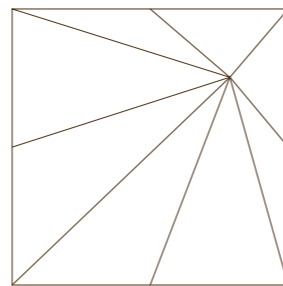


THREE-DIMENSIONAL CLADDING WITH BIO-BASED MATERIALS:

a parametric design following the seamless
tiling concept

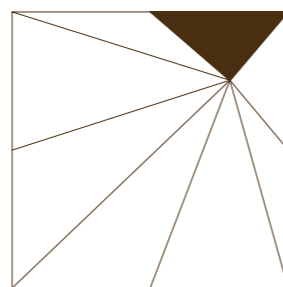


FINAL PRESENTATION

26th June 2023

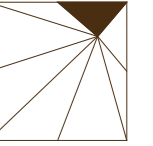
Laura Romano

CONTEXT

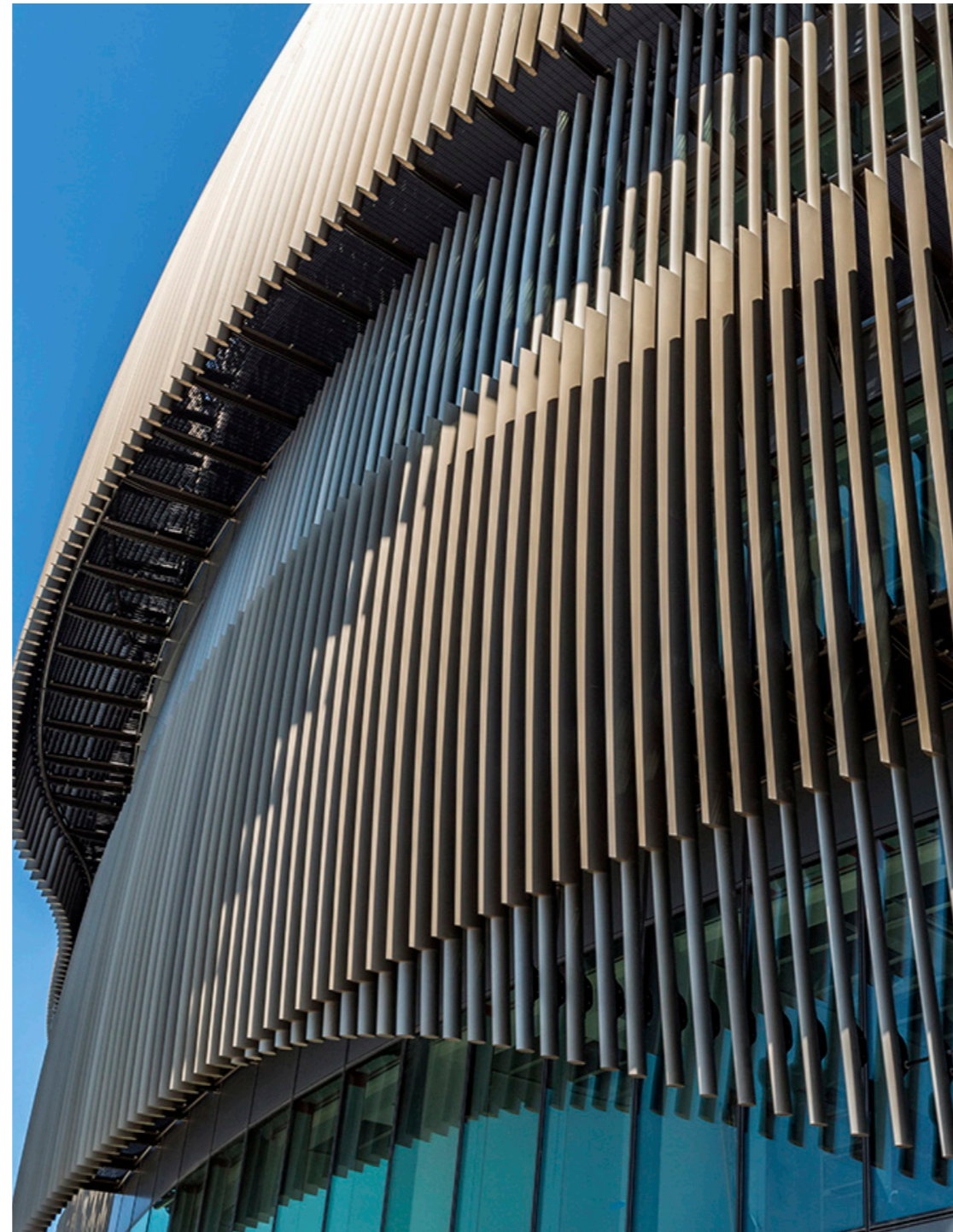


CONTEXT

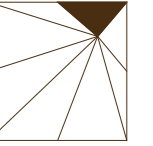




“WHAT IS THE RELEVANCE OF THREE-DIMENSIONALITY IN EXTERNAL CLADDING?”



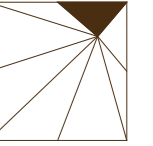
THEATRE ZUIDPLEIN - STUDIO RAP (2020)



“WHAT IS THE RELEVANCE OF THREE-DIMENSIONALITY IN EXTERNAL CLADDING?”



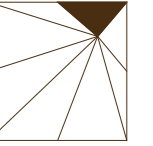
THE BROAD - DILLER SCOFIDIO + RENFRO (2015)



“WHAT IS THE RELEVANCE OF THREE-DIMENSIONALITY IN EXTERNAL CLADDING?”



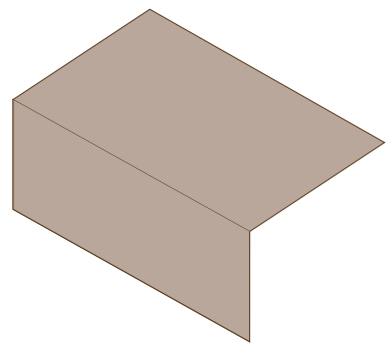
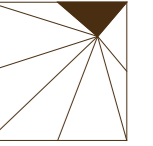
HARPA CONCERT HALL AND CONFERENCE CENTER - HENNING LARSEN ARCHITECTS (2005-2011)



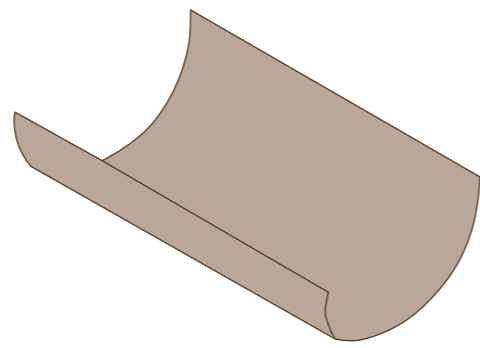
“WHAT IS THE RELEVANCE OF THREE-DIMENSIONALITY IN EXTERNAL CLADDING?”



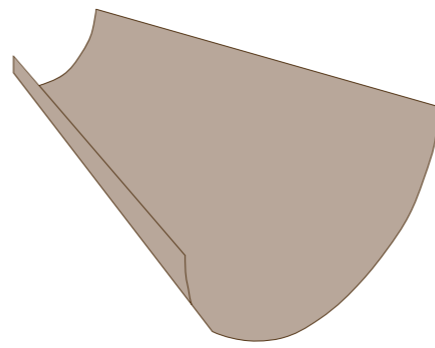
THREE-DIMENSIONAL DESIGN



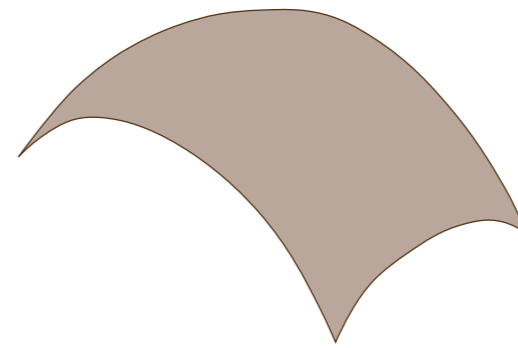
SUM OF PLANAR
SHAPES



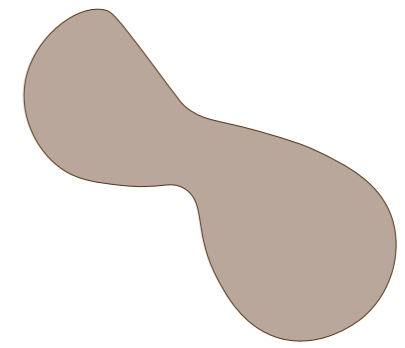
SINGLY CURVED



CONIC

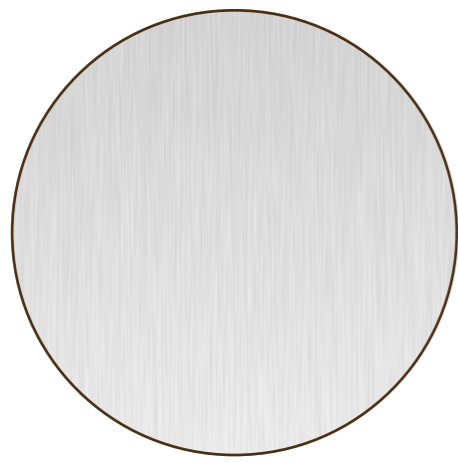
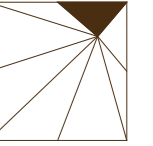


DOUBLY CURVED

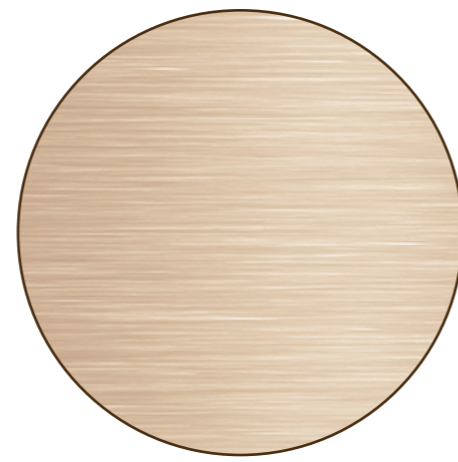


FREEFORM

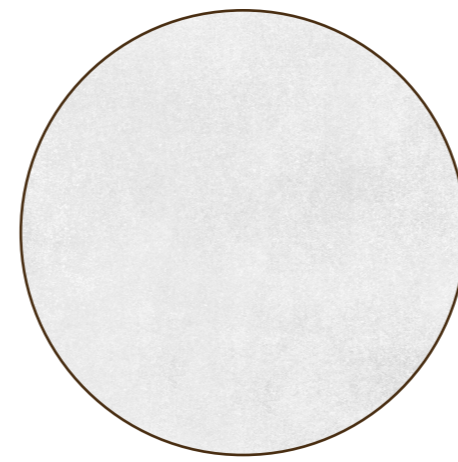
THREE-DIMENSIONAL MATERIALS



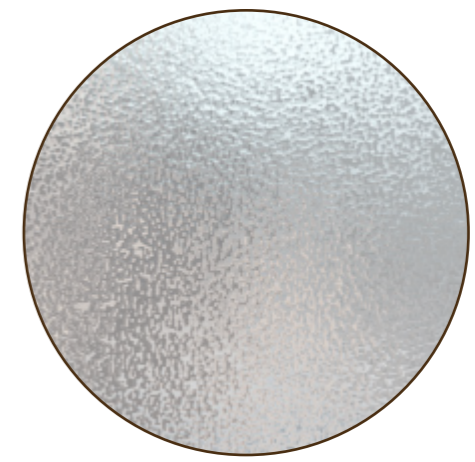
ALUMINIUM



BRONZE AND
OTHER METALS

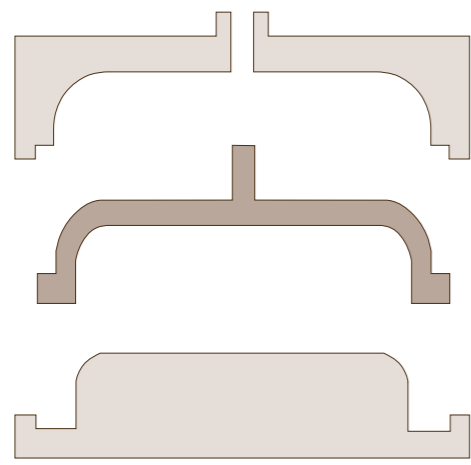
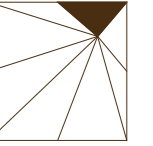


CONCRETE

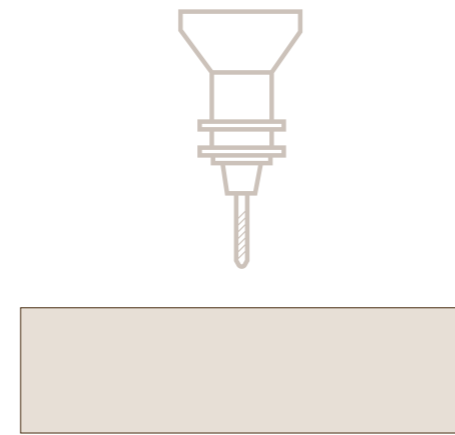


GLASS

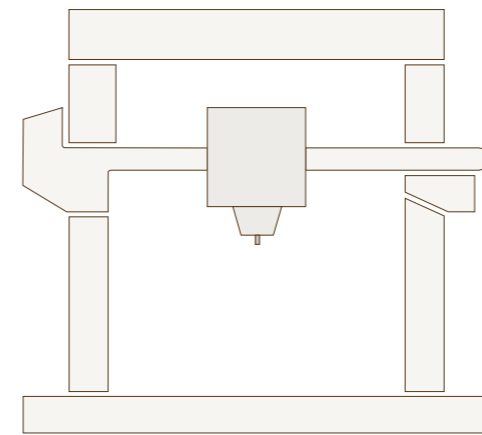
THREE-DIMENSIONAL MANUFACTURING



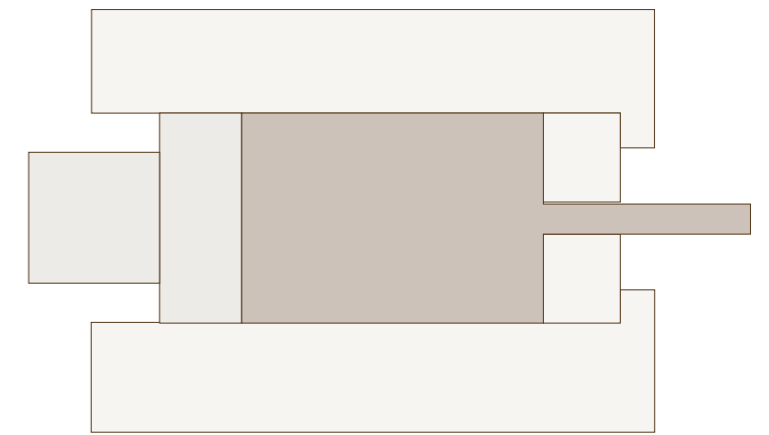
MOULDING



CNC MACHINING



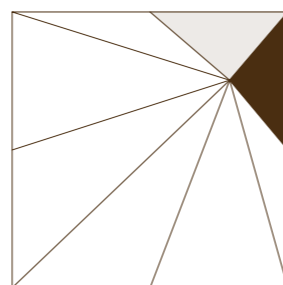
3D PRINTING



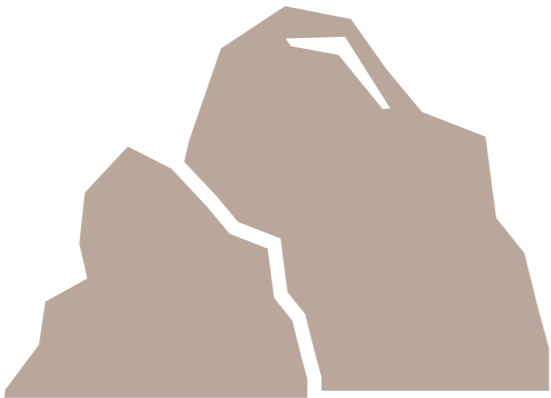
EXTRUSION



PROBLEM STATEMENT



PROBLEM STATEMENT



MATERIAL EXTRACTION
AND PRODUCTION



ENERGY
CONSUMPTION

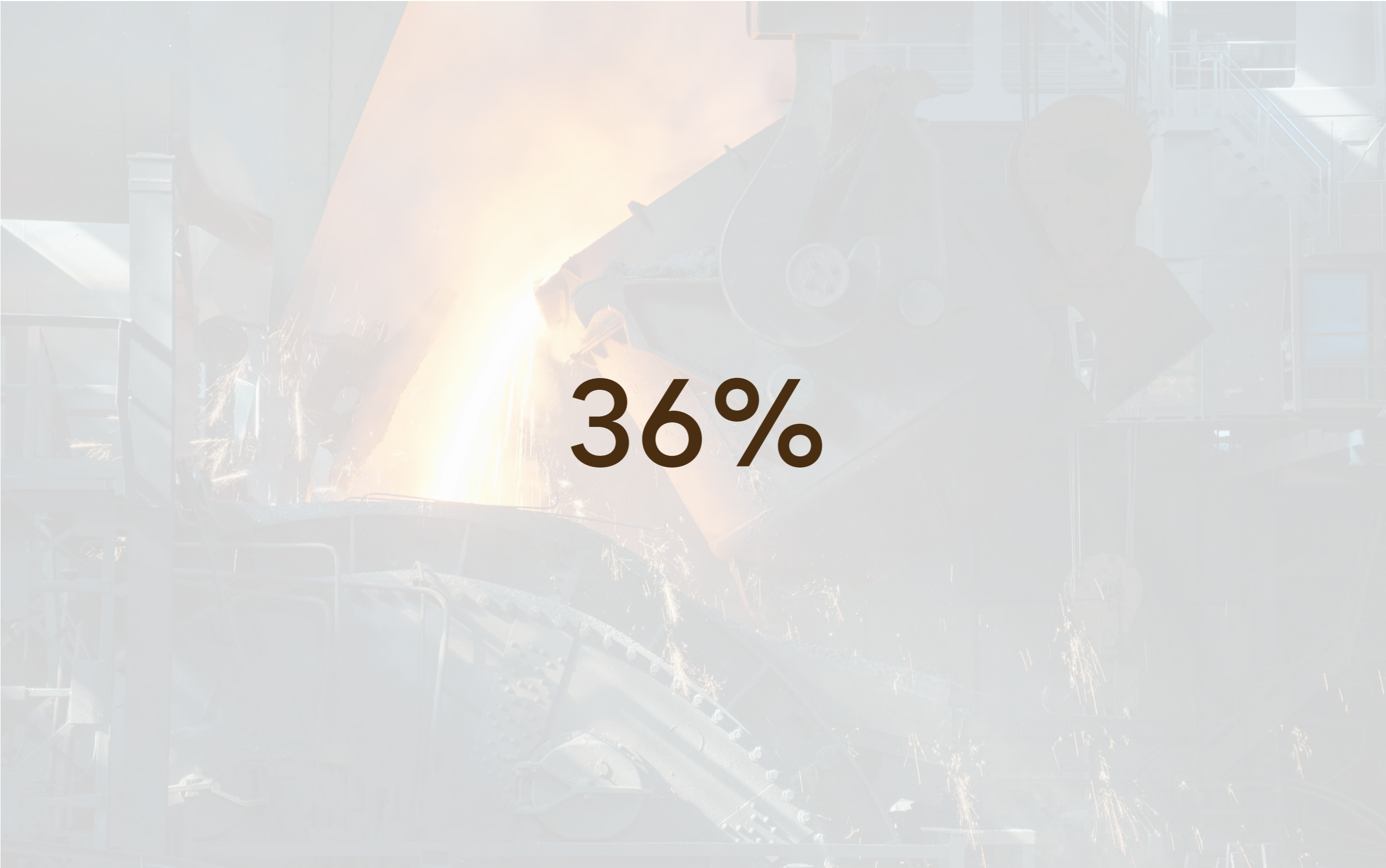


WASTE

MATERIAL EXTRACTION



ENERGY CONSUMPTION



36%

CARBON EMISSIONS



39%



MATERIALS USE INCREASE BETWEEN 2011 AND 2060



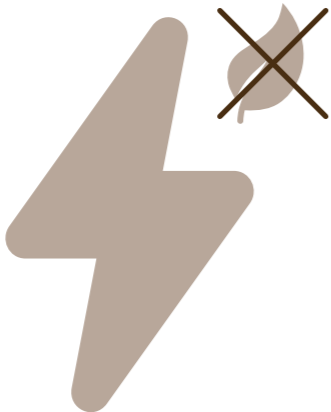
2011



2060

Material Category	2011 (Gt)	2060 (Gt)
METALS	8 Gt	20 Gt
FOSSIL FUELS	14 Gt	24 Gt
BIOMASS	20 Gt	37 Gt
NON-METALLIC MINERALS	37 Gt	86 Gt

RESOURCES QUALITATIVE IMPACTS



NON-RENEWABLE

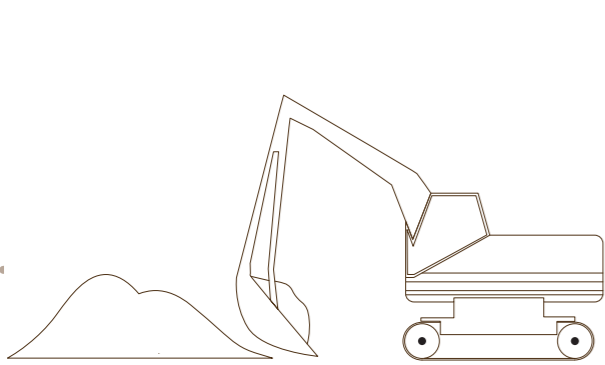


LIMITED LIFETIME

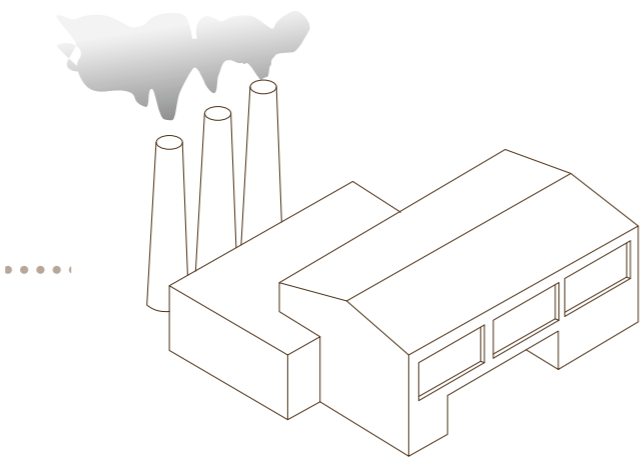


BIO-DIVERSITY LOSS

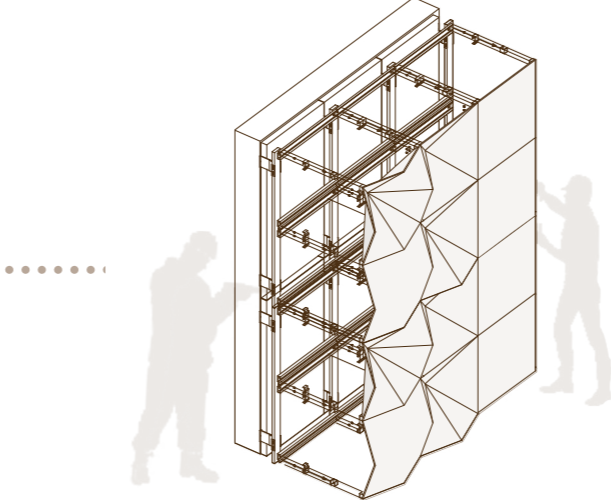
FROM LINEAR...



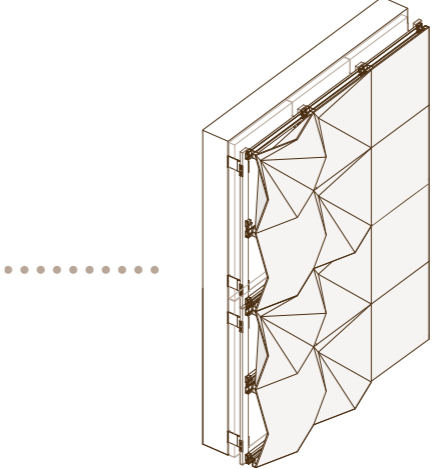
EXTRACTION



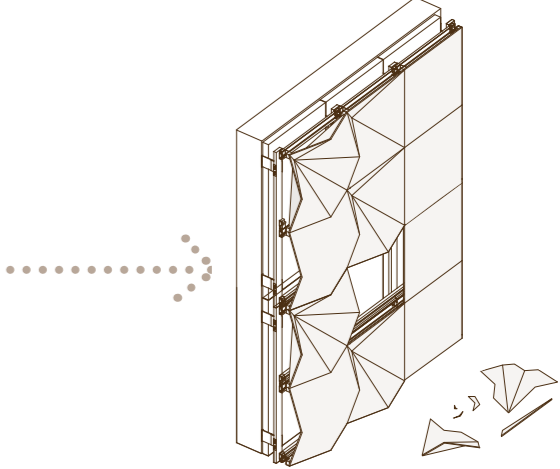
PRODUCTION



ERECTION

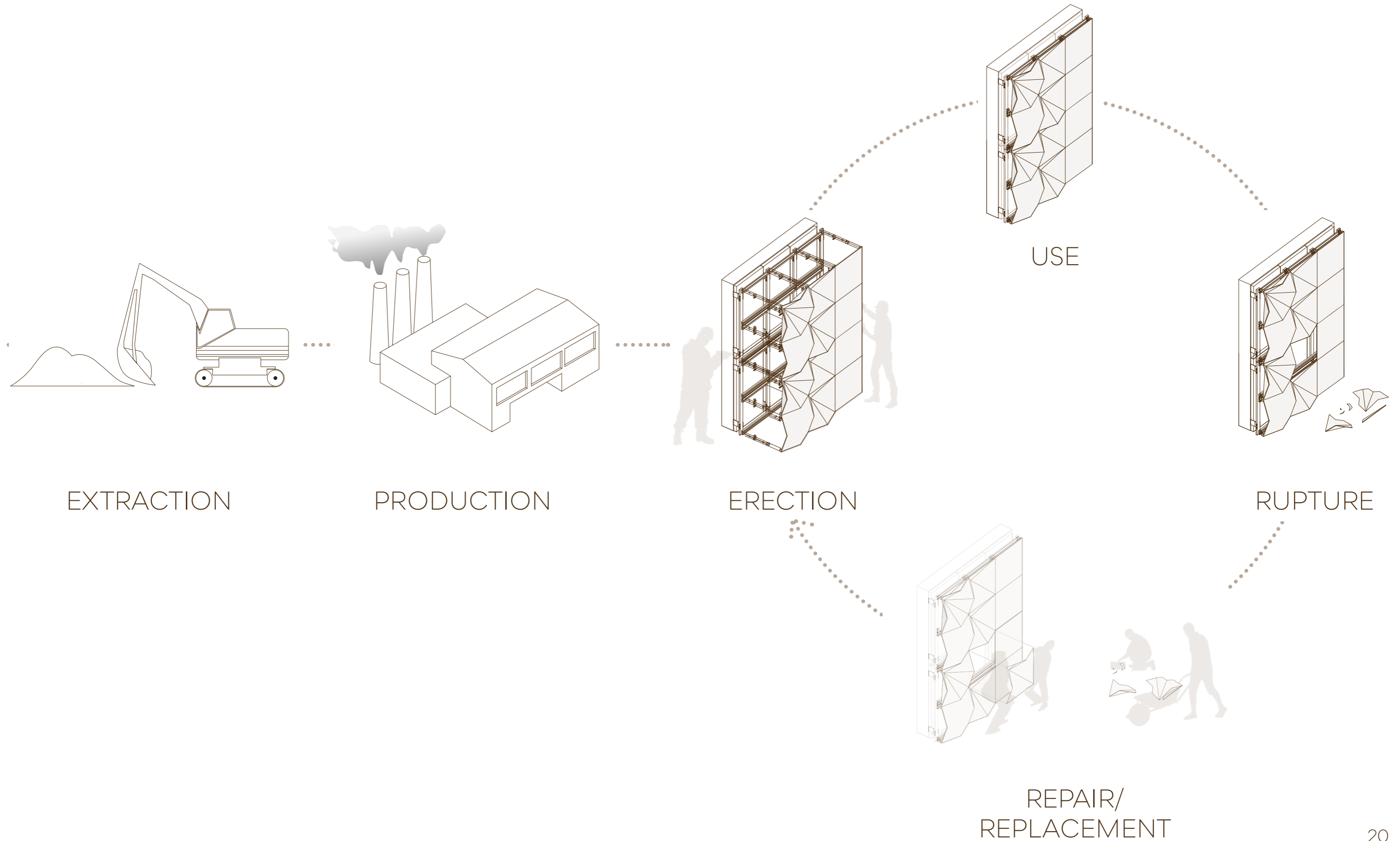
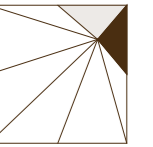


USE

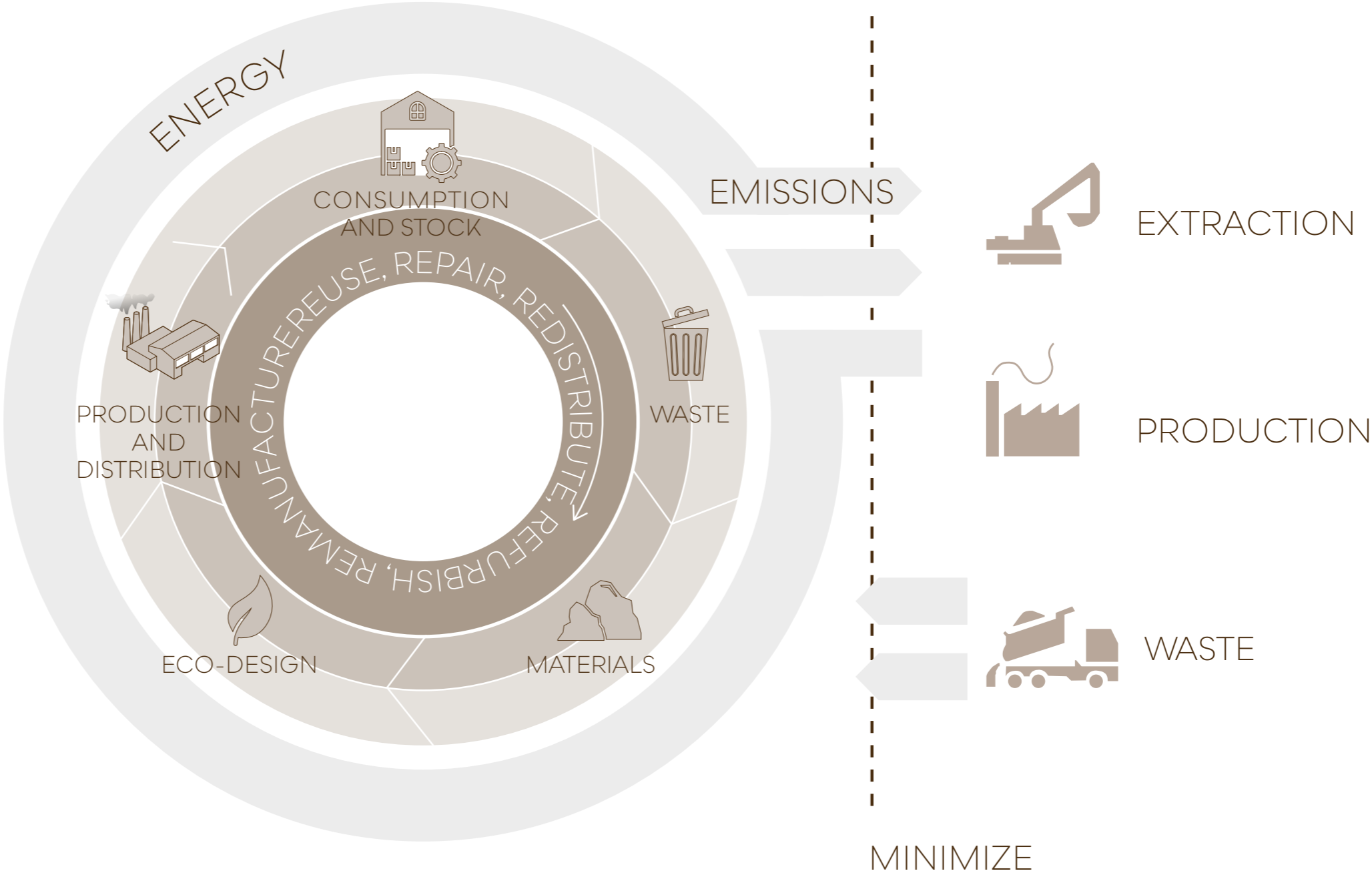


DEMOLITION

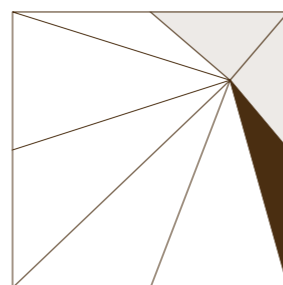
...TO CIRCULAR ECONOMY



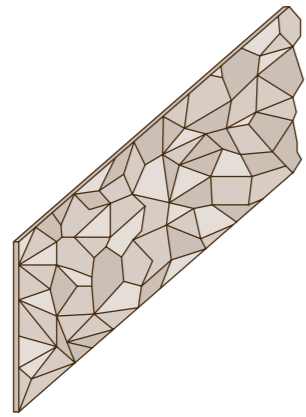
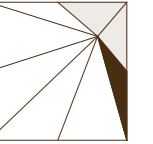
MINIMIZATION EXTRACTION AND EMISSIONS WITH CE



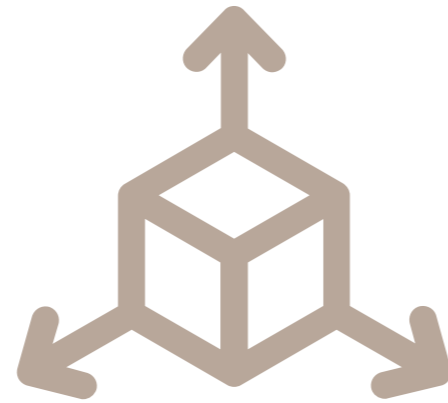
OBJECTIVE



AIM AND OBJECTIVE



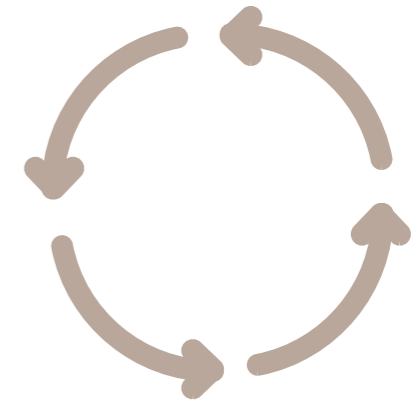
NEW DESIGN



THREE-
DIMENSIONAL

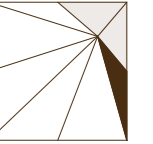


SUSTAINABLE
MATERIAL



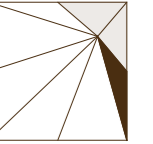
CIRCULAR
STRATEGY

RESEARCH QUESTION



HOW CAN EXTERNAL THREE-DIMENSIONAL CLADDING BE REALIZED USING CIRCULAR STRATEGIES, BIO-BASED MATERIALS AND MANUFACTURED WITH MOULDING?

DESIGN QUESTION

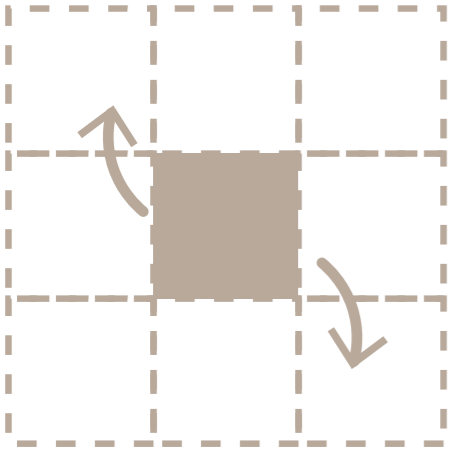


HOW CAN THE EXTERNAL THREE-DIMENSIONAL CLADDING BE **PARAMETRICALLY DESIGNED** TO **MINIMIZE** THE NUMBER OF **MODULAR MOULDS** WHILE ALLOWING **FLEXIBILITY** IN DIVERSE FACADE CONFIGURATIONS?

CIRCULAR DESIGN STRATEGIES



“HOW DOES CIRCULARITY AFFECTS THE FINAL PRODUCT REALIZATION?”



MODULARITY AND FLEXIBILITY



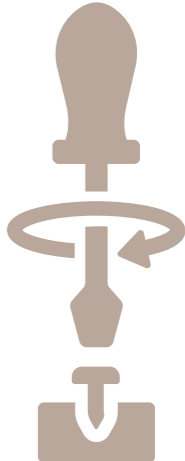
SUSTAINABLE MATETRIAL



MATERIAL USE MINIMIZATION

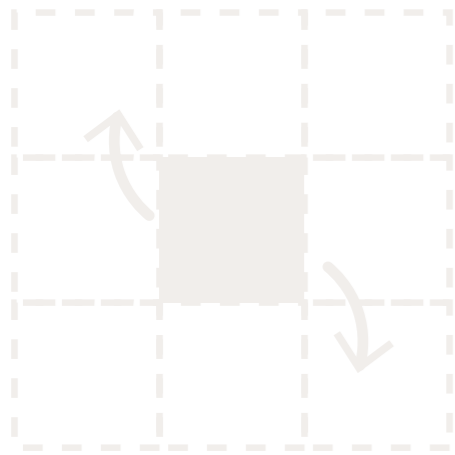


ADAPTABILITY



DESIGN FOR DISASSEMBLY

CIRCULAR DESIGN STRATEGIES



MODULARITY AND FLEXIBILITY



SUSTAINABLE MATETRIAL



MATERIAL USE MINIMIZATION

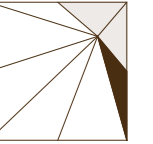


ADAPTABILITY



DESIGN FOR DISASSEMBLY

BIO-BASED MATERIALS



ORGANIC



RENEWABLE

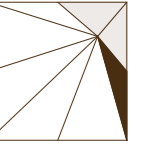


CAN BE MADE OF
RESIDUAL STREAMS



LOCAL
RESOURCES

BIO-BASED MATERIALS

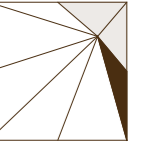


WOOD



WOOD

BIO-BASED MATERIALS



NON-WOOD



BIOPLASTICS



BIOCOMPOSITES

MATRIX

REINFORCEMENT

BIO-BASED MATERIALS



WOOD



BIOPLASTICS

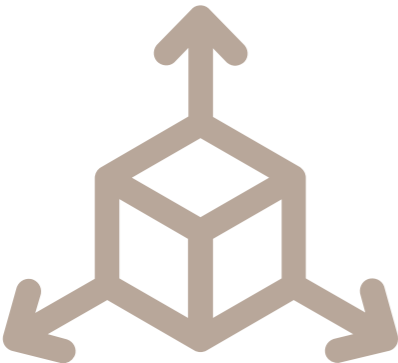


BIOCOMPOSITES

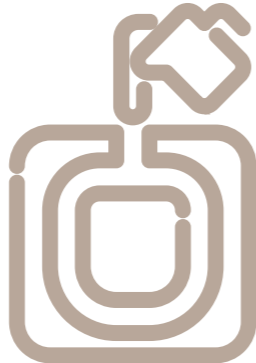
BIO-BASED MATERIALS



MATERIAL CHOICE CRITERIA



3D SUITABILITY



MOLDING
PROCESS



WASTE STREAMS %



CERTIFIED



COMPANY
PROXIMITY

BIO-BASED MATERIALS



MATERIALS LIST

“WHAT ARE THE AVAILABLE BIO-BASED MATERIALS THAT CAN BE USED FOR EXTERNAL CLADDING?”



NABASCO 50s



NABASCO 80s



NABASCO 100s



RESYSTA

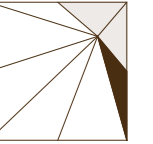


RE-PLEX



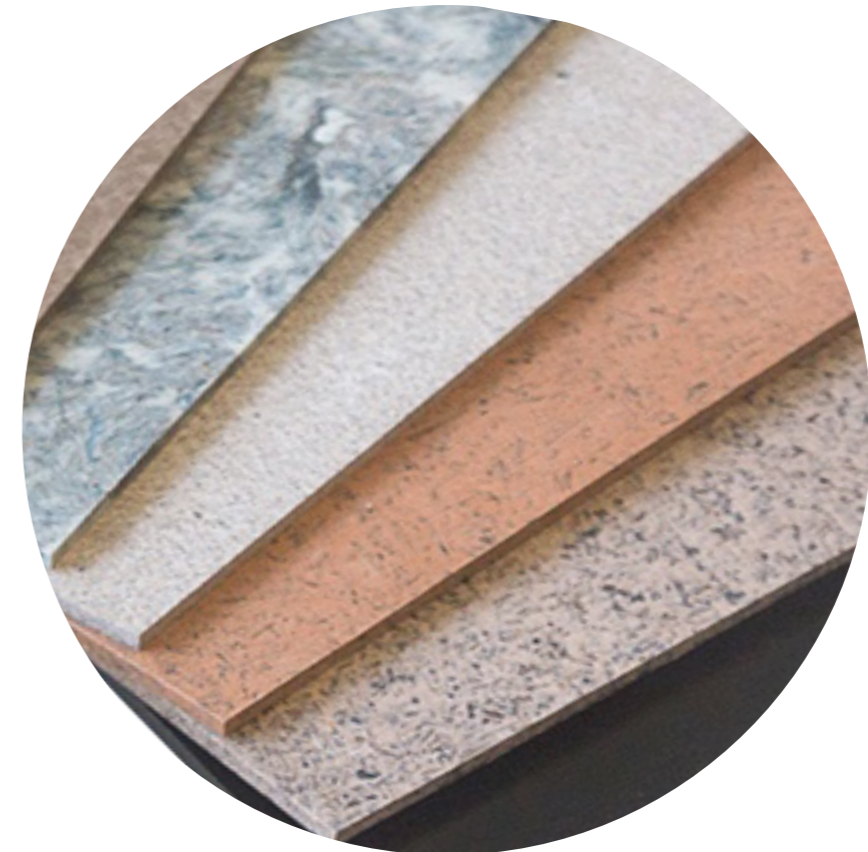
PHBV FABULOUS

BIO-BASED MATERIALS



NABASCO 80s

- BIOCOMPOSITE (natural fibers, resin and filler)
- BULK MOUNDING COMPOUND
- IT WITHSTANDS DIFFICULT GEOMETRIES
- DIFFERENT COLORS AVAILABILITY



BIO-BASED MATERIALS



NABASCO 80s



REED FIBERS



ROOF
CONSTRUCTION
INDUSTRIES
WASTE



PARTIALLY BIO-
BASED POLYESTER
RESIN

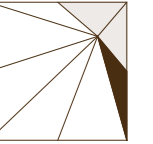


CALCITE (CaCO_3)
FILLER



WATER
TREATMENT
INDUSTRIES
WASTE

BIO-BASED MATERIALS



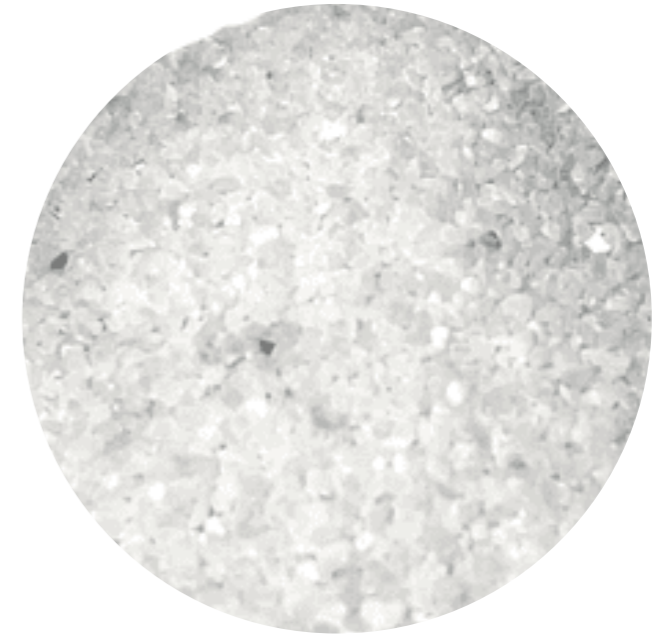
BY-PRODUCTS



REED FIBERS



PARTLY BIO-BASED
POLYESTER RESIN

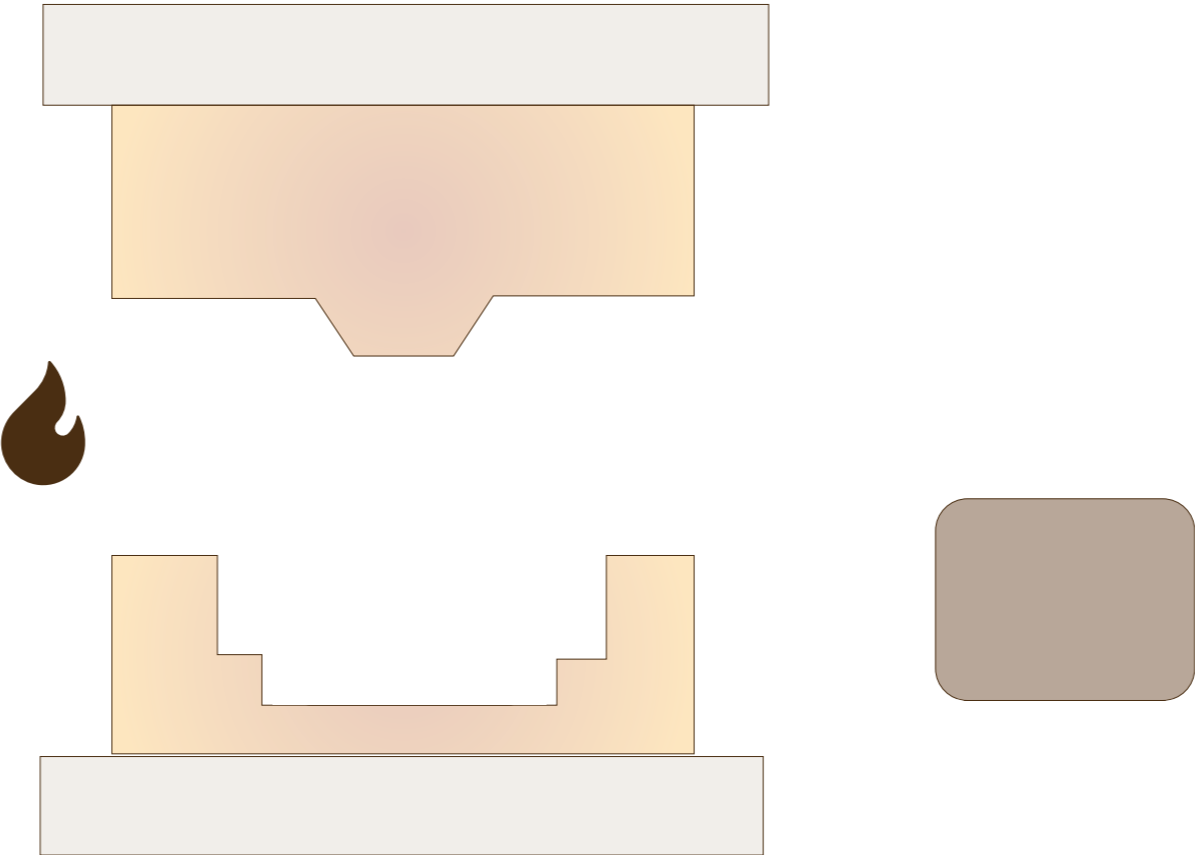


CALCITE (CaCO_3)
FILLER

BIO-BASED MATERIALS



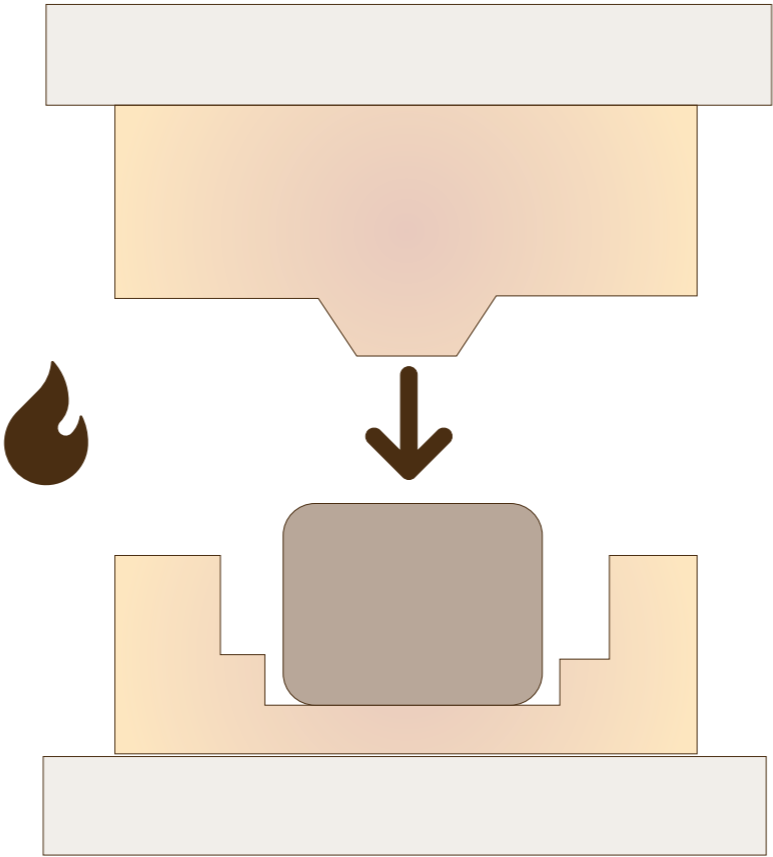
HOT PRESS PROCESS



BIO-BASED MATERIALS

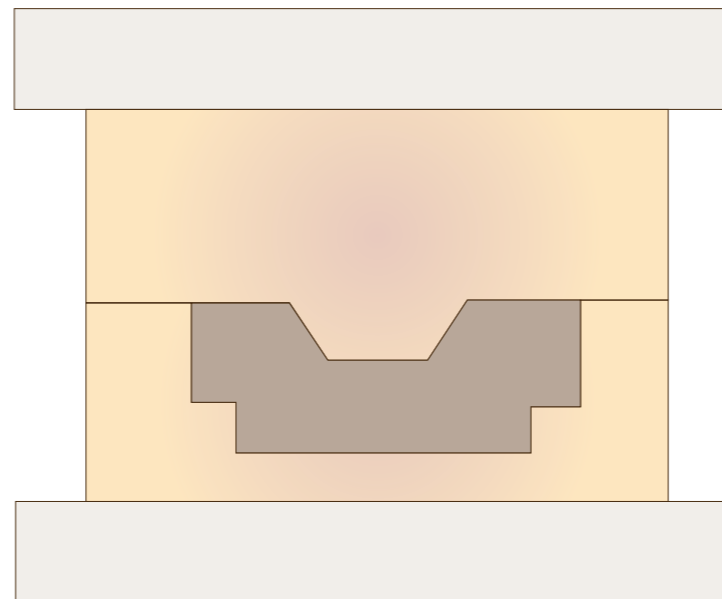
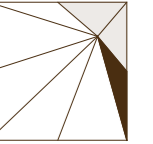


HOT PRESS PROCESS



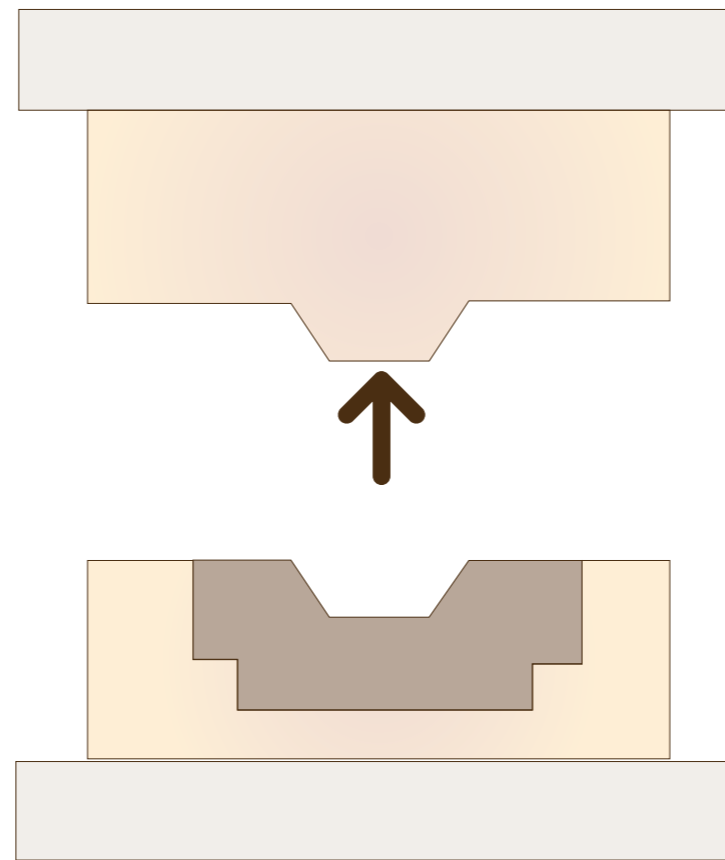
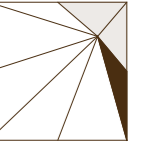
BIO-BASED MATERIALS

HOT PRESS PROCESS



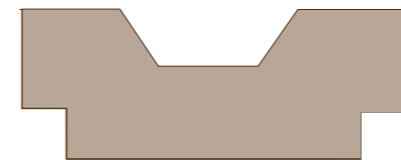
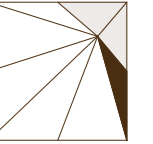
BIO-BASED MATERIALS

HOT PRESS PROCESS



BIO-BASED MATERIALS

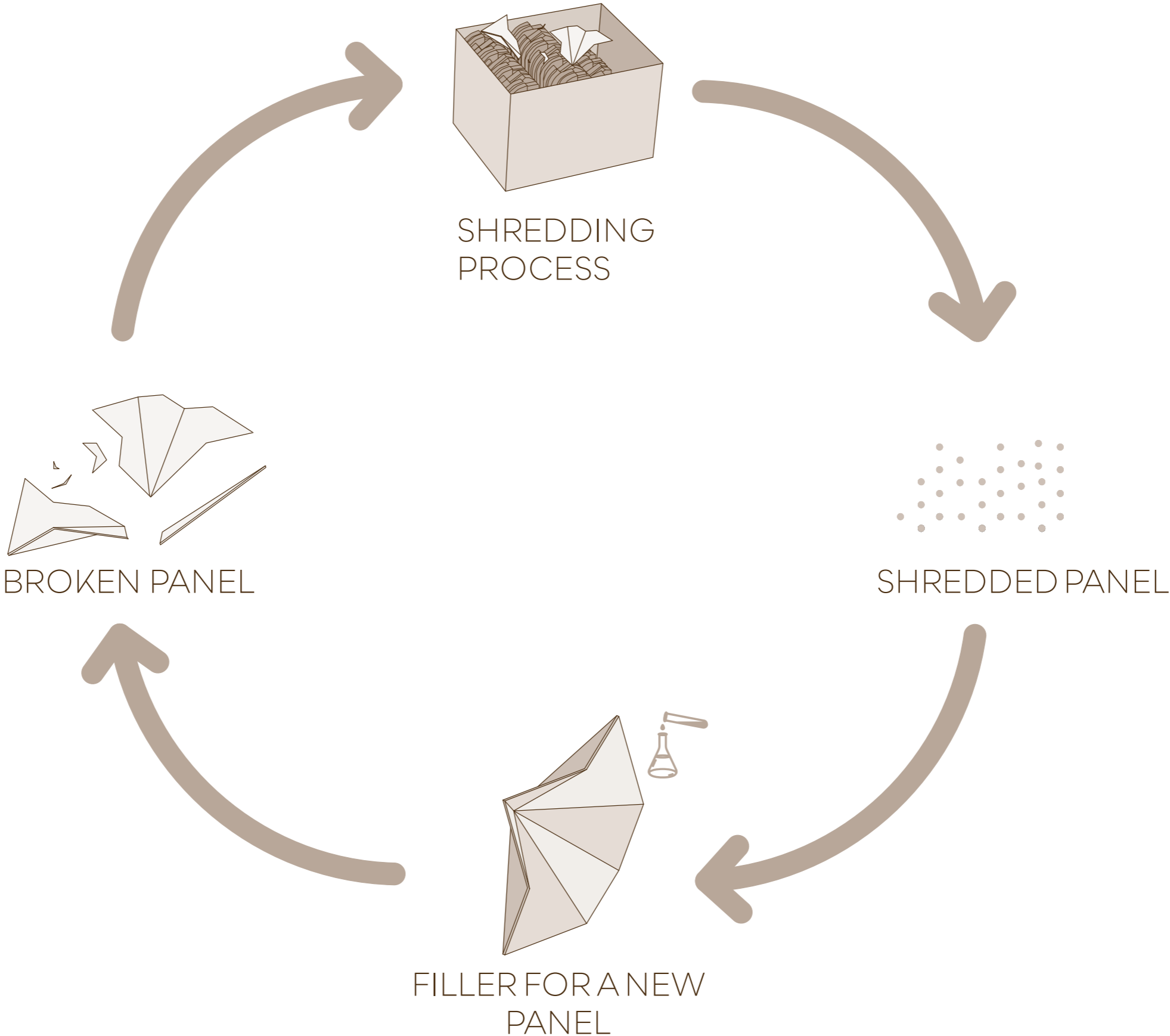
HOT PRESS PROCESS



BIO-BASED MATERIALS



NABASCO 80s



BIO-BASED MATERIALS



NABASCO 80s SERIES



NABASCO 8010

REED FIBERS
CALCITE
POLYESTER RESIN
GERMANY

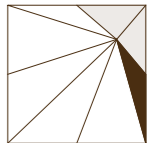
NABASCO 8012

REED FIBERS
CALCITE
POLYESTER RESIN
NETHERLANDS

NABASCO 8040

HEMP
FURAN
OLIVE STONE
NETHERLANDS

BIO-BASED MATERIALS



NABASCO 80s SERIES



NABASCO 8010

REED FIBERS
CALCITE
POLYESTER RESIN
GERMANY

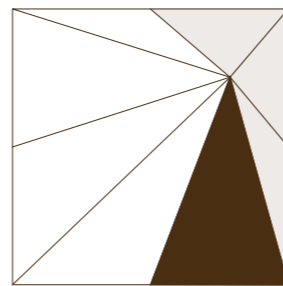
NABASCO 8012

REED FIBERS
CALCITE
POLYESTER RESIN
NETHERLANDS

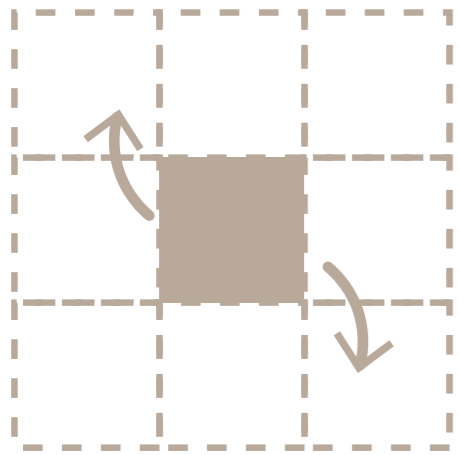
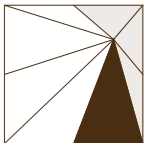
NABASCO 8040

HEMP
FURAN
OLIVE STONE
NETHERLANDS

CONCEPTUAL DESIGN



CIRCULAR DESIGN STRATEGIES



MODULARITY AND FLEXIBILITY



SUSTAINABLE MATETRIAL



MATERIAL USE MINIMIZATION

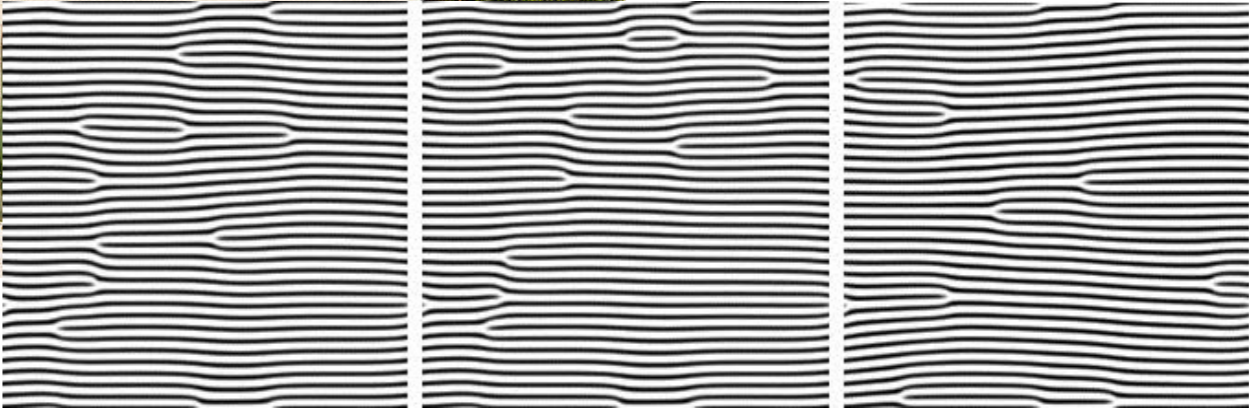
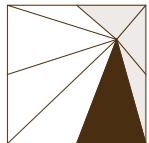


ADAPTABILITY

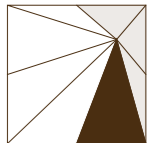


DESIGN FOR DISASSEMBLY

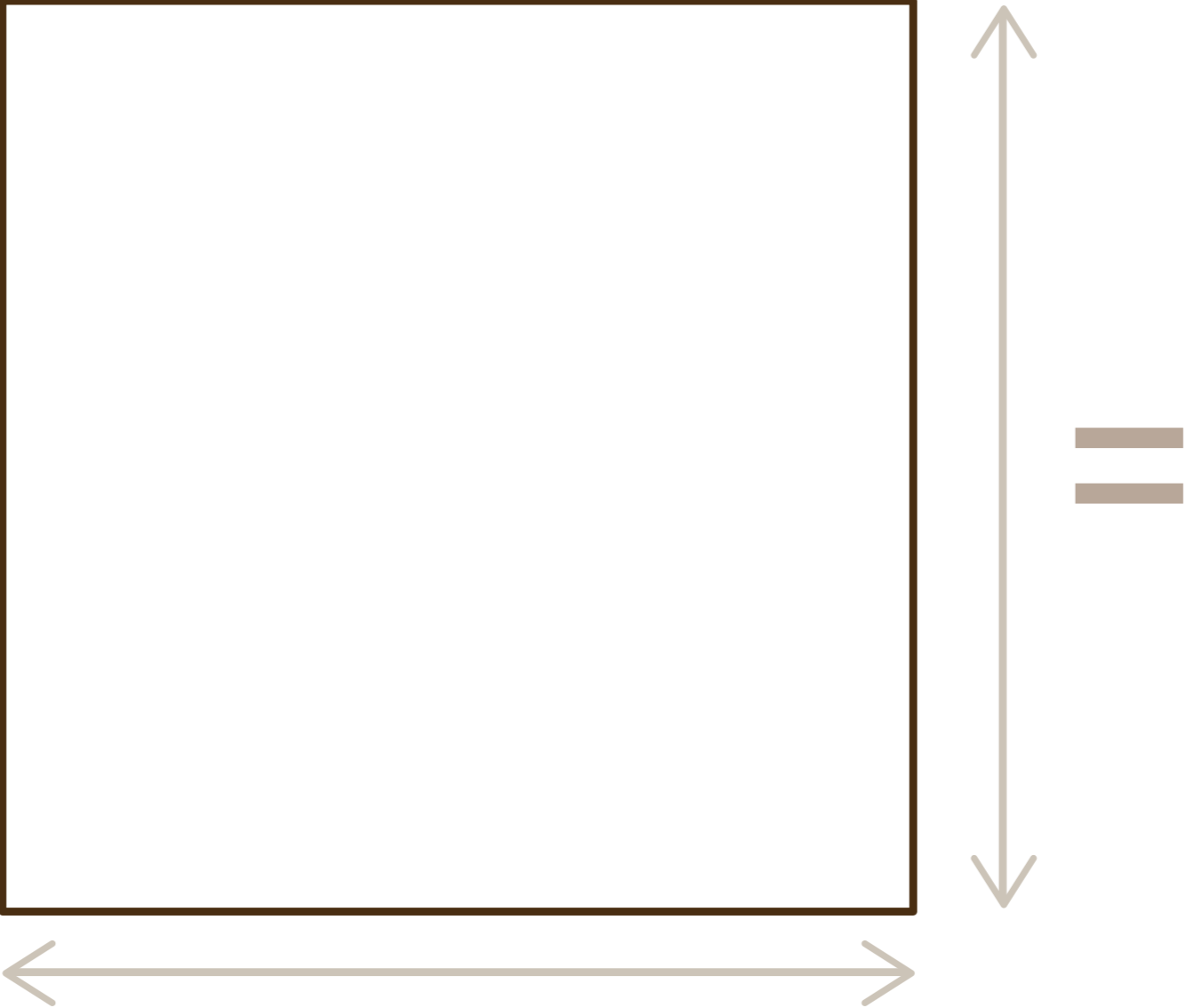
UAE PAVILION MILAN EXPO 2015 - FOSTER + PARTNERS



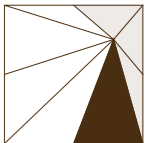
DESIGN PROCESS



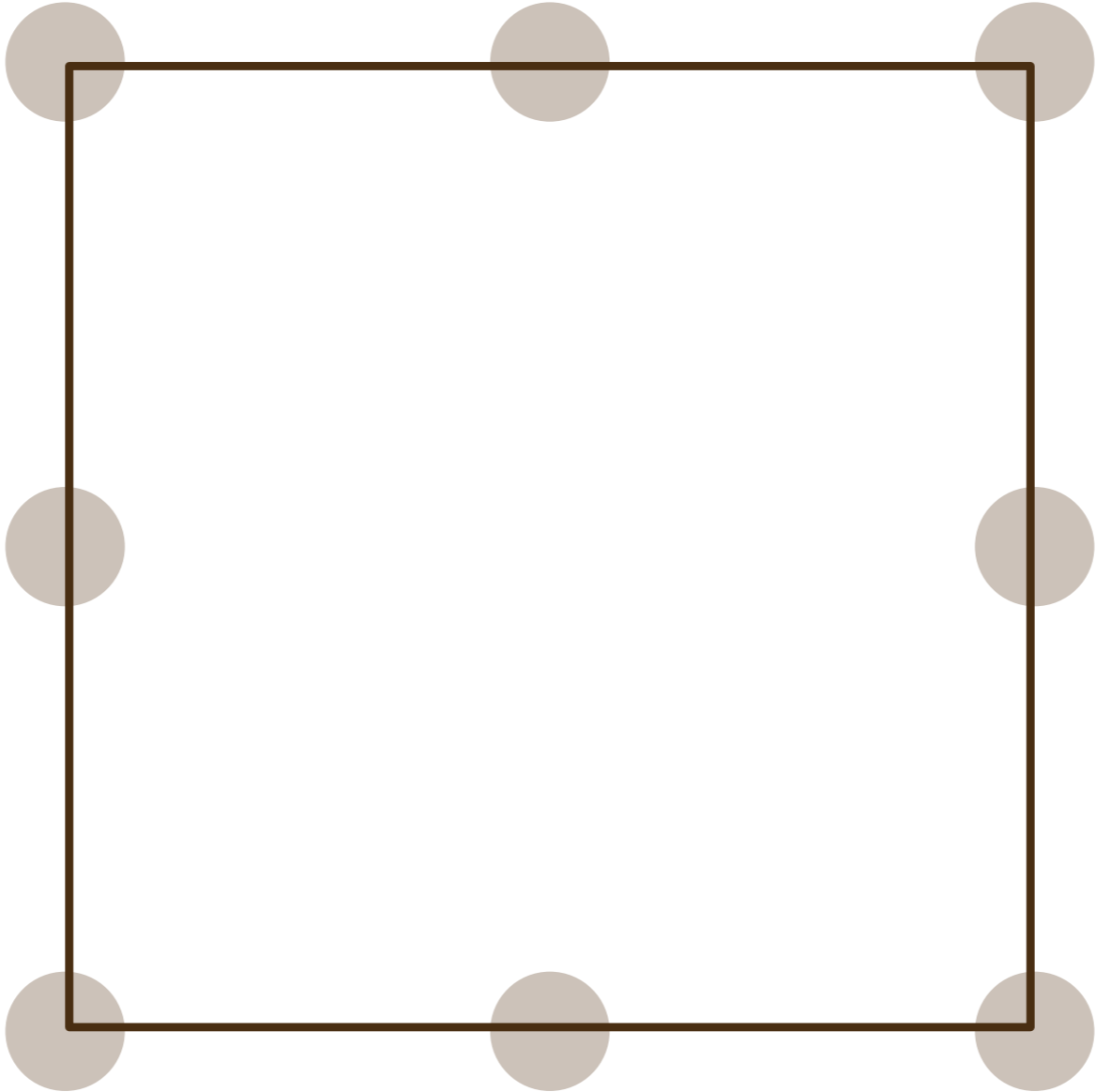
SQUARED SHAPE



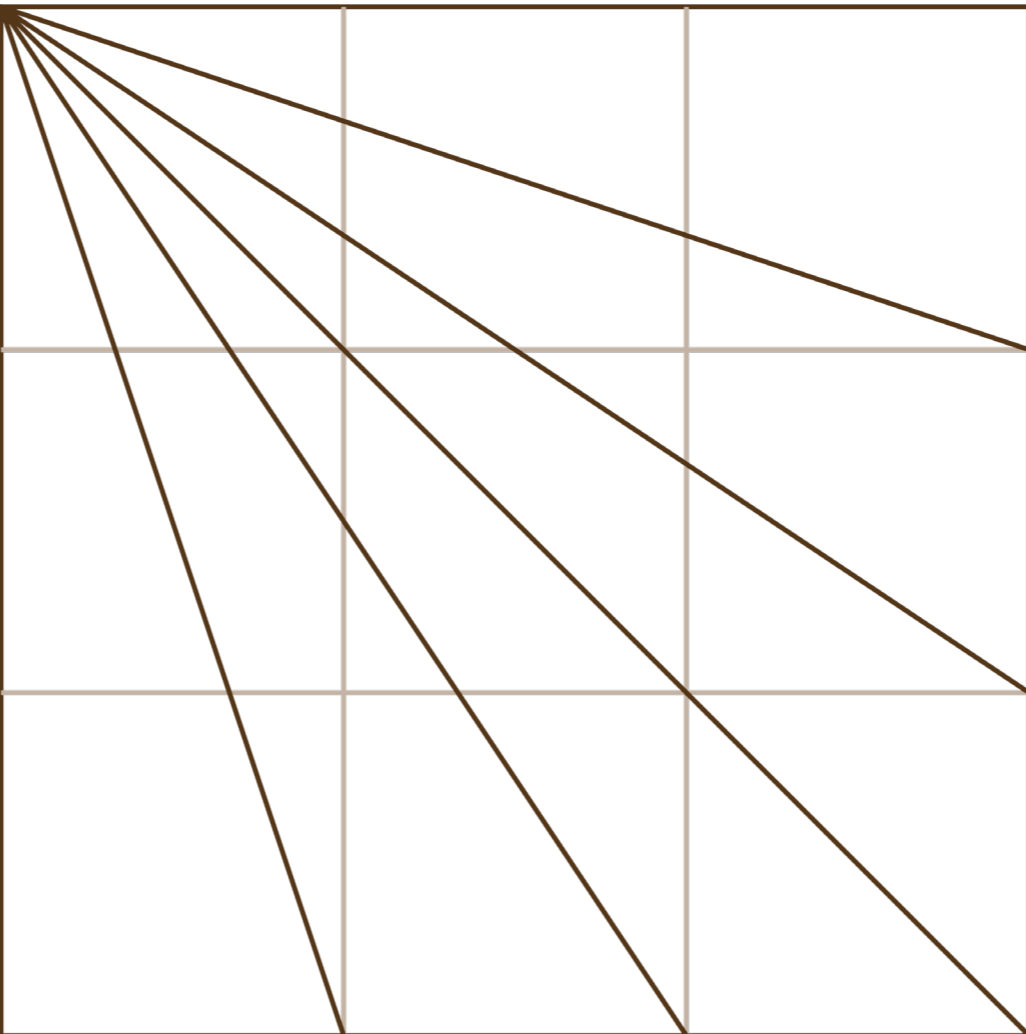
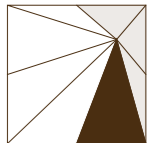
DESIGN PROCESS



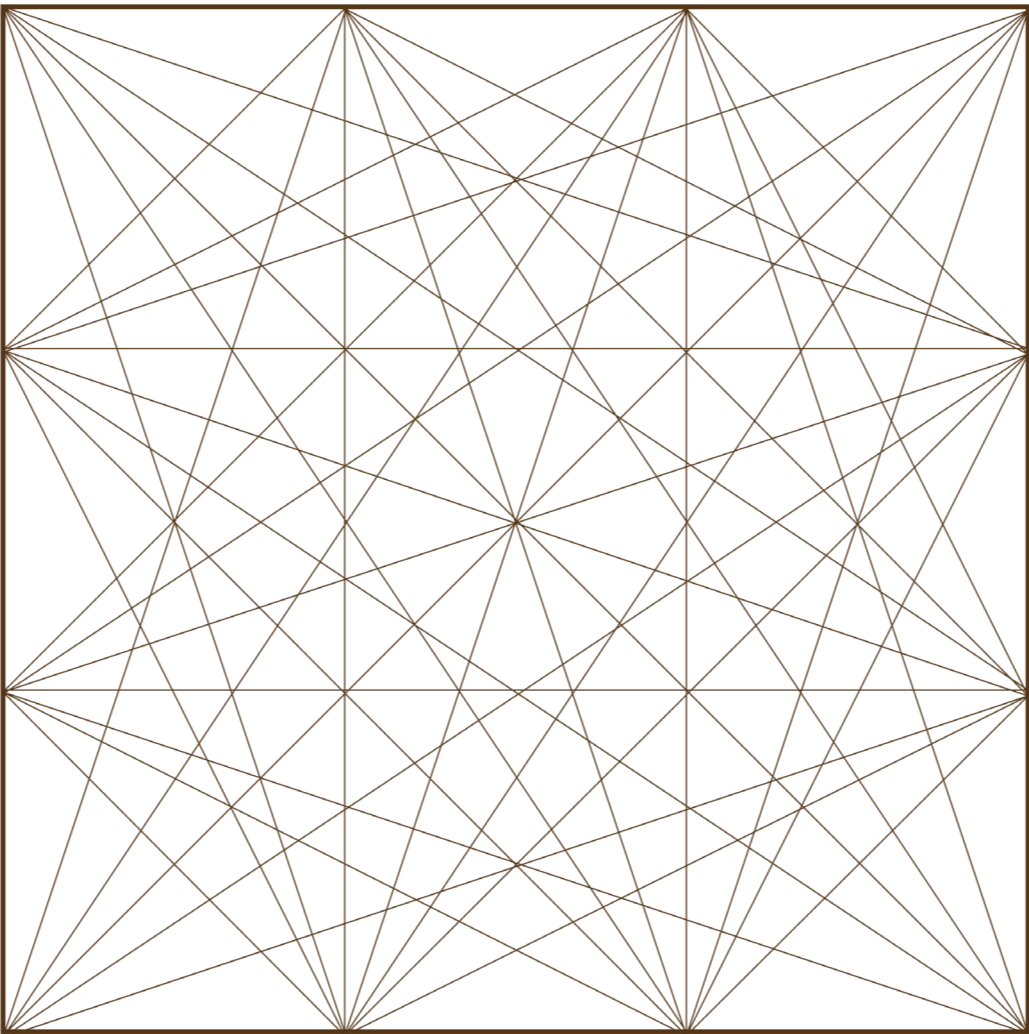
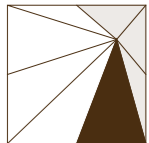
MATCHING POINTS



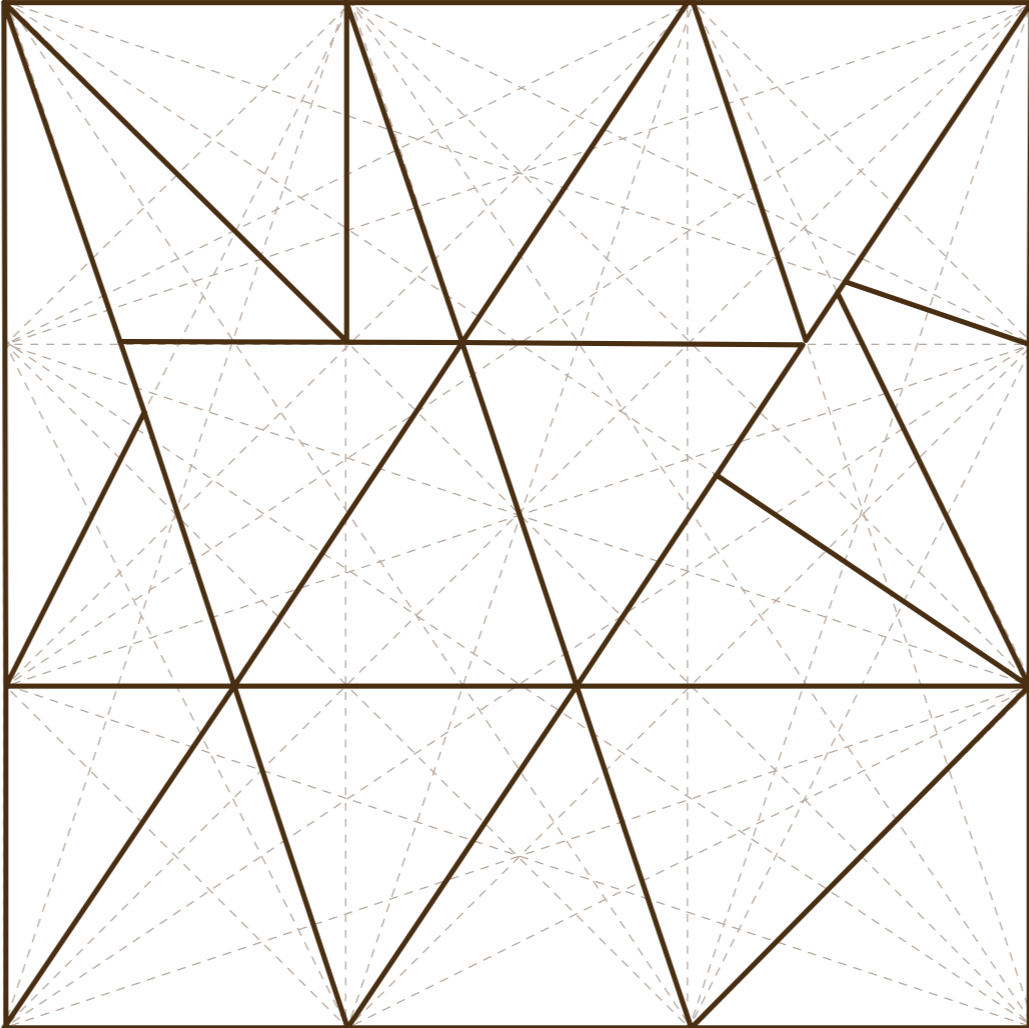
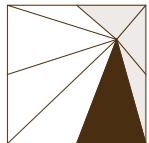
DESIGN PROCESS



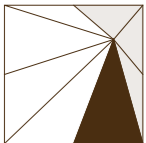
DESIGN PROCESS



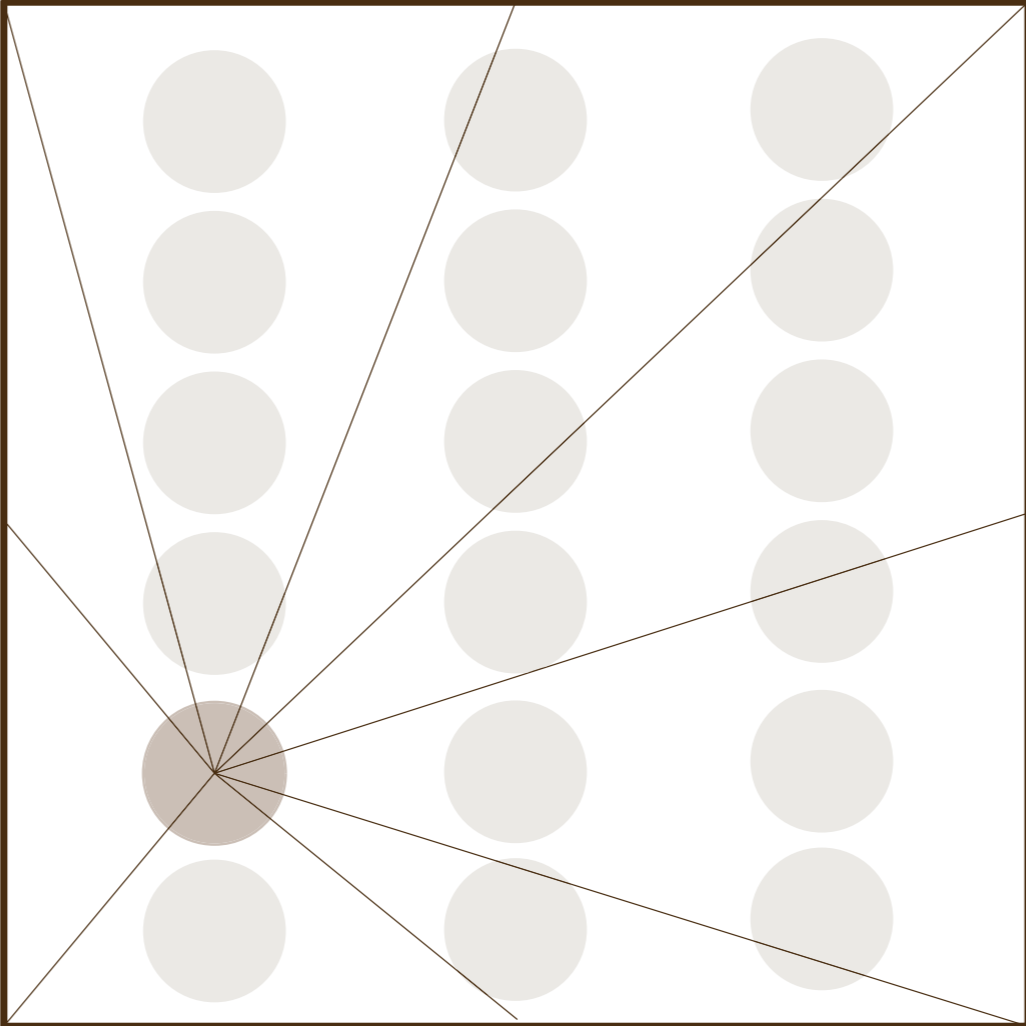
DESIGN PROCESS



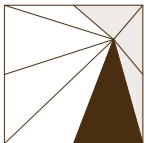
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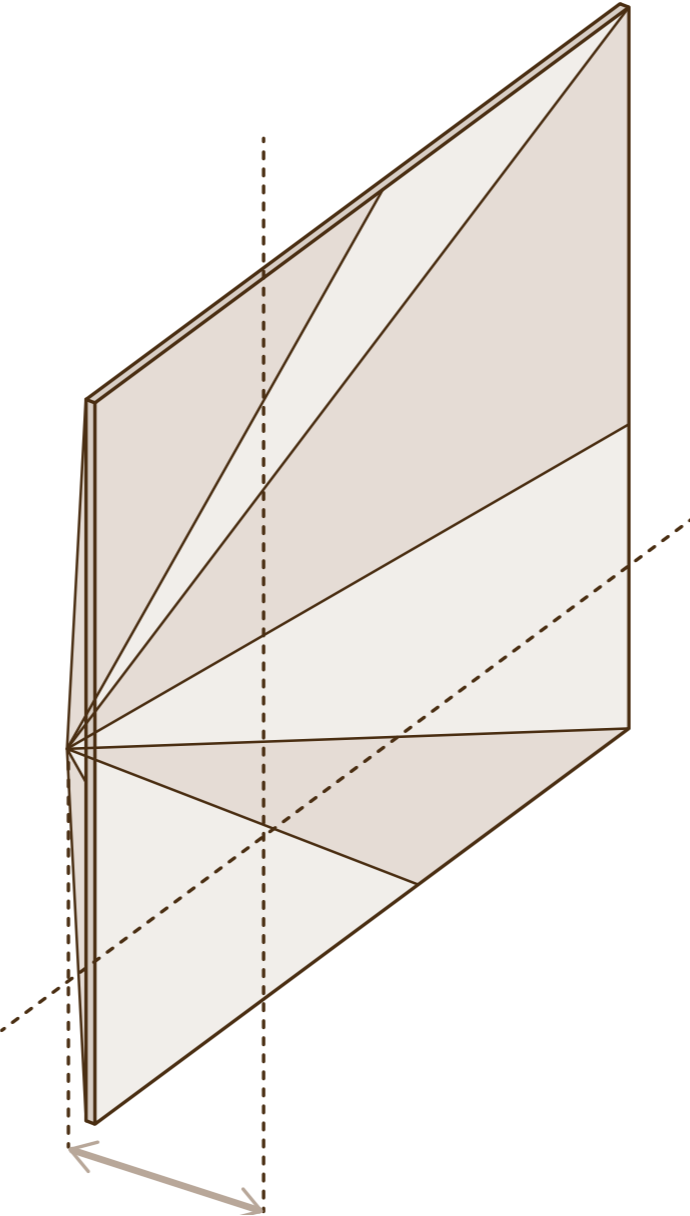
FOCAL POINT



DESIGN PROCESS

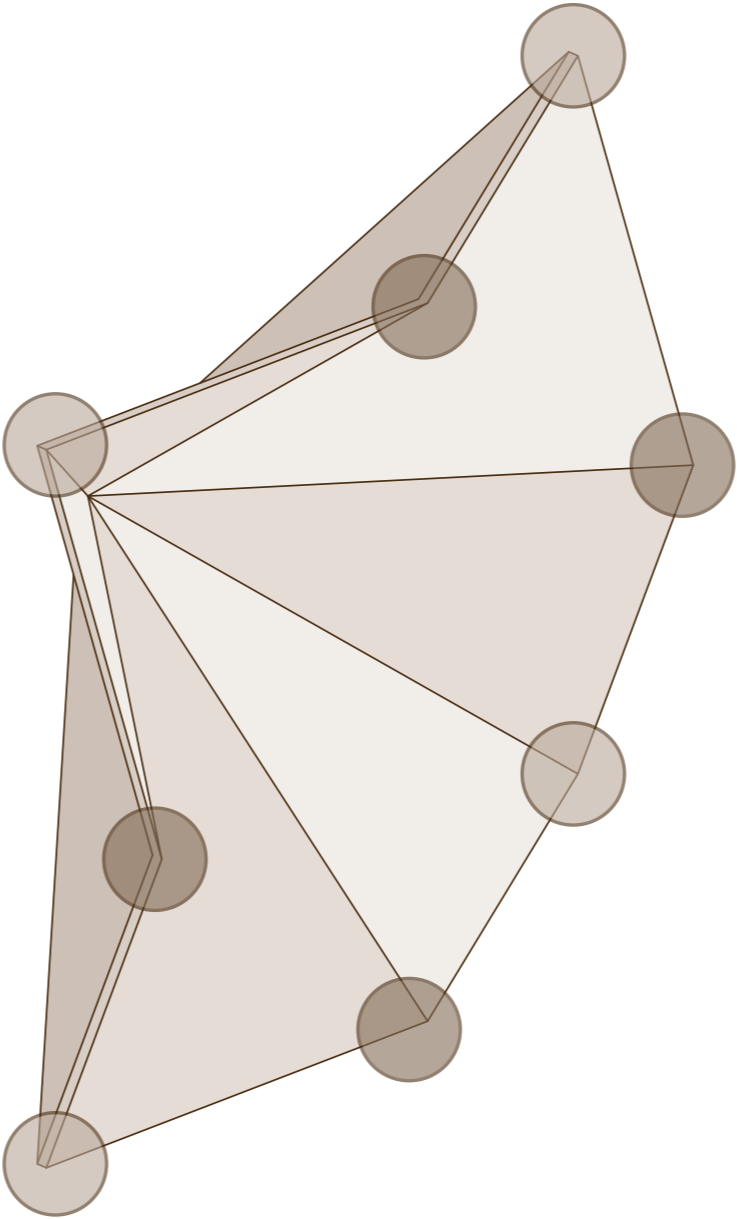
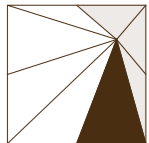


FOCAL POINT THREE-DIMENSIONALITY



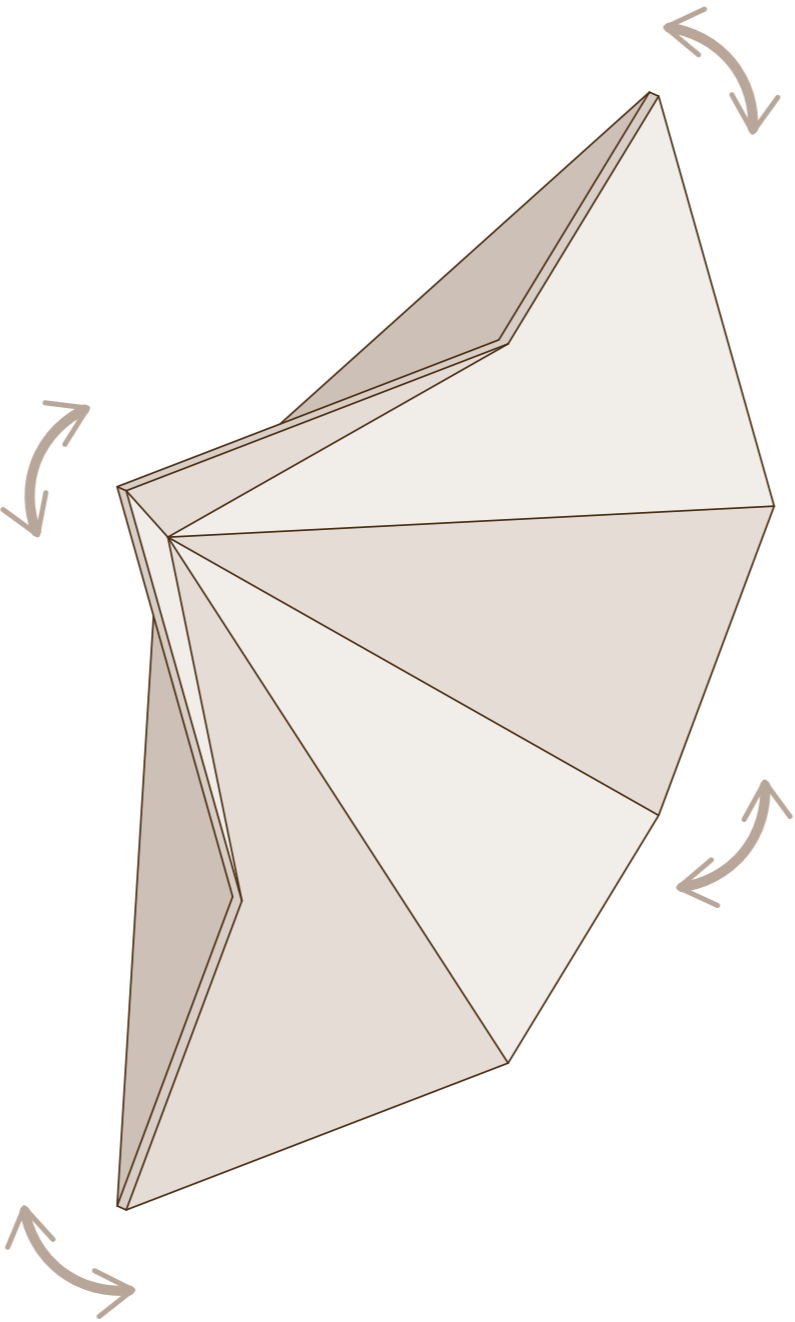
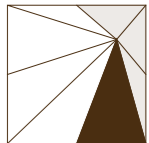
DESIGN PROCESS

COMPLEXITY INCREASE

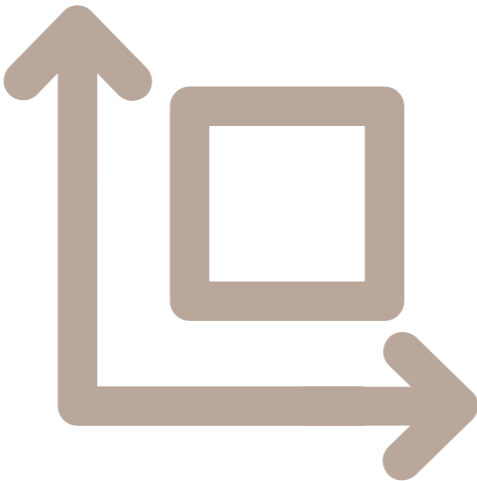
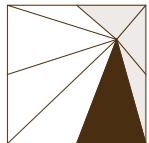


DESIGN PROCESS

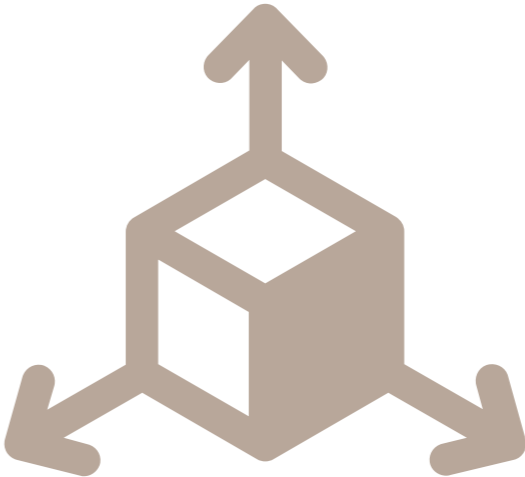
ROTATIONAL FREEDOM



DESIGN CONFIGURATIONS

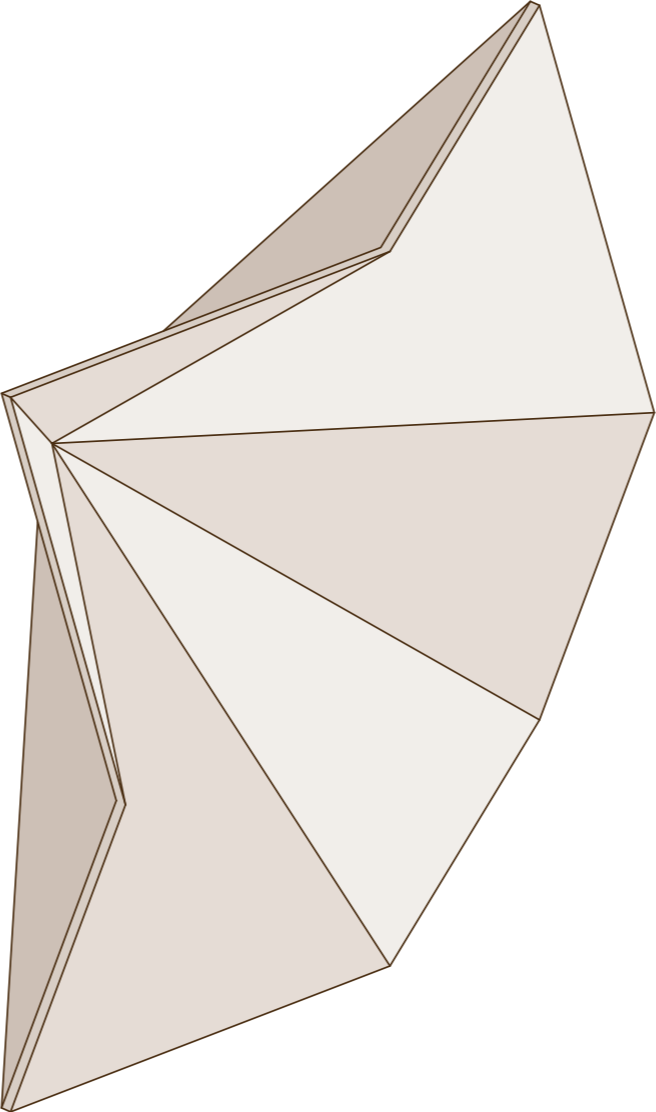
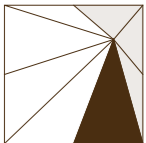


BI-DIMENSIONAL



THREE-DIMENSIONAL

DESIGN CONFIGURATIONS

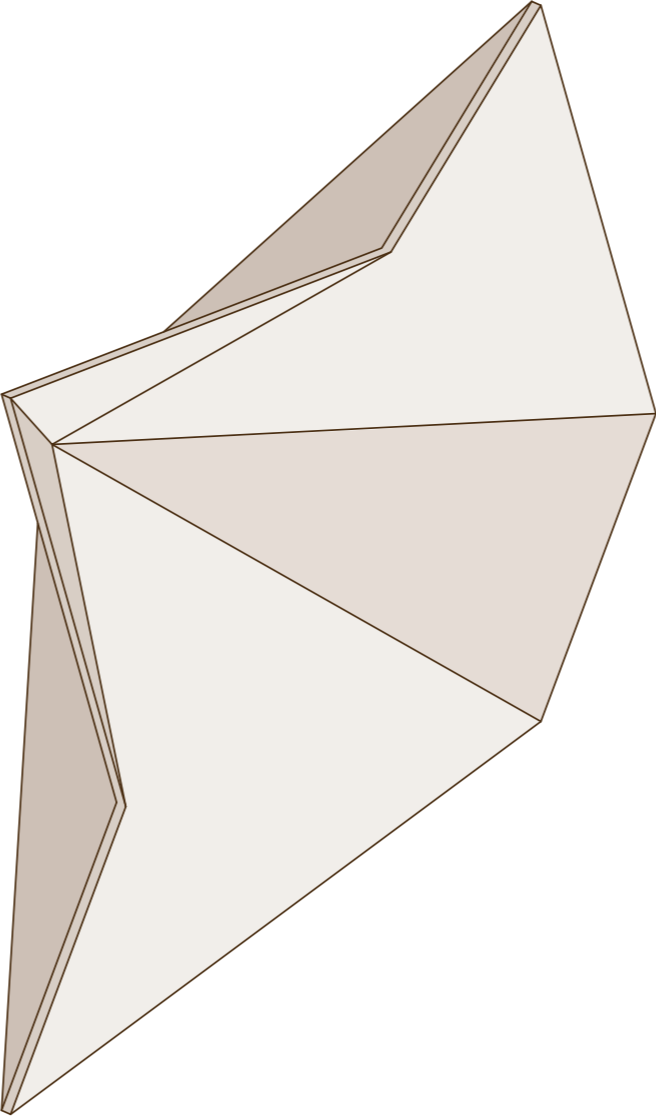
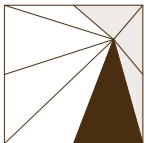


COMPLEX PANEL

4 3D EDGES

0 2D EDGES

DESIGN CONFIGURATIONS



BRIDGE 1 PANEL

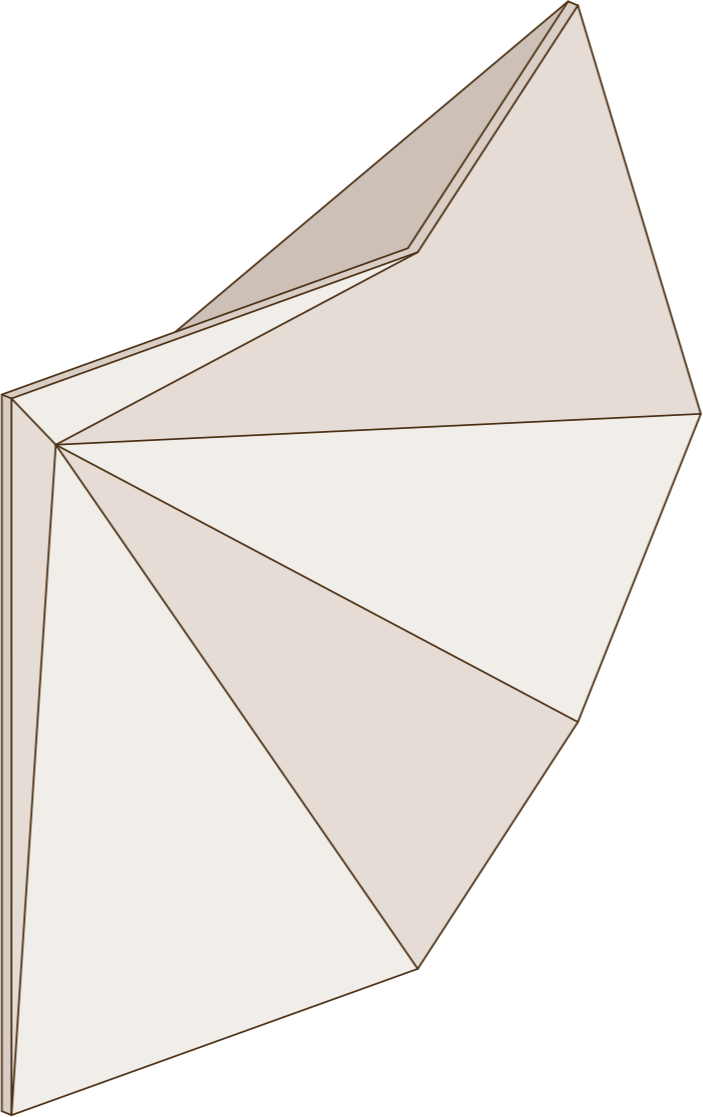
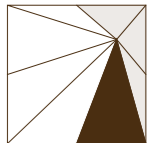
3

3D EDGES

1

2D EDGES

DESIGN CONFIGURATIONS



BRIDGE 2 PANEL A.

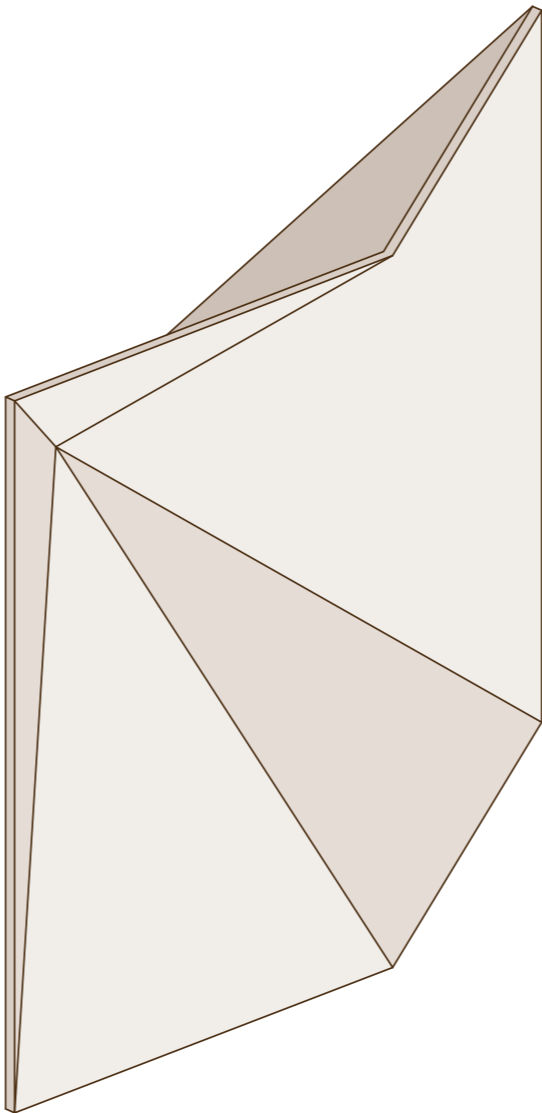
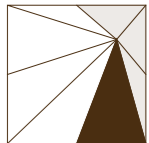
2

3D EDGES

2

2D EDGES

DESIGN CONFIGURATIONS



BRIDGE 2 PANEL P.

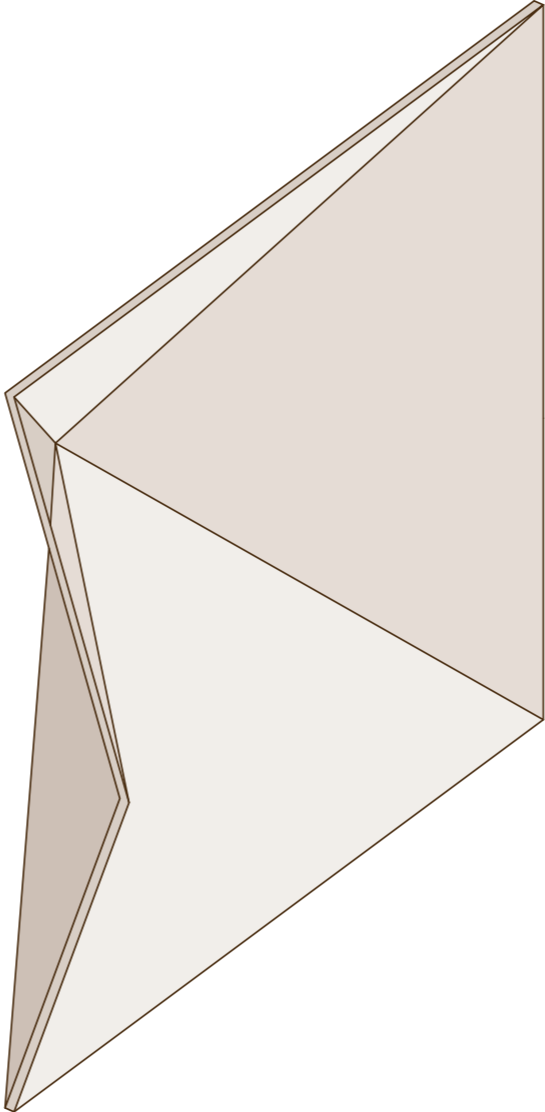
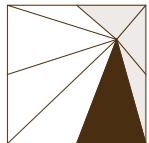
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3D EDGES

2

2D EDGES

DESIGN CONFIGURATIONS

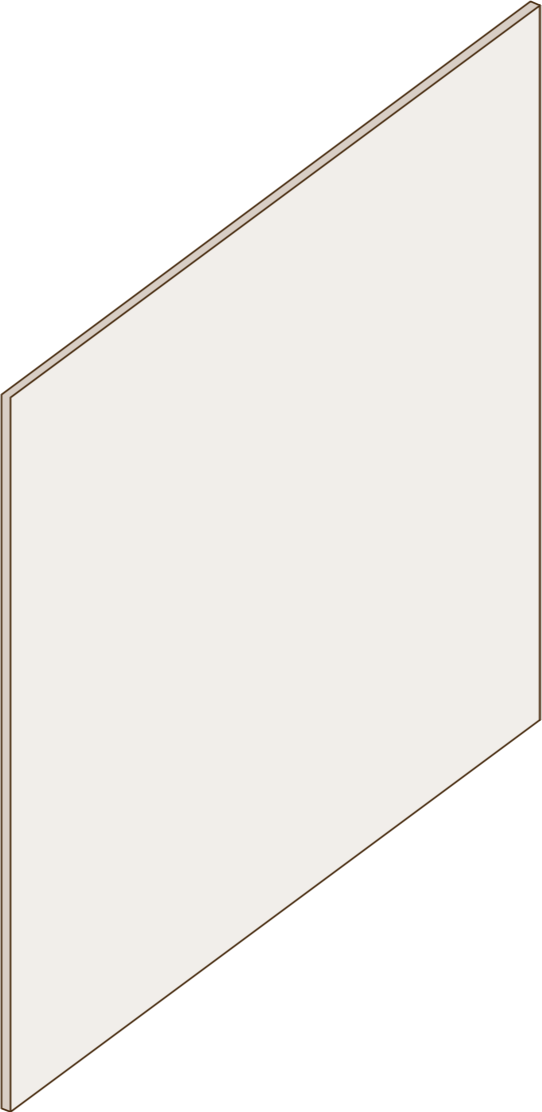
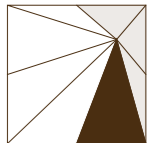


BRIDGE 3 PANEL

1 3D EDGES

3 2D EDGES

DESIGN CONFIGURATIONS



FLAT PANEL

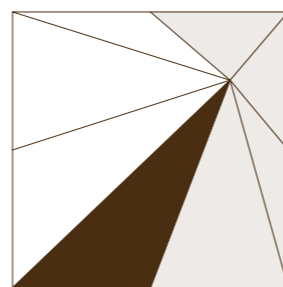
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3D EDGES

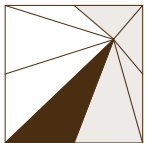
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2D EDGES

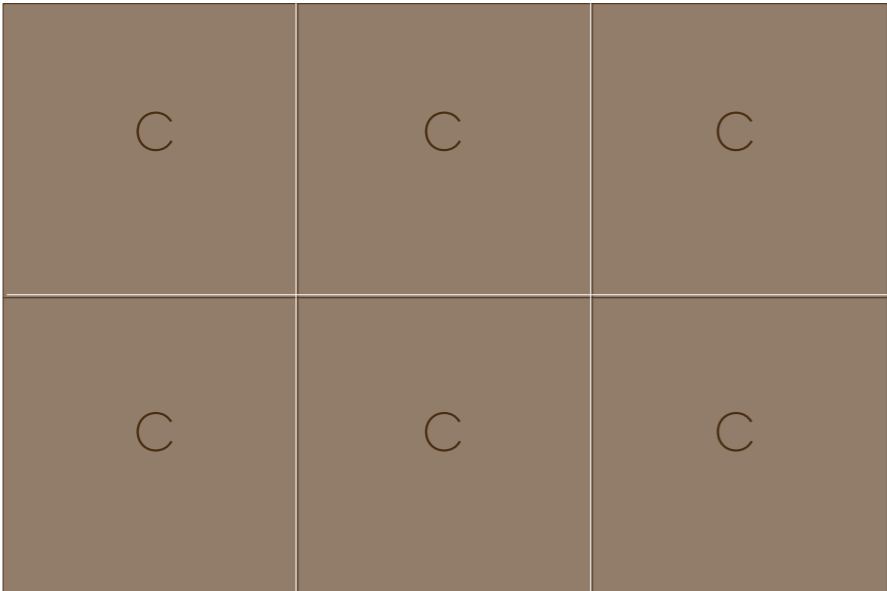
DESIGN DEVELOPMENT



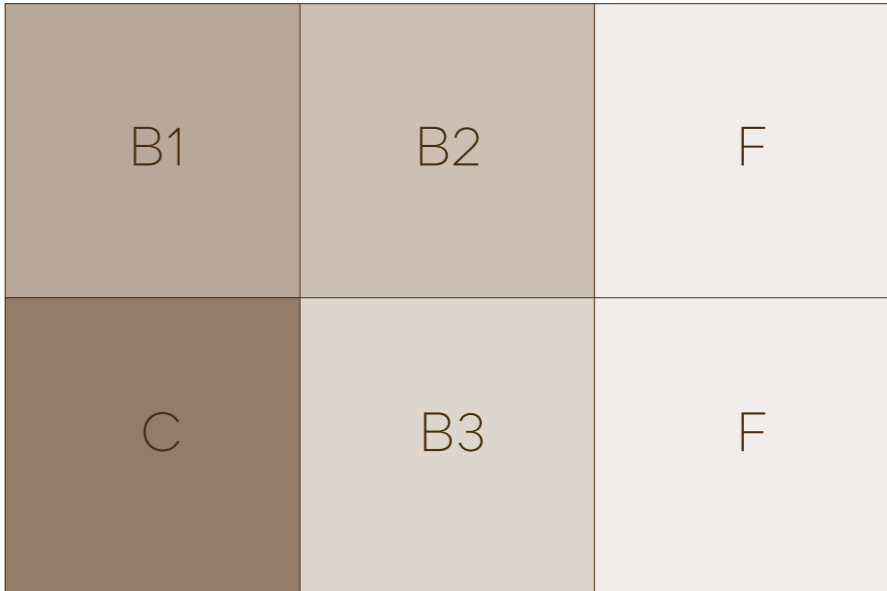
COMPUTATIONAL CONFIGURATIONS



SIX PANEL CONFIGURATIONS



ONE-PANEL
CONFIGURATION



ALL-PANEL
CONFIGURATION

● COMPLEX

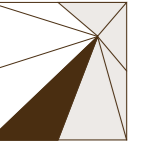
● BRIDGE 1

● BRIDGE 2

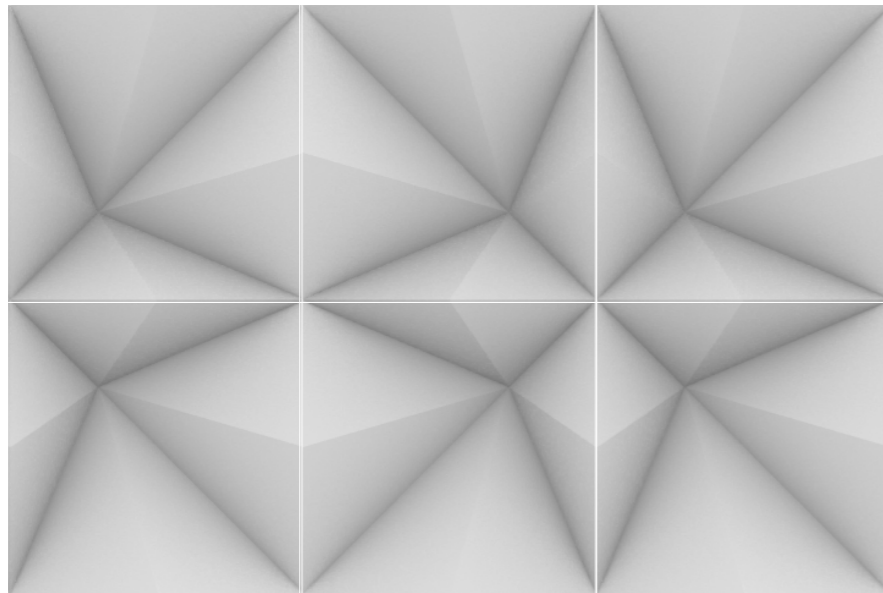
● BRIDGE 3

○ FLAT

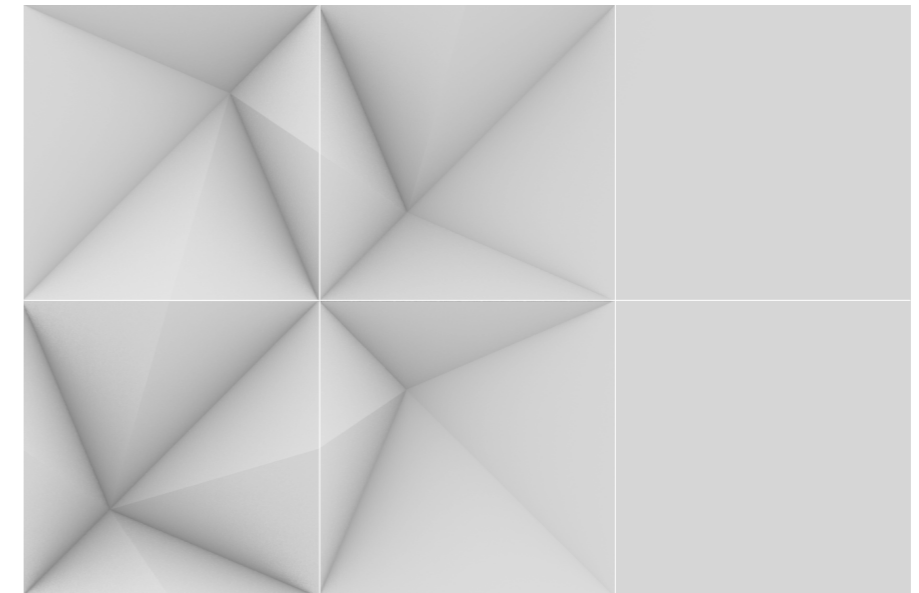
COMPUTATIONAL CONFIGURATIONS



SIX PANEL CONFIGURATIONS

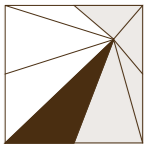


ONE-PANEL
CONFIGURATION

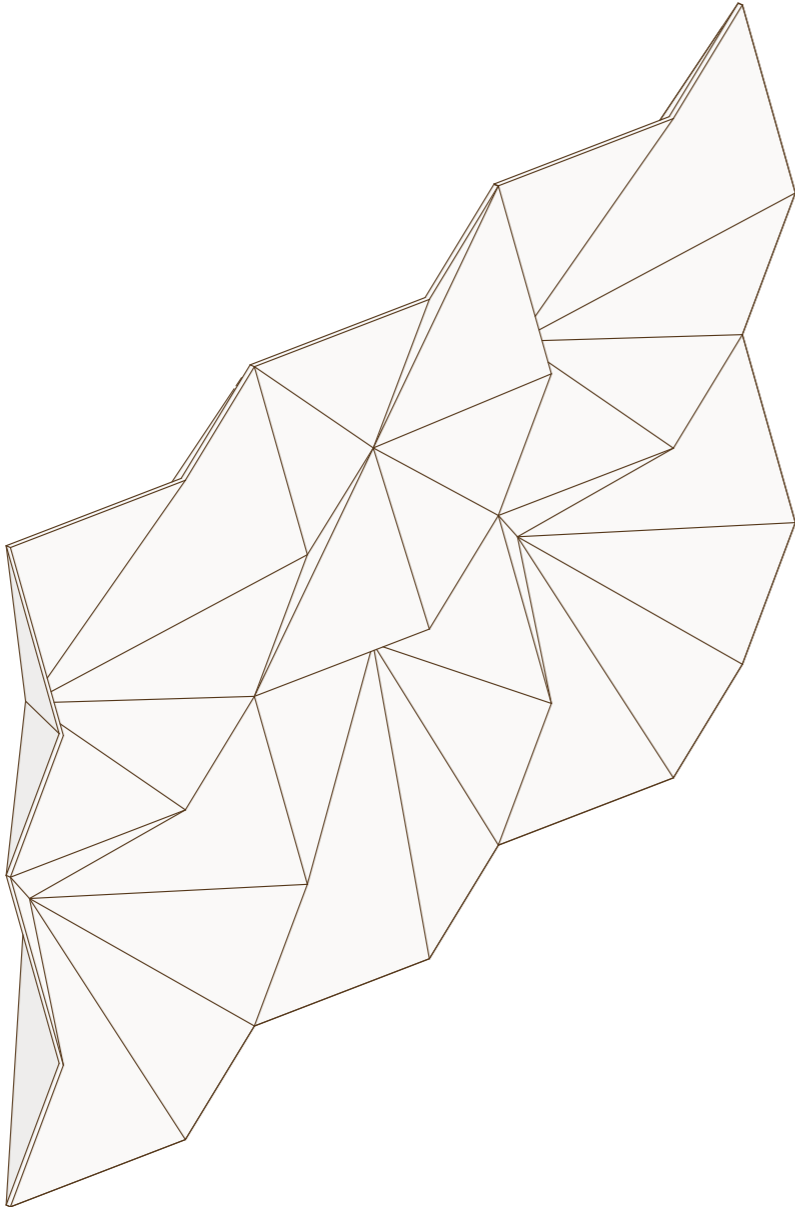


ALL-PANEL
CONFIGURATION

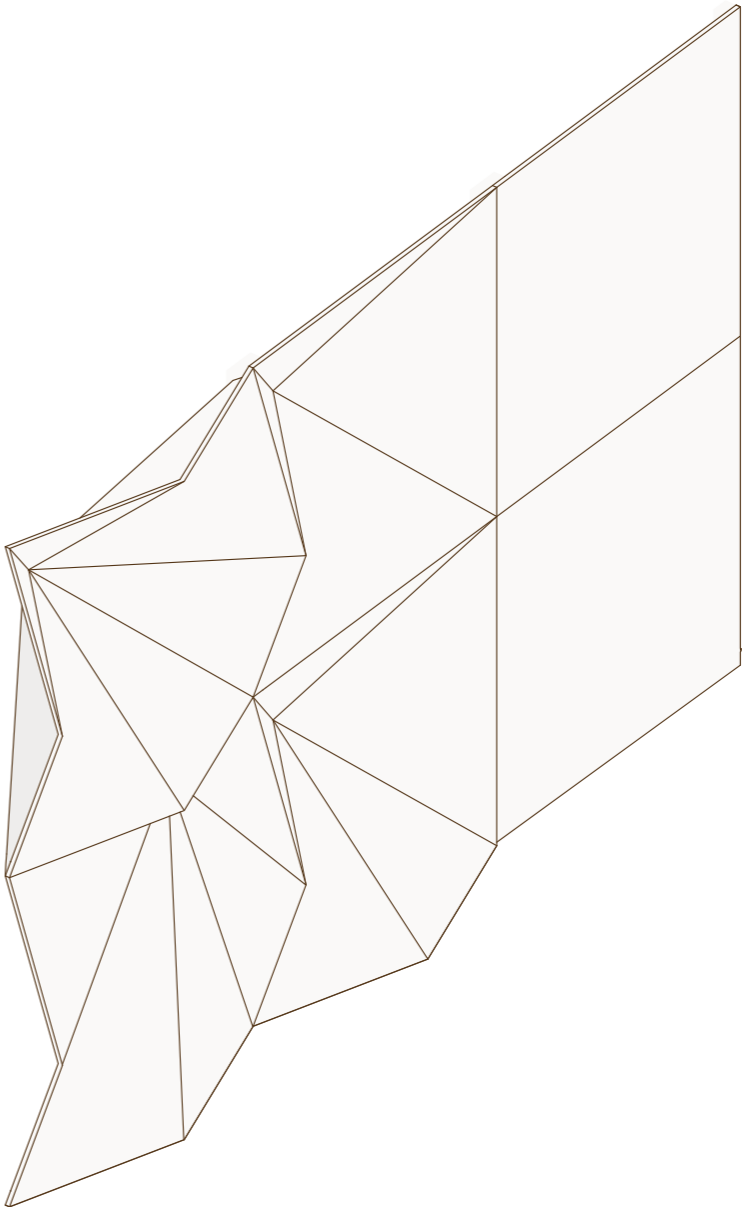
DESIGN SIX PANELS CONFIGURATIONS



FACADE 3D CONFIGURATION



ONE-PANEL
CONFIGURATION

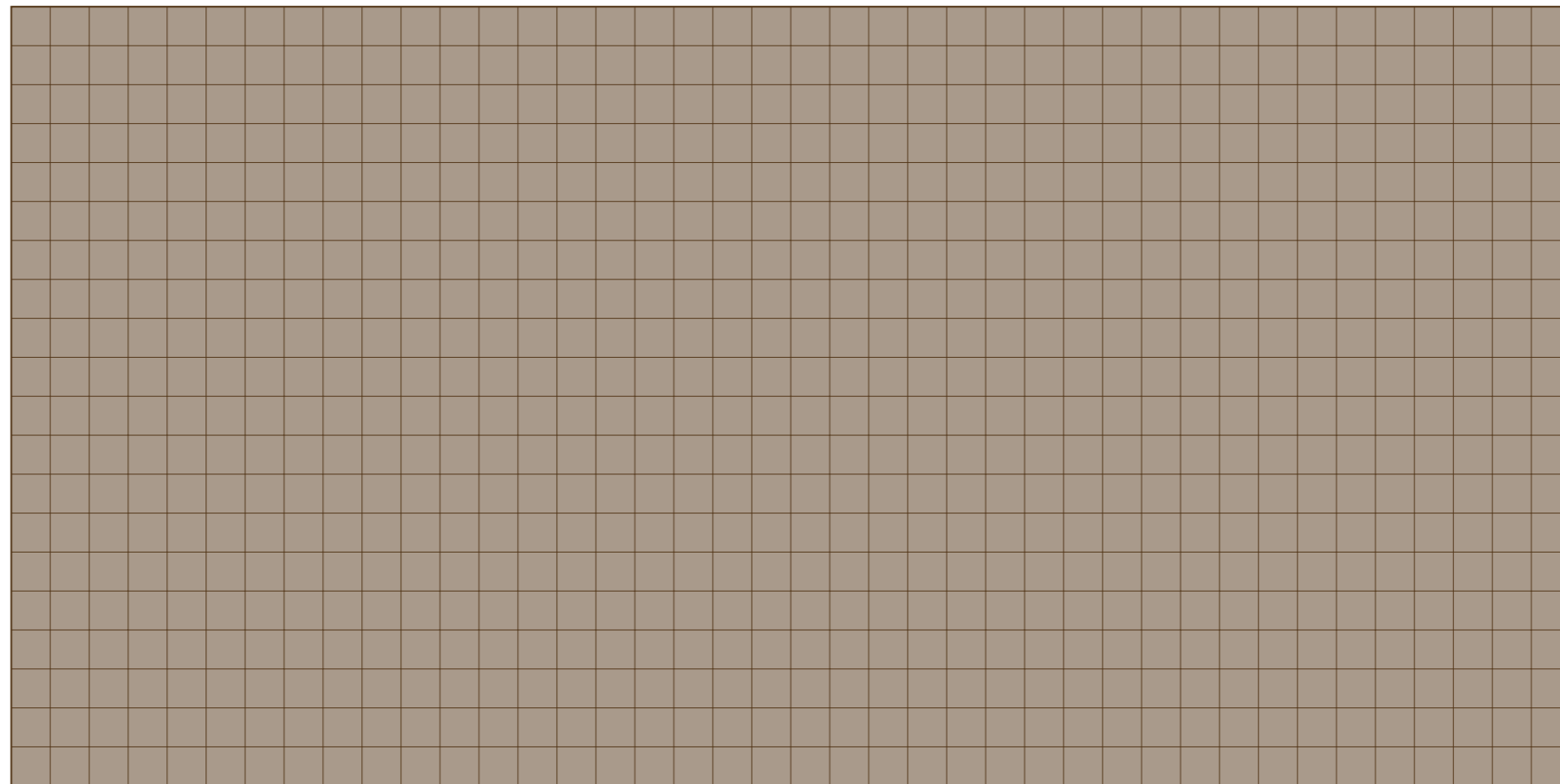


ALL-PANEL
CONFIGURATION

ONE-PANEL CONFIGURATION



FACADE CONFIGURATION



● COMPLEX

● BRIDGE 1

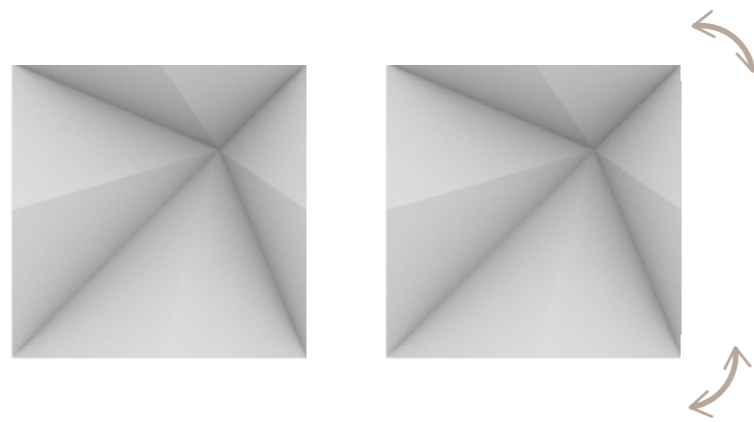
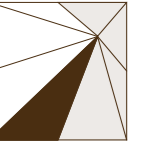
● BRIDGE 2

● BRIDGE 3

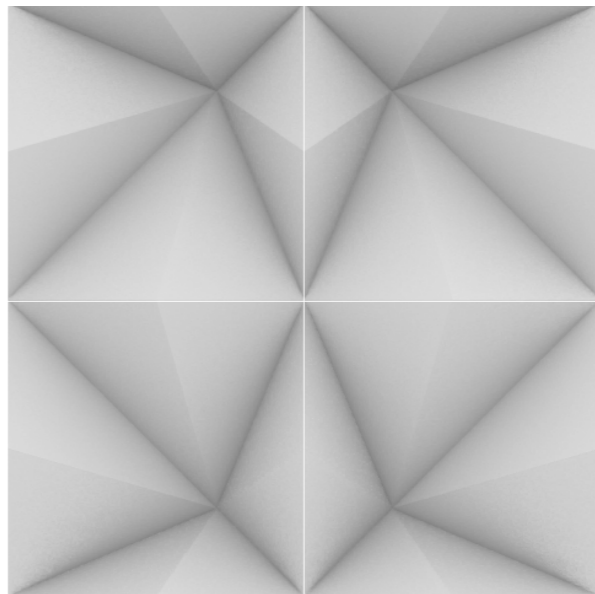
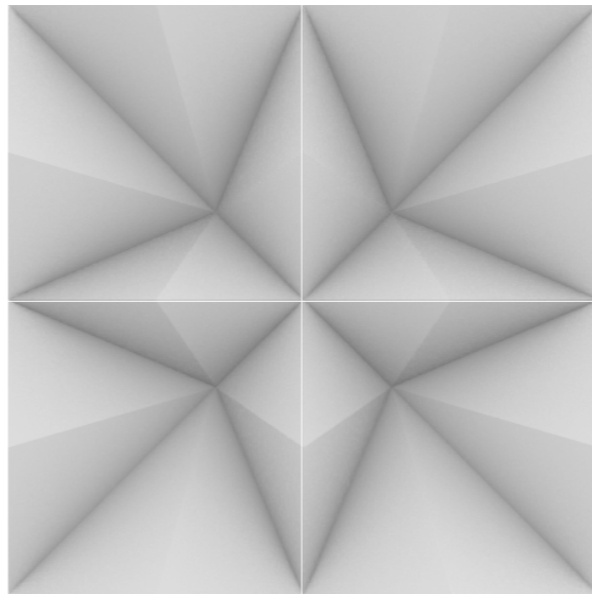
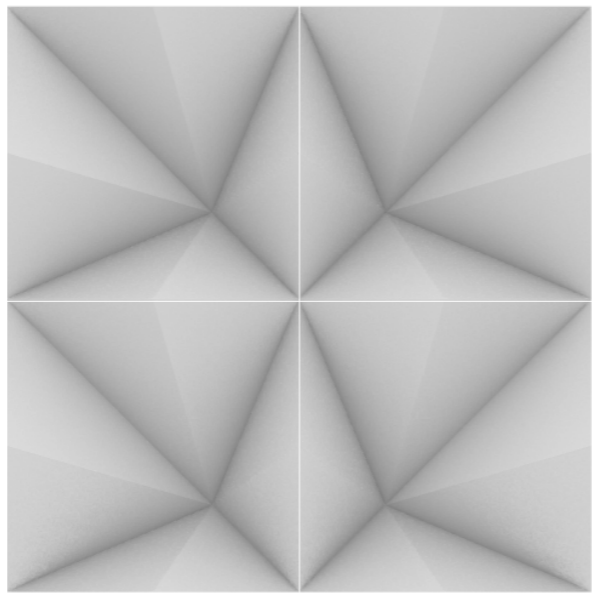
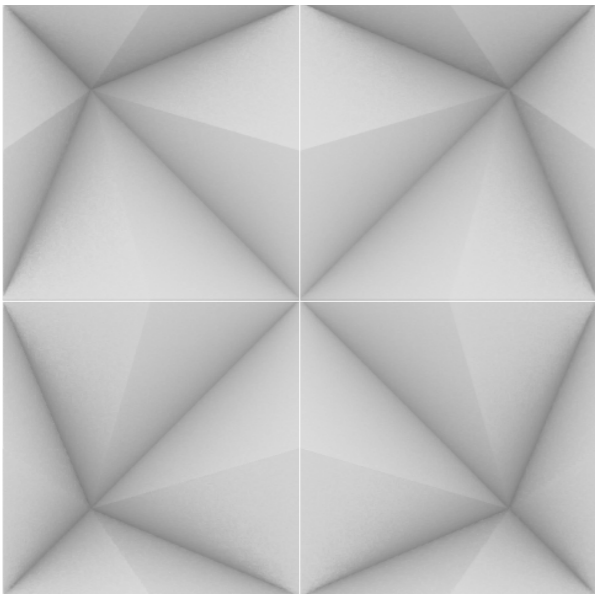
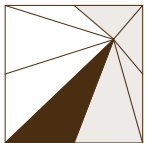
○ FLAT

ONE-PANEL CONFIGURATION

DESIGN CONSTRAINT



ONE-PANEL CONFIGURATION



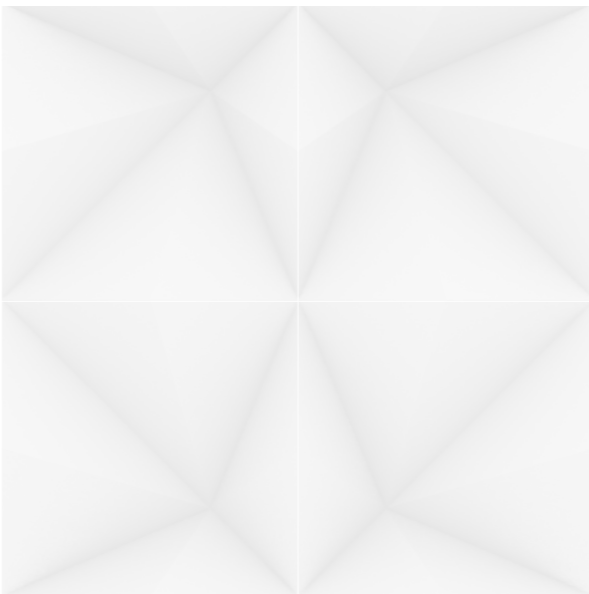
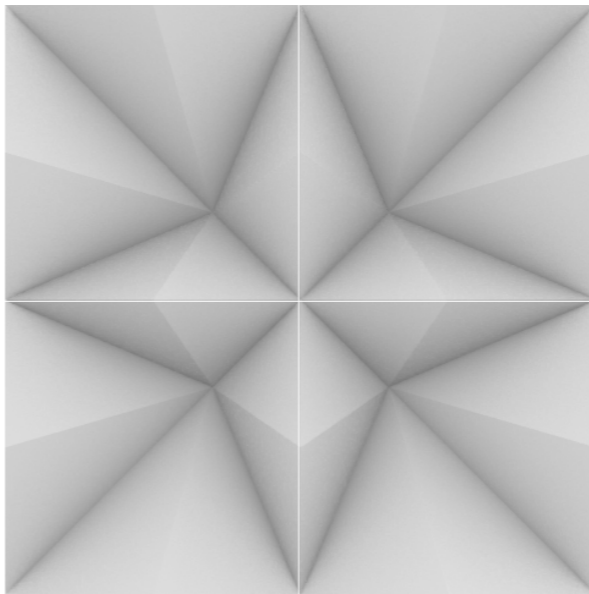
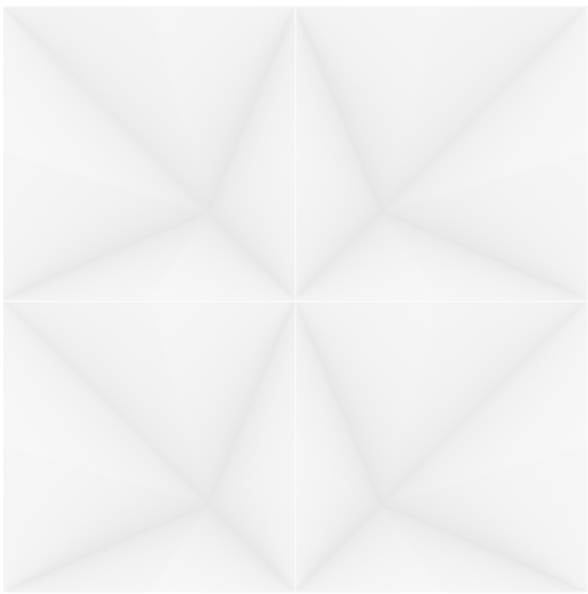
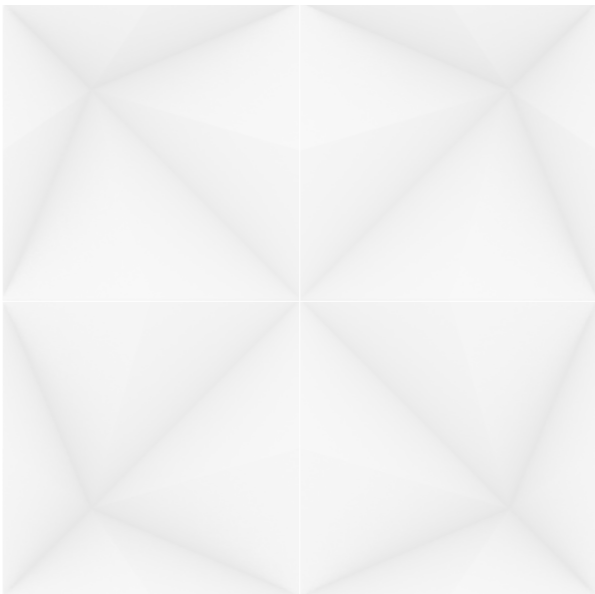
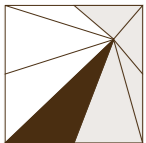
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180	270

270	180
270	180

270	180
0	90

0	90
270	180

ONE-PANEL CONFIGURATION



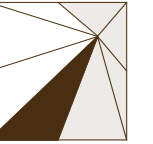
90	0
180	270

270	180
270	180

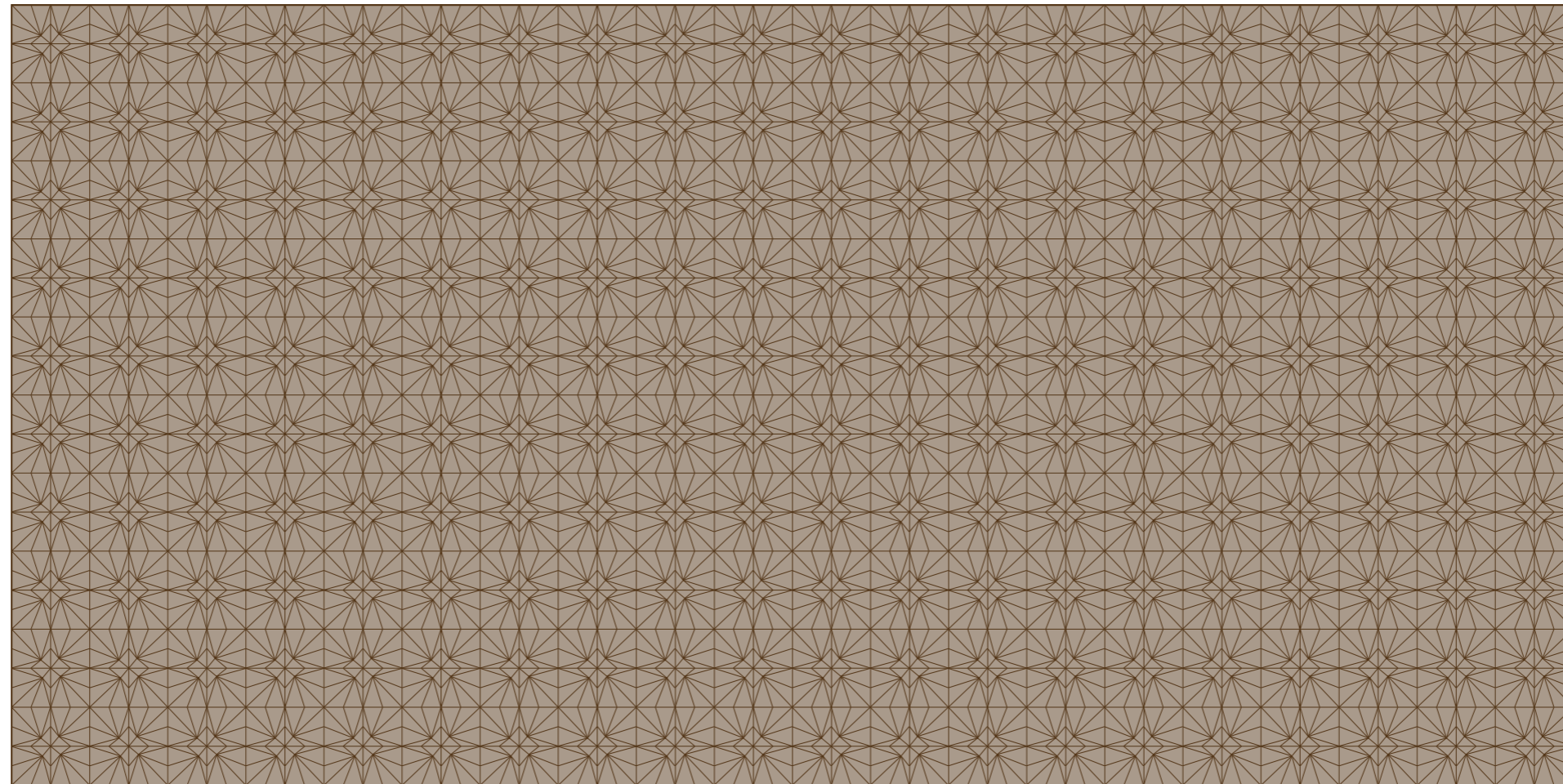
270	180
0	90

0	90
270	180

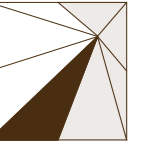
ONE-PANEL CONFIGURATION



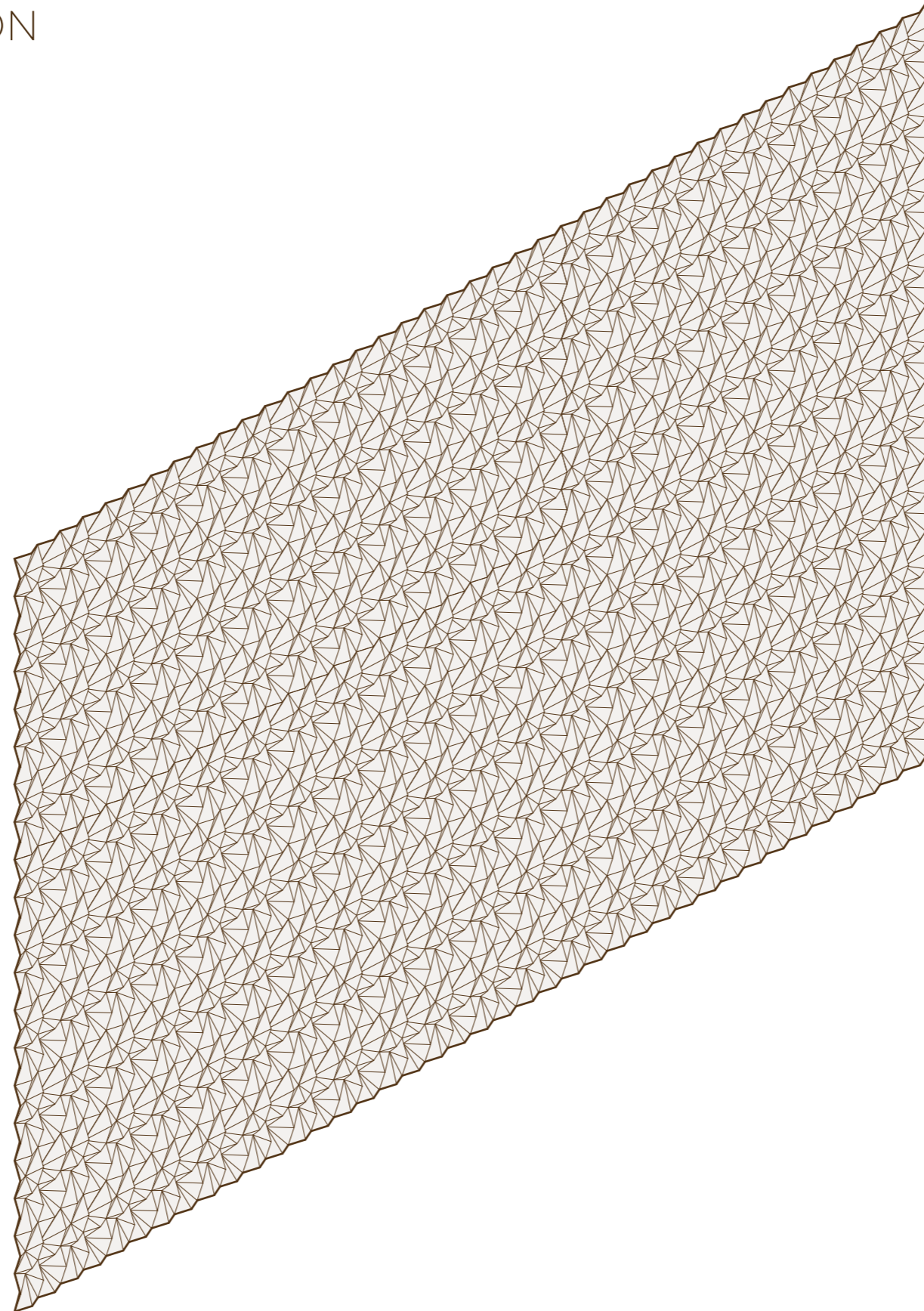
FACADE CONFIGURATION



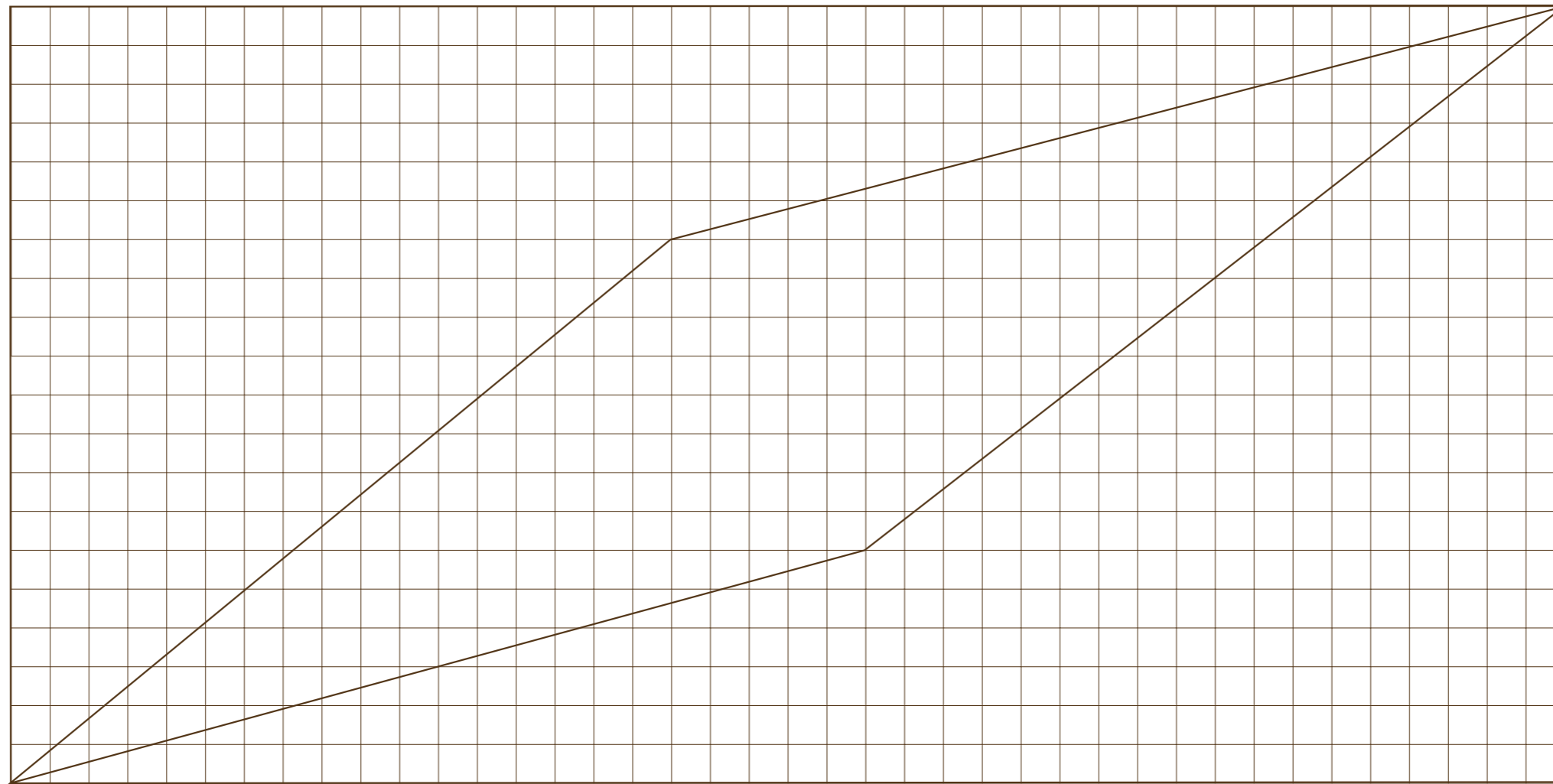
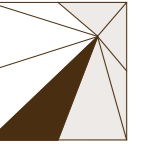
ONE-PANEL CONFIGURATION



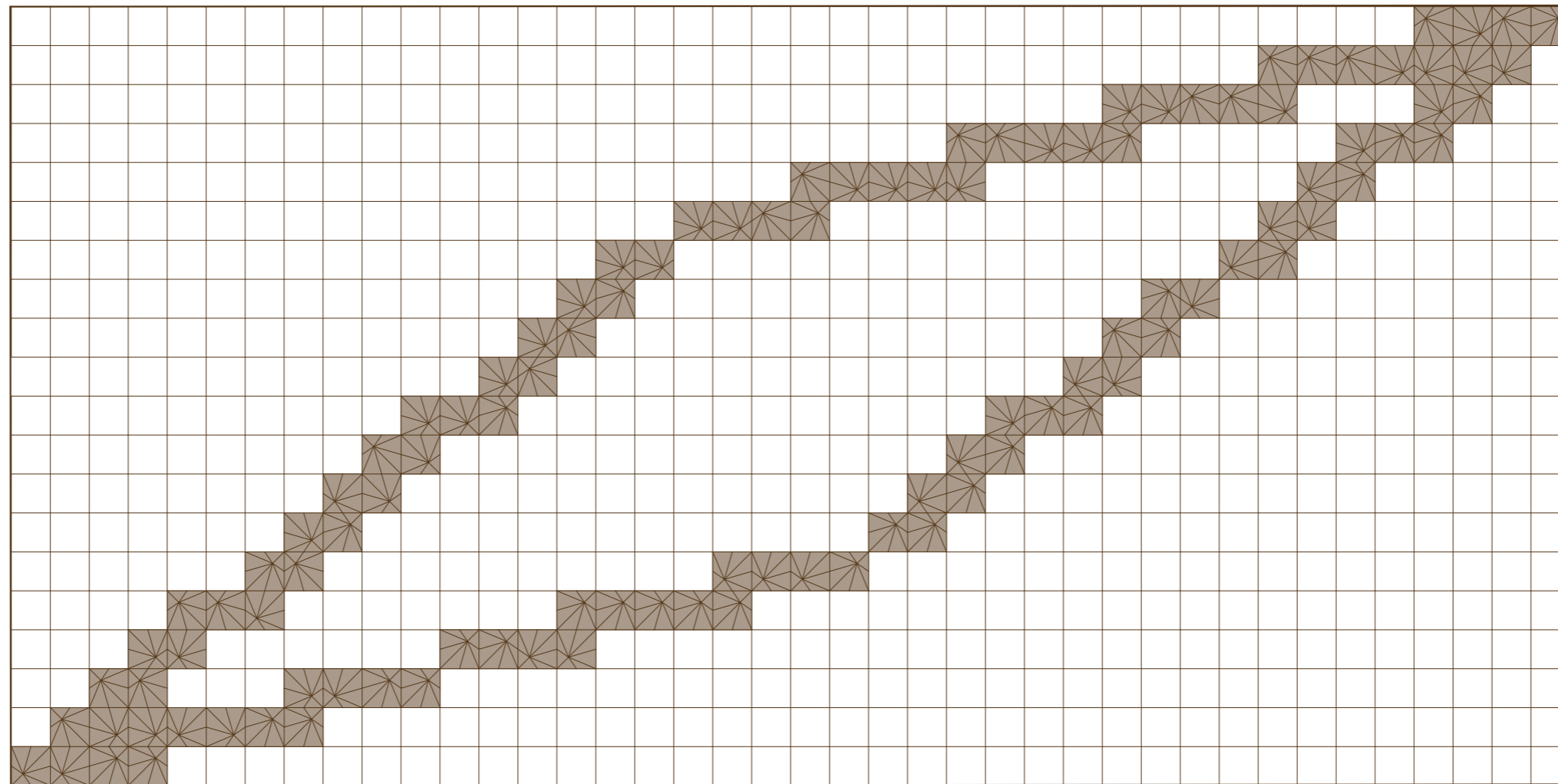
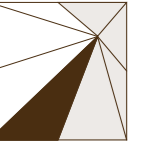
FACADE 3D CONFIGURATION



ALL-PANEL CONFIGURATION 1



ALL-PANEL CONFIGURATION 1



● COMPLEX

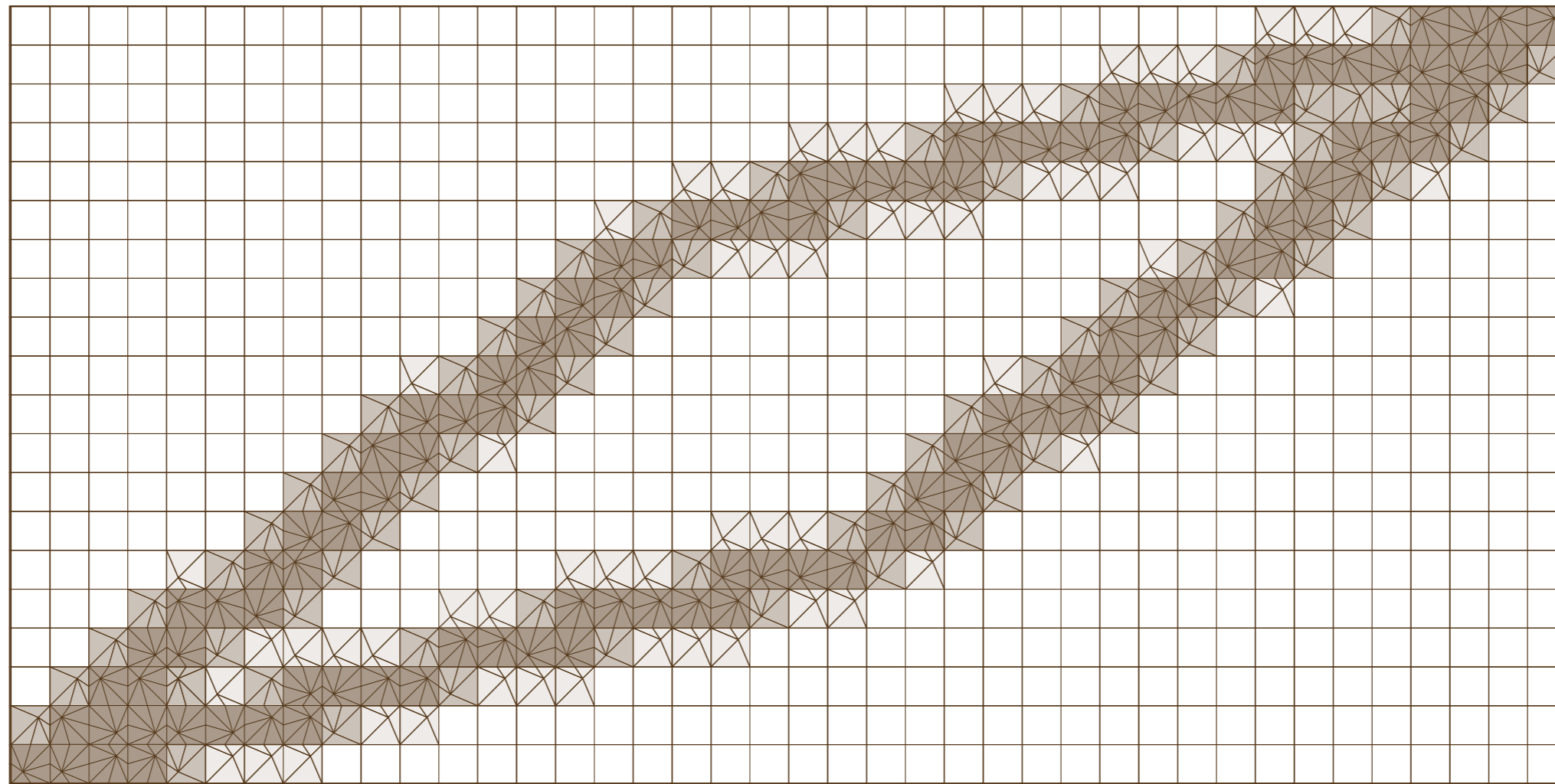
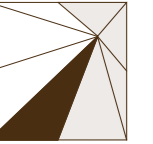
● BRIDGE 1

● BRIDGE 2

● BRIDGE 3

○ FLAT

ALL-PANEL CONFIGURATION 1



● COMPLEX

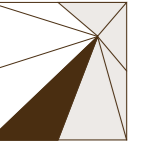
● BRIDGE 1

● BRIDGE 2

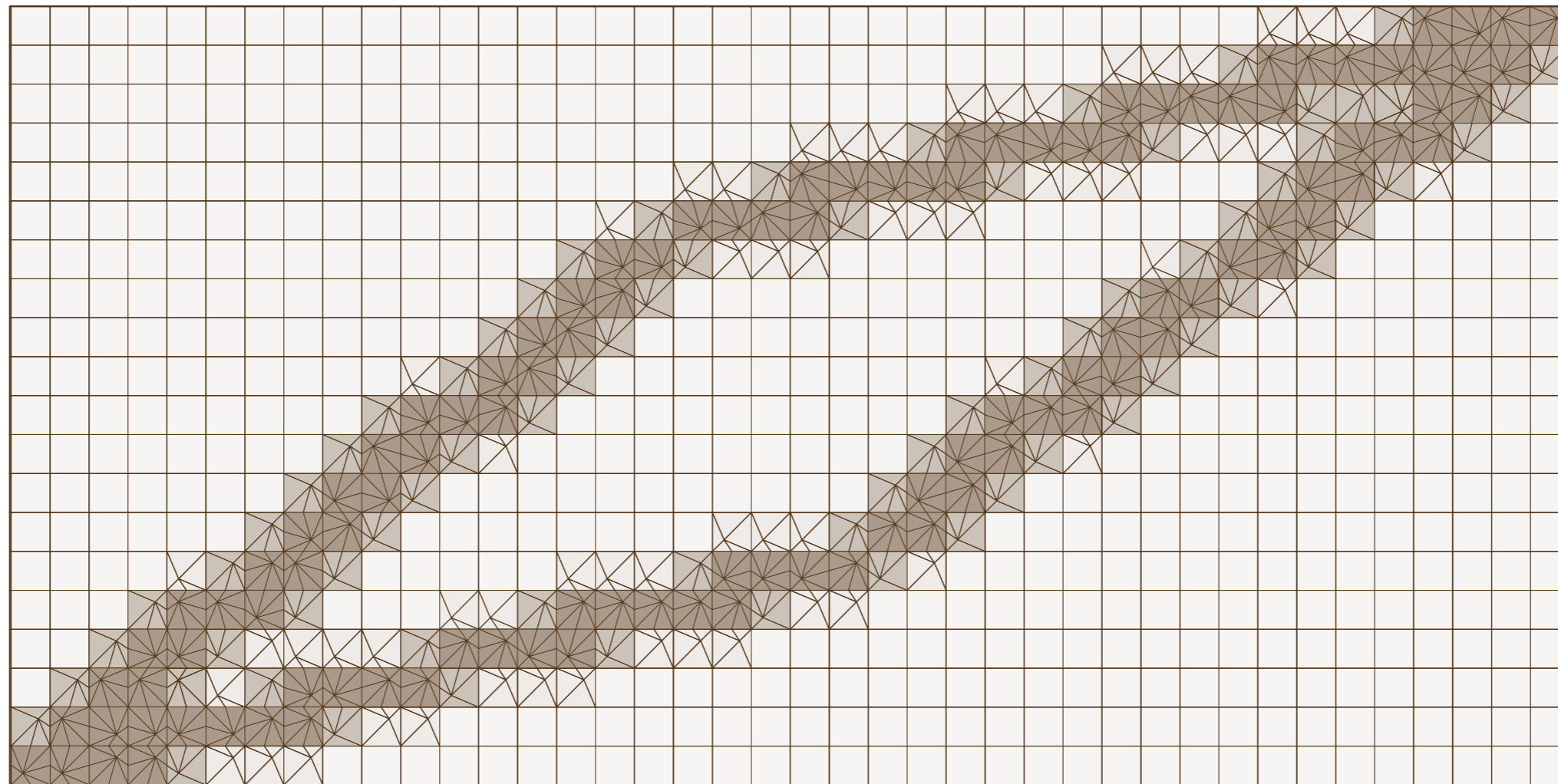
● BRIDGE 3

○ FLAT

ALL-PANEL CONFIGURATION 1



FACADE CONFIGURATION



● COMPLEX

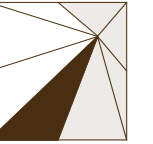
● BRIDGE 1

● BRIDGE 2

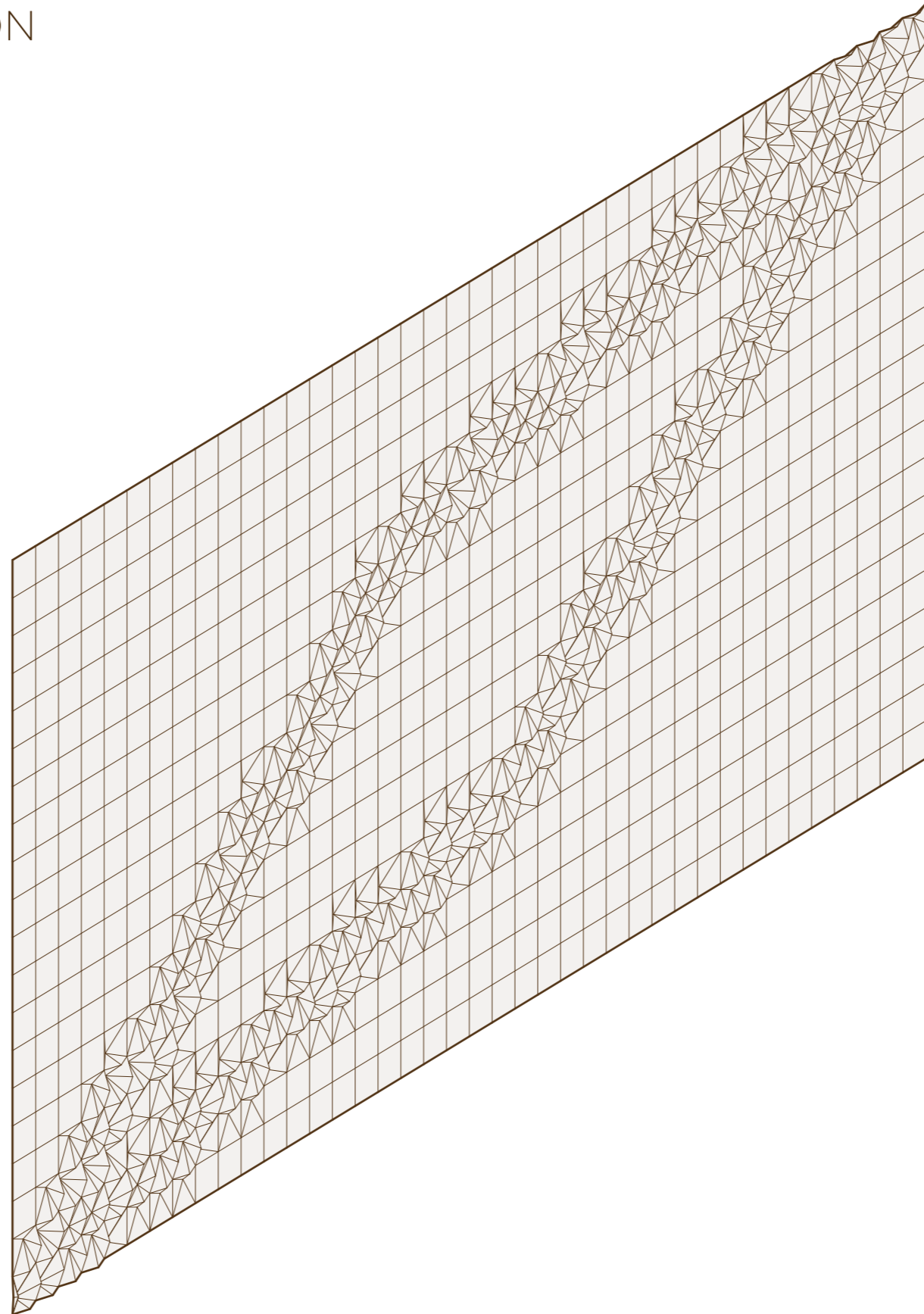
● BRIDGE 3

○ FLAT

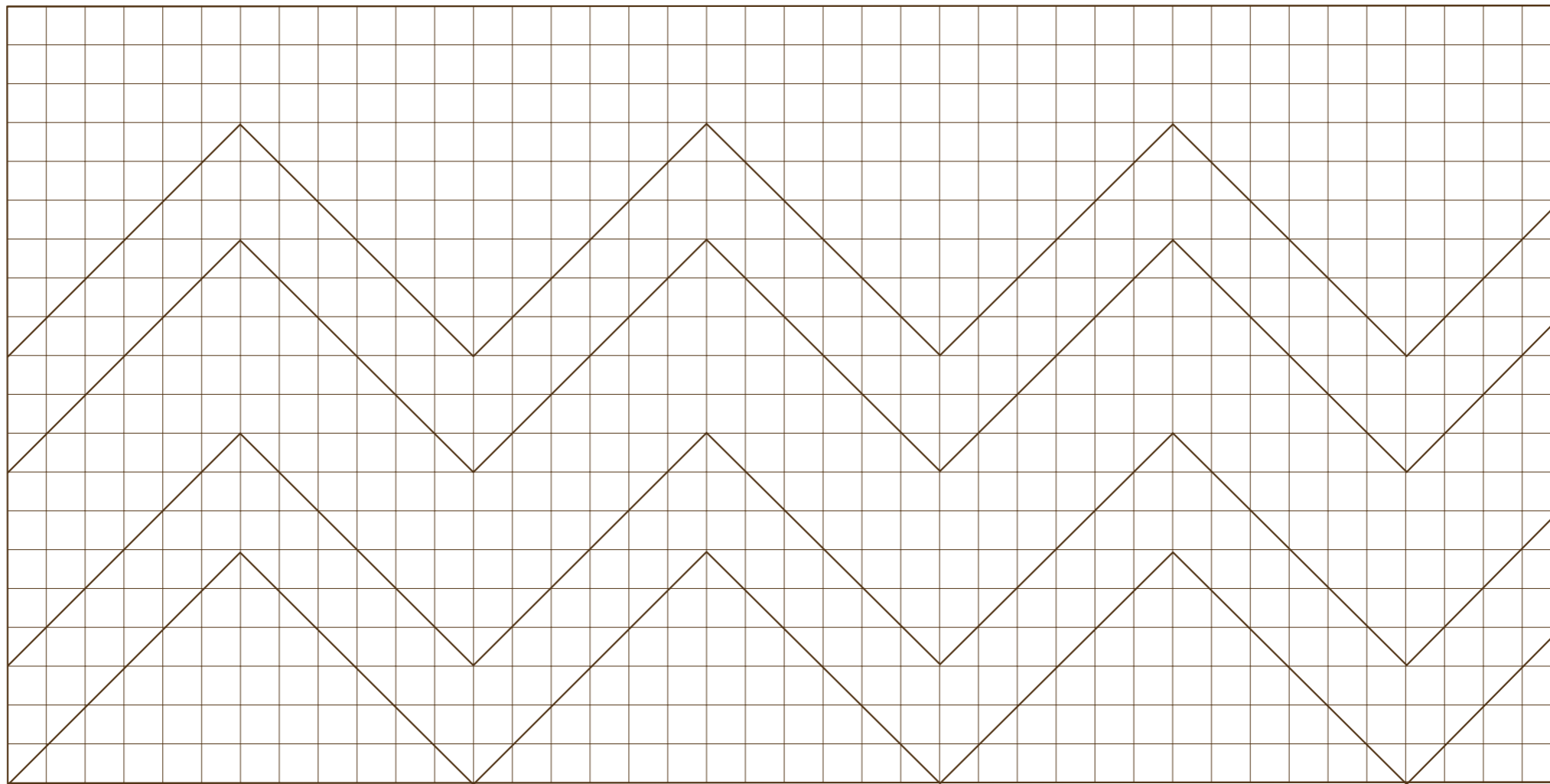
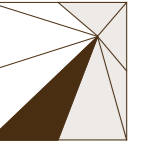
ALL-PANEL CONFIGURATION 1



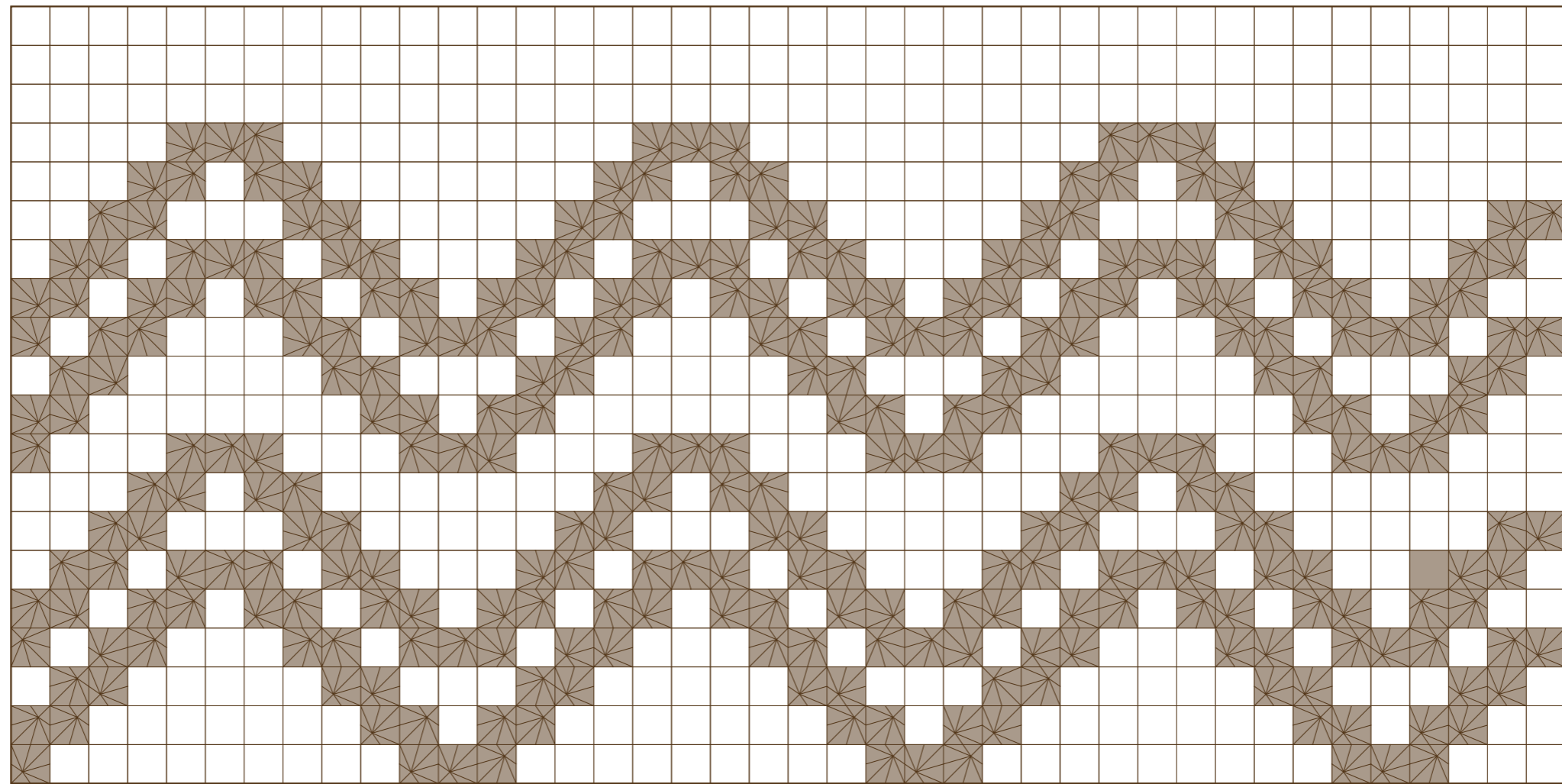
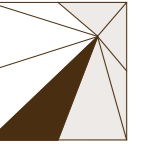
FACADE 3D CONFIGURATION



ALL-PANEL CONFIGURATION 2



ALL-PANEL CONFIGURATION 2



● COMPLEX

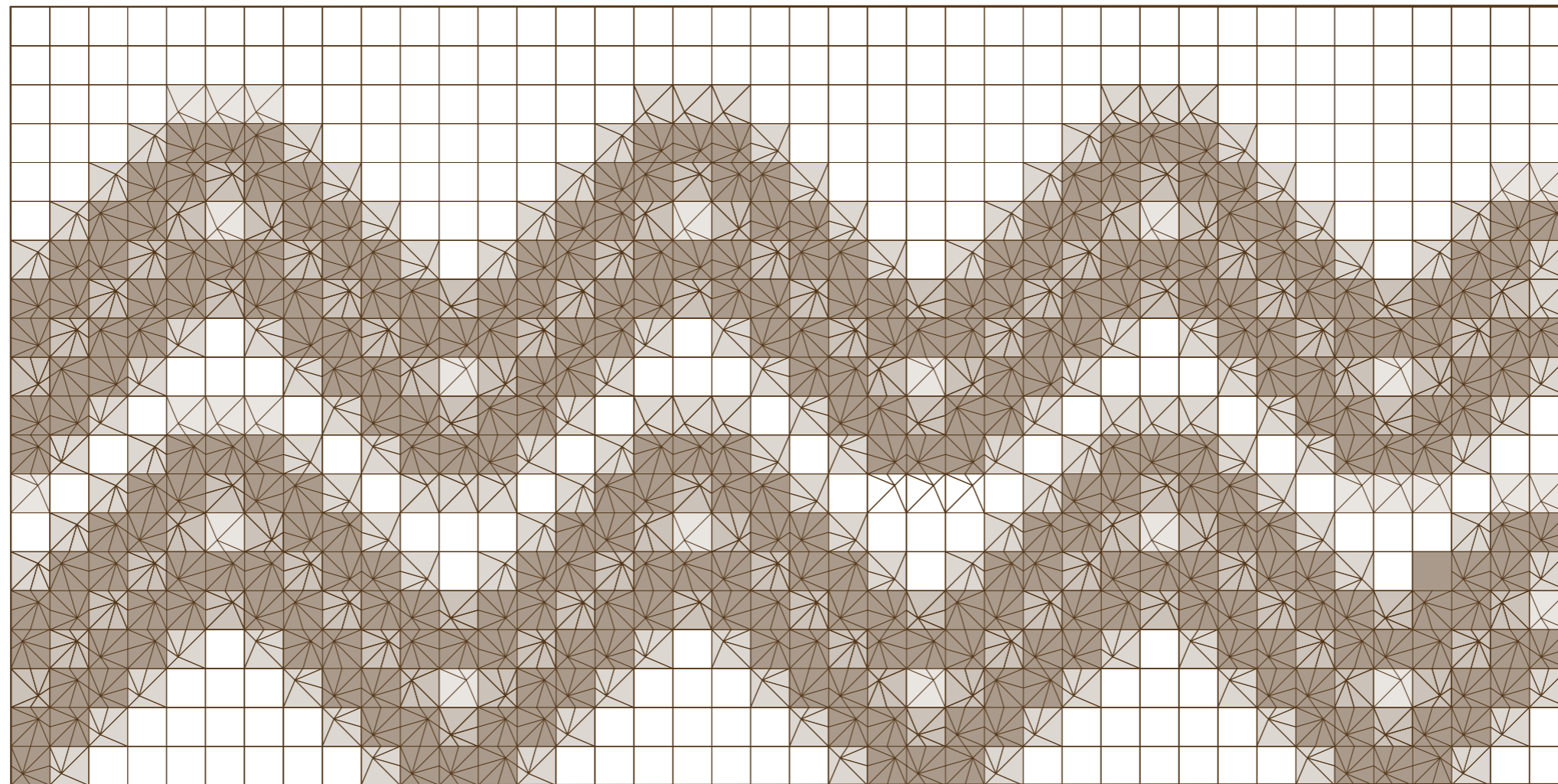
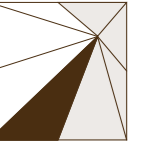
● BRIDGE 1

● BRIDGE 2

● BRIDGE 3

○ FLAT

ALL-PANEL CONFIGURATION 2



● COMPLEX

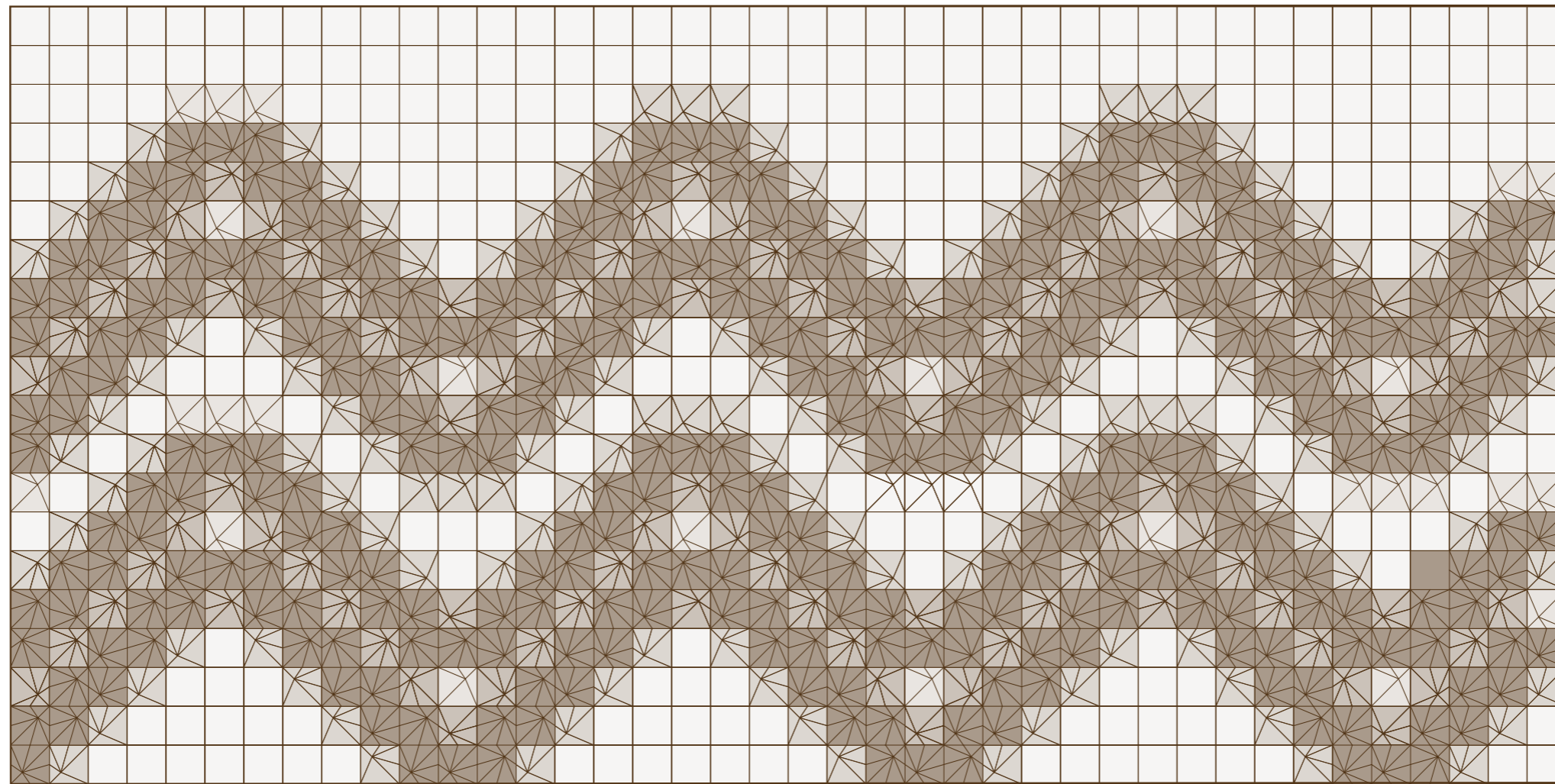
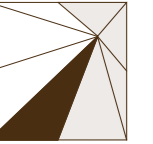
● BRIDGE 1

● BRIDGE 2

● BRIDGE 3

○ FLAT

ALL-PANEL CONFIGURATION 2



● COMPLEX

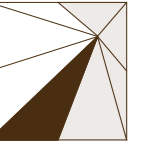
● BRIDGE 1

● BRIDGE 2

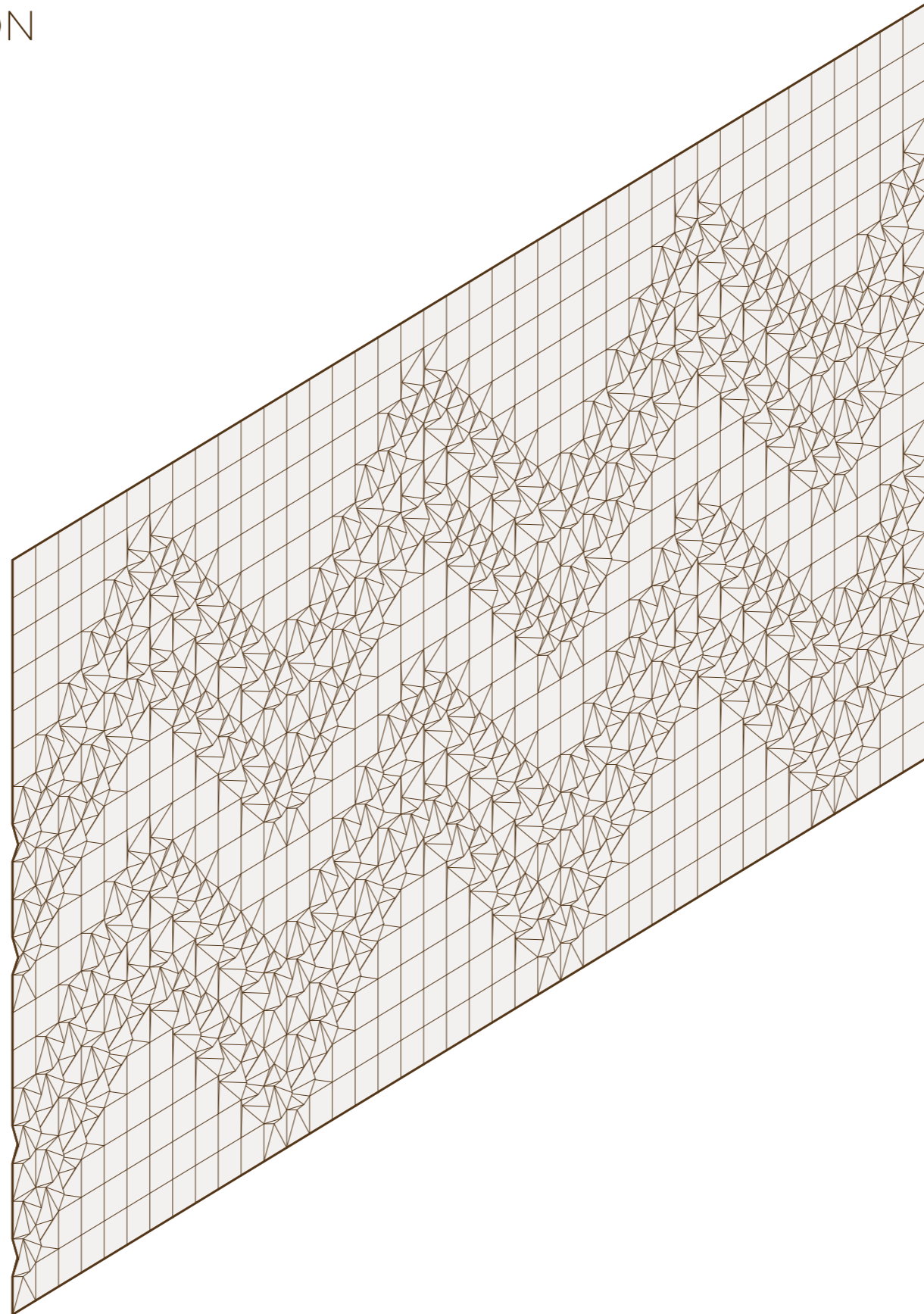
● BRIDGE 3

○ FLAT

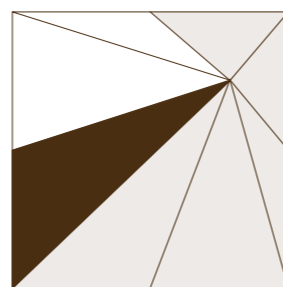
ALL-PANEL CONFIGURATION 2



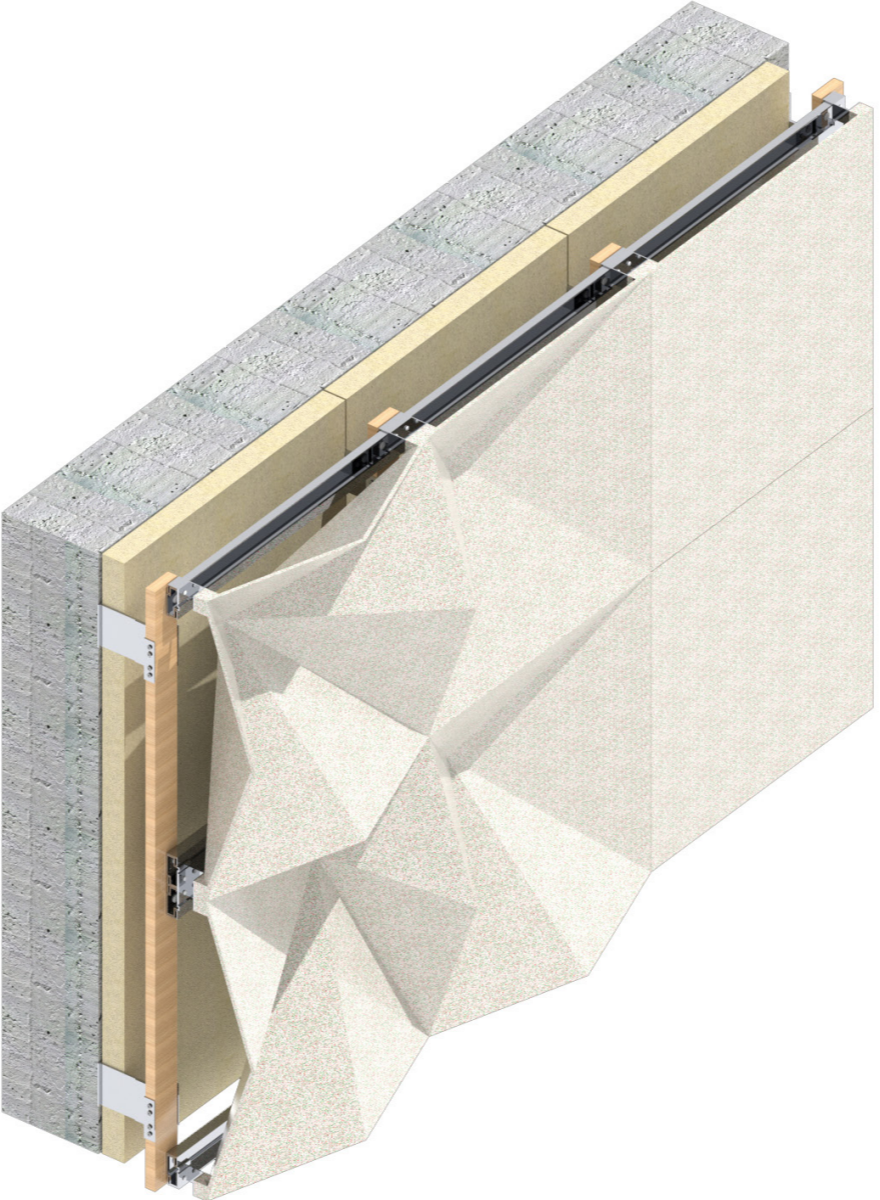
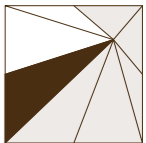
FACADE 3D CONFIGURATION



FINAL DESIGN



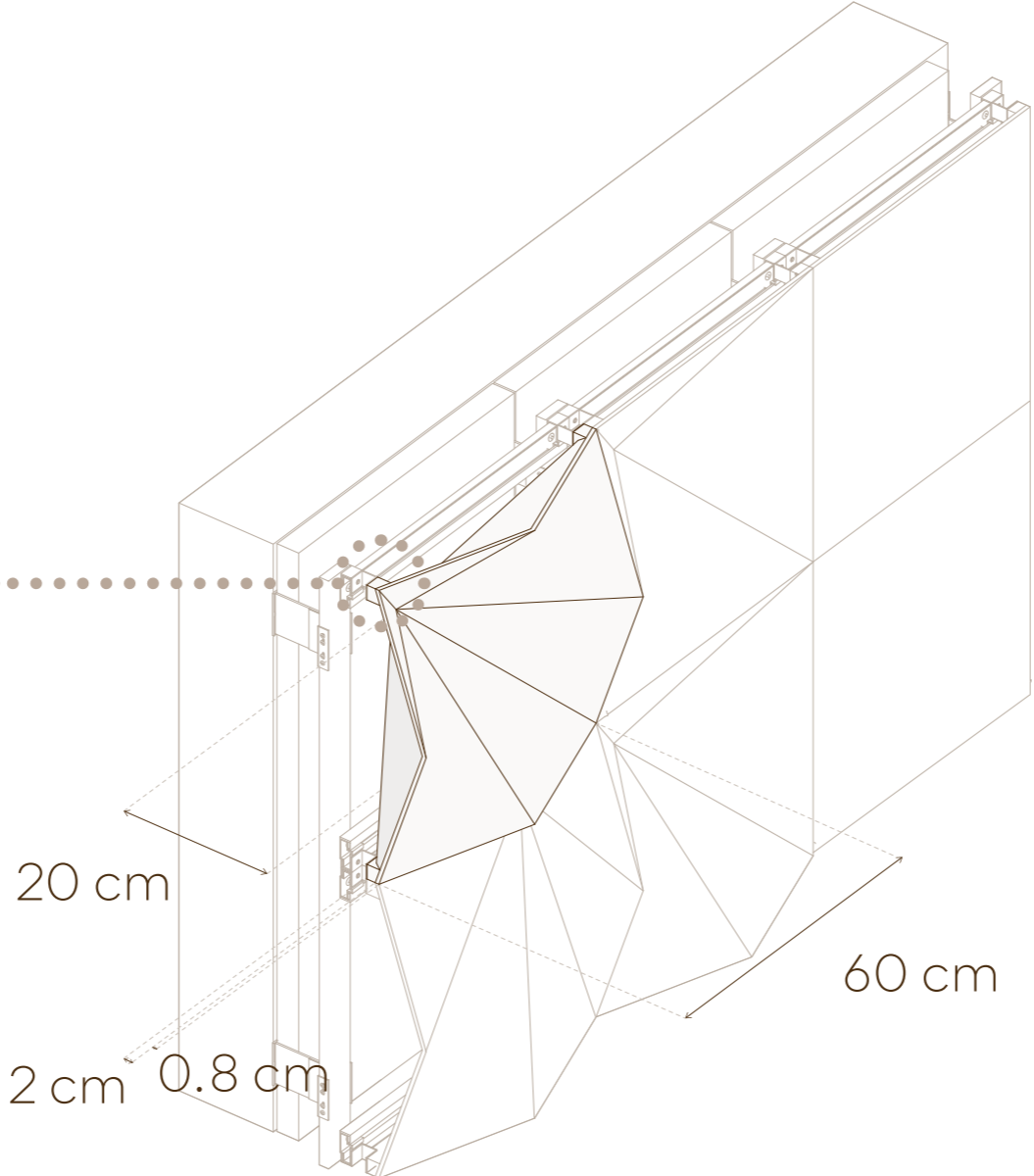
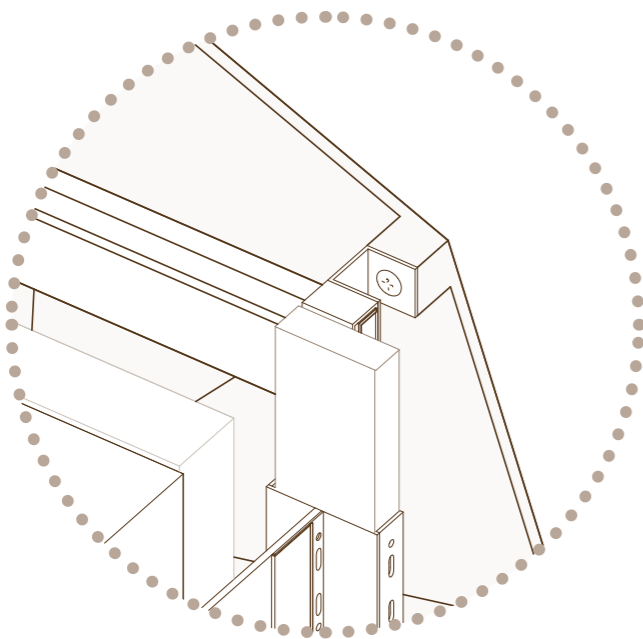
SIX-PANEL CONFIGURATION



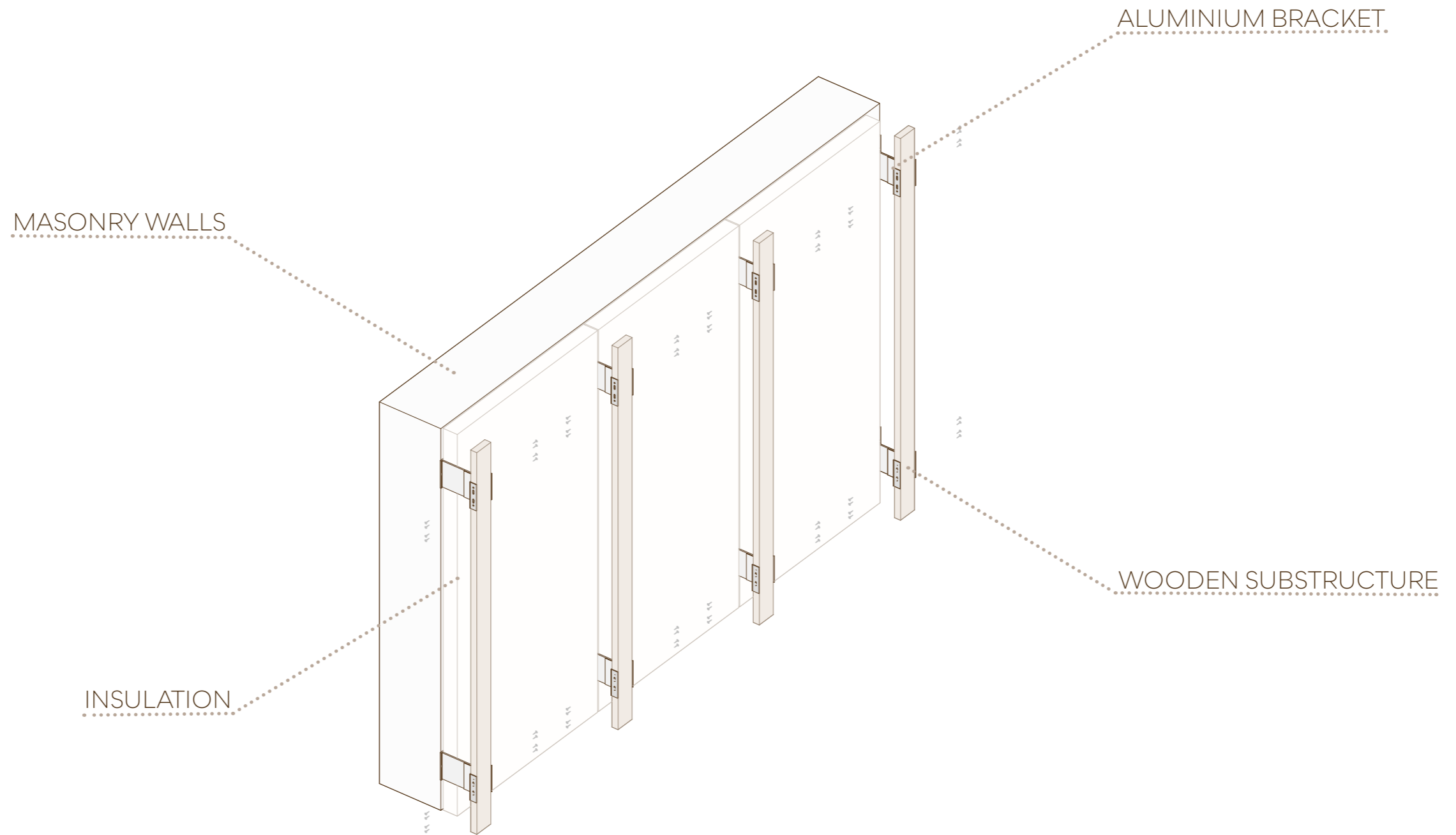
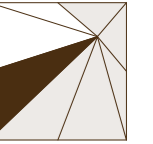
DESIGN DIMENSIONS



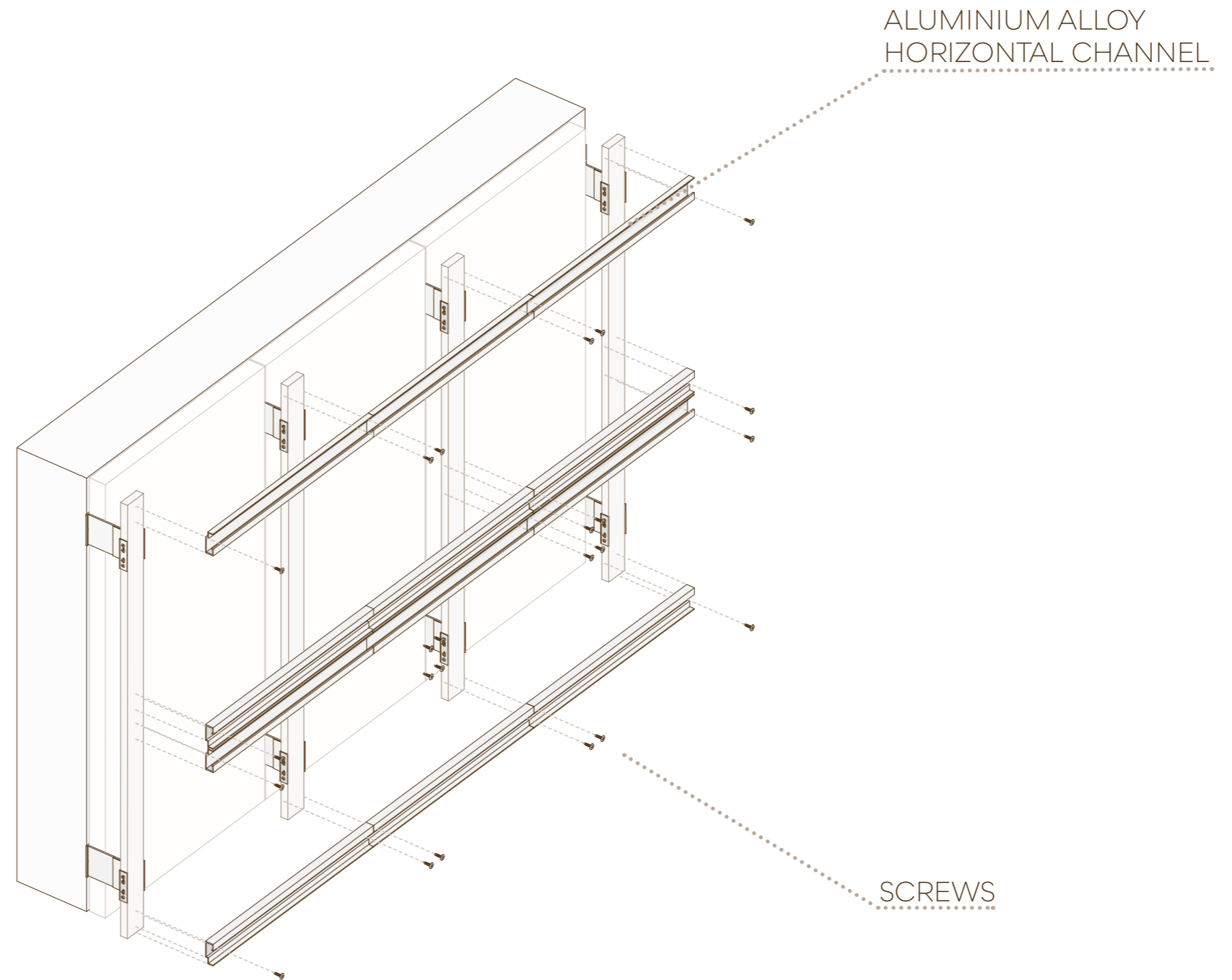
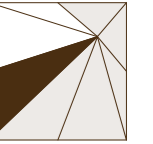
SQUARED MOLDED ELEMENT



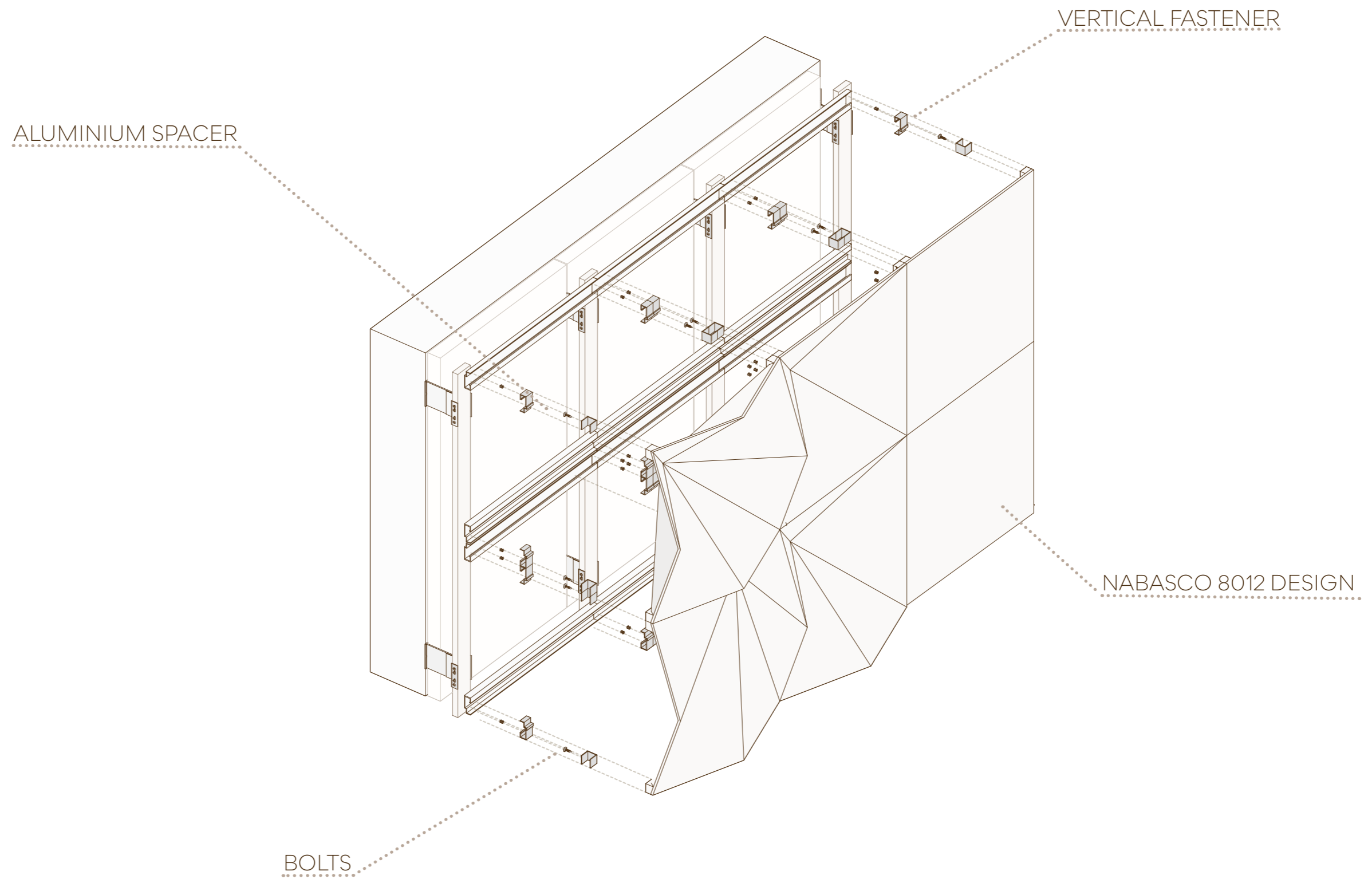
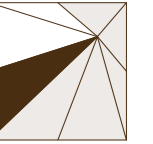
ASSEMBLY



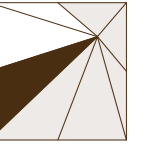
ASSEMBLY



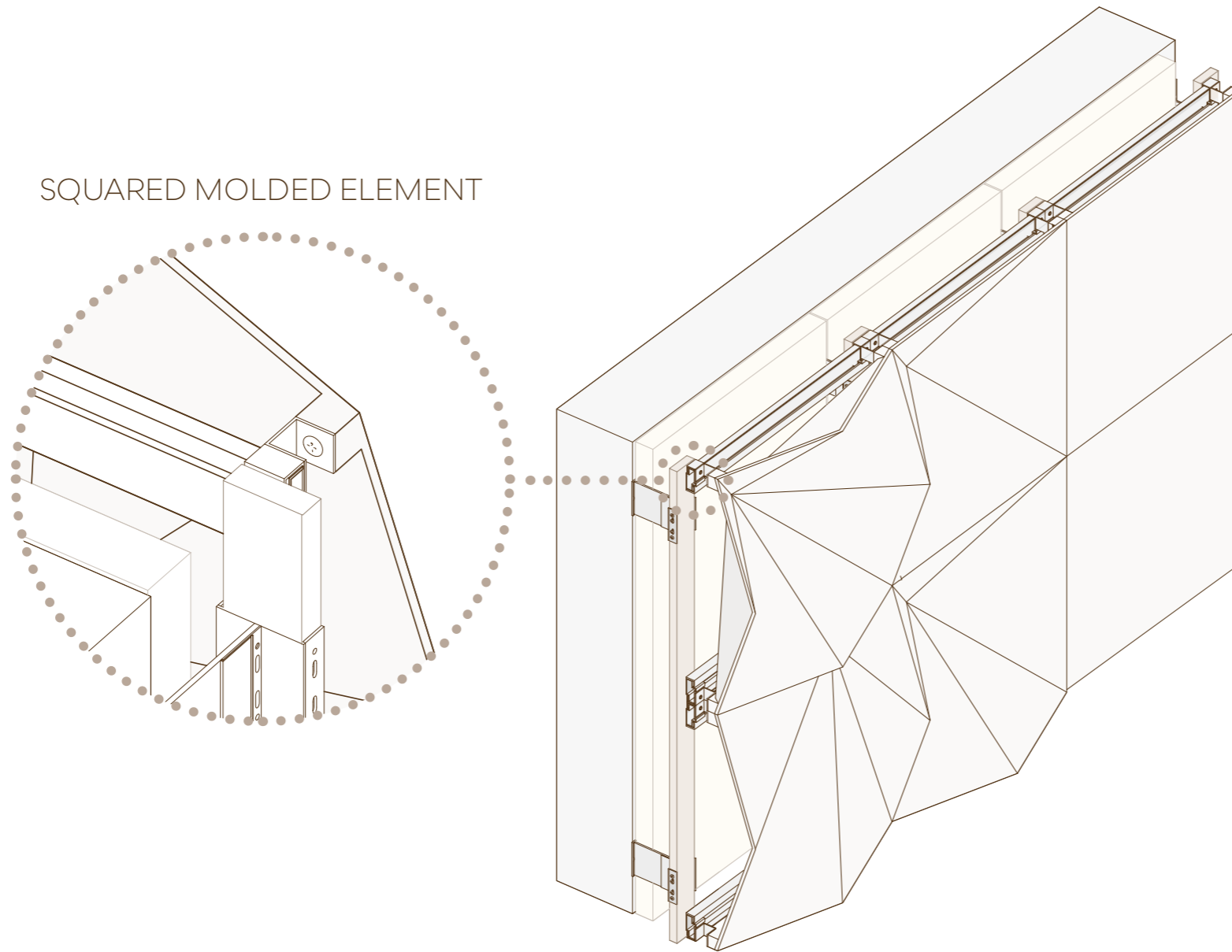
ASSEMBLY



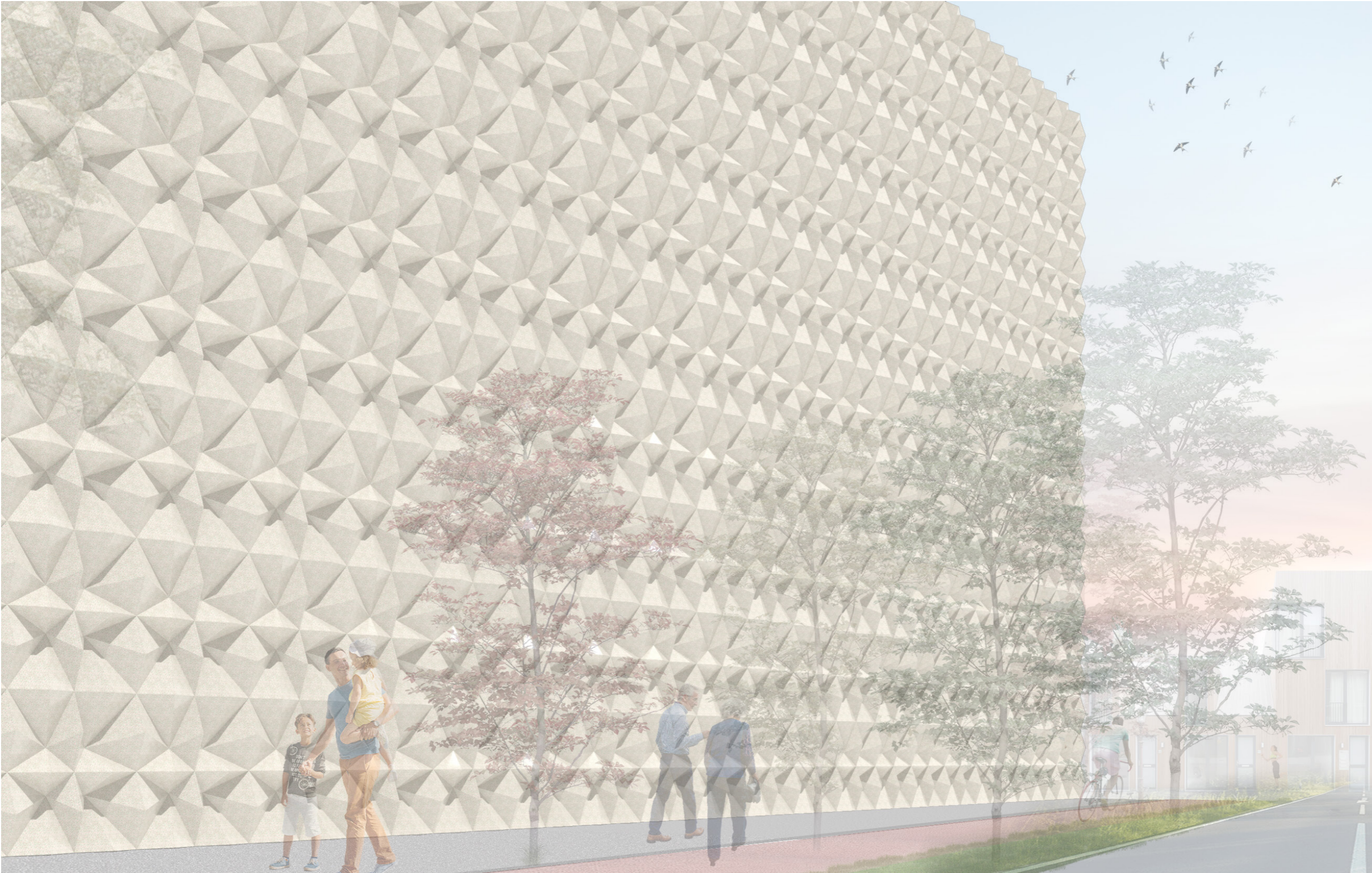
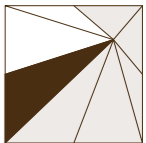
ASSEMBLY



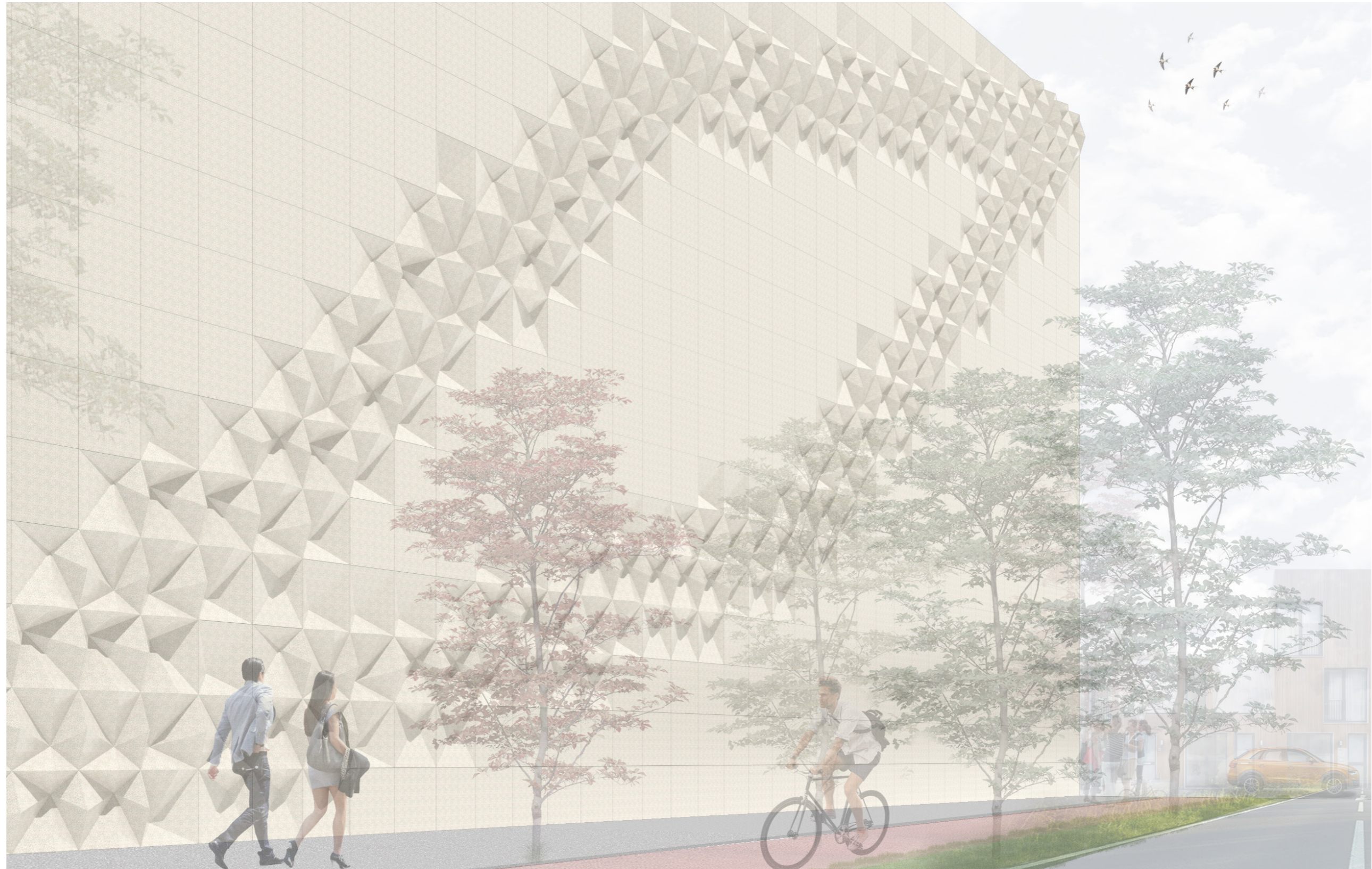
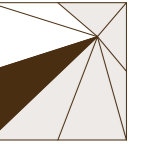
SQUARED MOLDED ELEMENT



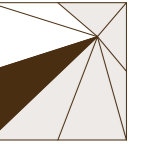
ONE-PANEL CONFIGURATION



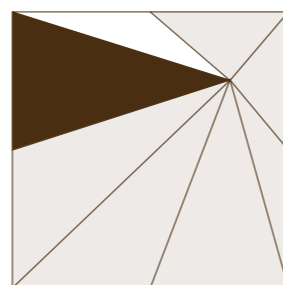
ALL-PANEL CONFIGURATION 1



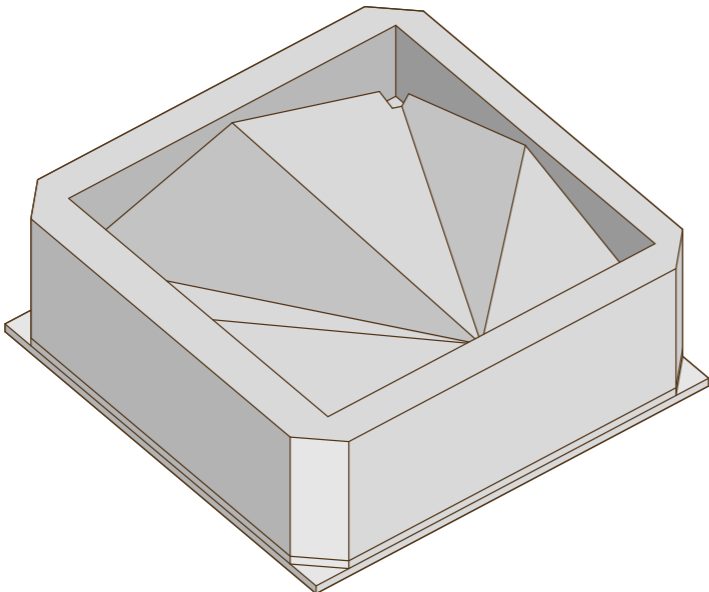
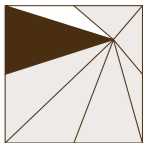
ALL-PANEL CONFIGURATION 2



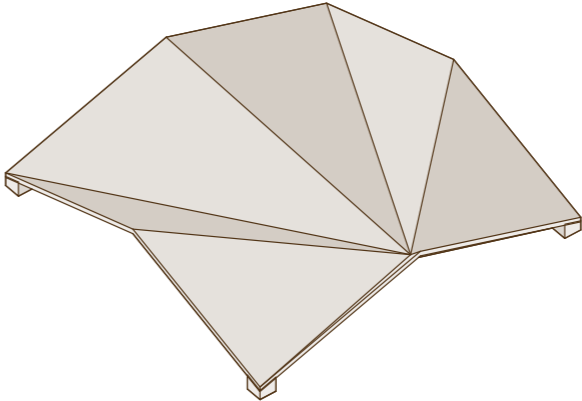
PROTOTYPING



PROTOTYPE

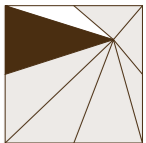


MOULD
REALIZATION



PANEL
REALIZATION

MOULD PROTOTYPE



WORKFLOW



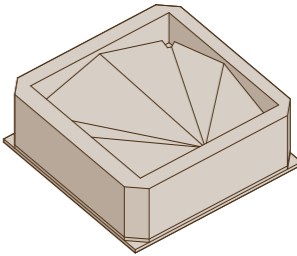
DIGITAL
MODELING



CNC
PROGRAMMING

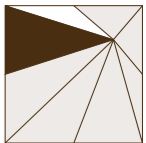


MACHINING

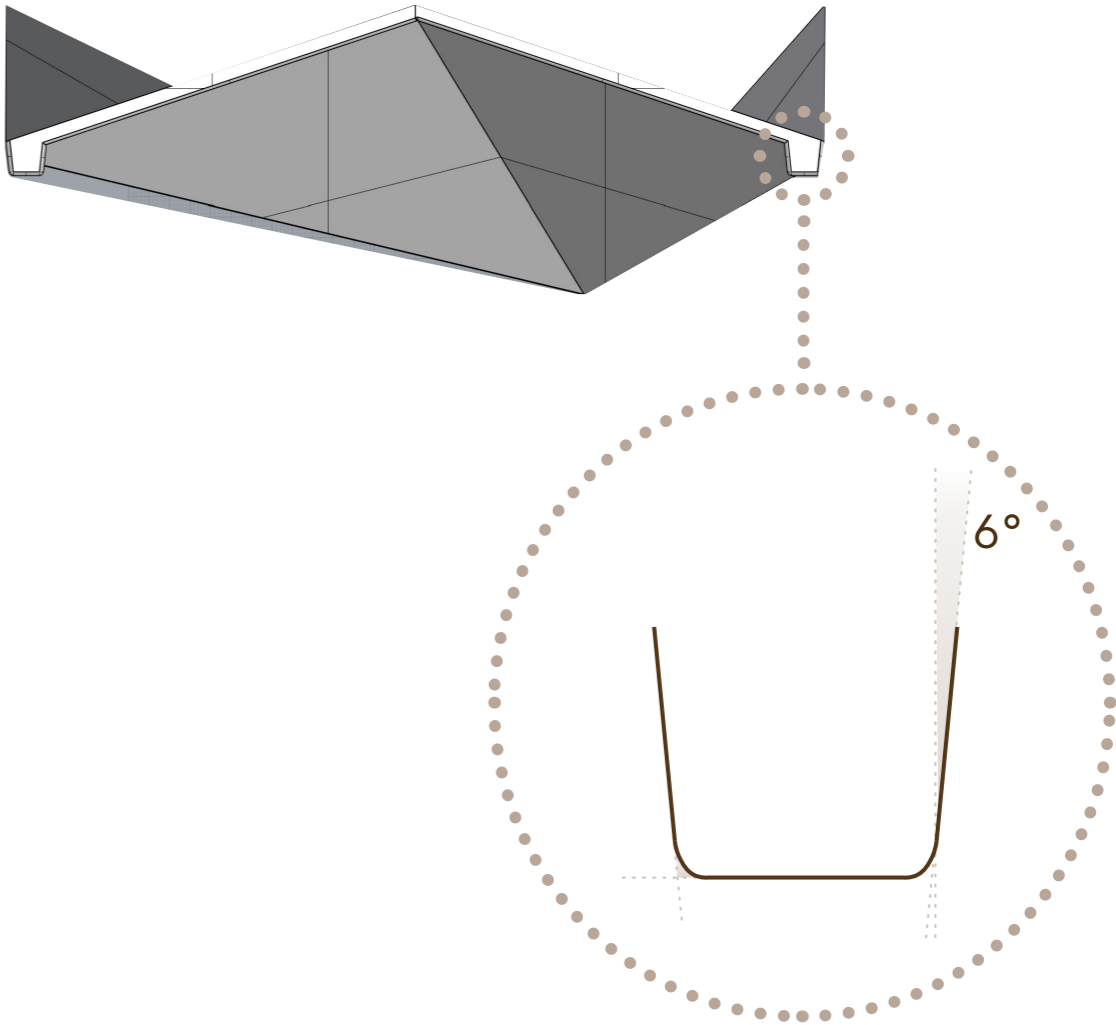
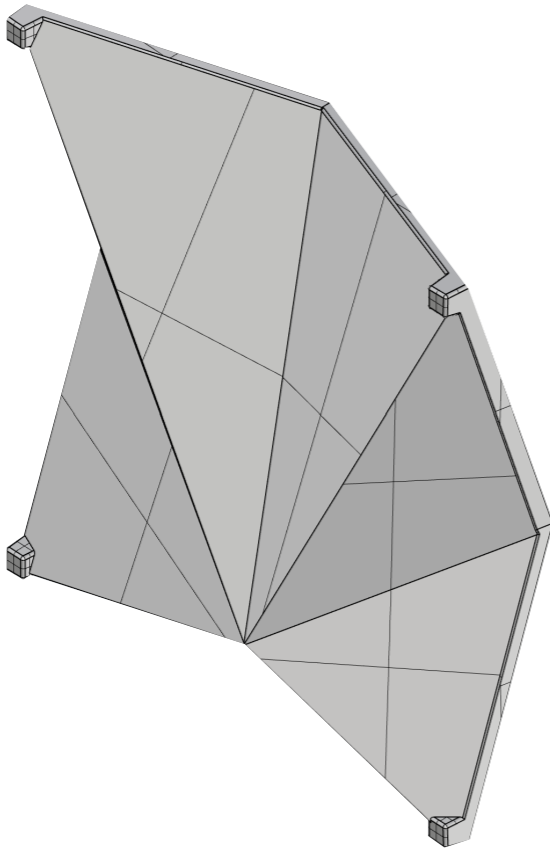


FINAL
MOULD

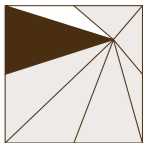
MOULD PROTOTYPE MODELING



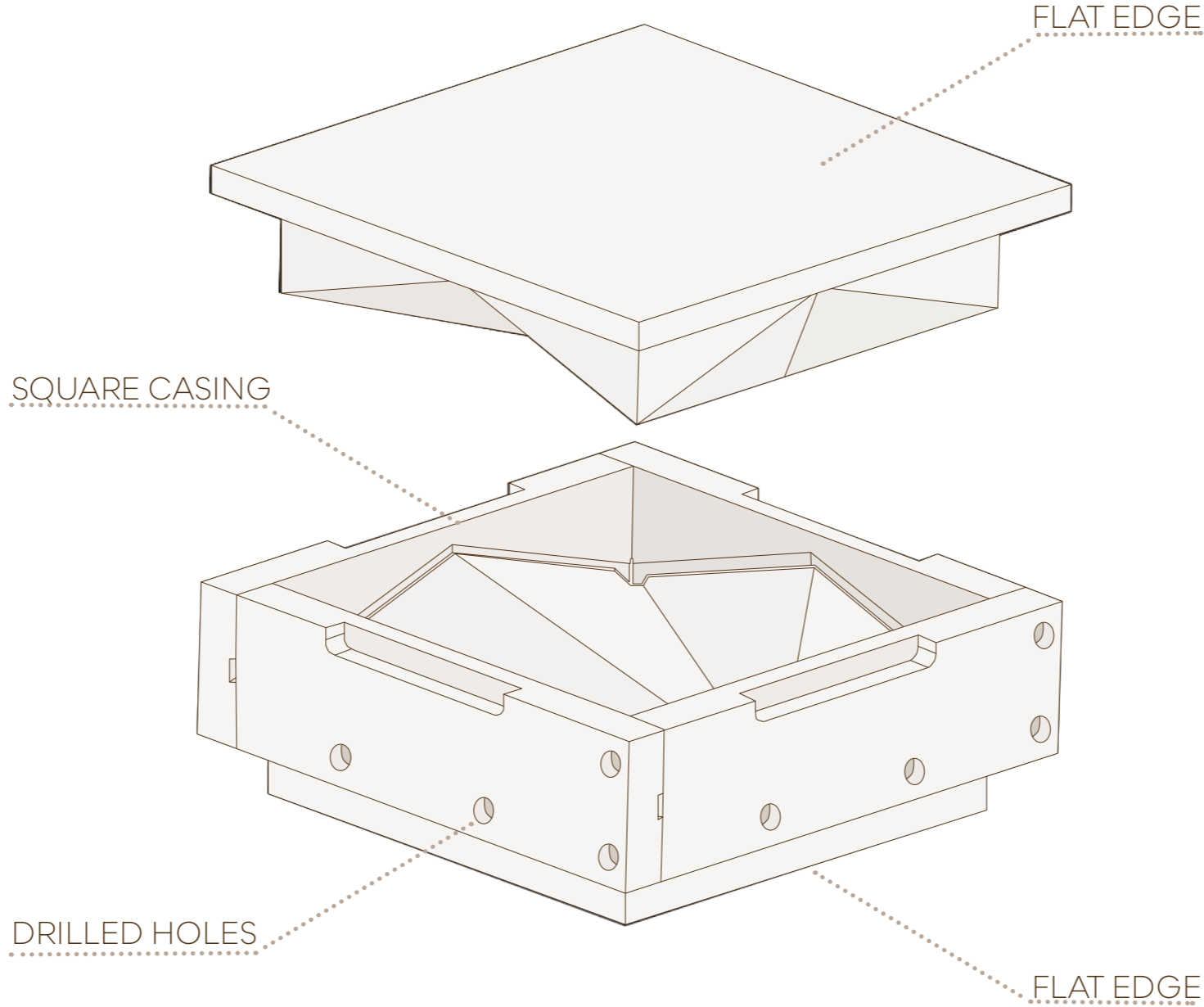
DESIGN CONSTRAINTS



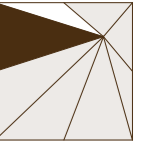
MOULD PROTOTYPE MODELING



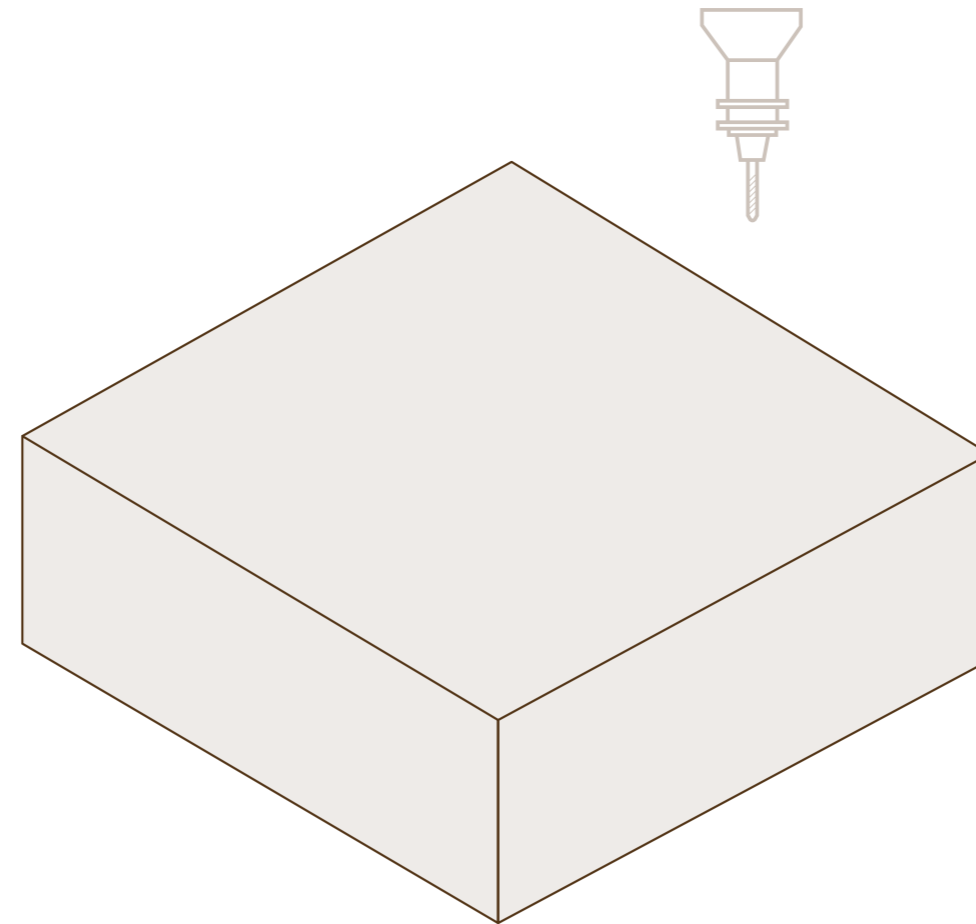
MOULD DESIGN



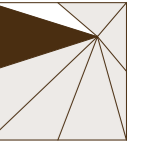
MOULD PROTOTYPE PROGRAMMING



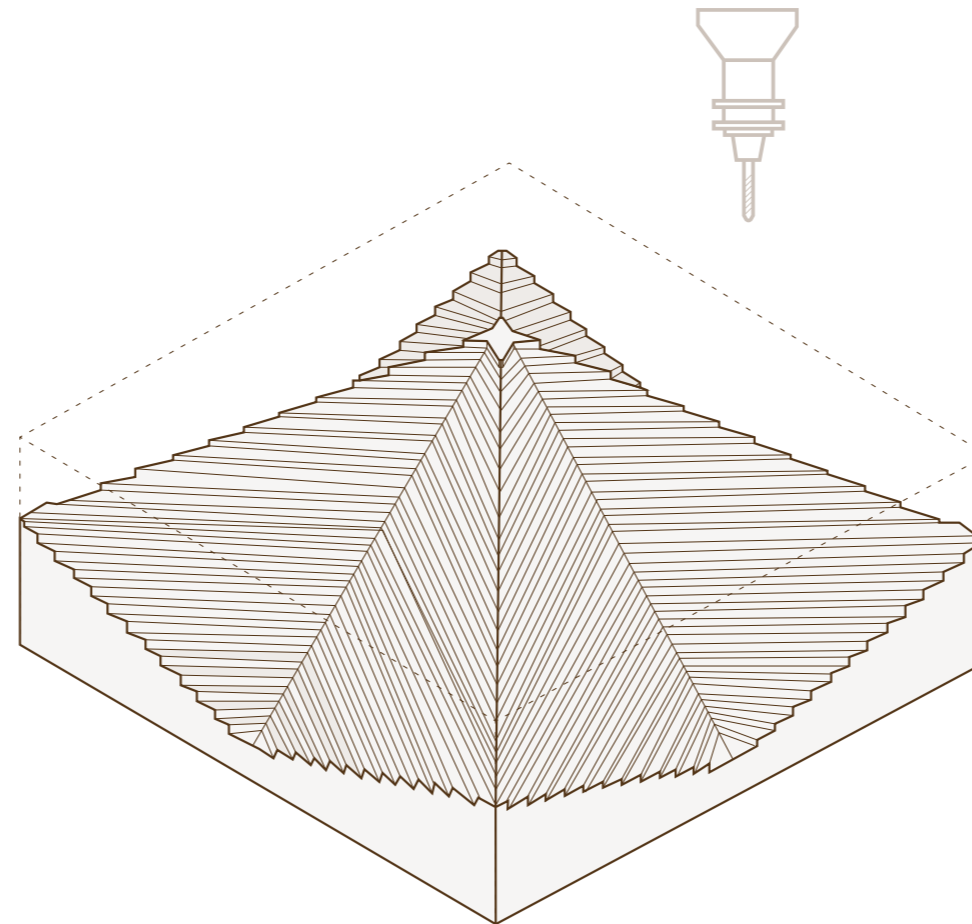
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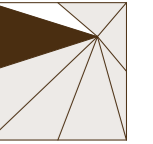
MOULD PROTOTYPE PROGRAMMING



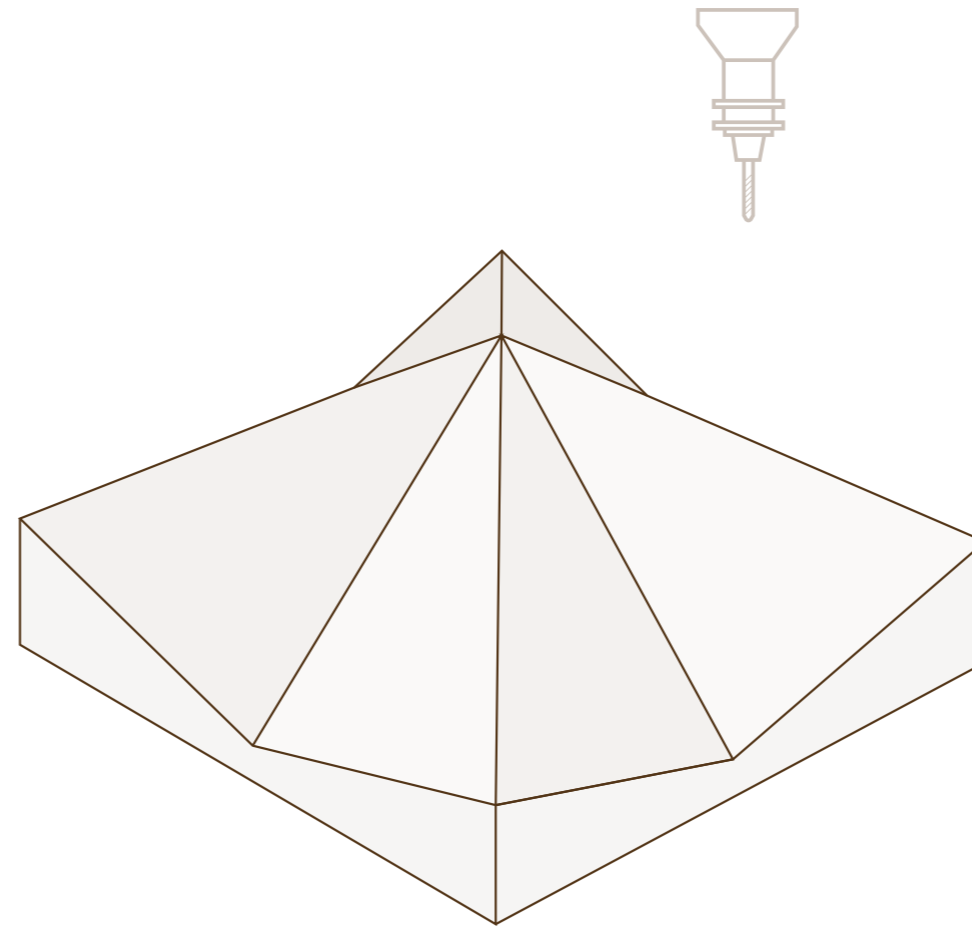
CNC PROGRAMMING - ROUGHING



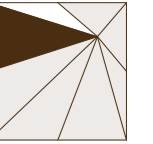
MOULD PROTOTYPE PROGRAMMING



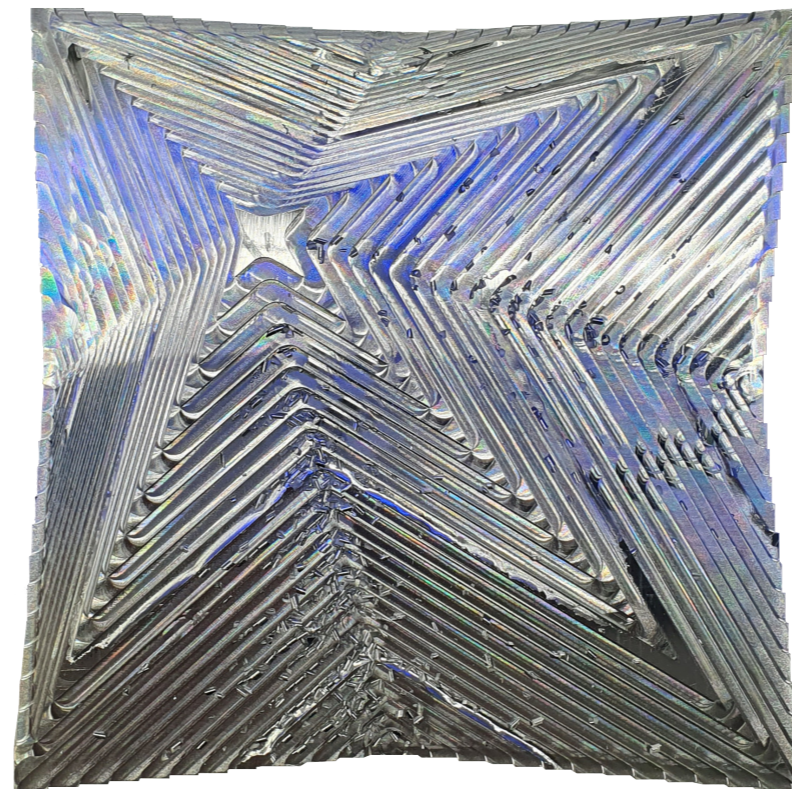
CNC PROGRAMMING - FINISHING



MOULD PROTOTYPE MACHINING

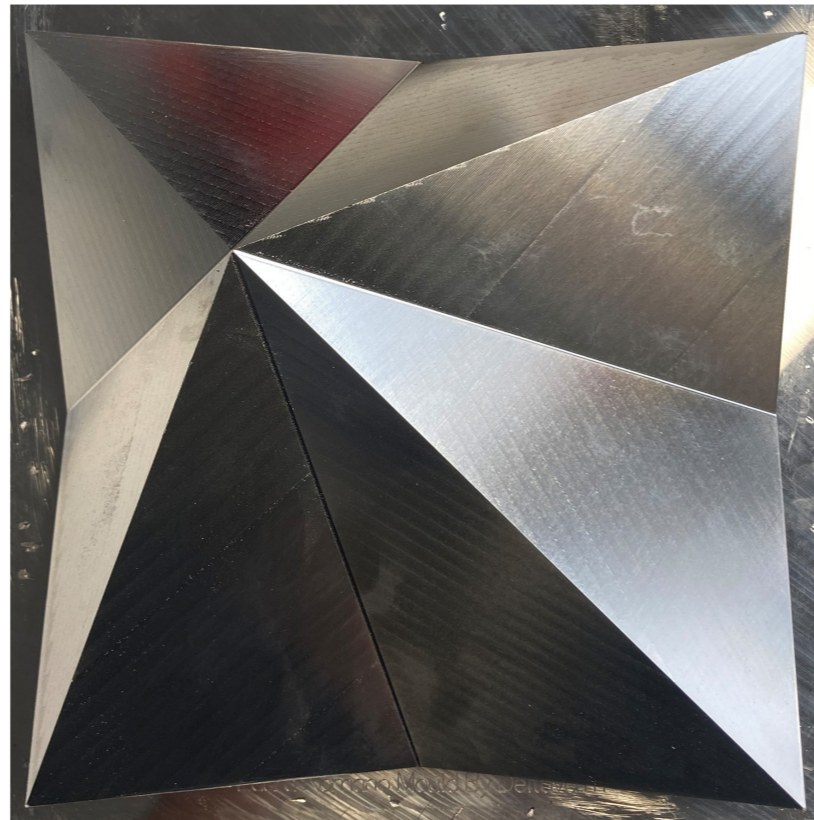
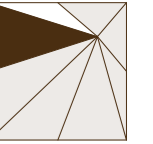


ROUGHING

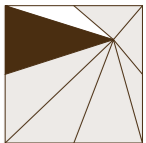


MOULD PROTOTYPE MACHINING

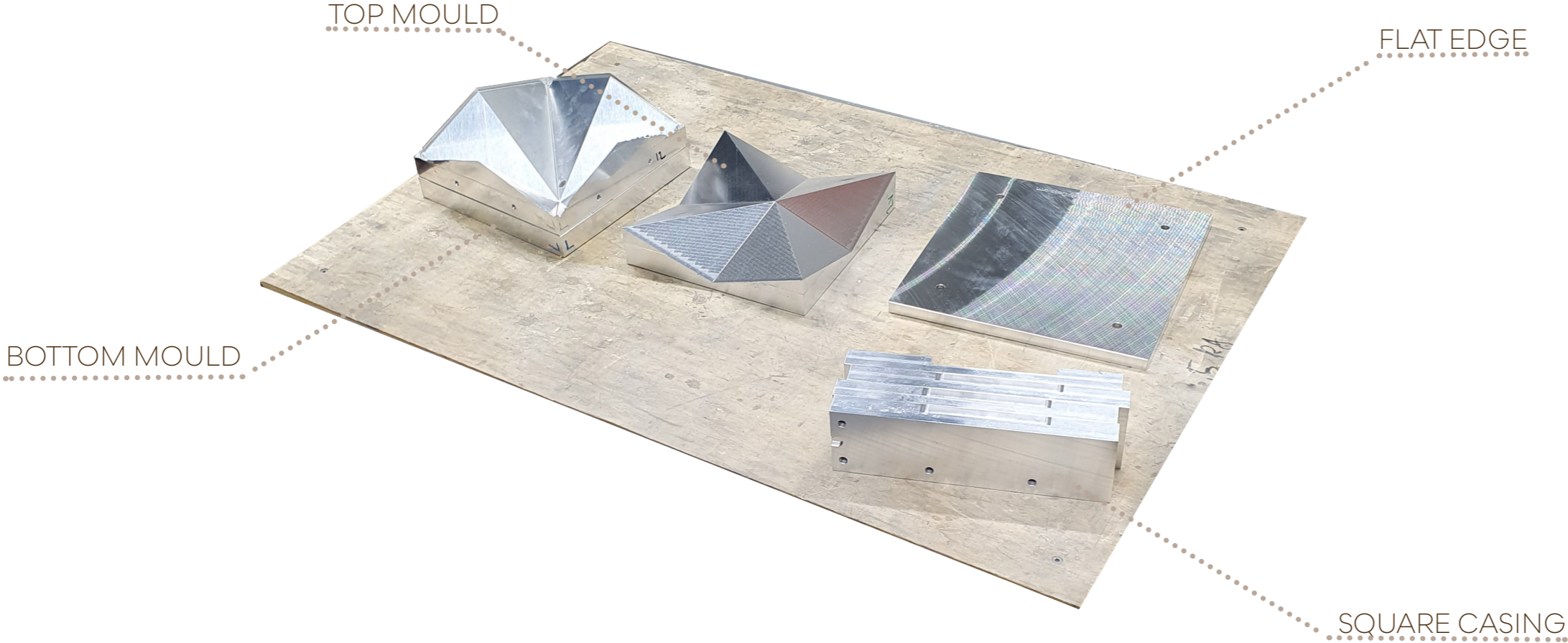
FINISHING



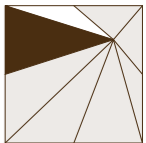
MOULD PROTOTYPE



ASSEMBLY



PANEL PROTOTYPE

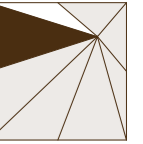


WORKFLOW



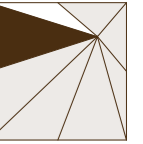
PANEL PROTOTYPE

BULK MOUNDING COMPOUND



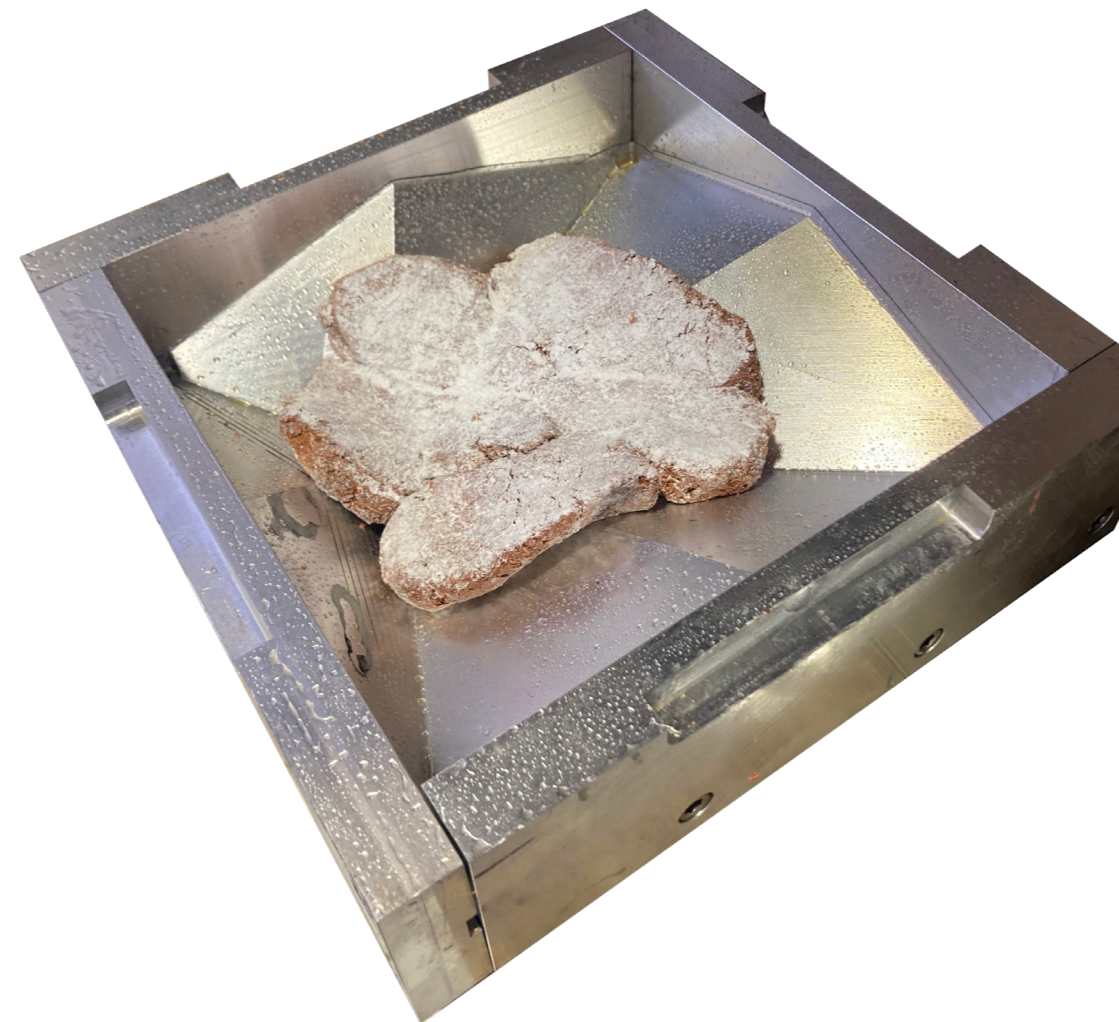
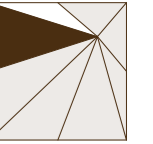
PANEL PROTOTYPE

BULK MOUNDING COMPOUND



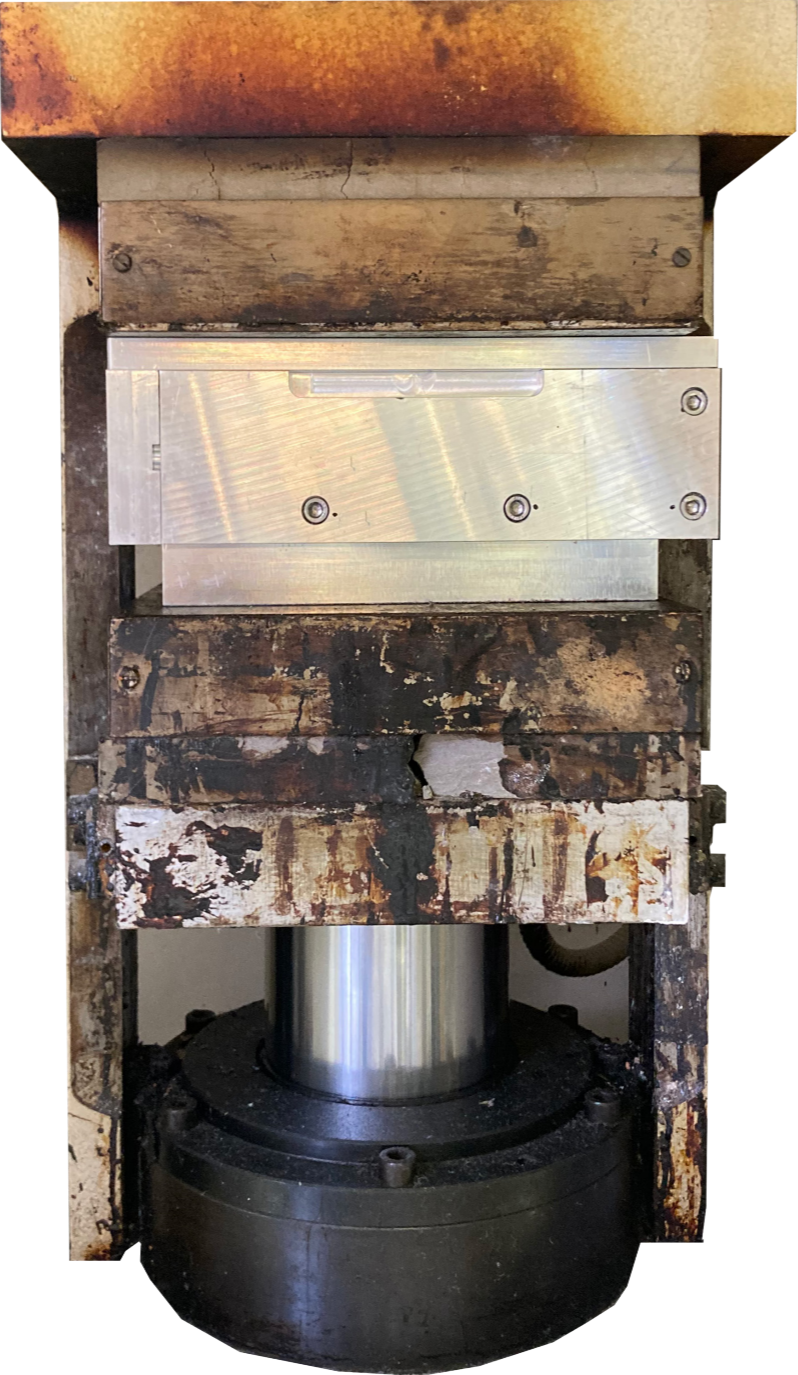
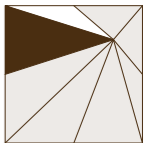
PANEL PROTOTYPE

PRE-PRESSING



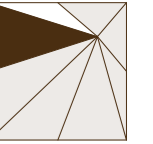
PANEL PROTOTYPE

HOT PRESSING

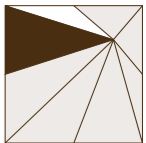


PANEL PROTOTYPE

COOLING



PANEL PROTOTYPE



FINAL PRODUCT



BACK SIDE

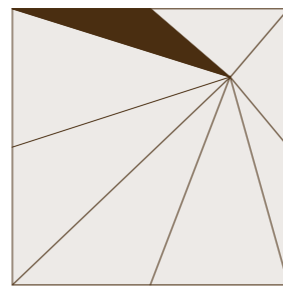


FRONT SIDE



RIGHT SIDE

CONCLUSIONS



FOUR DOMAINS OF CIRCULARITY



DESIGN



MATERIAL

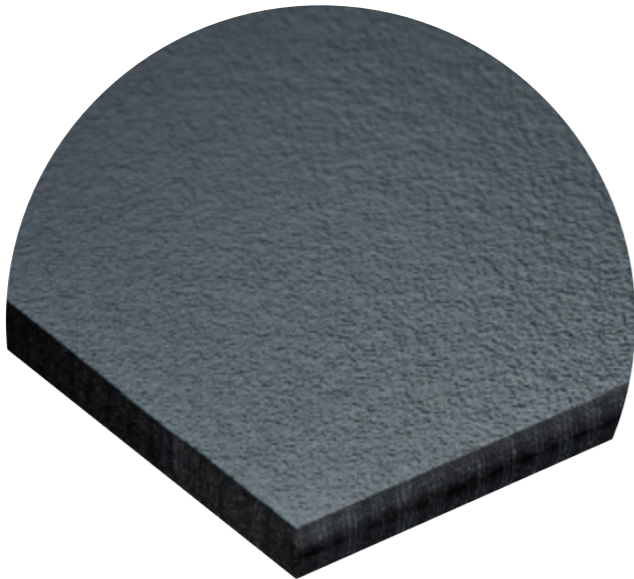


MANUFACTURING



MANAGEMENT

DESIGNS COMPARISON



TRESPA

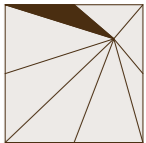


RESYSTA



NABASCO 8010

MATERIALS COMPARISON



ALUMINIUM WITH
BRONZE COATING



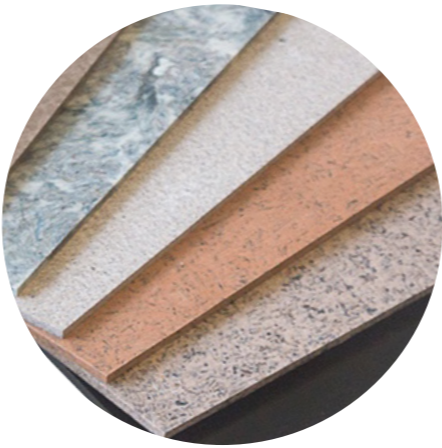
ALUMINIUM
COMPOSITE



LAMINATED
SAFETY GLASS



GFRC



NABASCO 8012

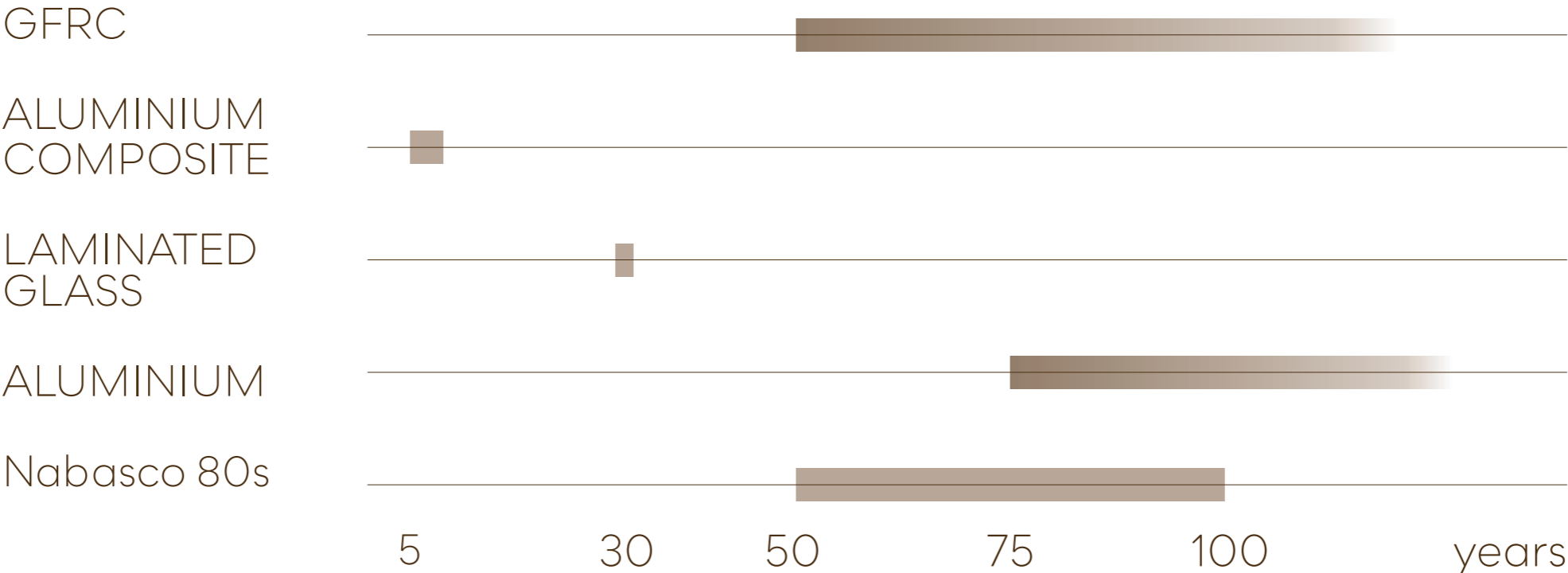


NABASCO 8040

MATERIALS COMPARISON



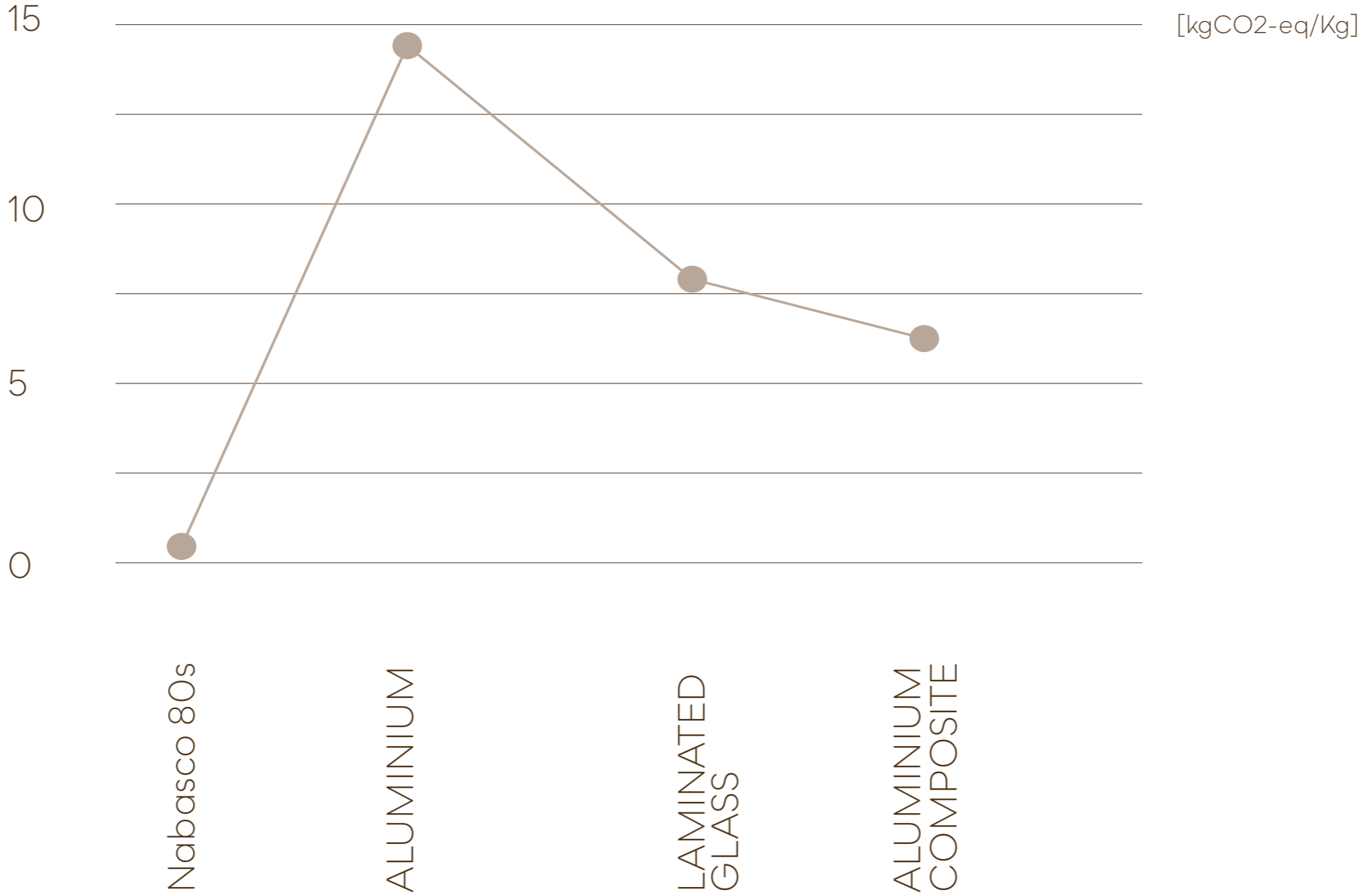
LIFESPAN



MATERIALS COMPARISON



CARBON FOOTPRINT



MATERIALS COMPARISON



END OF LIFE



RECYCLE



RECYCLE



RECYCLE



RECYCLE

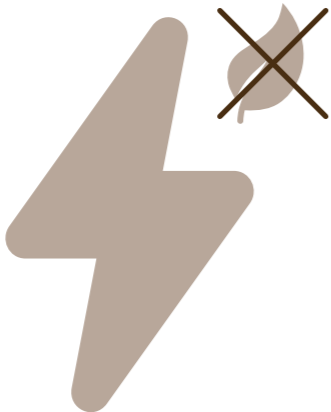


REPURPOSE



REPURPOSE

MANUFACTURING COMPARISON



TRADITIONAL
ENERGY-INTENSIVE
PRODUCTION

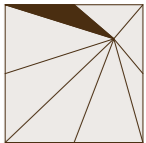


NON-RENEWABLE
MATERIAL USE



WASTE
GENERATION

MANUFACTURING COMPARISON

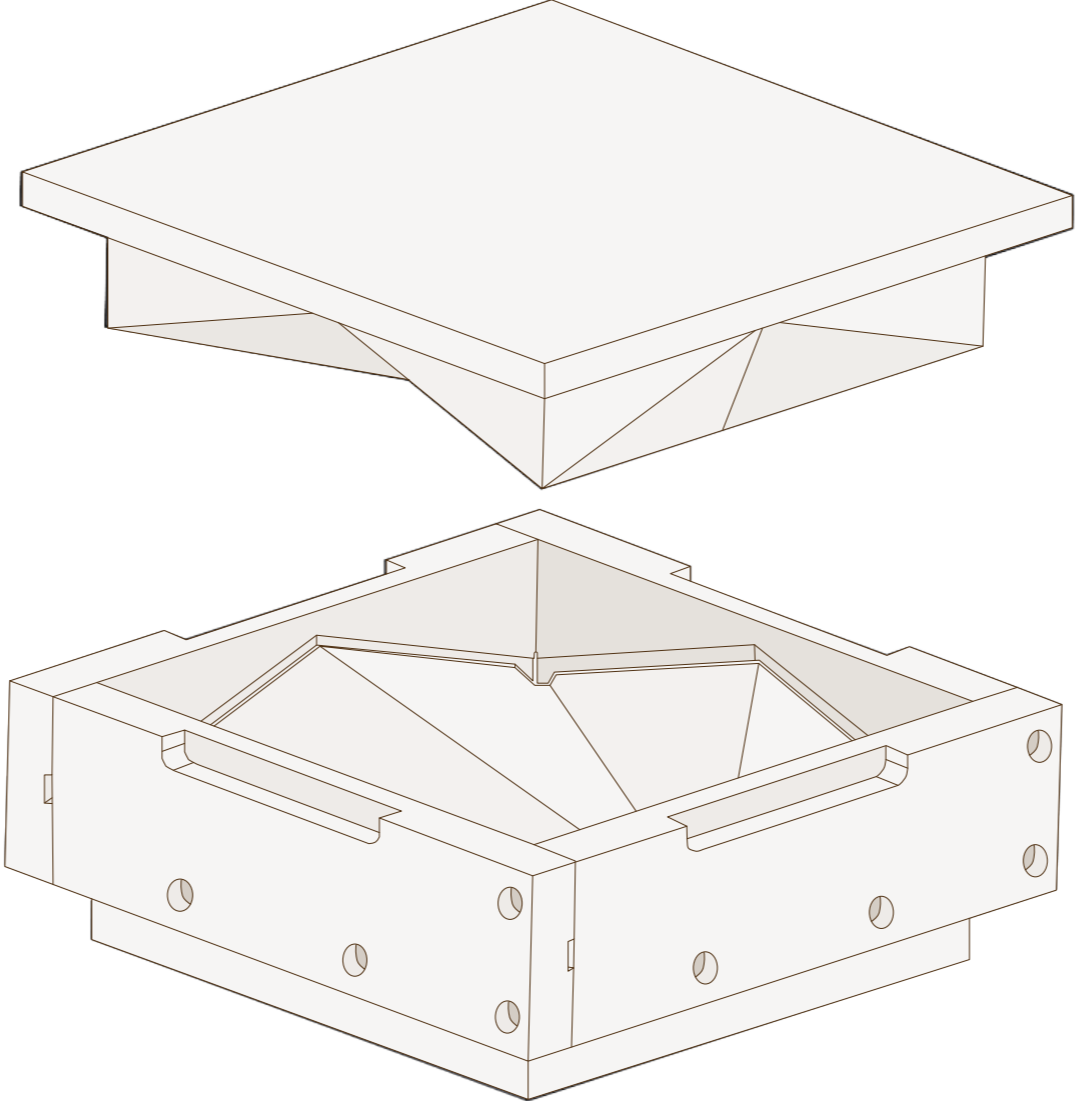


2500 panels

380 unique moulds



USUAL MANUFACTURING COMPARISON



X 500

USUAL MANUFACTURING COMPARISON

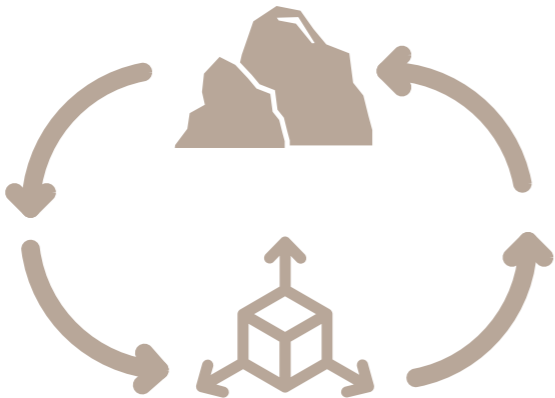


3000 panels

6 unique moulds



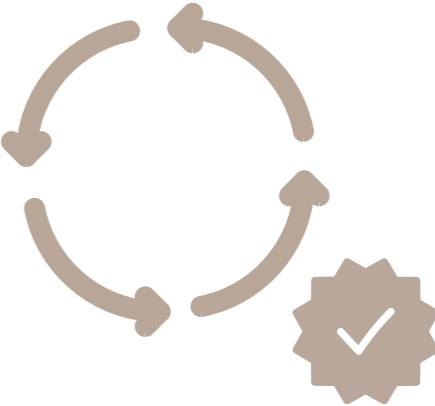
REFLECTIONS



MATERIAL AND 3D
DESIGN CORRELATION

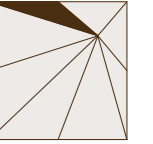


NEW DESIGN
SYSTEM



MORE CIRCULAR
PRODUCT

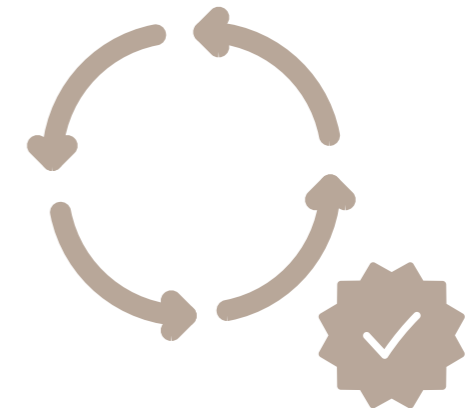
FURTHER EXPLORATIONS



MATERIAL
EXPLORATION

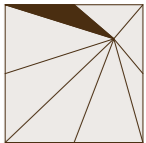


DIGITAL DESIGN



CIRCULARITY

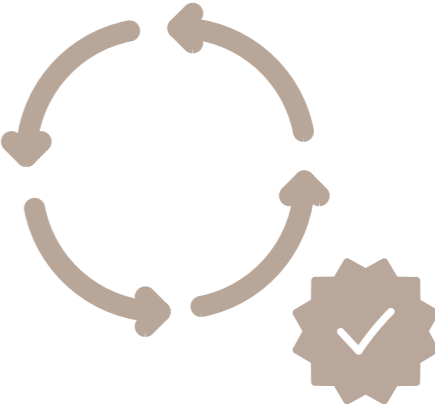
FURTHER EXPLORATIONS



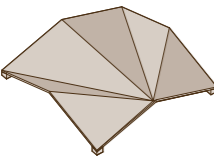
MATERIAL EXPLORATION



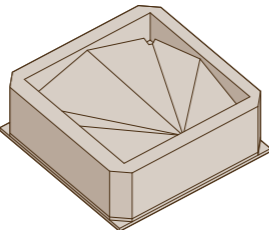
DIGITAL DESIGN



CIRCULARITY



PANEL



MOLD



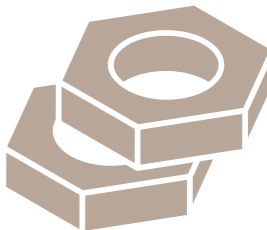
BACK SIDE



OPTIMIZATIONS



STRUCTURES



CONNECTIONS

THANK YOU

