal cast mould

Prototyping

2 days

1-2 days

1-2 hours

Silicone Mould

Made from pouring Silicone over foam block. Used for wax casting

Wax Casting

Hot wax pour inside silicone mould. Used for crystal cast mould

Crystal Cast Mould

Made from pouring over wax block. Used for casting glass inside kiln. Disposable after casting

Prototyping

2 days

Silicone Mould

Made from pouring Silicone over foam block. Used for wax casting

1-2 days

Wax Casting

Hot wax pour inside silicone mould. Used for crystal cast mould

1-2 hours

Crystal Cast Mould

Made from pouring over wax block. Used for casting glass inside kiln. Disposable after casting

1-1.5 weeks

Firing

Crystal cast mould and pots with shards are set-up in kiln for casting

Prototyping

2 days

Silicone Mould

Made from pouring Silicone over foam block. Used for wax casting

1-2 days

Wax Casting

Hot wax pour inside silicone mould. Used for crystal cast mould

1-2 hours

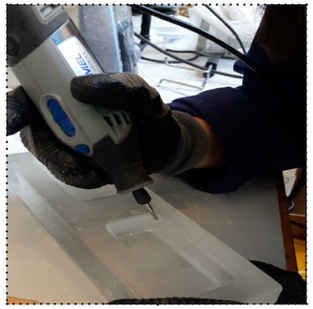
Crystal Cast Mould

Made from pouring over wax block. Used for casting glass inside kiln. Disposable after casting

1-1.5 weeks

Firing

Crystal cast mould and pots with shards are set-up in kiln for casting



2-3 hours

Post Process

Removing cast glass from the mould. Polishing with dental tools

Prototyping

2 days

Silicone Mould

Made from pouring Silicone over foam block. Used for wax casting

1-2 days

Wax Casting

Hot wax pour inside silicone mould. Used for crystal cast mould

1-2 hours

Crystal Cast Mould

Made from pouring over wax block. Used for casting glass inside kiln. Disposable after casting

1-1.5 weeks

Firing

Crystal cast mould and pots with shards are set-up in kiln for casting

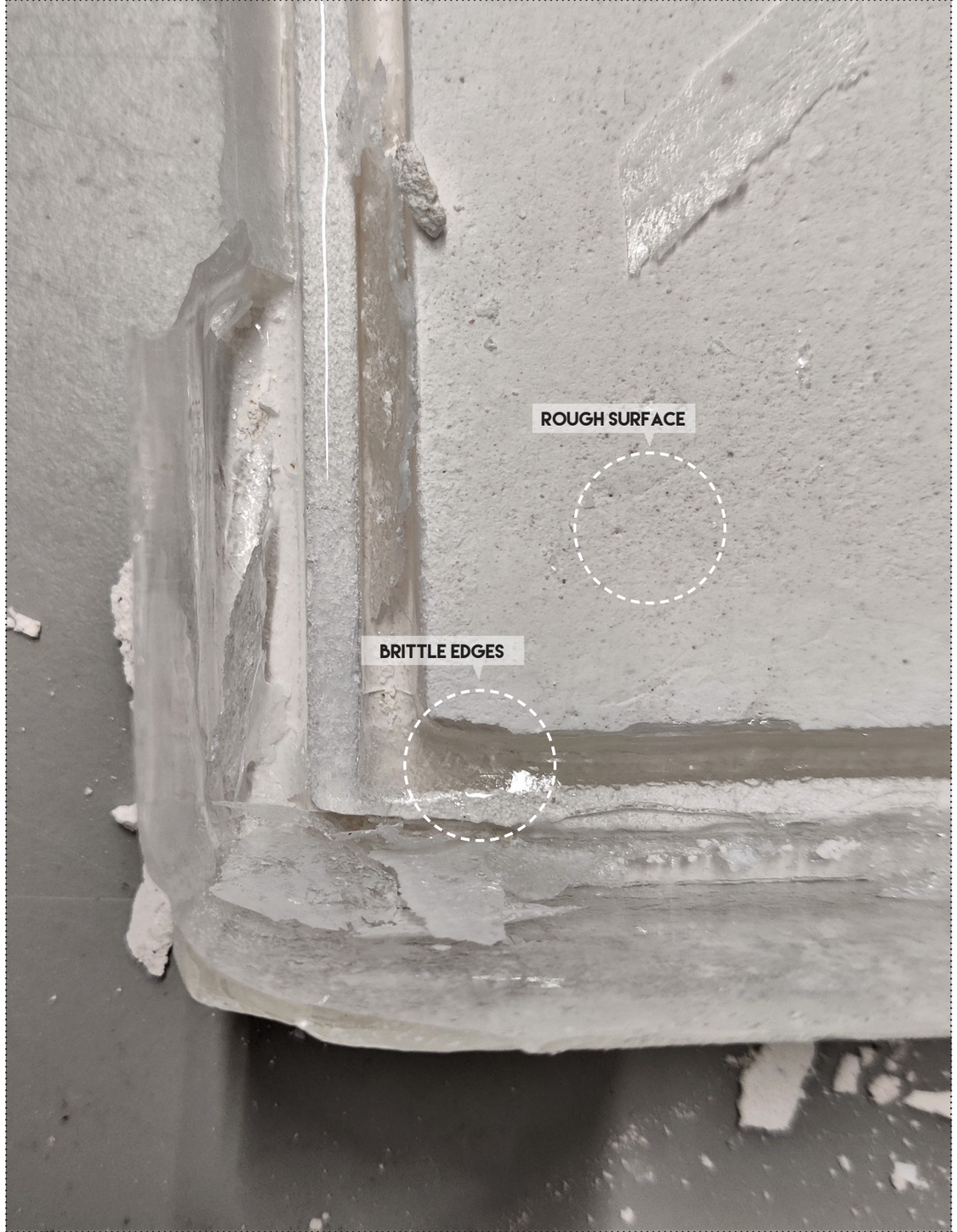
2-3 hours

Post Process

Removing cast glass from the mould. Polishing with dental tools

Brittle Mould - Failure

Recommendations:
Horizontal Casting
Simplification of small notches
Thicker mould walls
Smooth Draft angles

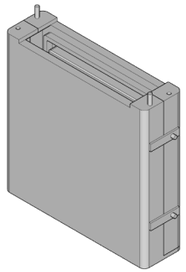


Hot Pour Casting

Industrial Manufacturing
High Precision Steel Mould
Reusable Mould
Regulated Annealing
Standardised process

[Casting of Soda-lime glass blocks at Poesia factory in Italy. Oikonomopoulou. F]

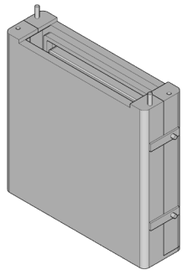
Manufacturing Process - Casting

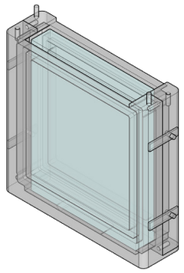


Mould set up

Pre-heating

Manufacturing Process - Casting





1200 C

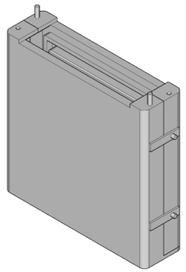
Mould set up

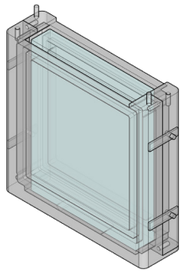
Pre-heating

Molten Glass

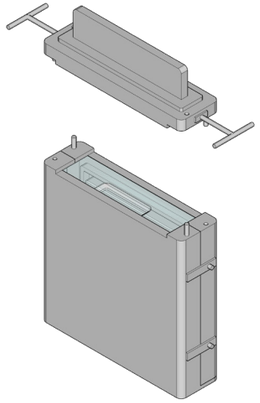
Pouring

Manufacturing Process - Casting





1200 C



Mould set up

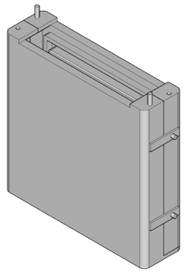
Pre-heating

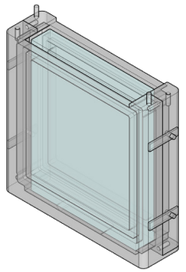
Molten Glass

Pouring

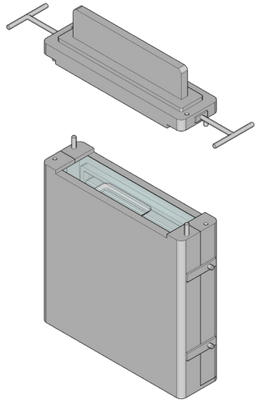
Hydraulic press

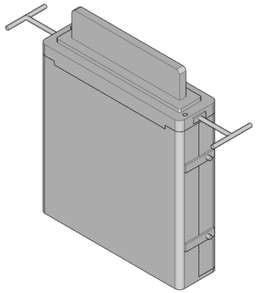
Manufacturing Process - Casting





1200 C





600 C

Mould set up

Pre-heating

Molten Glass

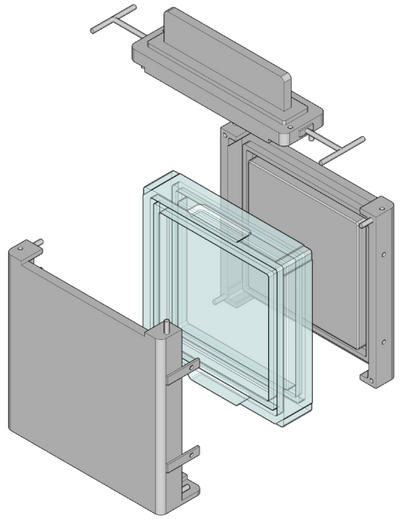
Pouring

Hydraulic press

Cool down

Softening Point

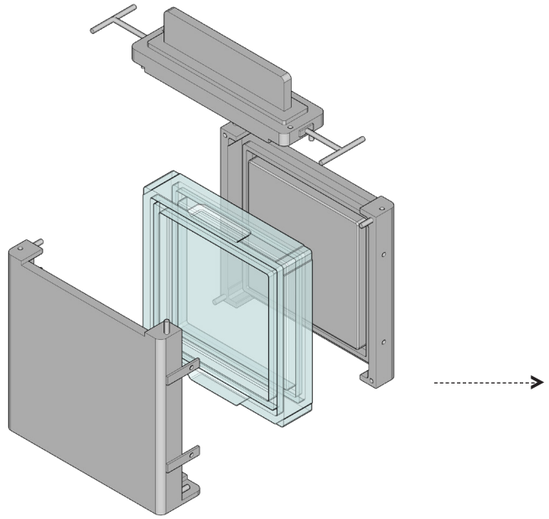
Manufacturing Process - Annealing

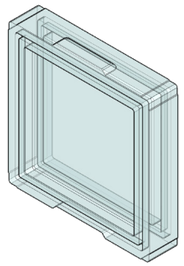


Open Mould

Transfer Block

Manufacturing Process - Annealing





80 C

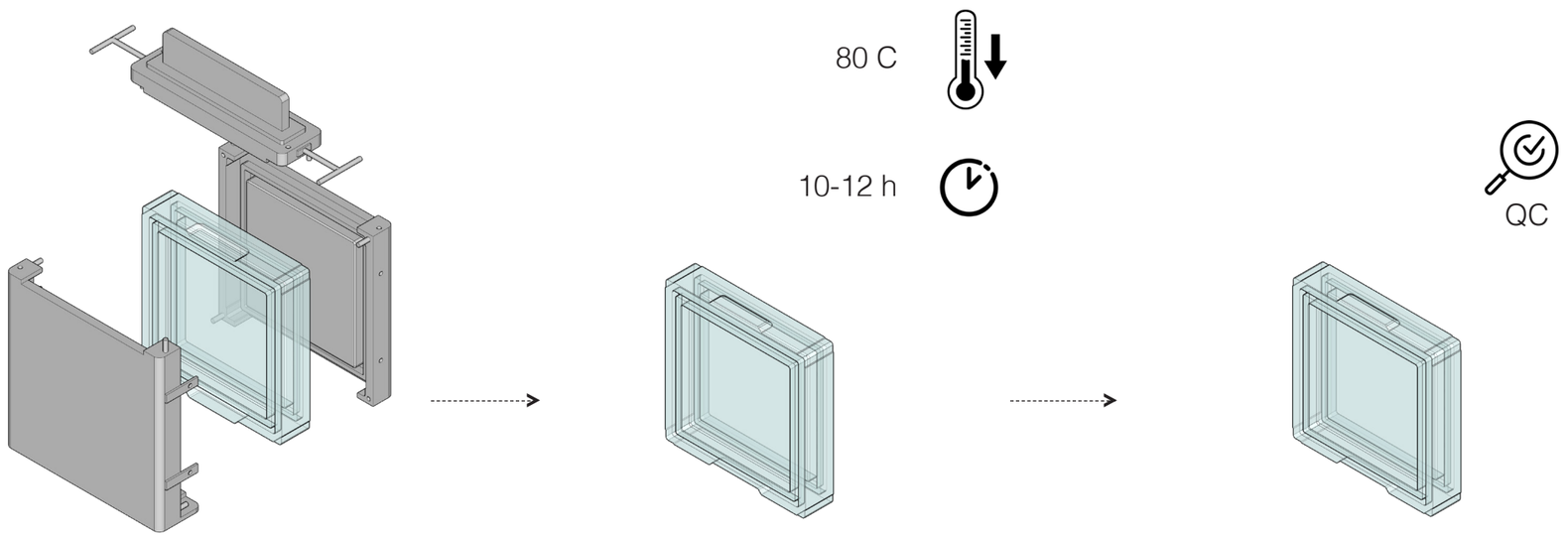
10-12 h

Open Mould

Transfer Block

Annealing

Manufacturing Process - Annealing



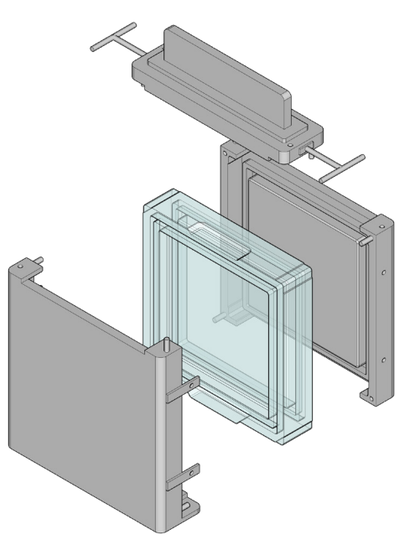
Open Mould

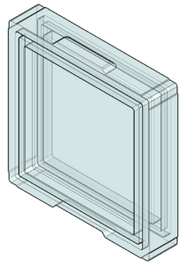
Transfer Block

Annealing

Quality Check

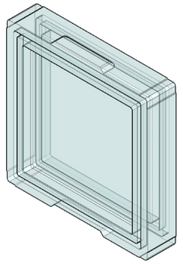
Manufacturing Process - Annealing



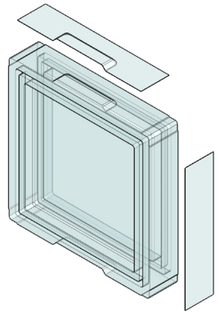


80 C

10-12 h



QC



Open Mould

Transfer Block

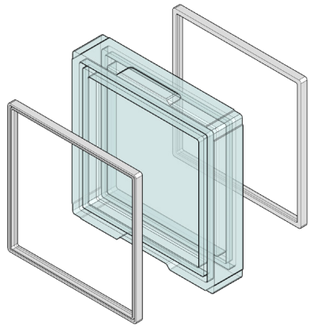
Annealing

Quality Check

Vaccum-forming

Interlayer

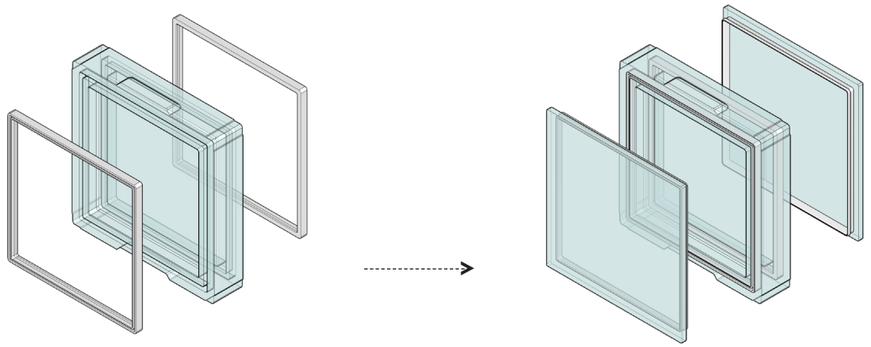
Manufacturing Process - Components Assembly



Snap fit profile

Placed in groove

Manufacturing Process - Components Assembly



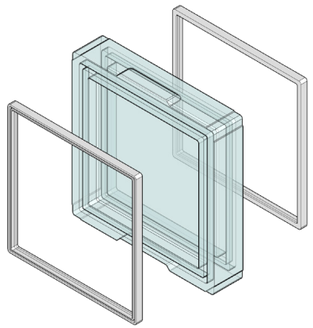
Snap fit profile

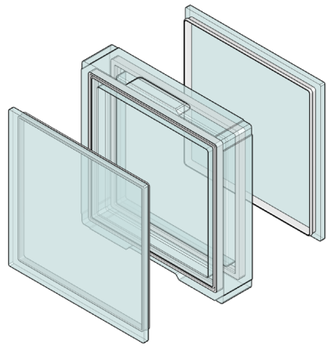
Placed in groove

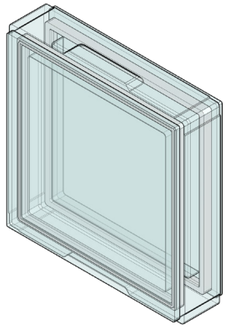
Snap-fit

Float glass placed

Manufacturing Process - Components Assembly







OK

QC

Snap fit profile

Placed in groove

Snap-fit

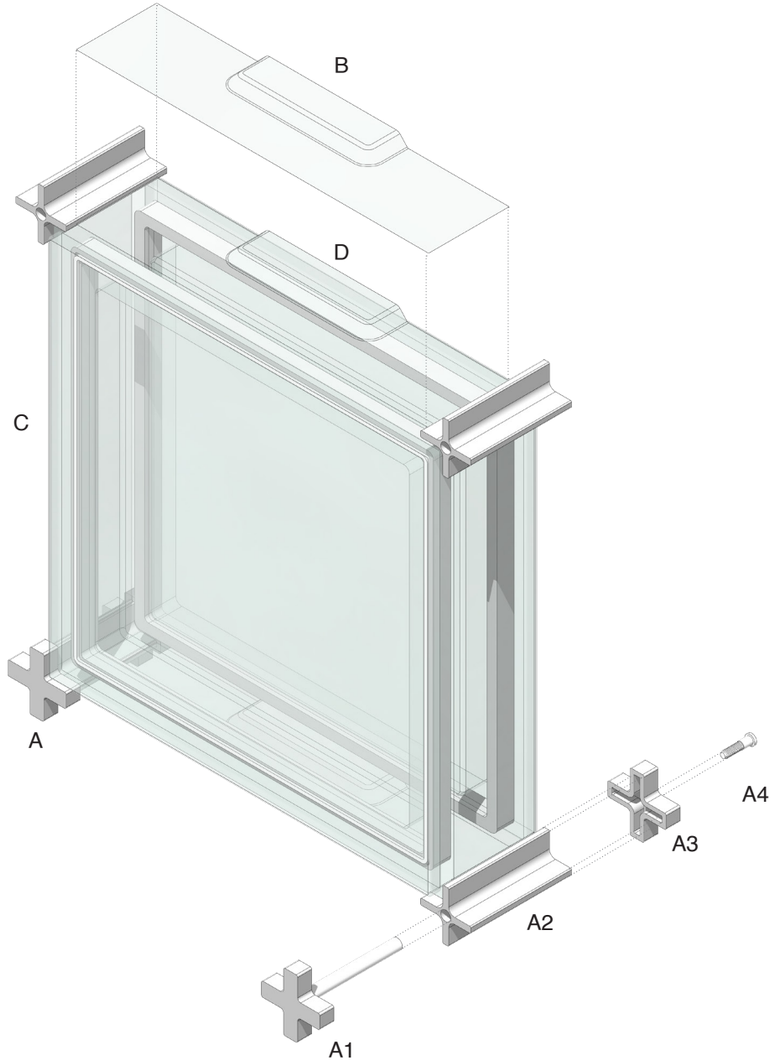
Float glass placed

Quality Check

Shipping

Or to Assembly

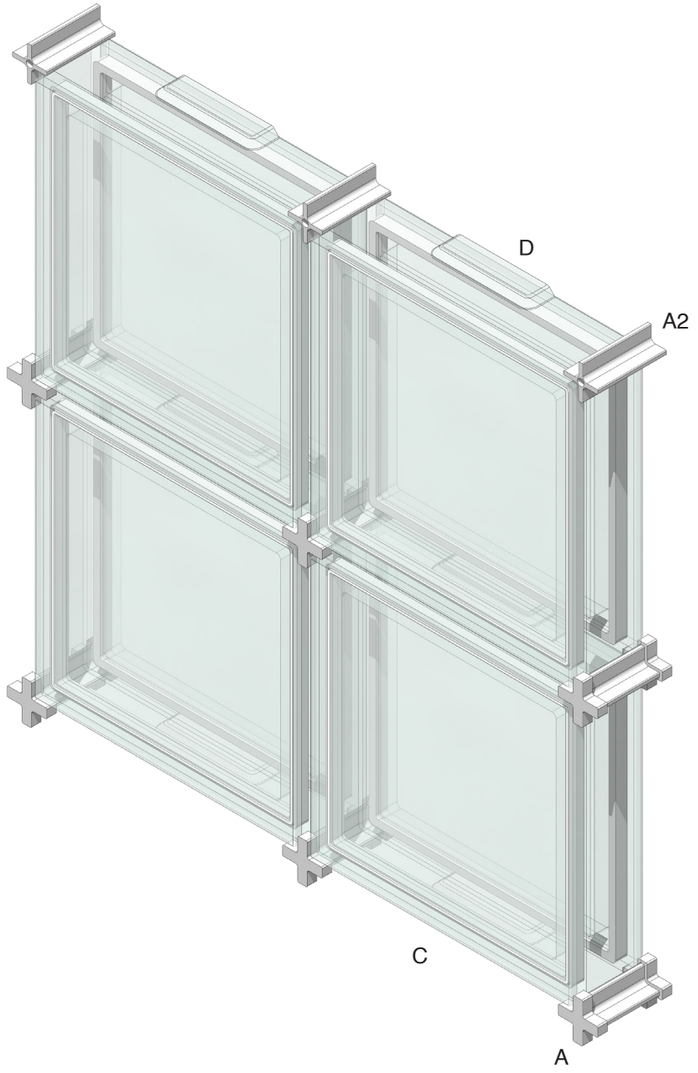
System Components



A - Teflon connection
A1 - Teflon connector with threaded screw cap
A2 - Plus shaped connector for alignment
A3 - Cover cap
A4 - Screw for securing connection
B - Interlayer - 2mm thk Vivak 1mm thk softcore aluminium
C - Hybrid Glass Block (400.400)
D - Alignment interlock

*All dimensions in mm

System Components

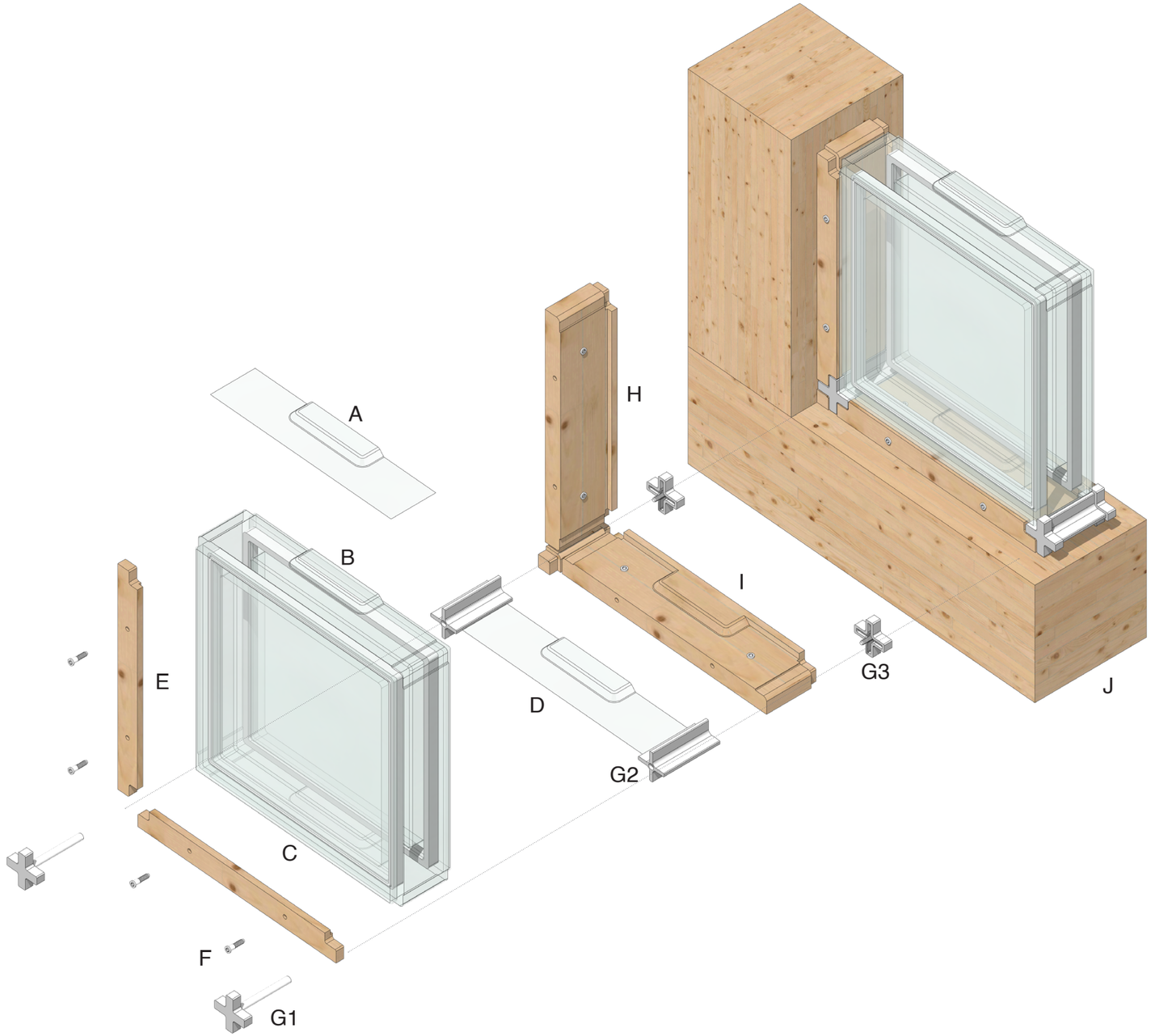


A - Teflon connection
A2 - Plus shaped connector for alignment
A3 - Cover cap
C - Hybrid Glass Block (400.400)
D - Alignment interlock

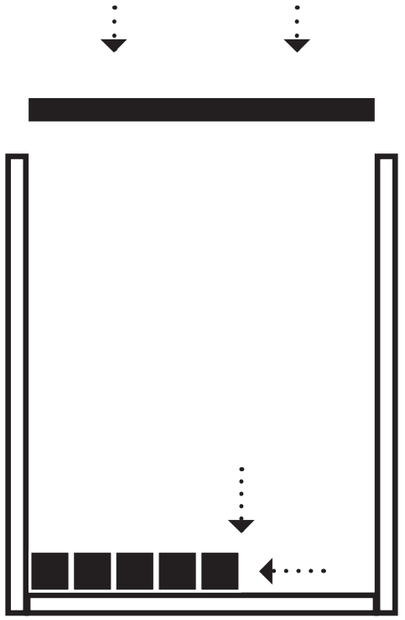
*All dimensions in mm

Assembly components

A - Interlayer - 2mm thk Vivak
1mm thk softcore aluminium
B - Alignment Interlock
C - Hybrid Glass Block (400.400)
D - Soft Padding or Interlayer with 4mm thk
E - Reversible Cover Plate
F - Screw for securing cover plate with base plate
J - CLT frame
H - Vertical plate
I - Base plate with alignment interlock
G1 - Teflon connector with threaded screw cap
G2 - Plus shaped connector for alignment
G3 - Cover cap



Assembly System Approaches

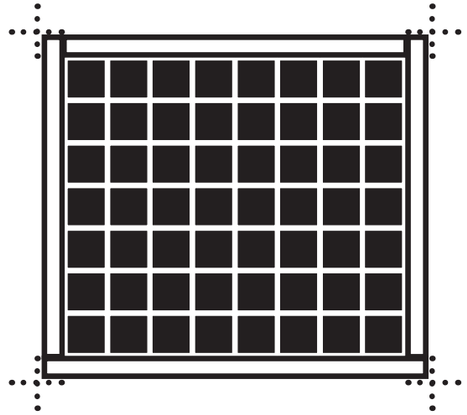


Local Assembly

High Precision on site

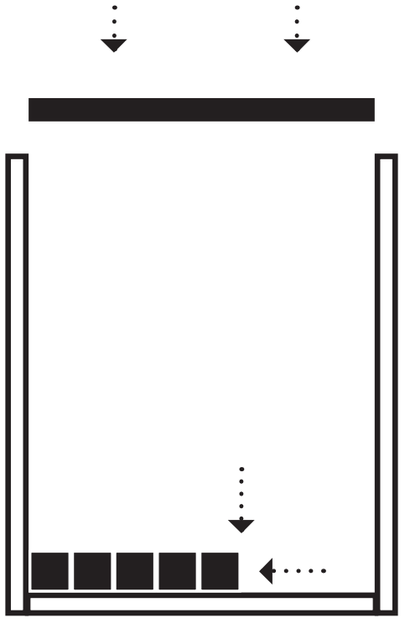
Buckling

Specific to Case study



Modular Assembly

Assembly System Approaches



Local Assembly

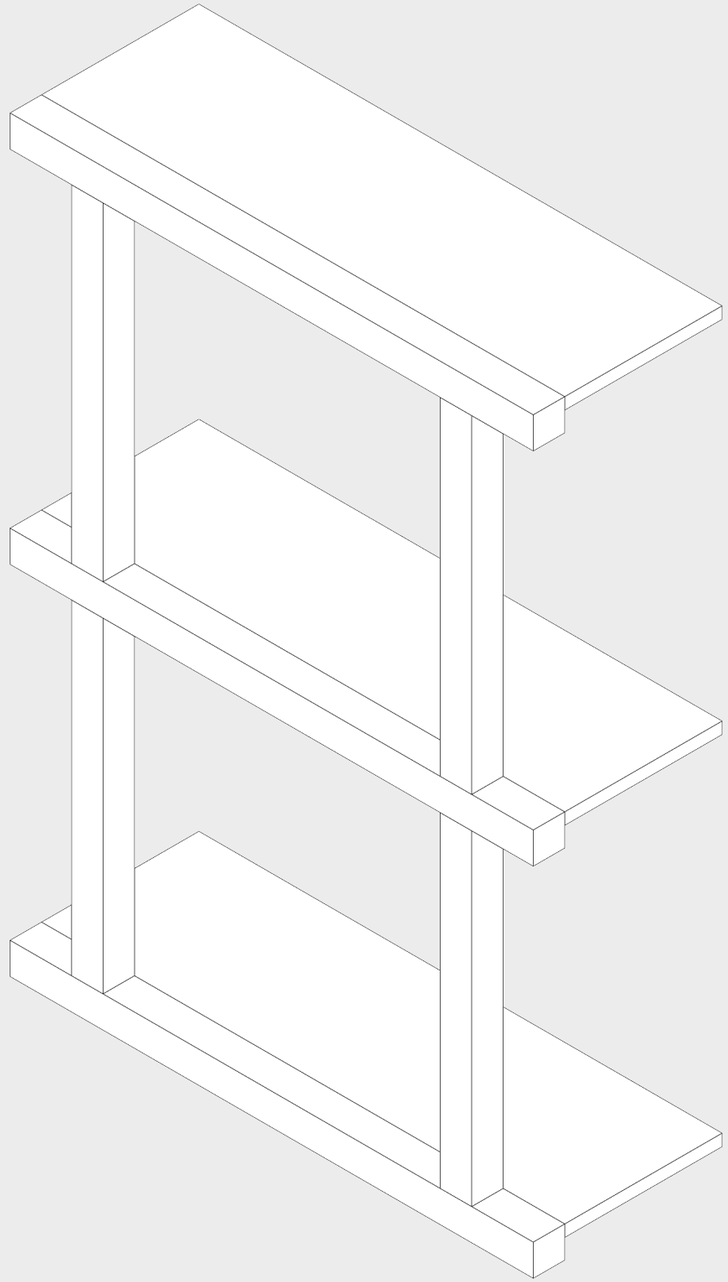
High Precision on site

Buckling

Specific to Case study

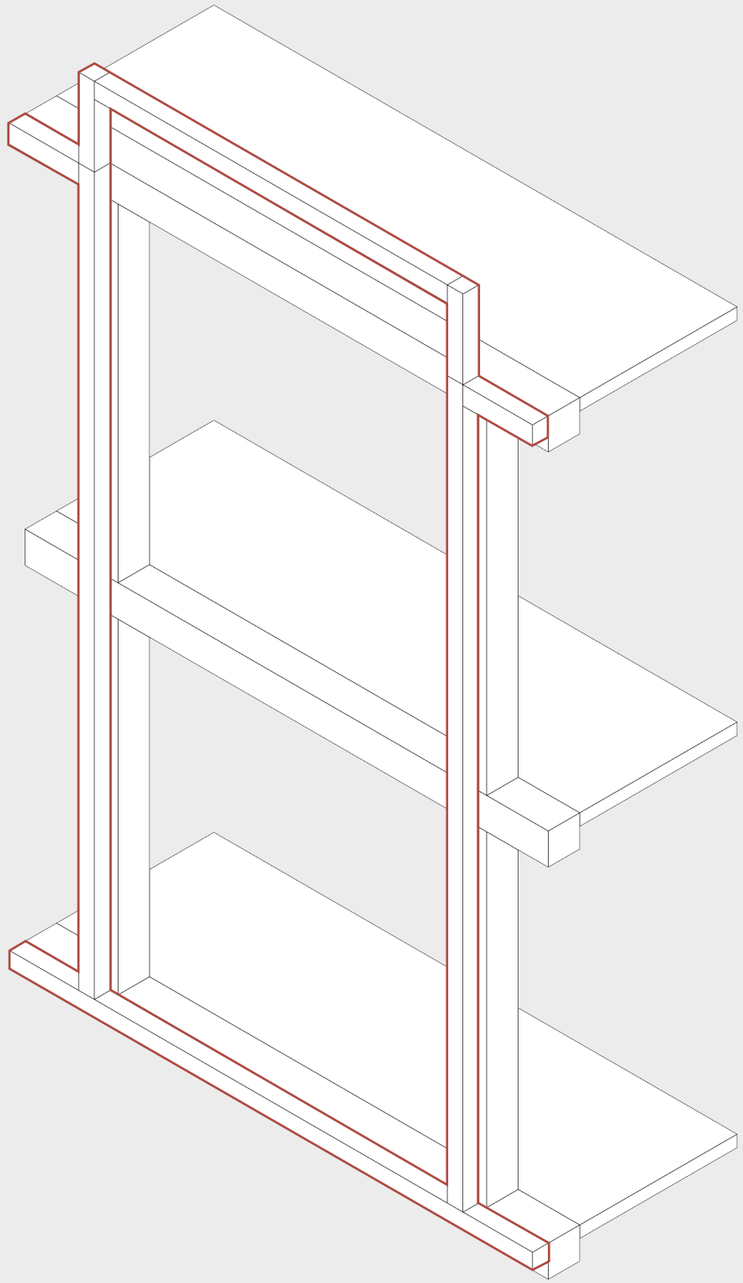
Modular Assembly

Assembly System



Assembly System

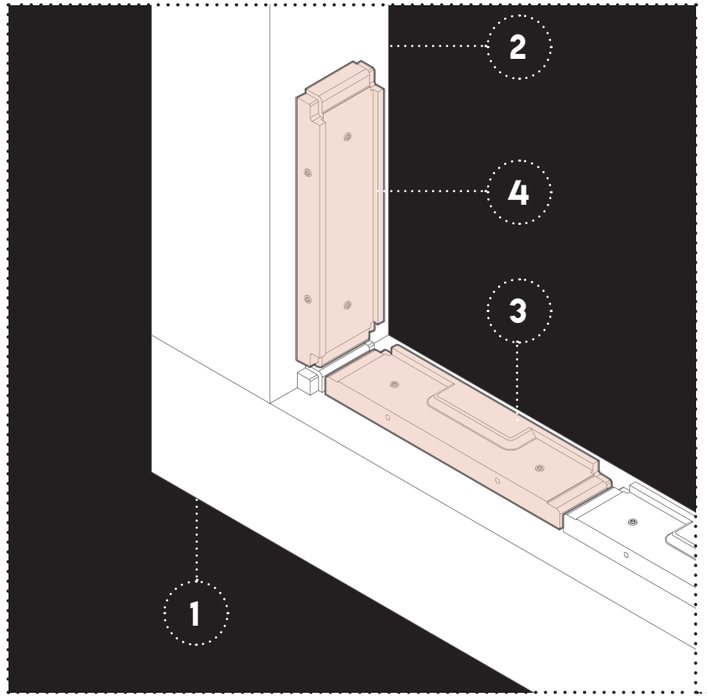
Step - 1-2



Site Clearance & construct frame

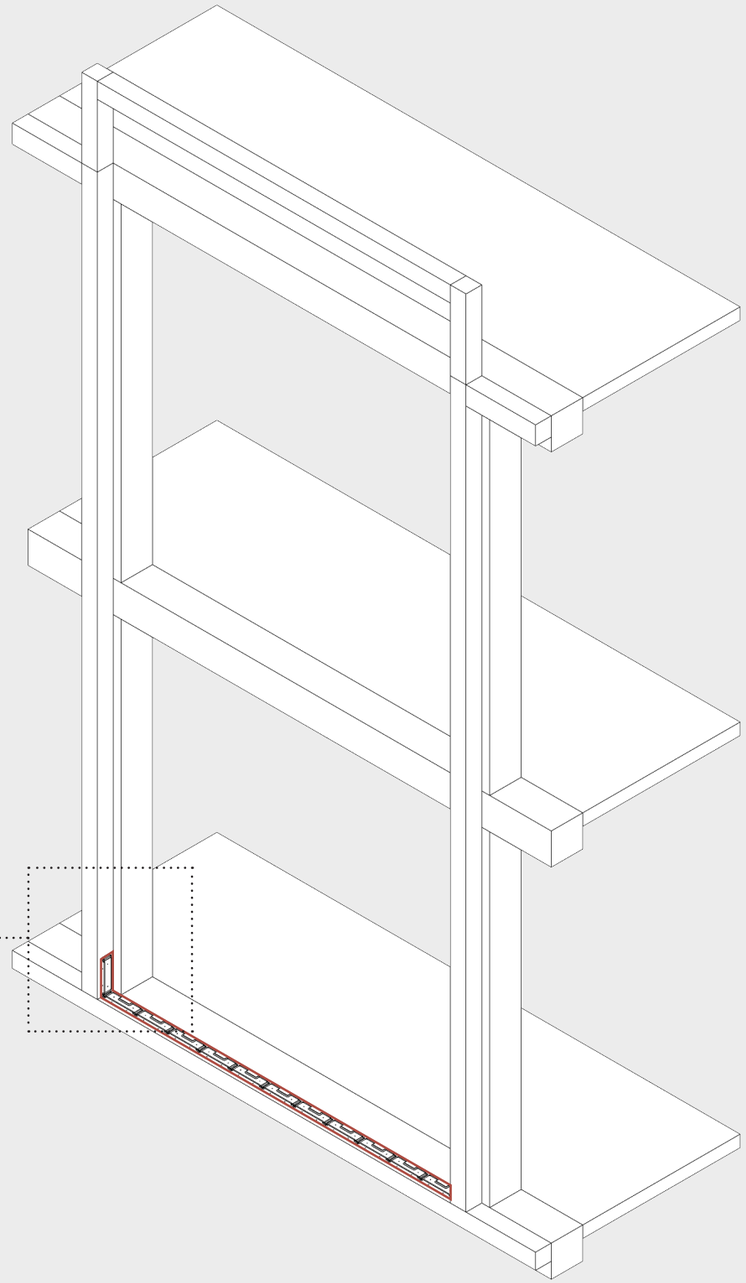
Assembly System

Step - 3

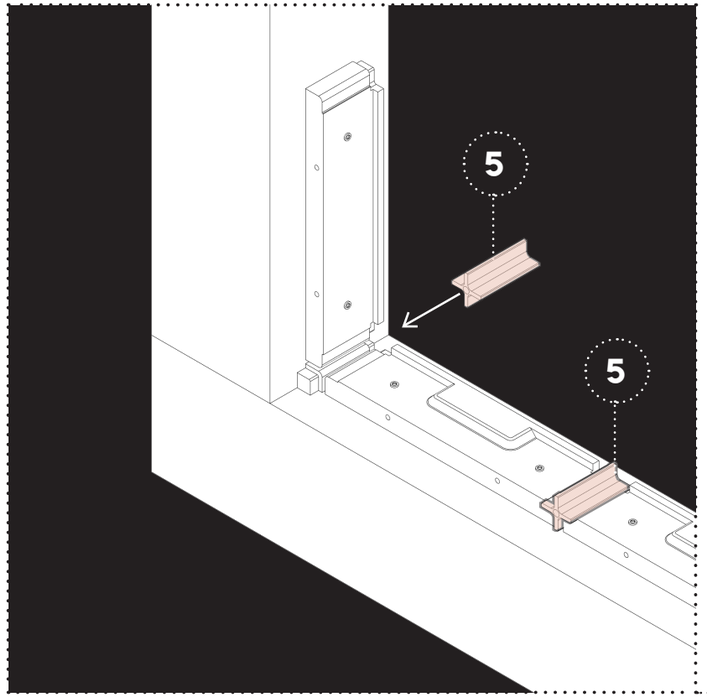


Screw side & base plate

1. Bottom frame
2. Vertical frame
3. Base Plate
4. Side Plate

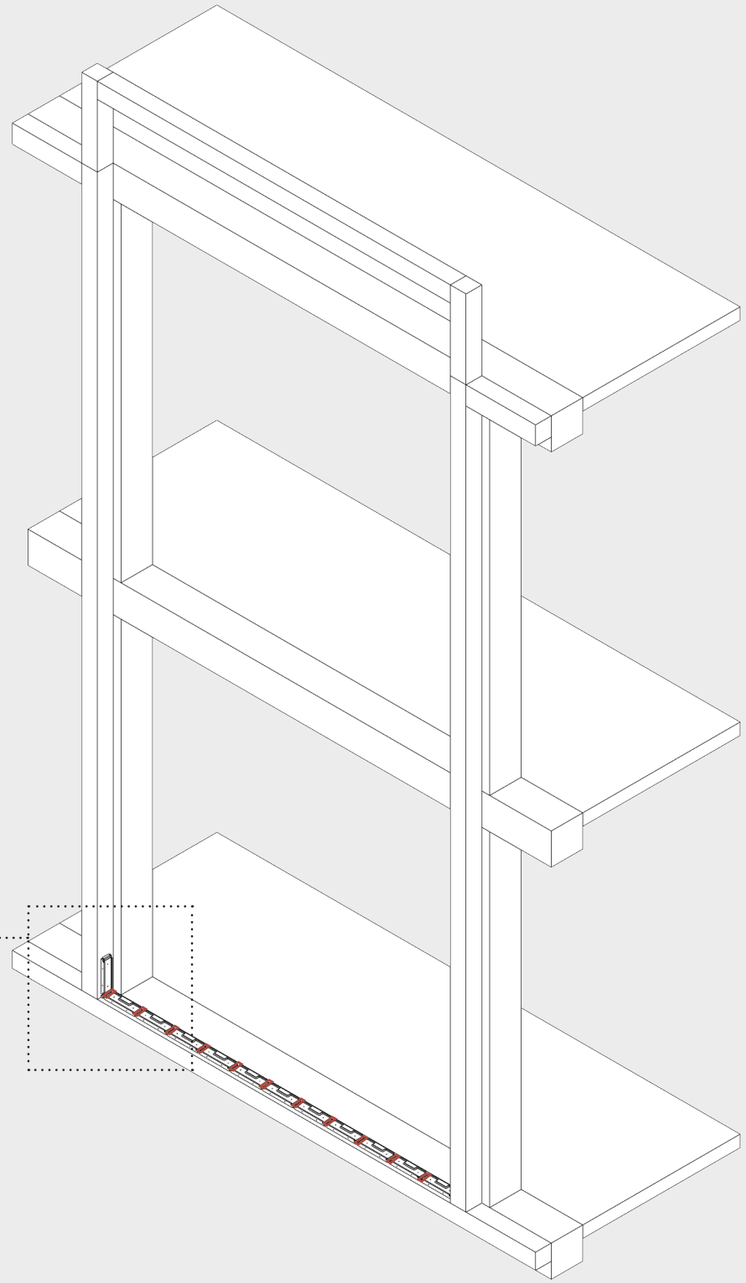


Step - 4

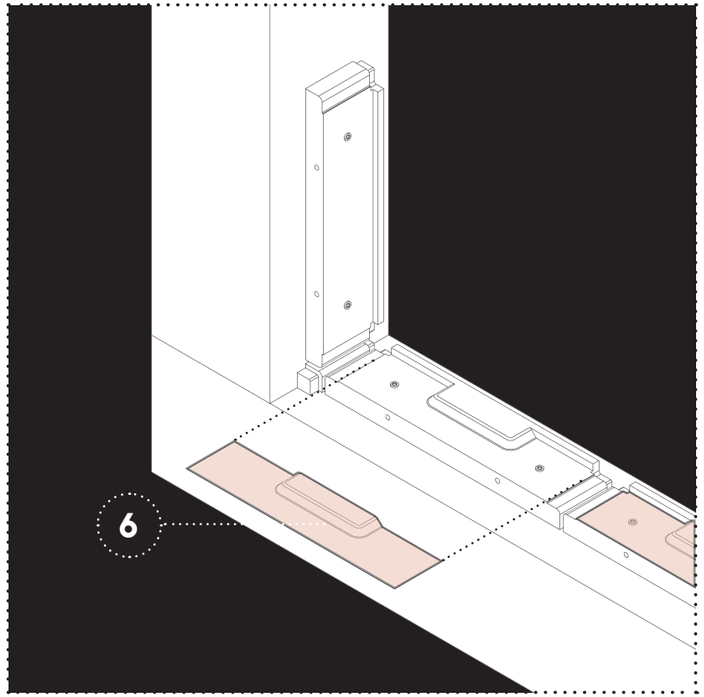


Connectors in between plates

5. Plus shaped connector

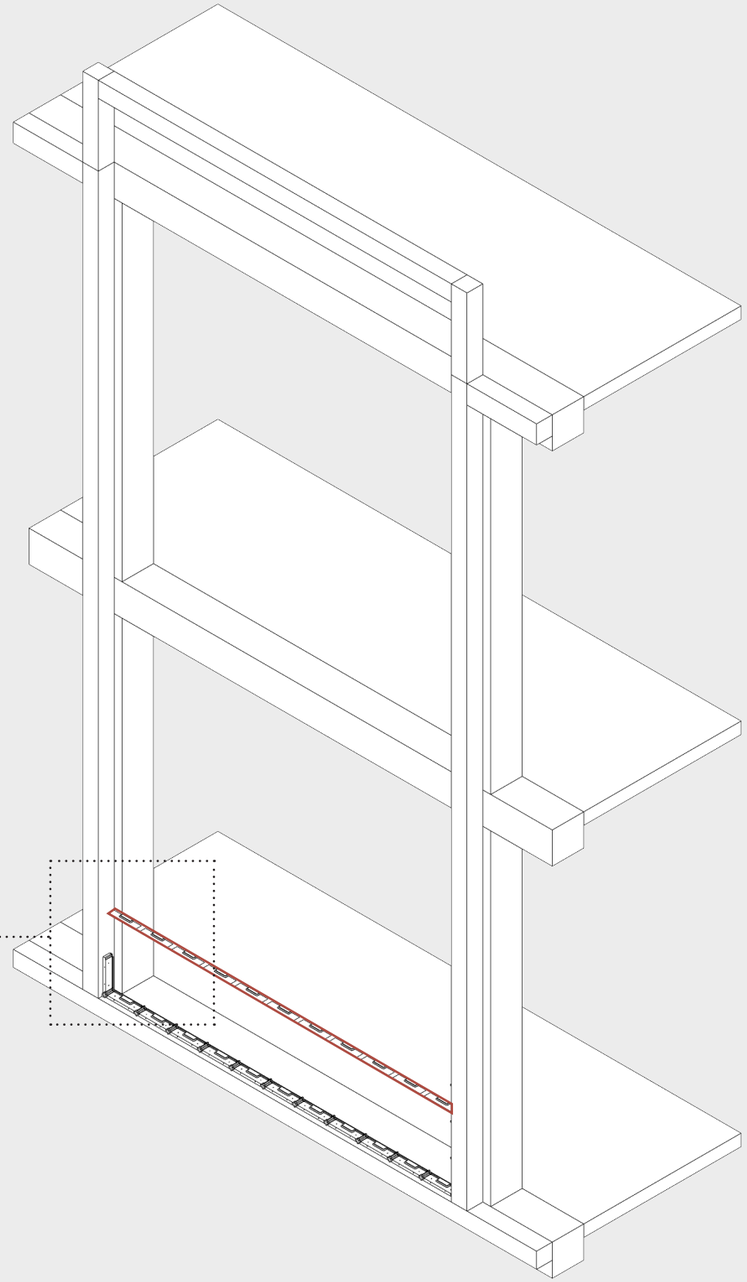


Step - 5

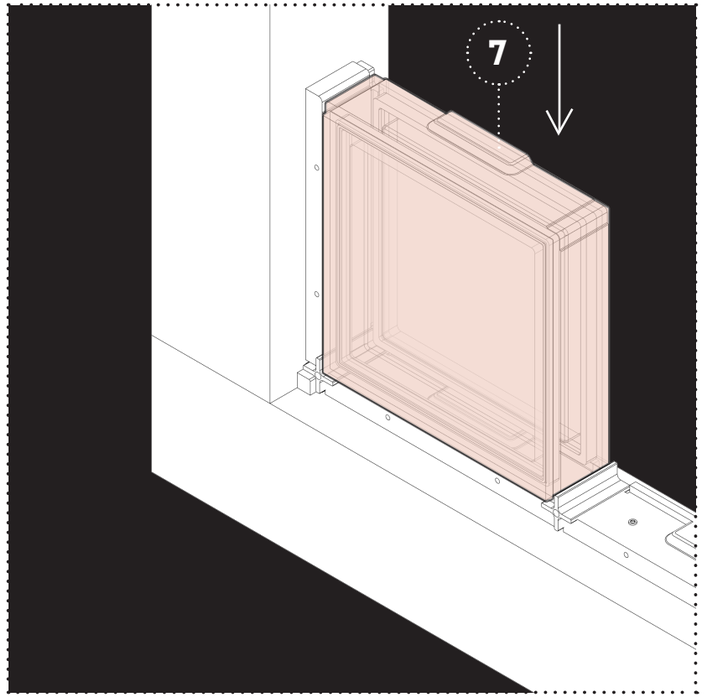


Slid in Soft Padding

6. Interlayer or soft padding - 2 to 4 [mm]

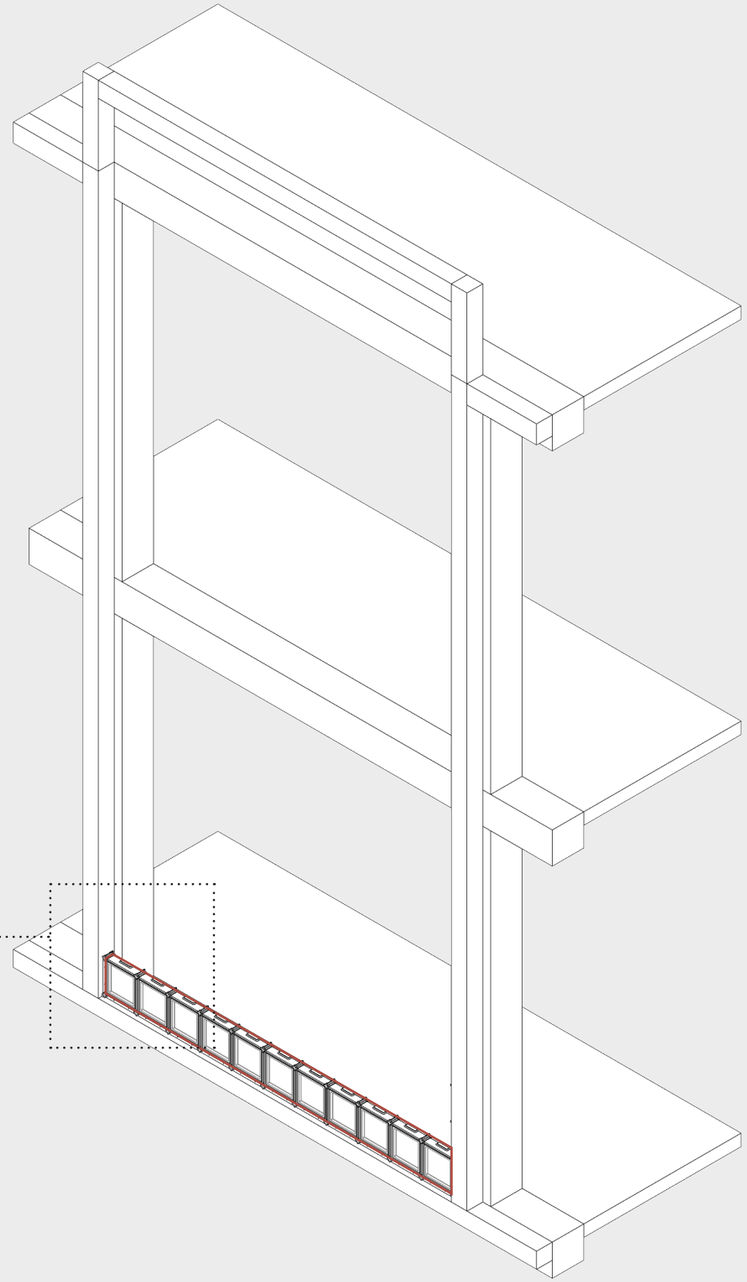


Step - 6

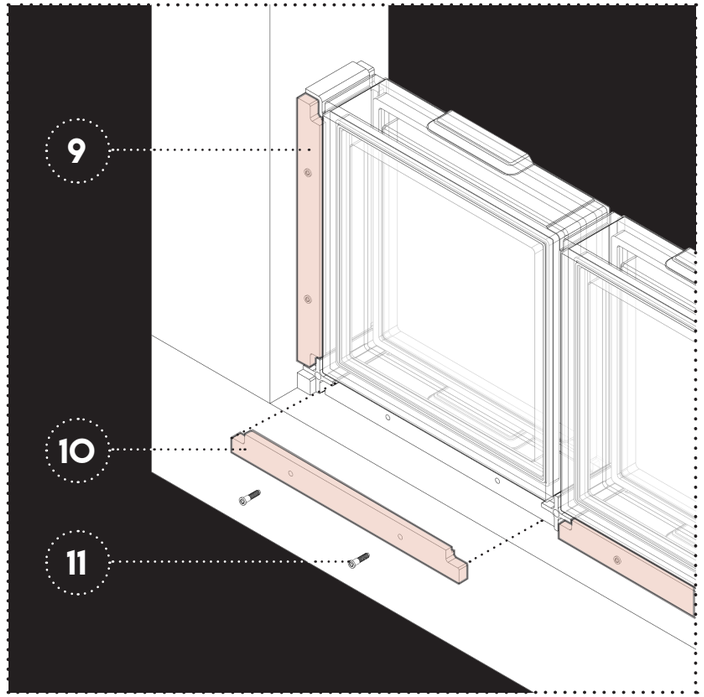


Place Glass Block on corner

7. Hybrid Glass Block

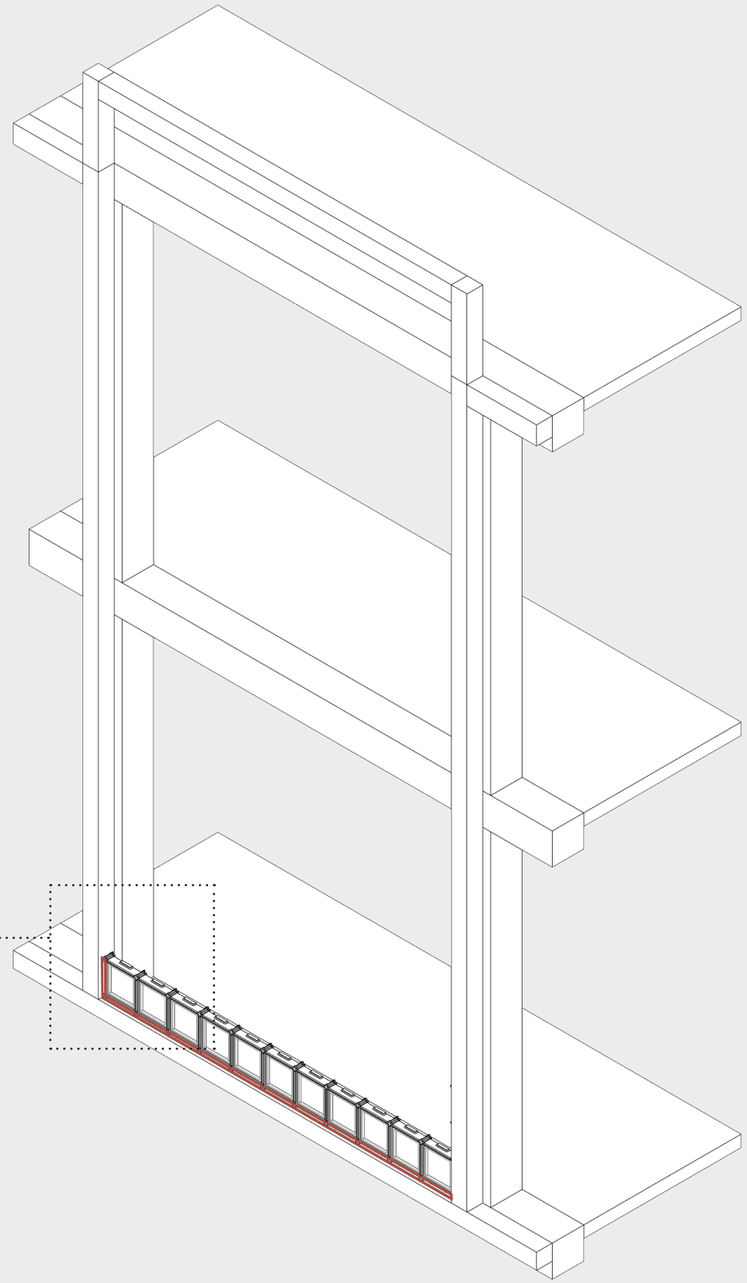


Step - 7

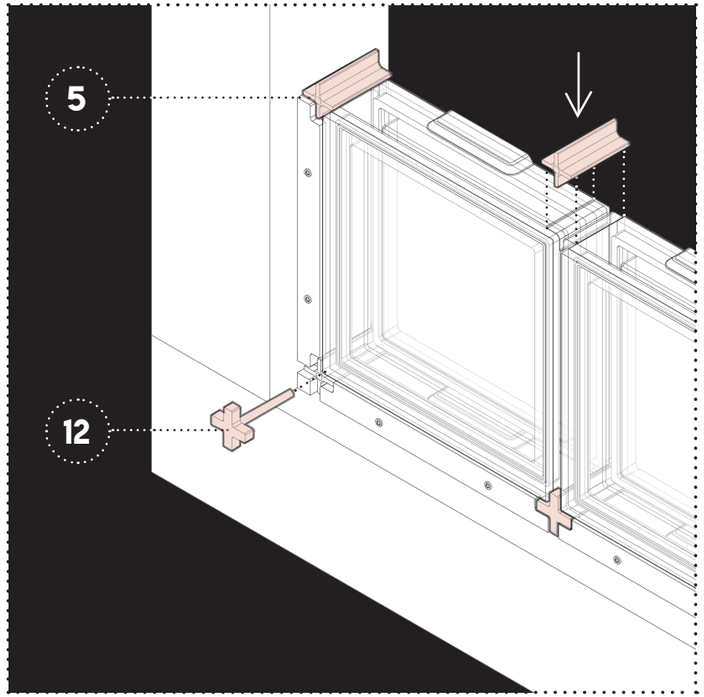


Secure Block with cover plates

9. Side Cover plate
10. Front Cover Plate
11. Screw



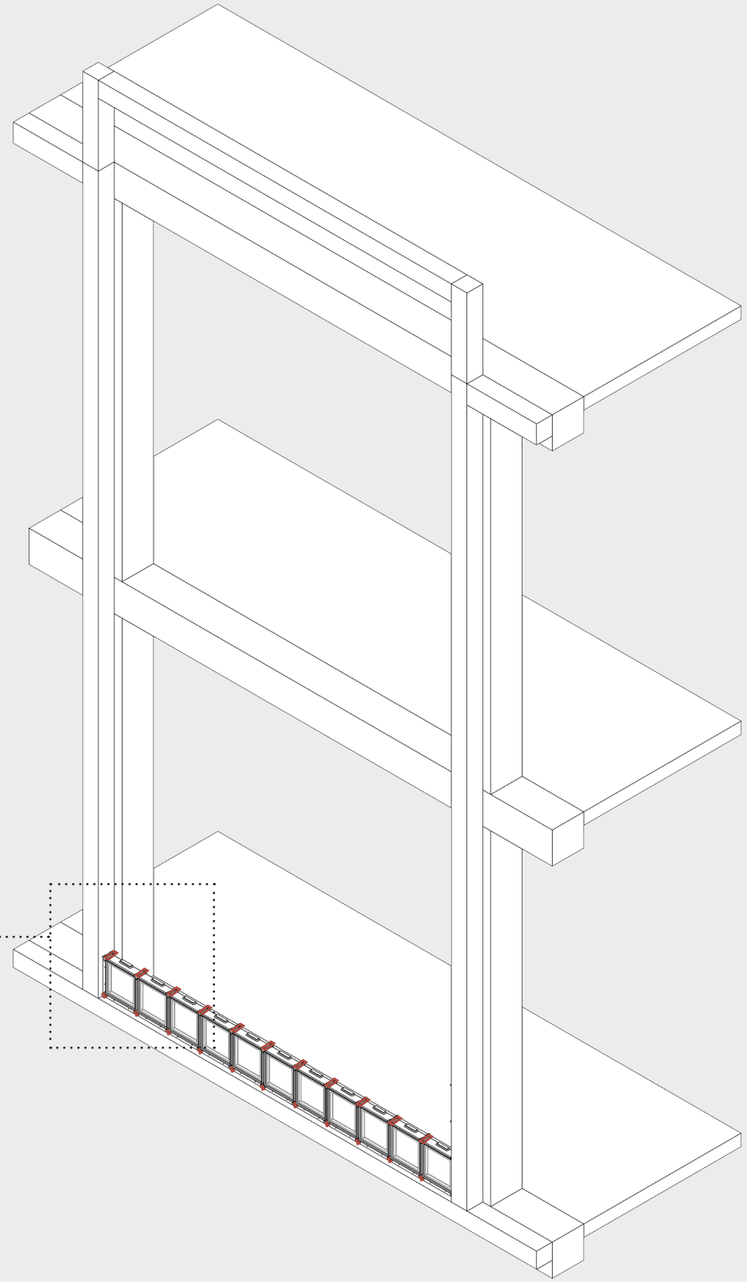
Step - 8 & 9



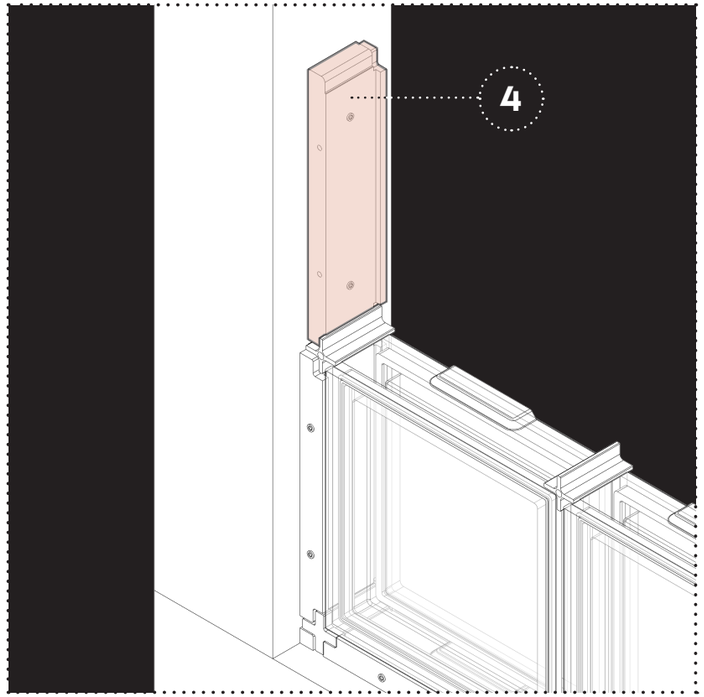
Secure Connection (front -back)

Place connector between blocks

5. Plus shaped connector
12. Teflon Connector with threaded screw cap

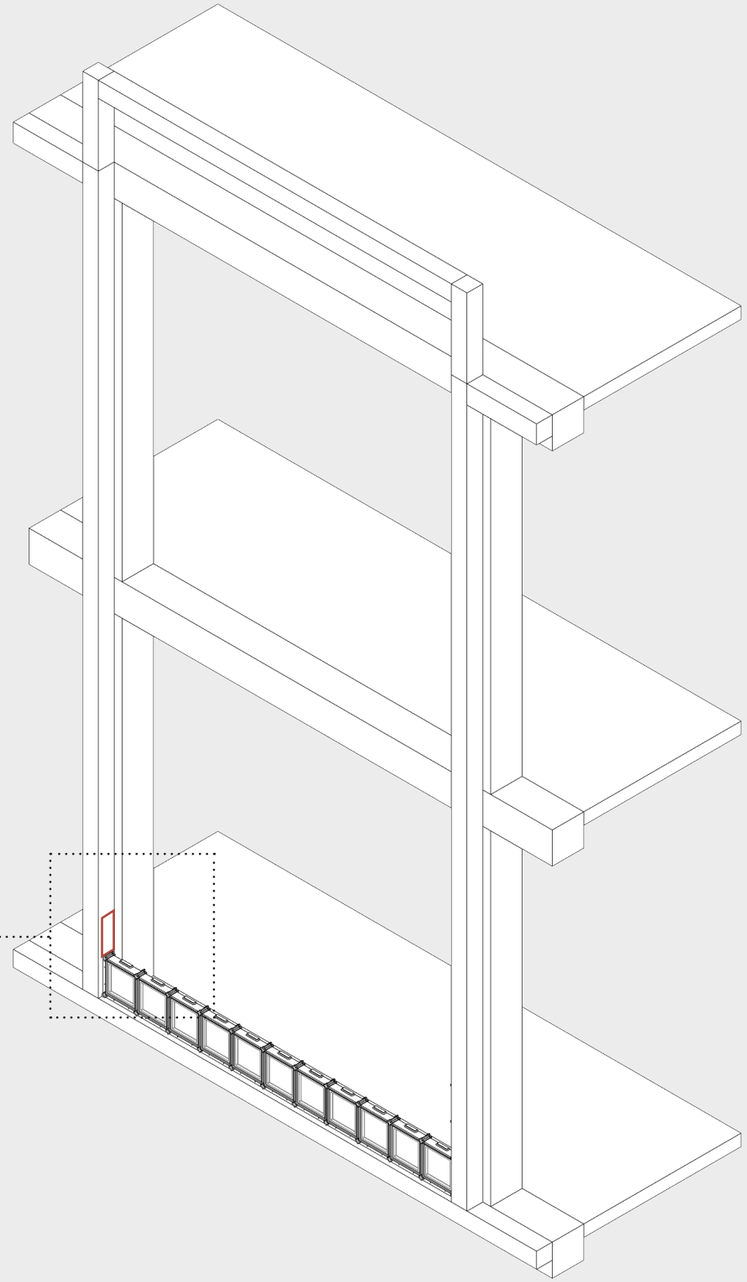


Step - 10

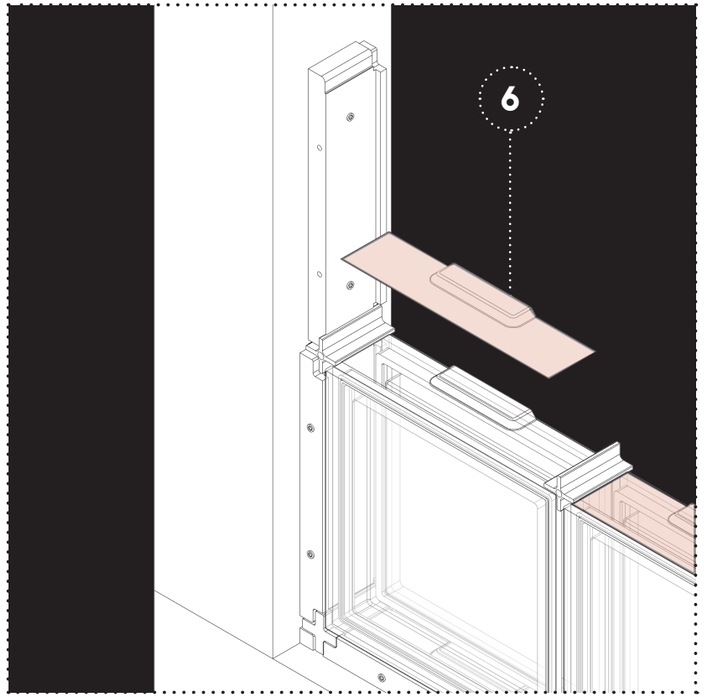


Screw Side plate (1st course)

4. Side plate

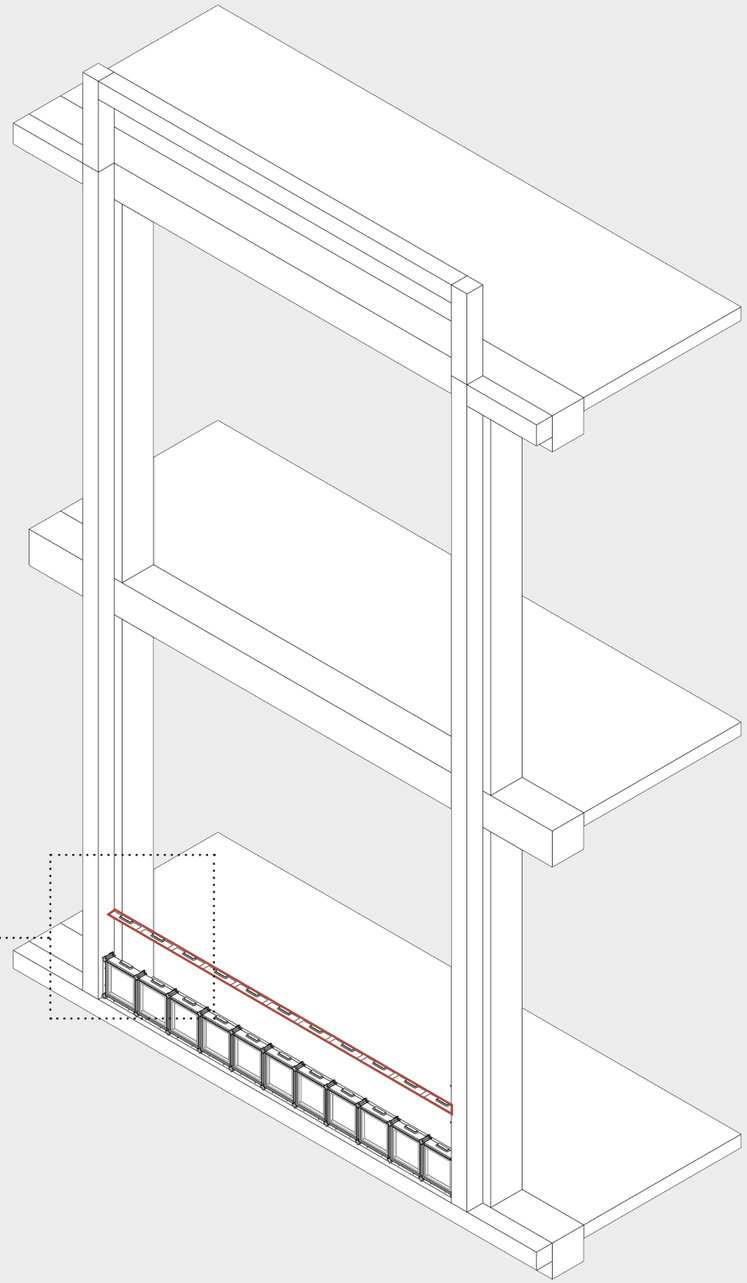


Step - 11



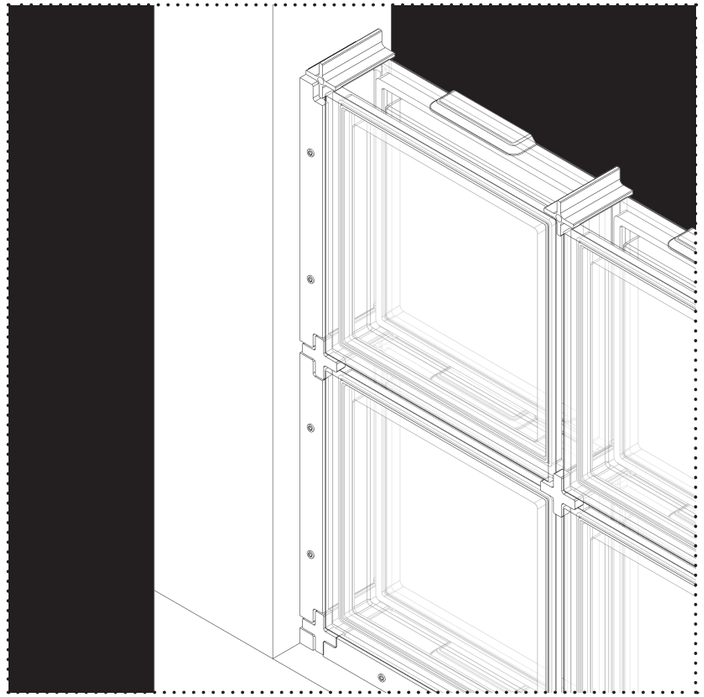
Place interlayer over glass block

6. Interlayer (Vivak PETG - 2 mm or softcore aluminum -1 mm)

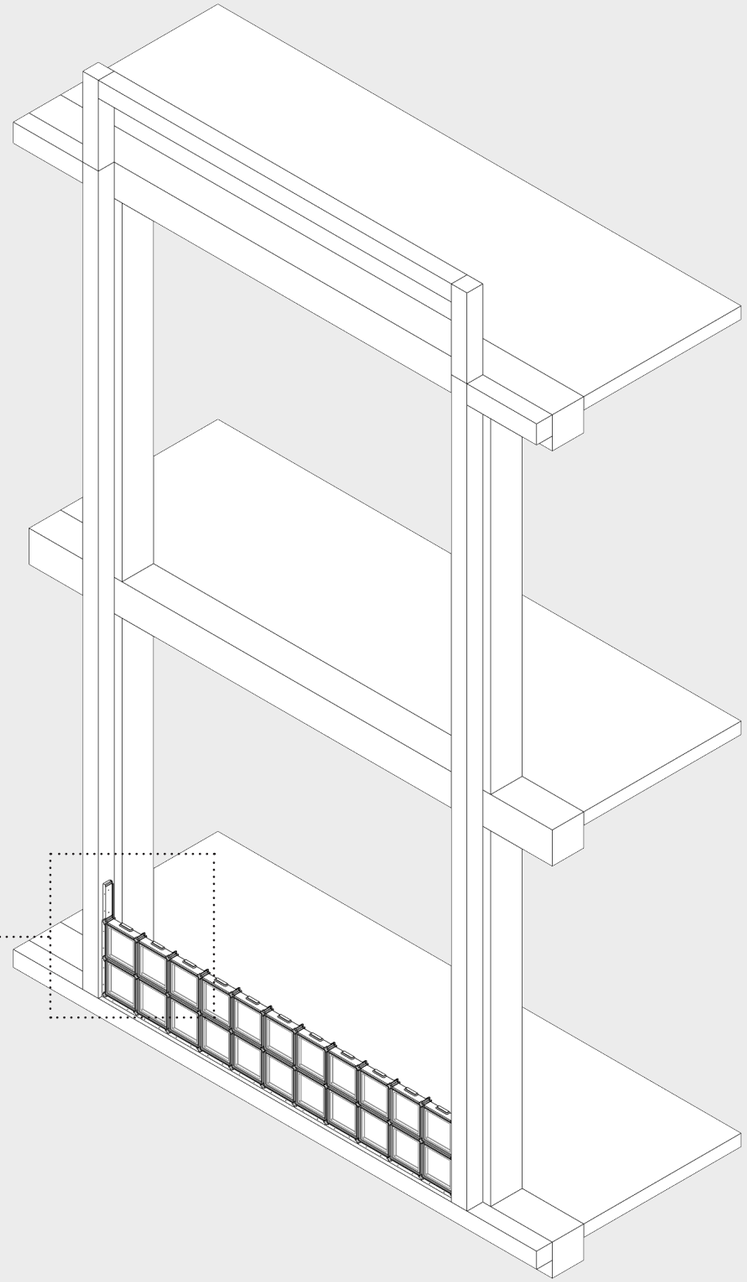


Assembly System

Step - 12

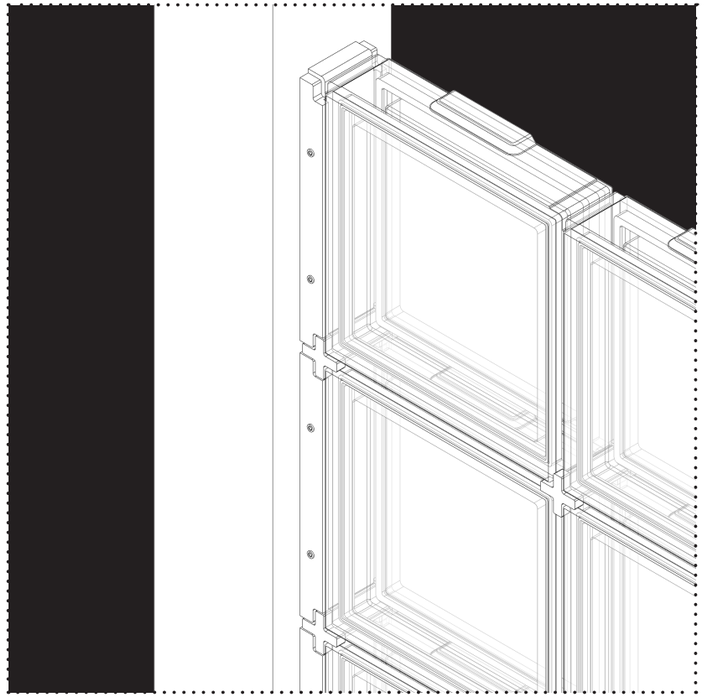


Repeat Step 6-9

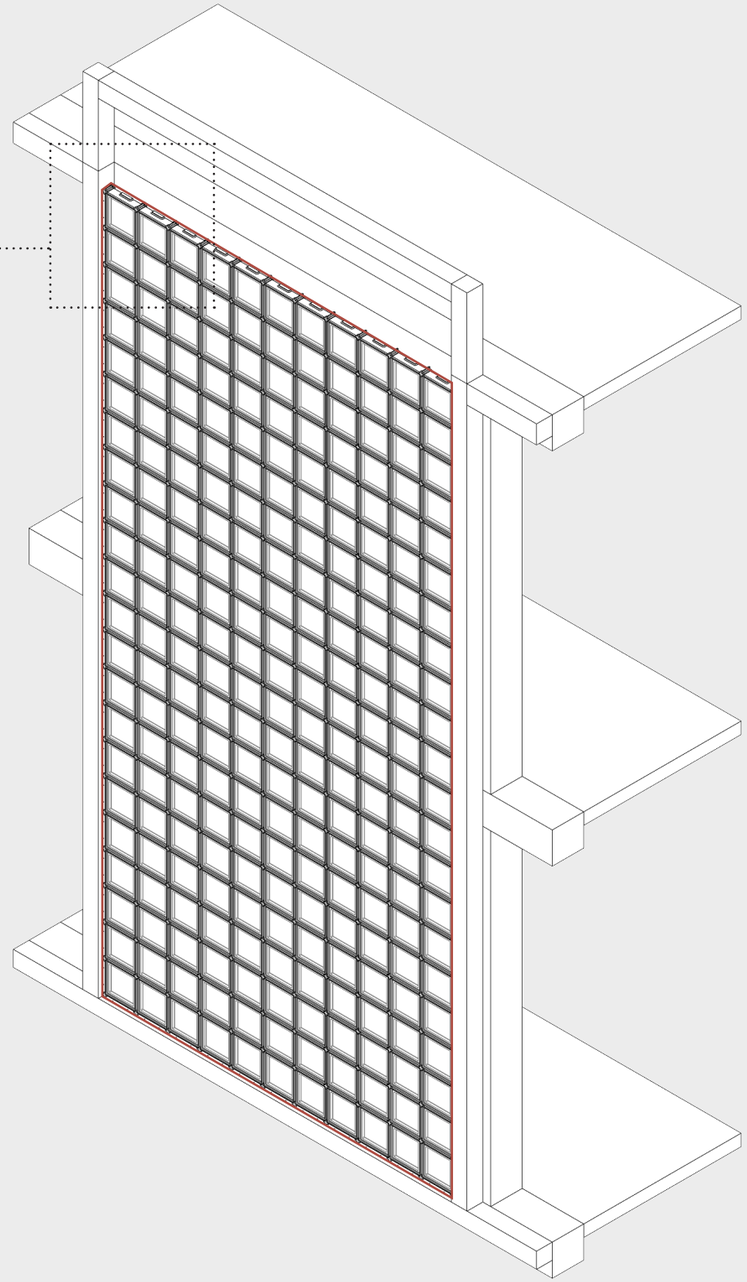


Assembly System

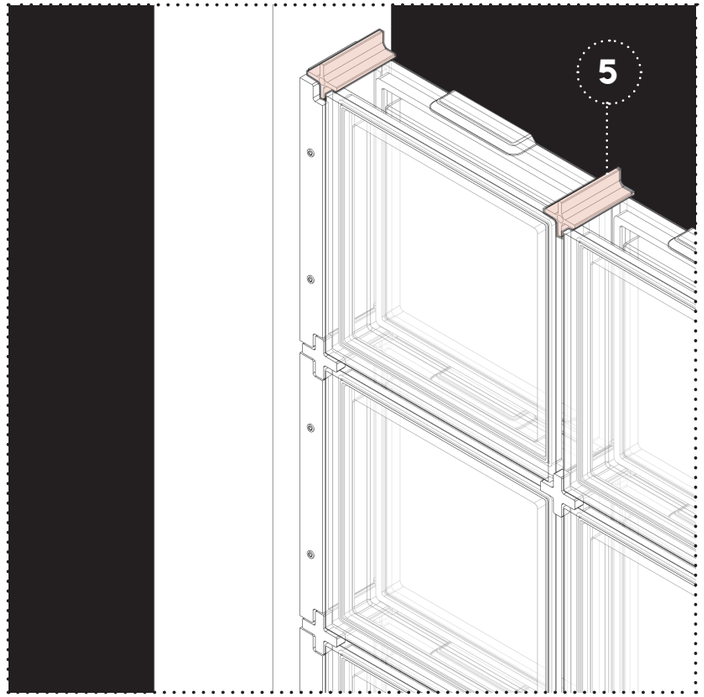
Step - 13



Repeat Step 6-9 till last course

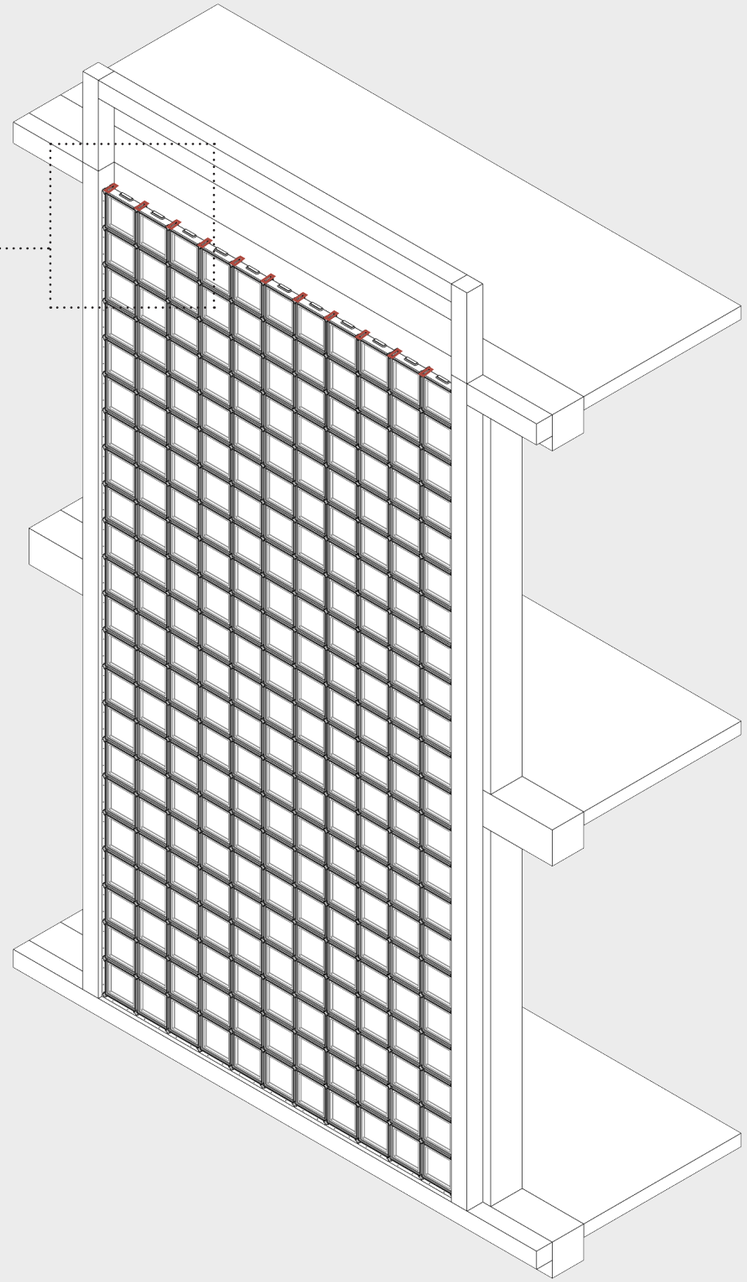


Step - 14

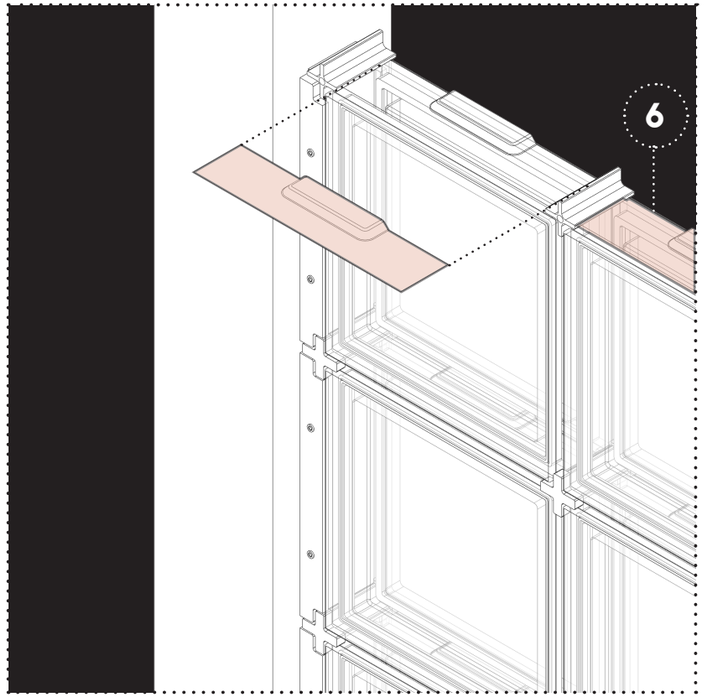


Place connectors between blocks

5. Plus shaped connector

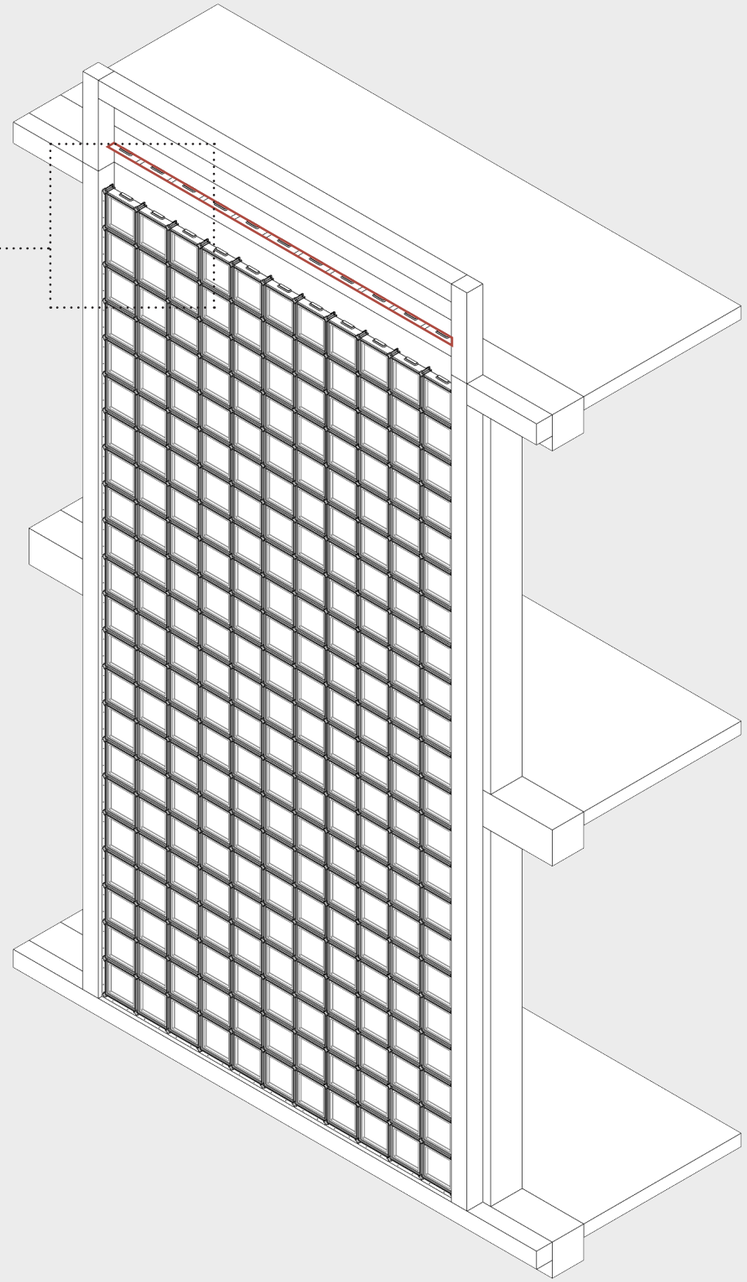


Step - 15

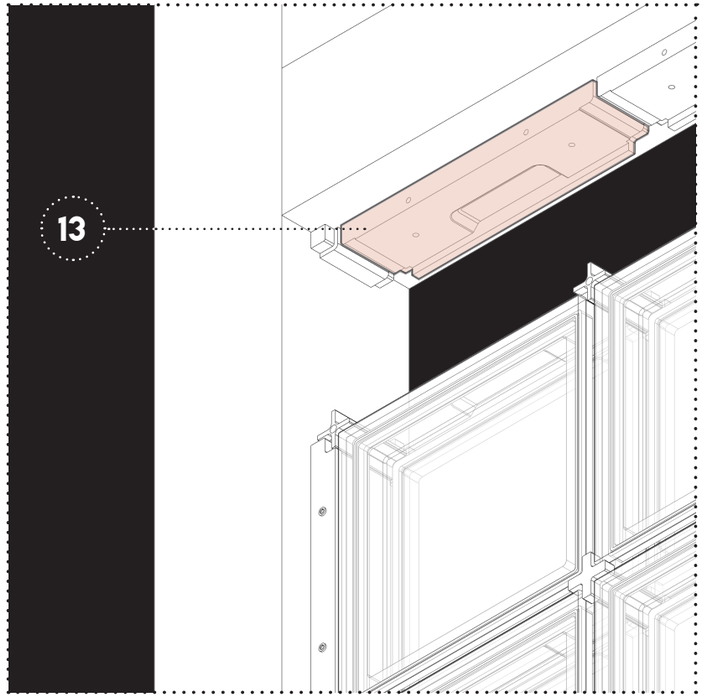


Slide the soft padding

6. Interlayer or Soft Padding - 2 to 4 [mm]

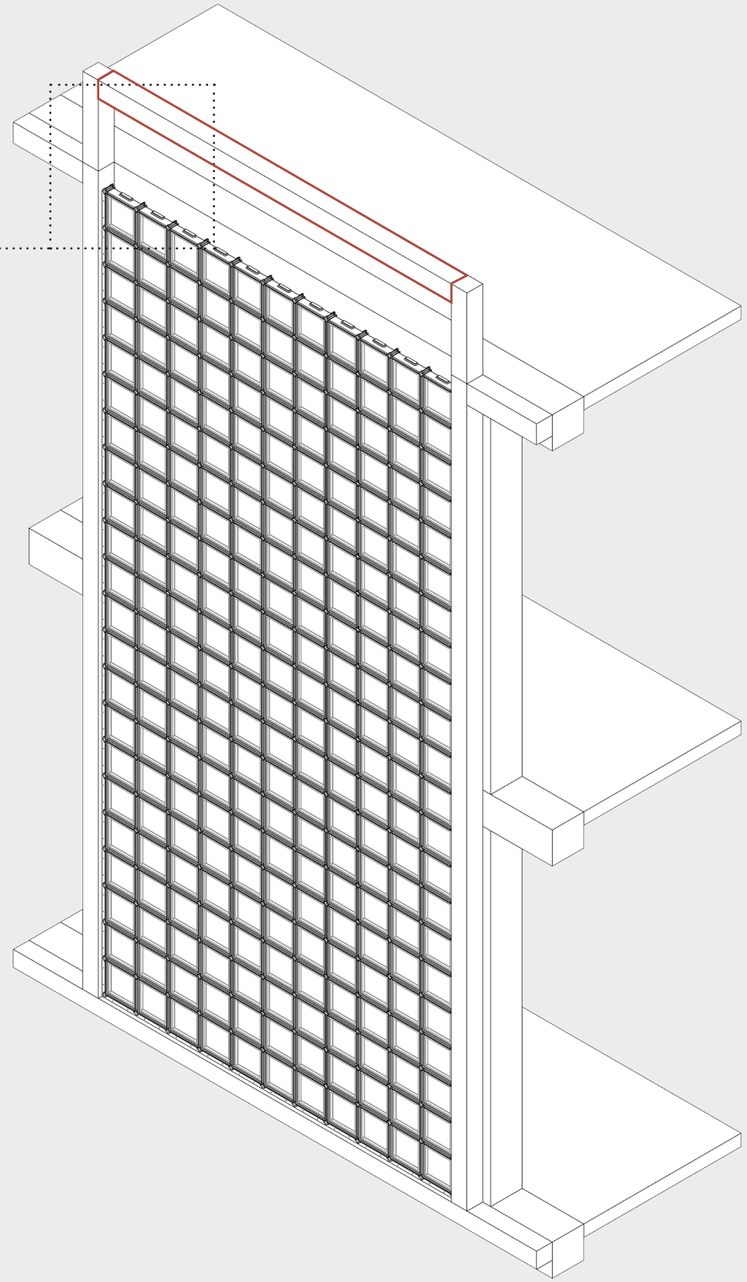


Step - 16

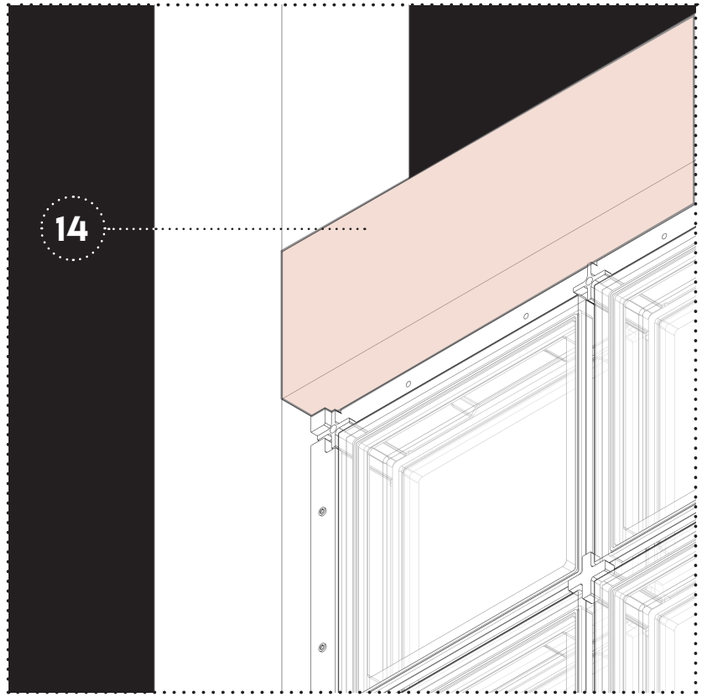


Top Plate screwed to beam

6. Top Plate with alignment dip

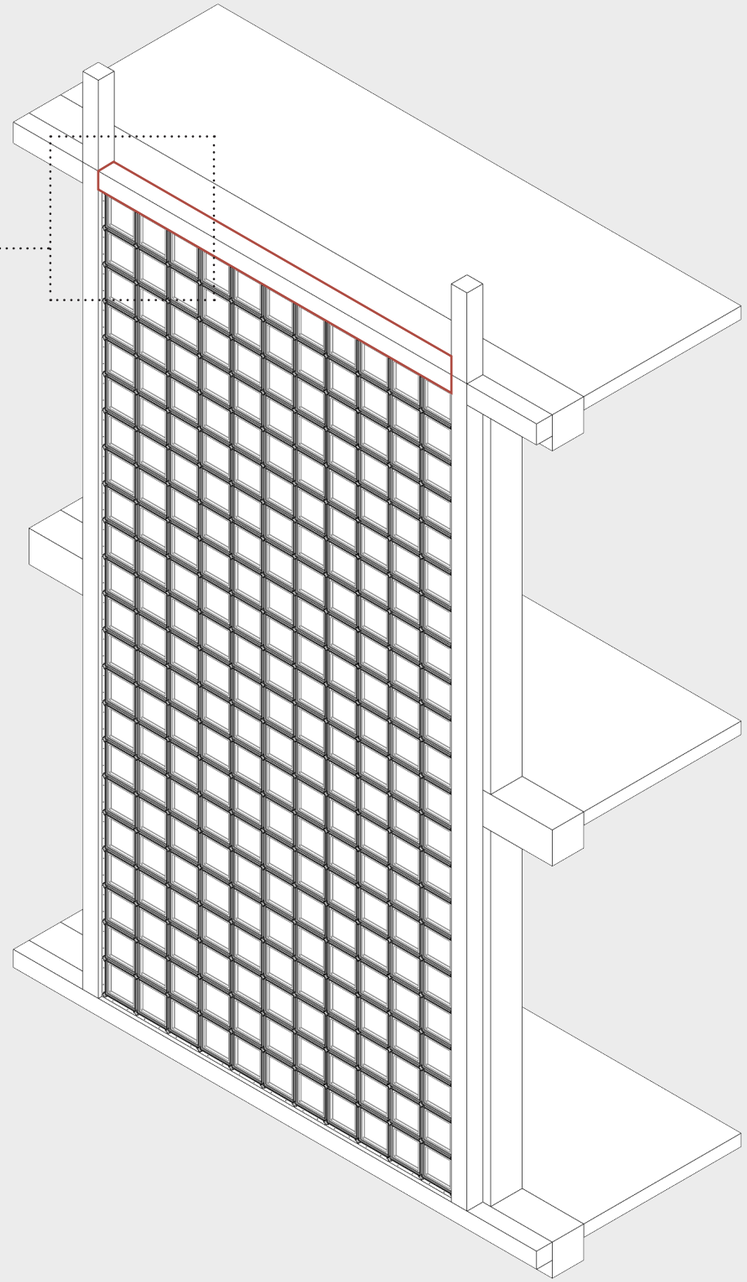


Step - 17

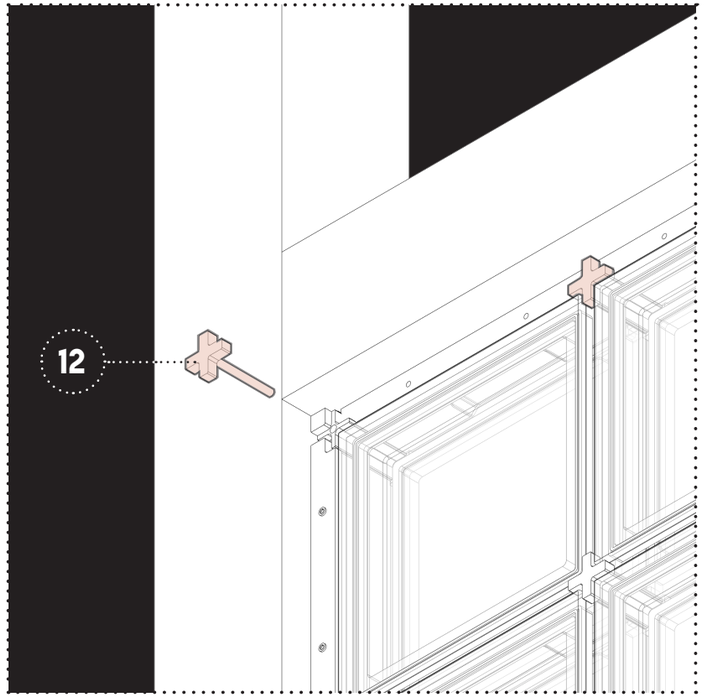


Top Beam is Lowered

14. Top beam

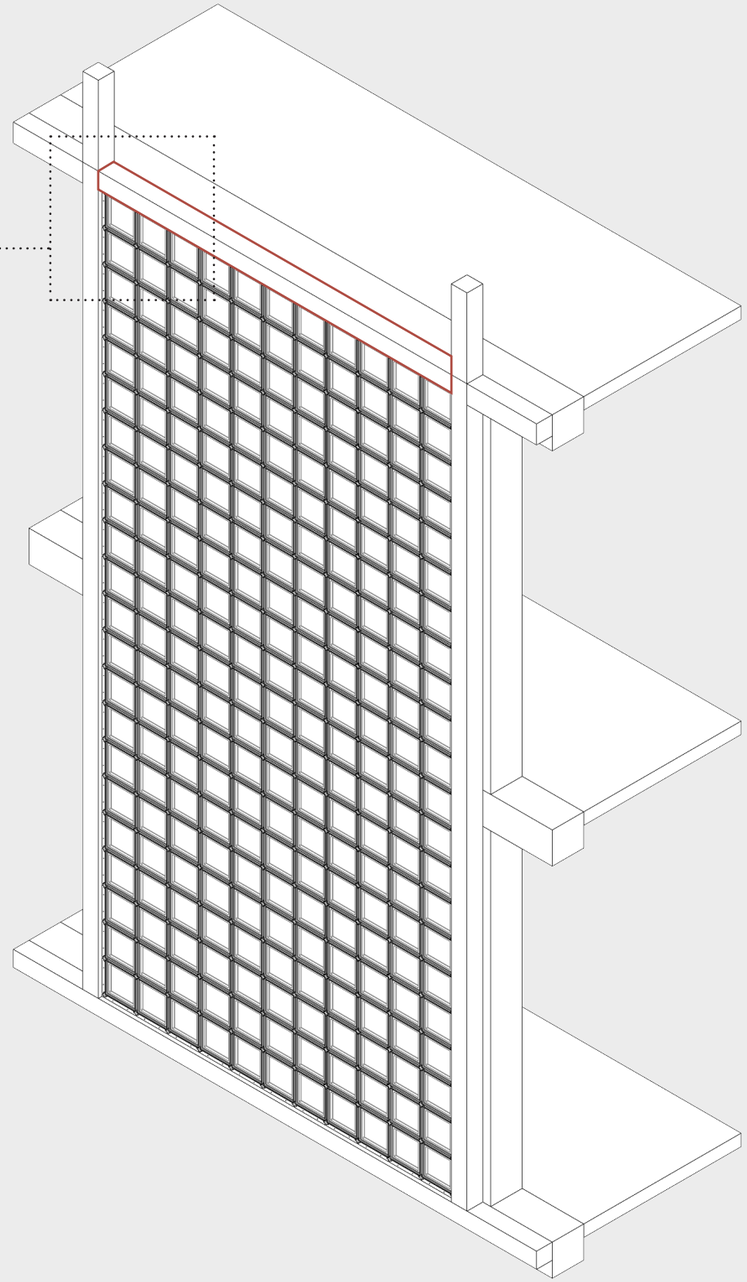


Step - 18

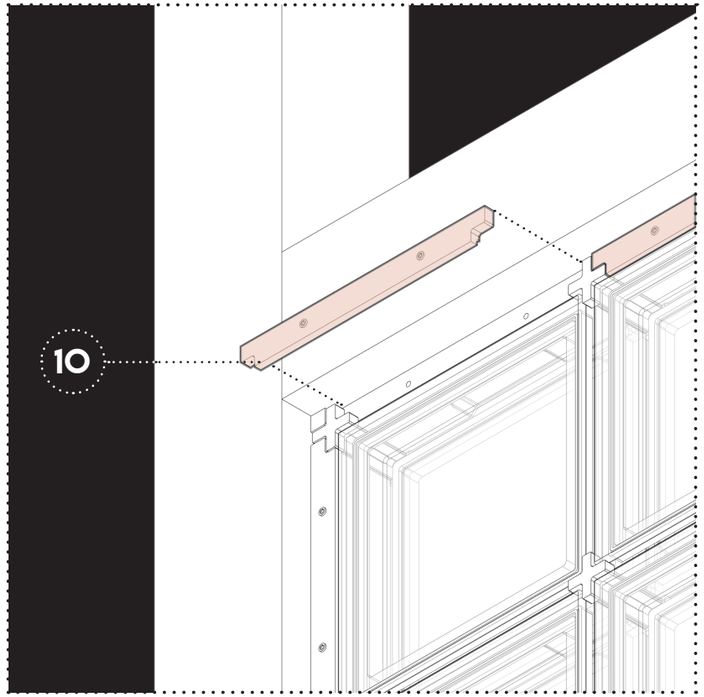


Top connection secured

12. Teflon connector with threaded screw

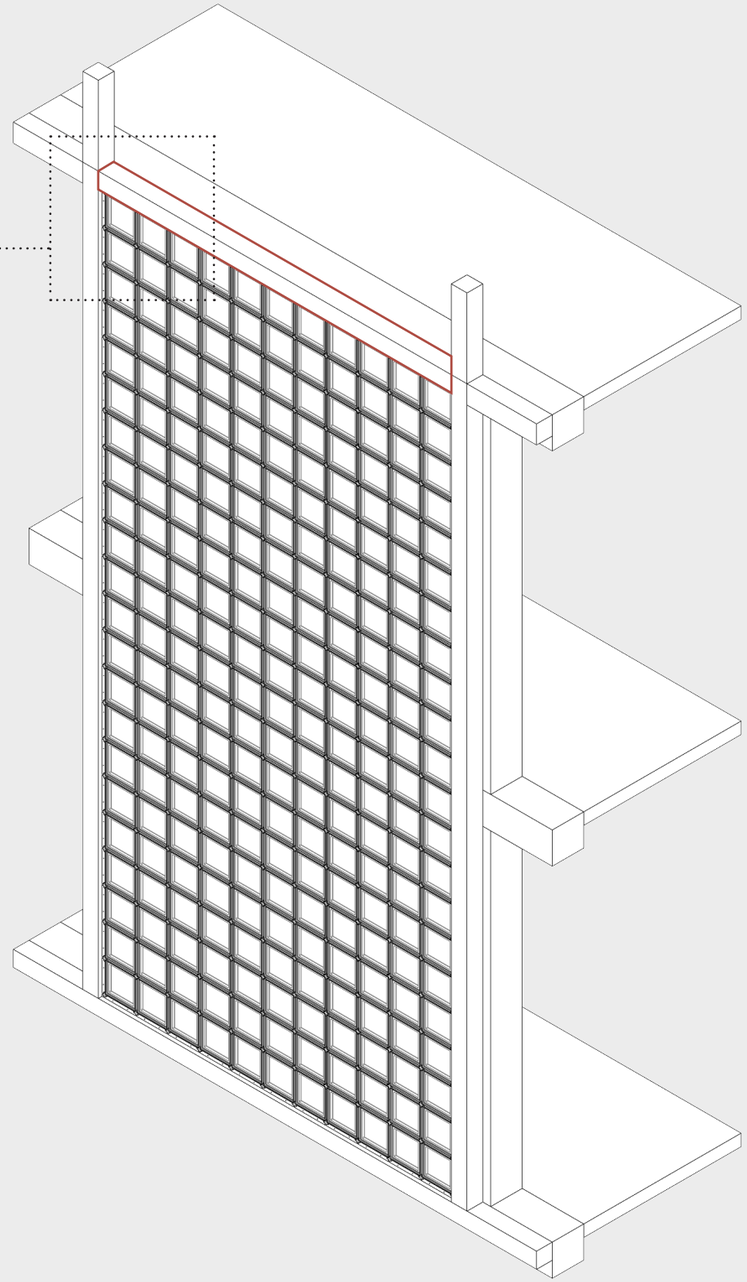


Step - 19



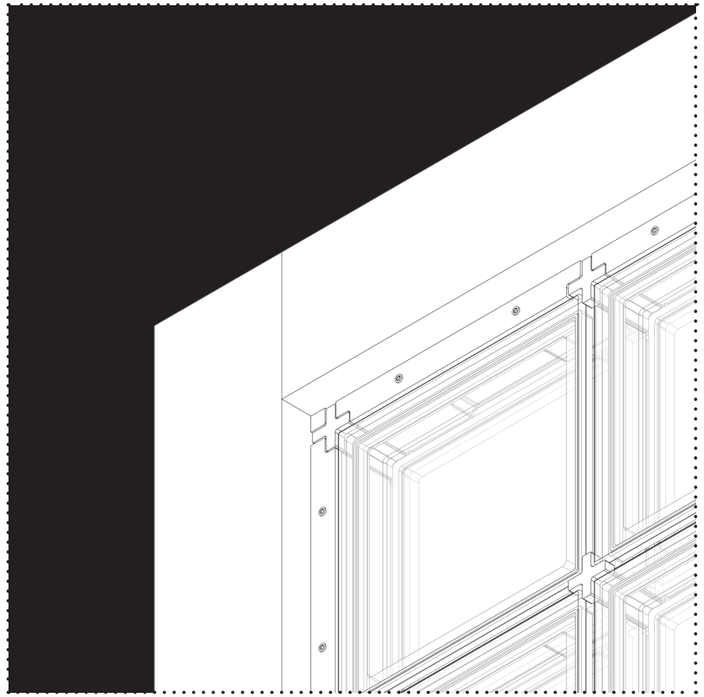
Screw the cover plate

10. Front Cover plate

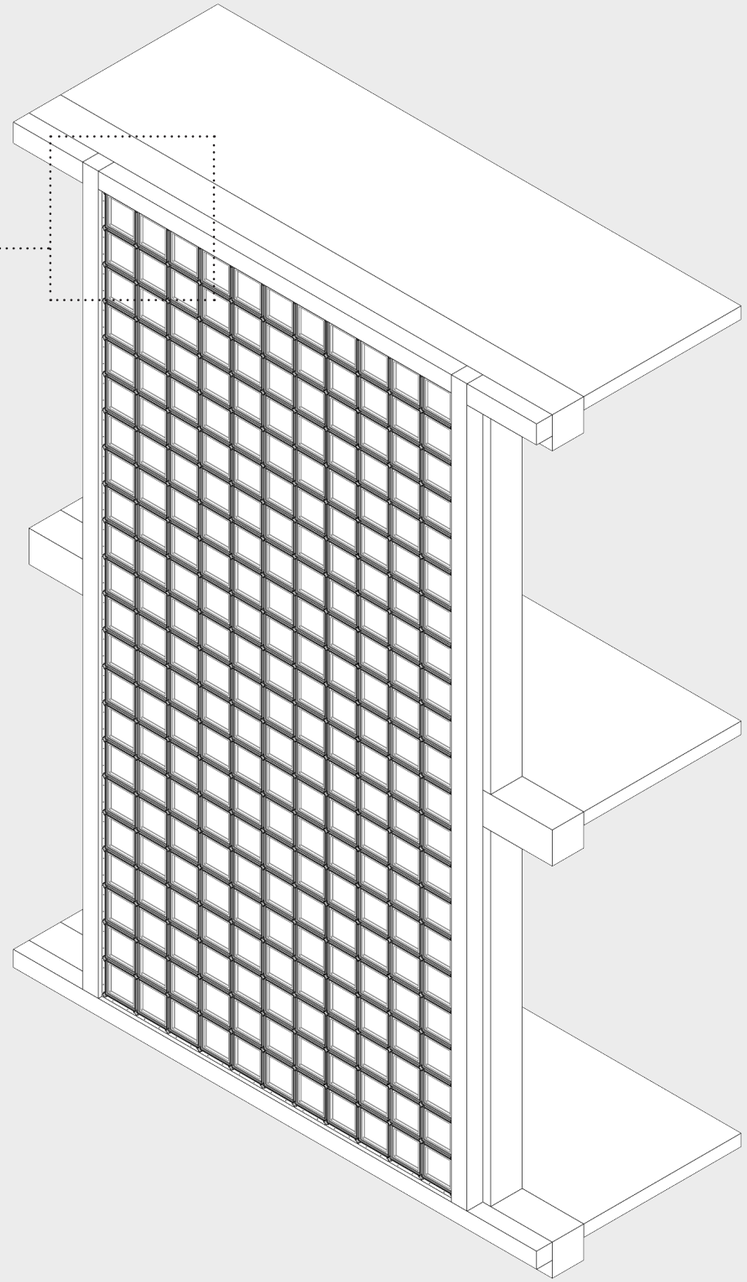


Assembly System

Step - 20

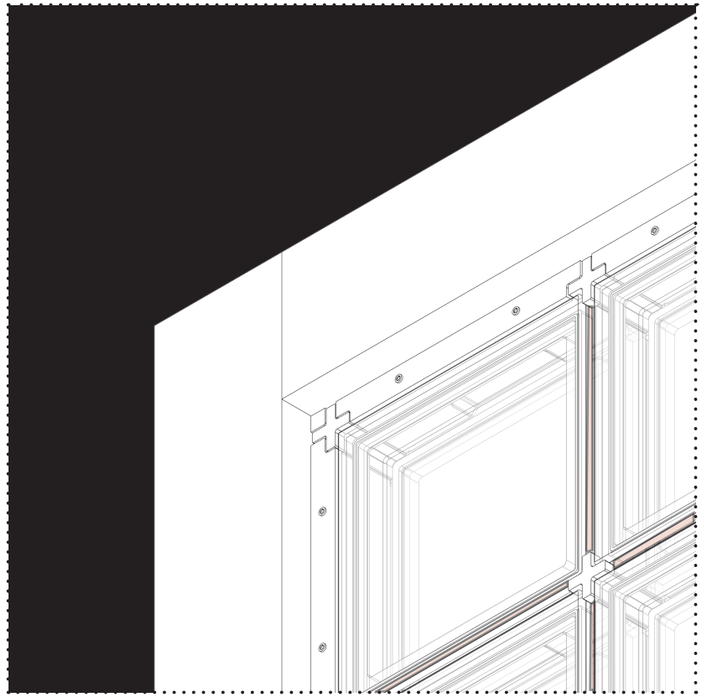


The extended frame is removed

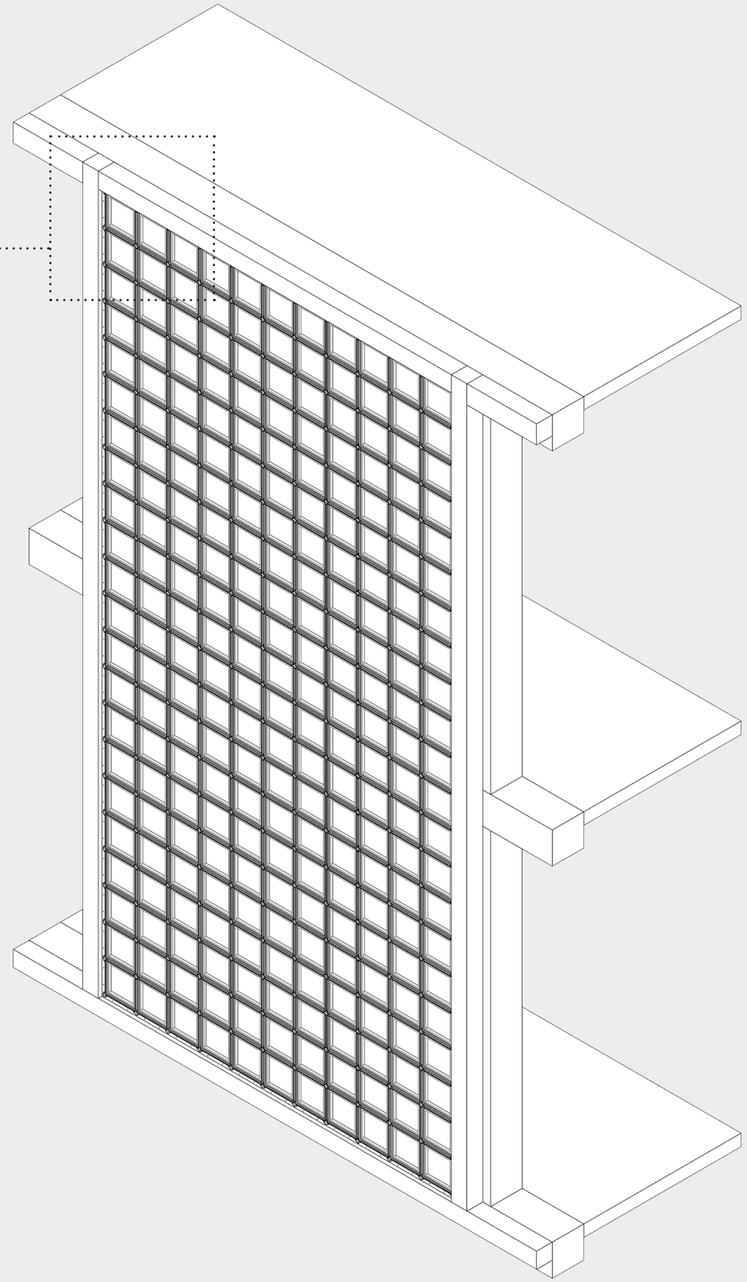


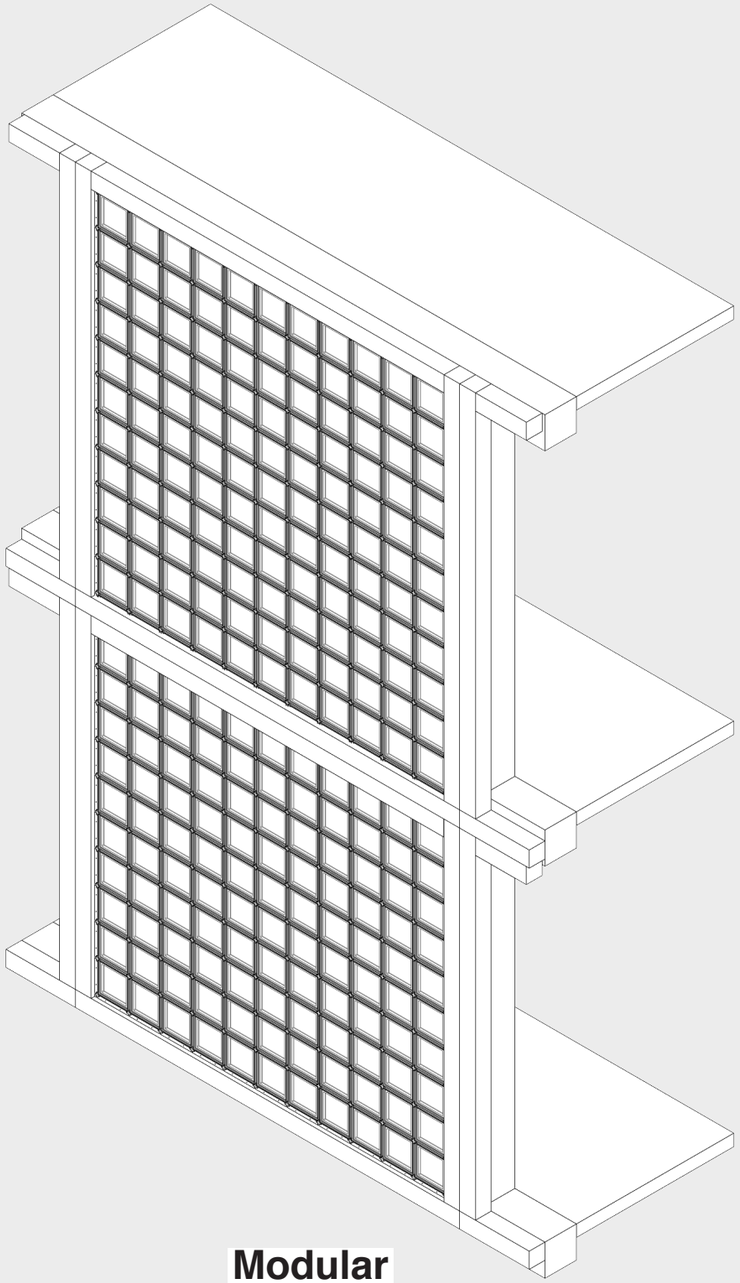
Assembly System

Step - 20

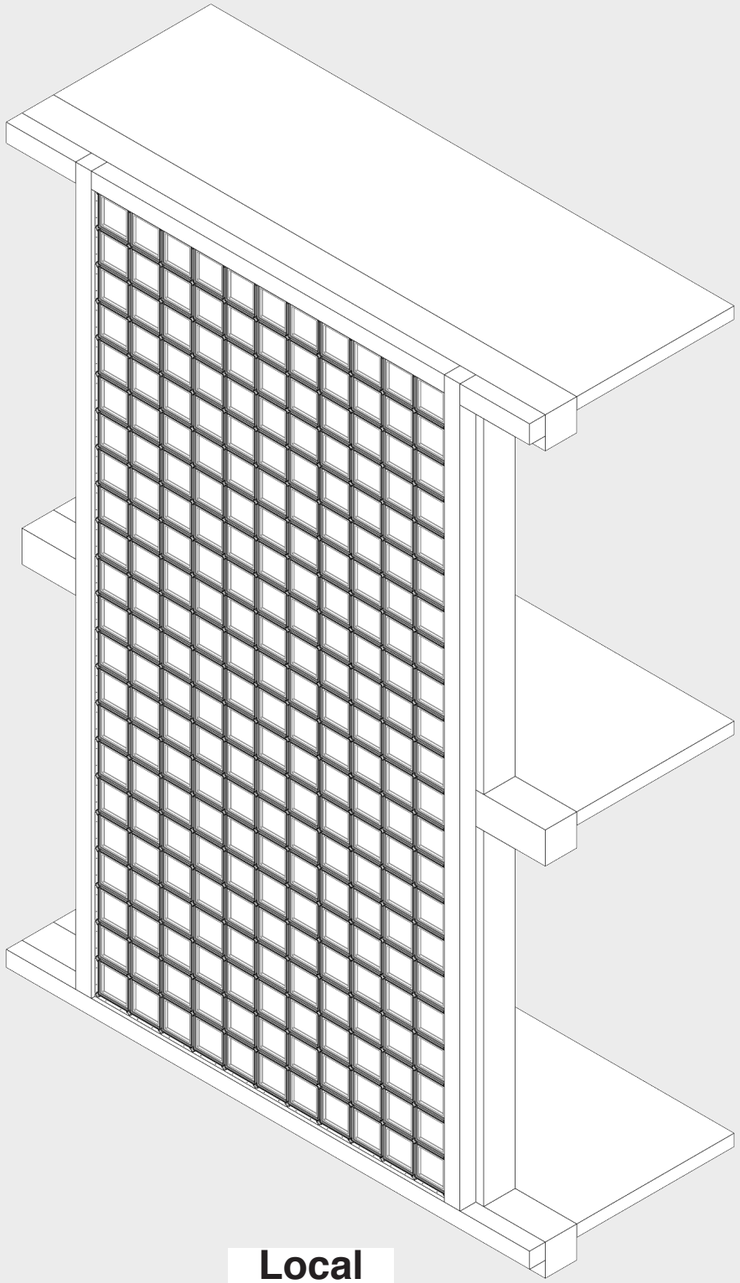


Gaps sealed with silicone

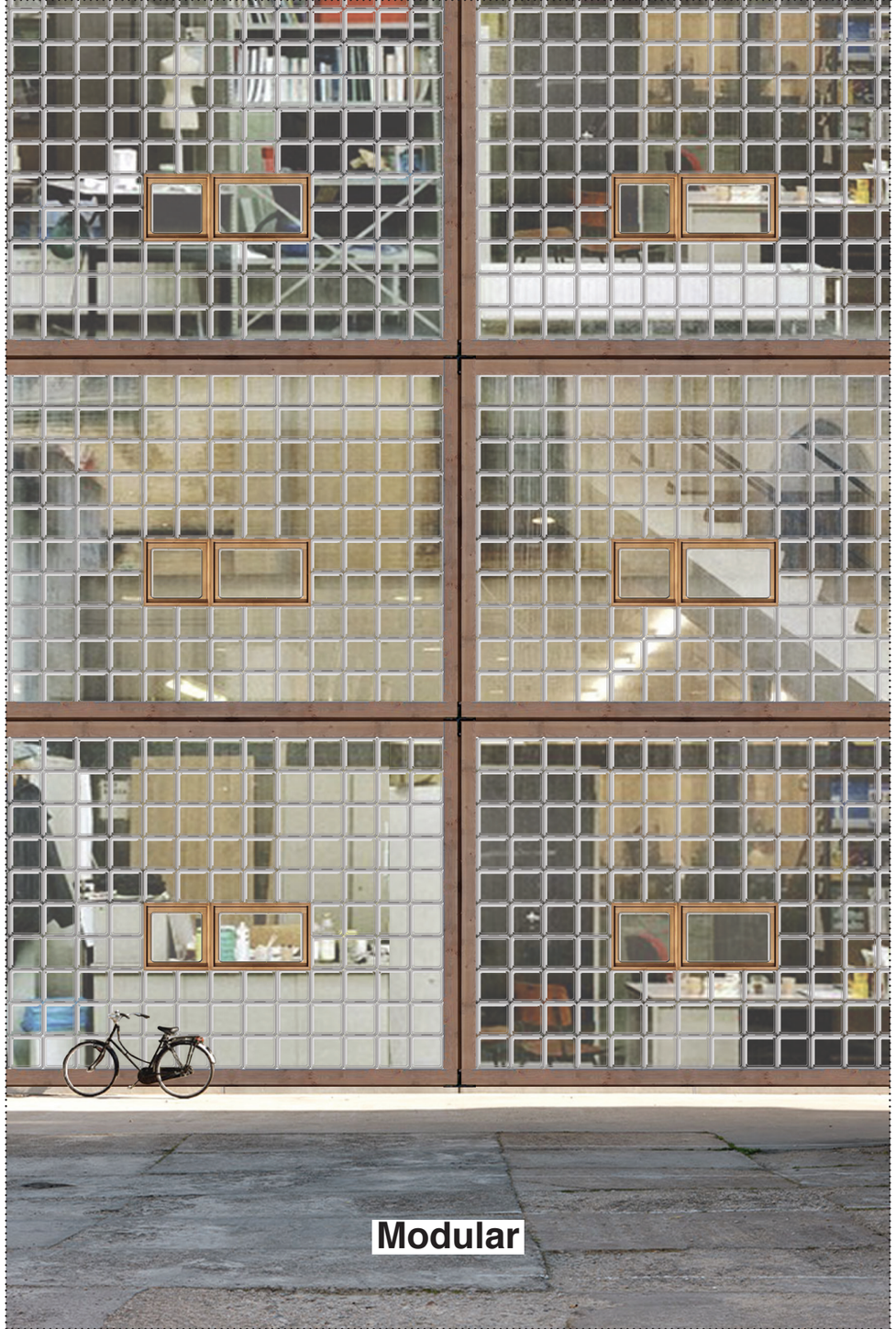


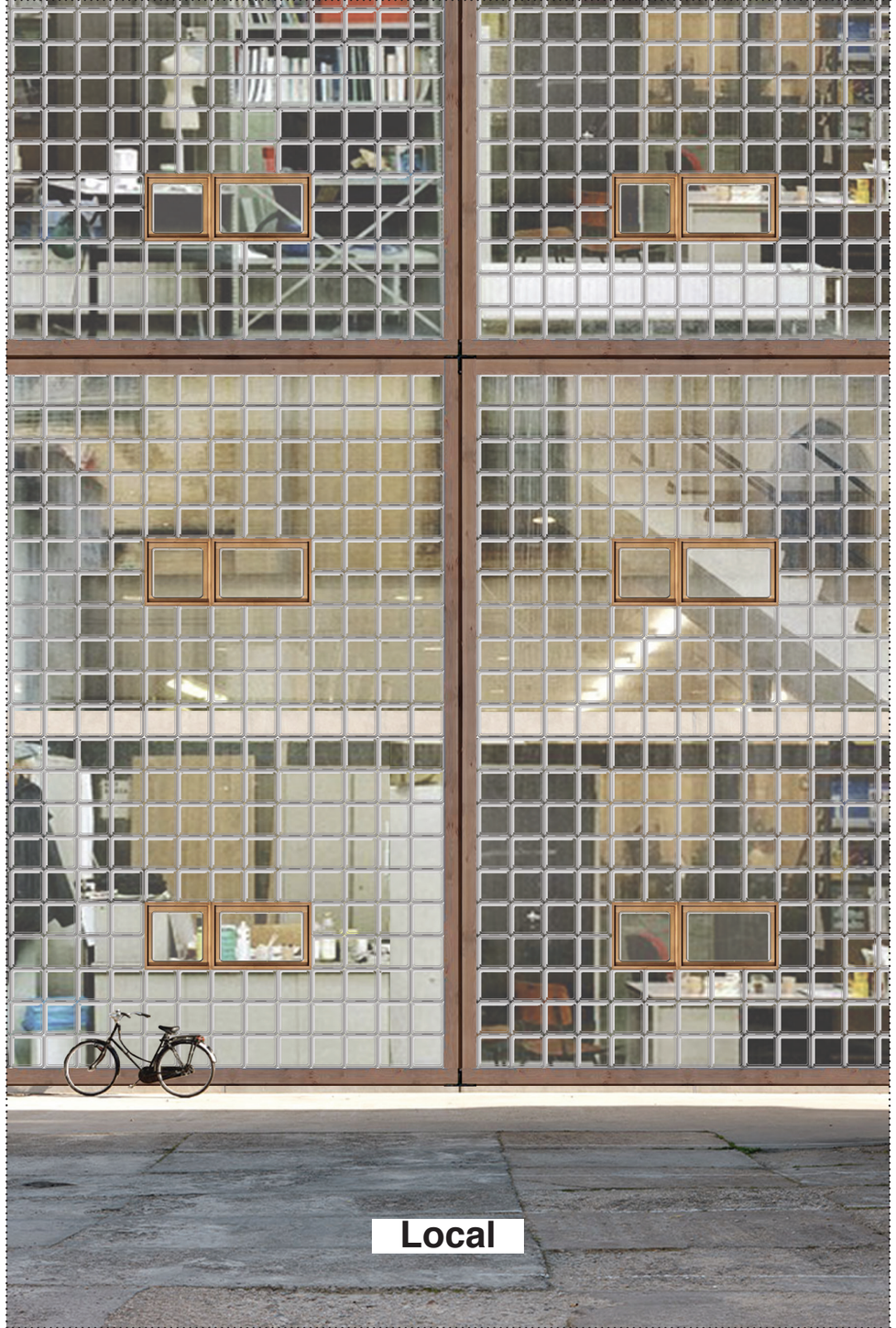


Modular

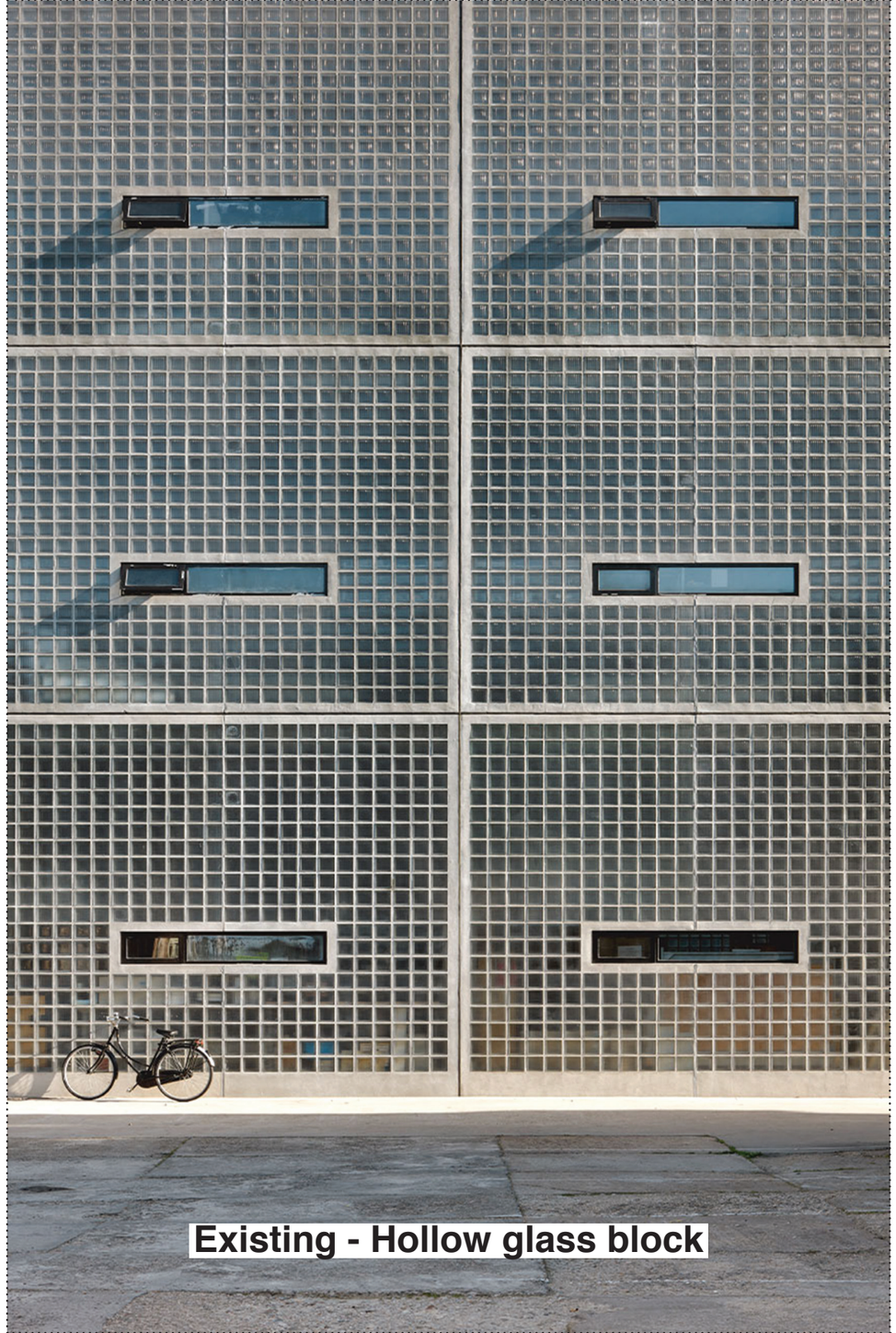


Local

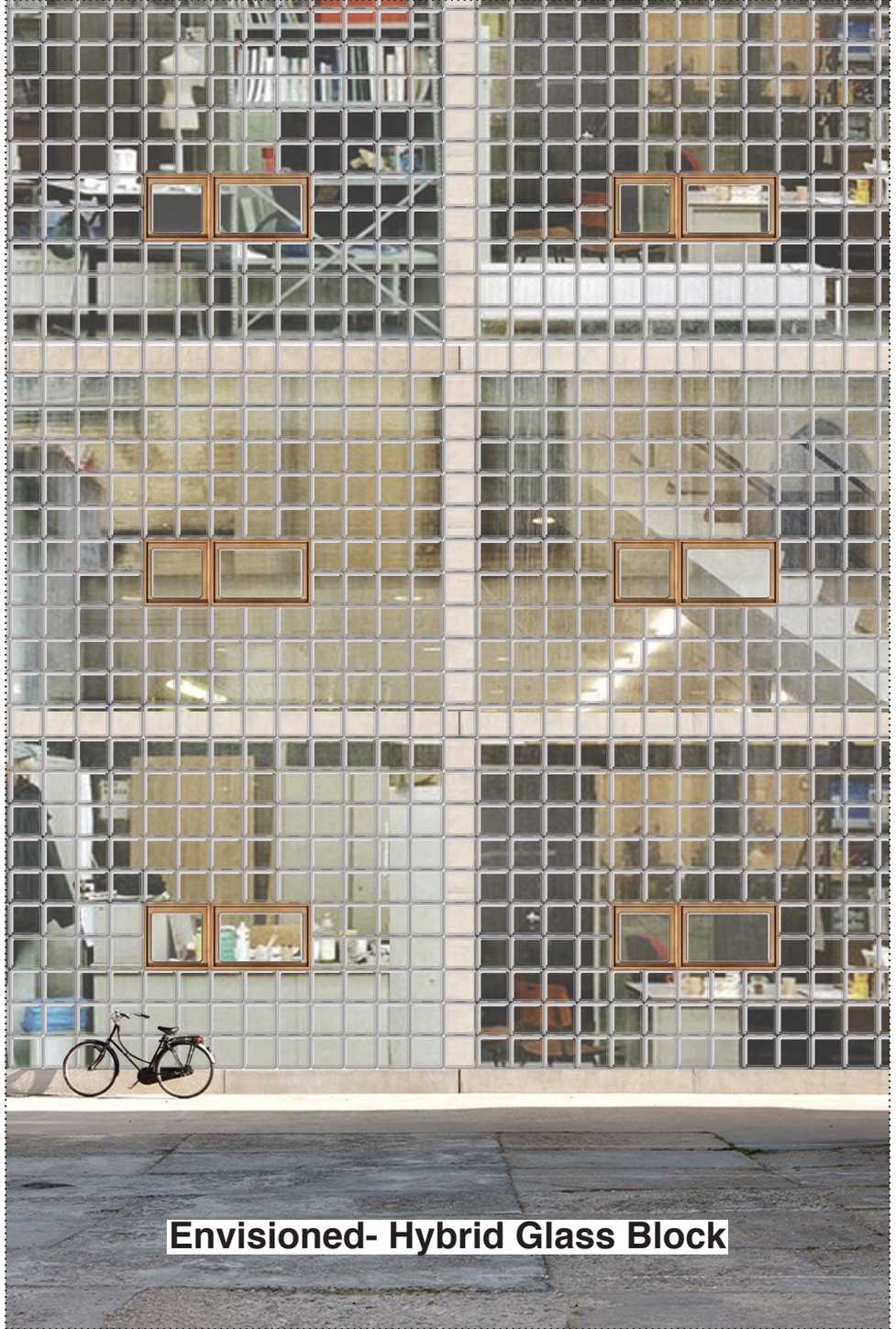

Modular


Local

[Academy of Arts, Maastricht. Archdaily]



Existing - Hollow glass block



Envisioned- Hybrid Glass Block

[Academy of Arts, Maastricht. Envisioned View]

[Academy of Arts, Maastricht. Archdaily]

[Academy of Arts, Maastricht. Envisioned View]

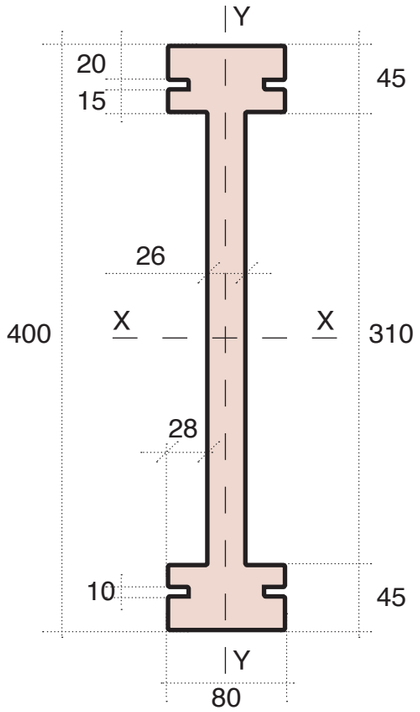
[Academy of Arts, Maastricht. Archdaily]

[Academy of Arts, Maastricht. Envisioned View]

D

Design Evaluation

Structural Evaluation - Numerical

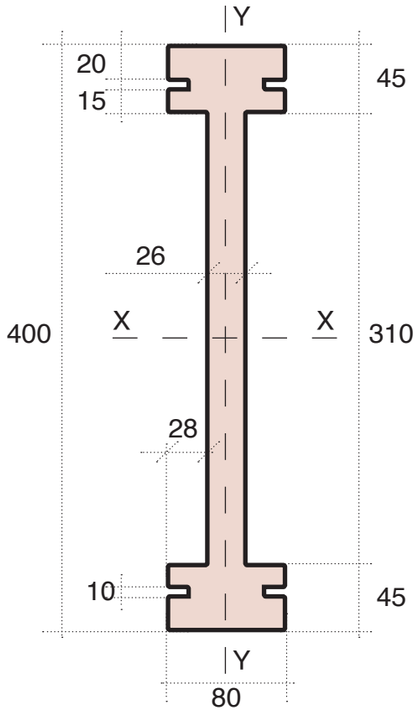


Compressive Load

for 10T loading
0.04 [MPa] < 0.5 [MPa]

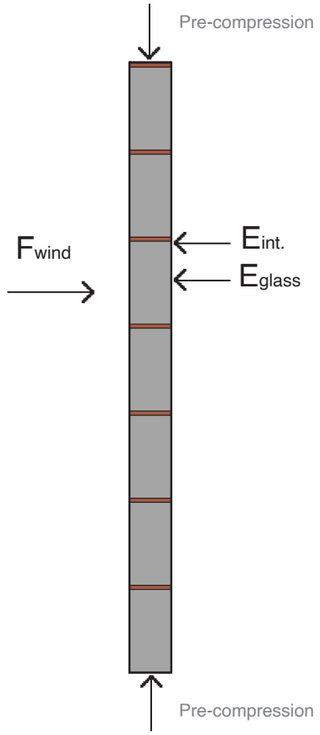
*All dimensions in mm

Structural Evaluation - Numerical



Compressive Load

for 10T loading
0.04 [MPa] < 0.5 [MPa]

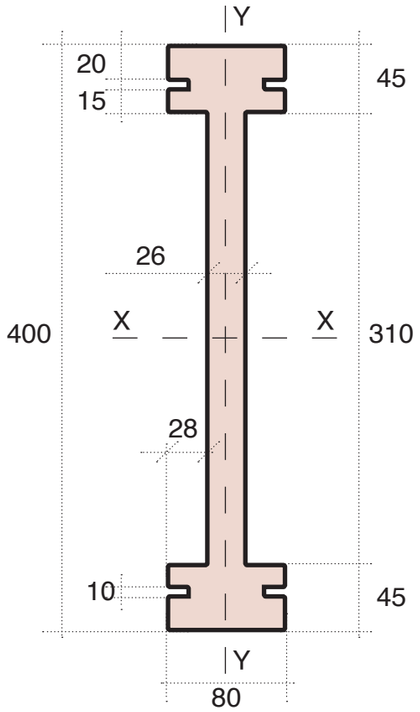


Effective Stiffness

55.4 [GPa]

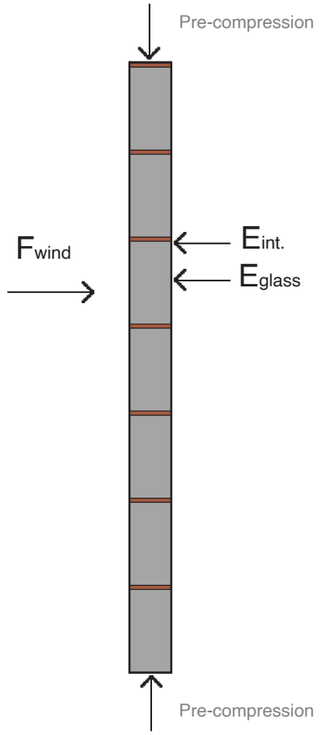
*All dimensions in mm

Structural Evaluation - Numerical



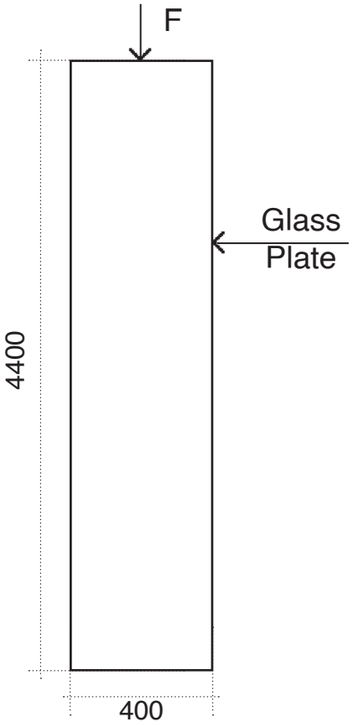
Compressive Load

for 10T loading
0.04 [MPa] < 0.5 [MPa]



Effective Stiffness

55.4 [GPa]

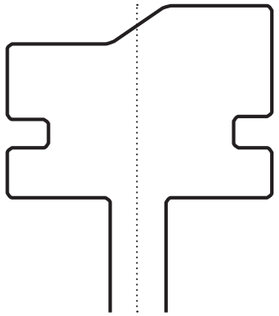


Thickness

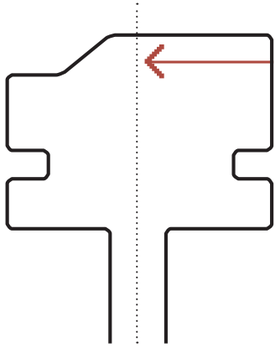
t = 45 [mm] > 20 [mm]

*All dimensions in mm

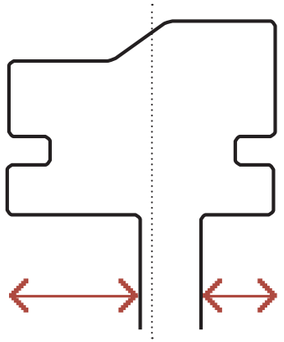
Structural Evaluation - Analytical



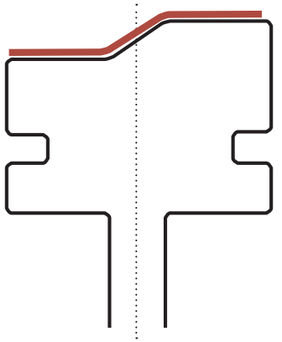
Exisiting



1. large interlock



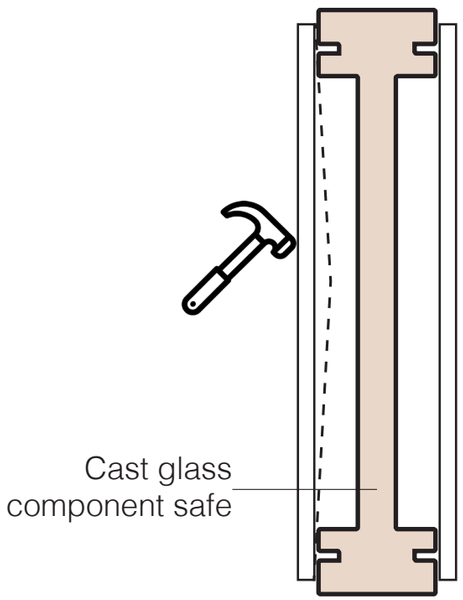
2. Unequal cavity



3. Hard interlayer

Structural Eccentricity

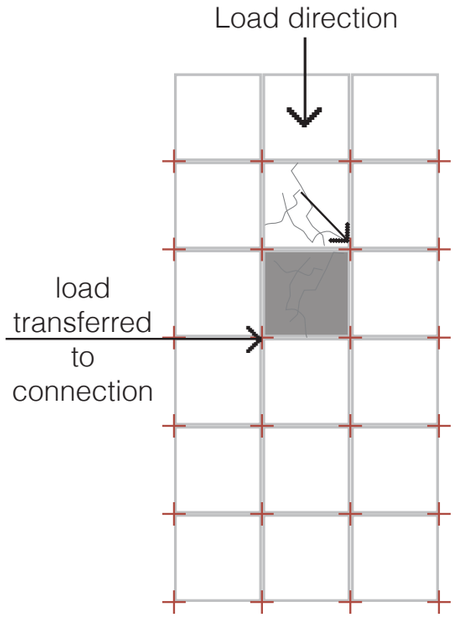
Structural Evaluation - Analytical



Structural Redundancy

Vandalism

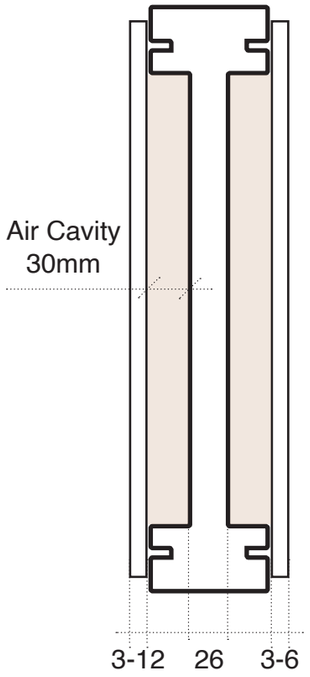
Structural Evaluation - Analytical



Structural Redundancy

Structural failure

Thermal Evaluation - Numerical

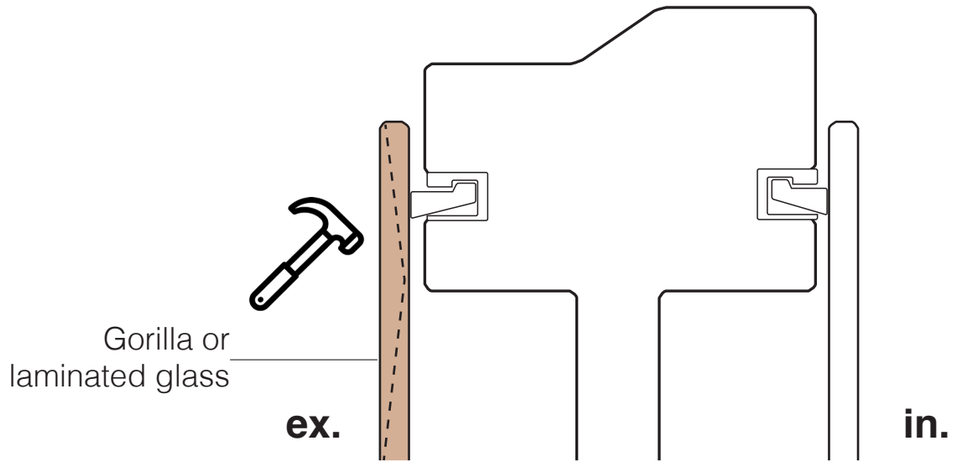


U - Value

1.8 - 2.1 [W/m2K]

*All dimensions in mm

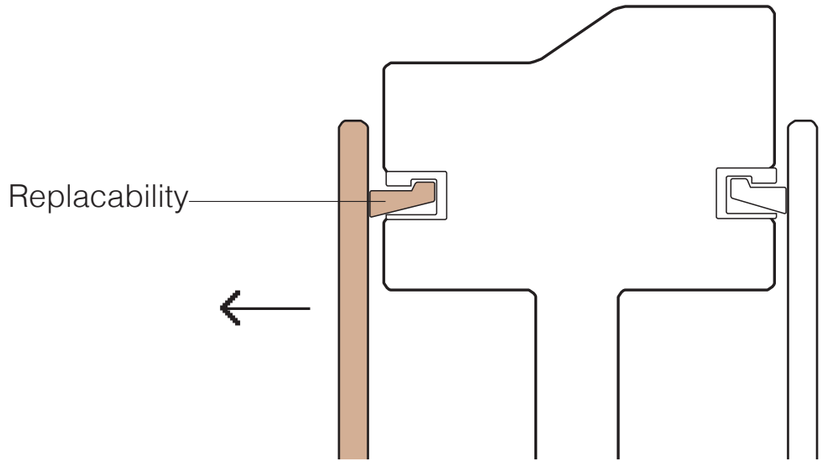
Thermal Evaluation - Analytical



Thermal Redundancy

Vandalism

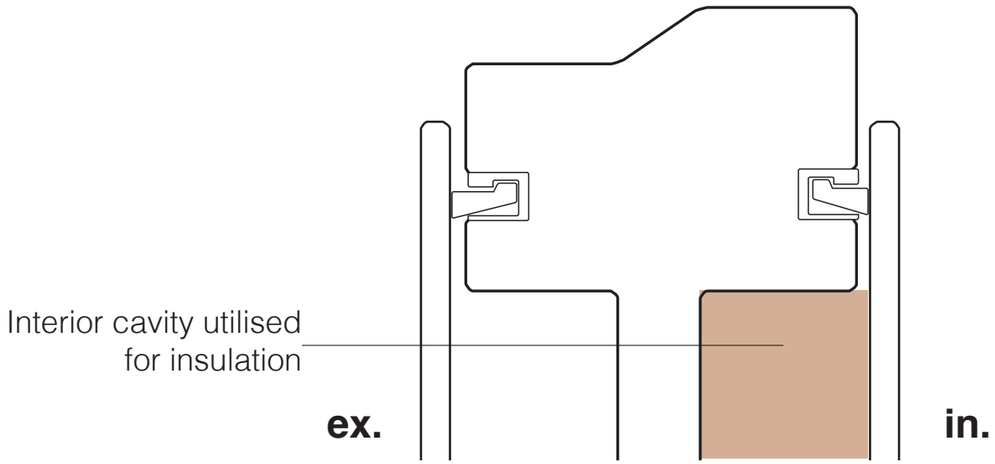
Thermal Evaluation - Analytical



Thermal Redundancy

Vandalism or structural impact

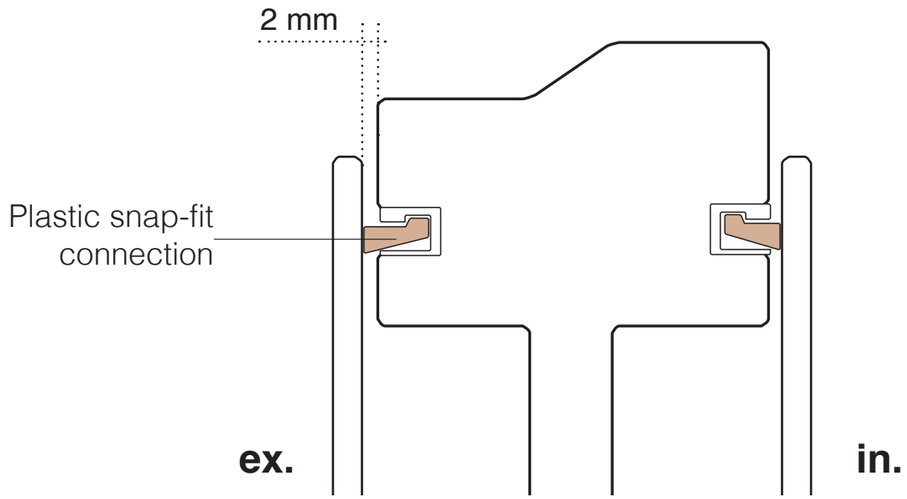
Thermal Evaluation - Analytical



Thermal Redundancy

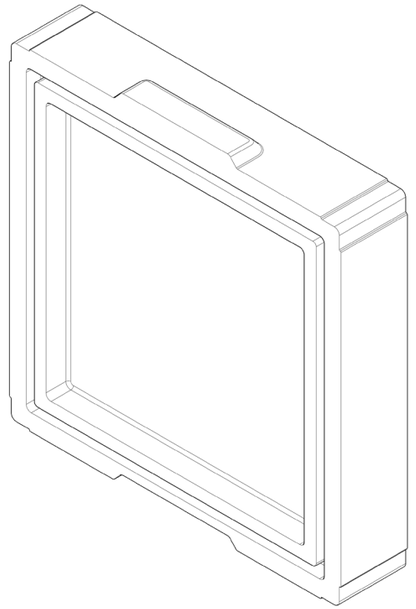
Thermal bridging

Thermal Evaluation - Analytical



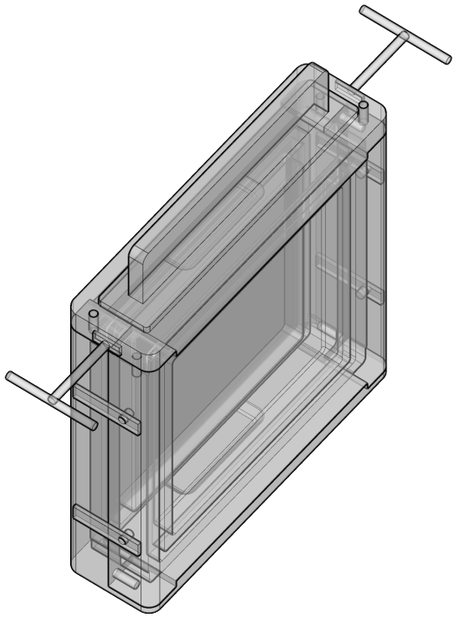
No Thermal bridging

Manufacturing Evaluation - Analytical



Single Standard Component

Manufacturing Evaluation - Analytical



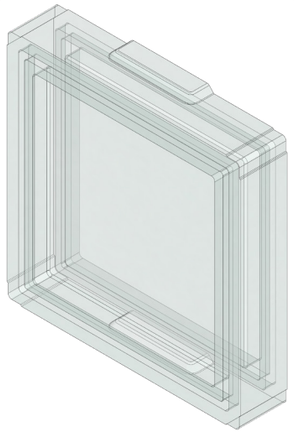
Single Mould Design

Manufacturing Evaluation - Analytical

400 x 400

45 thk

13.38 [kg]



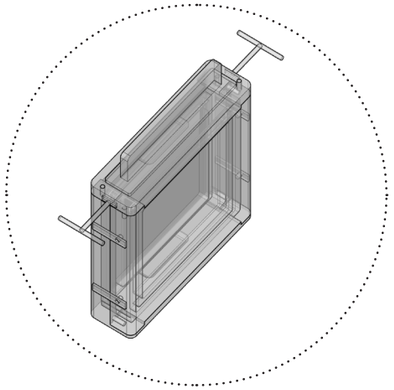
10 -12 [hours]

Optimized Annealing time

*All dimensions in mm

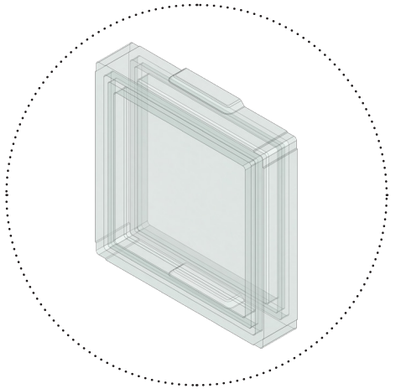
Manufacturing Evaluation - Analytical

Steel Mould



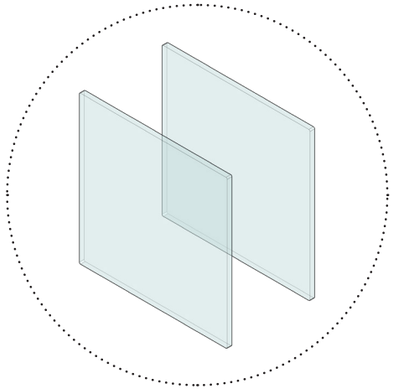
CNC Milling

Cast Glass



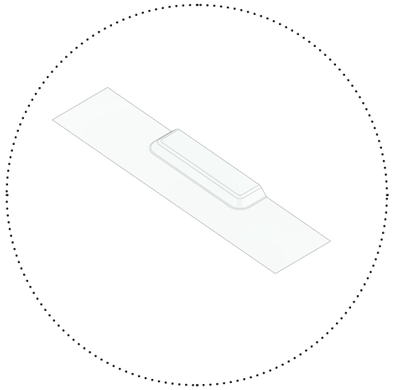
Hot Pour Casting

Glass panels



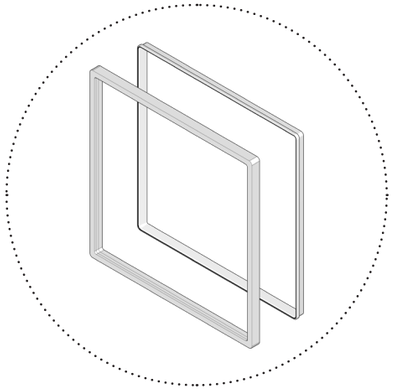
Float glass

Interlayer



Injection Moulding

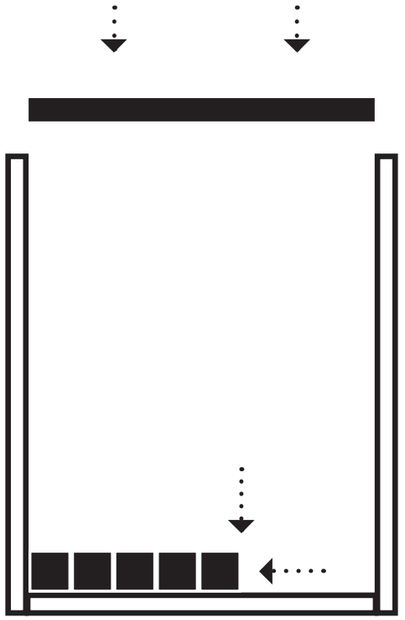
Connections



Extrusion

Standard Manufacturing Process

Assembly System Evaluation - Analytical

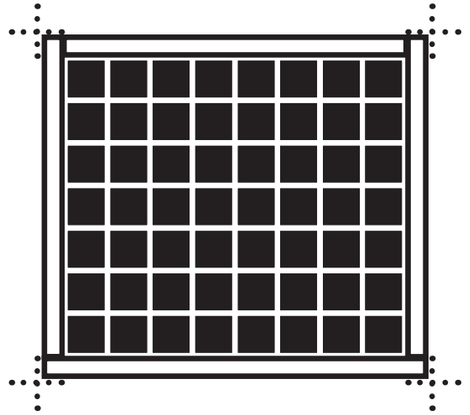


Local Assembly

High Precision on site

Buckling

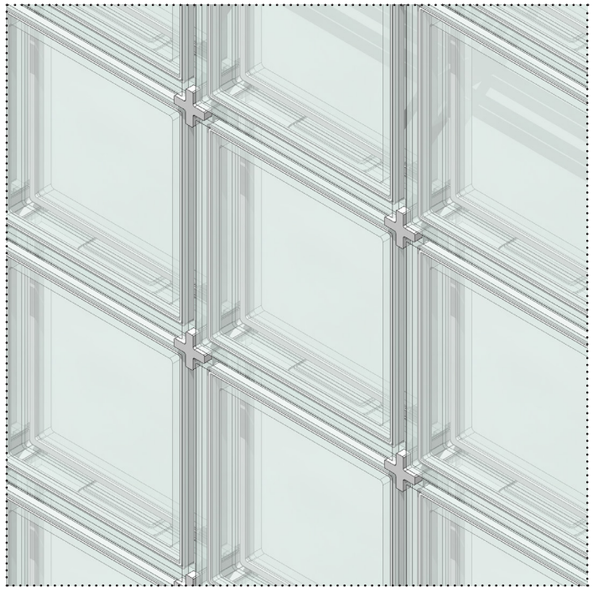
Specific to Case study



Modular Assembly

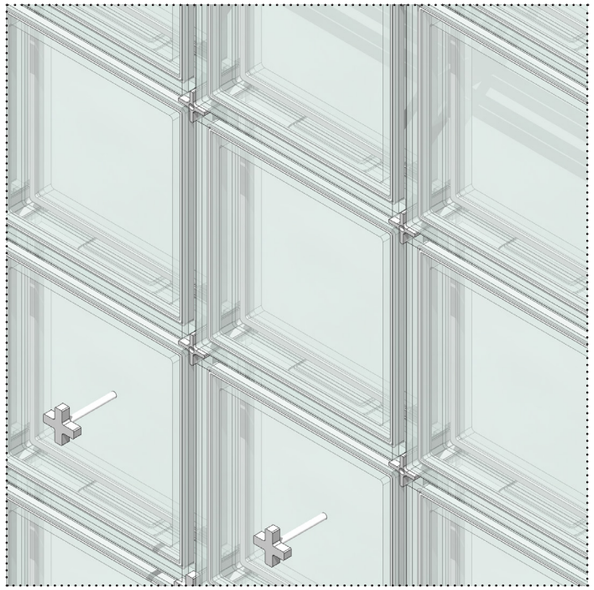
Compromised Transparency

Assembly System Evaluation - Analytical



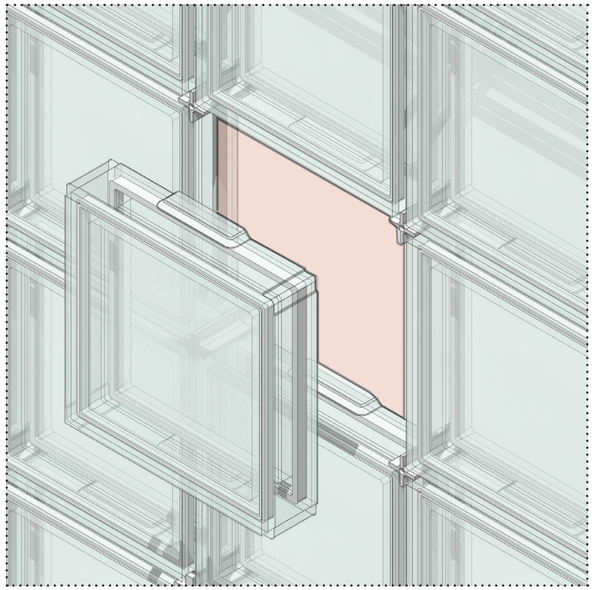
Replacability

Assembly System Evaluation - Analytical



Replacability

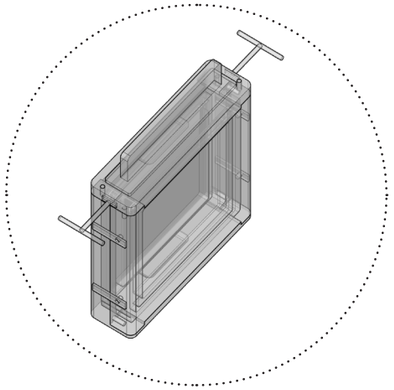
Assembly System Evaluation - Analytical



Replacability

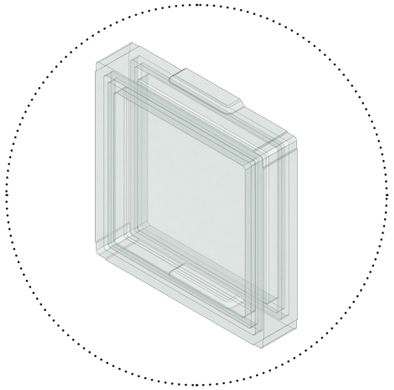
Sustainability Evaluation - Analytical

Steel Mould



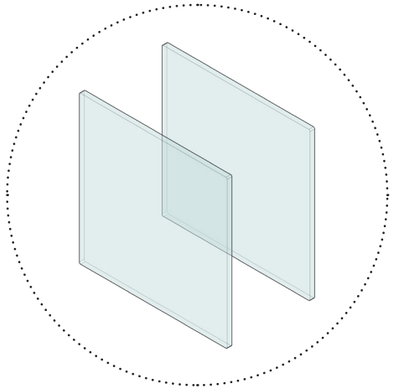
Reusable

Cast Glass



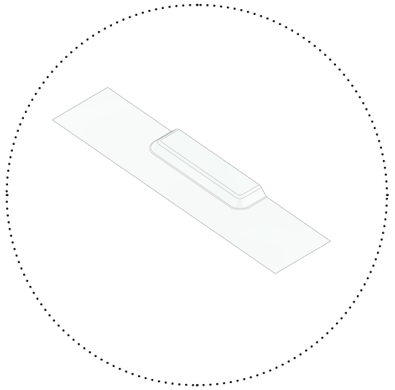
Recyclable

Glass panels



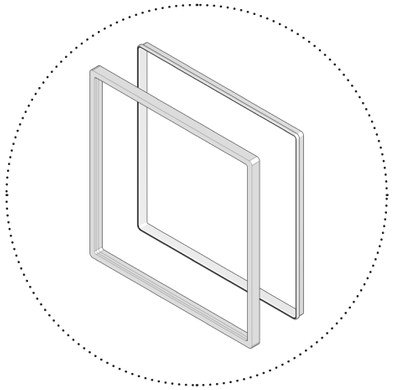
Recyclable

Interlayer



Reusable

Connections

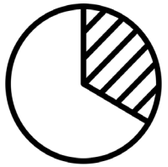


Reusable

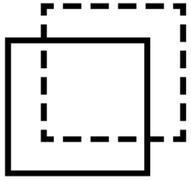
Reuse - Recycle

What are the main **design considerations** and **challenges** in **designing** and **manufacturing** a hybrid glass block system that exhibits good **thermal** and **structural performance**?

Design Considerations & Challeneges

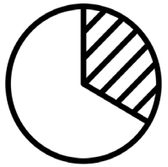


Material Composition

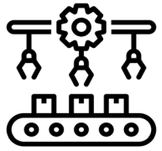


Optical Desiribility

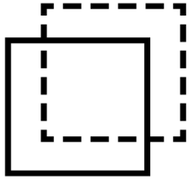
Design Considerations & Challeneges



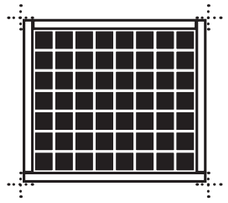
Material Composition



Standardisation



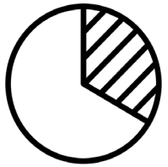
Optical Desiribility



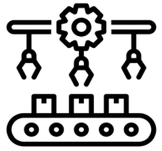
Assembly System

Tolerances

Design Considerations & Challeneges

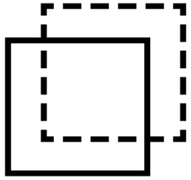


Material Composition

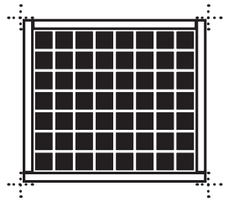


Standardisation

Building Standards



Optical Desiribility



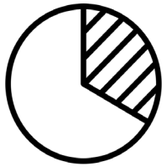
Assembly System

Tolerances

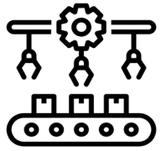
Safety

Maintenance

Design Considerations & Challeneges

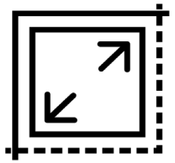


Material Composition

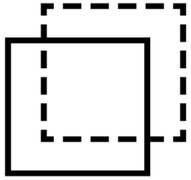


Standardisation

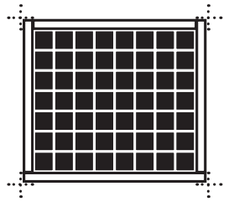
Building Standards



Design Scale
Boundary Condition



Optical Desiribility



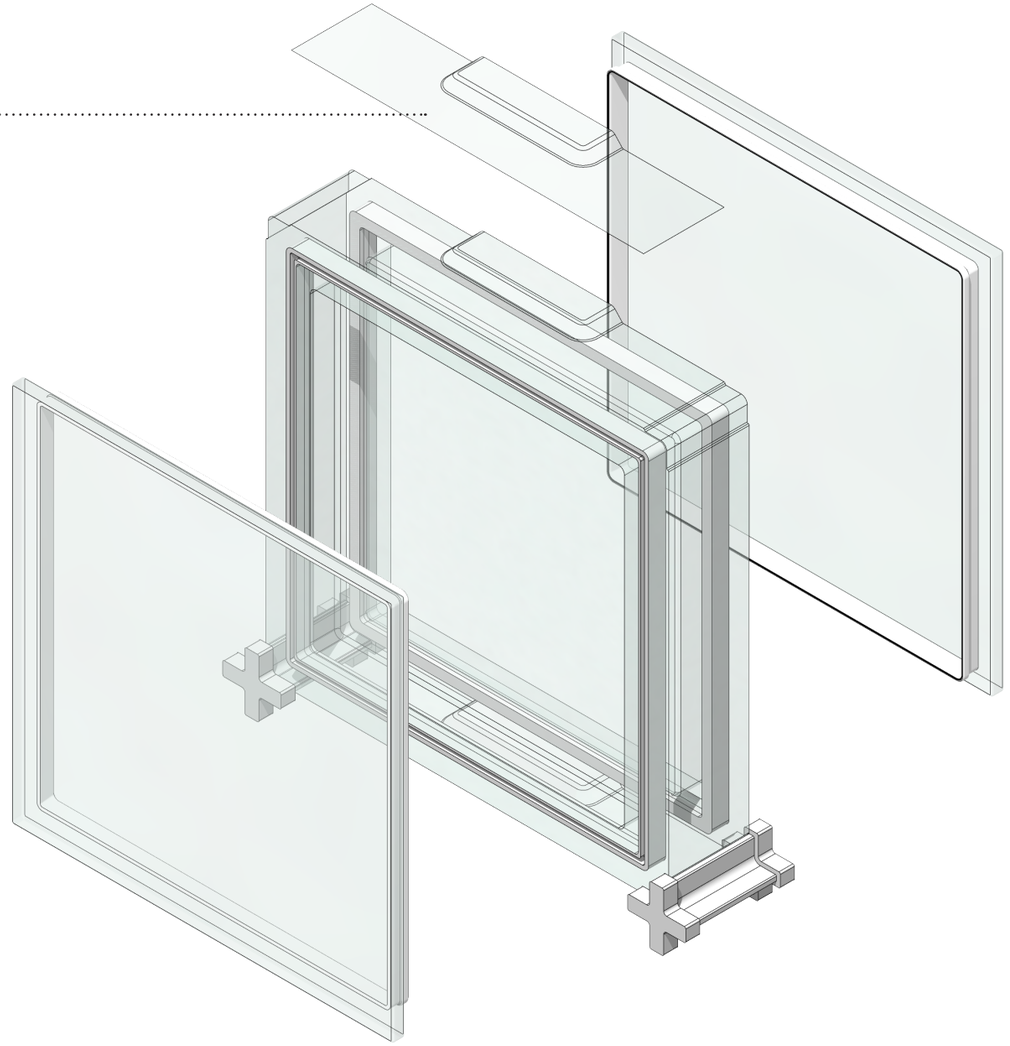
Assembly System
Tolerances

Safety
Maintenance

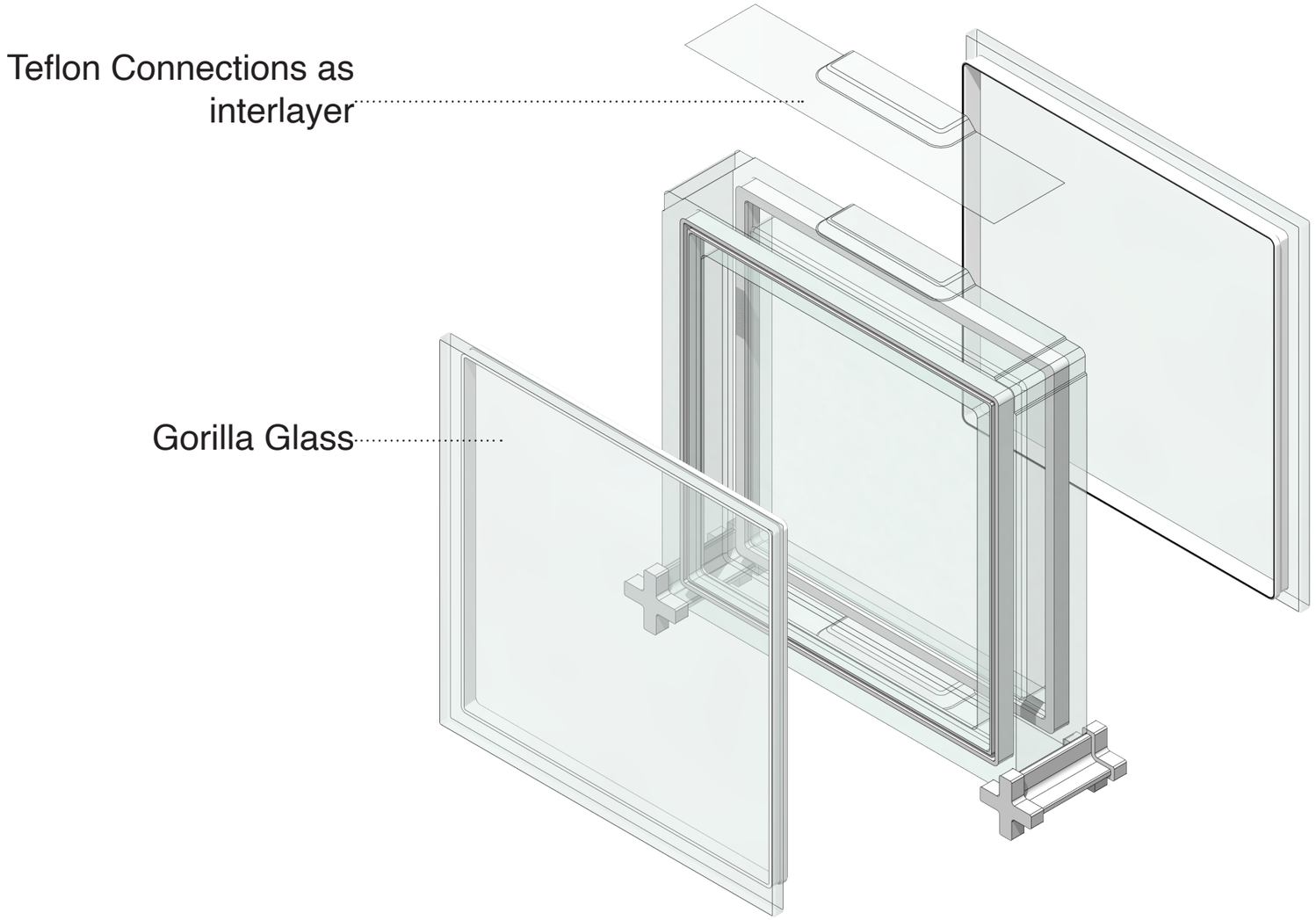
Recyclability

Recommendations

Teflon Connections as interlayer



Recommendations

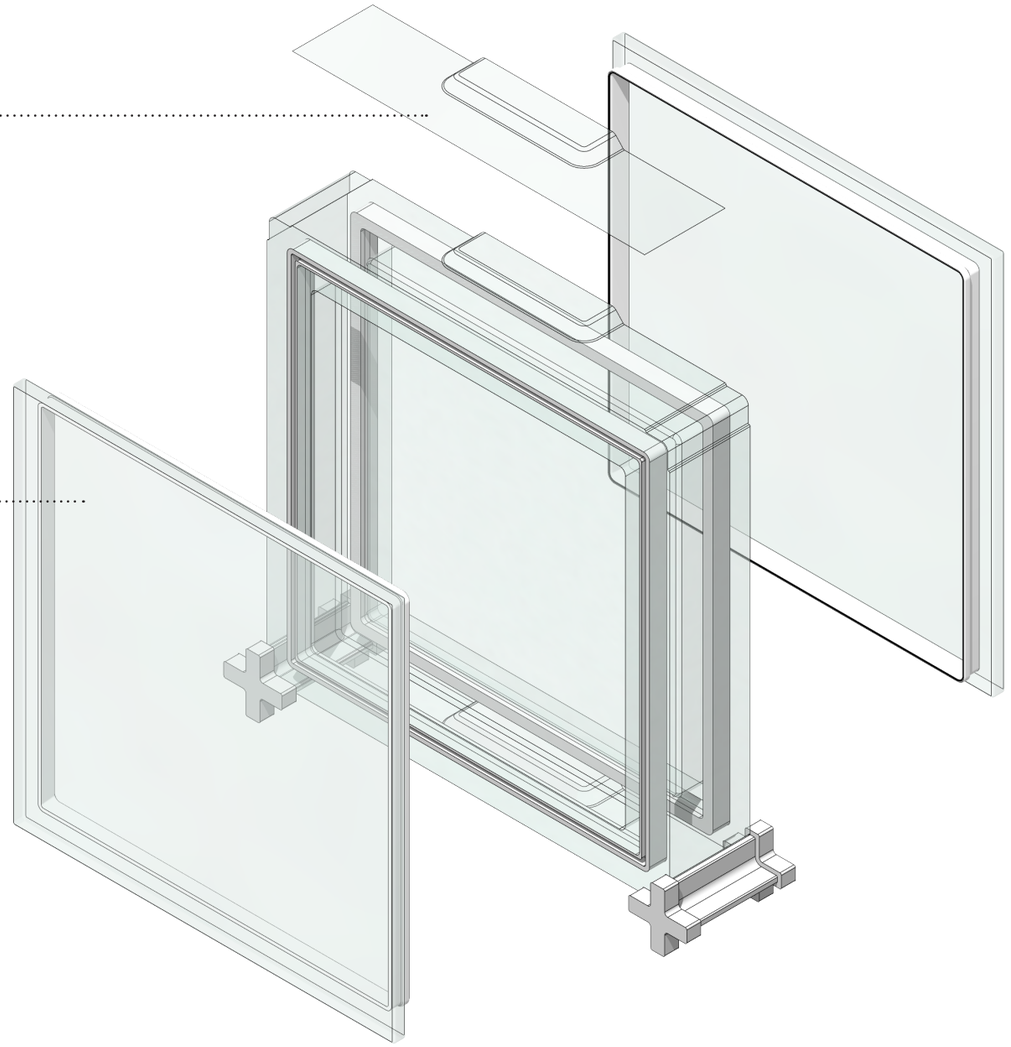


Recommendations

Teflon Connections as interlayer

Gorilla Glass

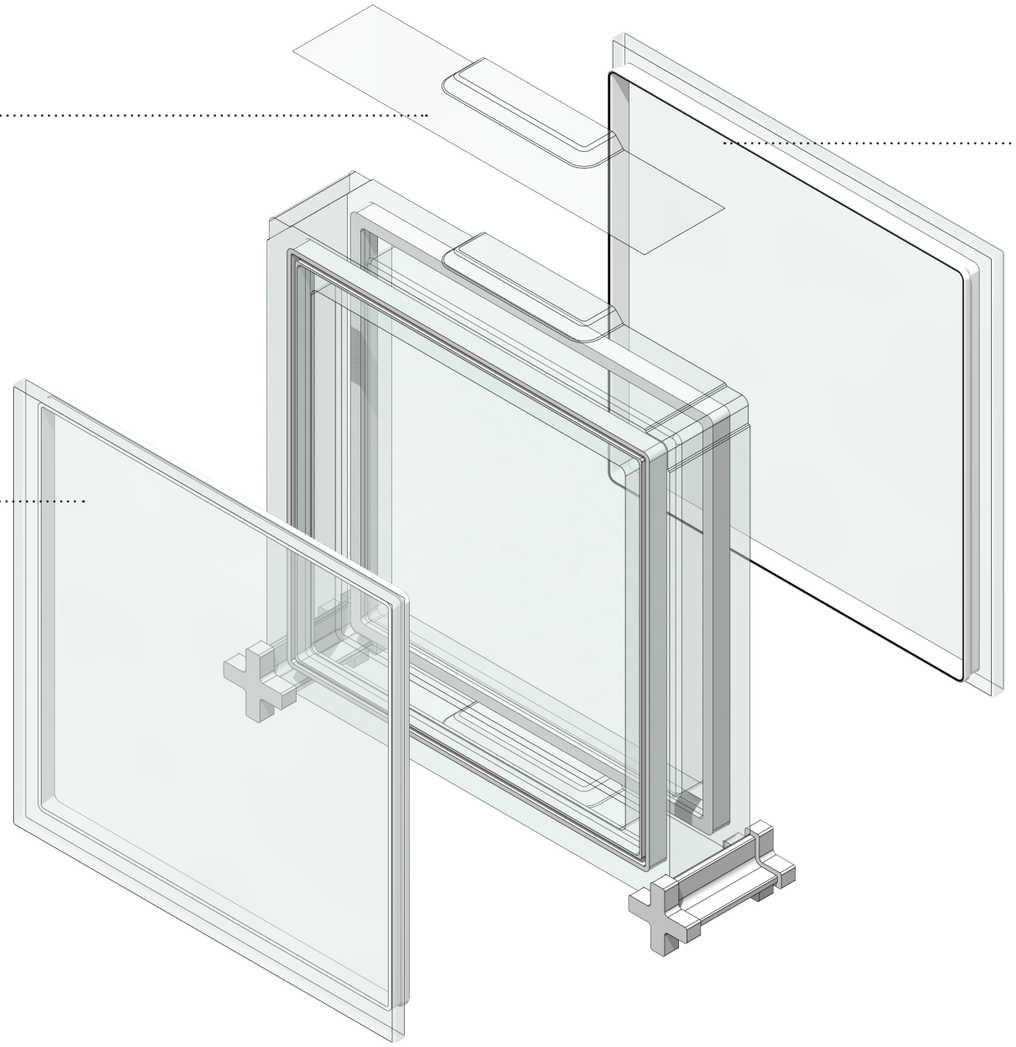
Prototyping-Validation



Recommendations

Teflon Connections as interlayer

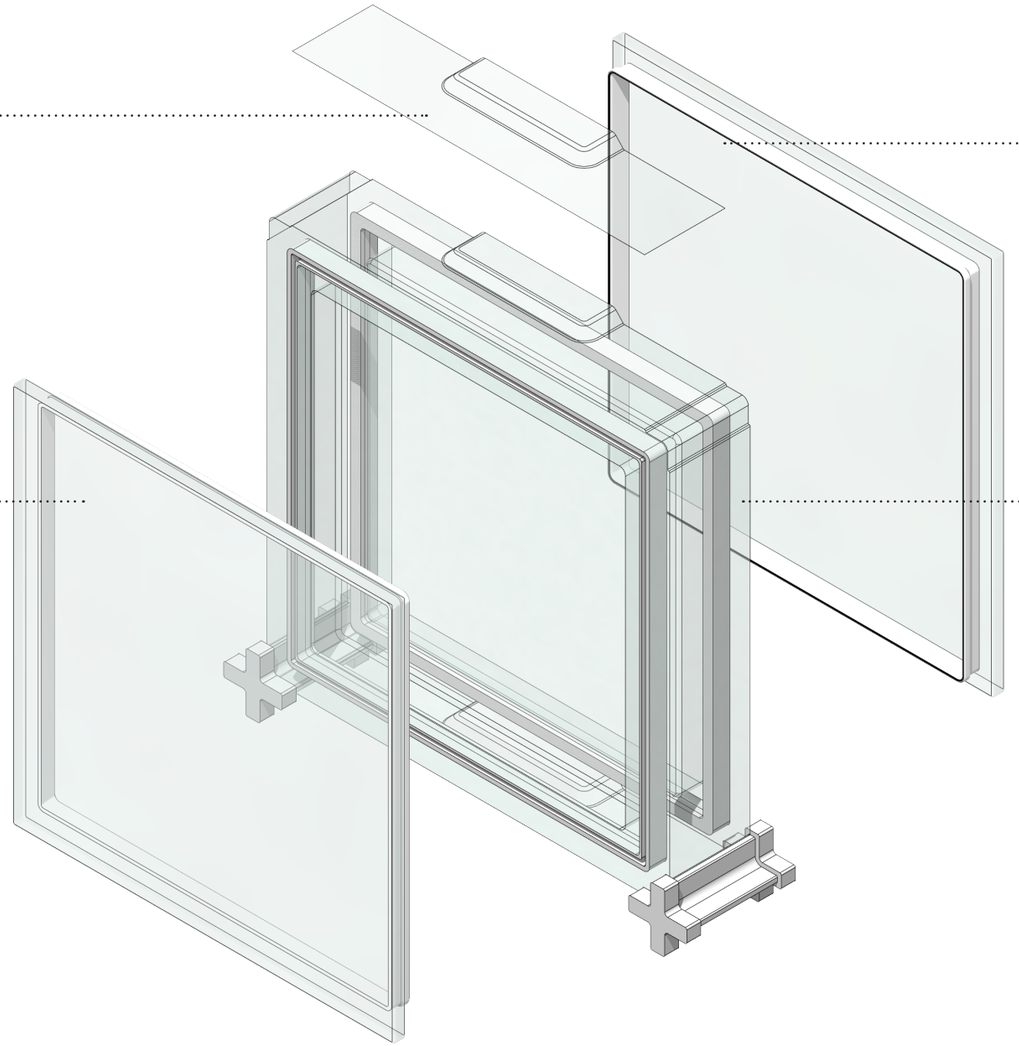
Enhancement of Snap-fit connection



Gorilla Glass

Prototyping-Validation

Recommendations



Teflon Connections as interlayer

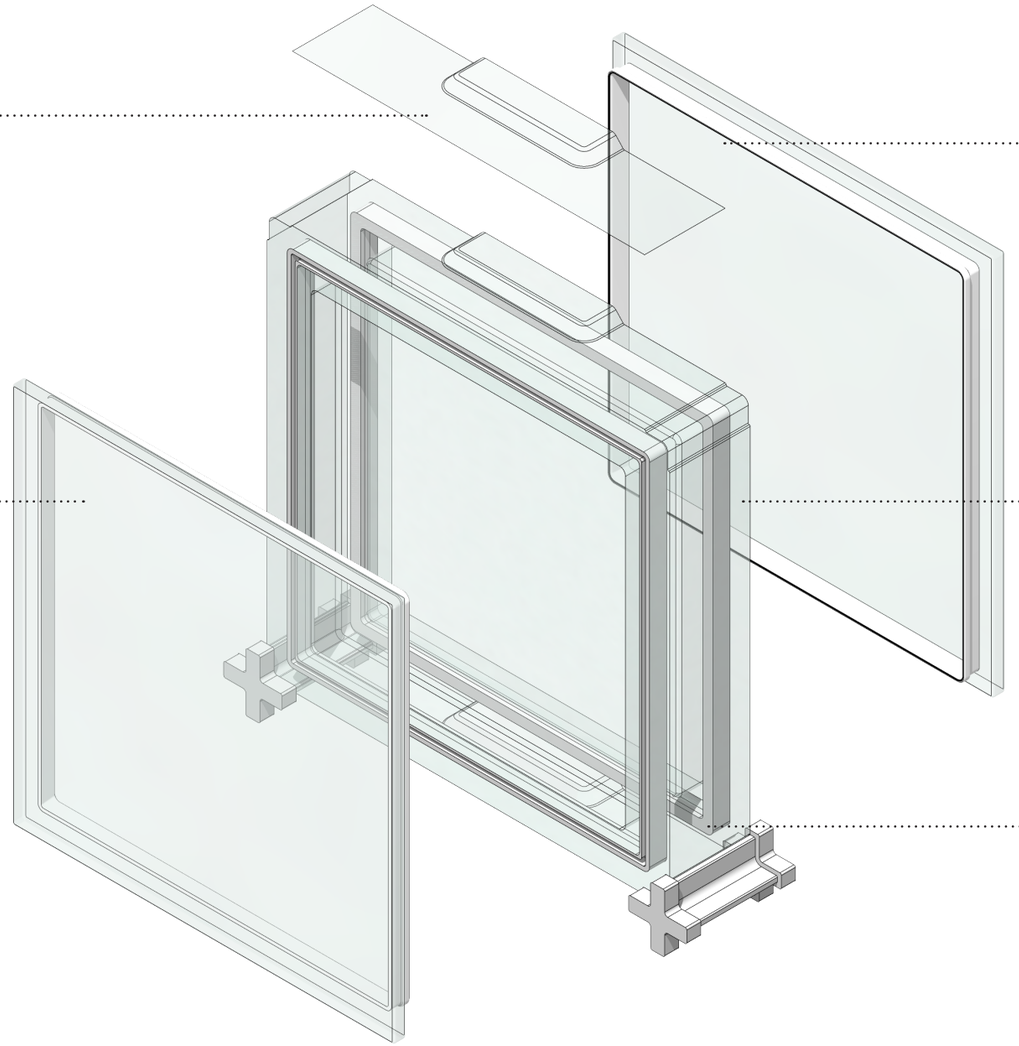
Enhancement of Snap-fit connection

Gorilla Glass

Recycled Cast Glass

Prototyping-Validation

Recommendations



Teflon Connections as interlayer

Enhancement of Snap-fit connection

Gorilla Glass

Recycled Cast Glass

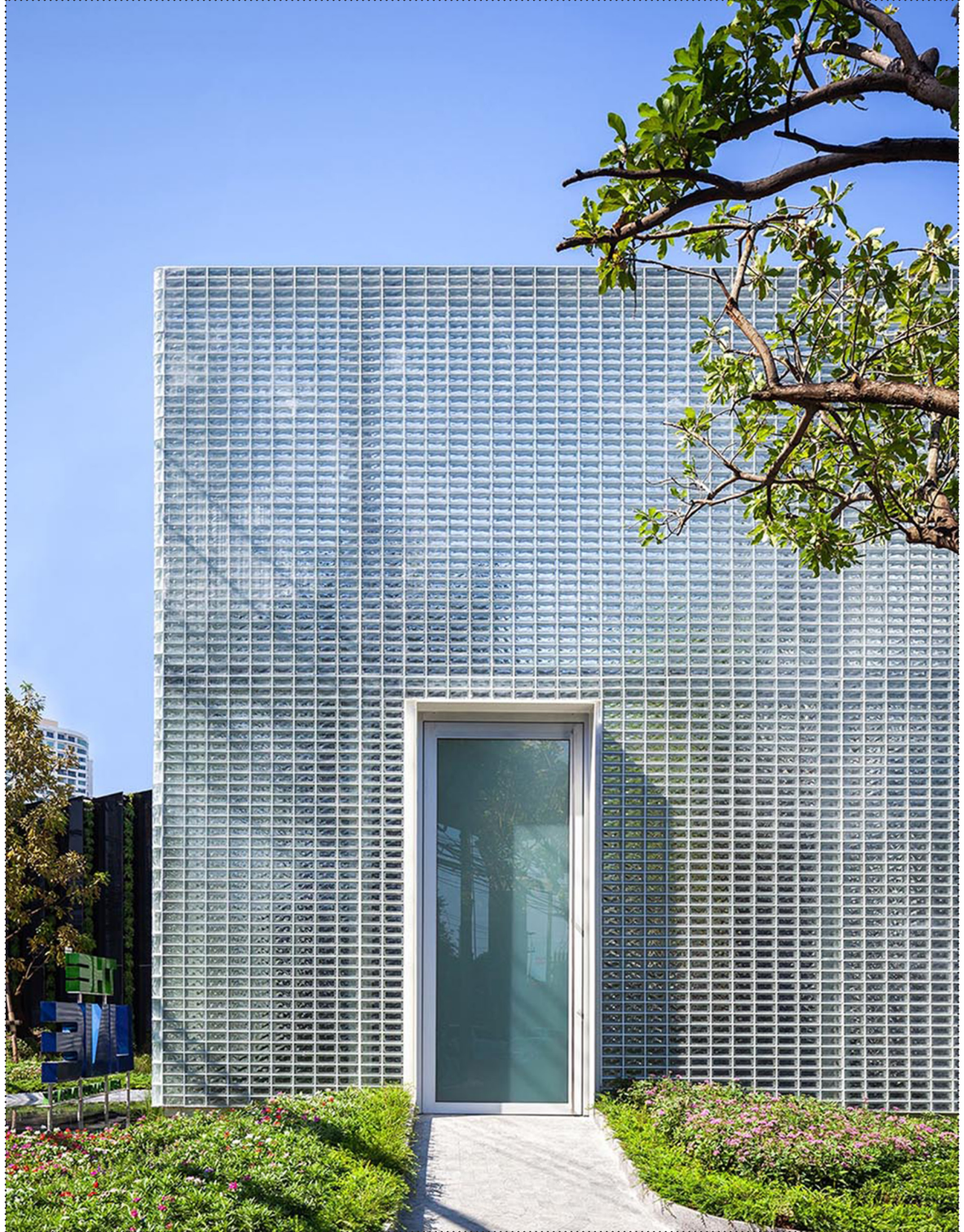
Prototyping-Validation

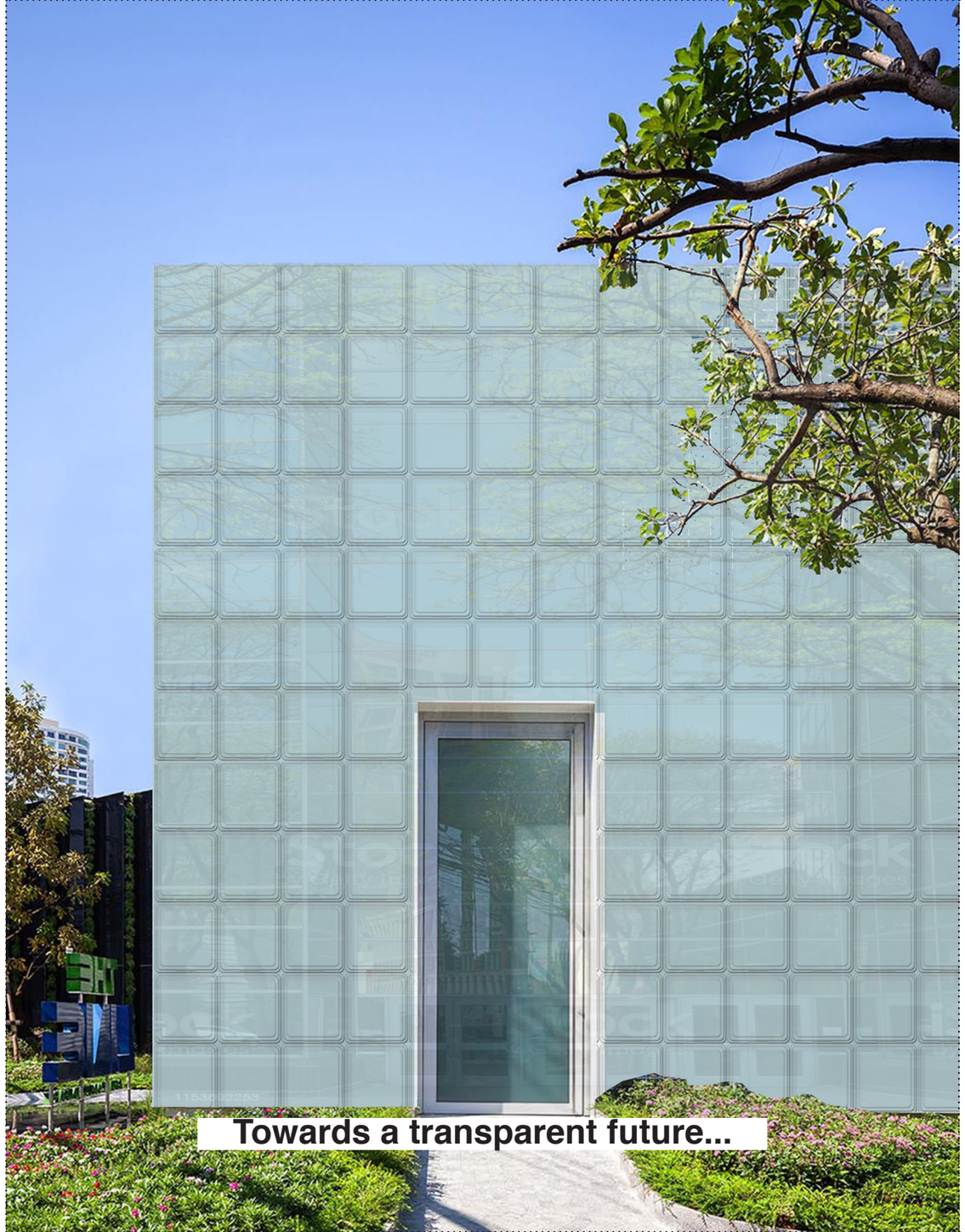
Cross-section Optimization

- Curved Surfaces
- Vertical Stacking
- Limited Configurations
- Numerical Validation

Potential Application

	Hollow	Solid	**Hybrid**
			
U-Value [W/m2K]	**1.8 - 2.5**	4.1 - 4.9	**1.8 - 2.1**
Compressive Str. [MPa]	3 - 6	**82 - 400**	**Good**
Transparency	Low	**High**	**High**
Recyclable (Cast glass)	No	**Yes***	**Yes**
Reversibility	Non - reversible	**Yes**	**Yes**




Towards a transparent future...

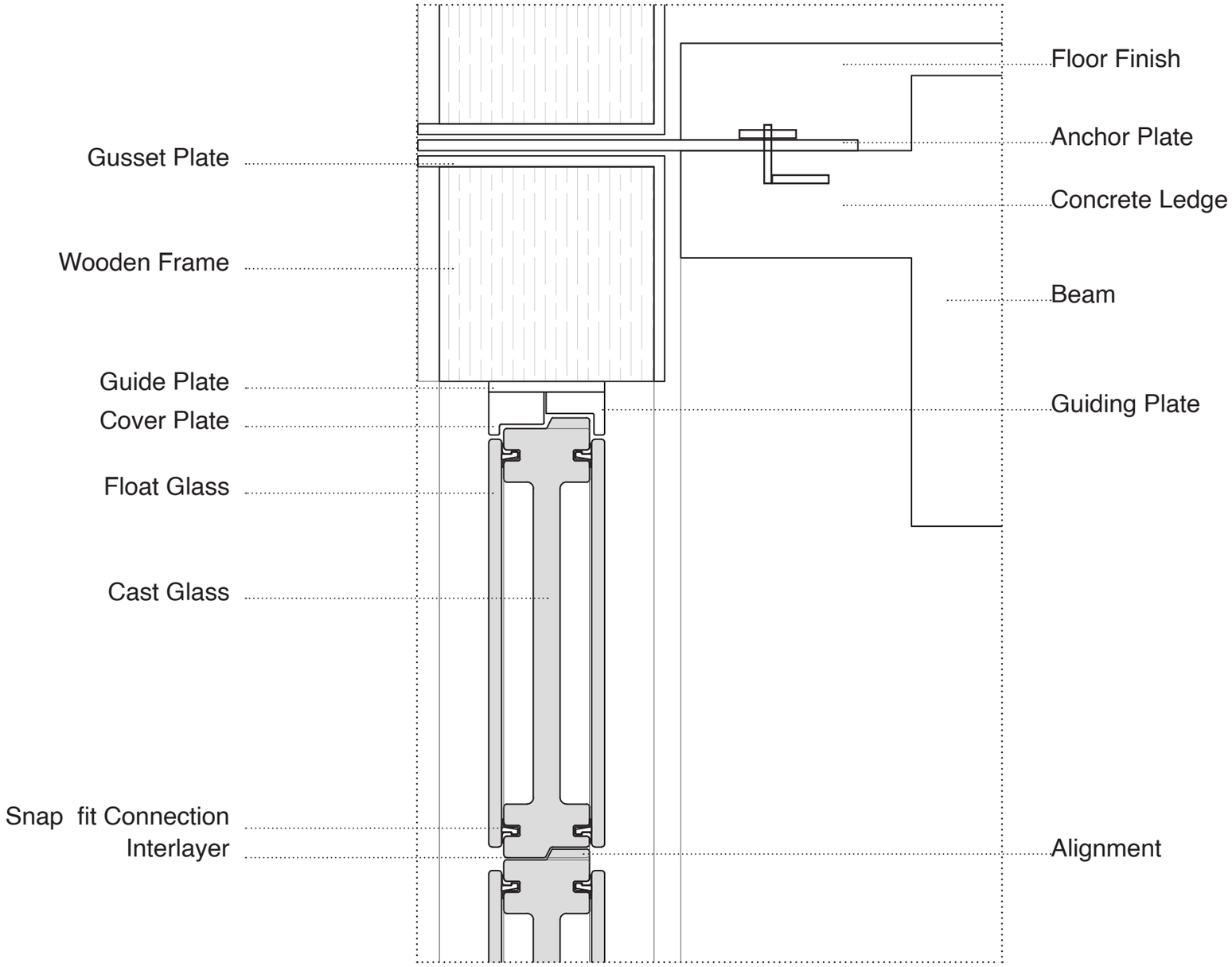
Thesis Presentation

MSc in Architecture, Urbanism & Building Sciences
Building Technology Track

June 20th, 2022 - BK, TuDelft

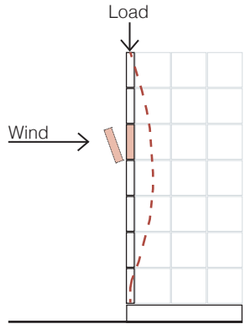
Anurag Sonar . 5201756

Cross-Section



Risk Scenario Analysis

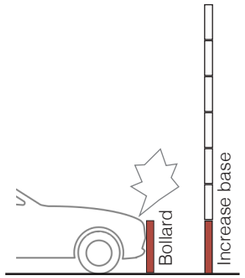
STRUCTURAL DAMAGE



Probability - 0.5
Exposure - 0.5
Consequence - 40
Safety factor - 4

Risk - 10

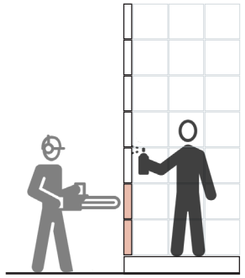
VEHICLE IMPACT



Probability - 0.5
Exposure - 0.5
Consequence - 40

Risk - 10

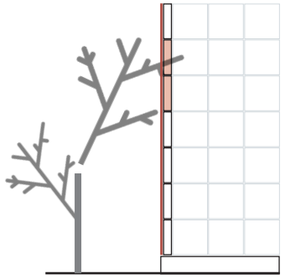
VANDALISM



Probability - 0.5
Exposure - 0.5
Consequence - 7

Risk - 1.75

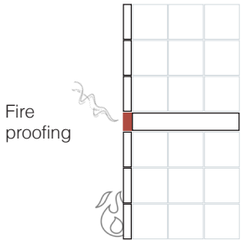
ACCIDENTIAL IMPACT



Probability - 3
Exposure - 1
Consequence - 7

Risk - 21

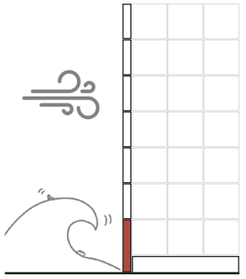
FIRE



Probability - 0.5
Exposure - 0.5
Consequence - 40

Risk - 10

NATURAL CALAMITY



Probability - 10
Exposure - 1
Consequence - 1

Risk - 10