

AT THE CONFLUENCE OF DESIGN BY NATURE AND STRUCTURAL DESIGN

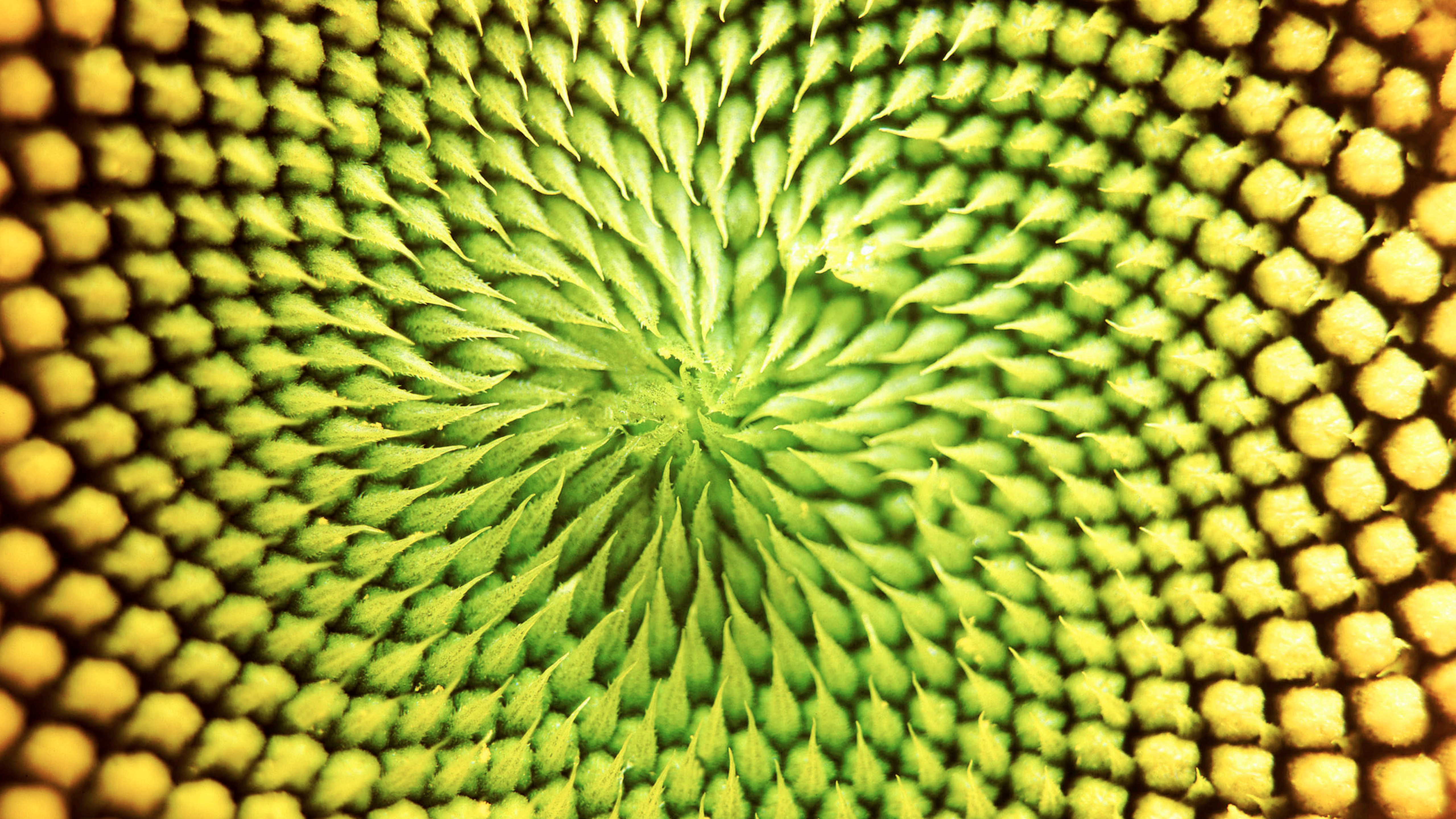
An anticlastic surfaced roof supported by a fractal-like branching structure

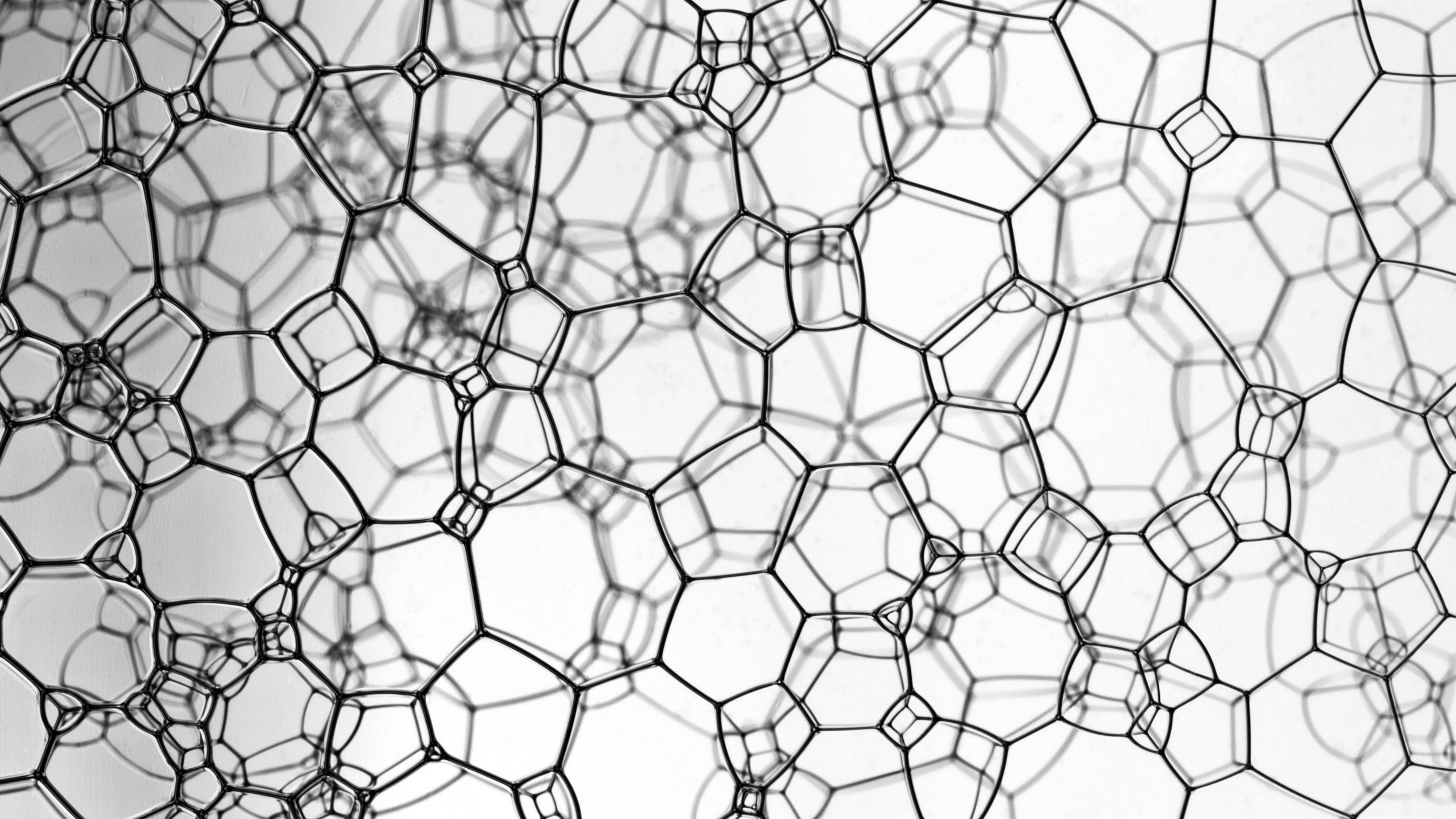
Maurits Stoffer - P5 - Sustainable Design Graduation - 25.01.18

1st mentor: Andrew Borgart - 2nd mentor: Koen Mulder

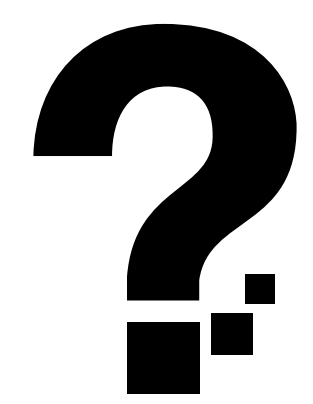






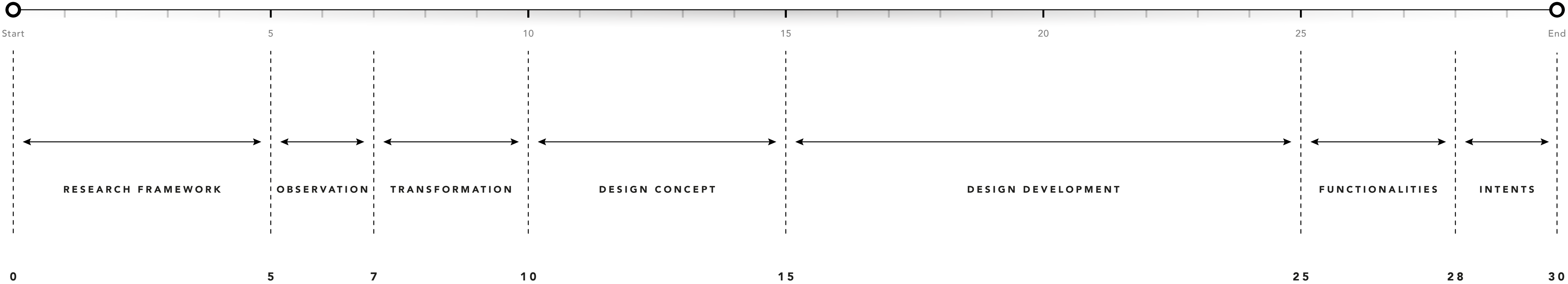






content

30 MINUTES



research framework

introduction

“You could look at nature as being like a catalog of products, and all of those have benefited from a 3.8 billion year research and development period. And given that level of investment, it makes sense to use it.”

Michael Pawlyn

introduction

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Michael Pawlyn

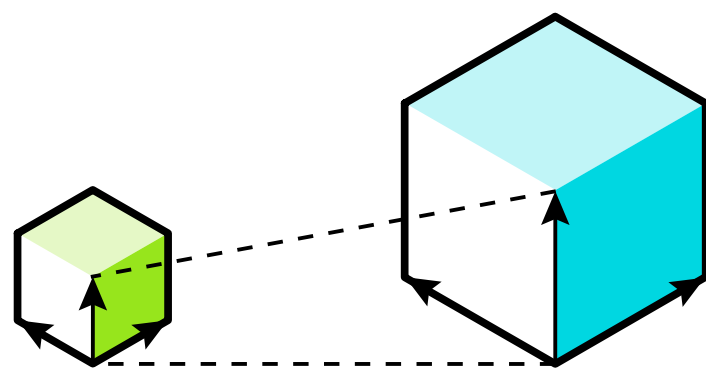
objective

A new structural principle that is emulated by natural design principles

problem statement

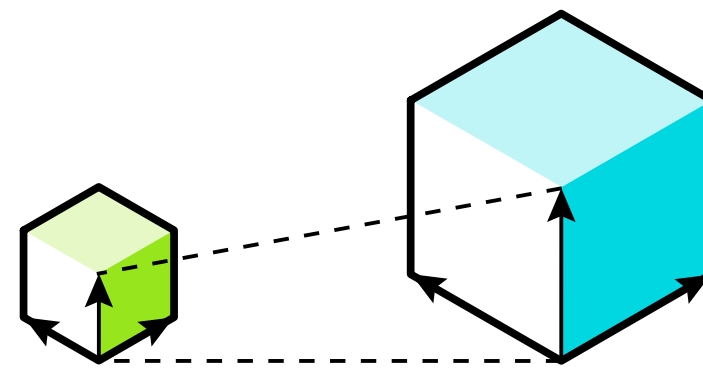
We do not make fully use of nature's time-tested patterns and strategies

1:1 copy conflict



MAGNITUDE
SIZE & SCALING

1:1 copy conflict

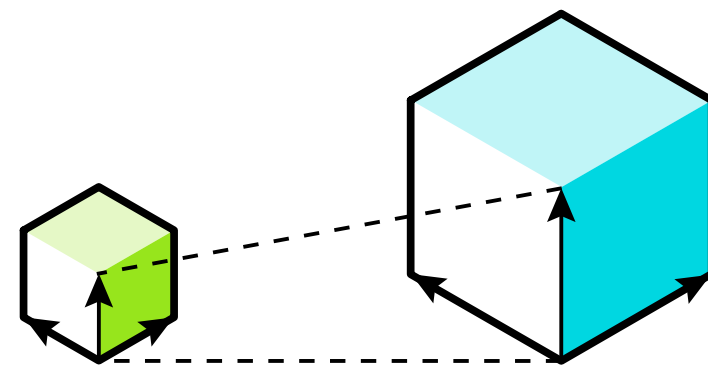


MAGNITUDE
SIZE & SCALING



FORCE TRANSFER
WEIGHT & LOADING

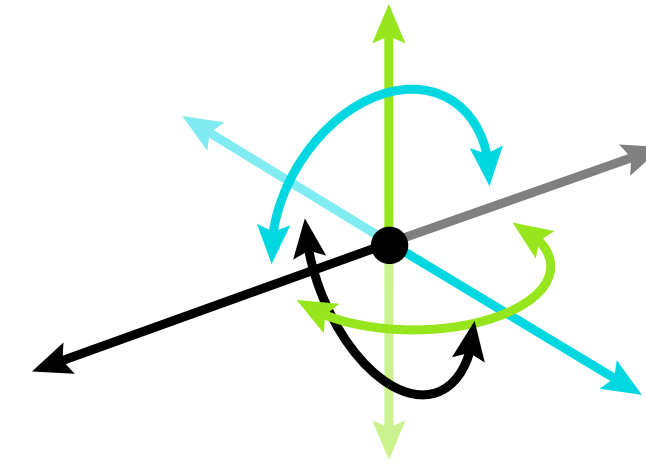
1:1 copy conflict



MAGNITUDE
SIZE & SCALING

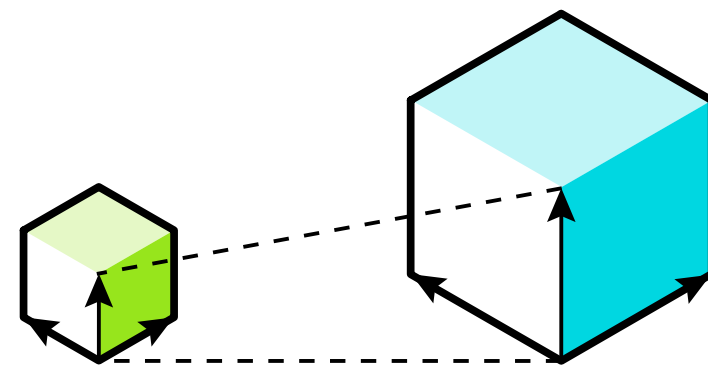


FORCE TRANSFER
WEIGHT & LOADING



KINEMATICAL FREEDOM
MOVEMENT & STABILITY

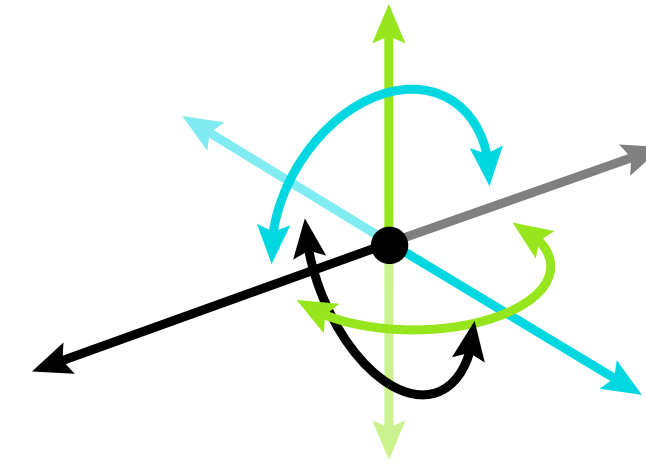
1:1 copy conflict



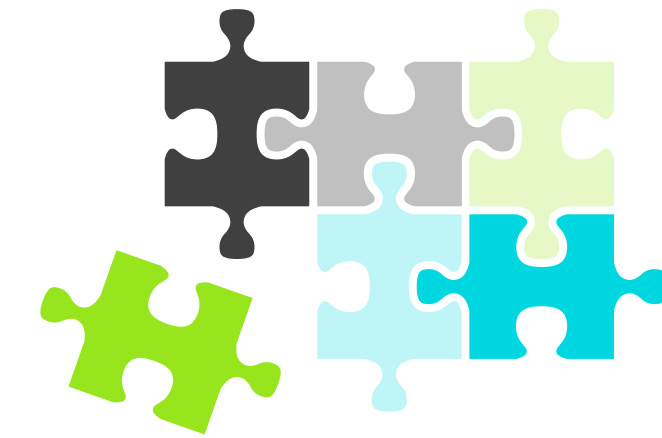
MAGNITUDE
SIZE & SCALING



FORCE TRANSFER
WEIGHT & LOADING



KINEMATICAL FREEDOM
MOVEMENT & STABILITY



COMPONENTS
MATERIALS & CONNECTIONS

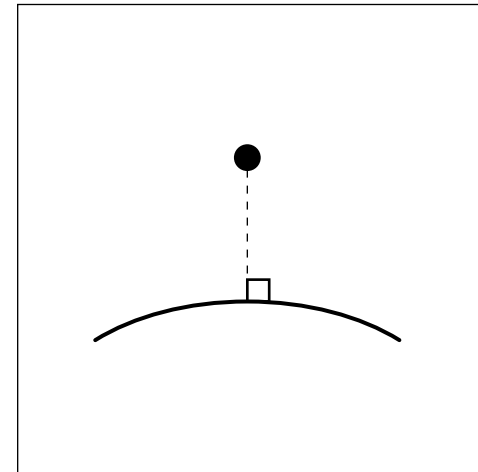
research question

How to find a new structural design intent that is inspired by the design by nature?

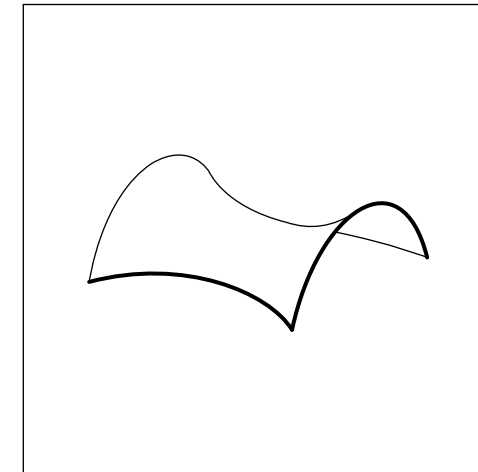
observation

2. OBSERVATION

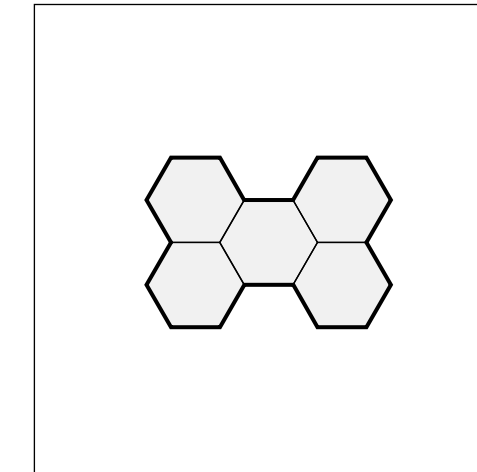
physical phenomena



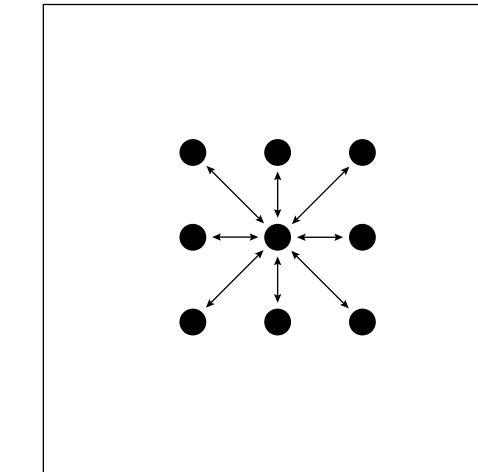
SHORTEST PATH



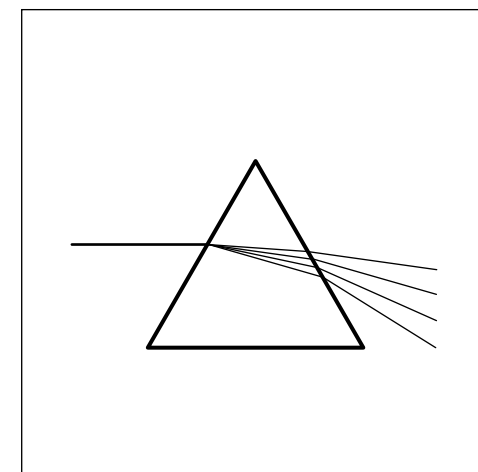
MINIMAL SURFACE



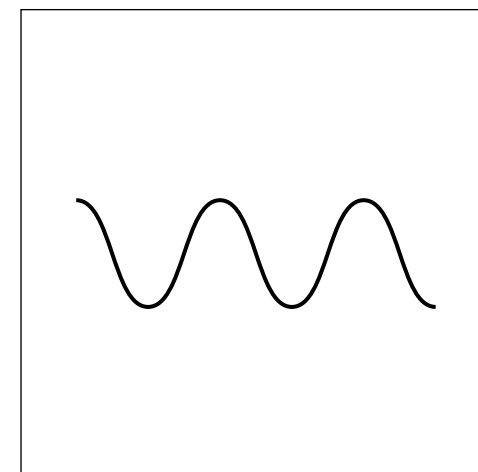
CLOSEST PACKING



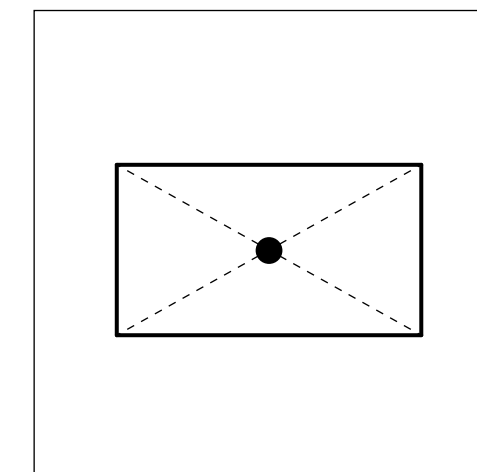
SURFACE TENSION



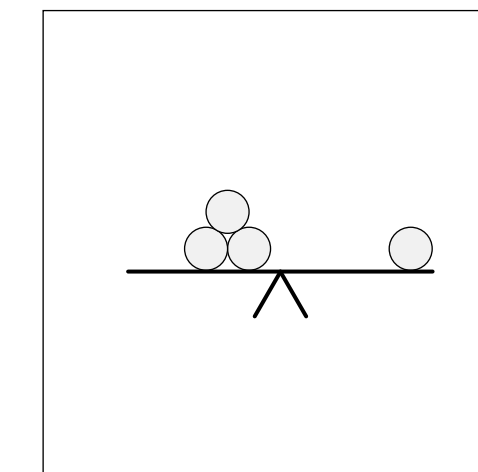
LIGHT SCATTERING



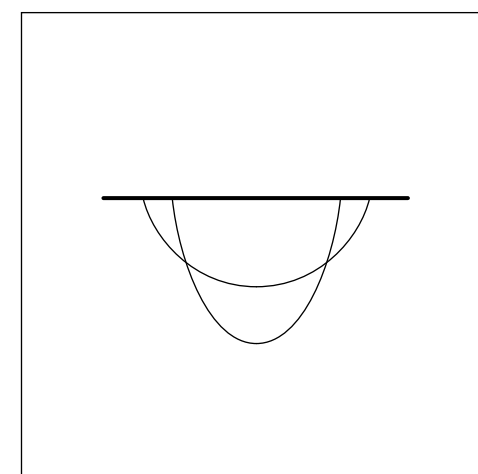
WAVE MOTION



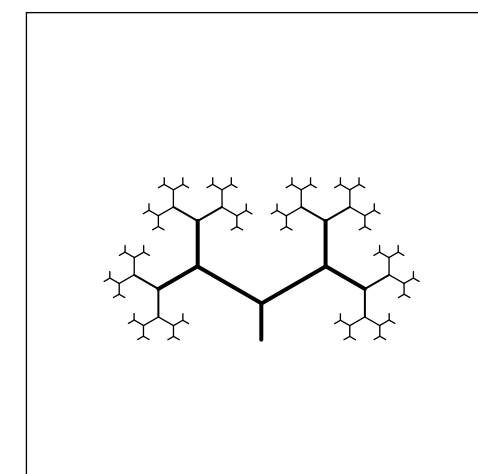
CENTRE OF GRAVITY



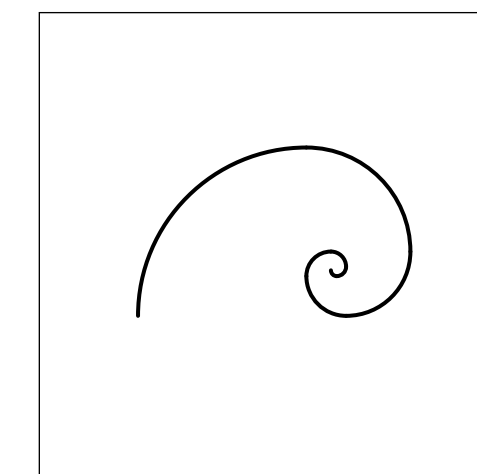
EQUILIBRIUM



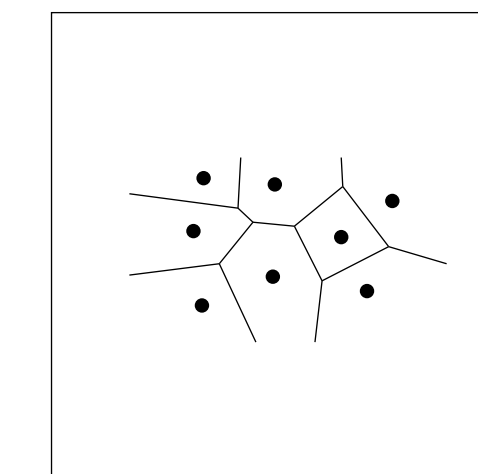
CATENARY



FRACTALS



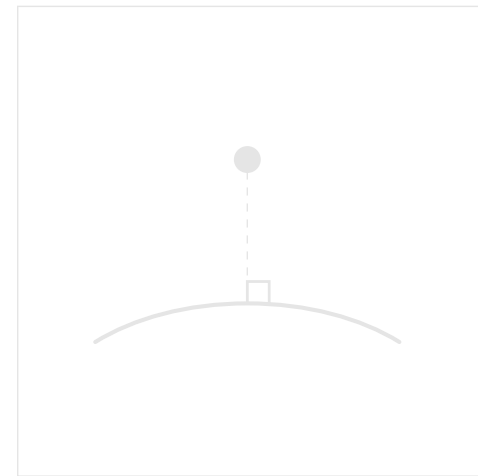
GOLDEN RATIO



VORONOI

2. OBSERVATION

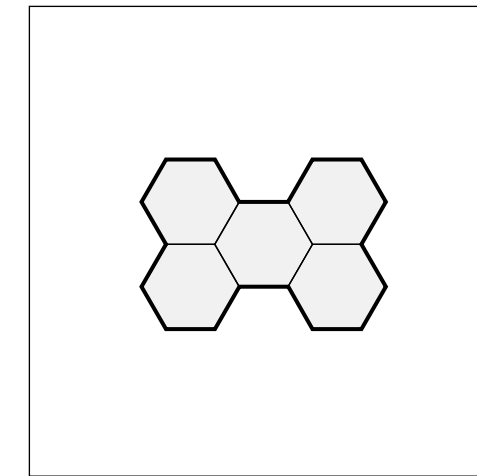
physical phenomena



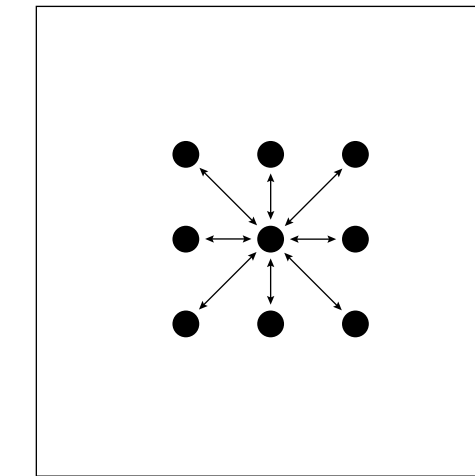
SHORTEST PATH



MINIMAL SURFACE



CLOSEST PACKING



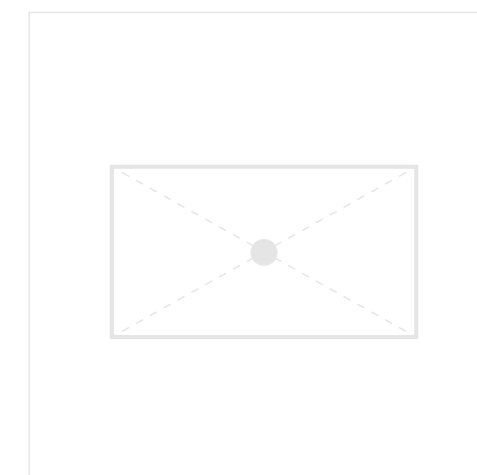
SURFACE TENSION



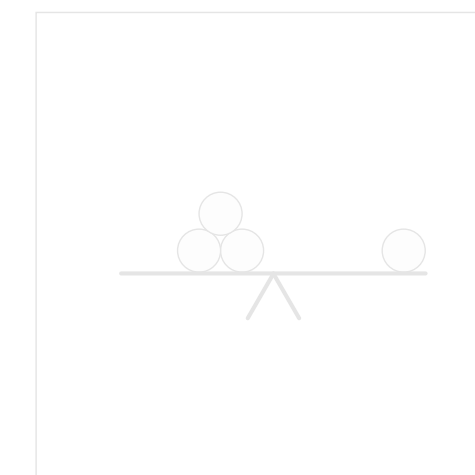
LIGHT SCATTERING



WAVE MOTION



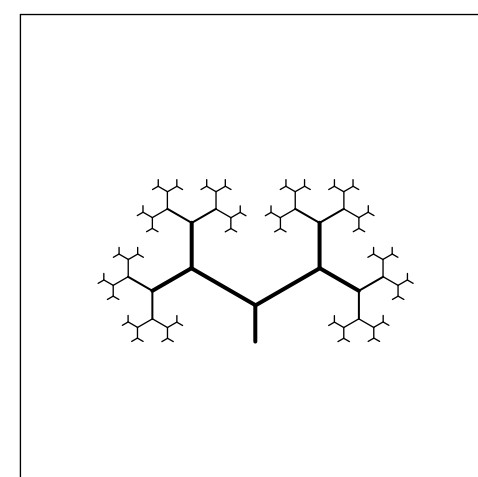
CENTRE OF GRAVITY



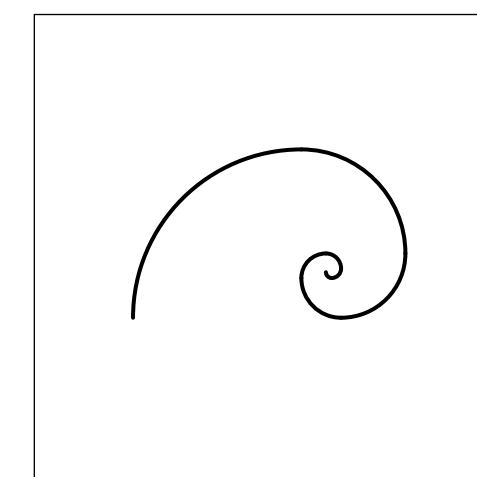
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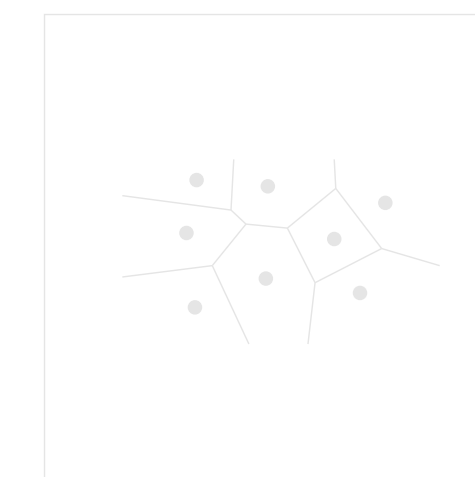
CATENARY



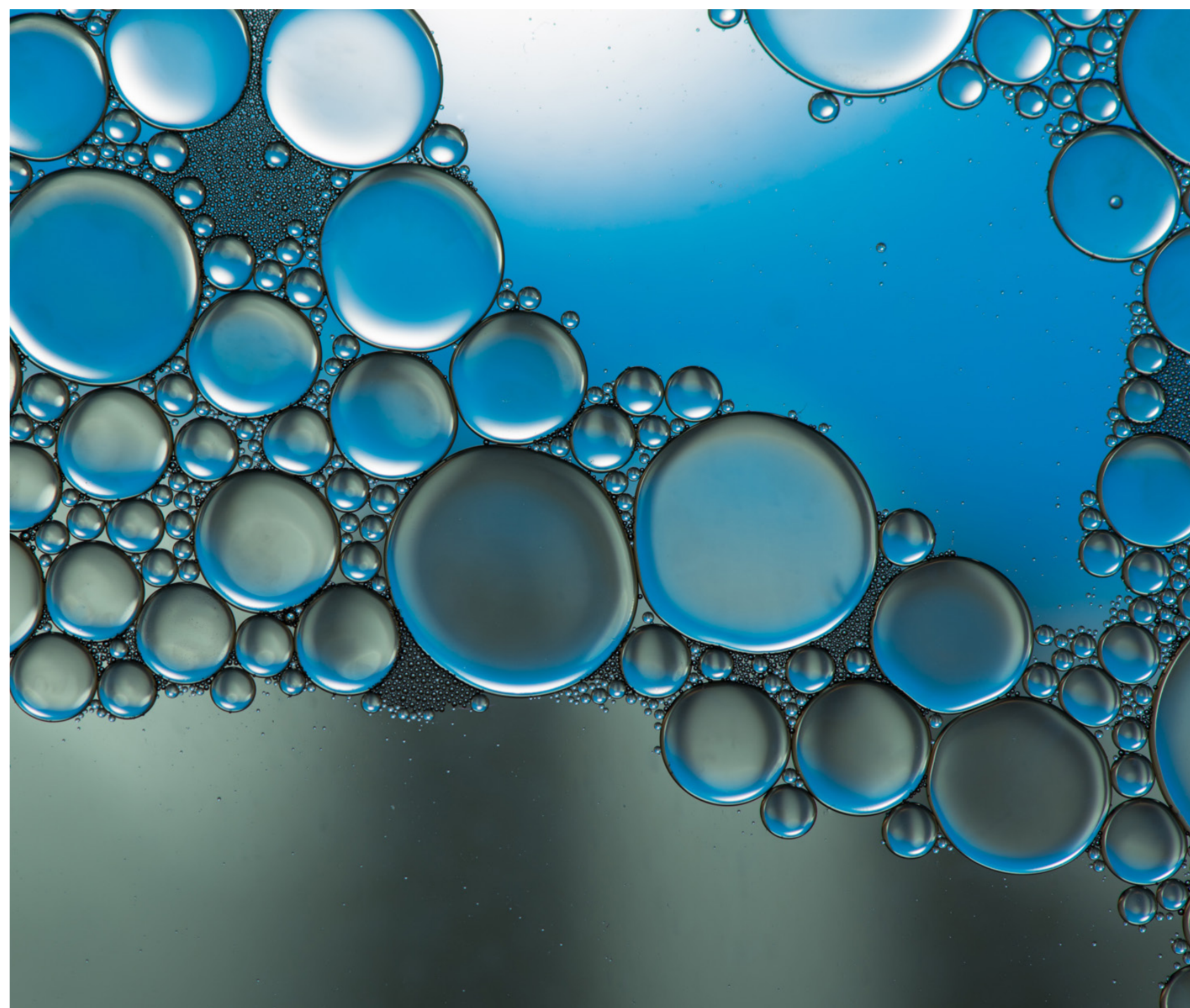
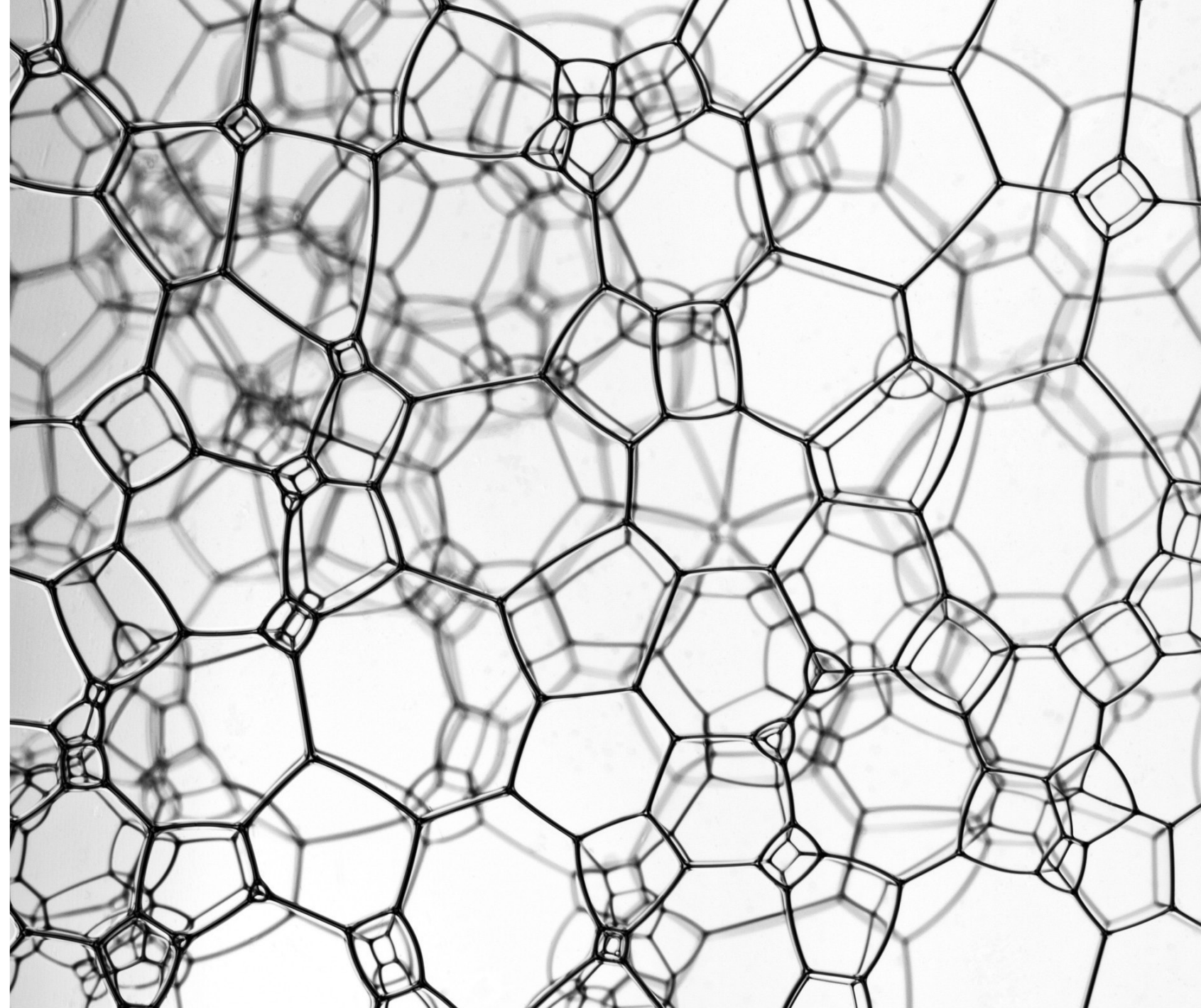
FRACTALS



GOLDEN RATIO

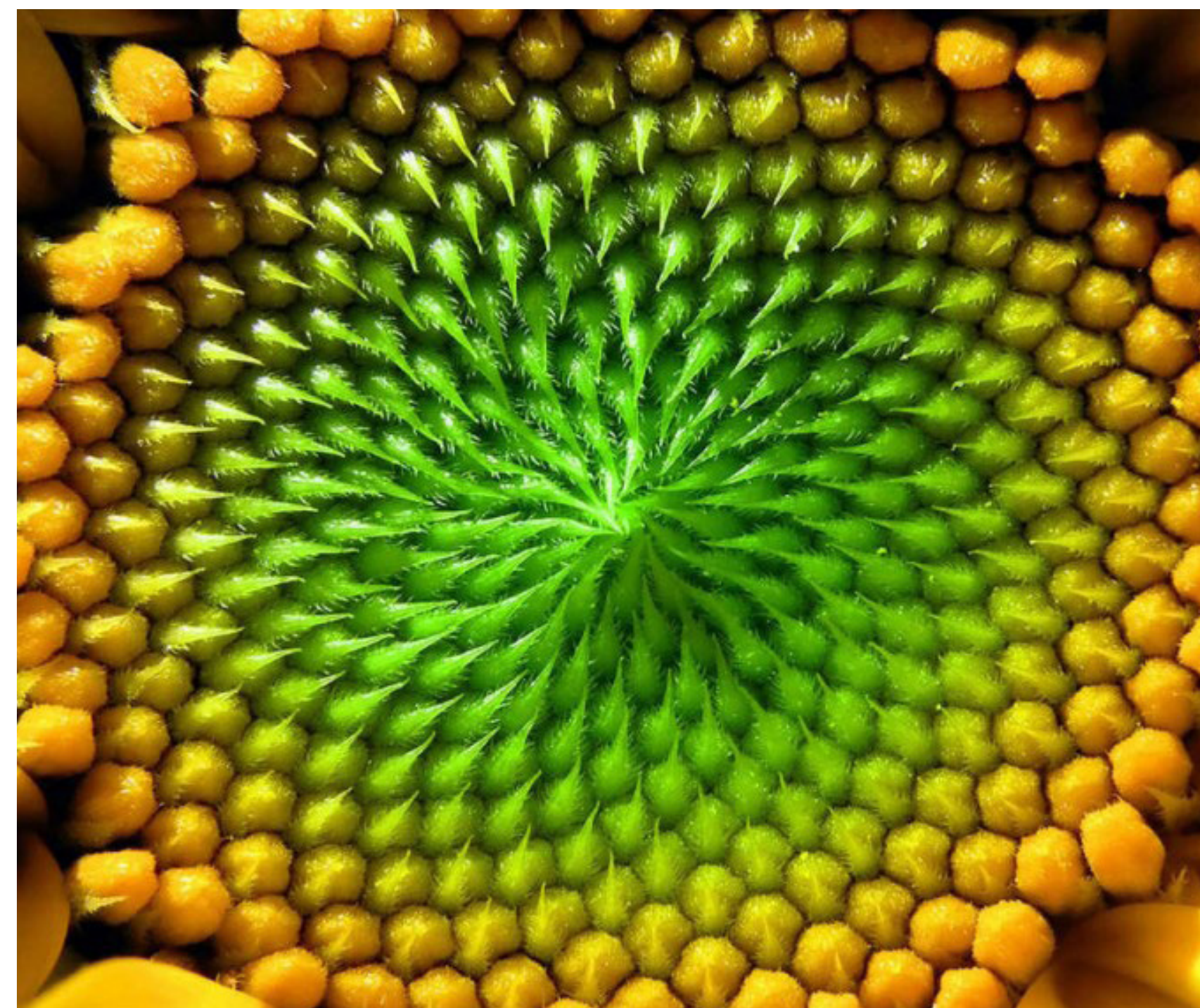
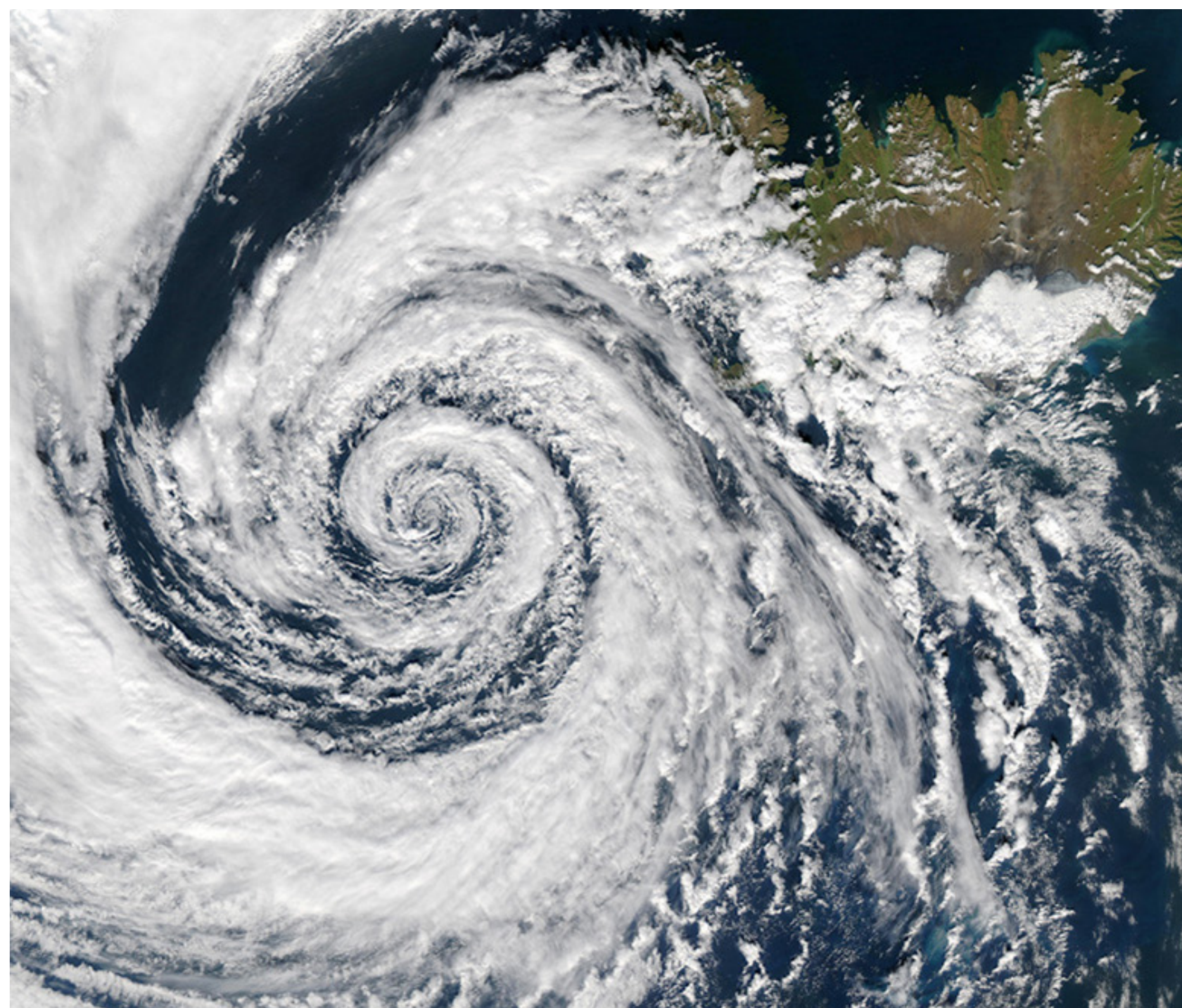
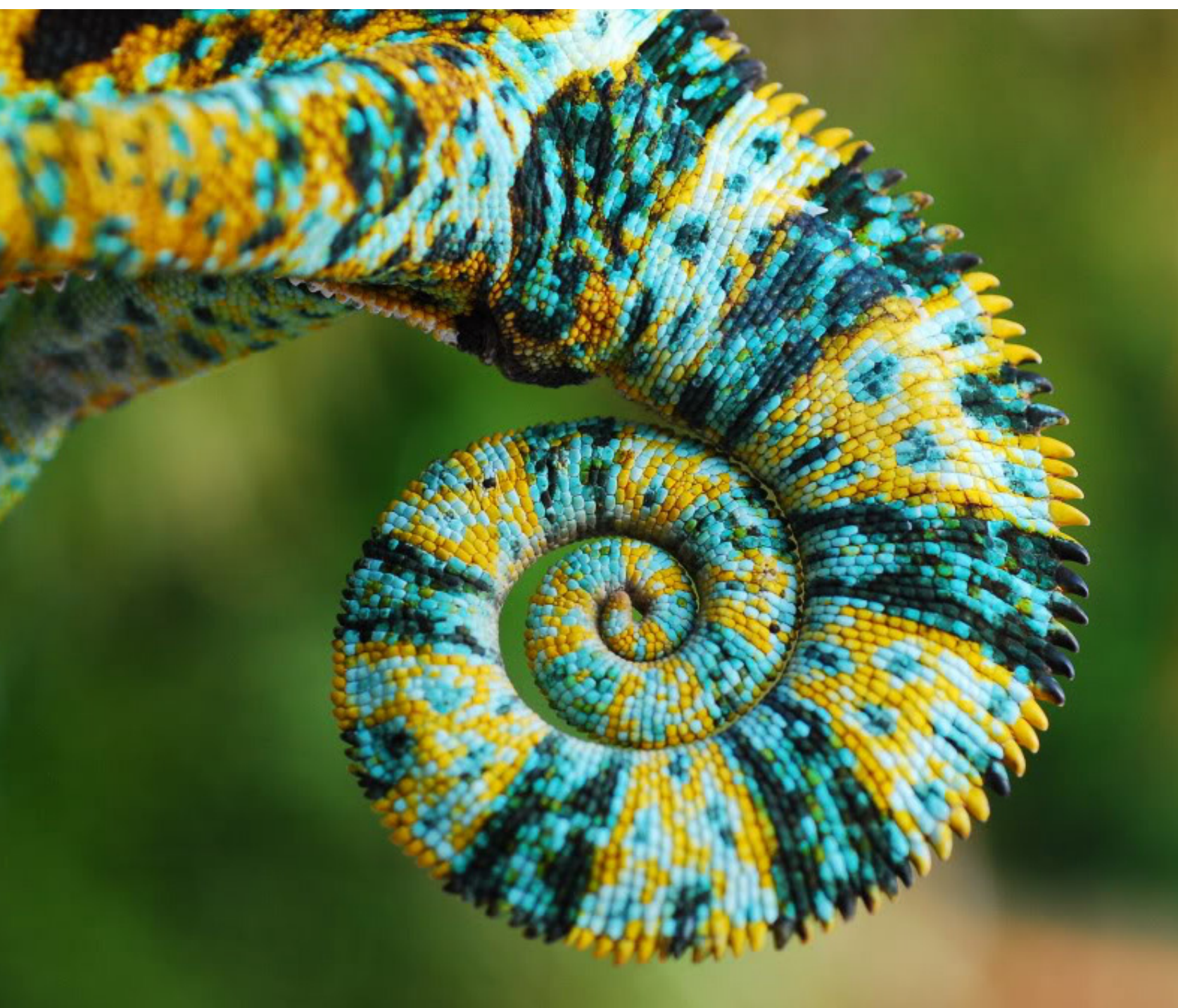


VORONOI









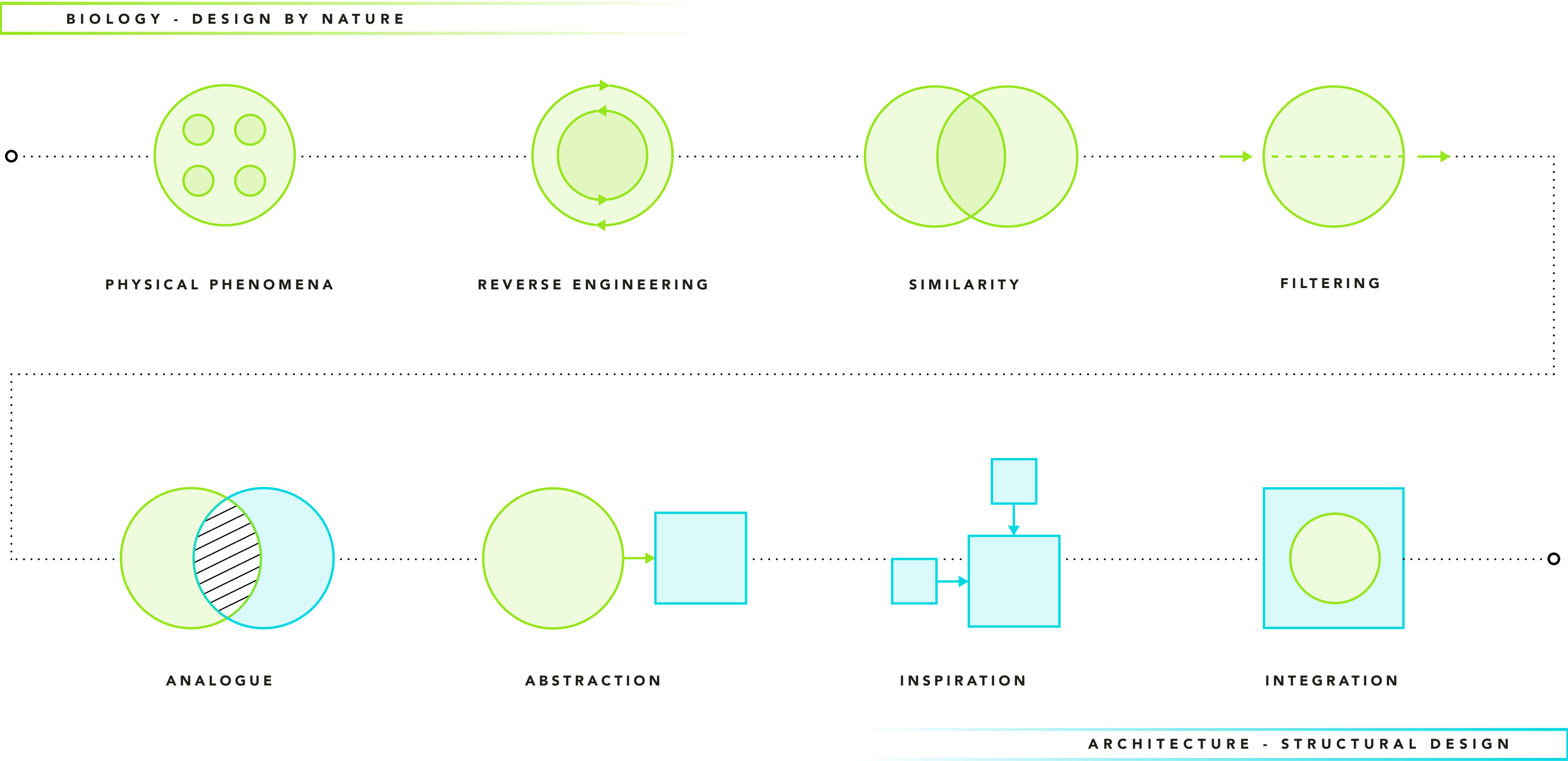
transformation

methodology

“The more abstract a concept is, the more adaptable it is within another discipline.”

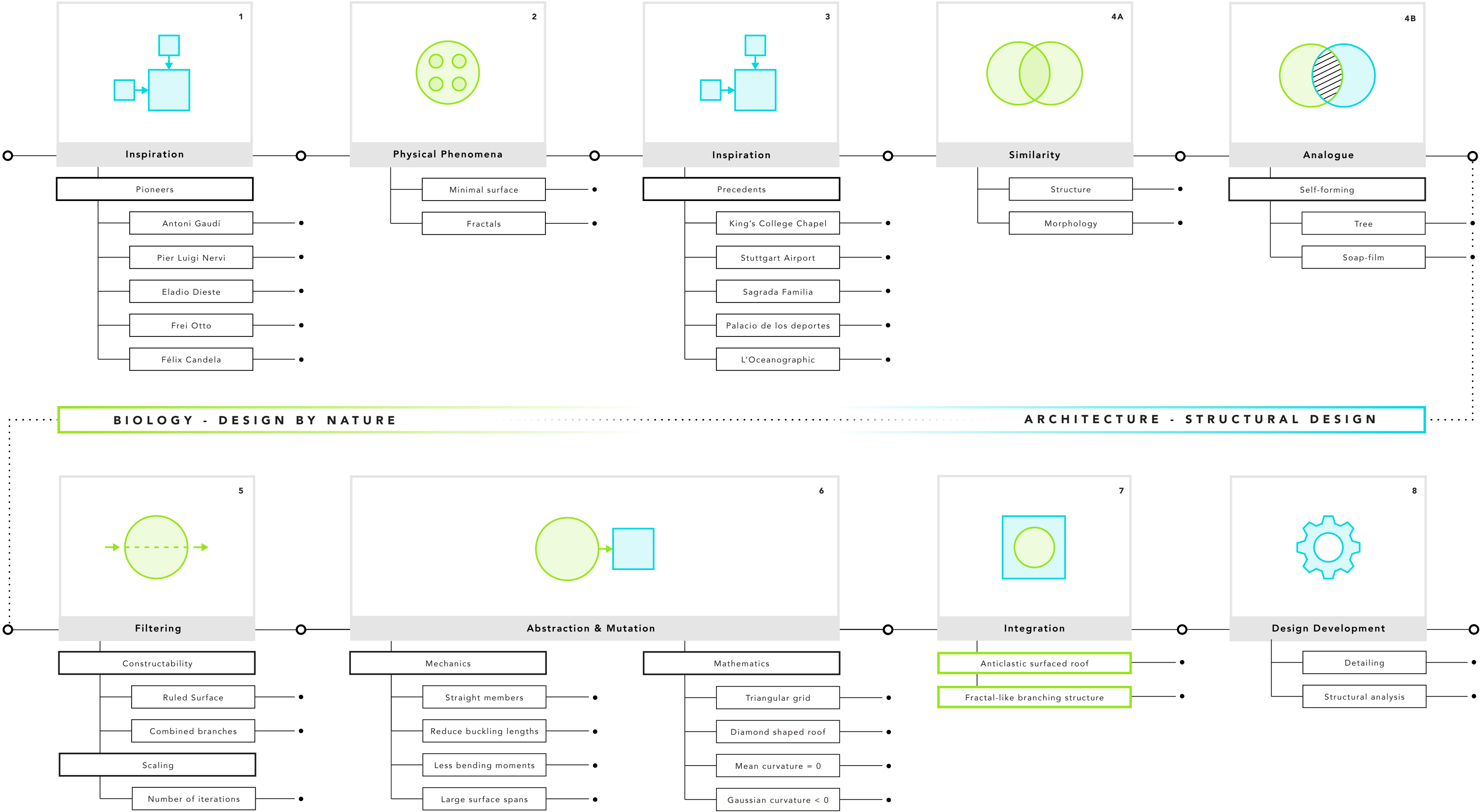
Genrich Altschuller

methodology

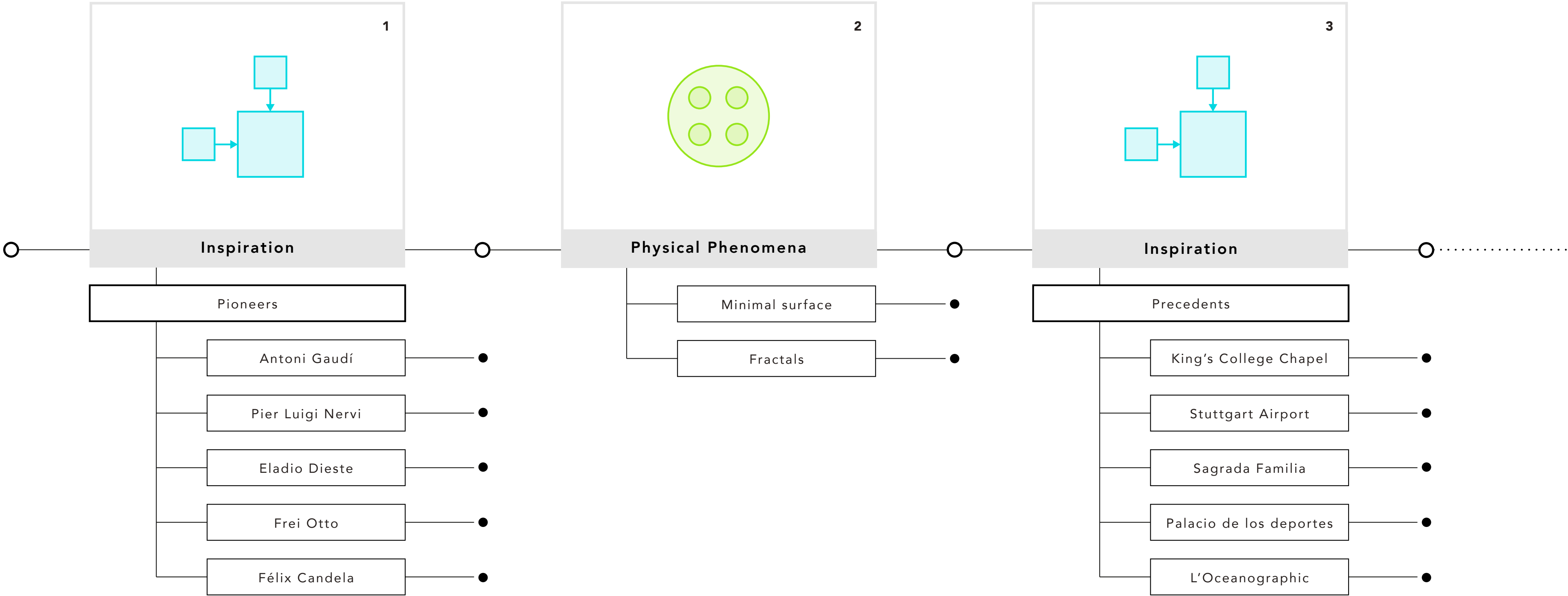


3. TRANSFORMATION

methodology

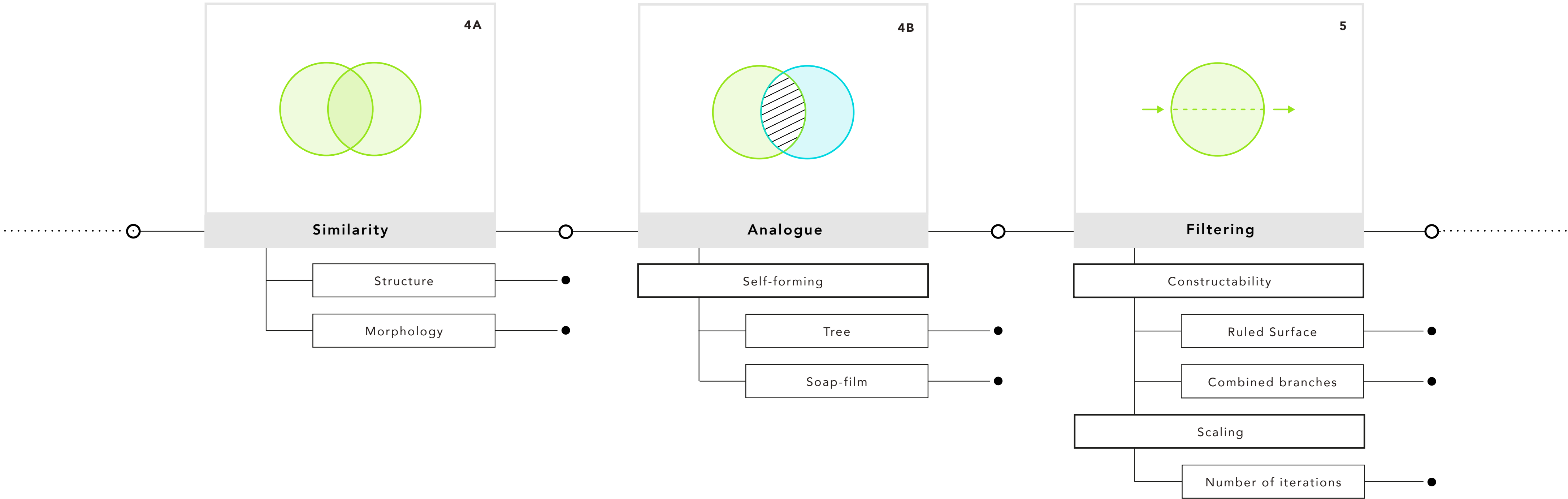


methodology

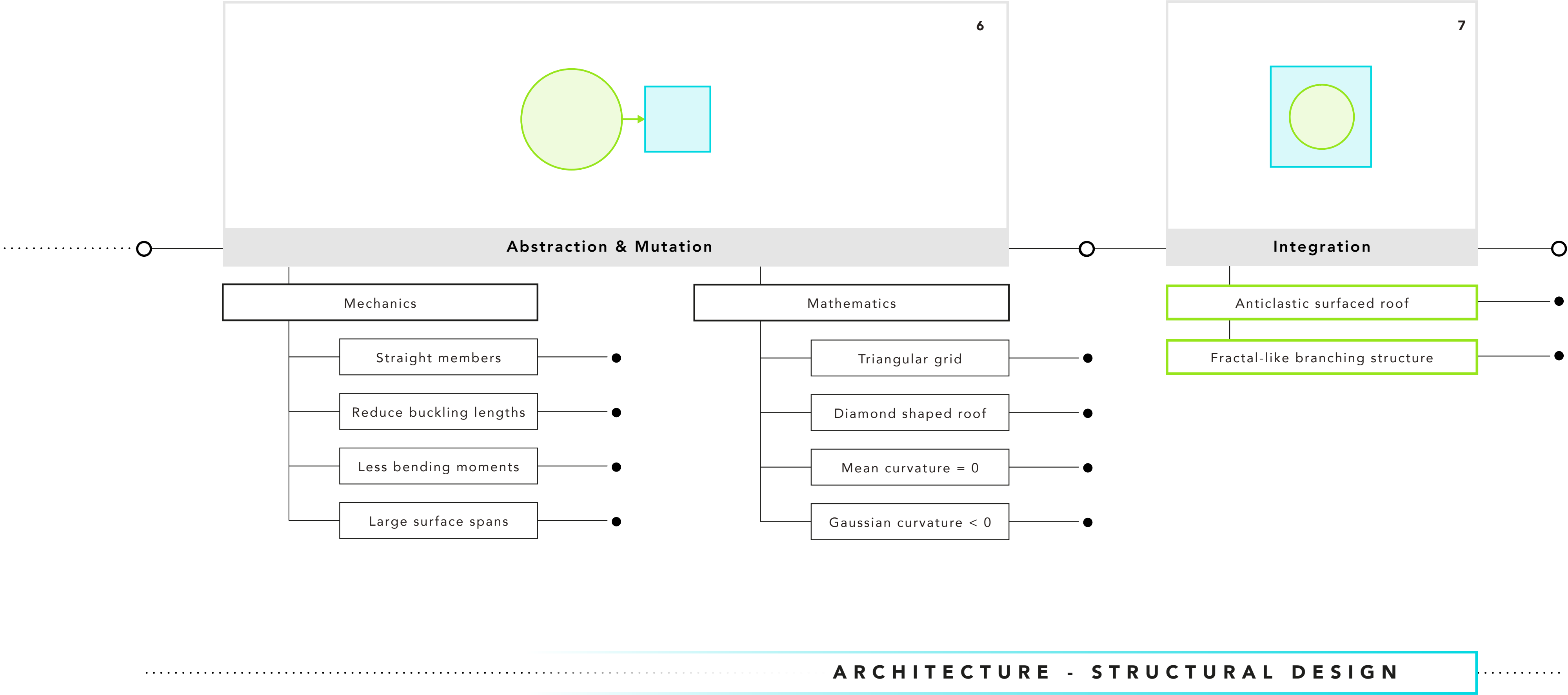


BIOLOGY - DESIGN BY NATURE

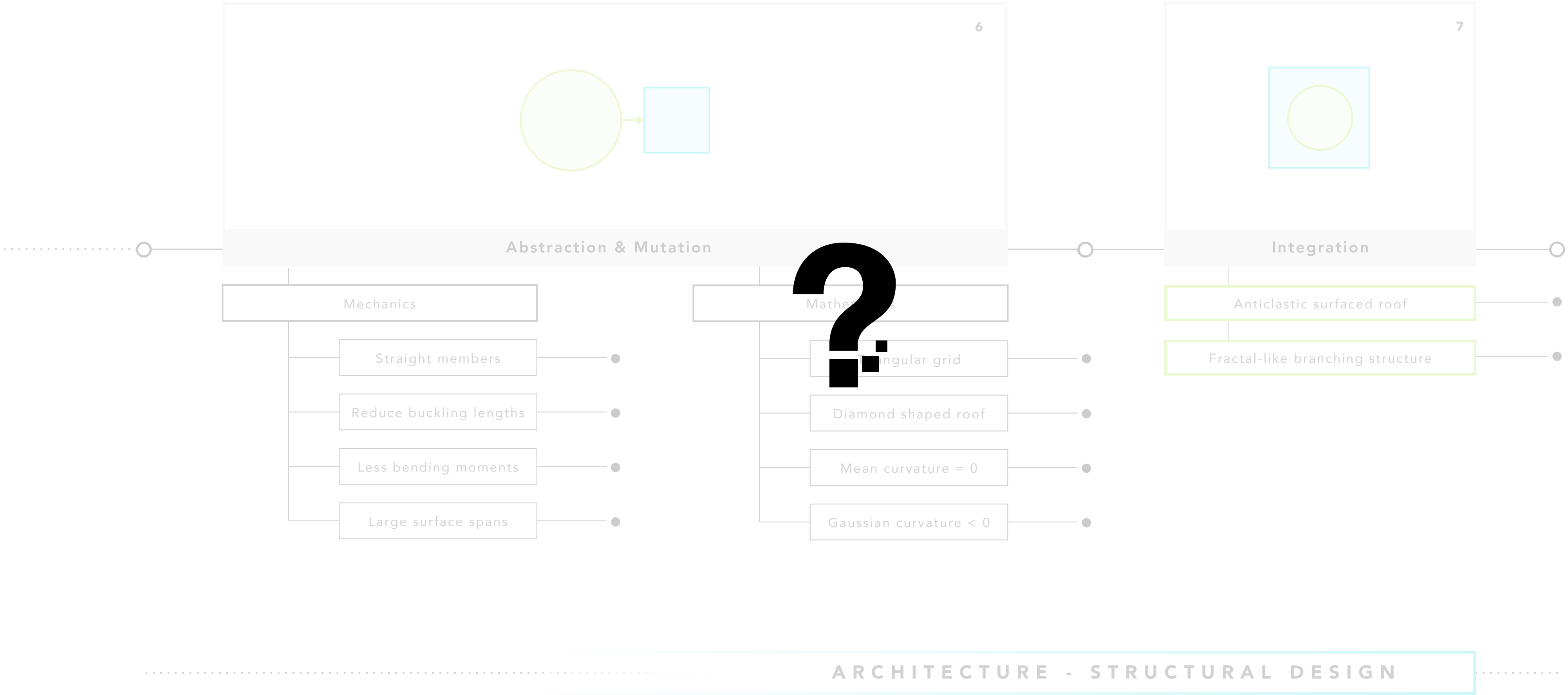
methodology



methodology

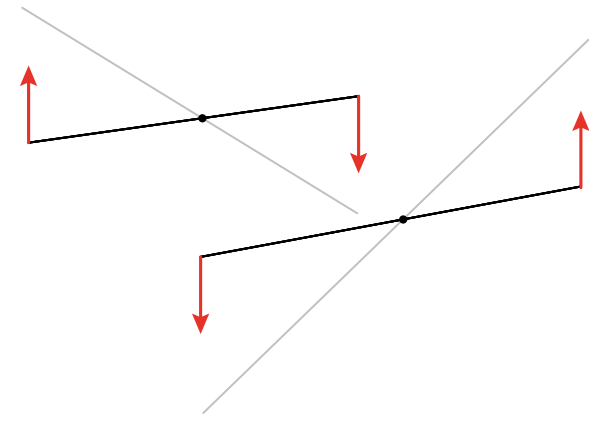


methodology

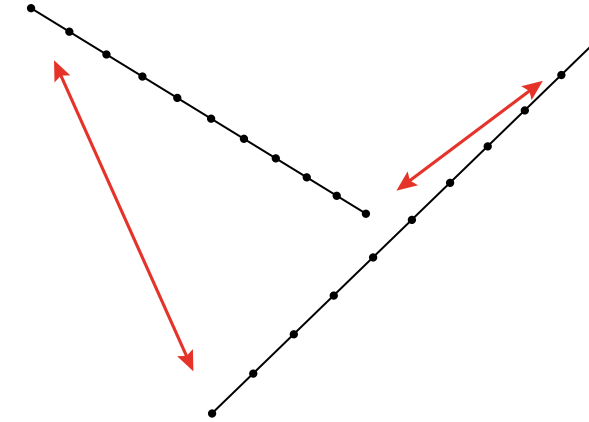


design concept

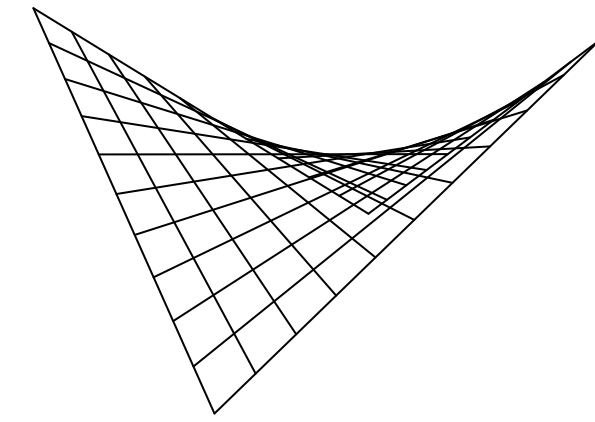
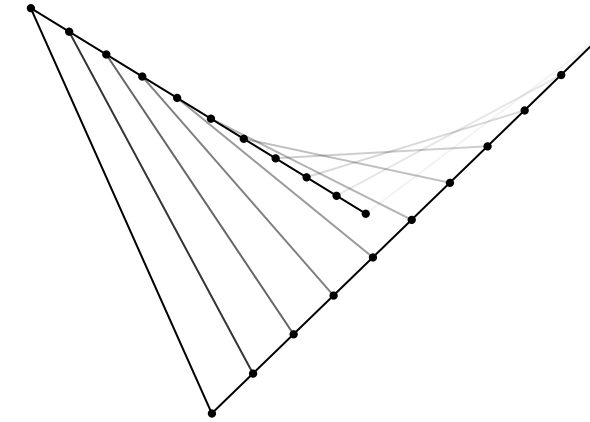
further research



1. ROTATE TWO EDGES

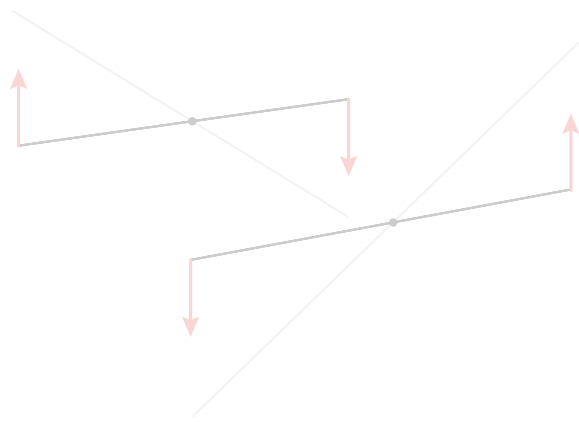


2. CONNECT EDGES

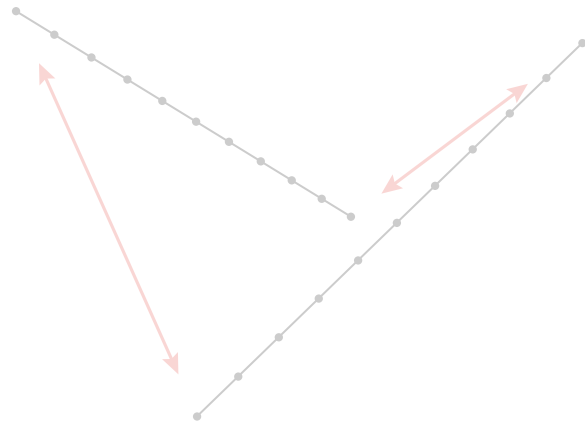


3. RULED SURFACE

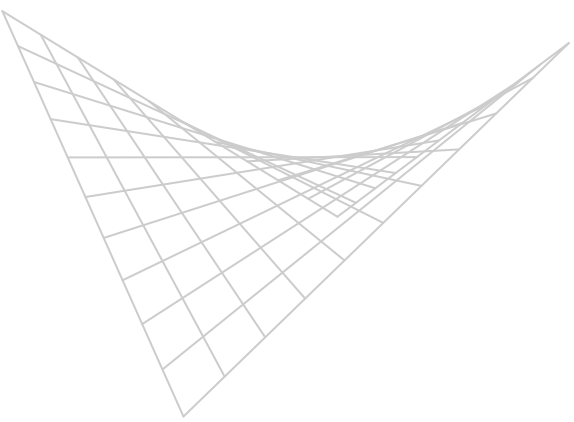
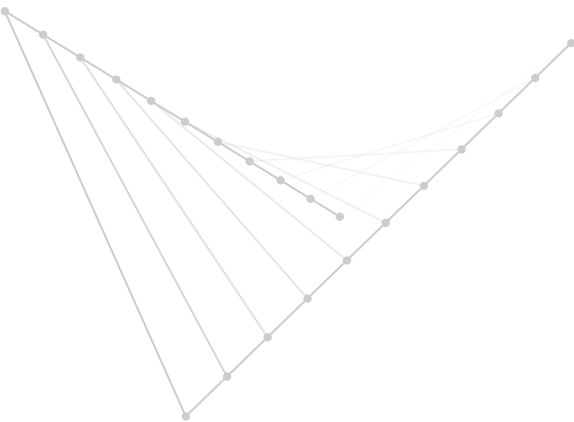
further research



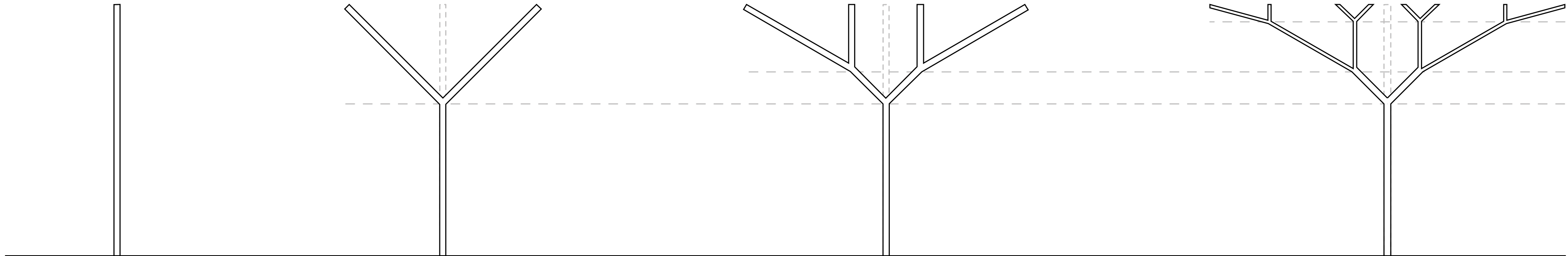
1. ROTATE TWO EDGES



2. CONNECT EDGES



3. RULED SURFACE



BASE

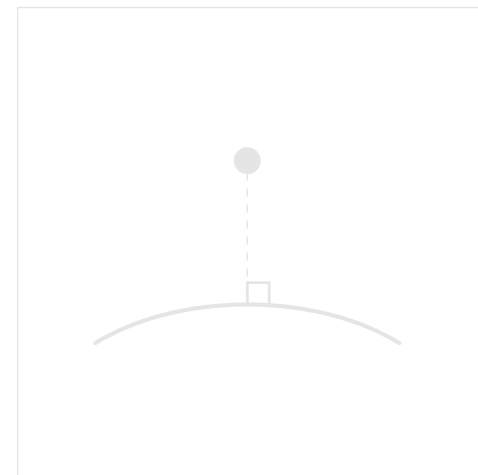
1 ITERATION

2 ITERATIONS

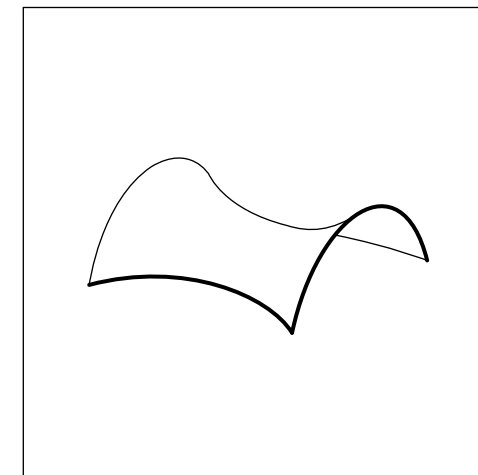
3 ITERATIONS

4. DESIGN CONCEPT

further research



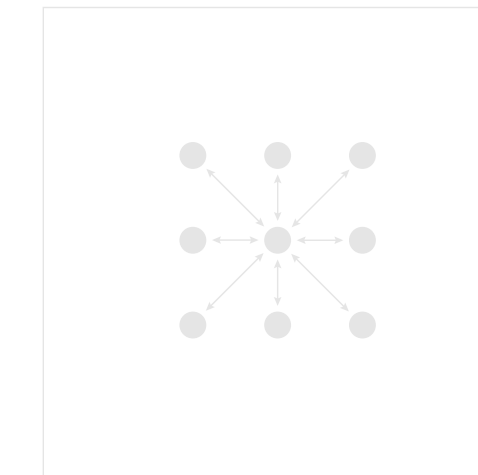
SHORTEST PATH



MINIMAL SURFACE



CLOSEST PACKING



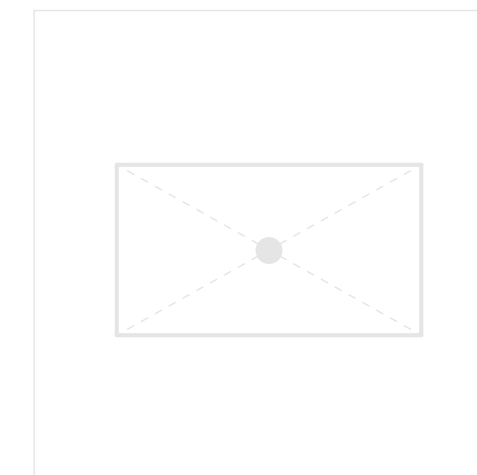
SURFACE TENSION



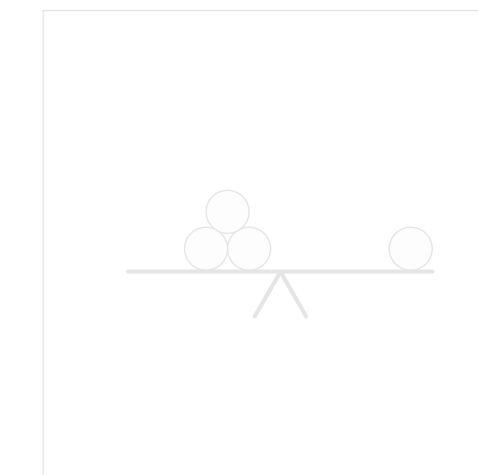
LIGHT SCATTERING



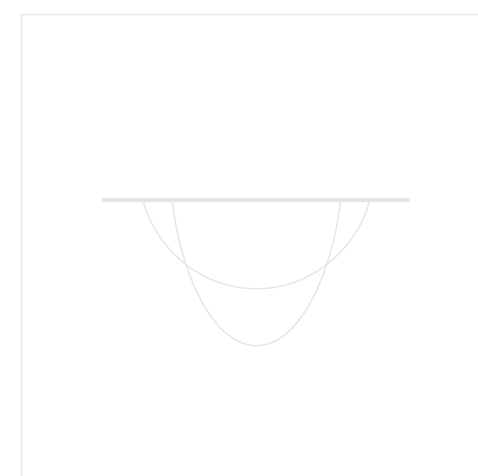
WAVE MOTION



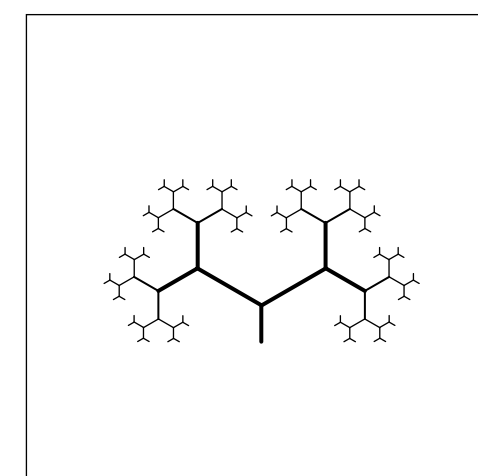
CENTRE OF GRAVITY



EQUILIBRIUM



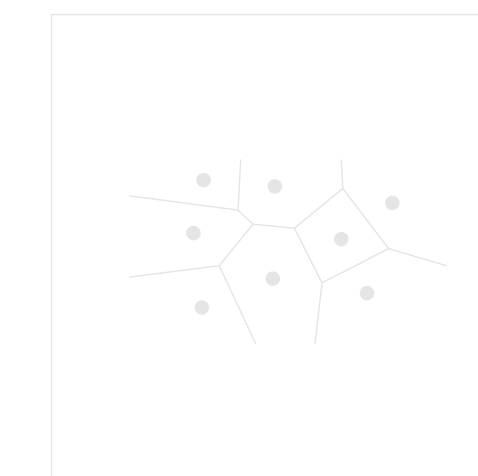
CATENARY



FRACTALS



GOLDEN RATIO



VORONOI







GRAVEDAD CERO"









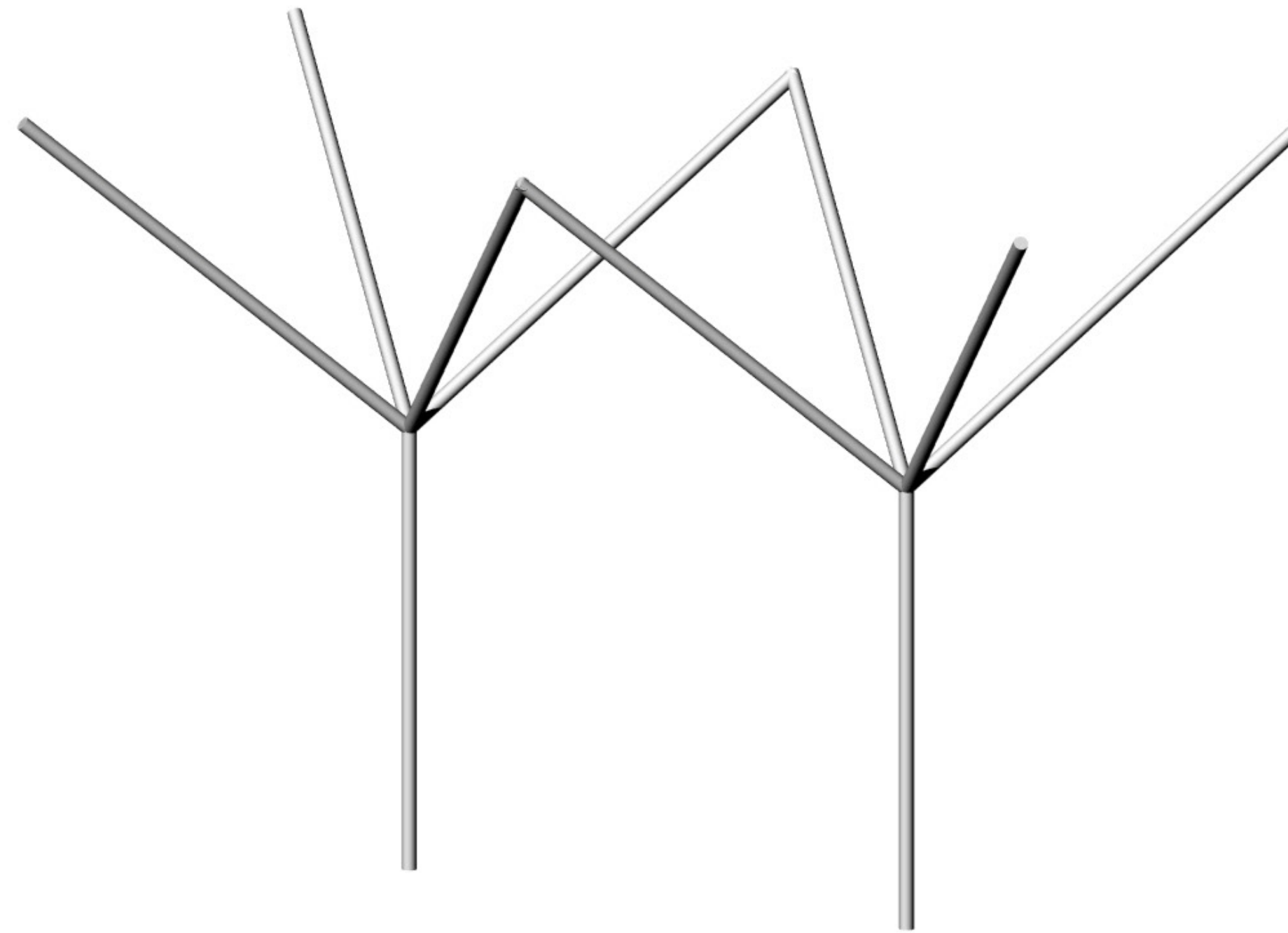
further research - main concept

Aligning the branches of the last iteration with the edges of the hyperbolic paraboloids.

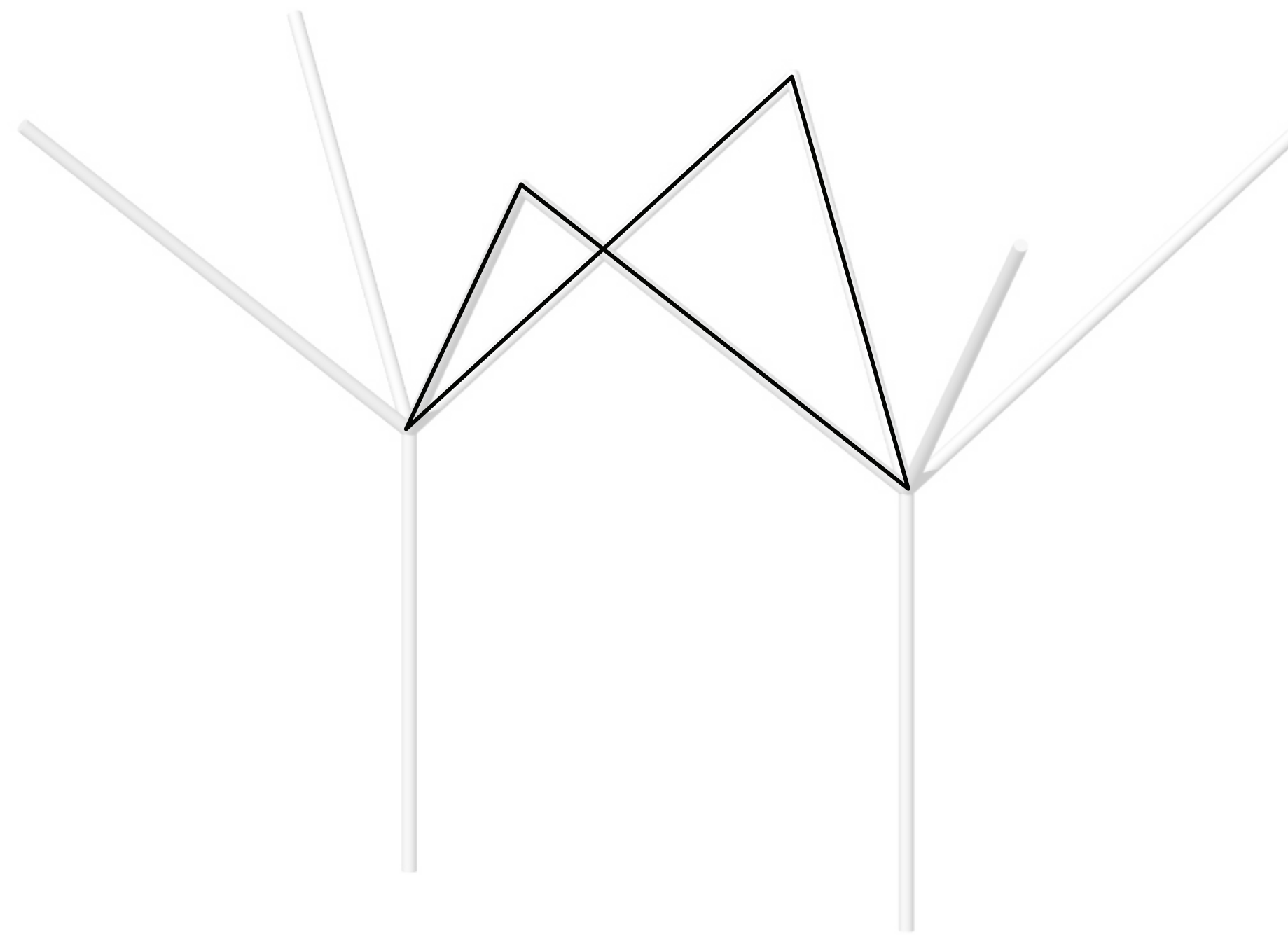
further research - main concept



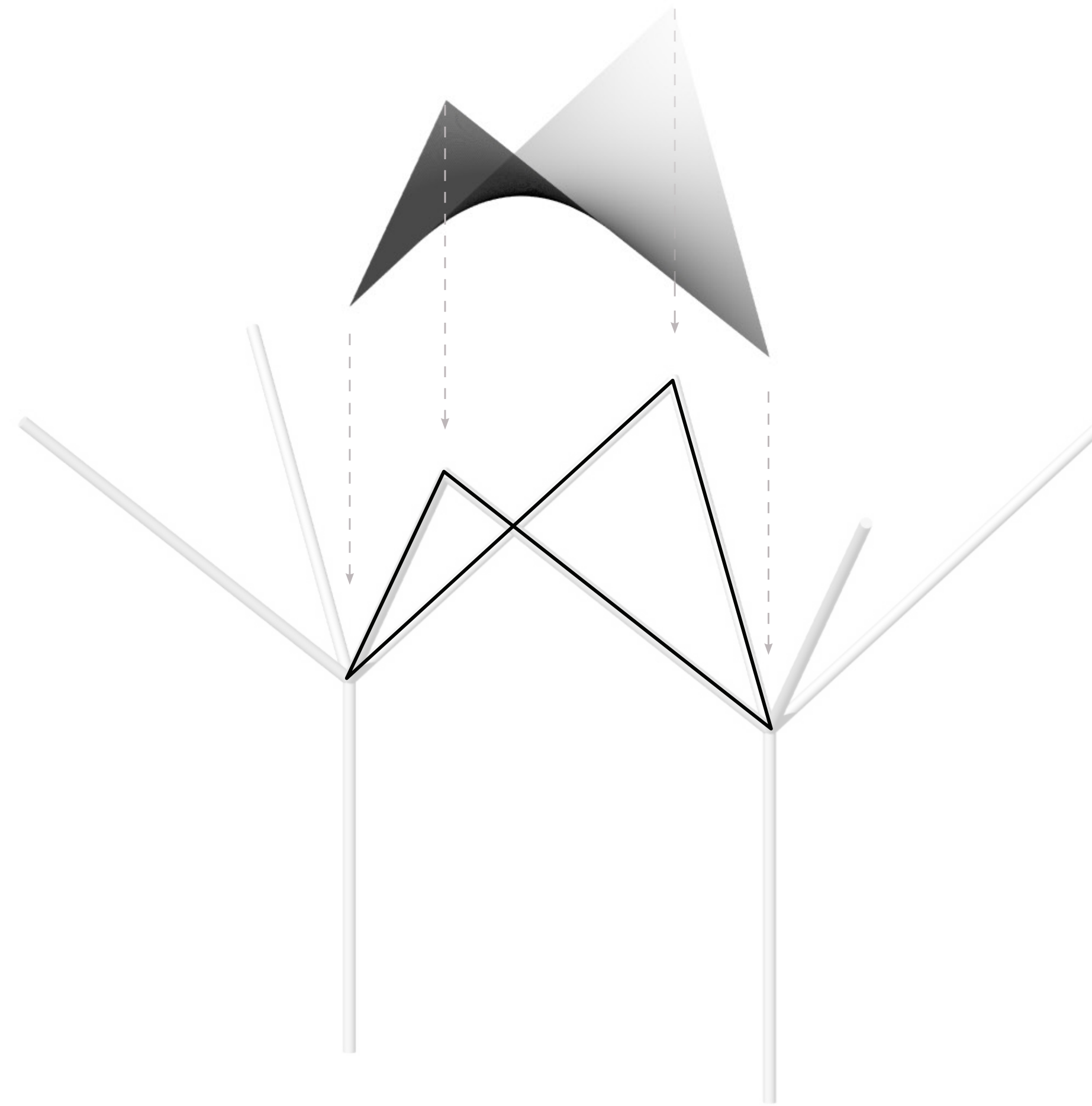
further research - main concept



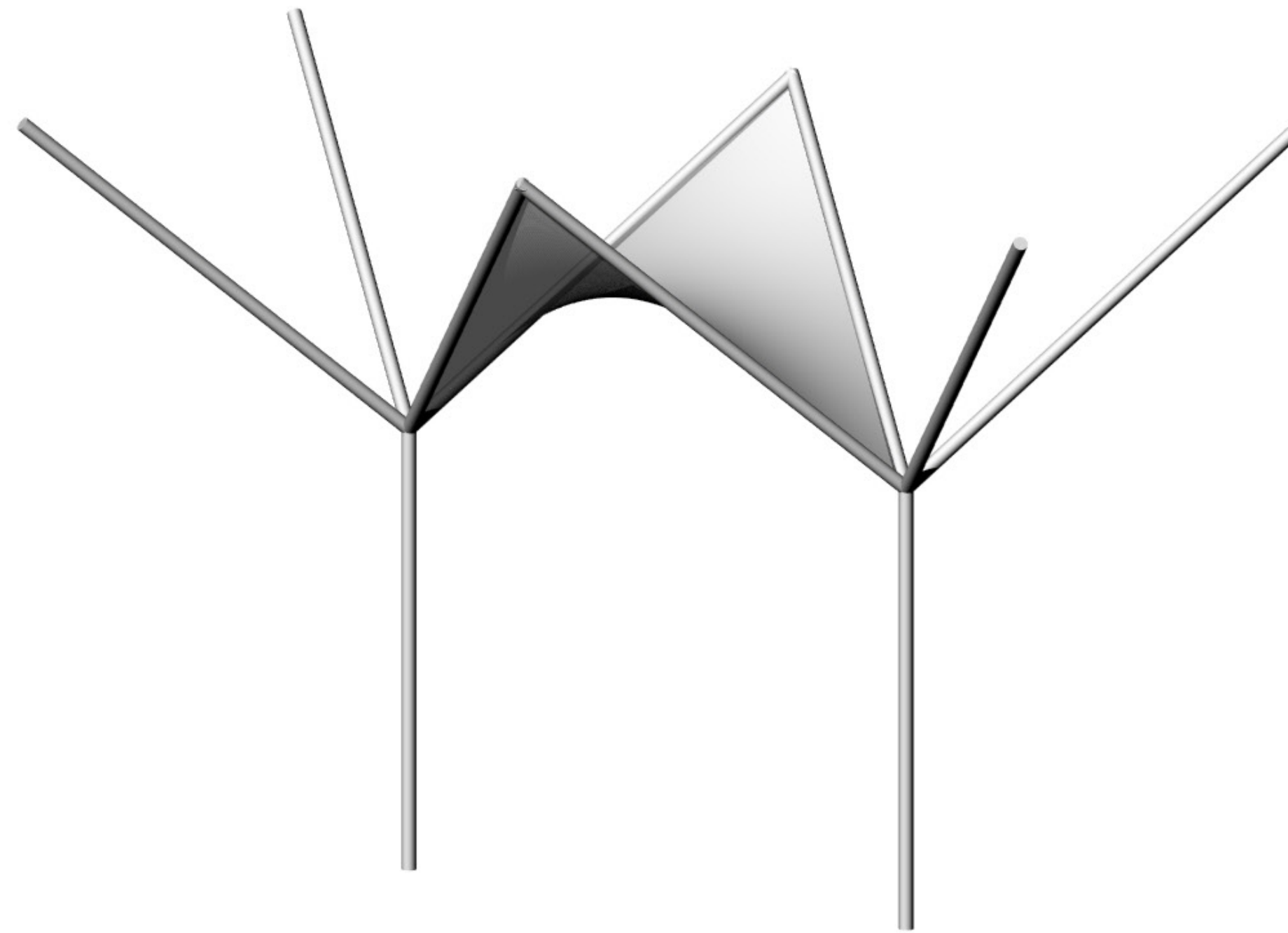
further research - main concept



further research - main concept



further research - main concept

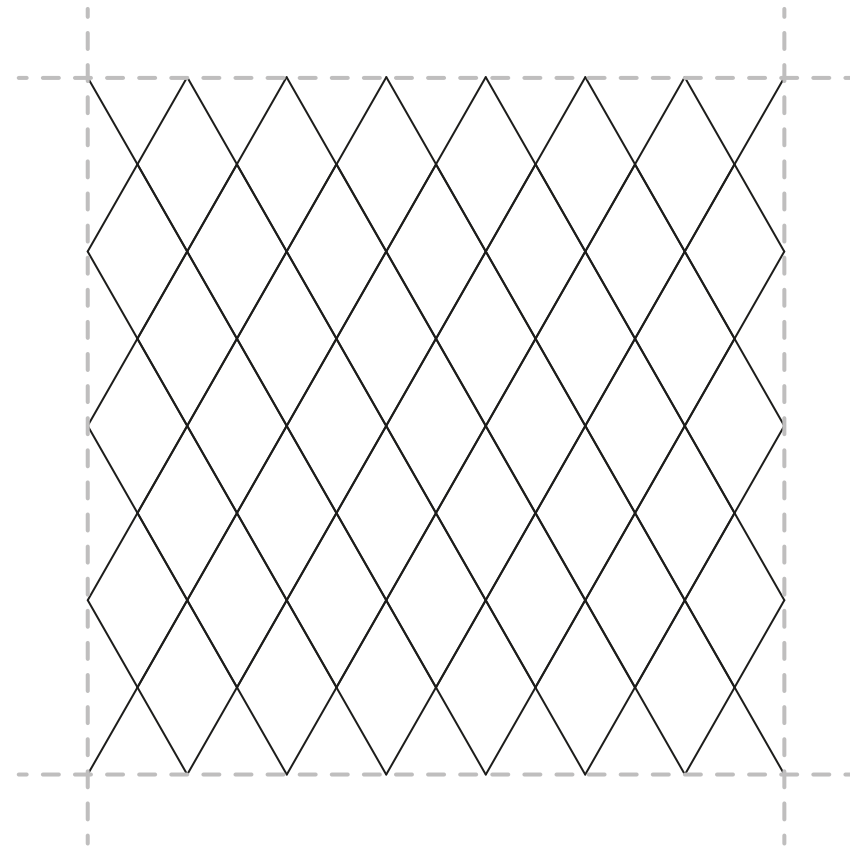


further research - constraint

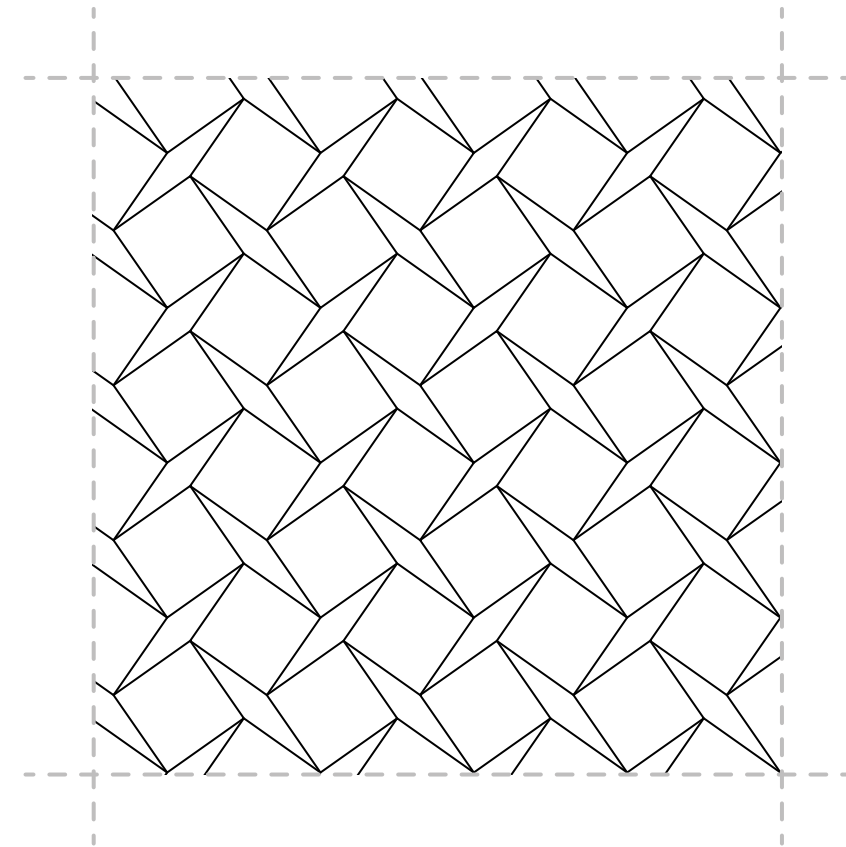
The branches of the last iteration need to comprise closed diamonds - a quadrilateral grid

further research - constraint

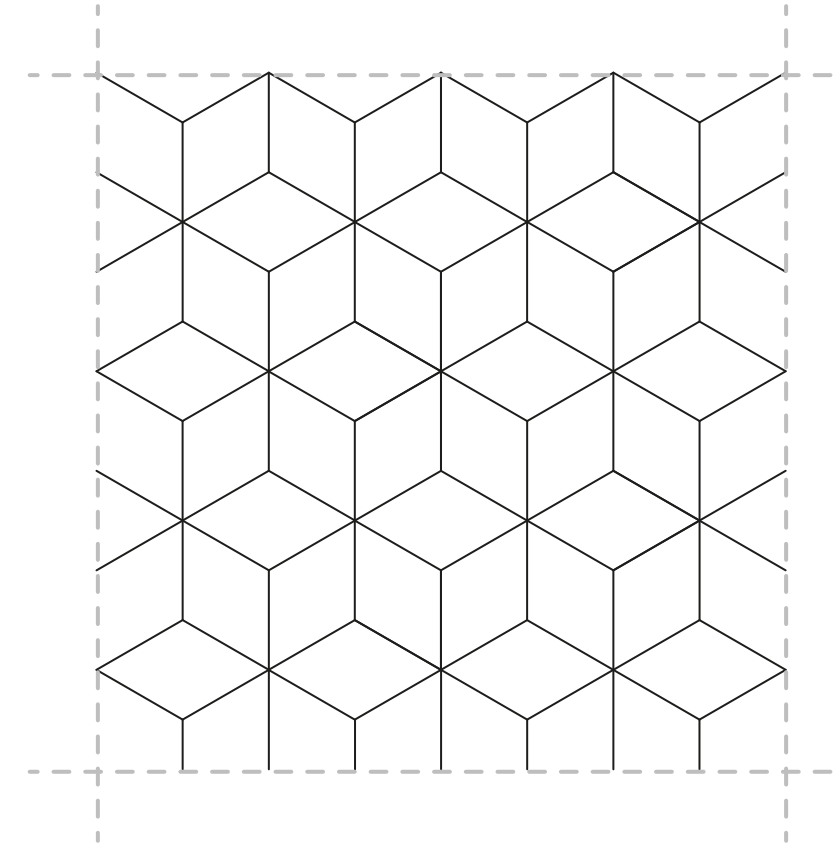
SQUARED QUADRILATERAL



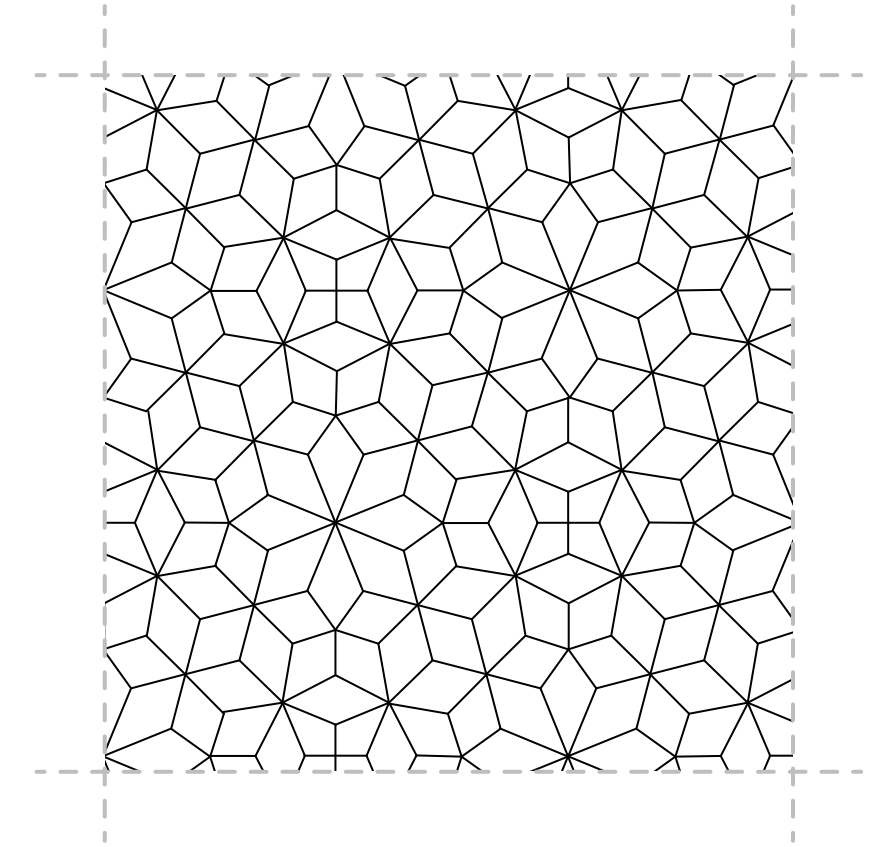
SQUARED QUADRILATERAL



HEXAGONAL QUADRILATERAL

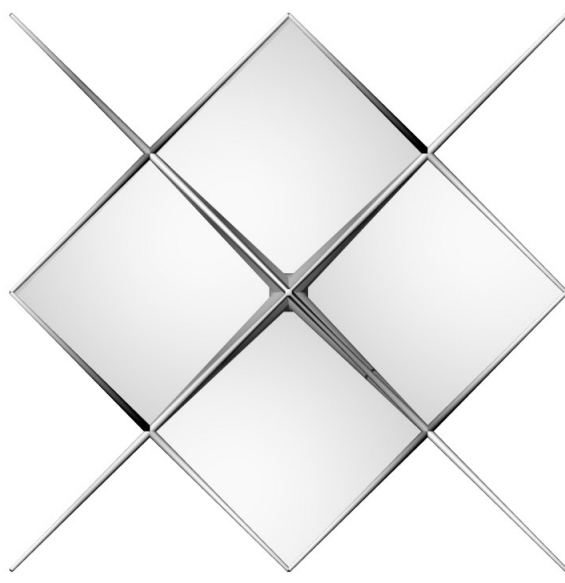
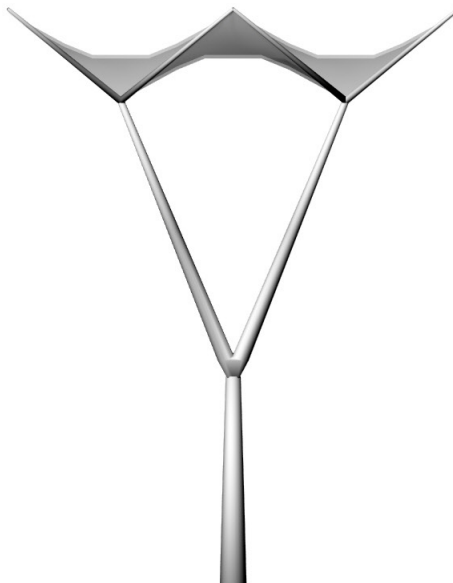
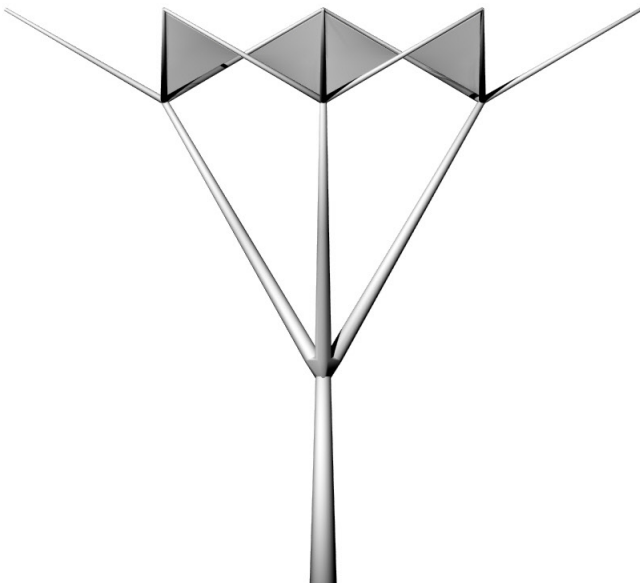
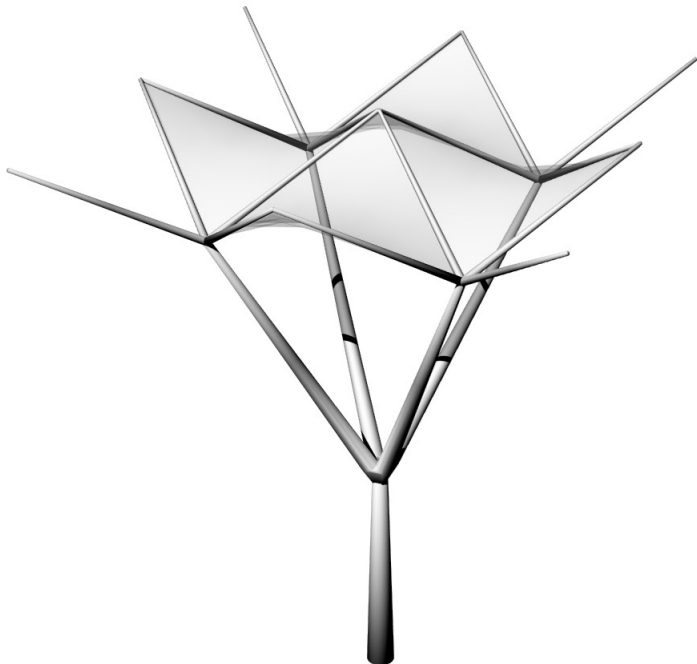


APERIODIC QUADRILATERAL

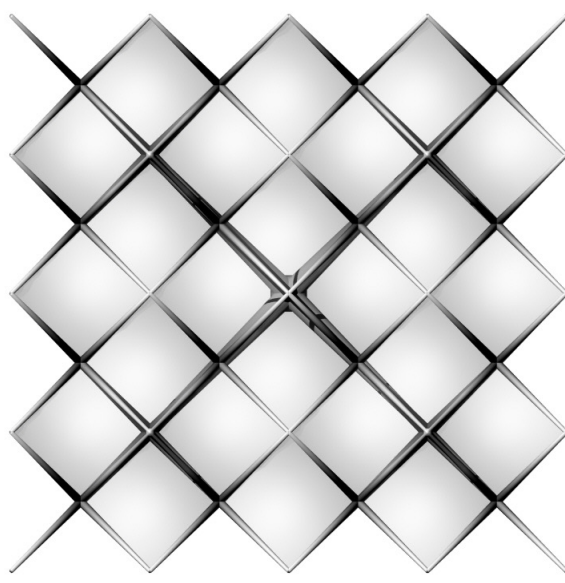
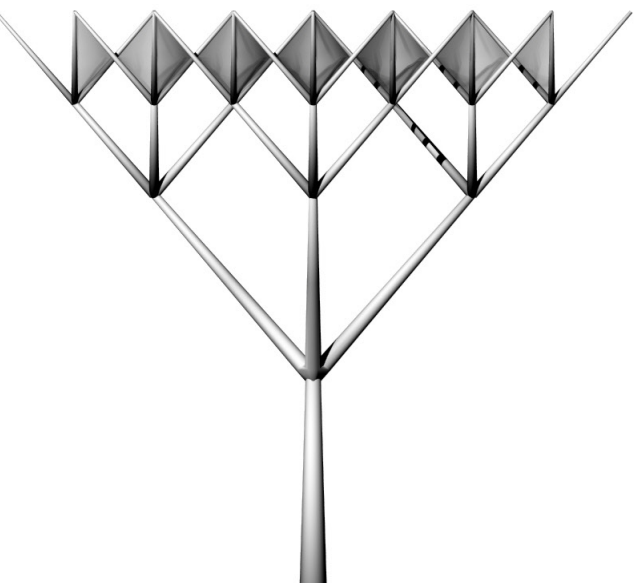
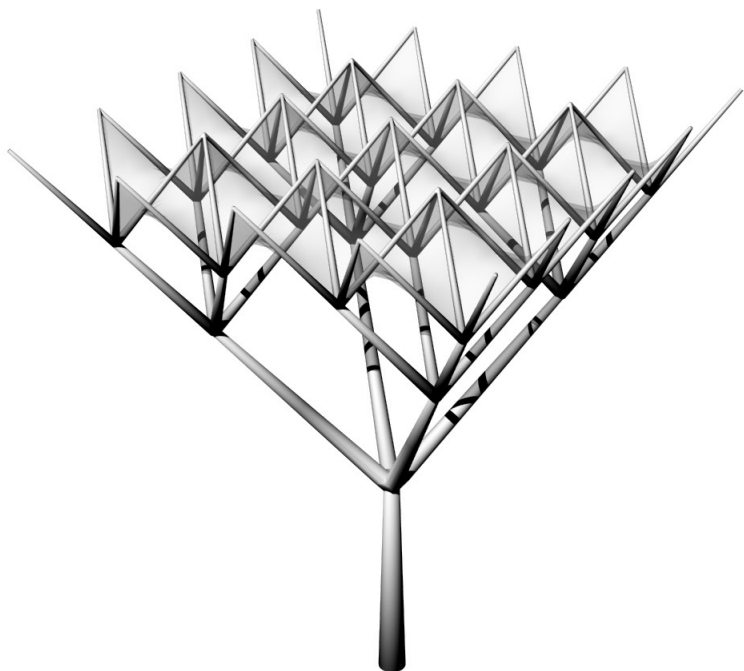


parameters & variations

SQUARED QUADRILATERAL
2 ITERATIONS

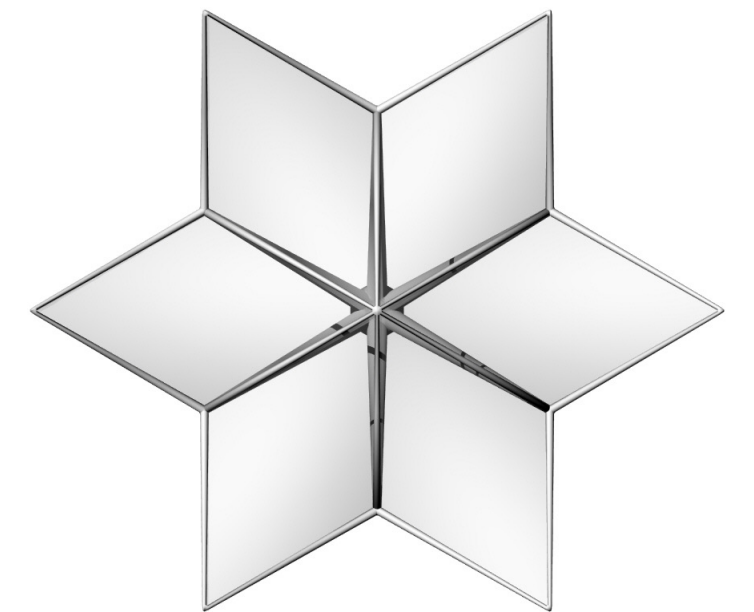
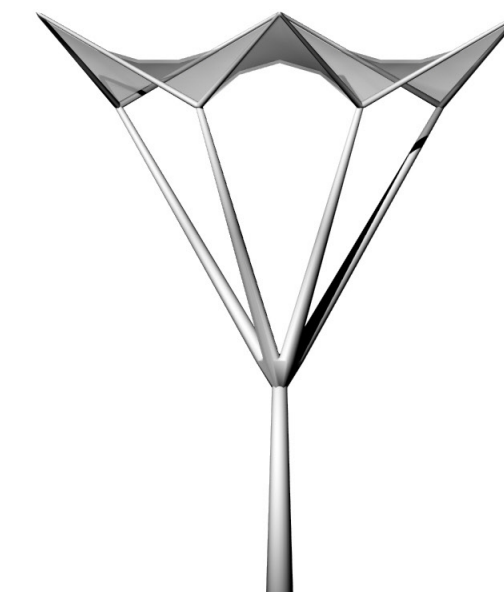
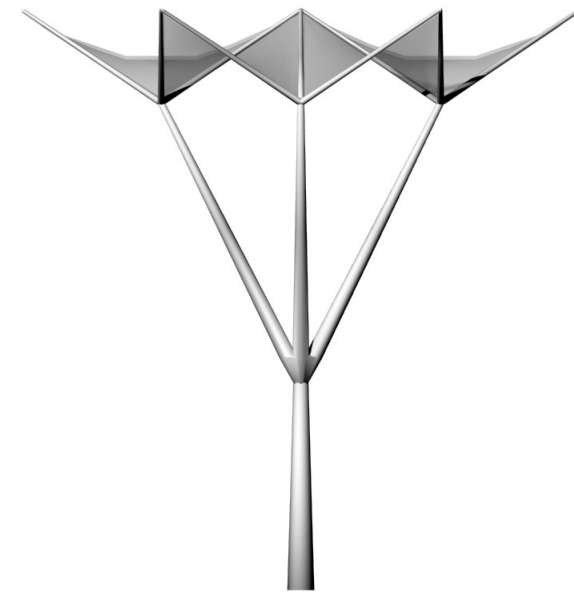


SQUARED QUADRILATERAL
3 ITERATIONS

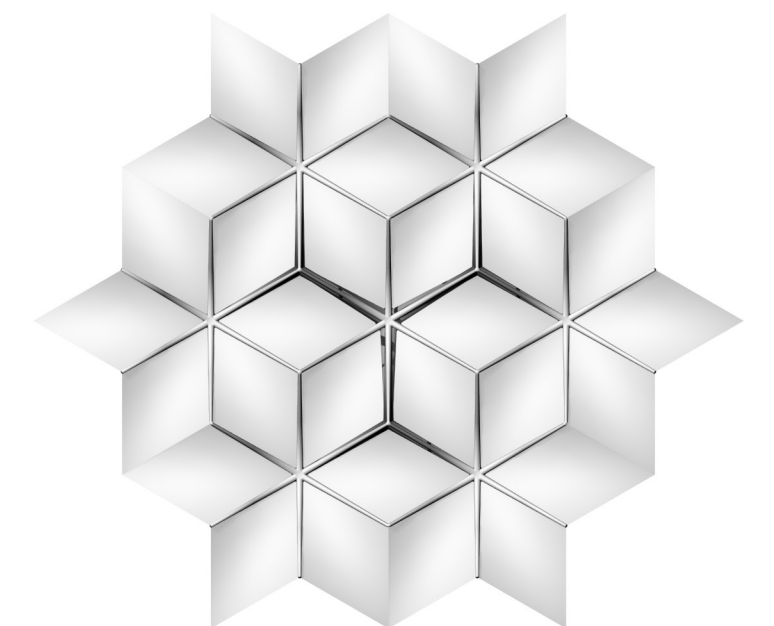
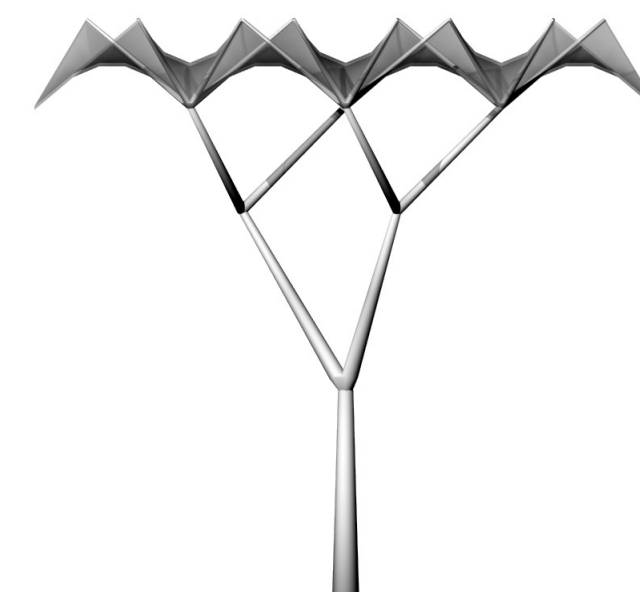
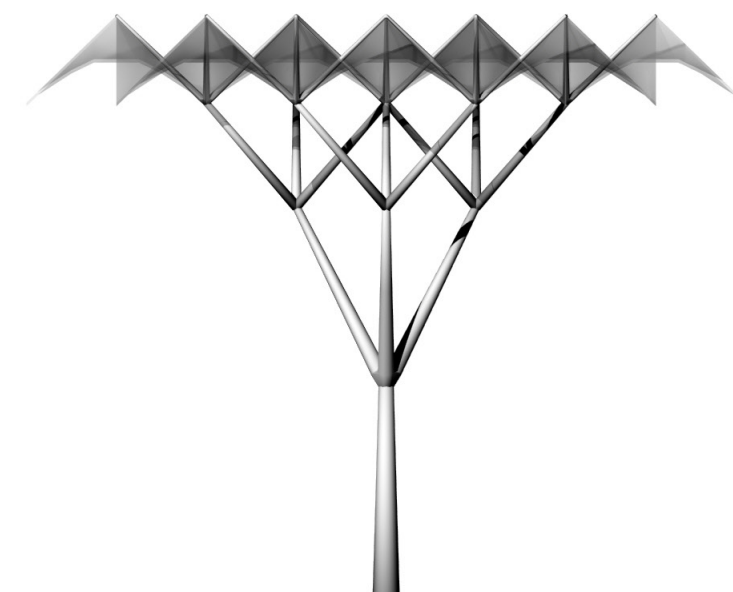
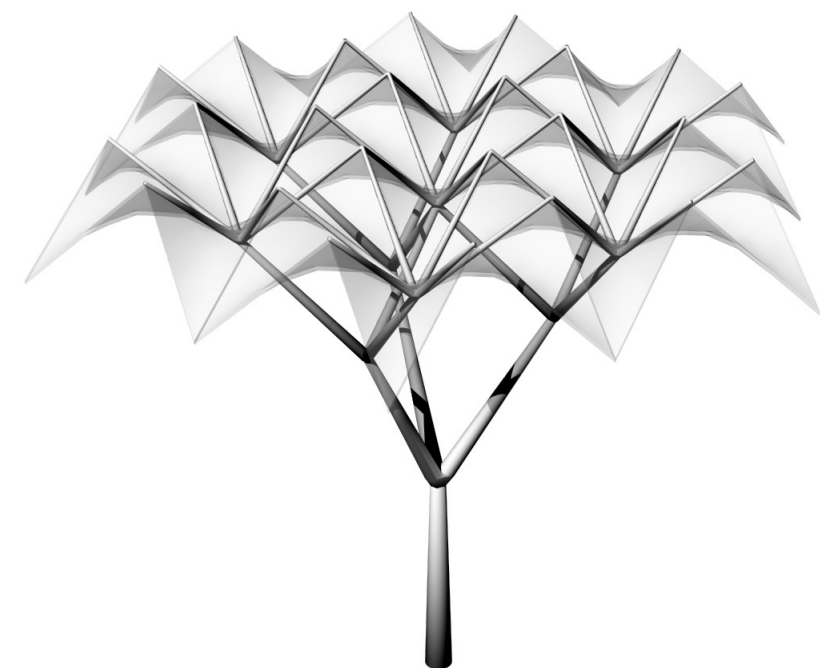


parameters & variations

HEXAGONAL QUADRILATERAL
2 ITERATIONS



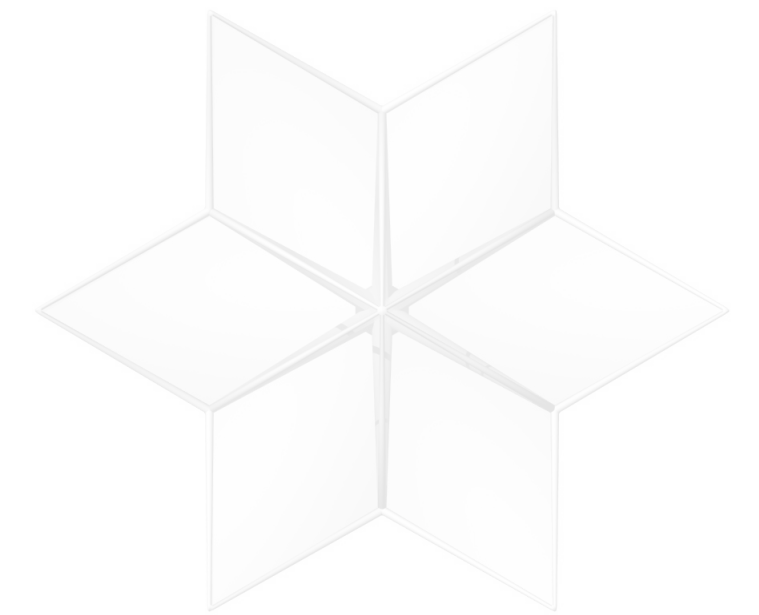
HEXAGONAL QUADRILATERAL
3 ITERATIONS



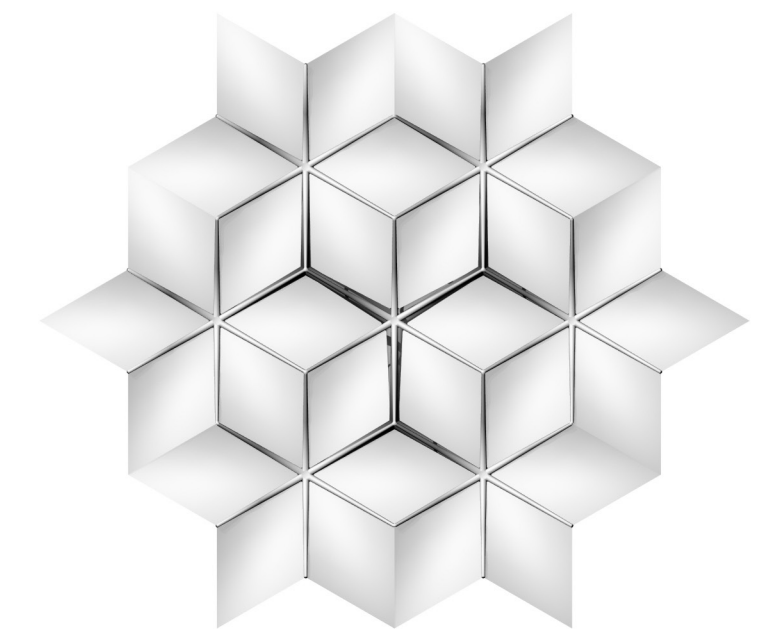
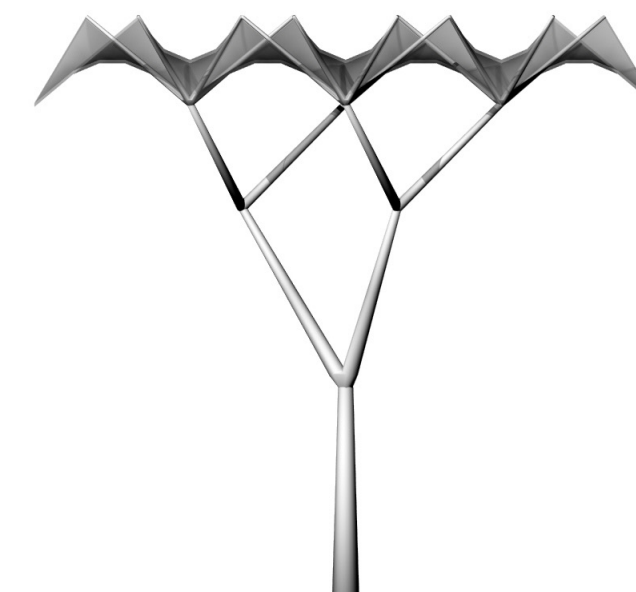
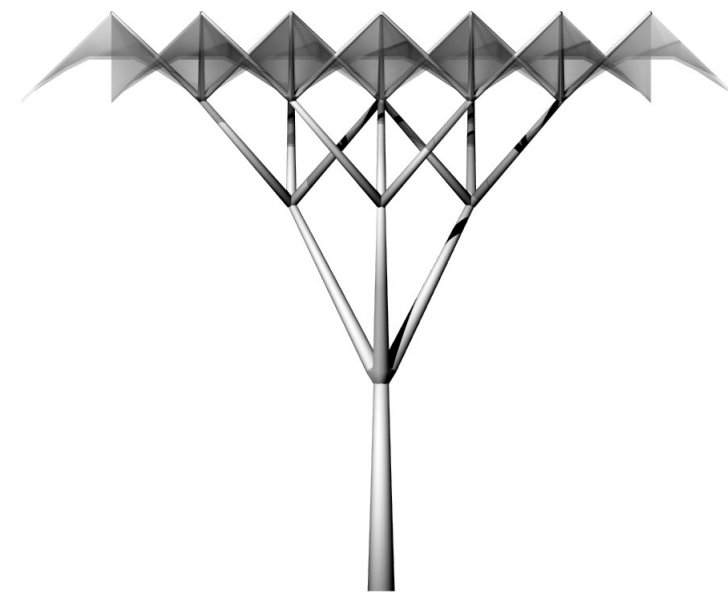
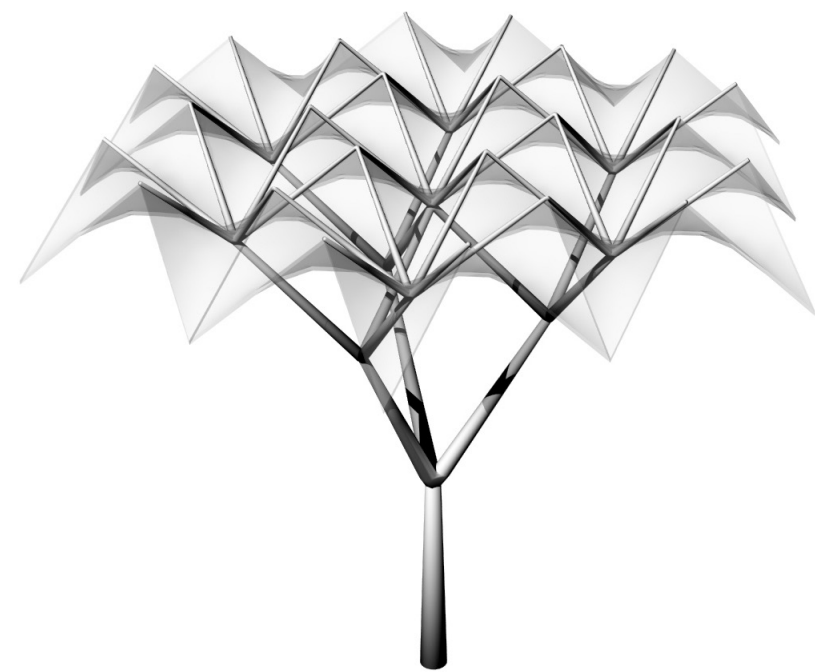
4. DESIGN CONCEPT

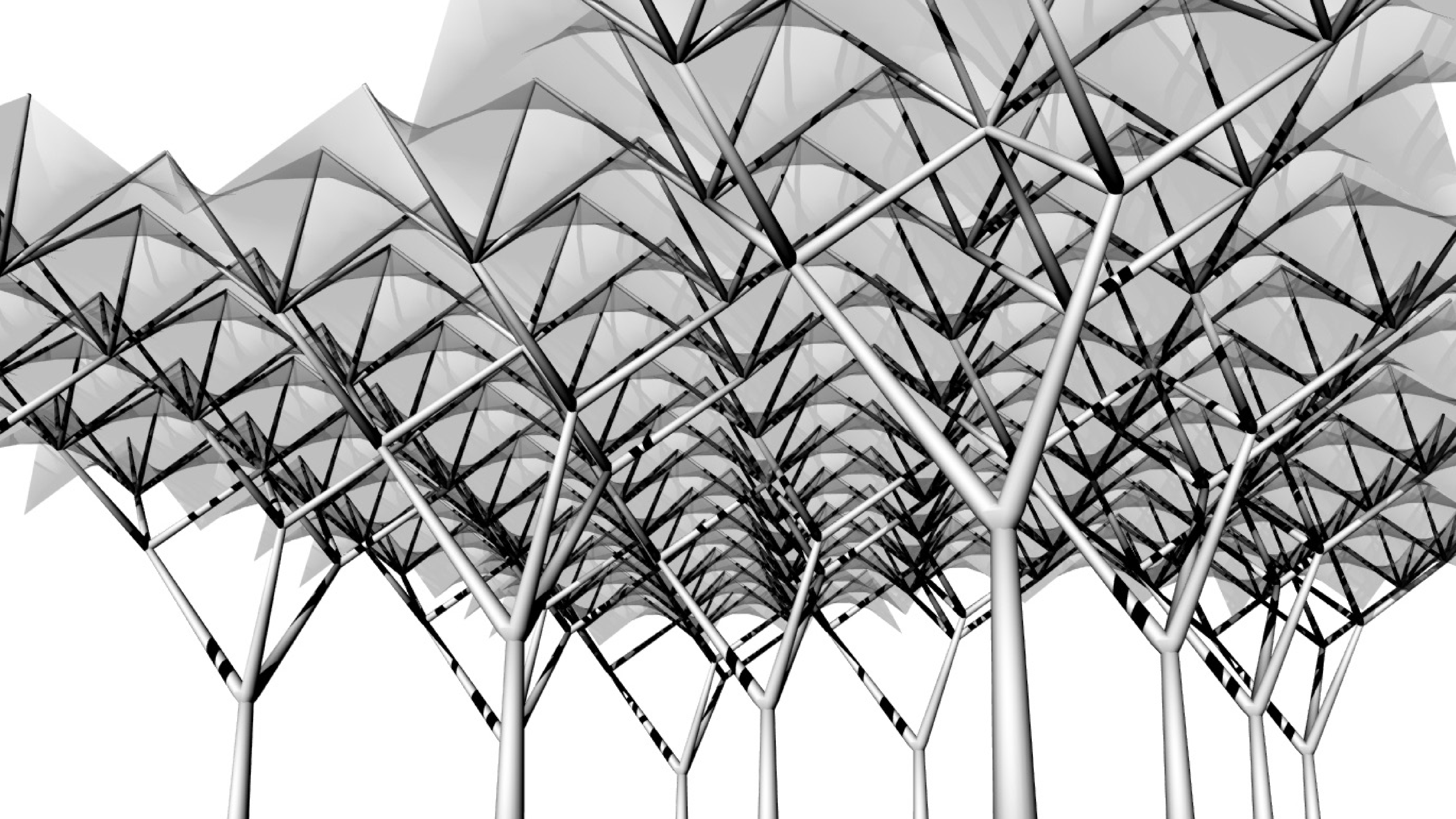
parameters & variations

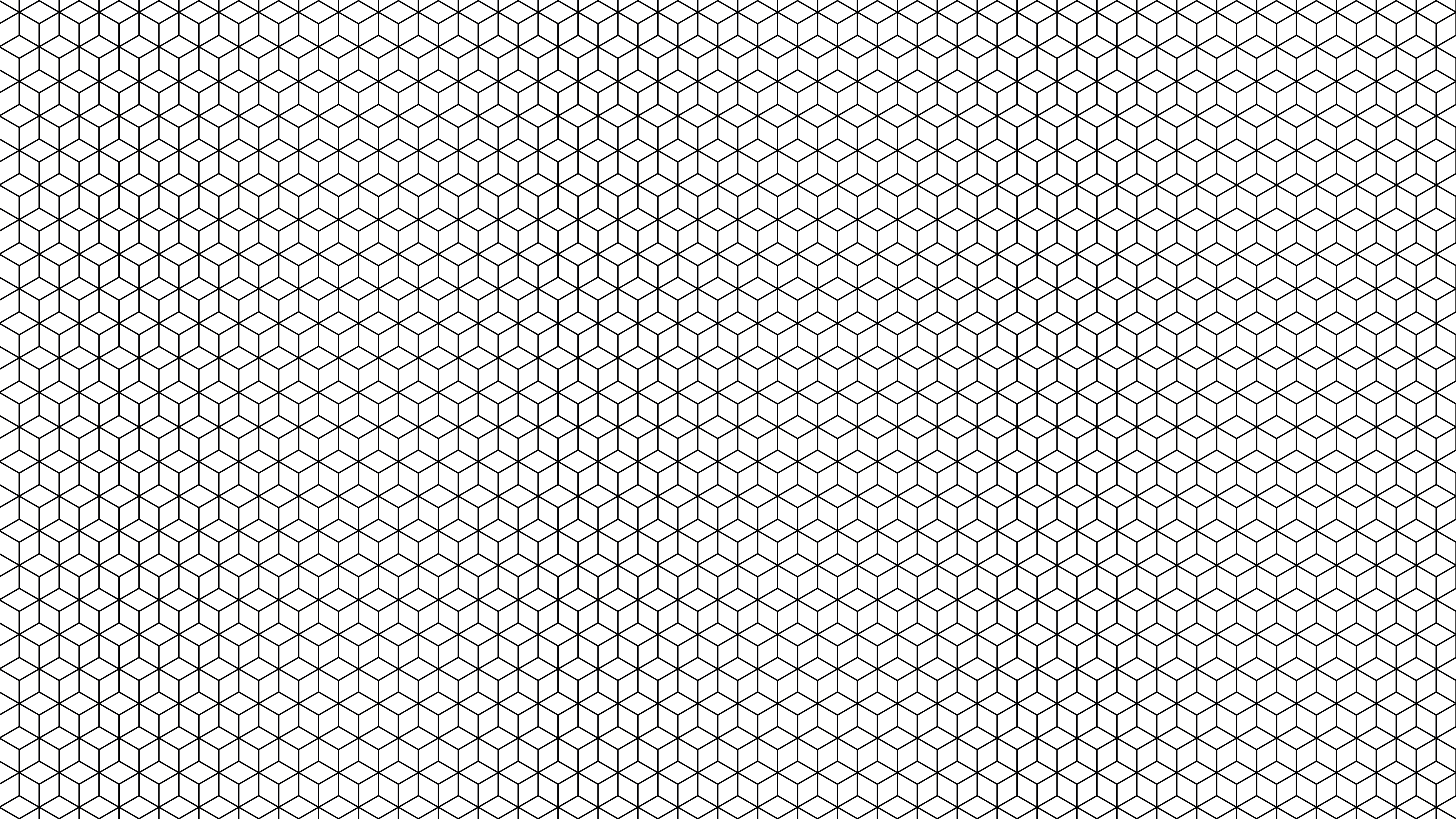
HEXAGONAL QUADRILATERAL
2 ITERATIONS

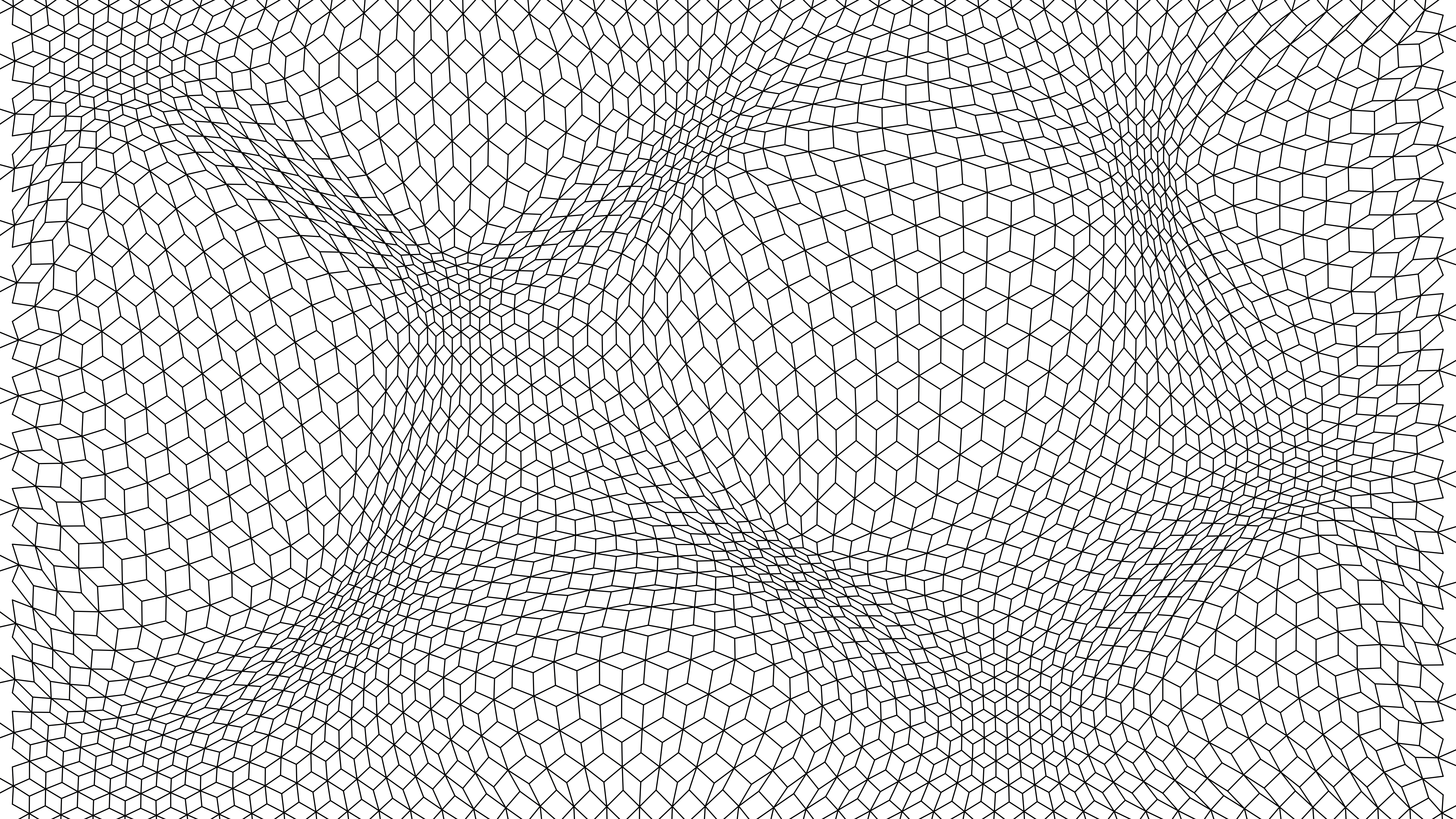


HEXAGONAL QUADRILATERAL
3 ITERATIONS







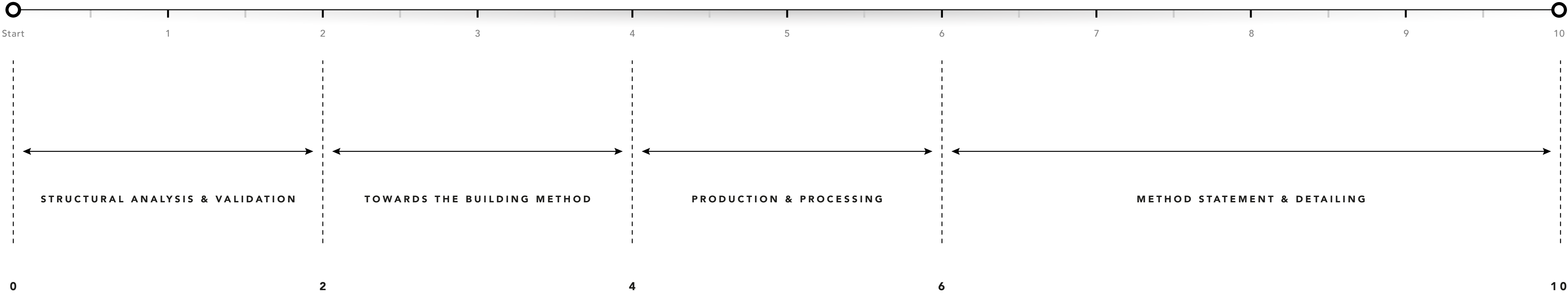




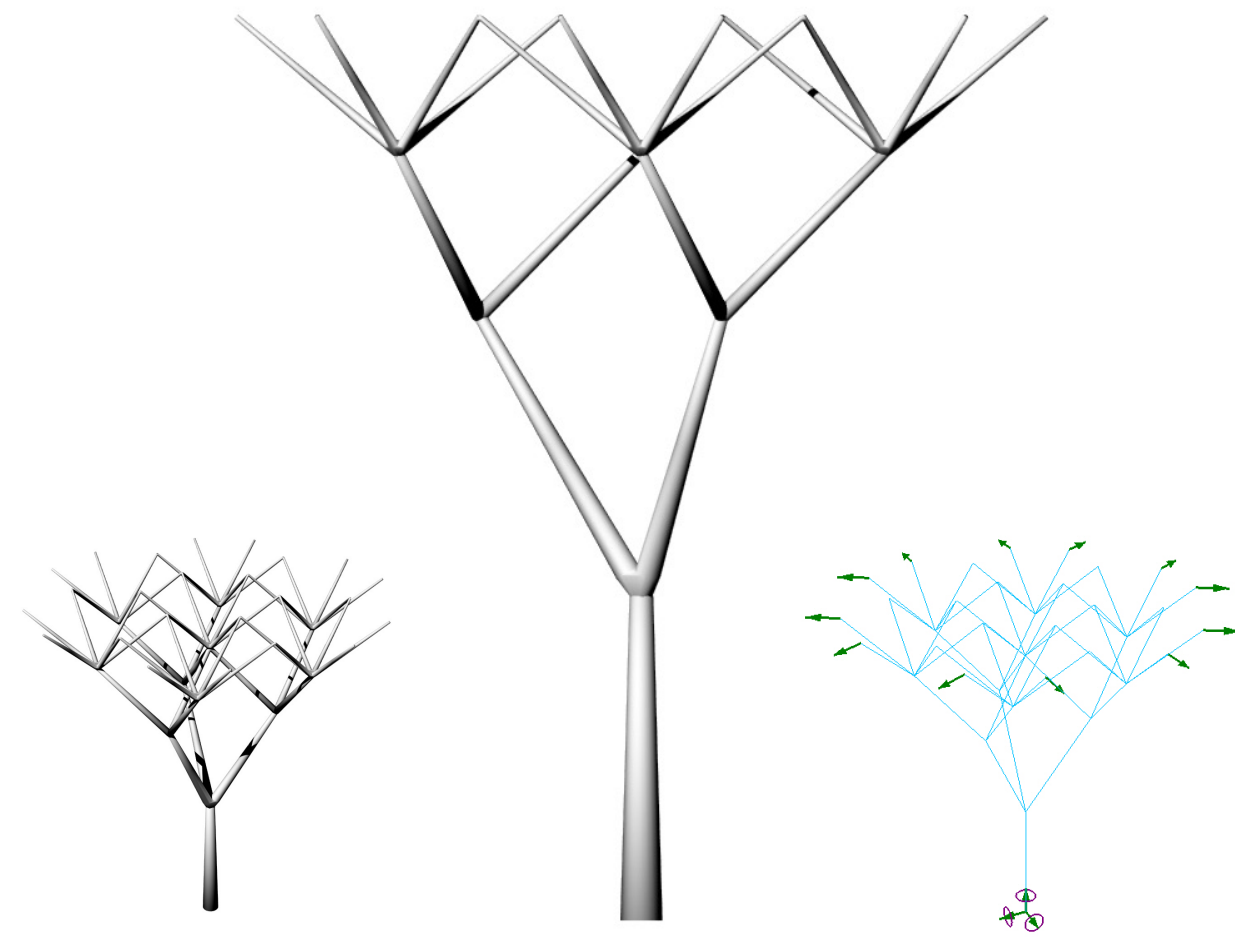
design development

timeline

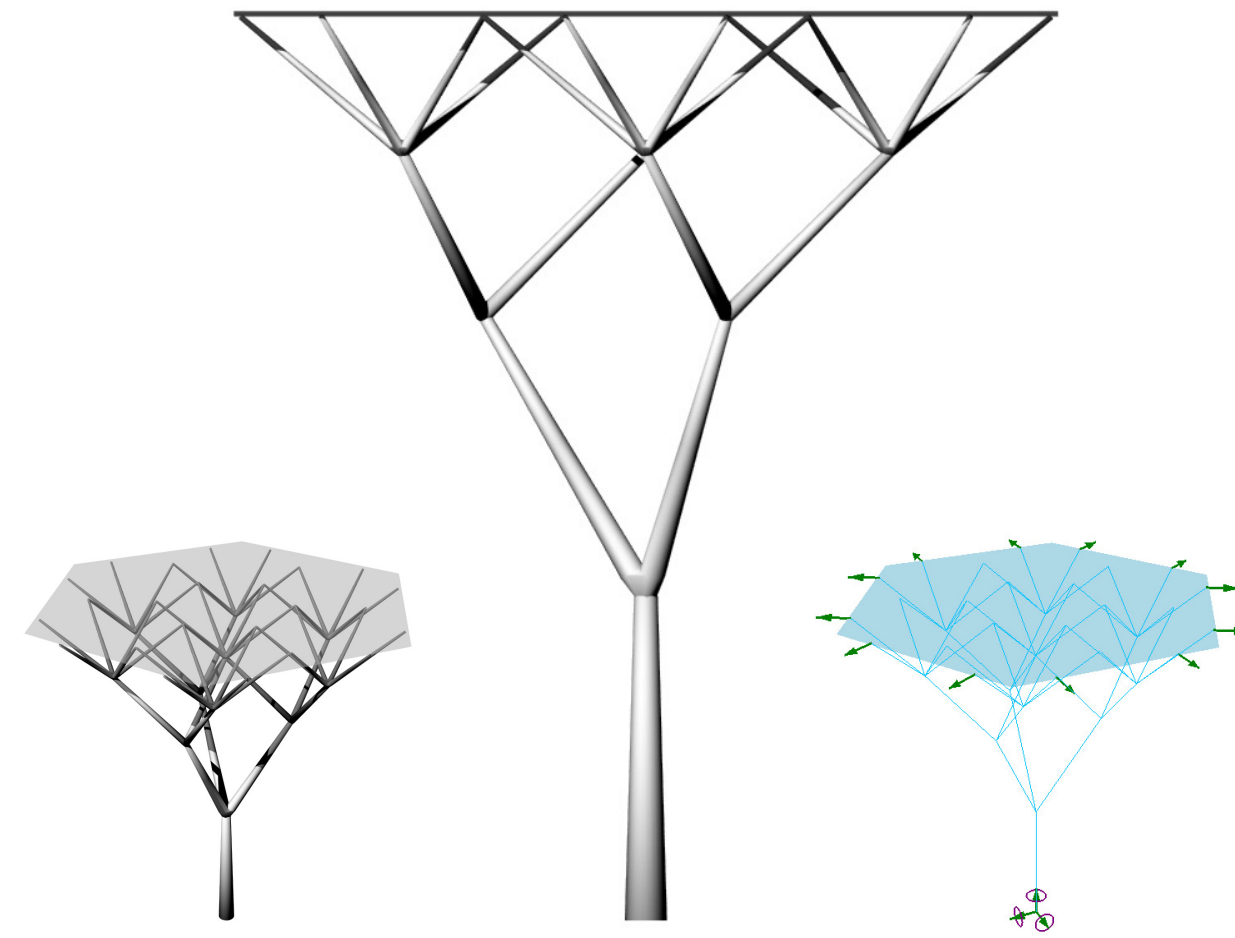
10 MINUTES



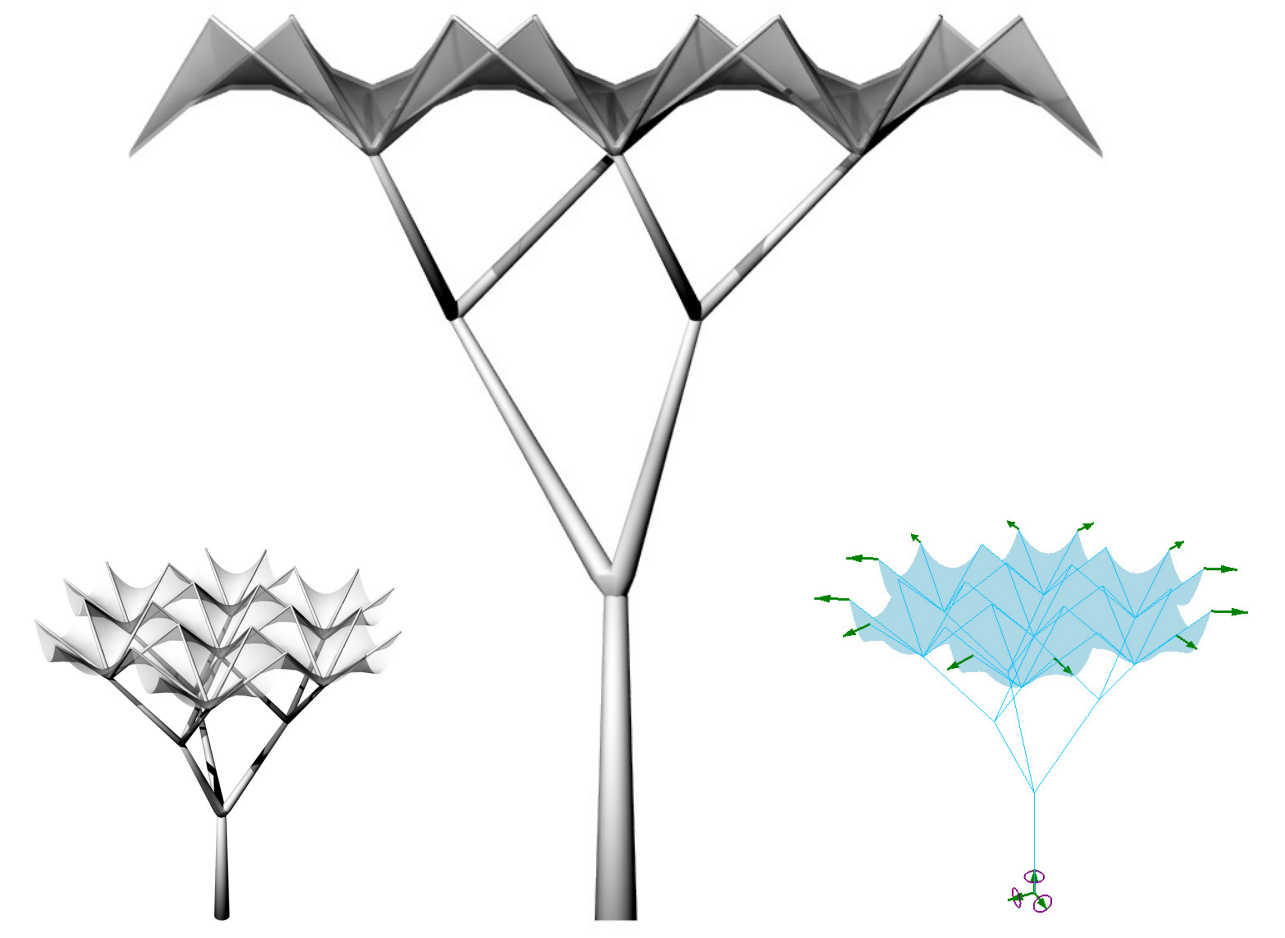
structural analysis & validation



WITHOUT ROOF

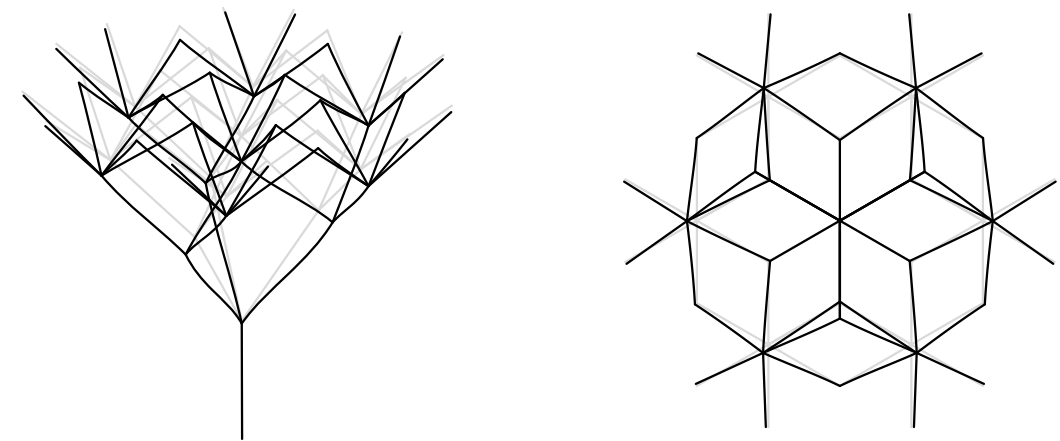
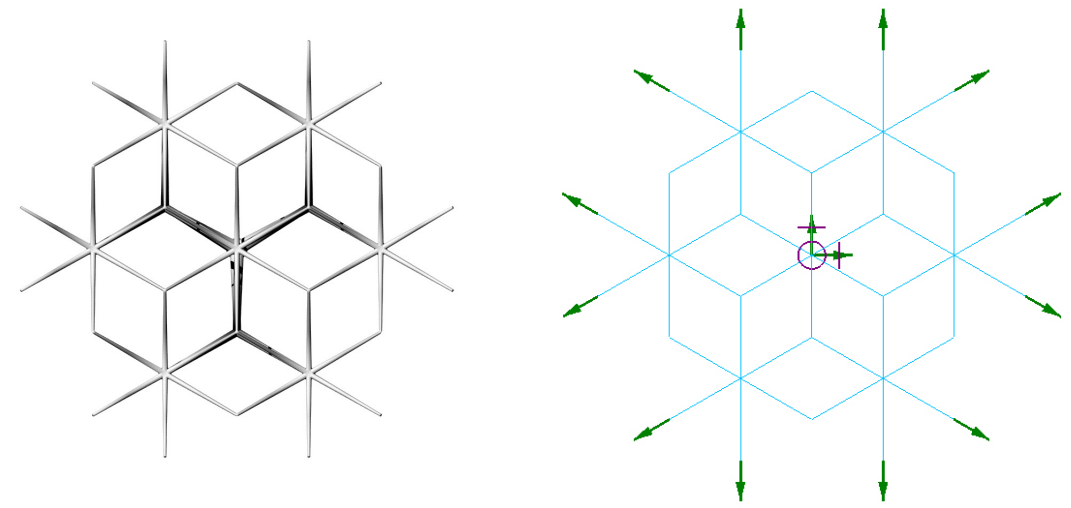


FLAT ROOF

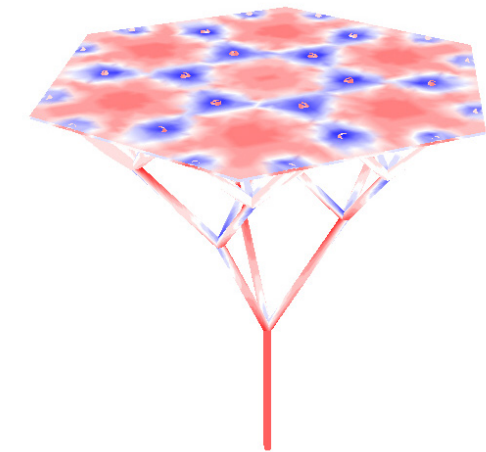
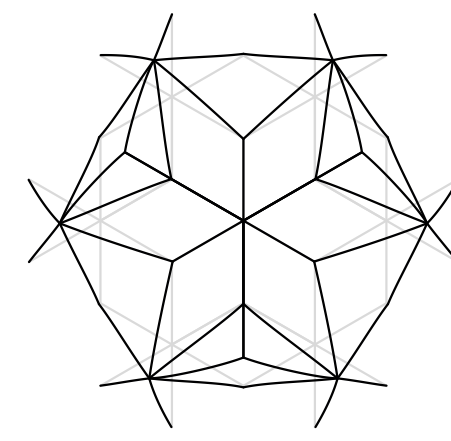
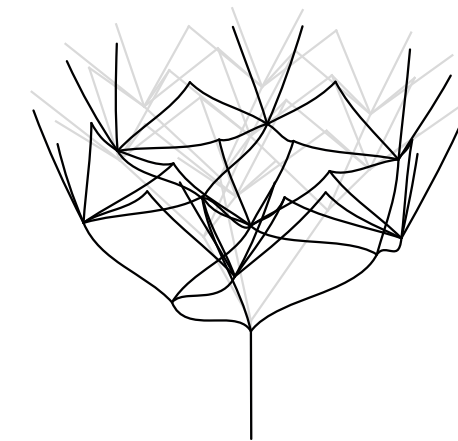
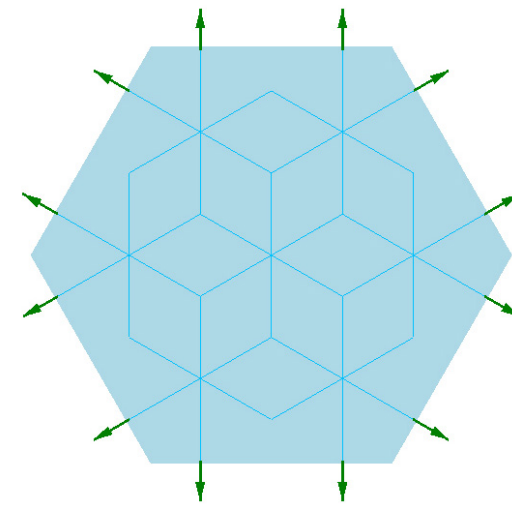
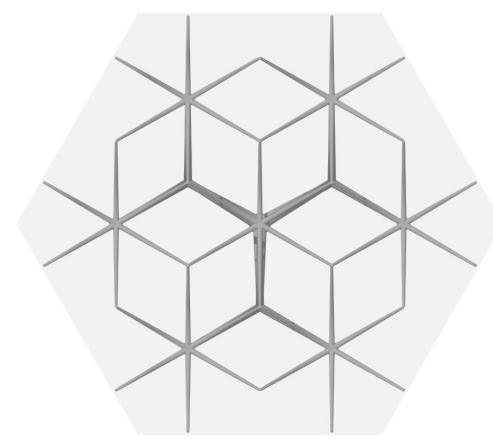


DOUBLE CURVED ROOF

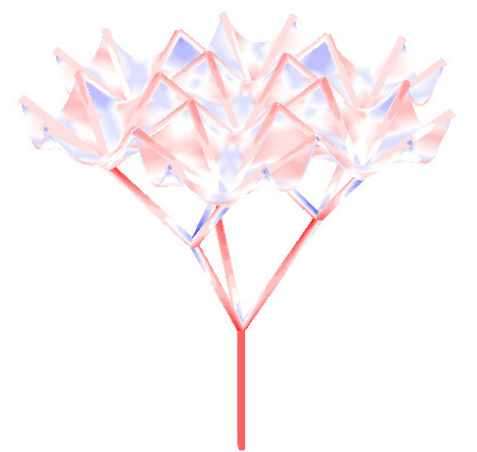
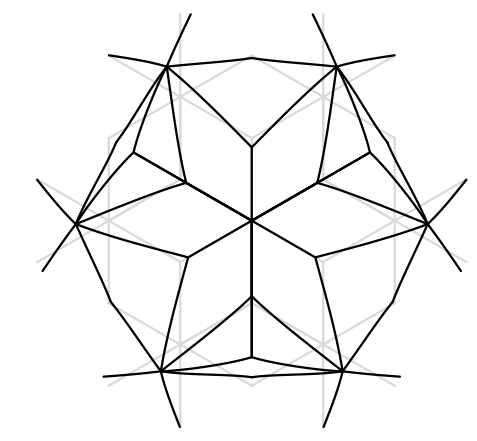
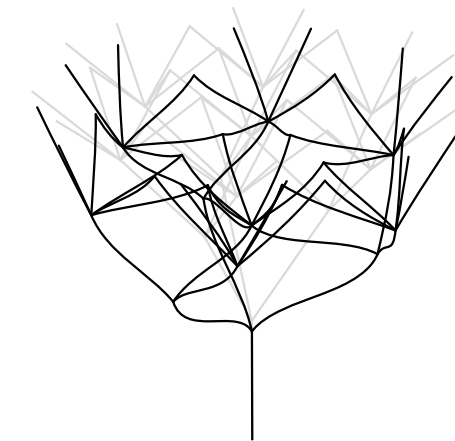
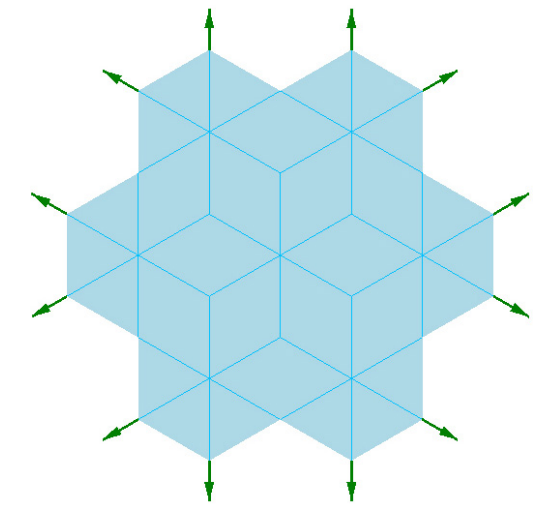
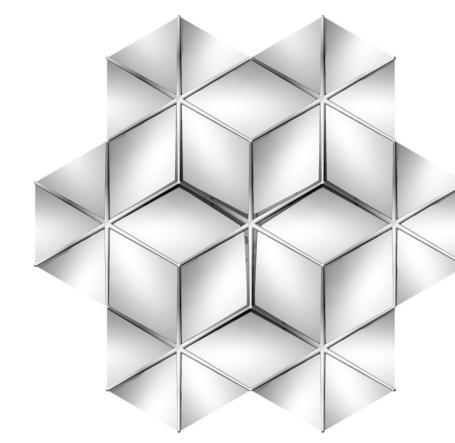
structural analysis & validation



WITHOUT ROOF

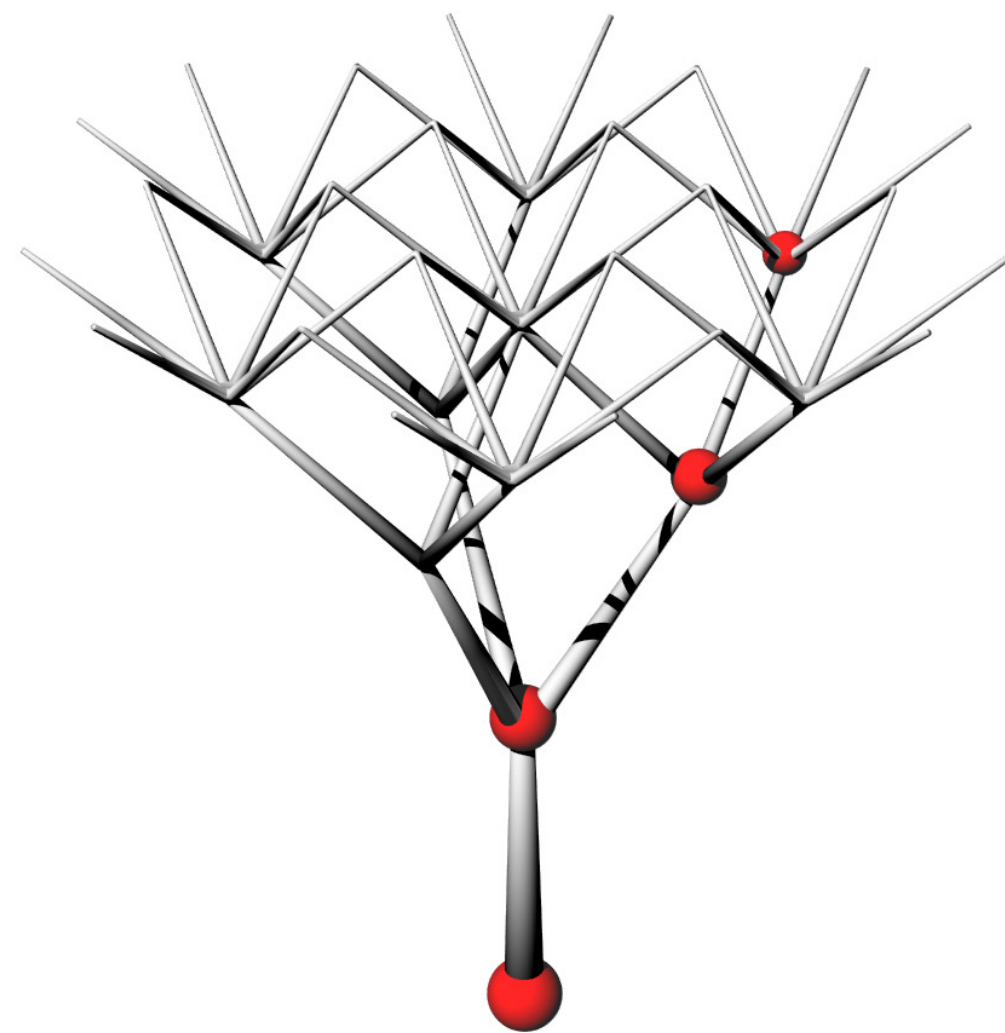


FLAT ROOF

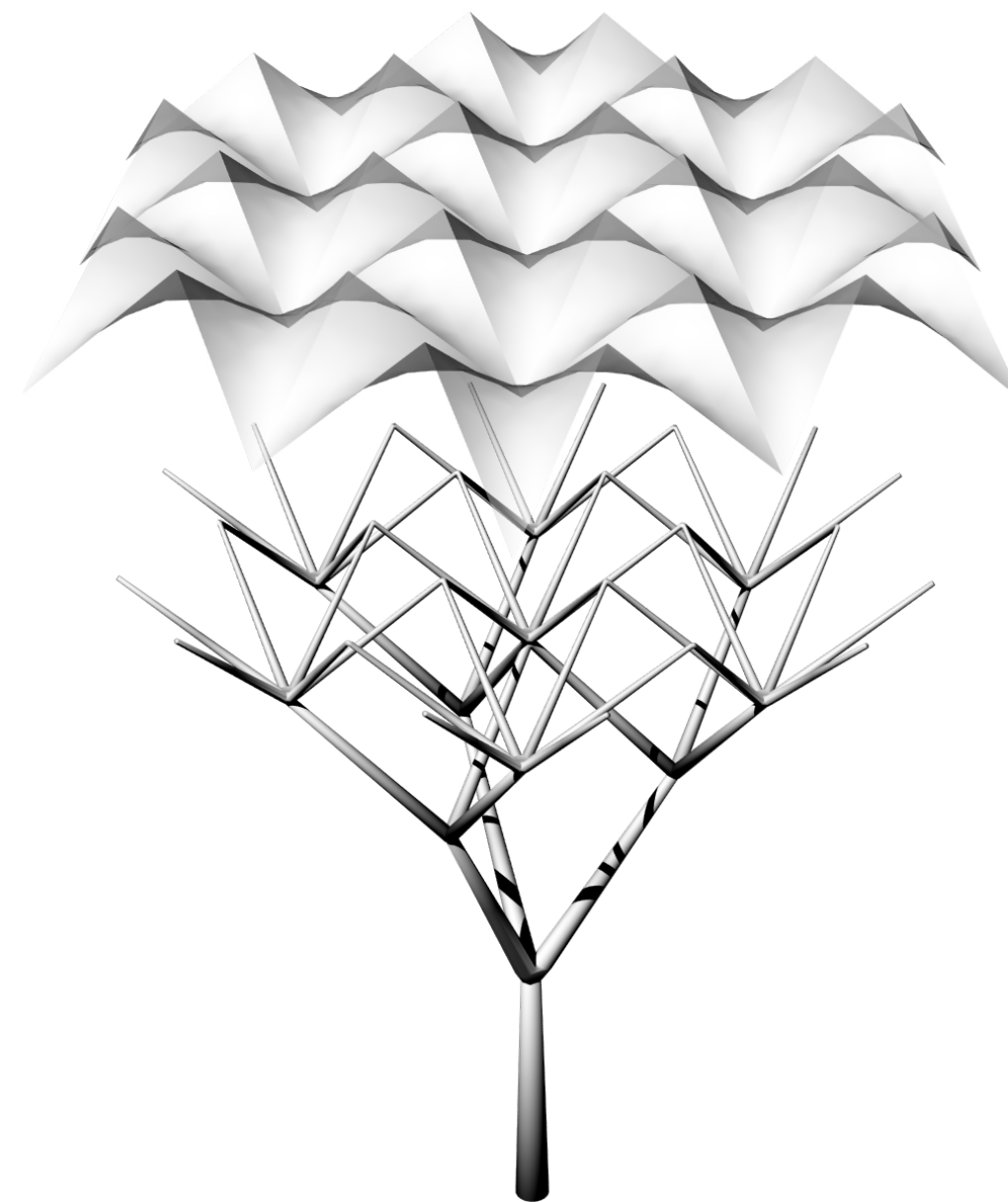


DOUBLE CURVED ROOF

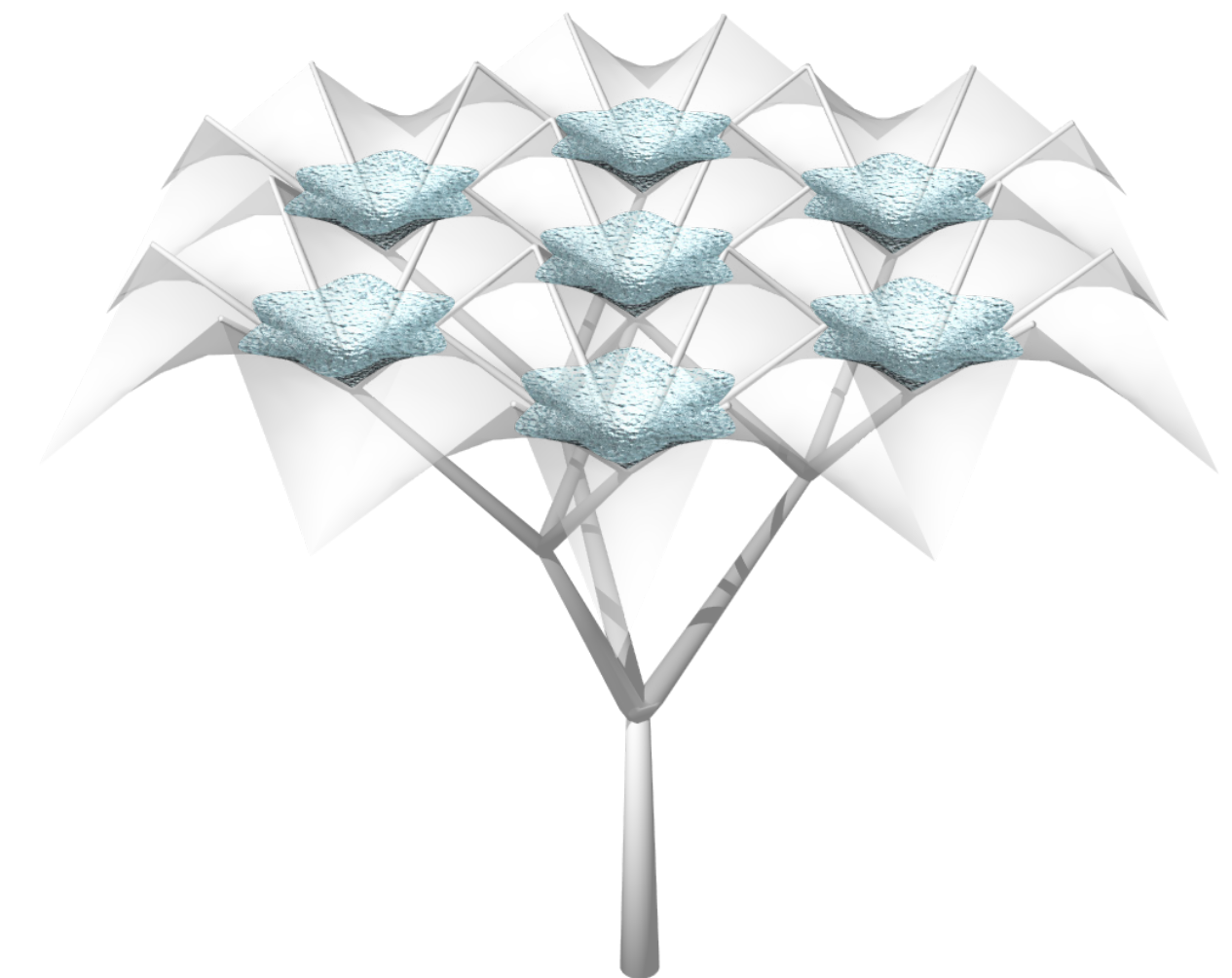
first steps towards the building method



BRANCHING CONNECTIONS

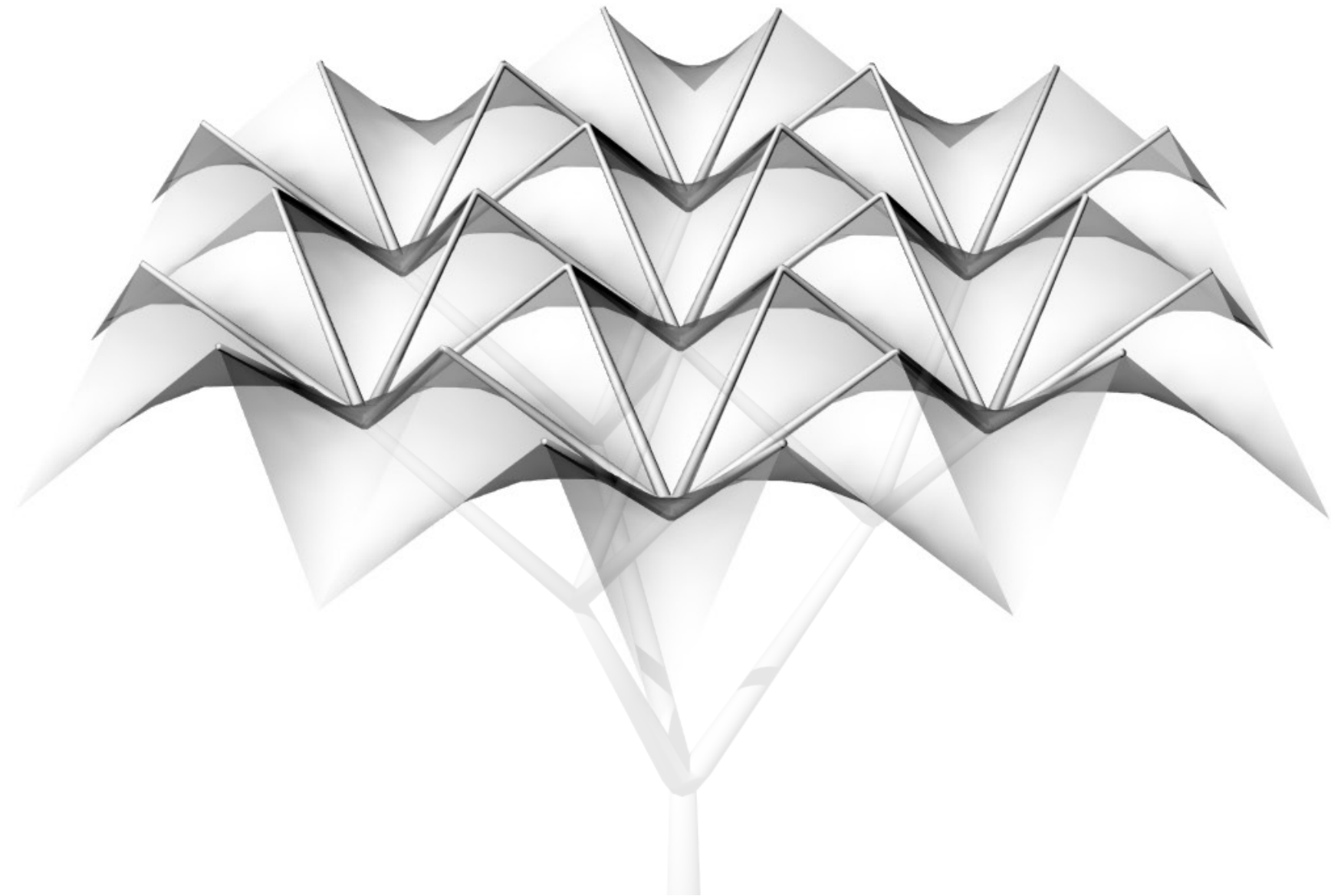


ASSEMBLY STRUCTURAL COMPONENTS

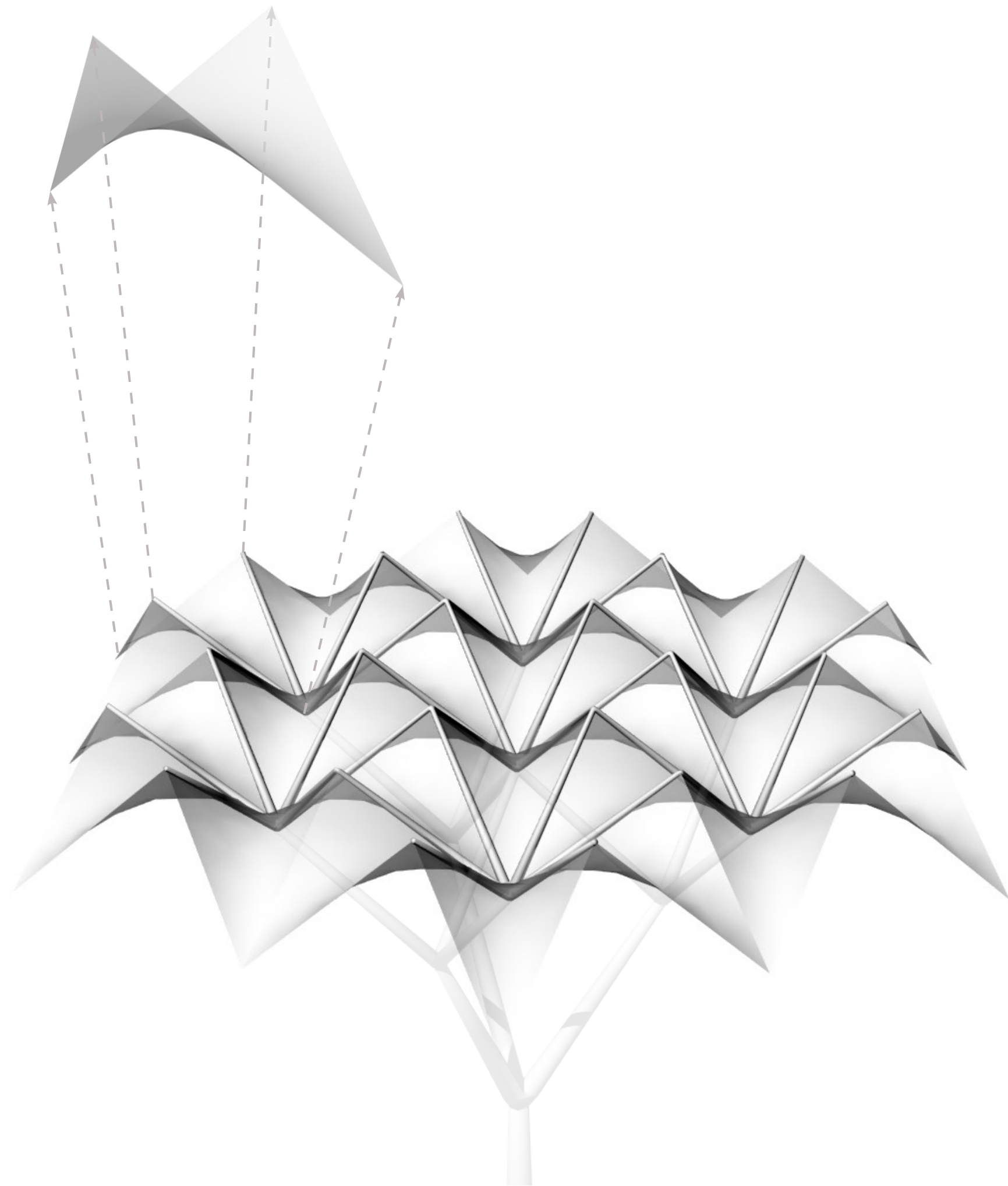


WATERMANAGEMENT

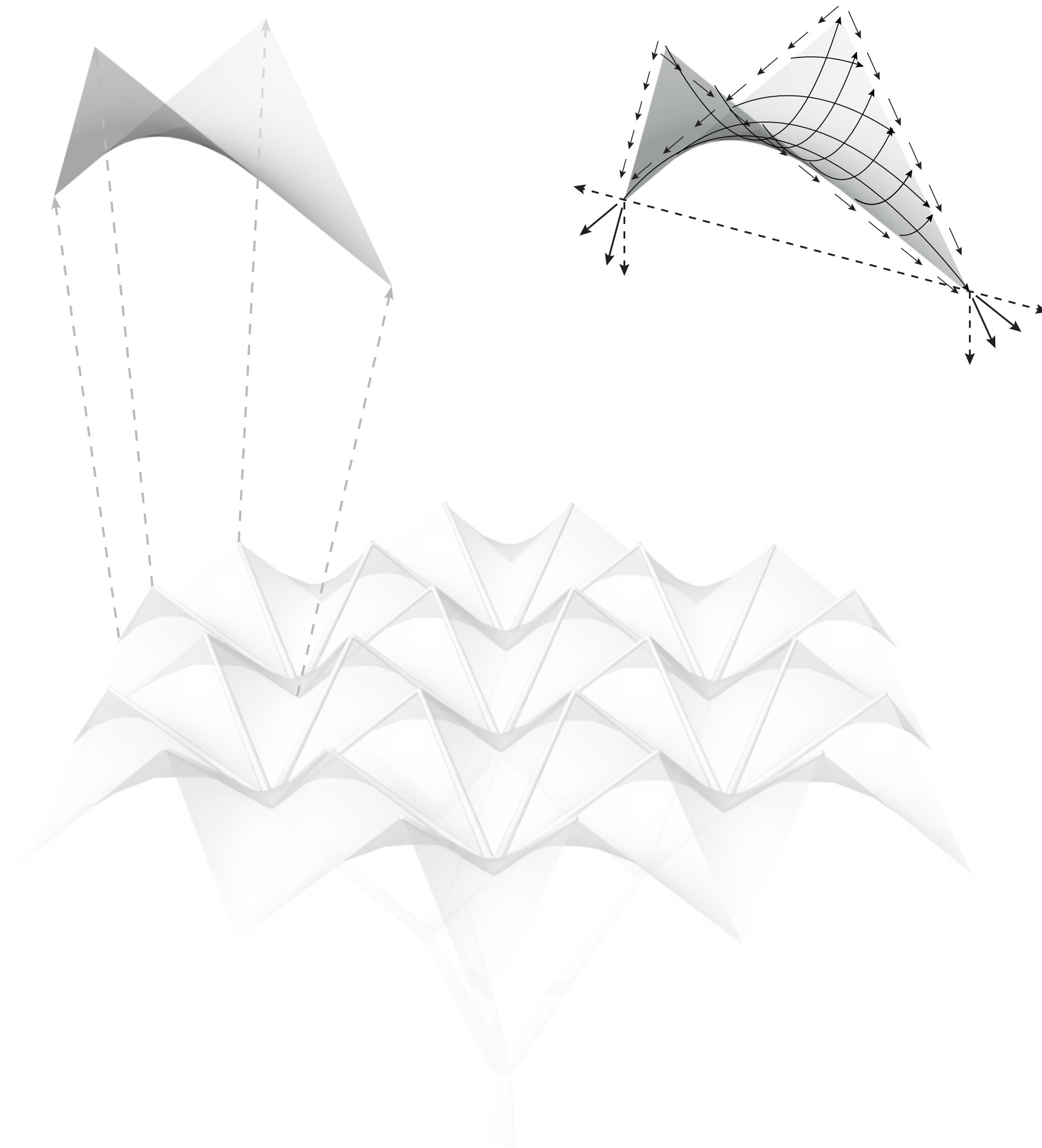
first steps - straight generatrices



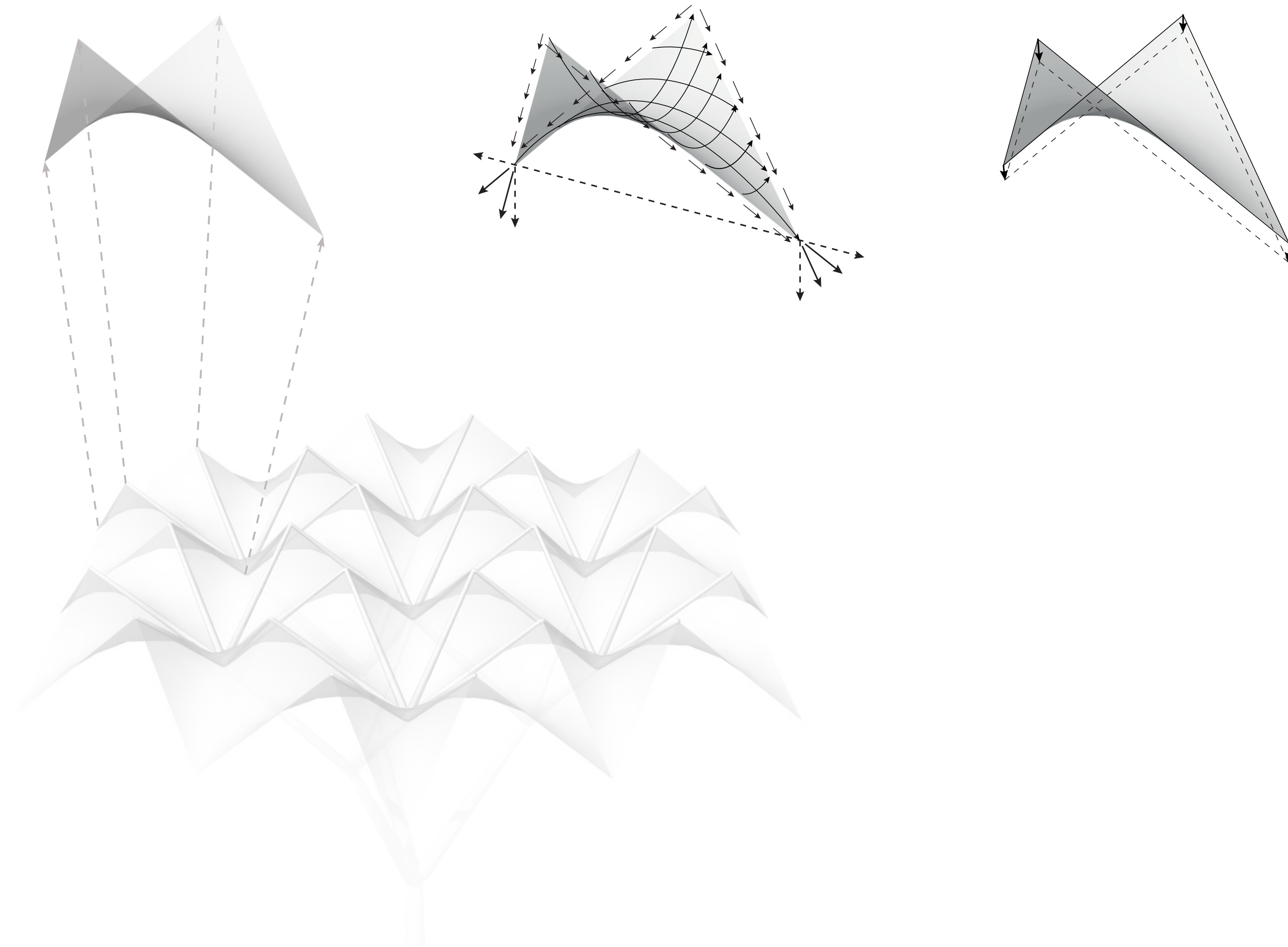
first steps - straight generatrices



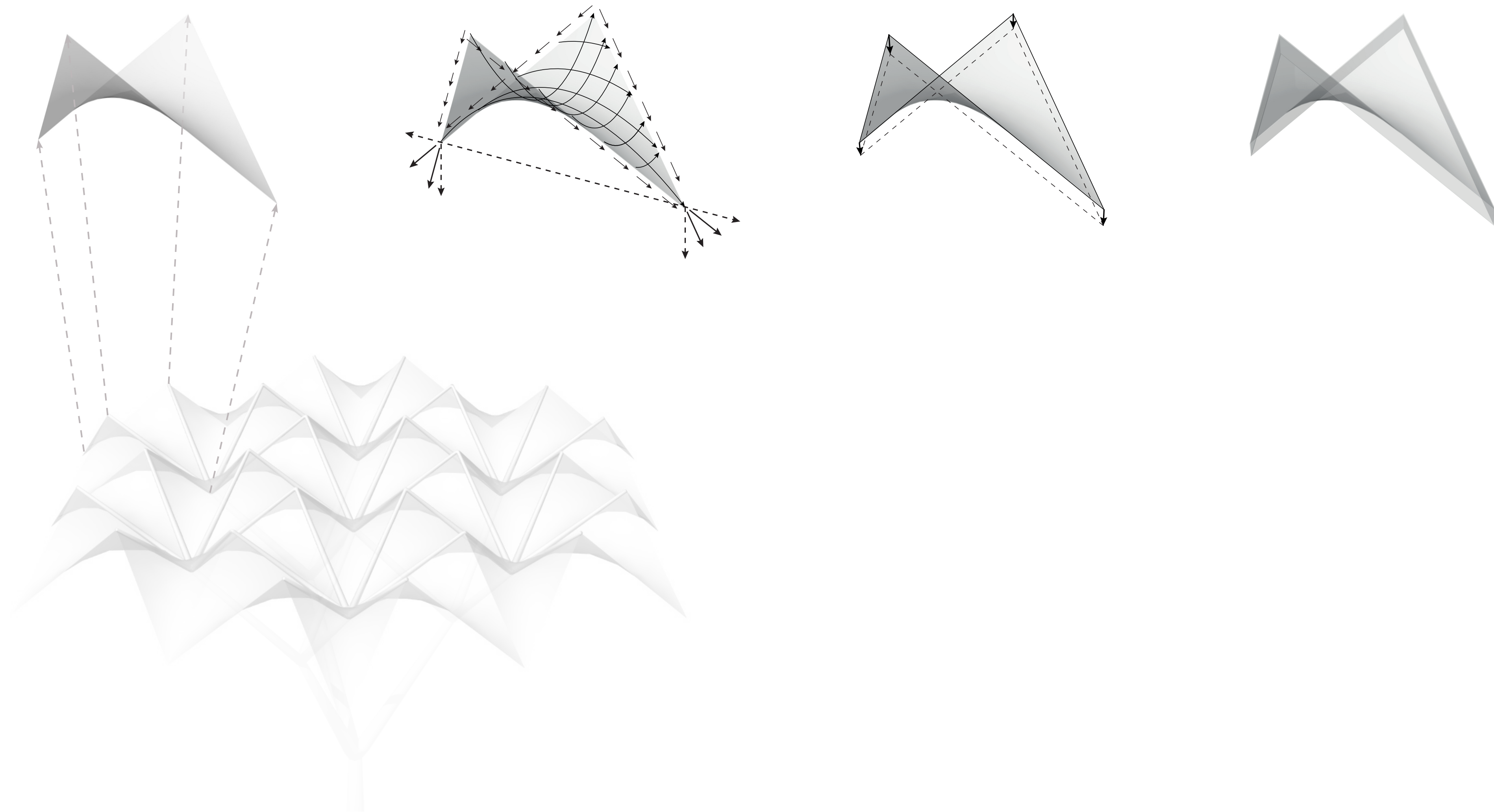
first steps - straight generatrices



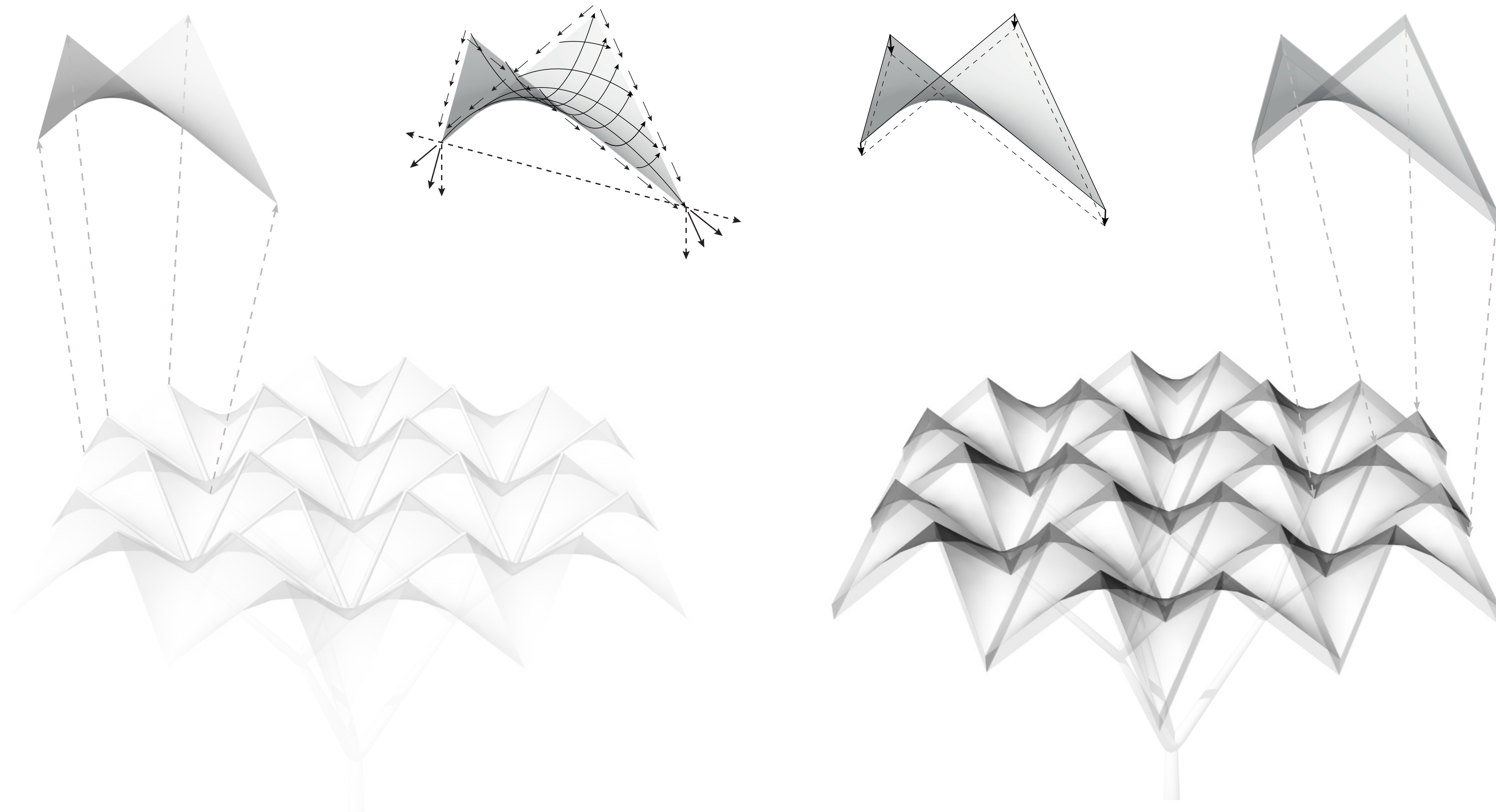
first steps - straight generatrices



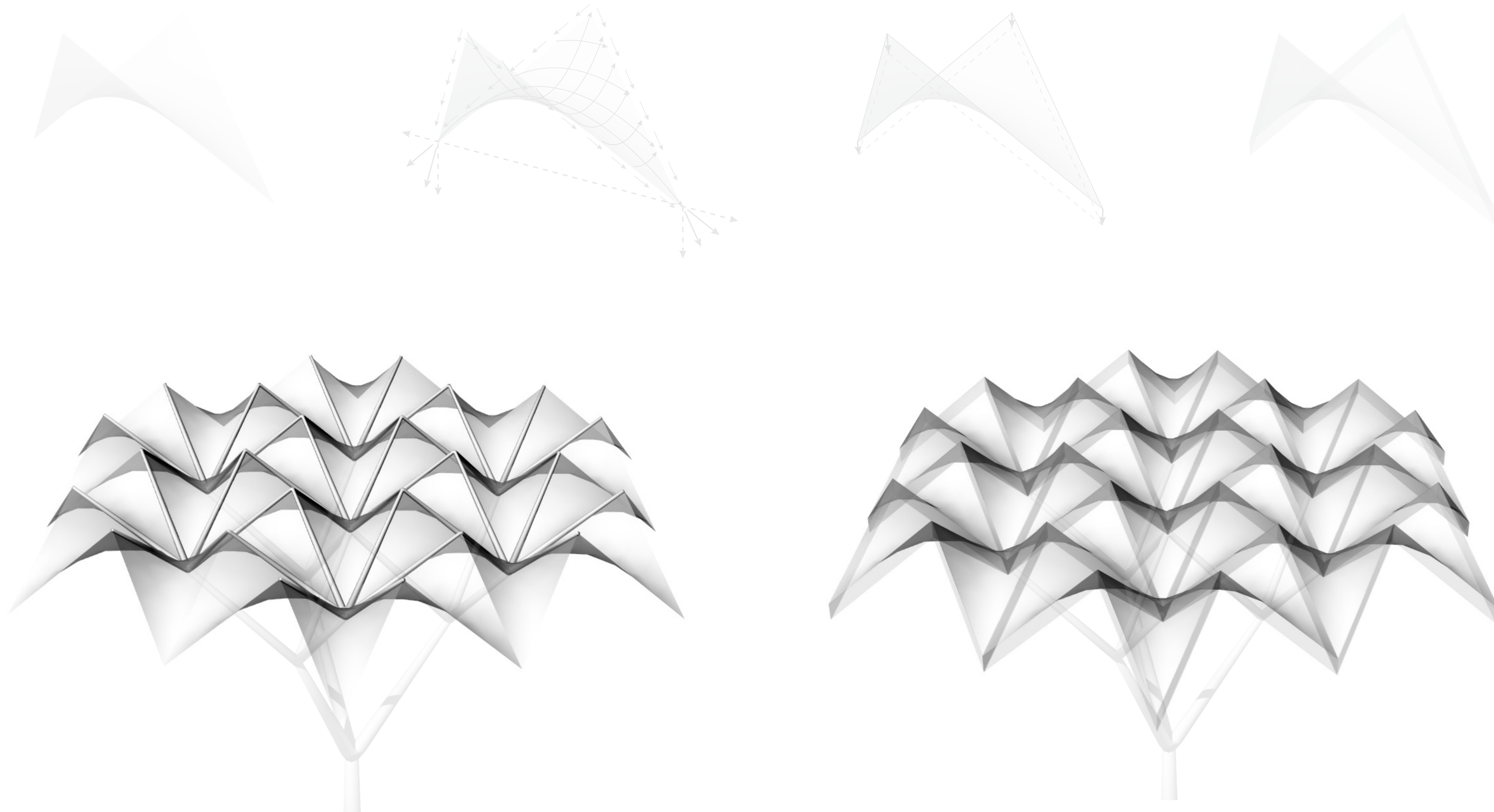
first steps - straight generatrices



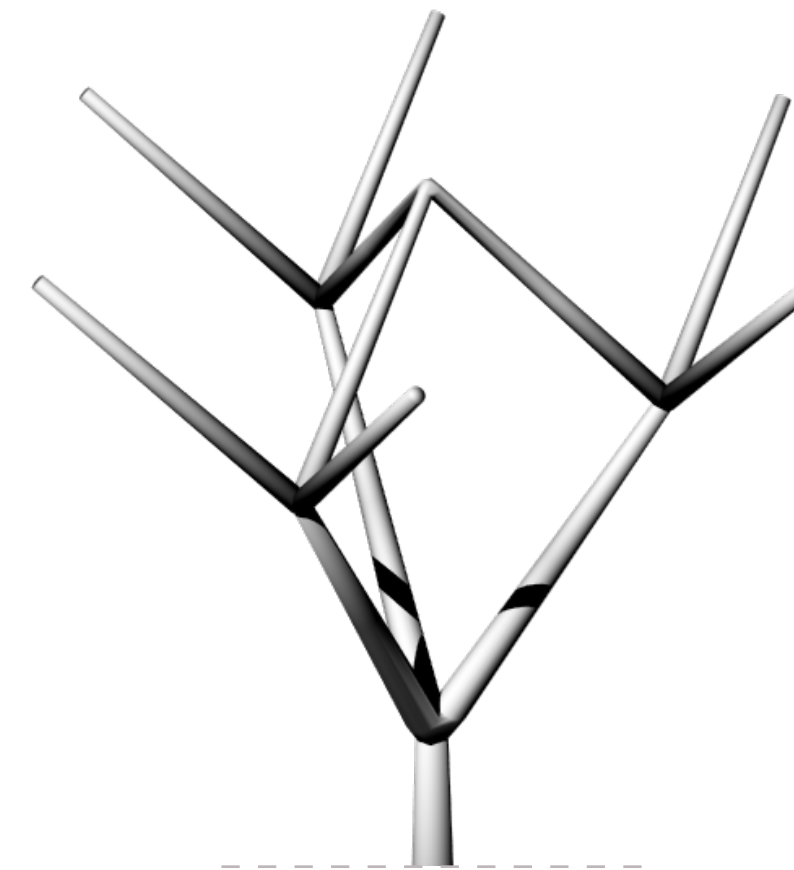
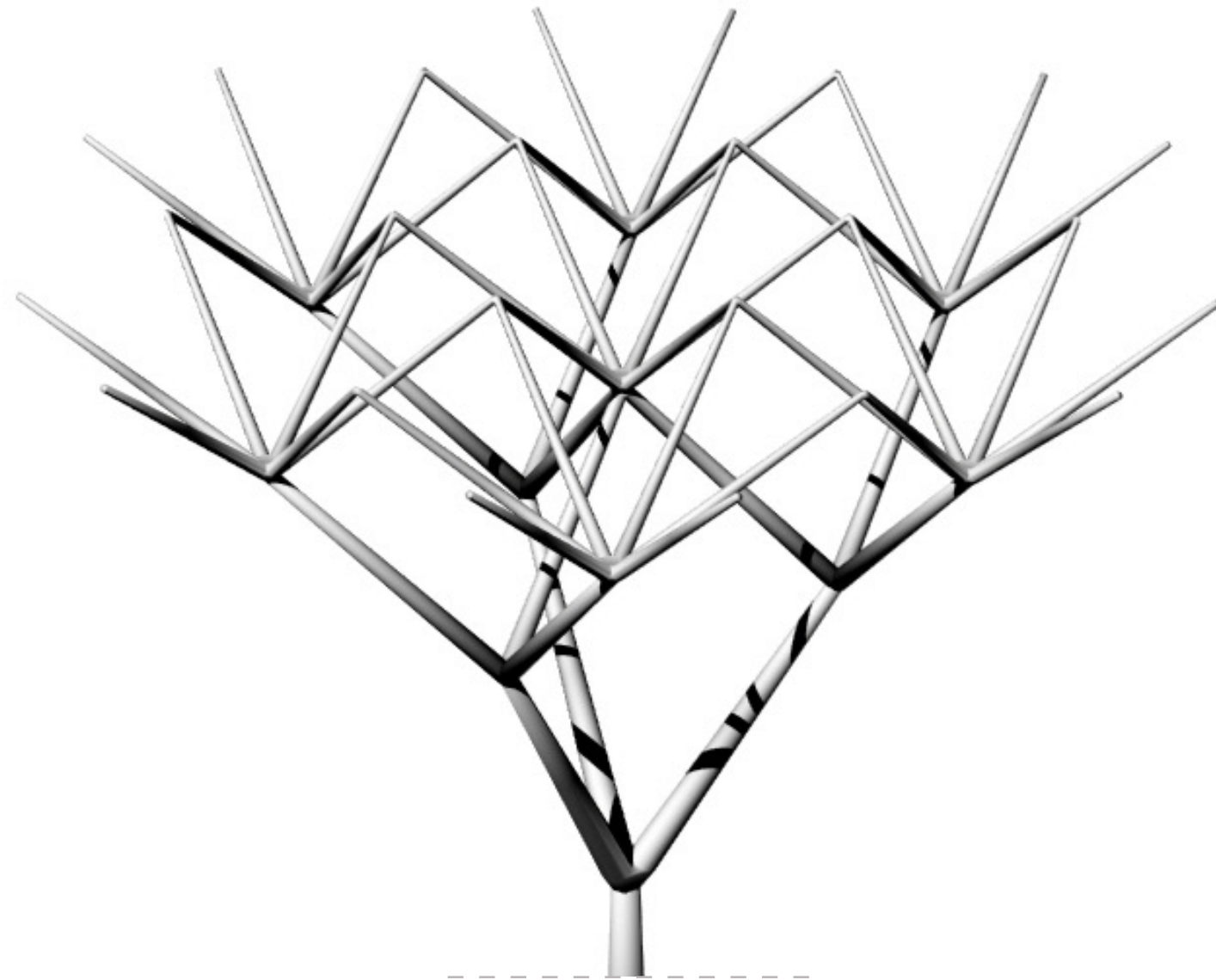
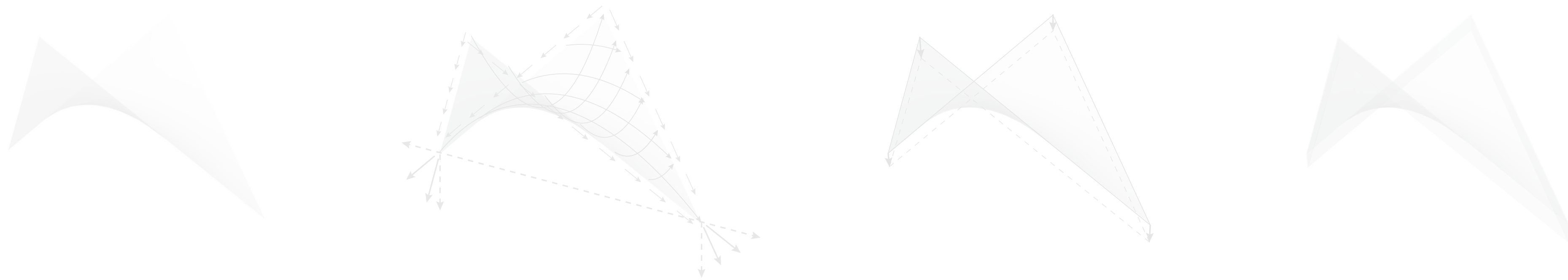
first steps - straight generatrices



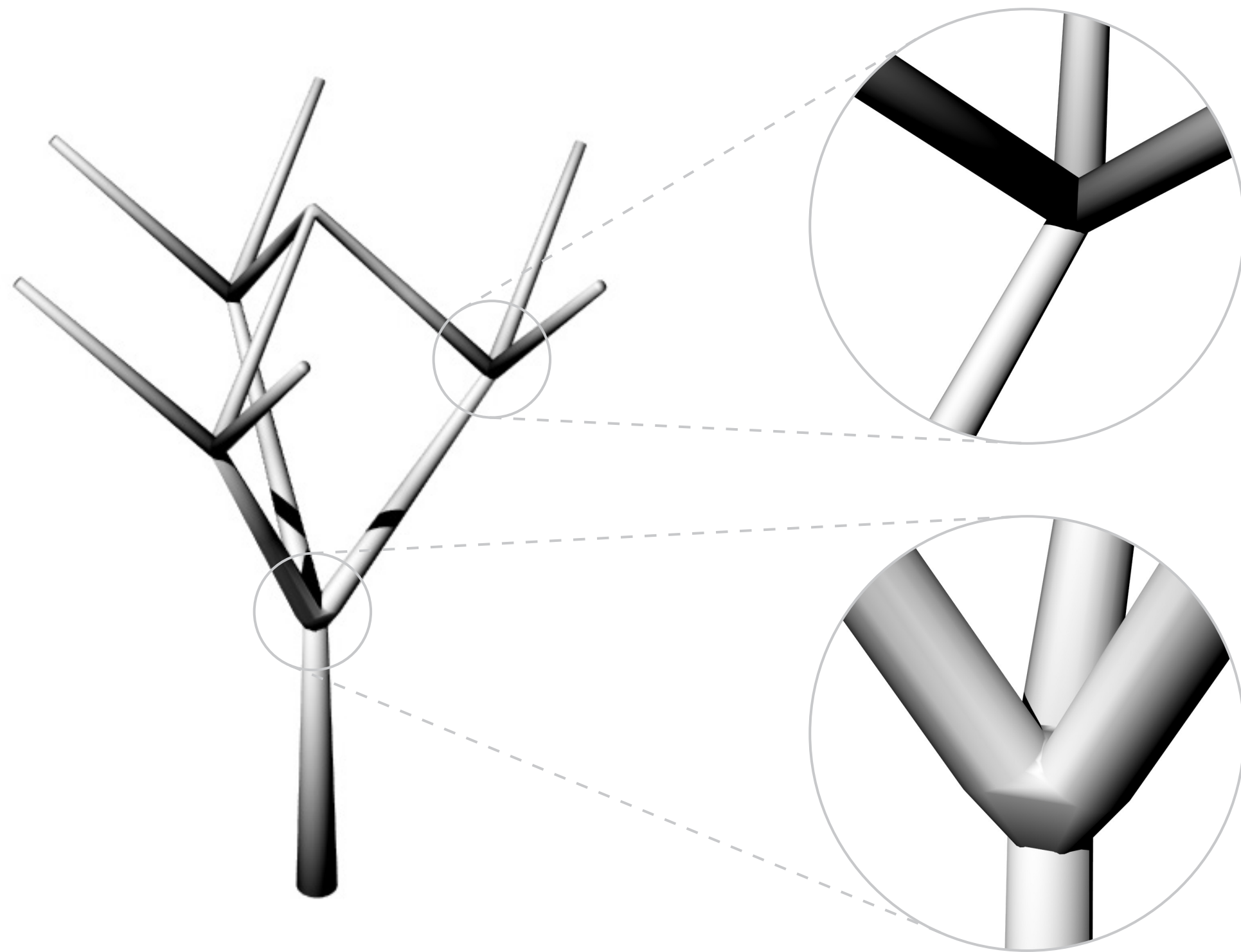
first steps - straight generatrices



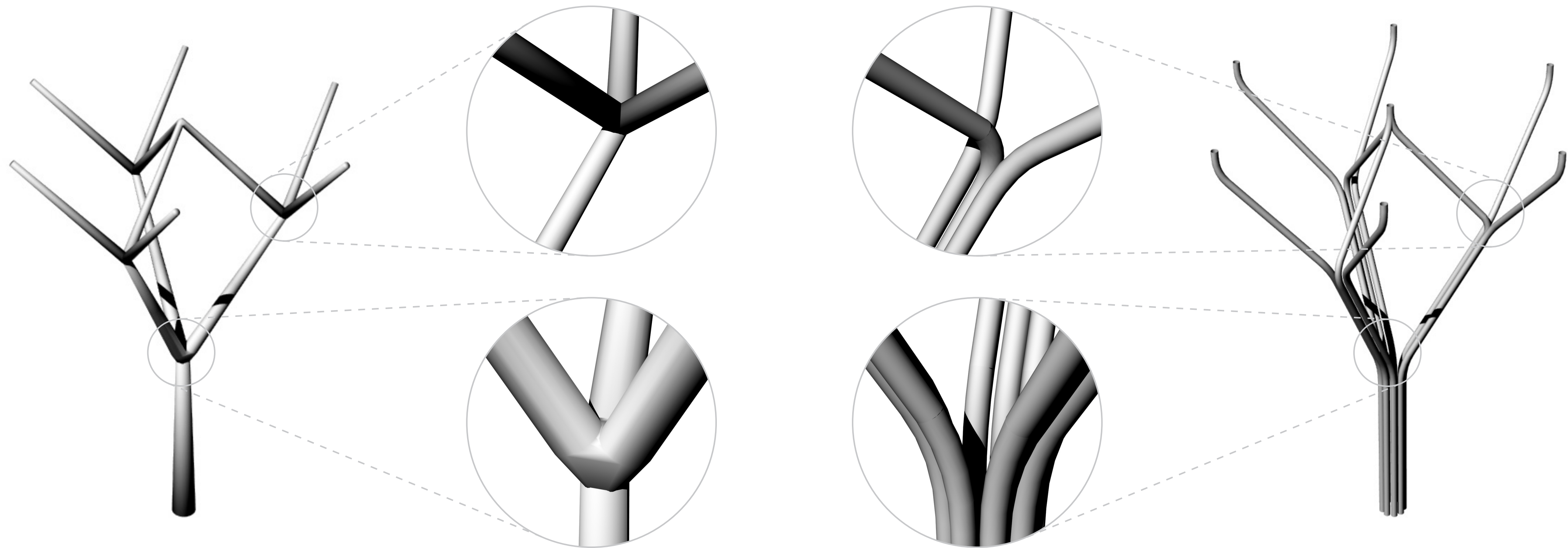
first steps - straight generatrices



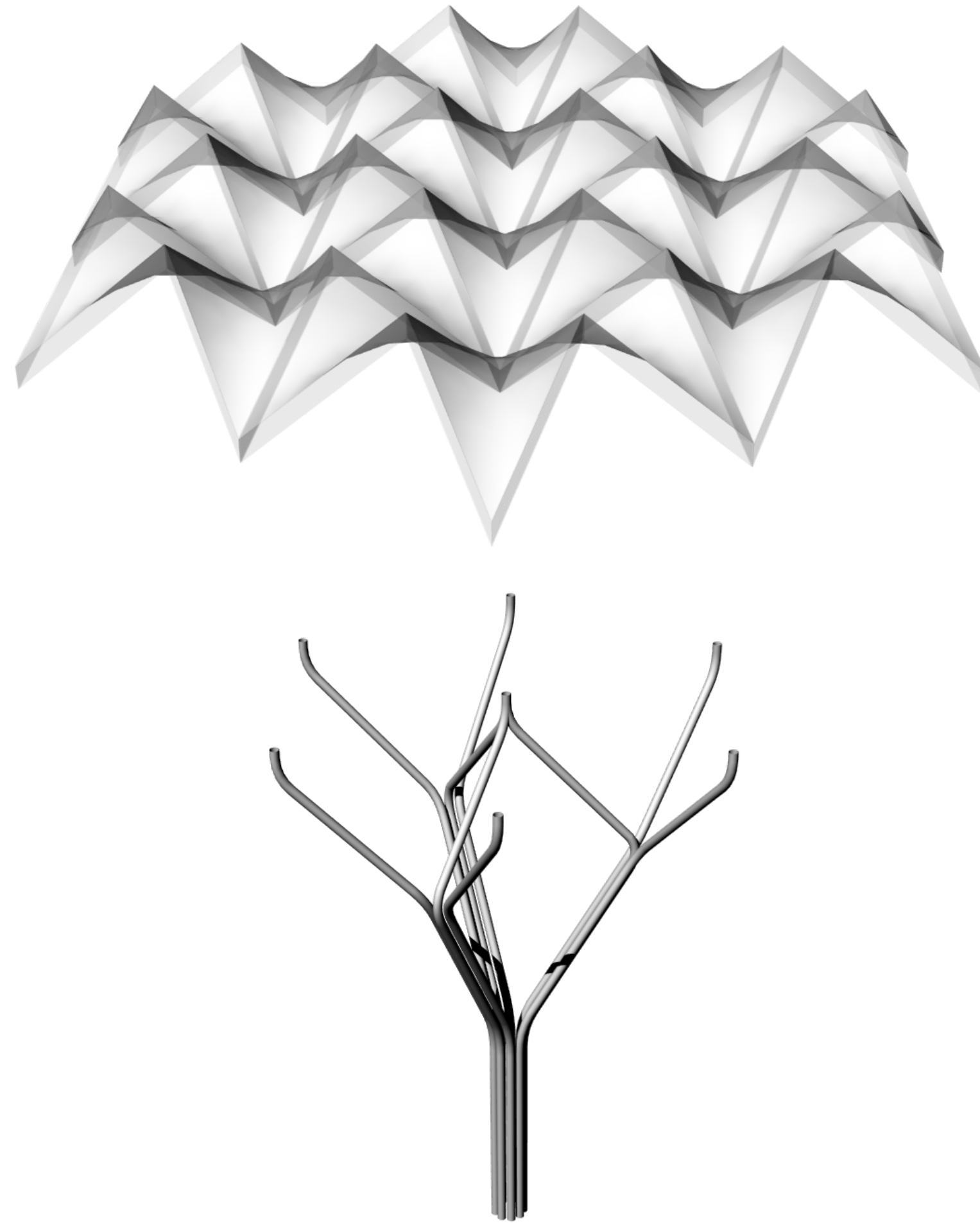
first steps - combined uniform tubes



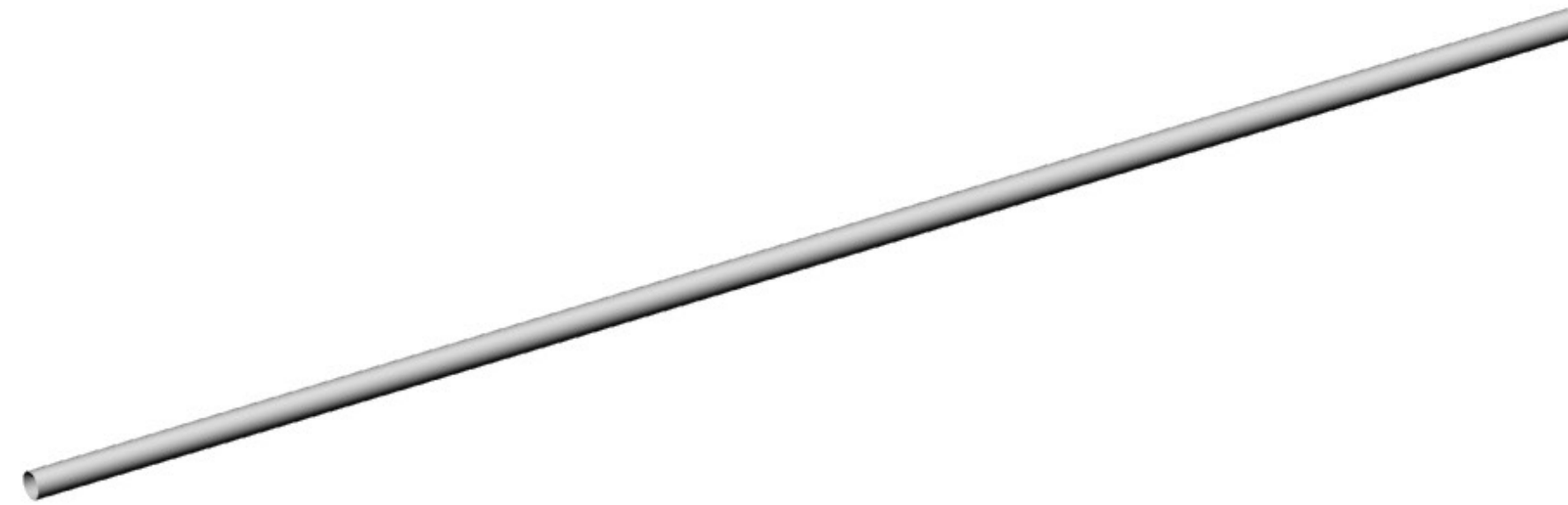
first steps - combined uniform tubes



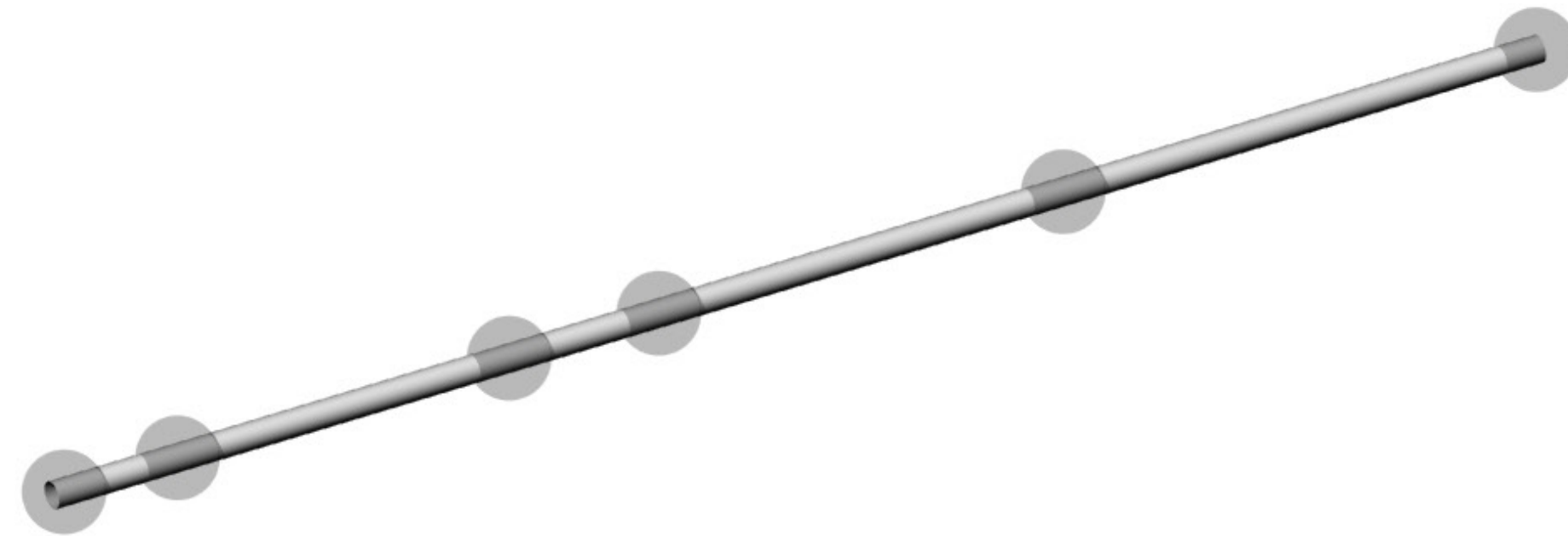
production & processing



production - tubes



production - tubes



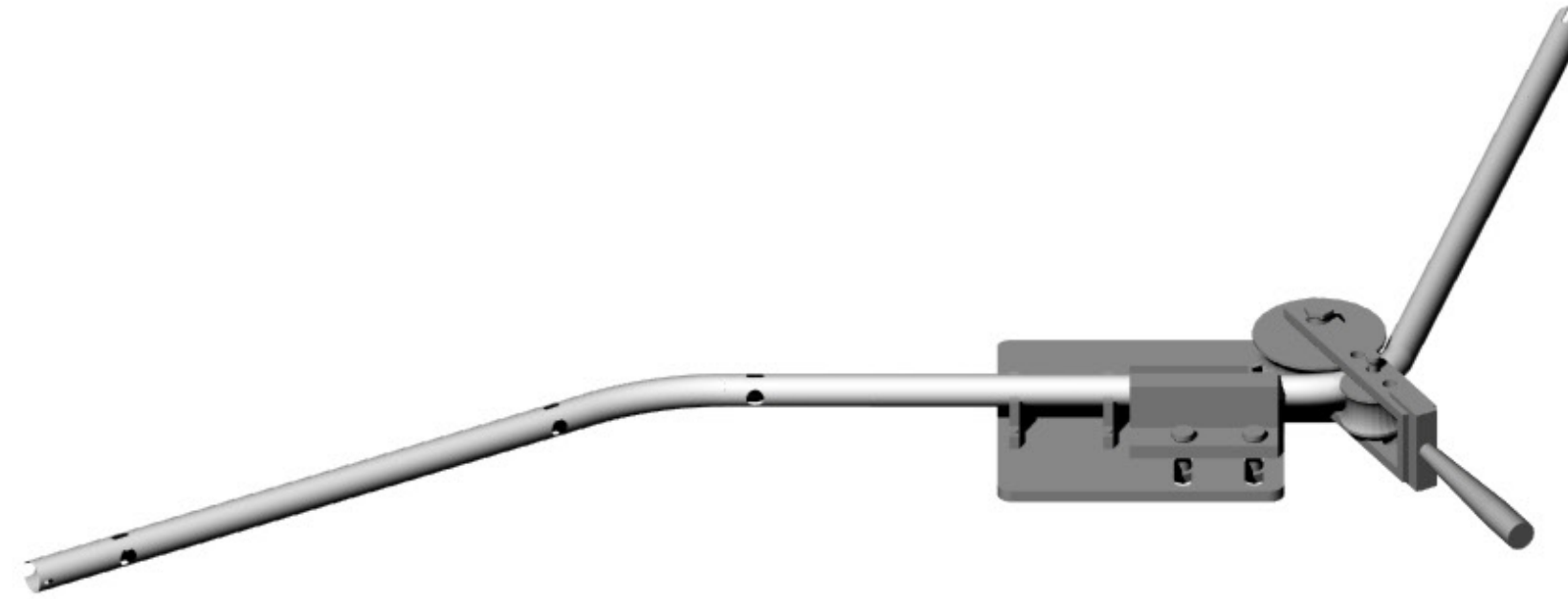
production - tubes



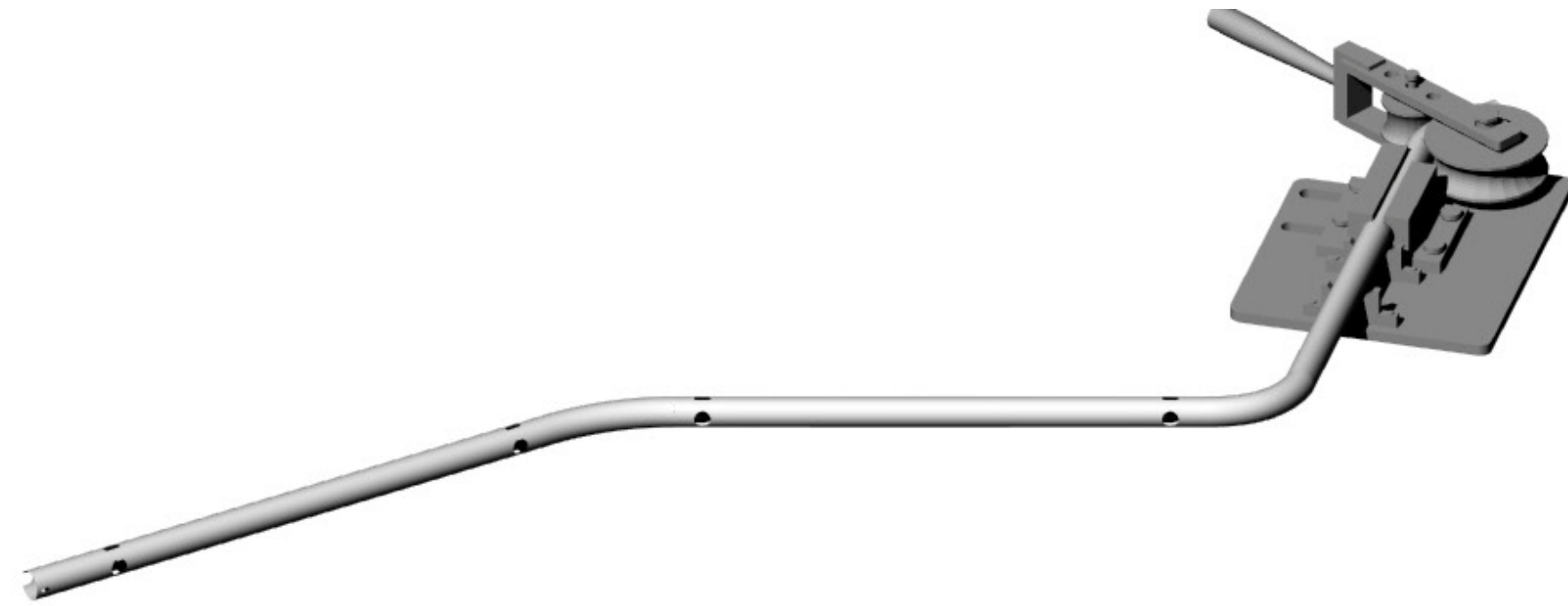
production - tubes



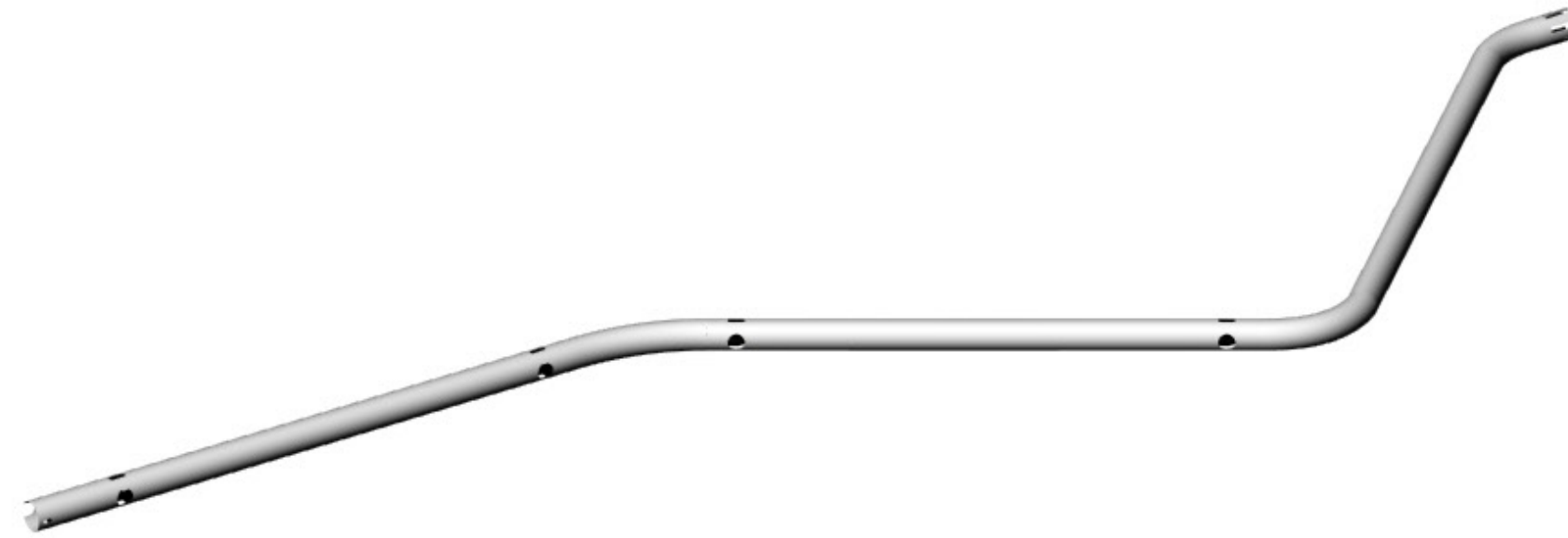
production - tubes



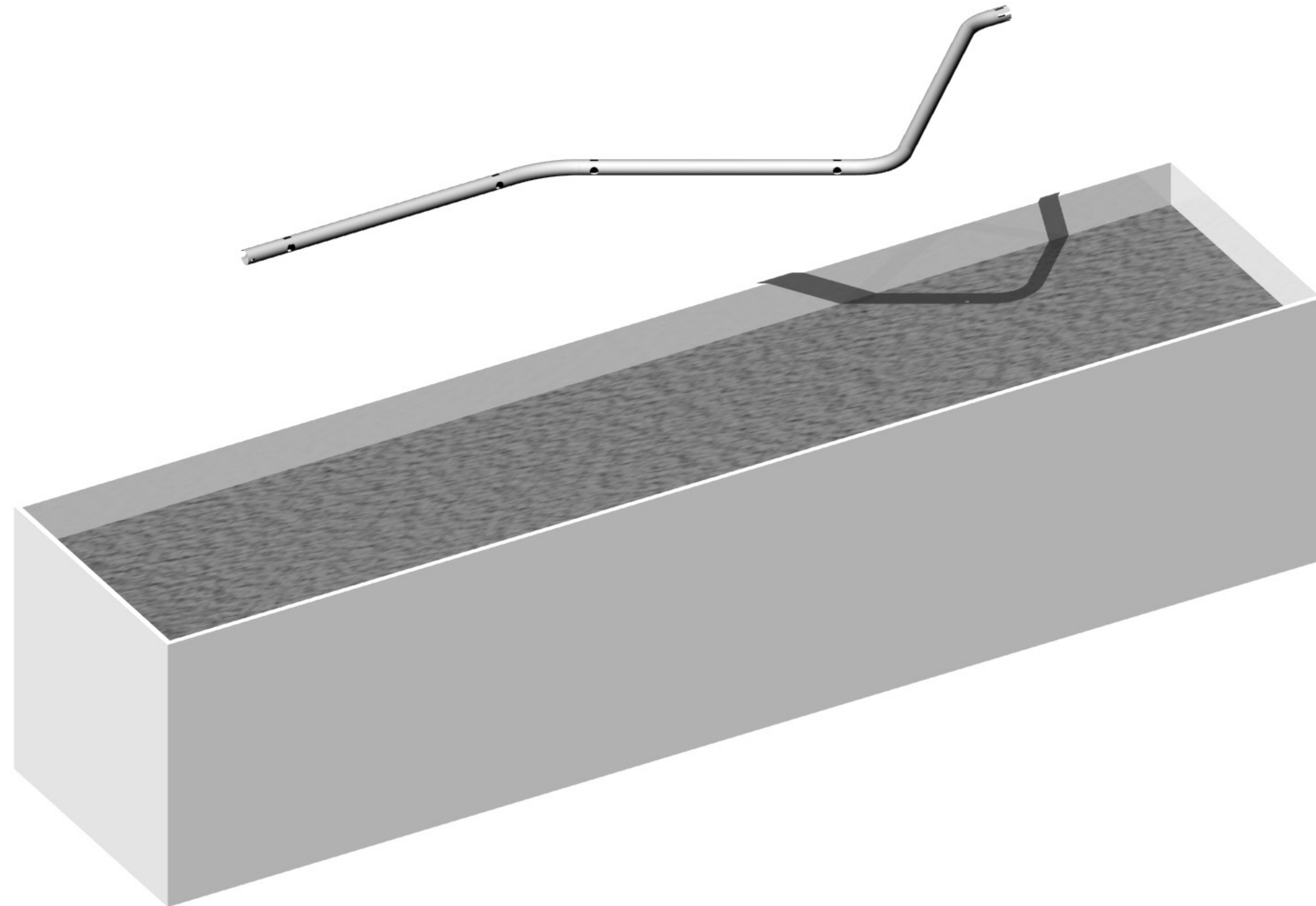
production - tubes



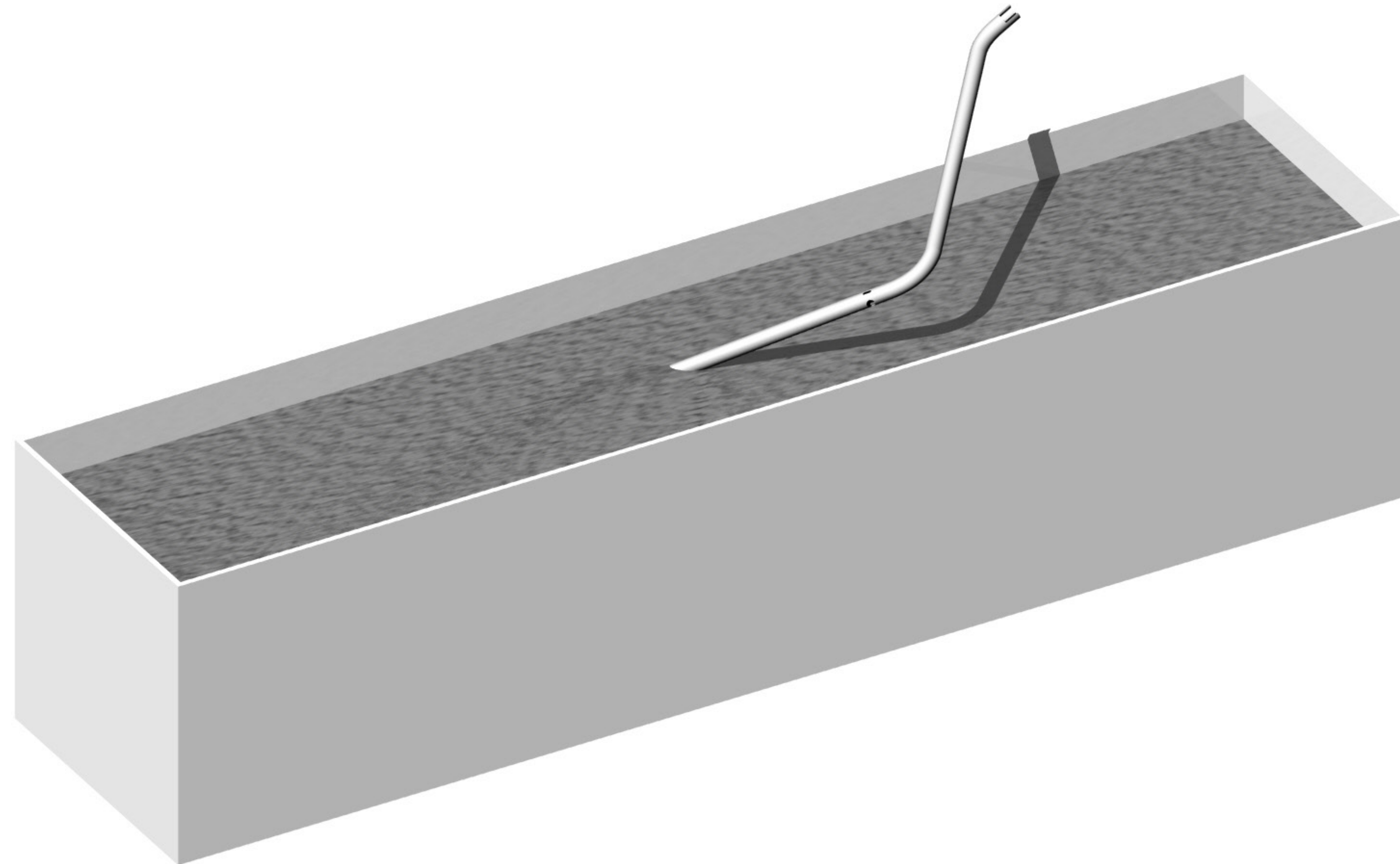
production - tubes



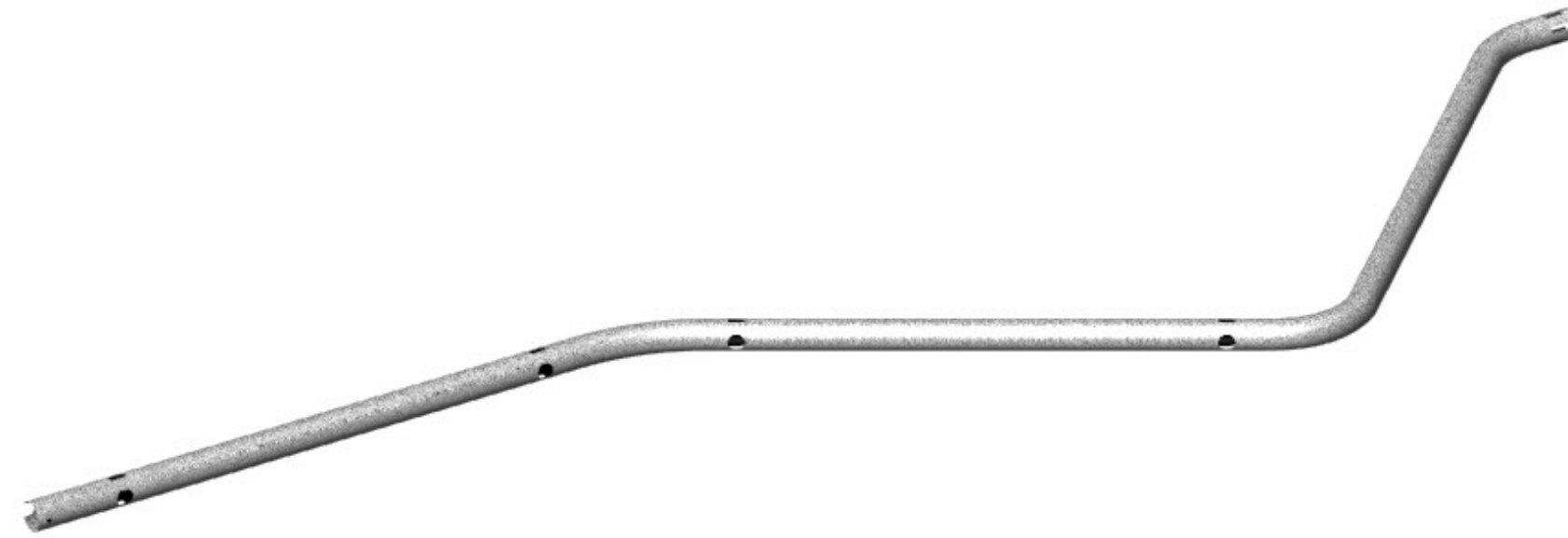
production - tubes



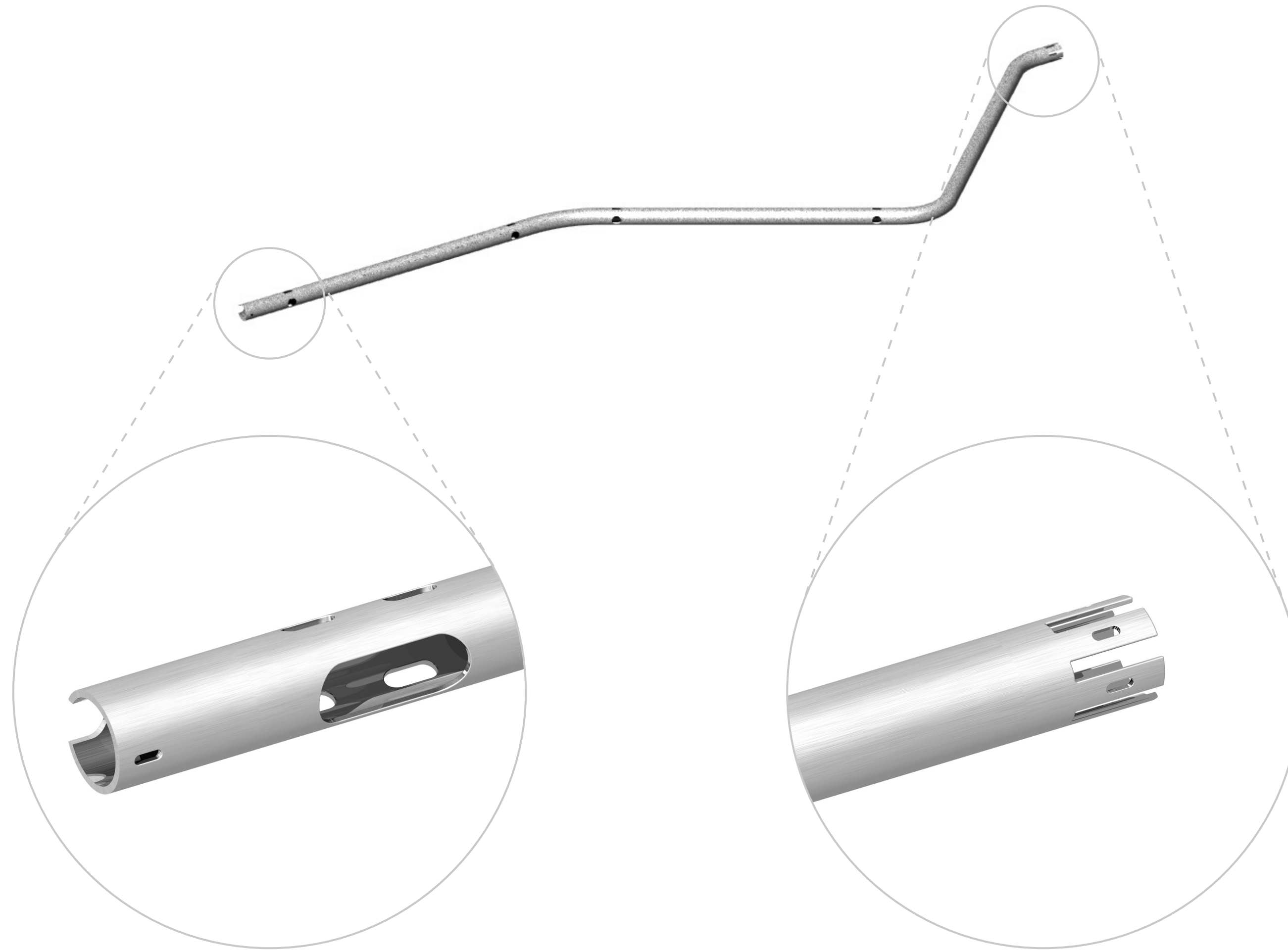
production - tubes



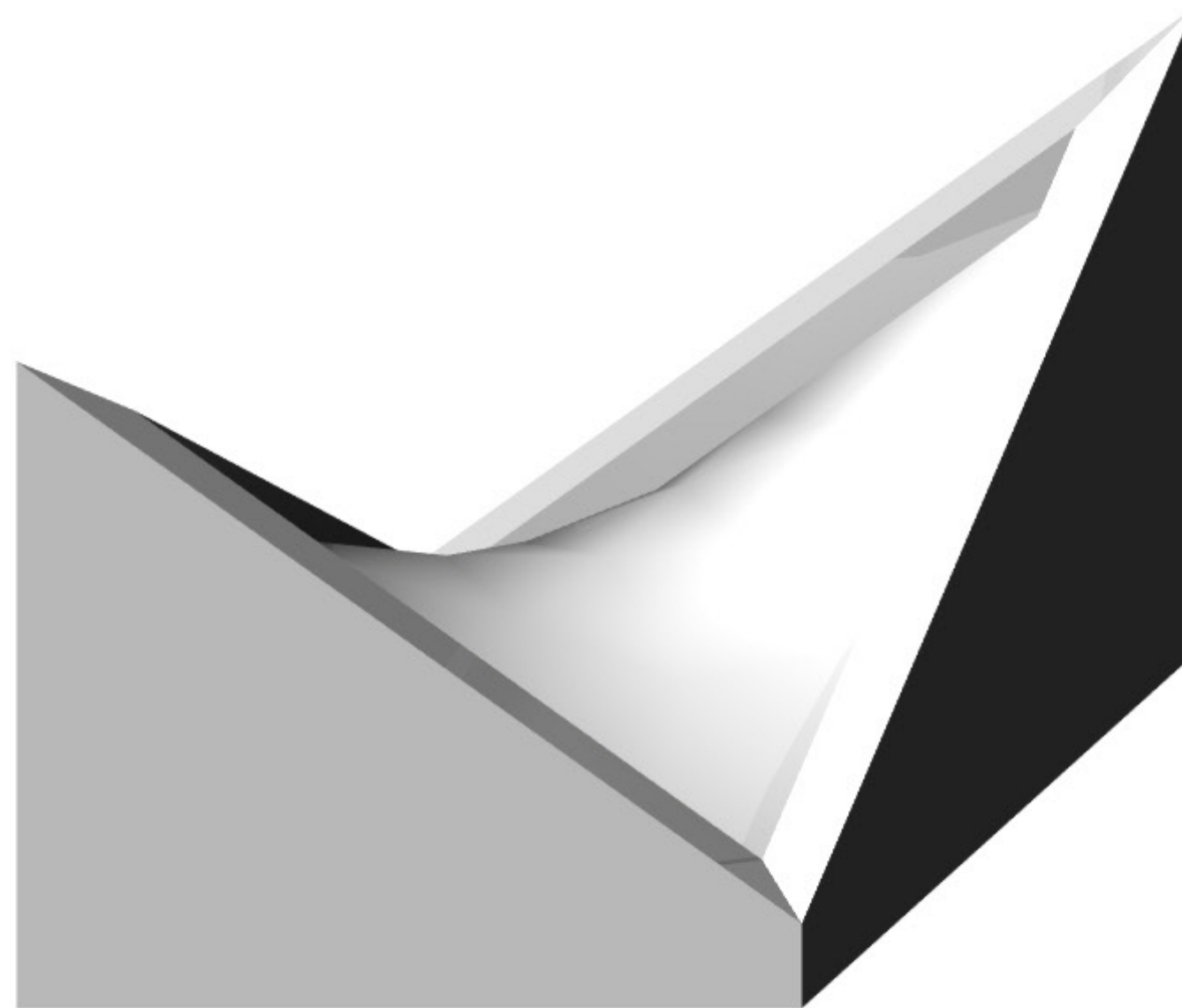
production - tubes



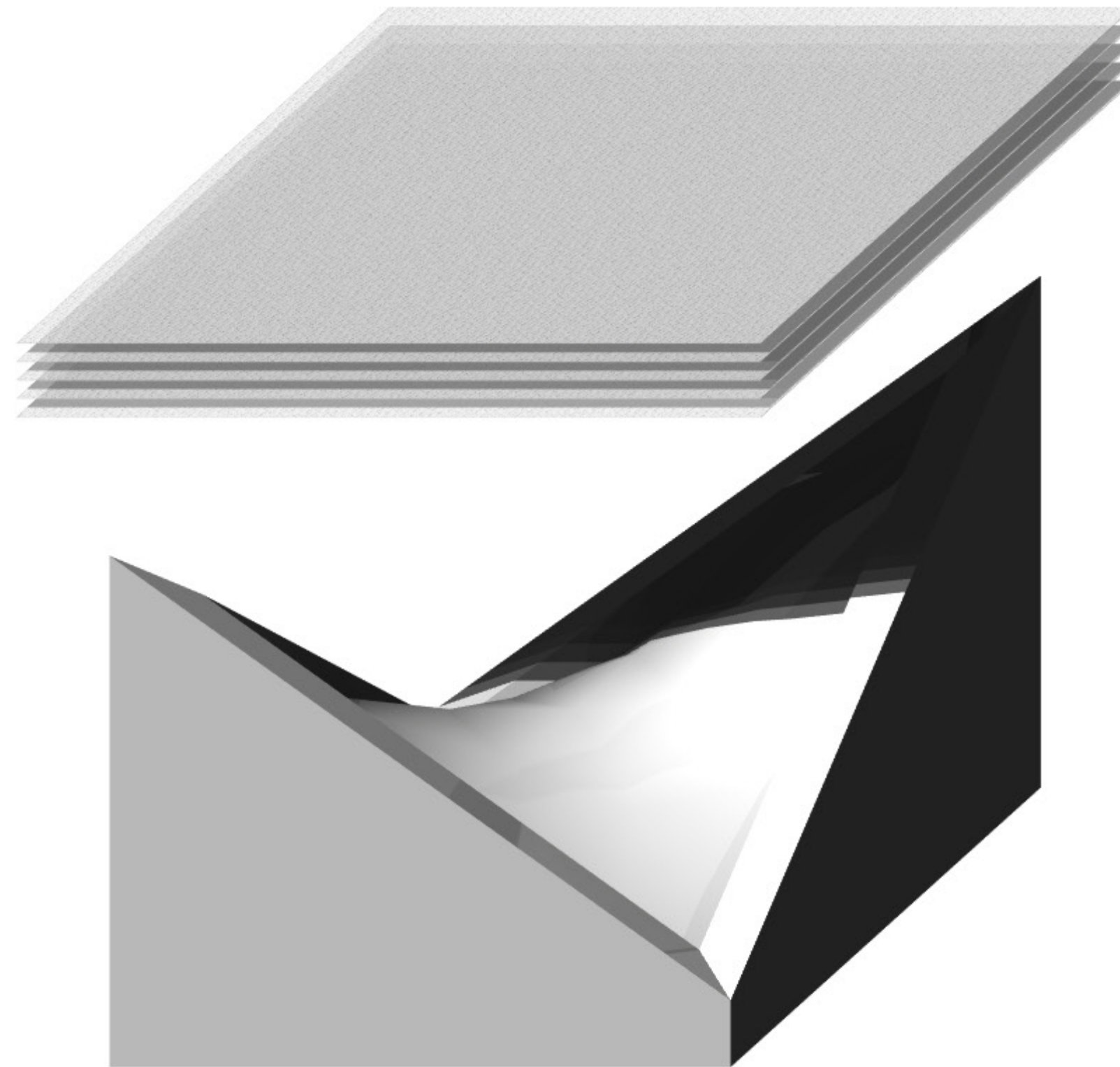
production - tubes



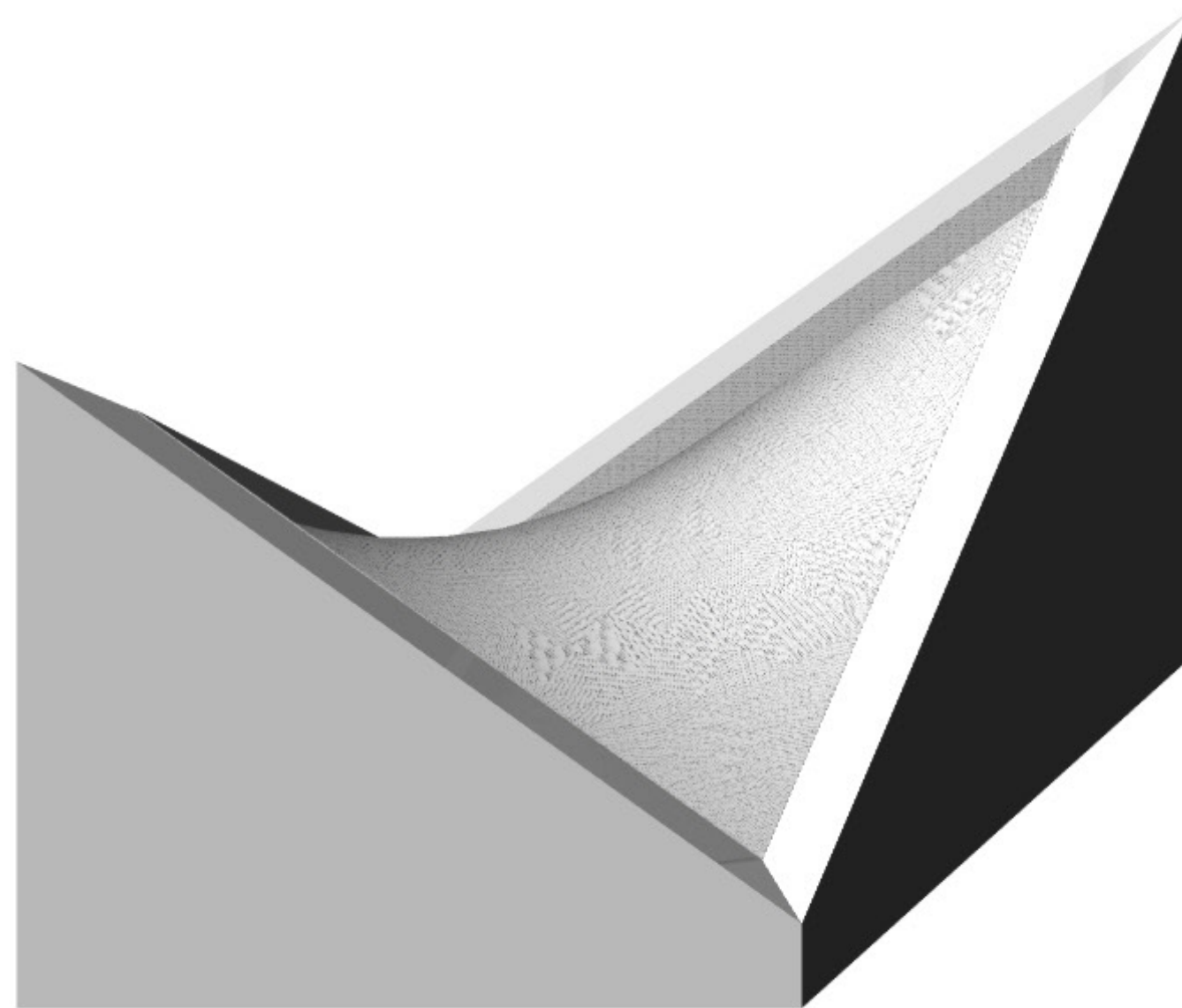
production - anticlastic panels



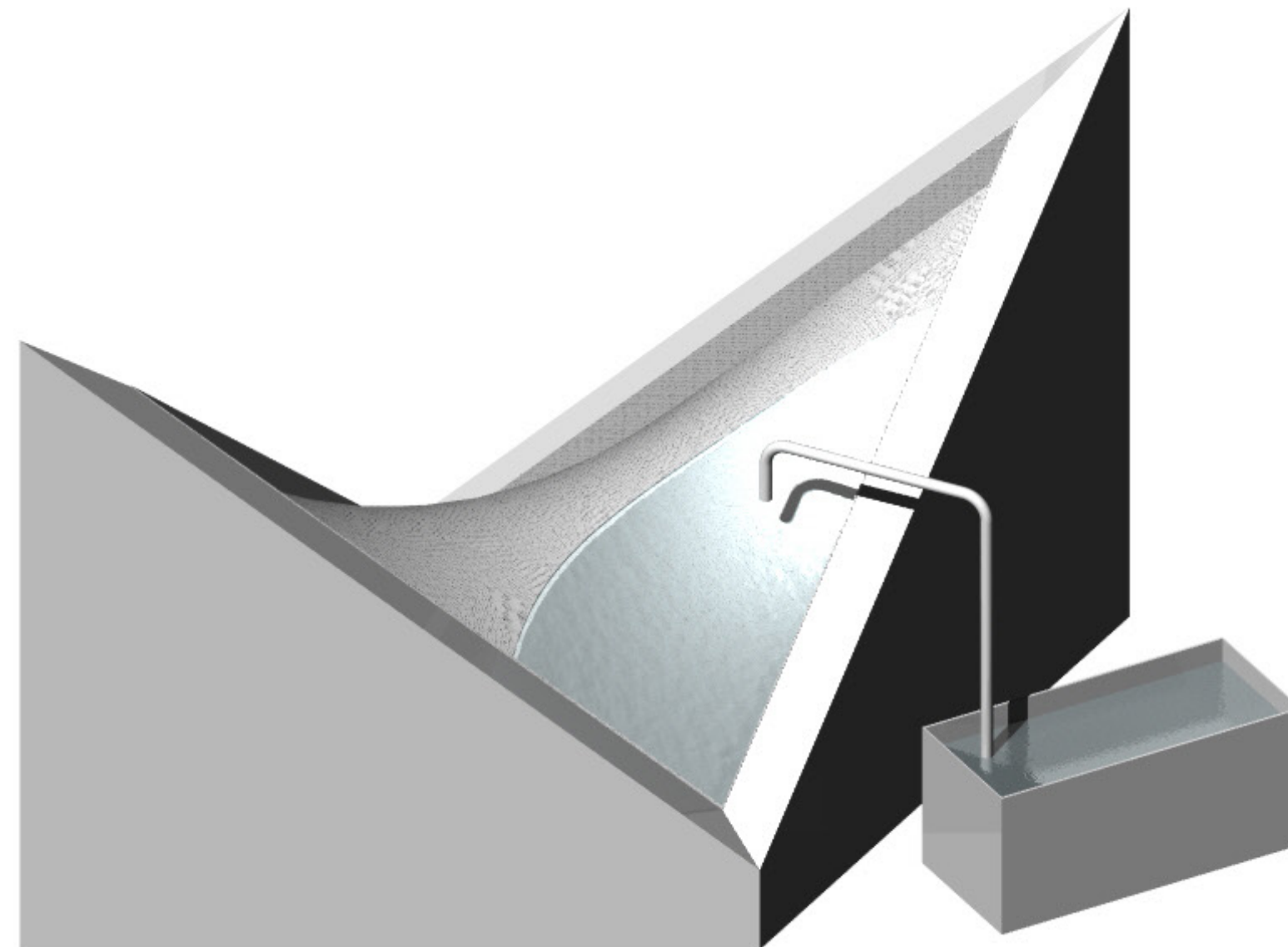
production - anticlastic panels



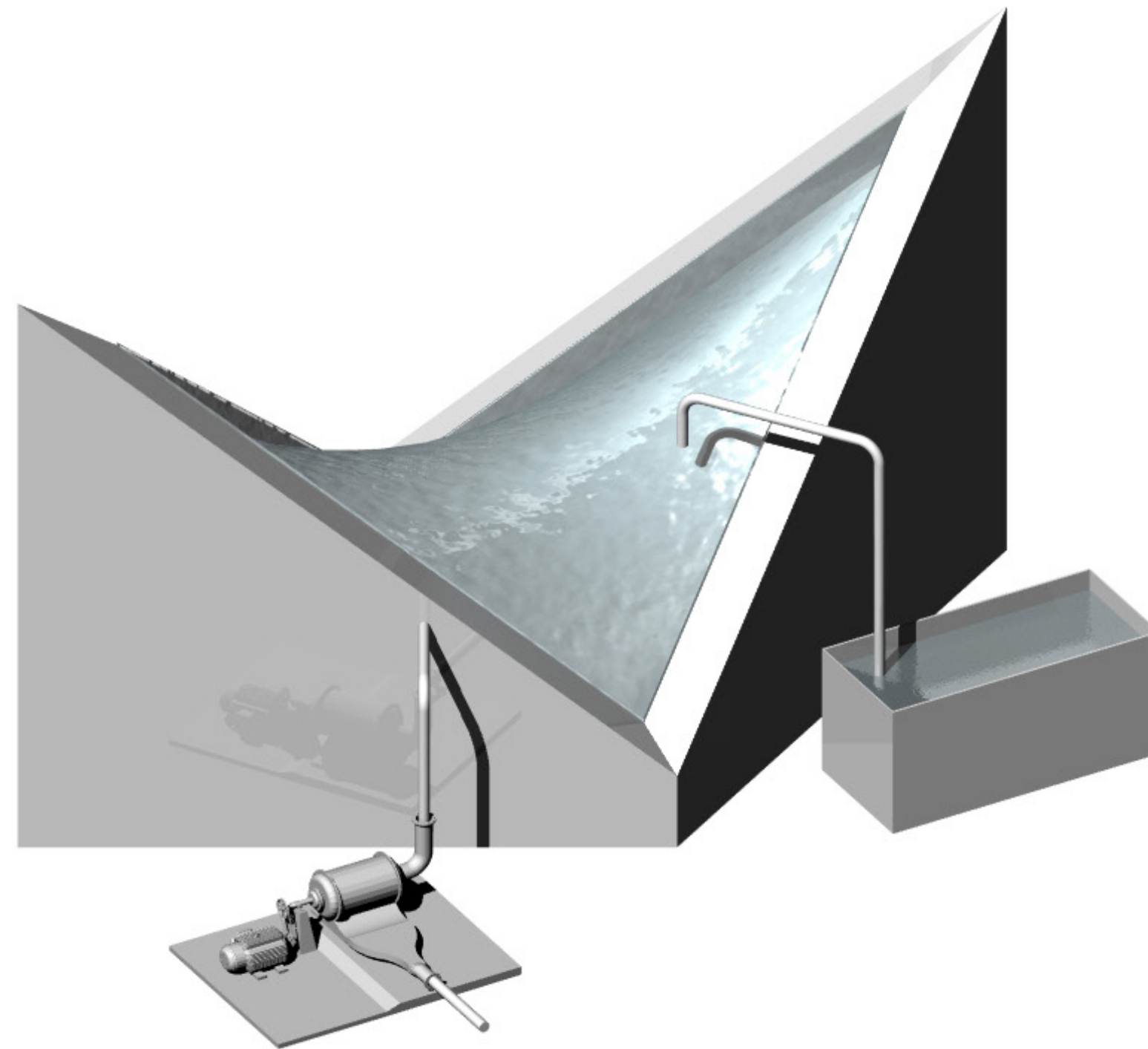
production - anticlastic panels



production - anticlastic panels



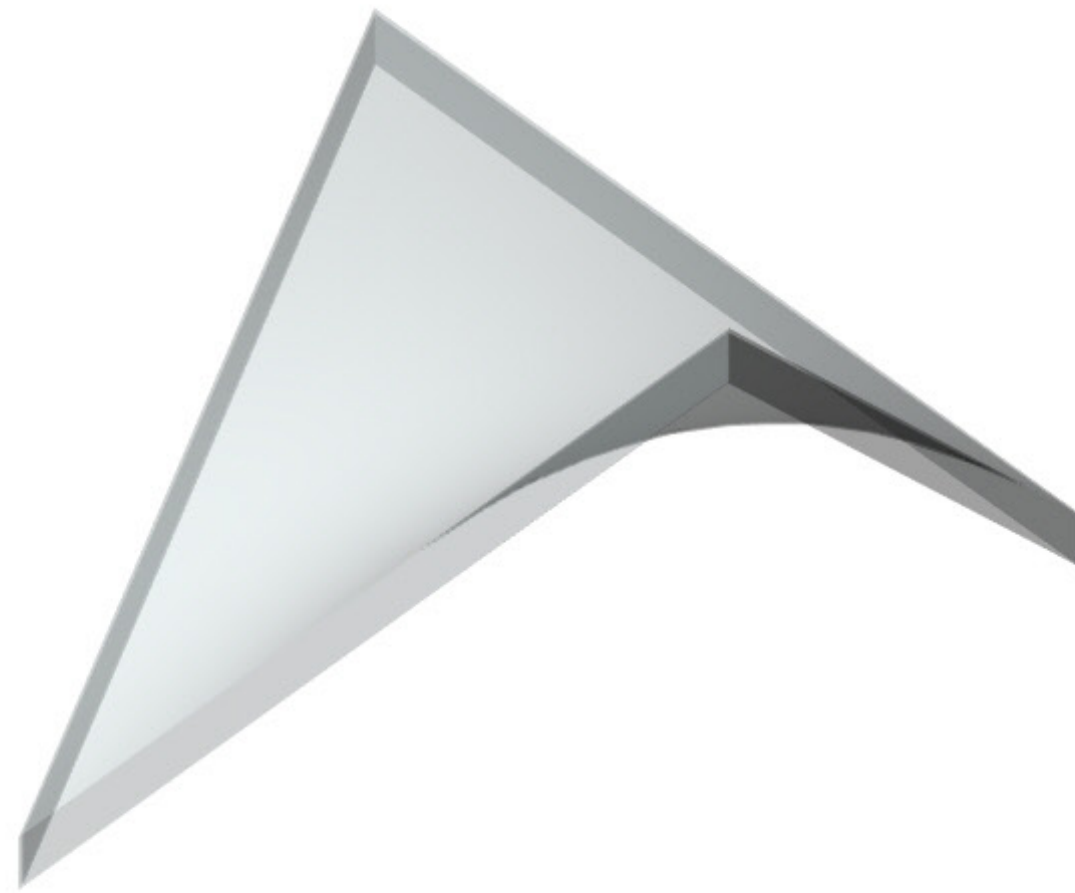
production - anticlastic panels



production - anticlastic panels



production - anticlastic panels



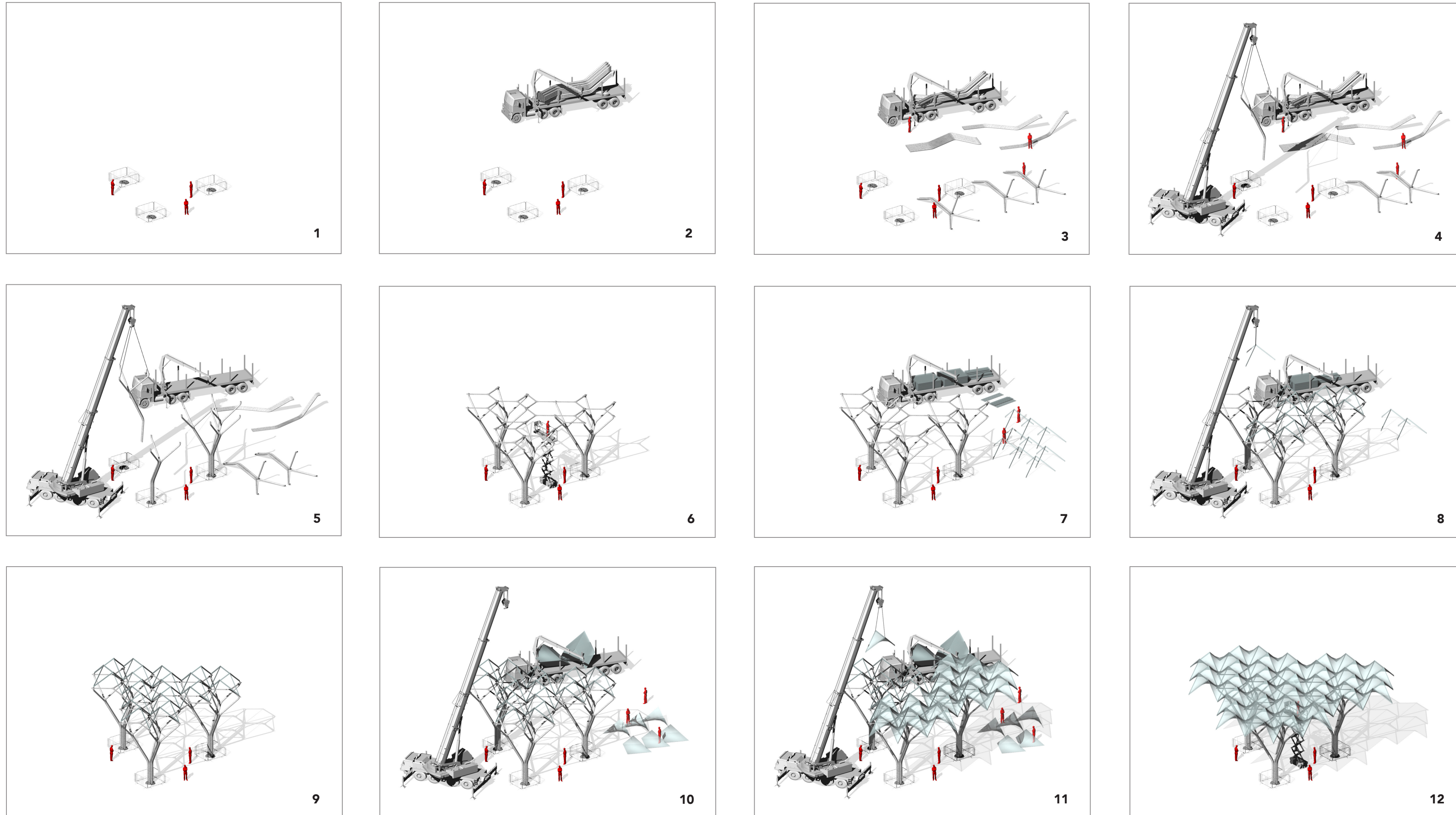
production - anticlastic panels



production - anticlastic panels



method statement & detailing



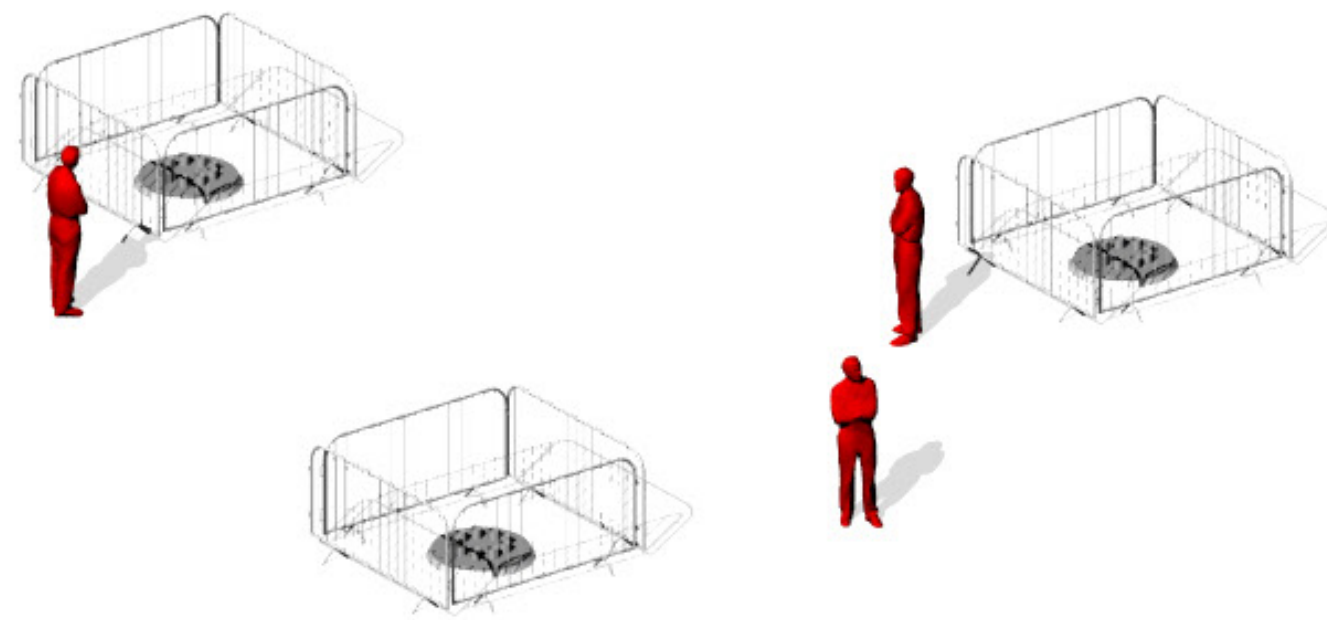
method statement



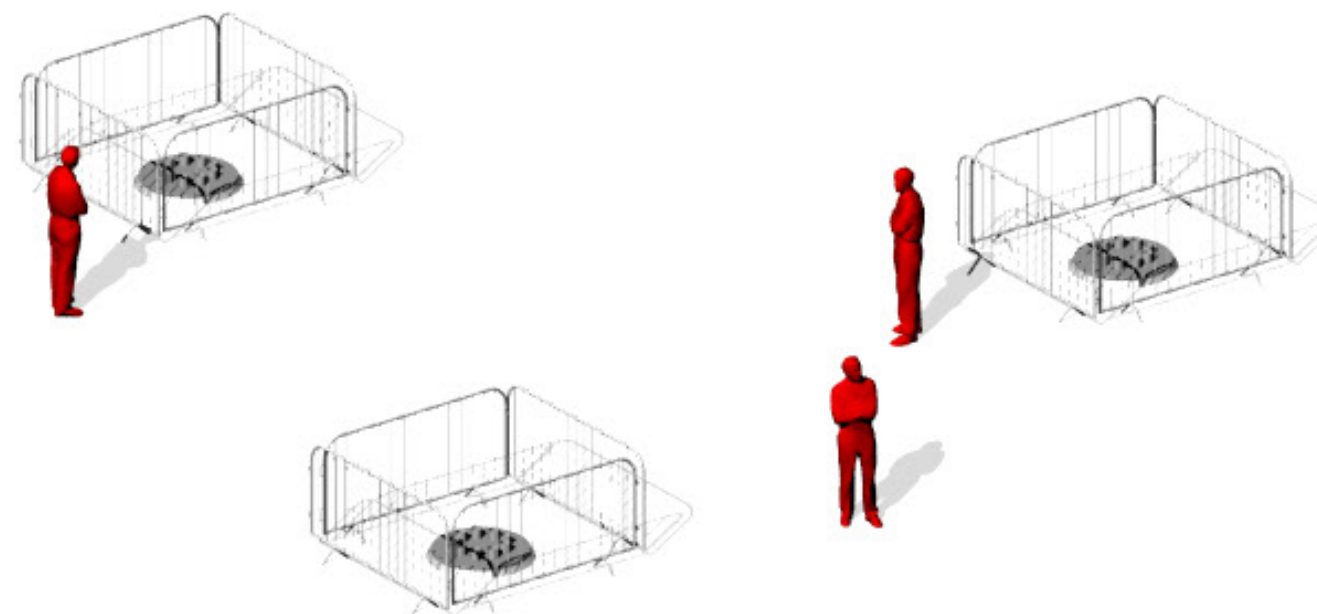
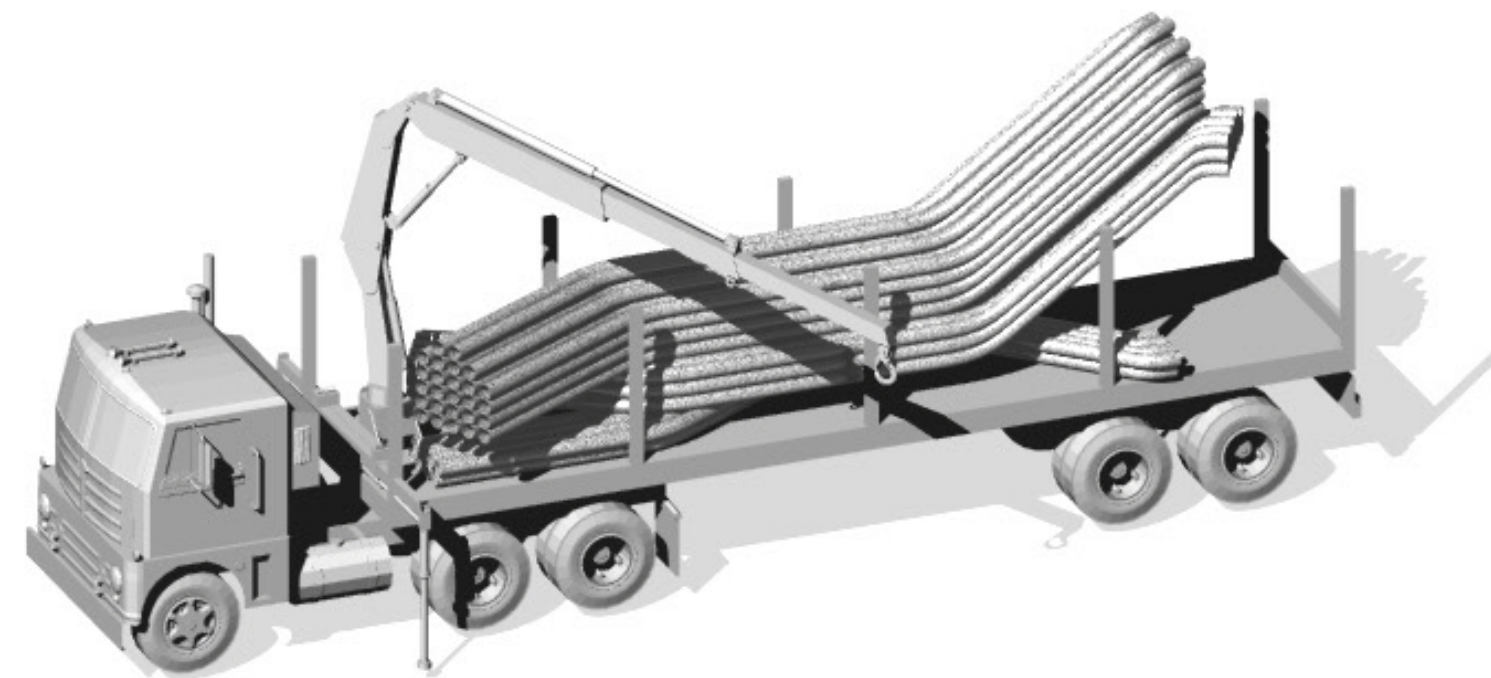
method statement



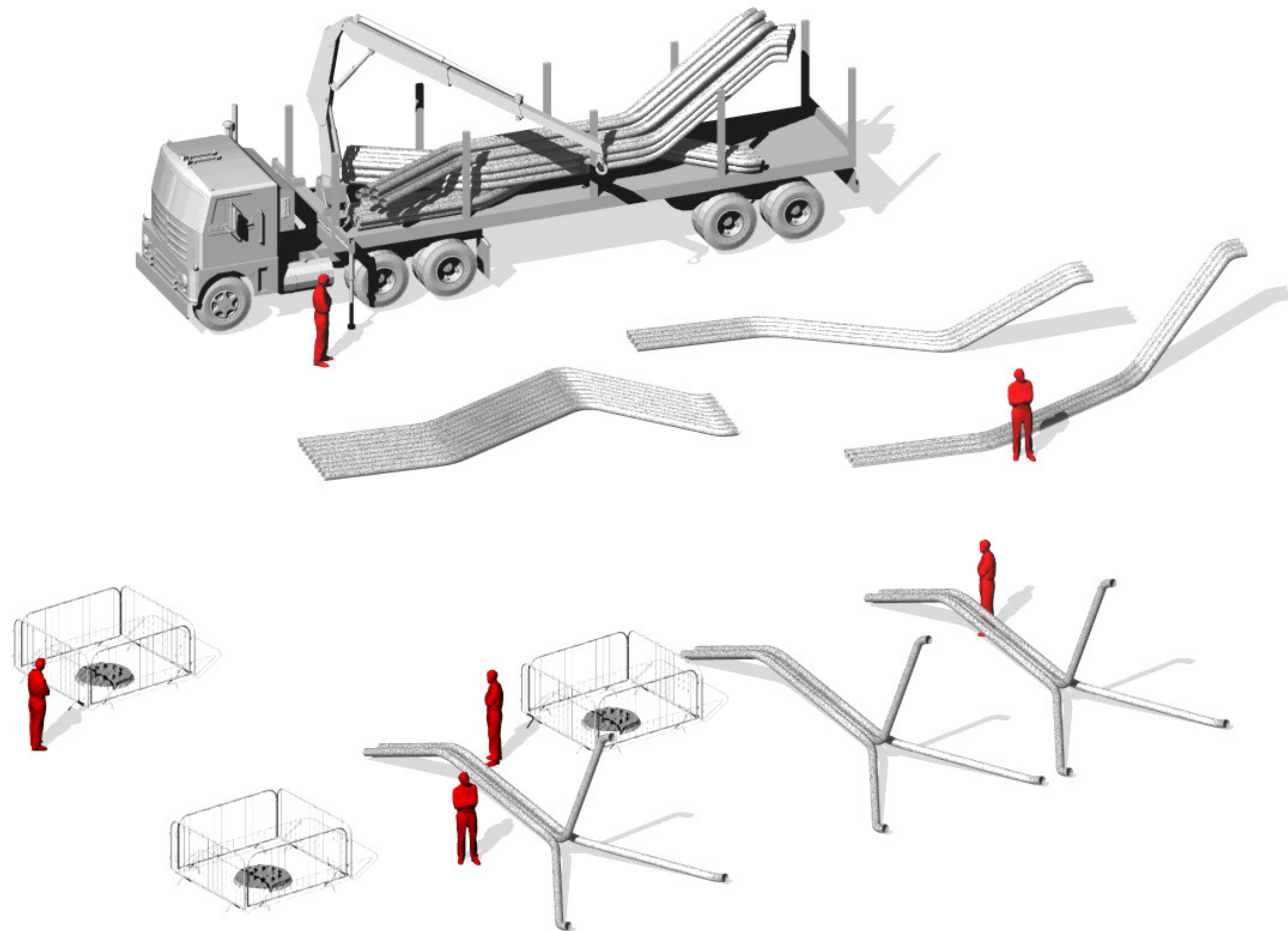
method statement



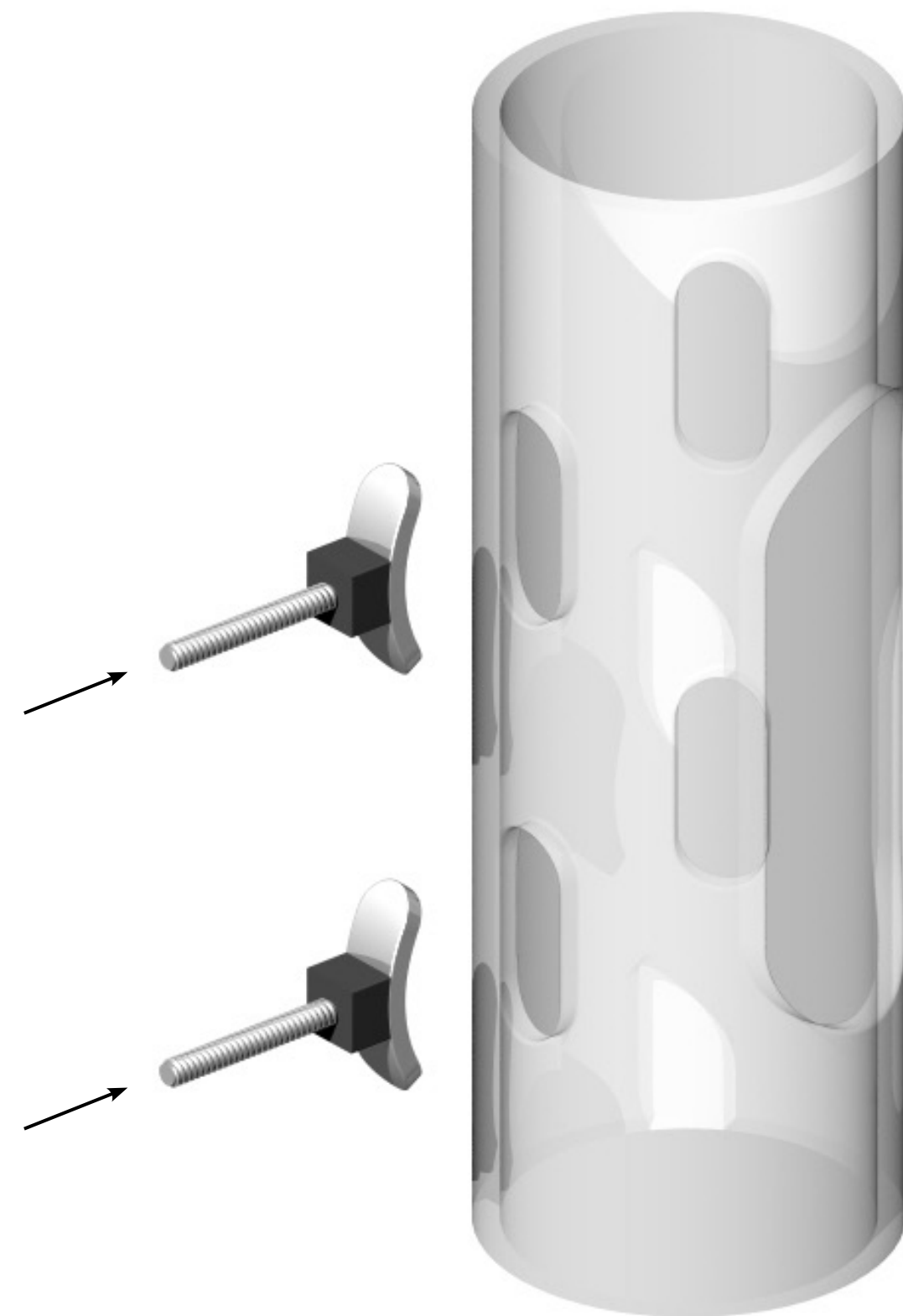
method statement



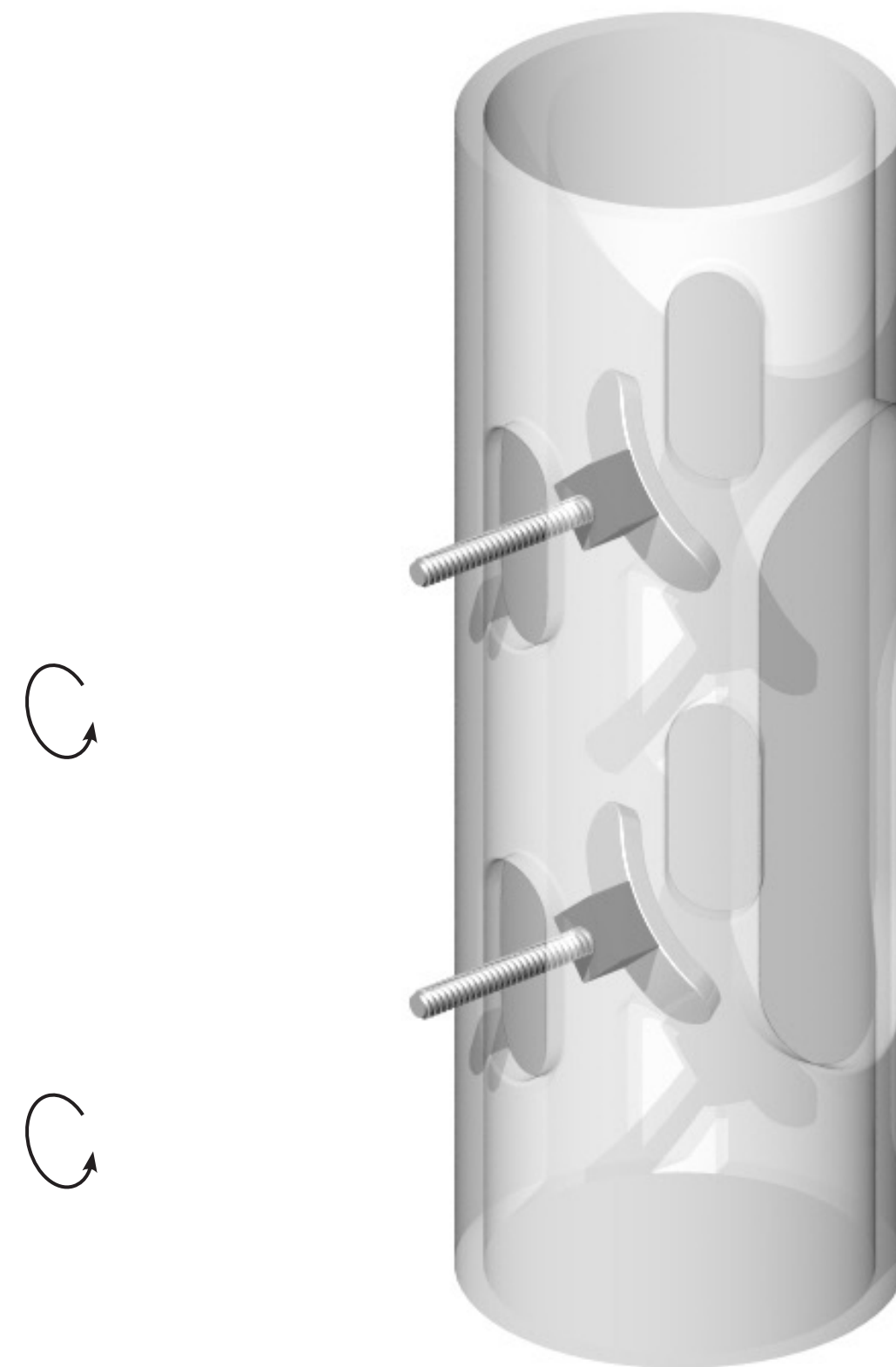
method statement



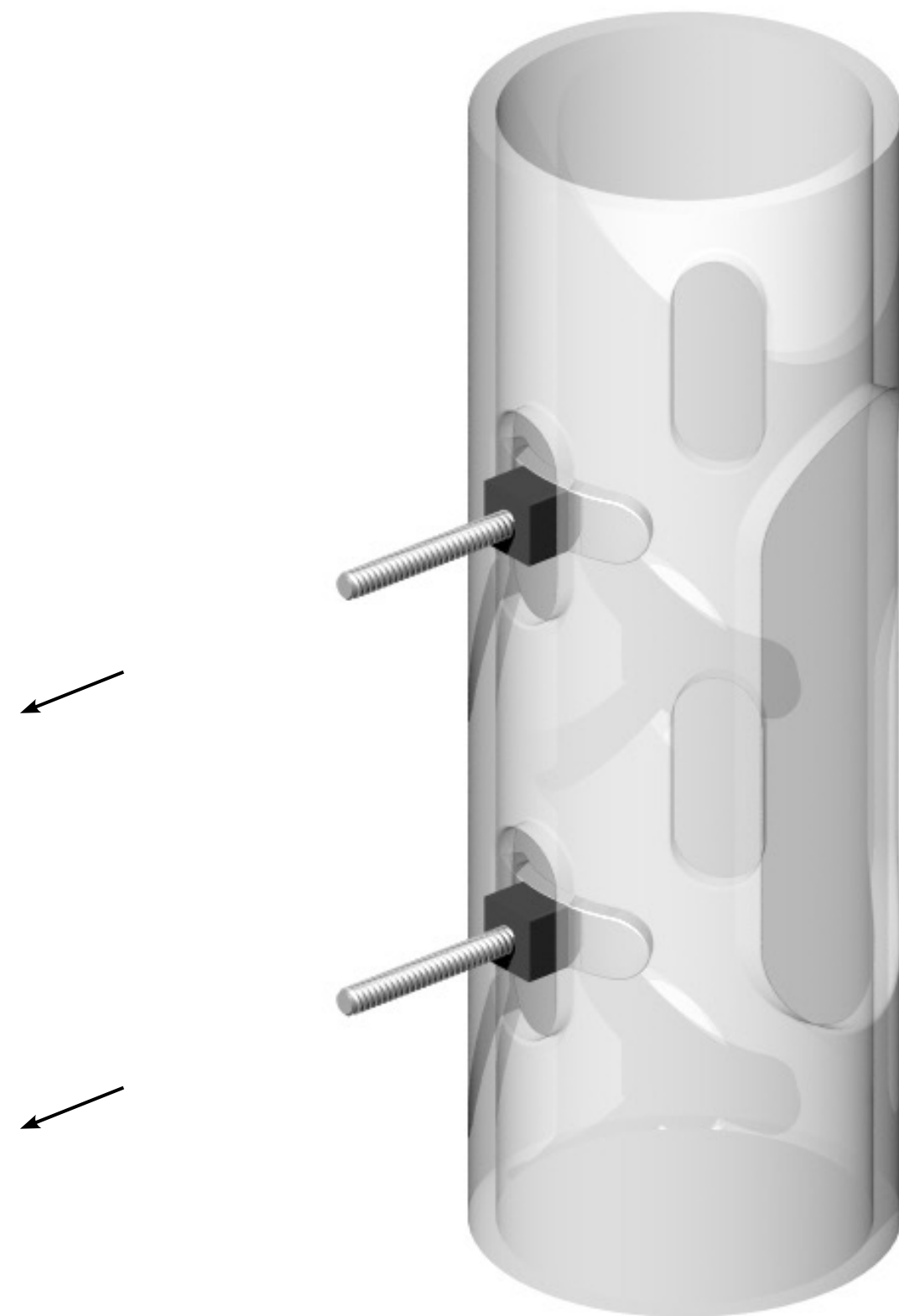
detailing - tube connector



detailing - tube connector



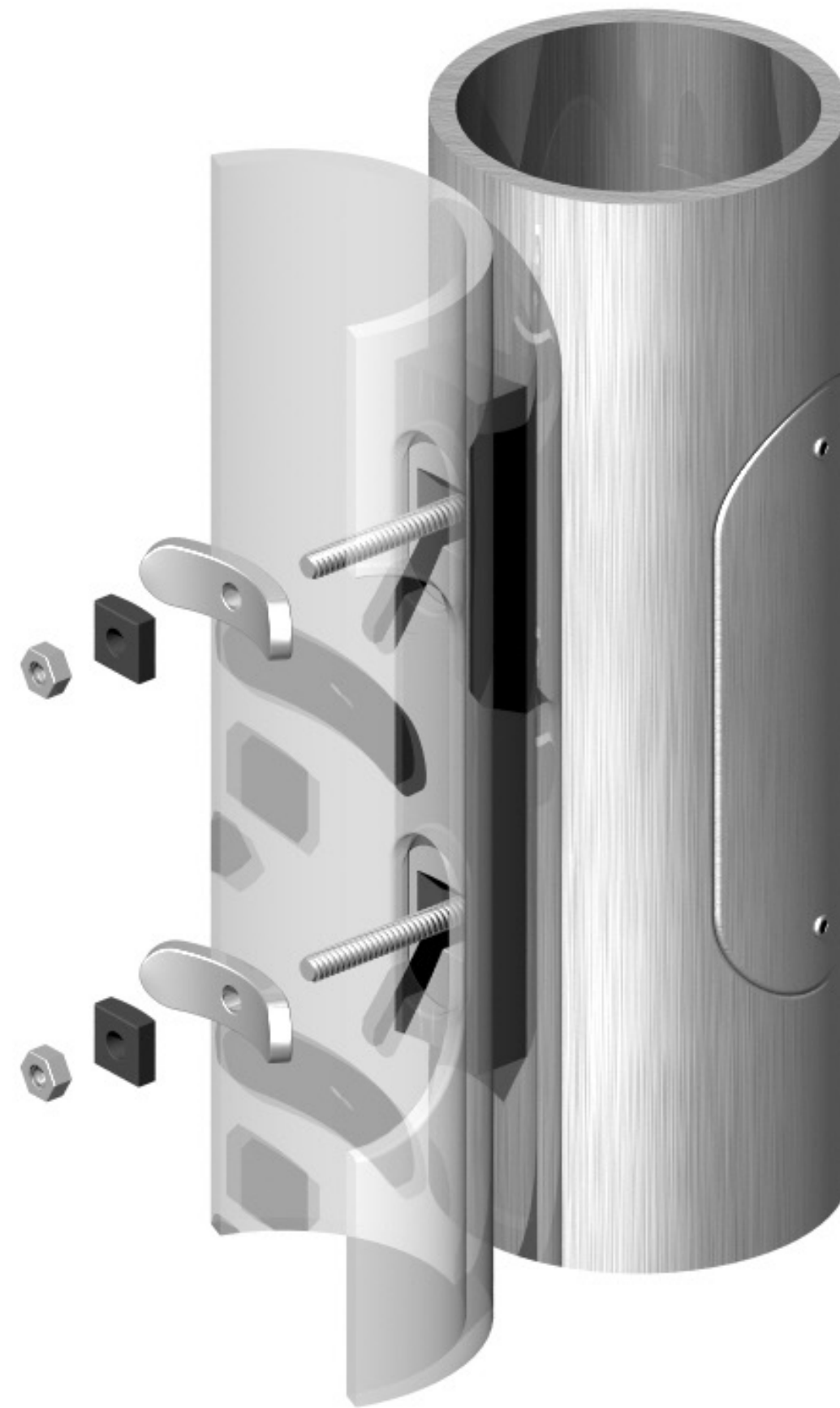
detailing - tube connector



detailing - tube connector



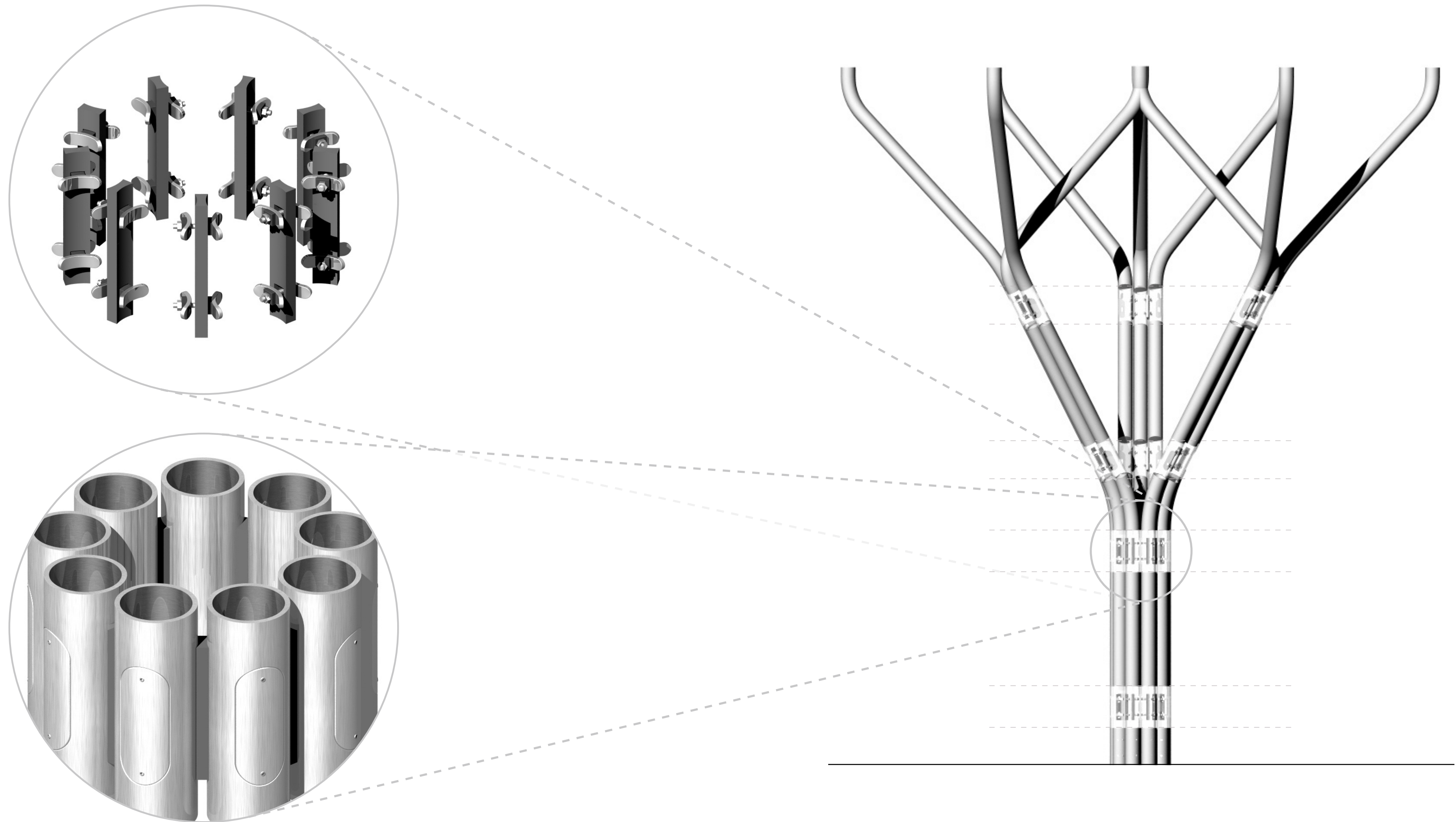
detailing - tube connector

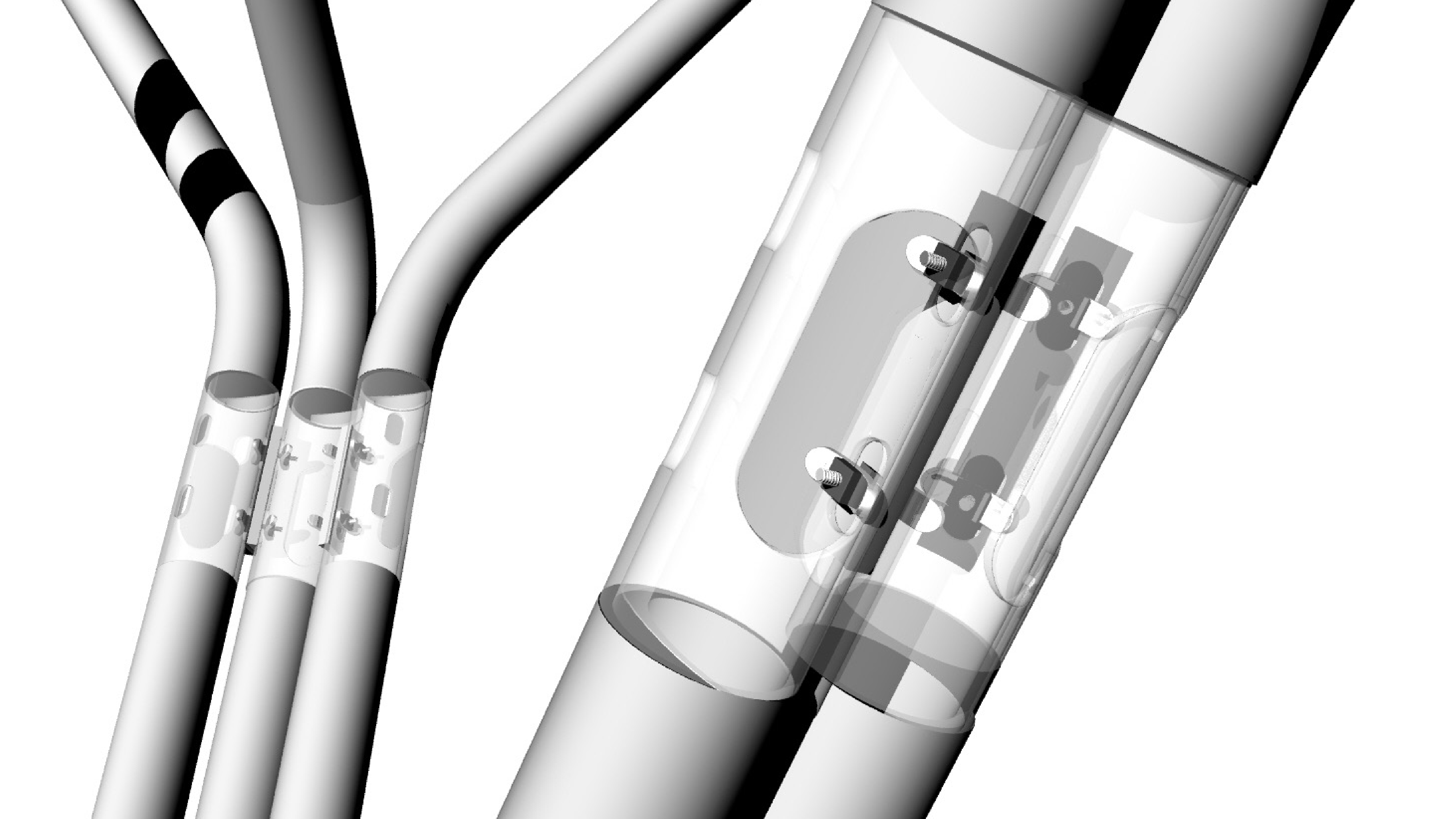


detailing - tube connector

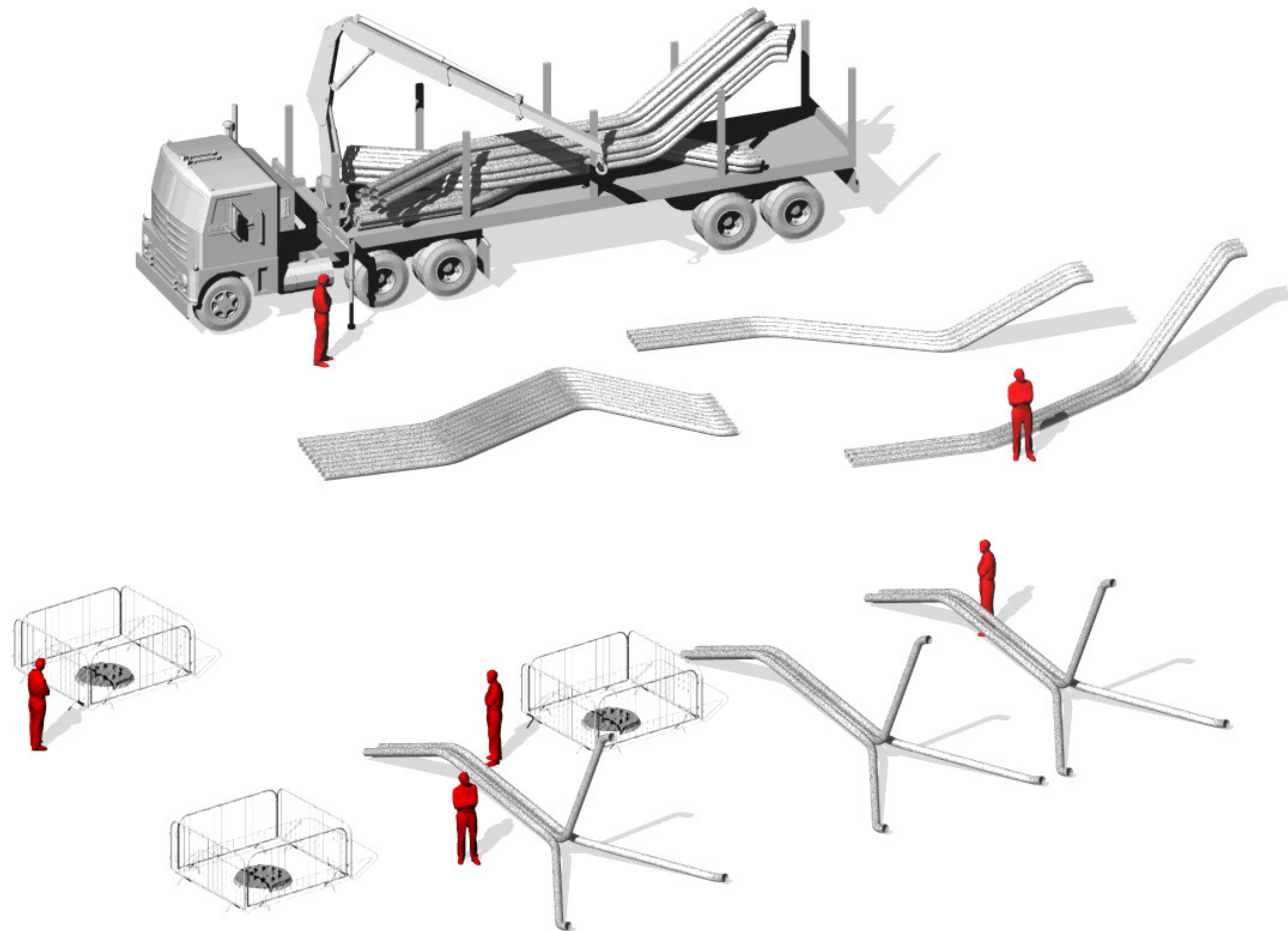


detailing - tube connector

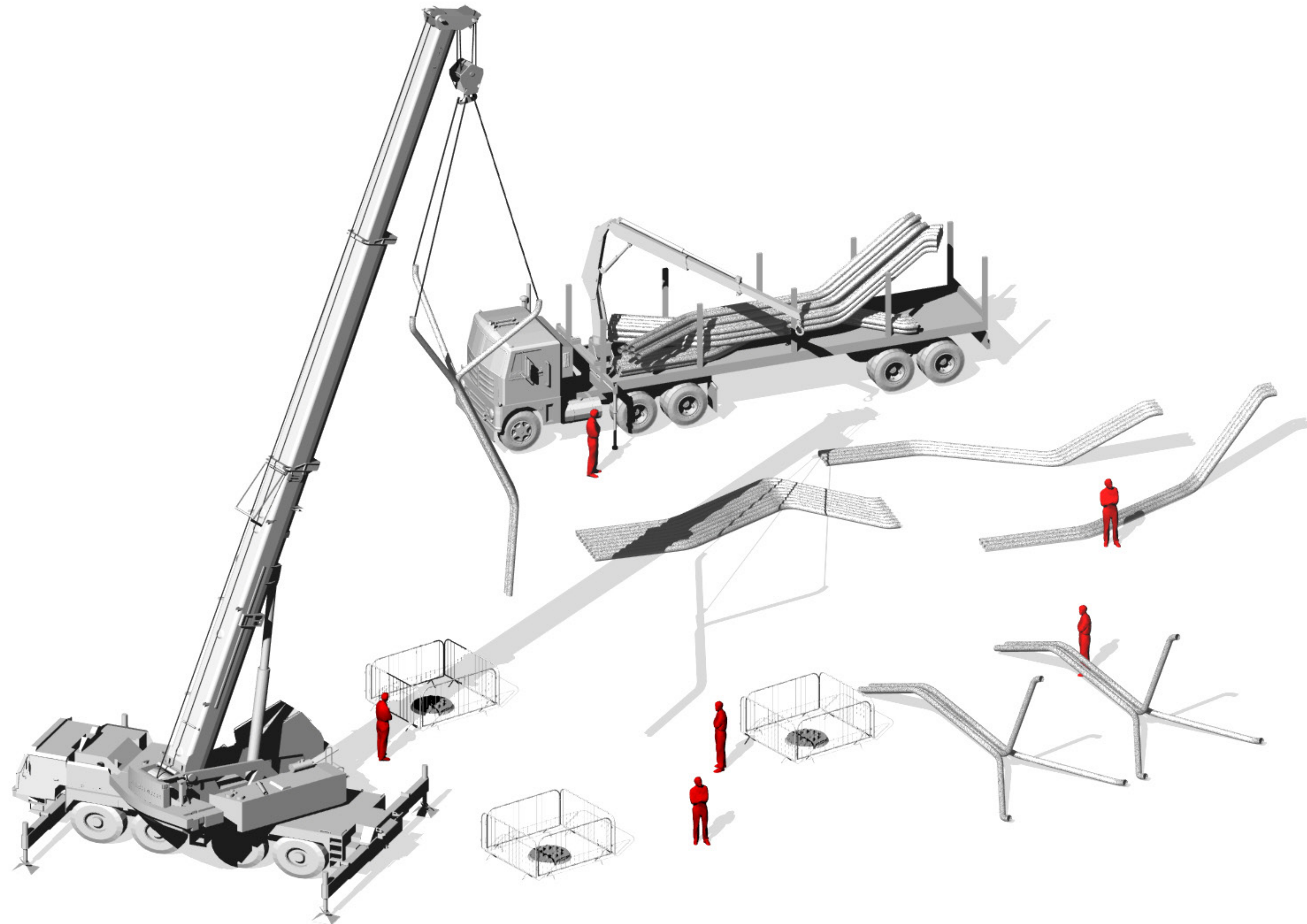




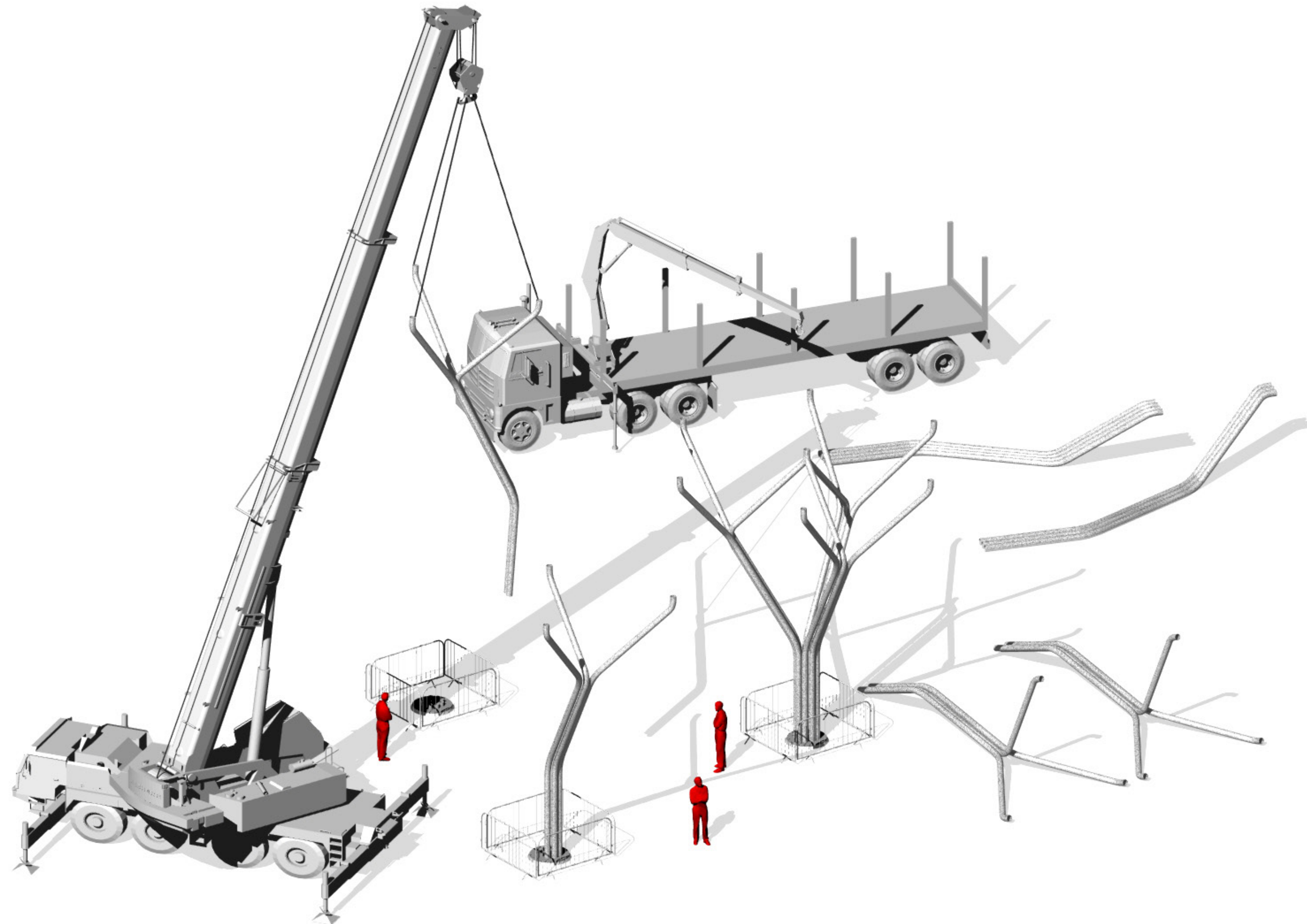
method statement



method statement



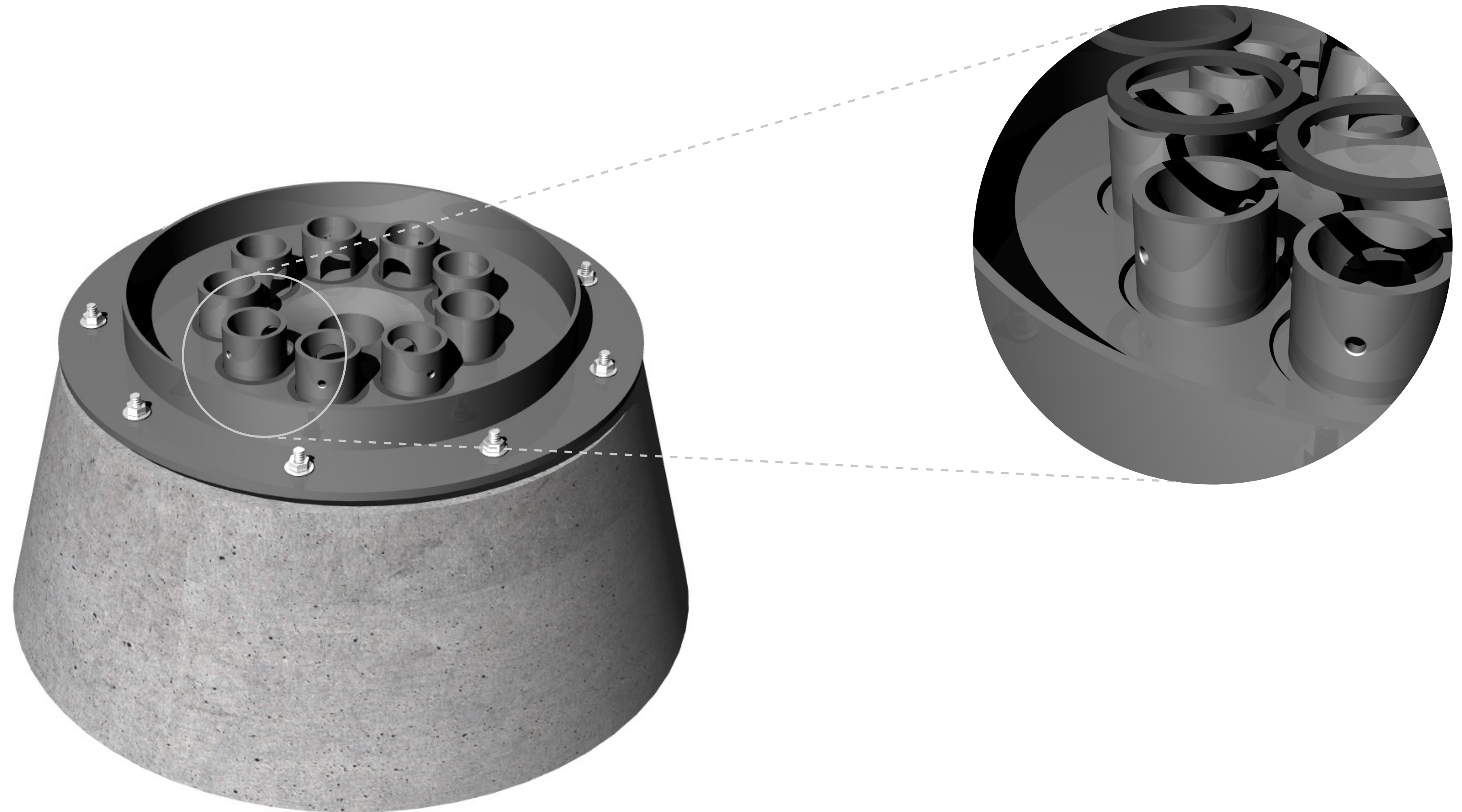
method statement



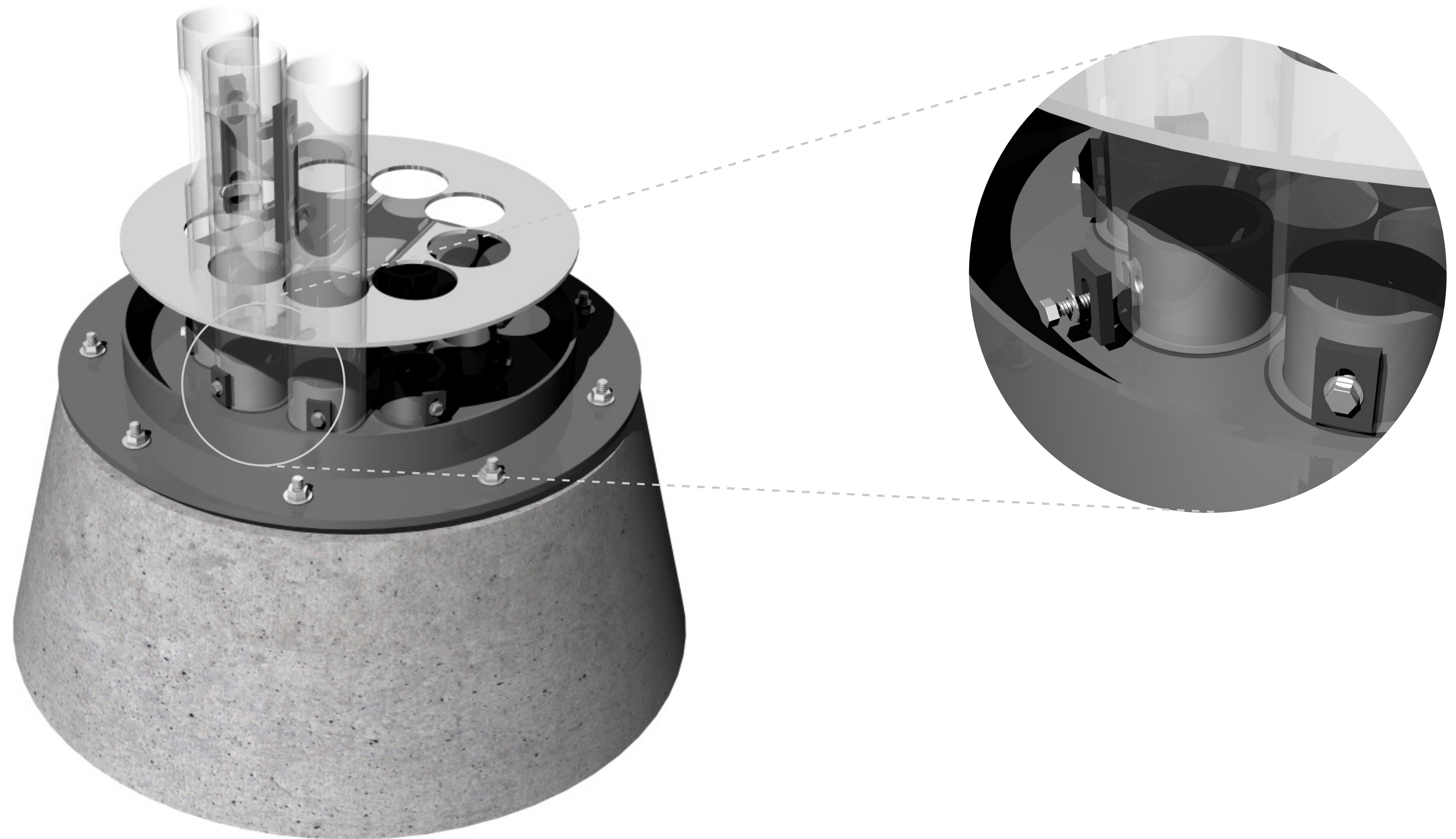
detailing - bearing



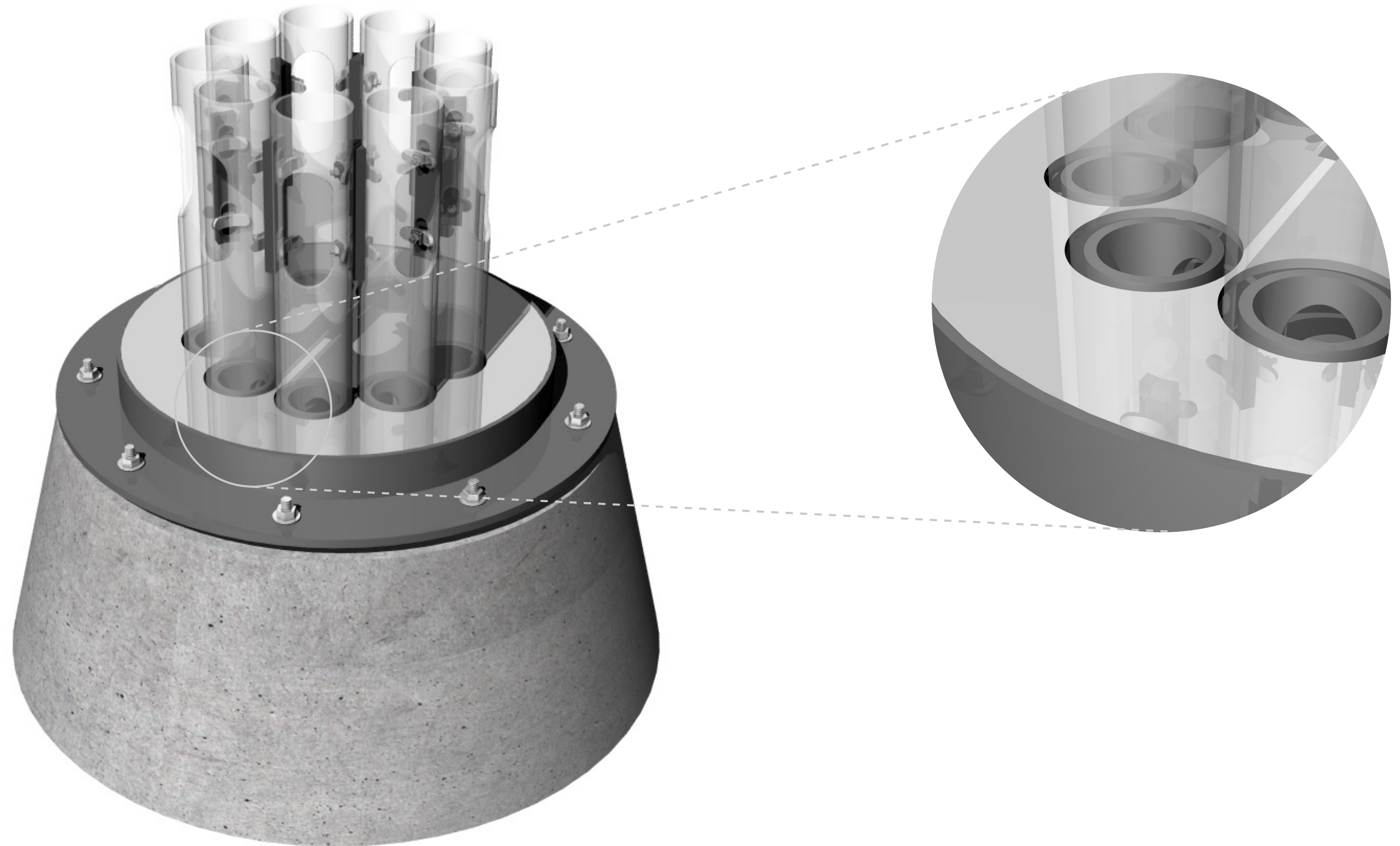
detailing - bearing



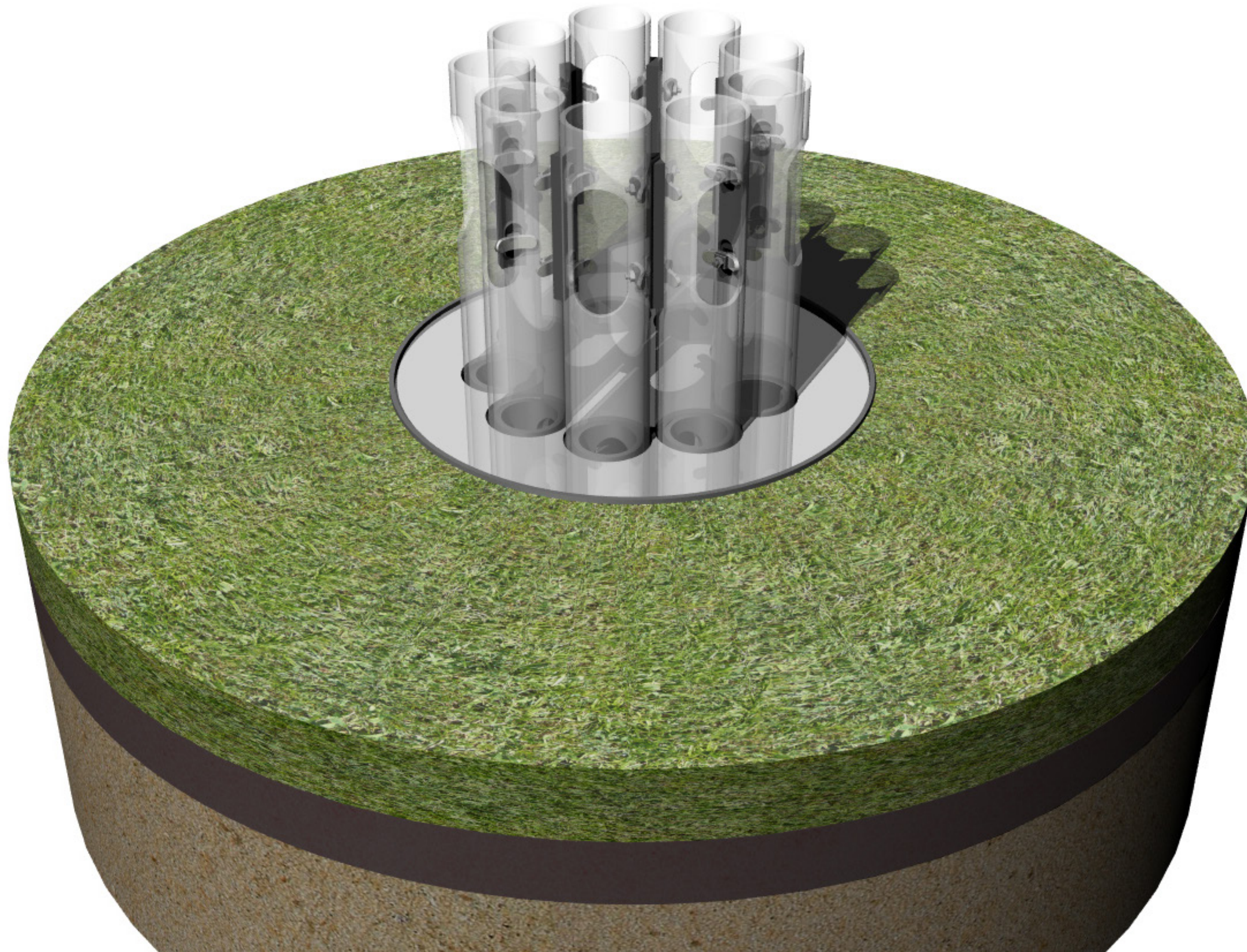
detailing - bearing



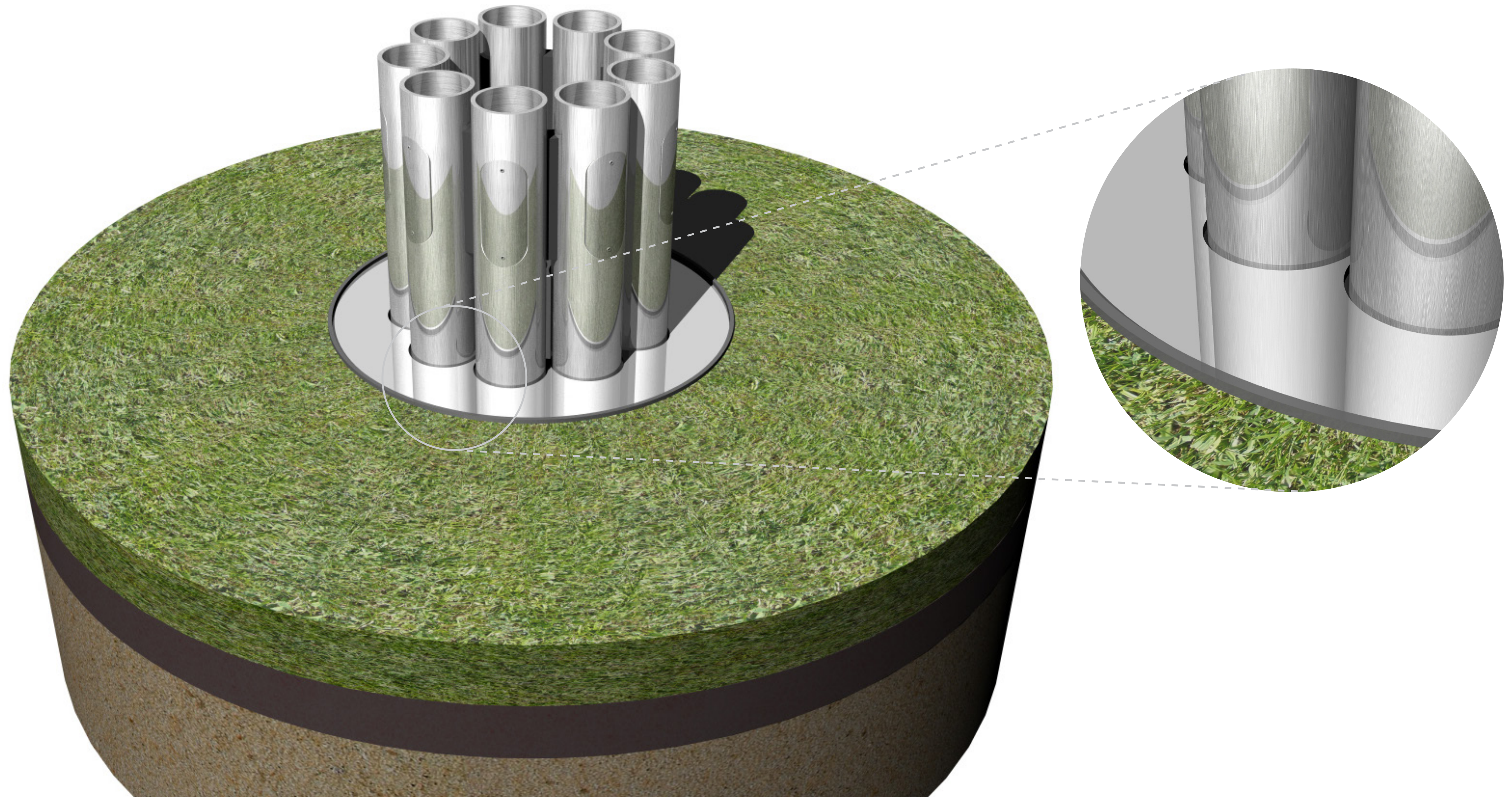
detailing - bearing



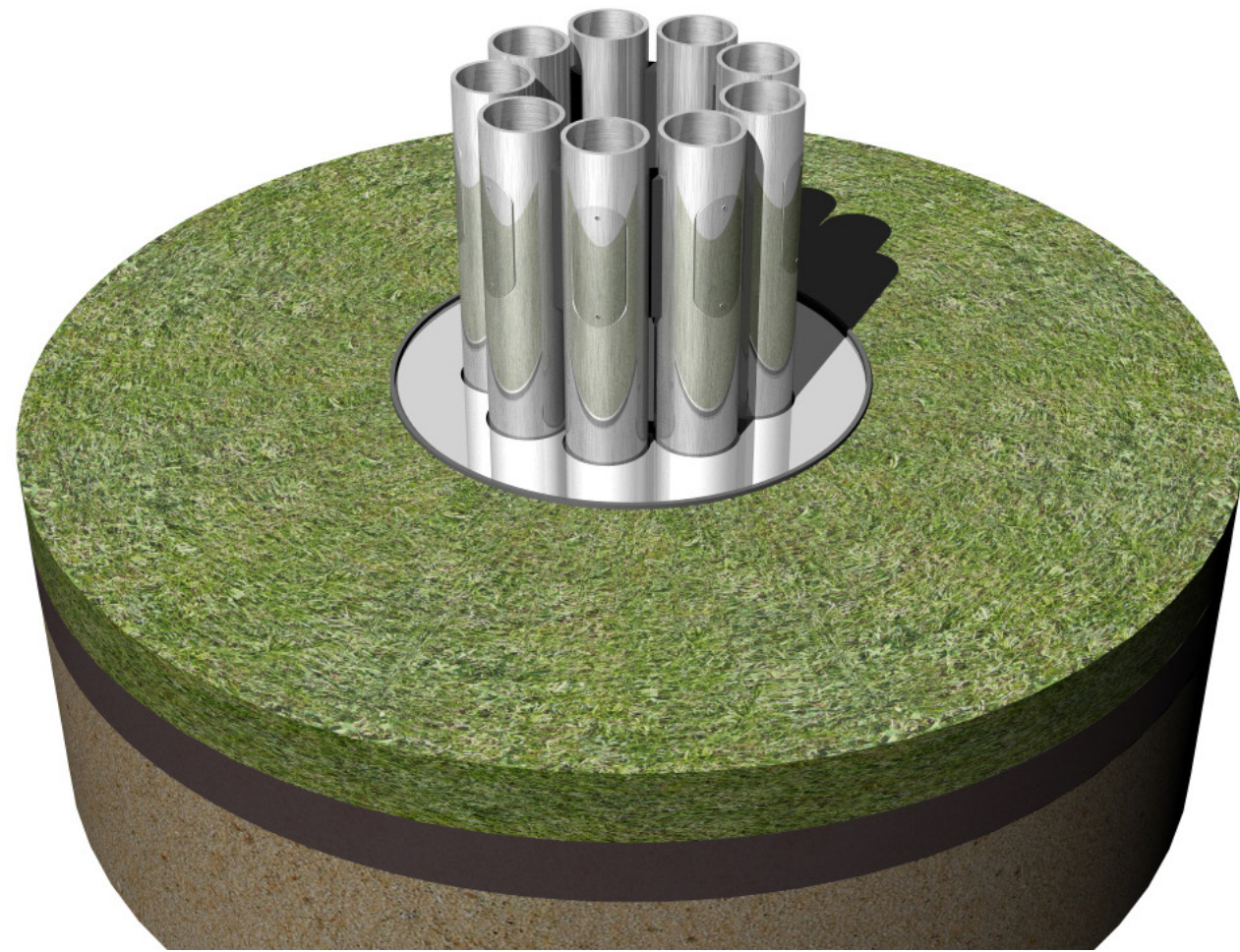
detailing - bearing



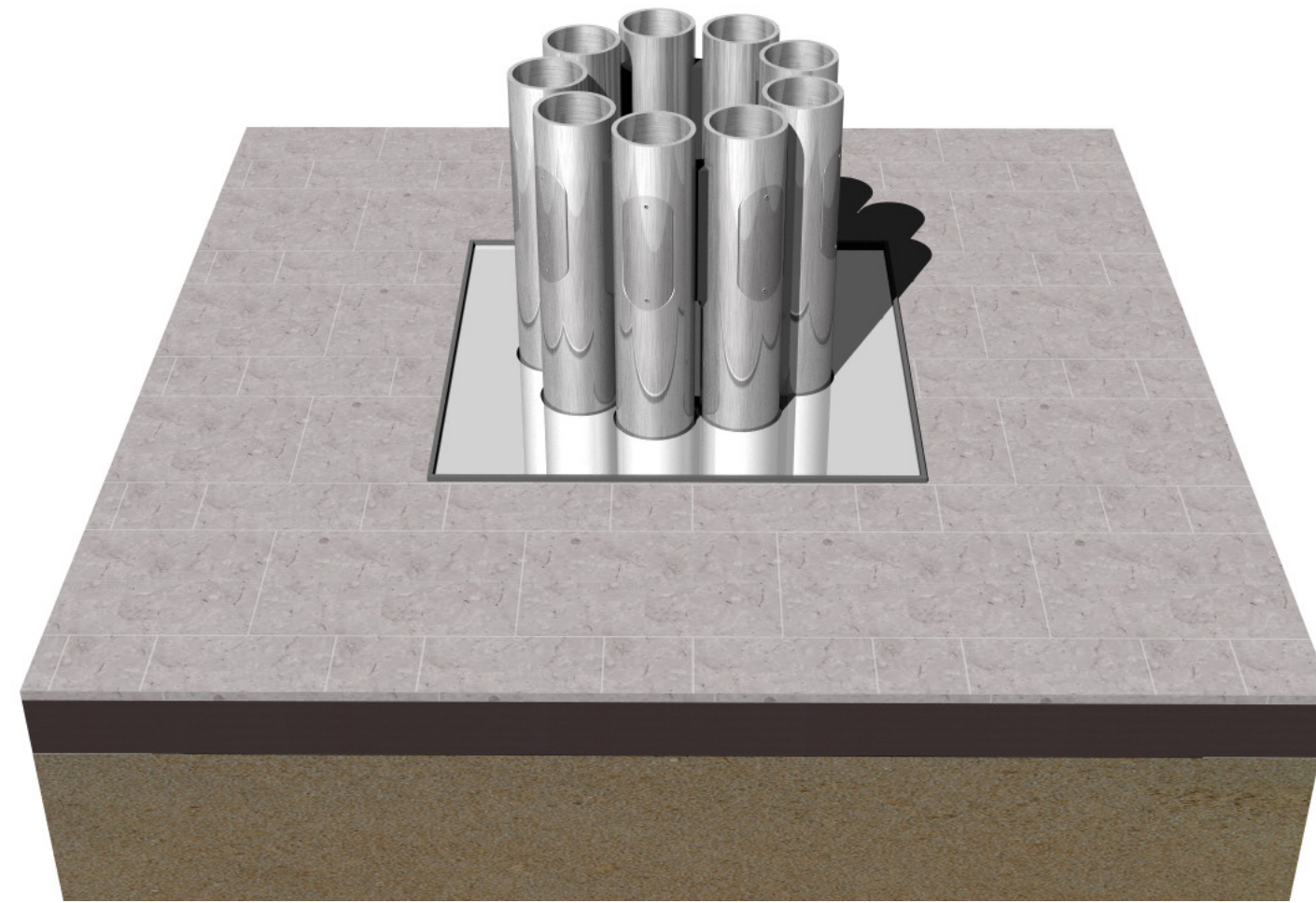
detailing - bearing



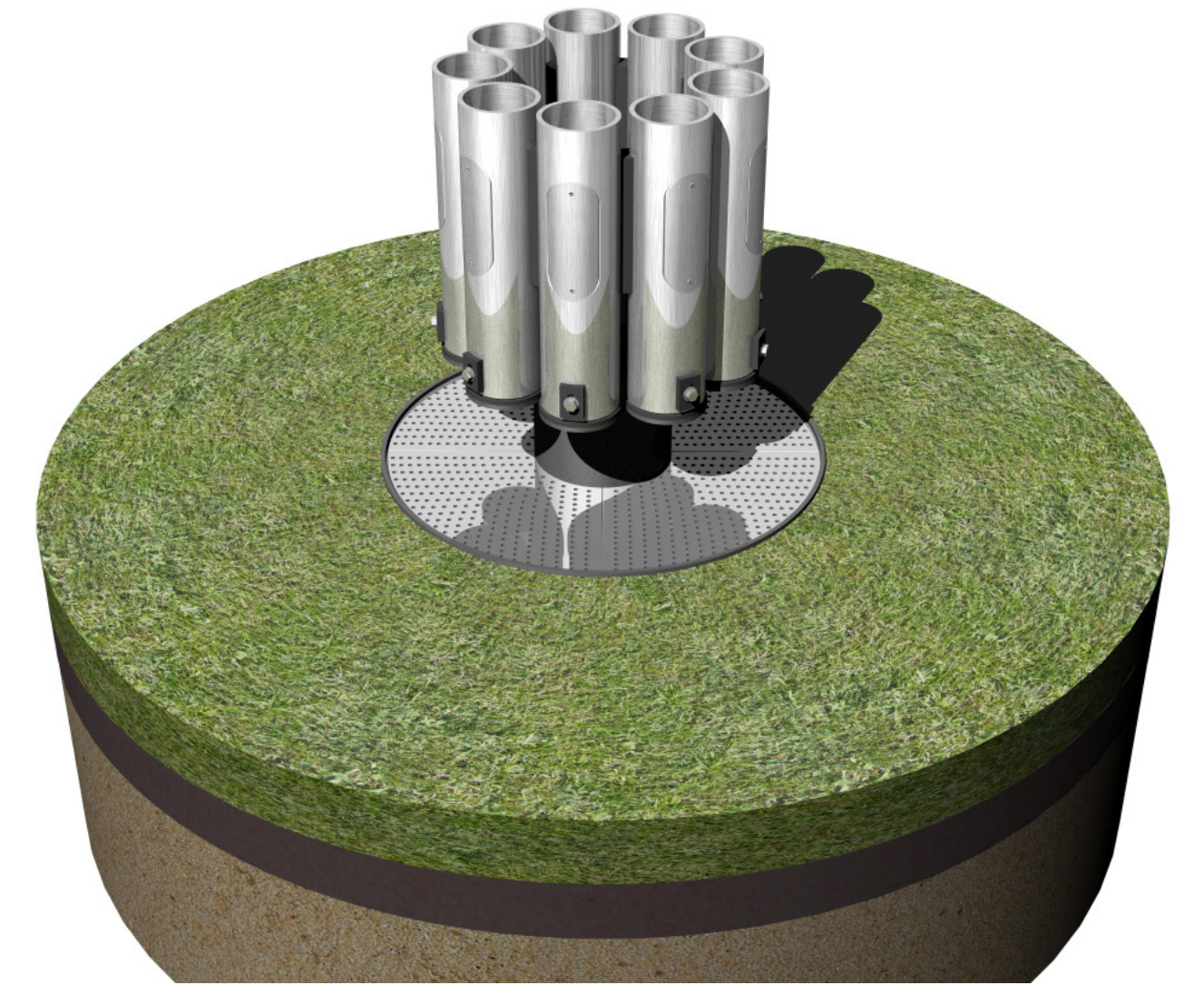
detailing - bearing



LAWN

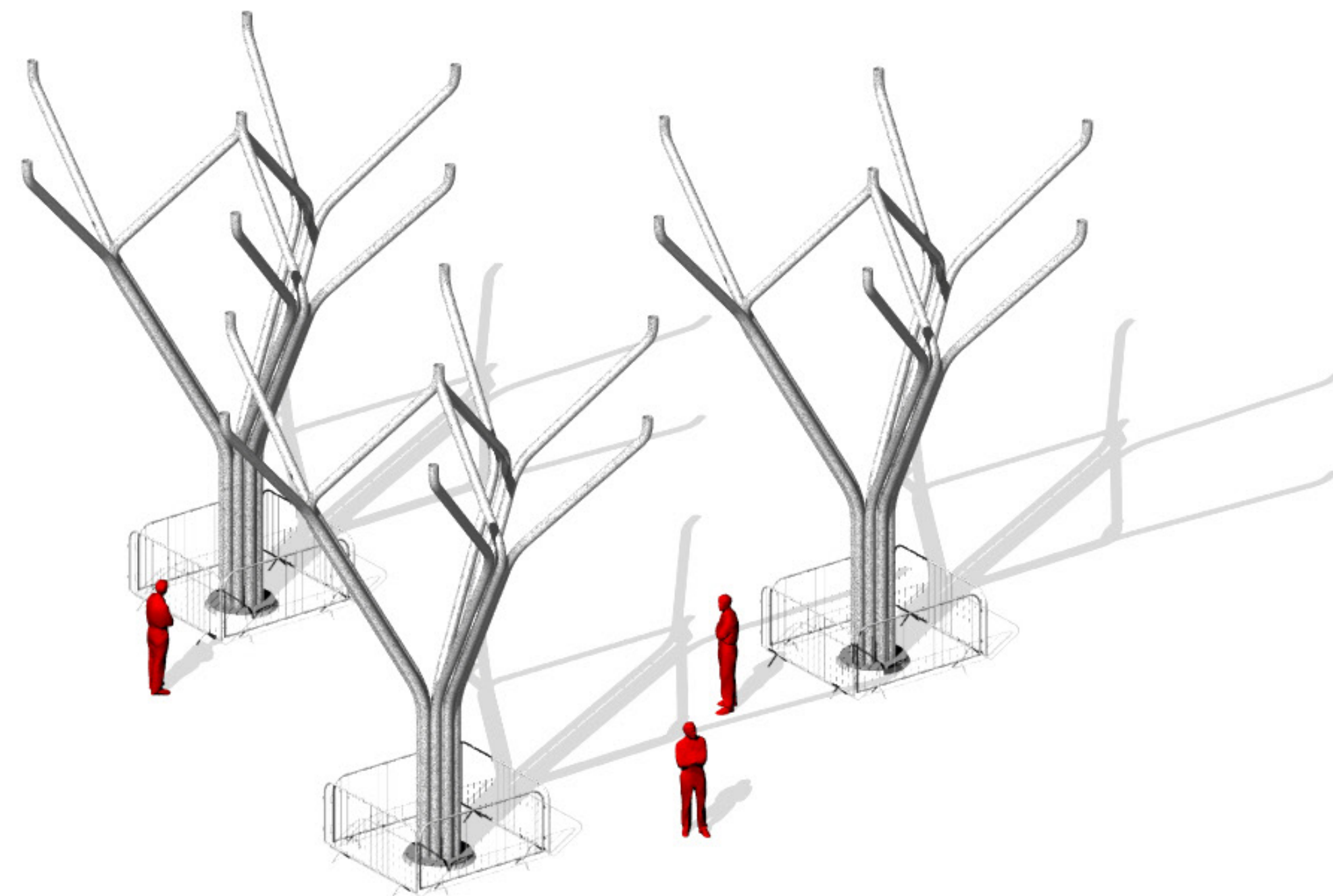


TILED SQUARE

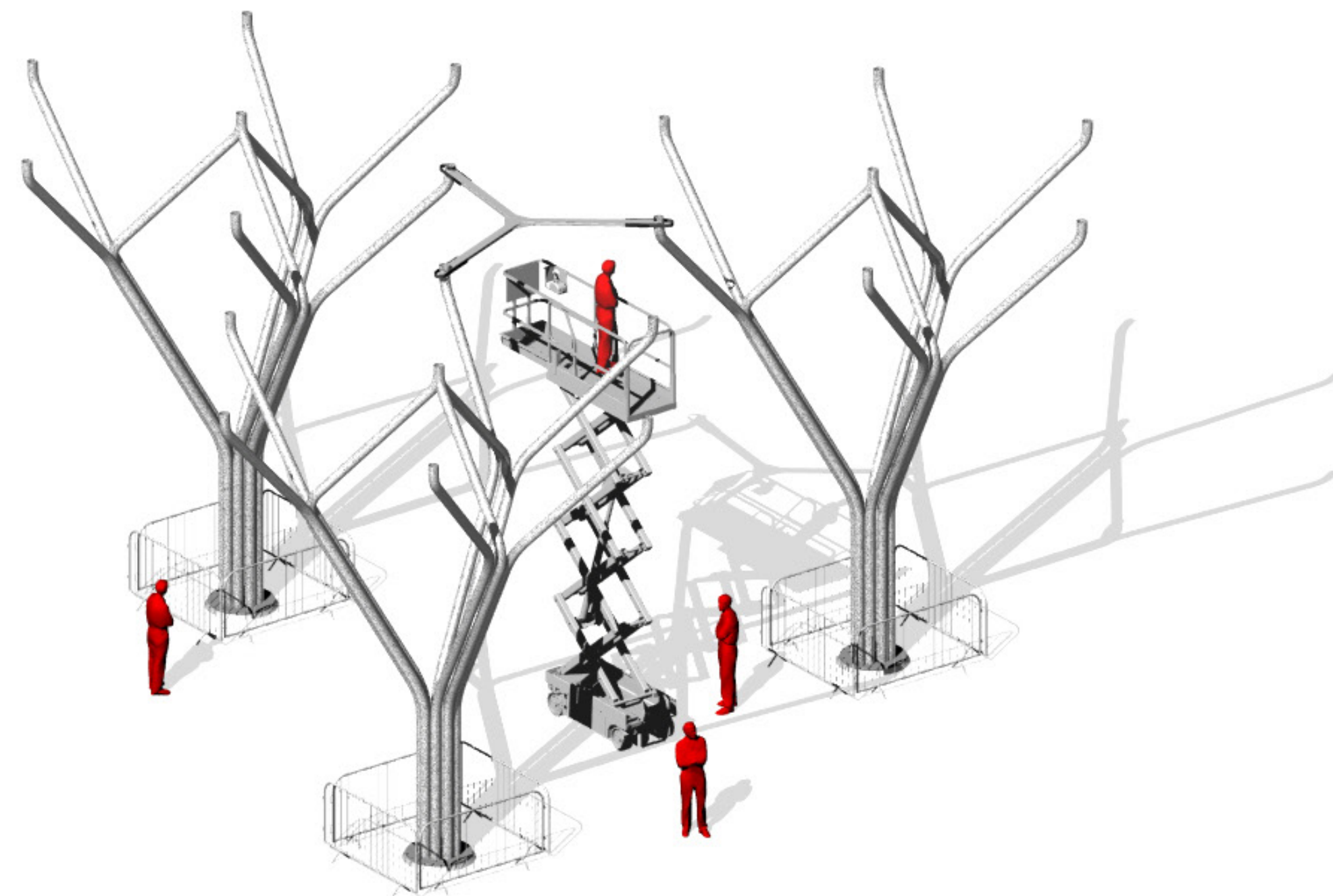


EXTERIOR WATERDRAINAGE

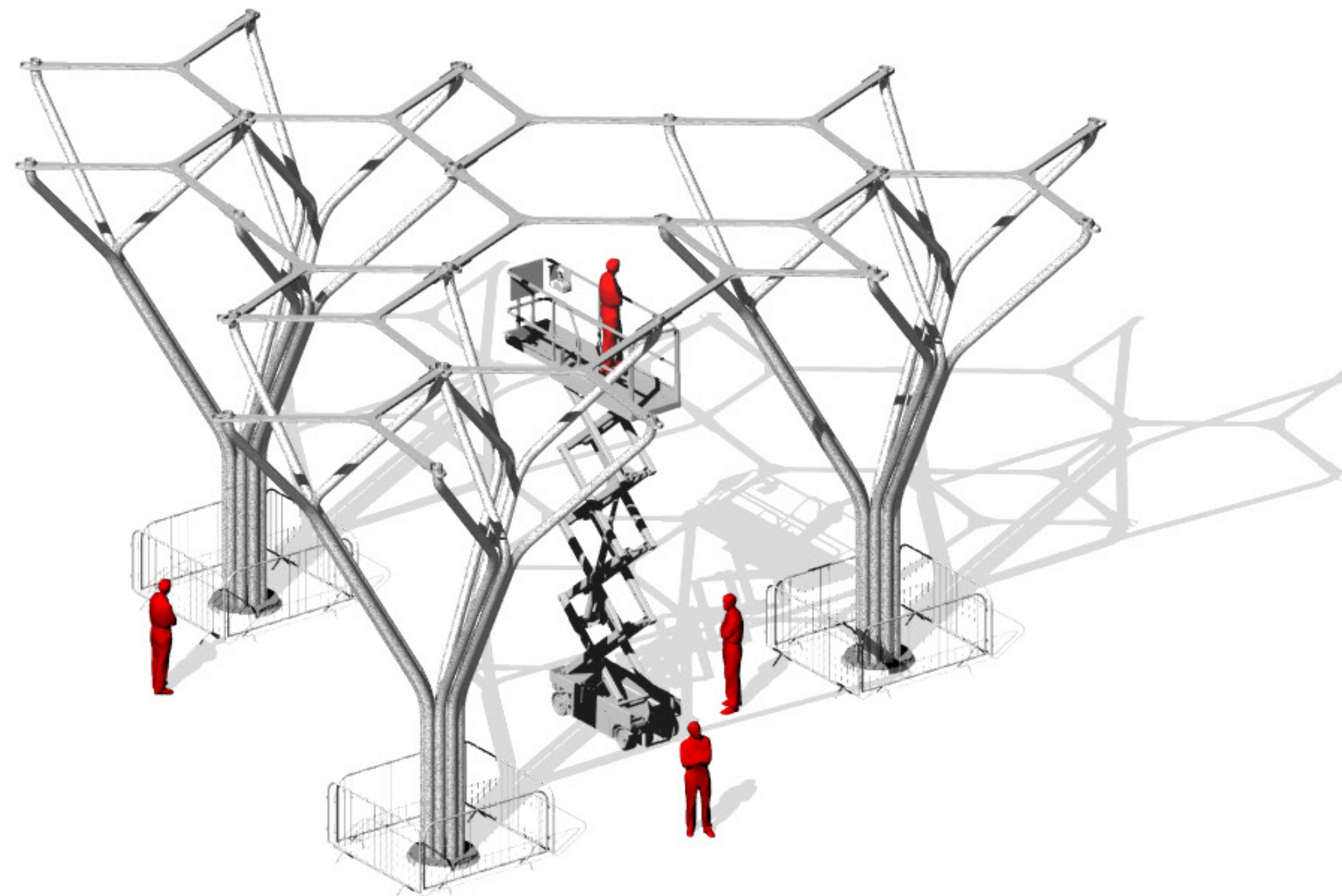
method statement



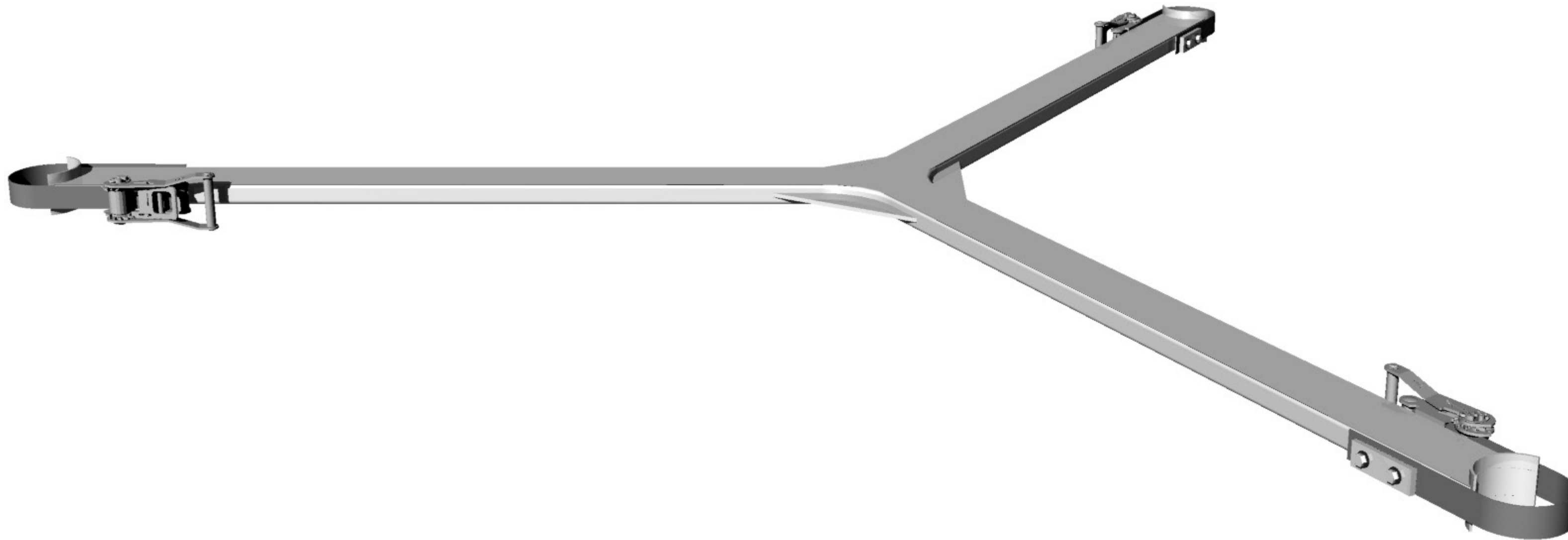
method statement



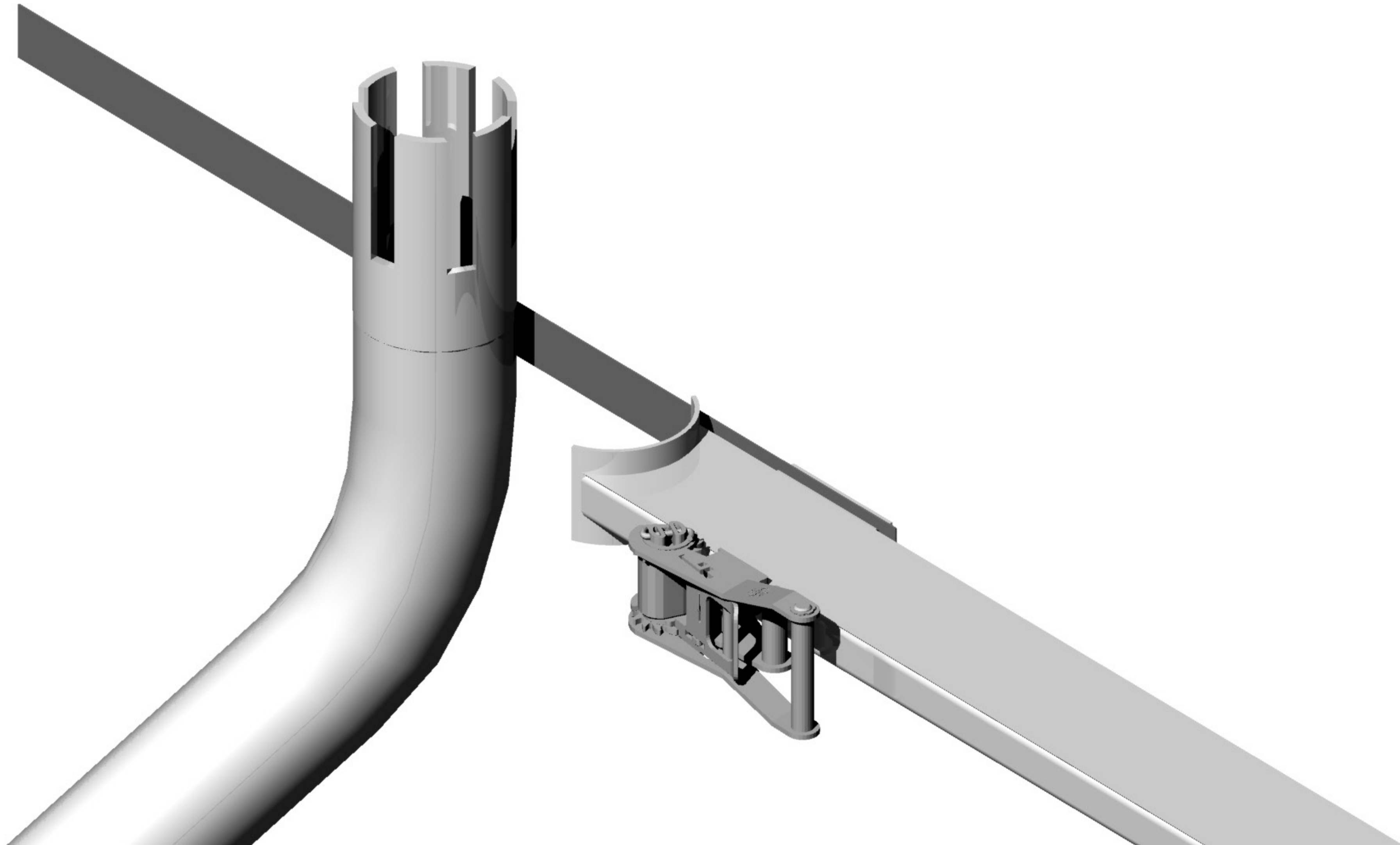
method statement



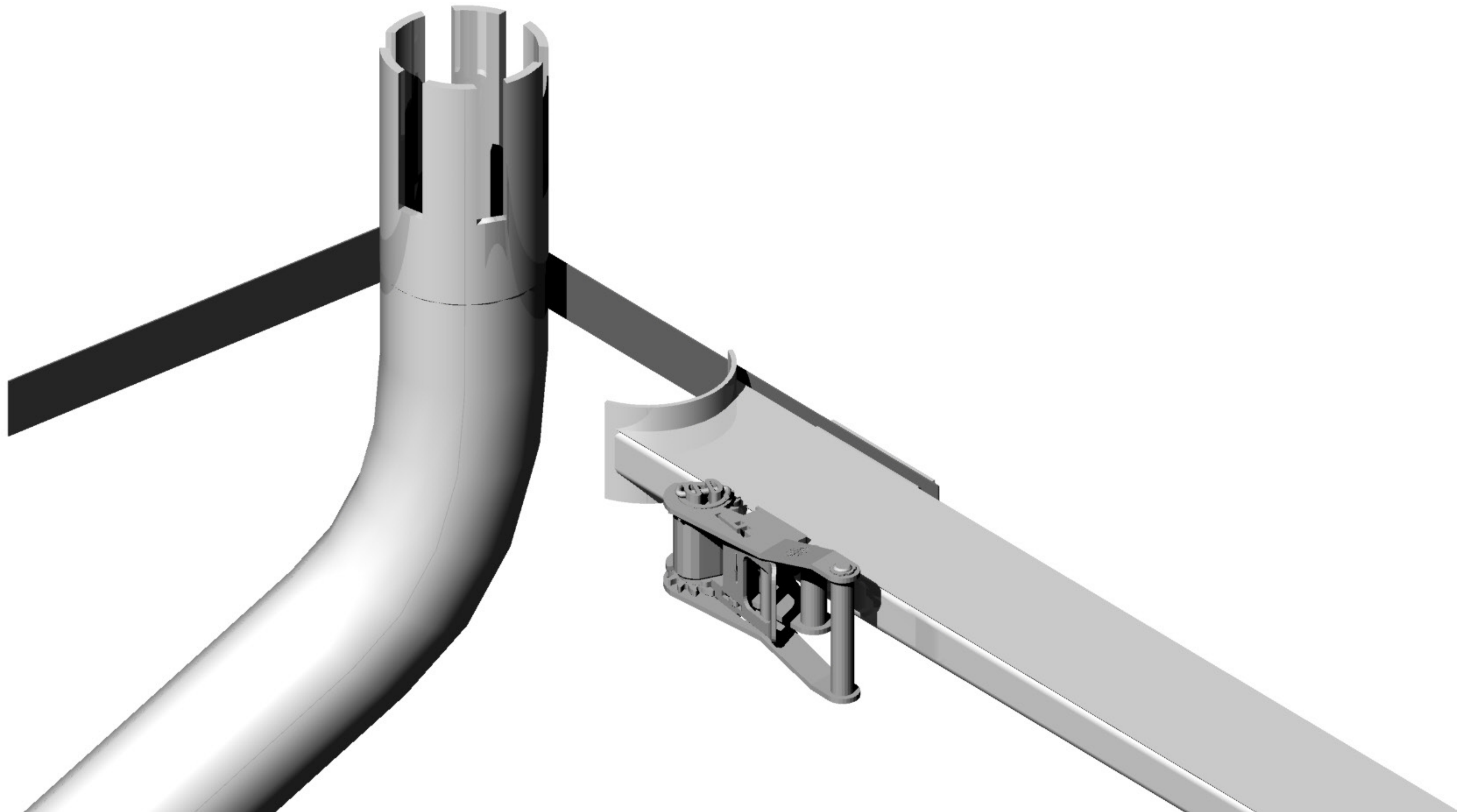
detailing - strapping tool



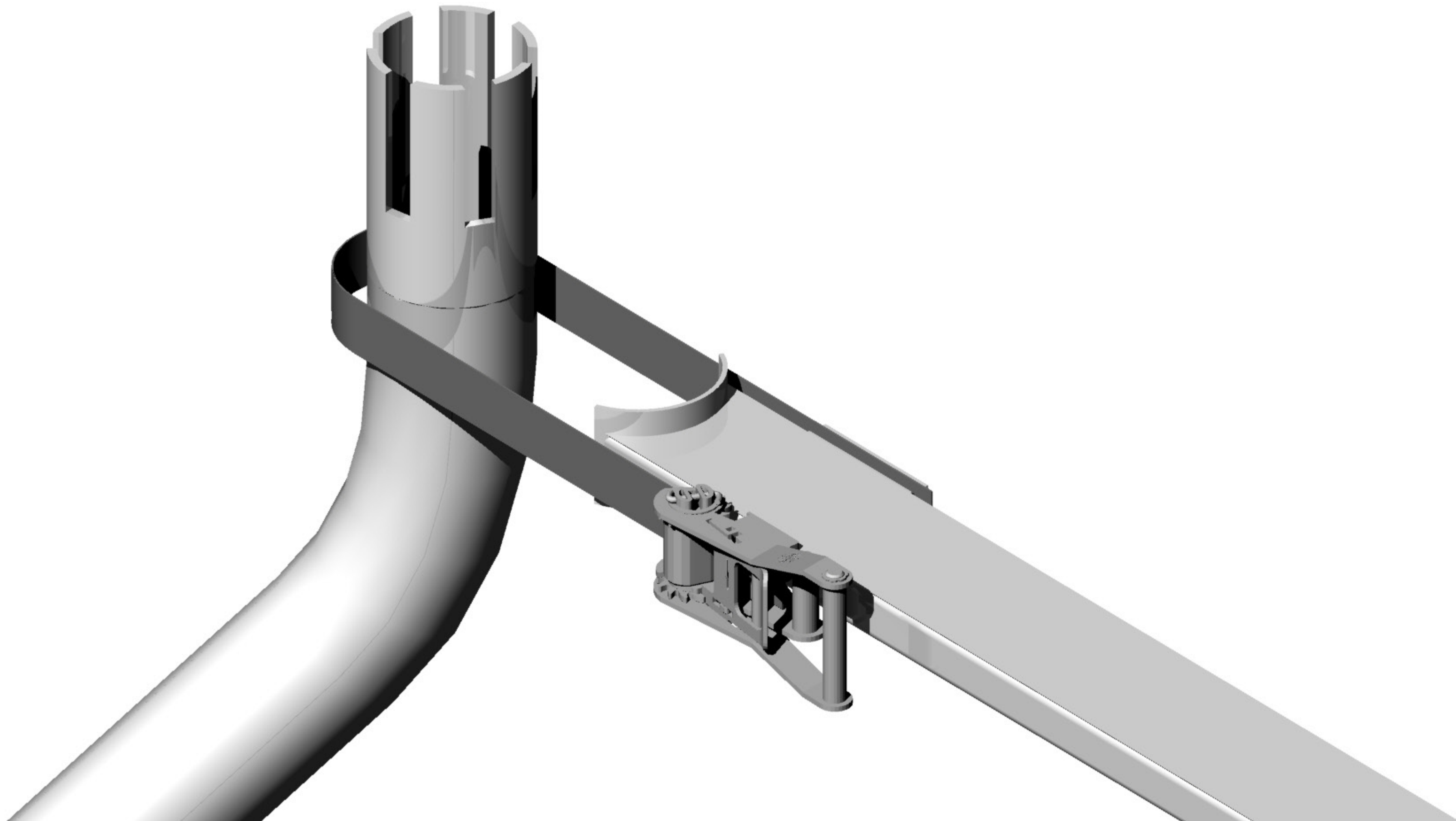
detailing - strapping tool



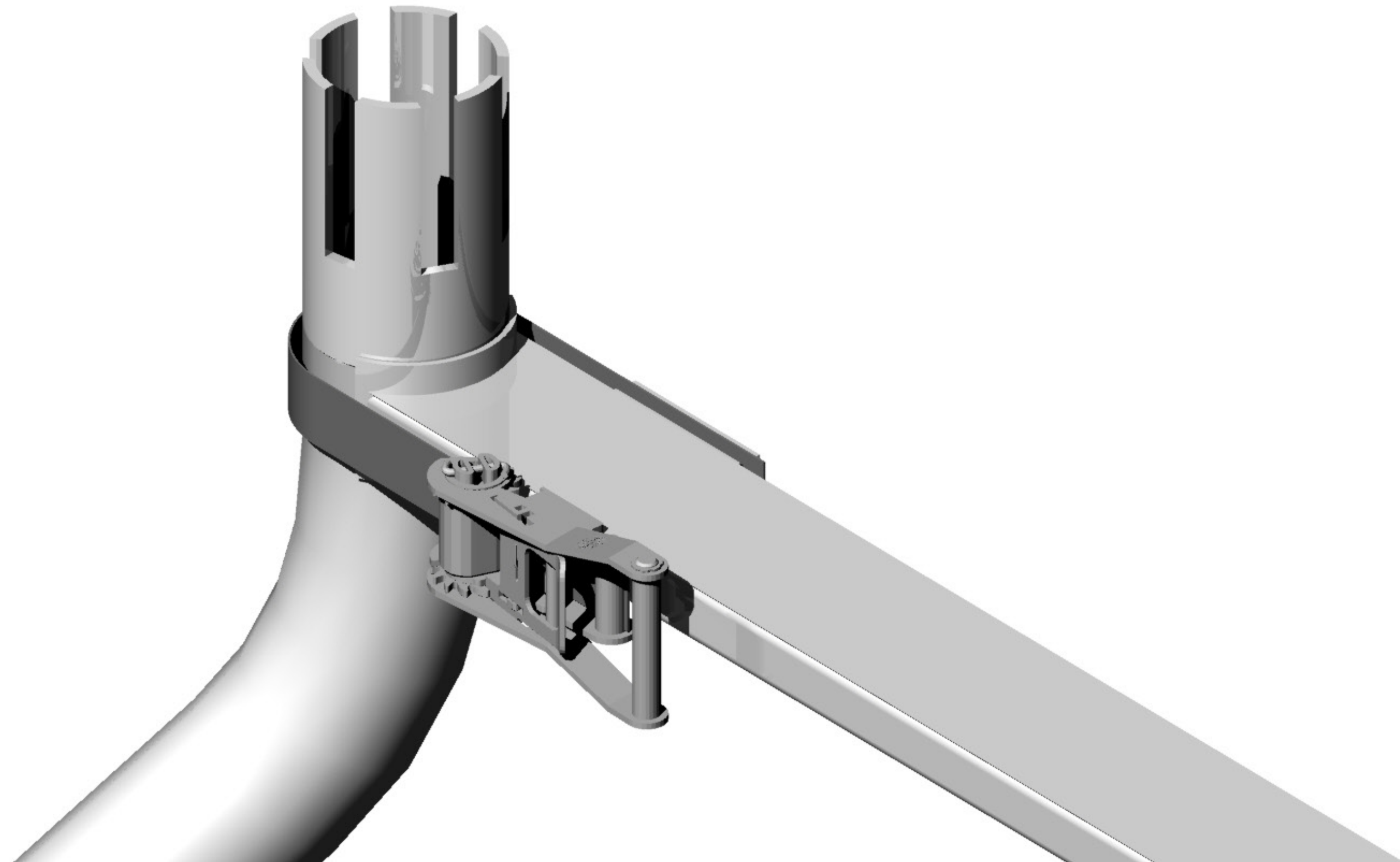
detailing - strapping tool



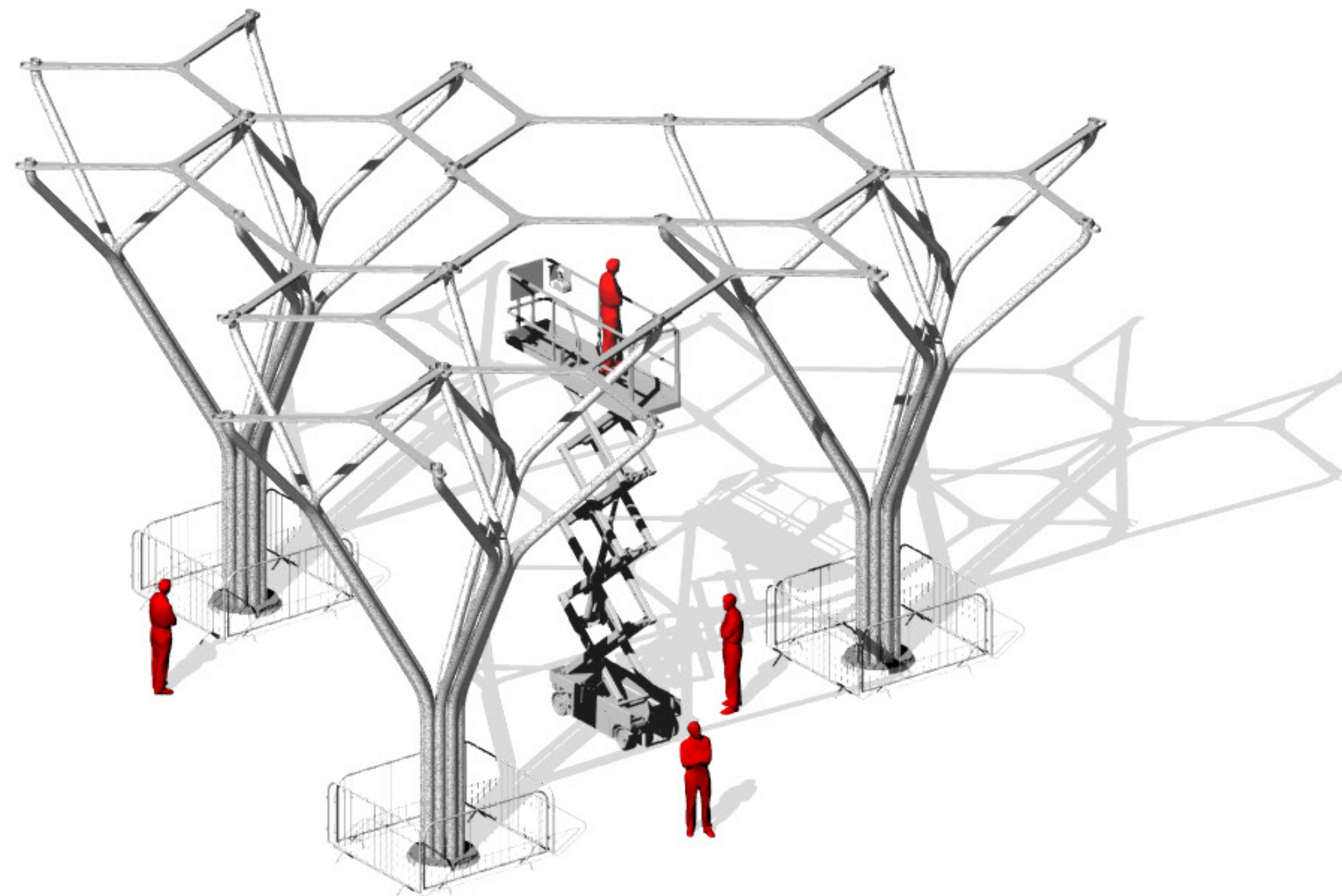
detailing - strapping tool



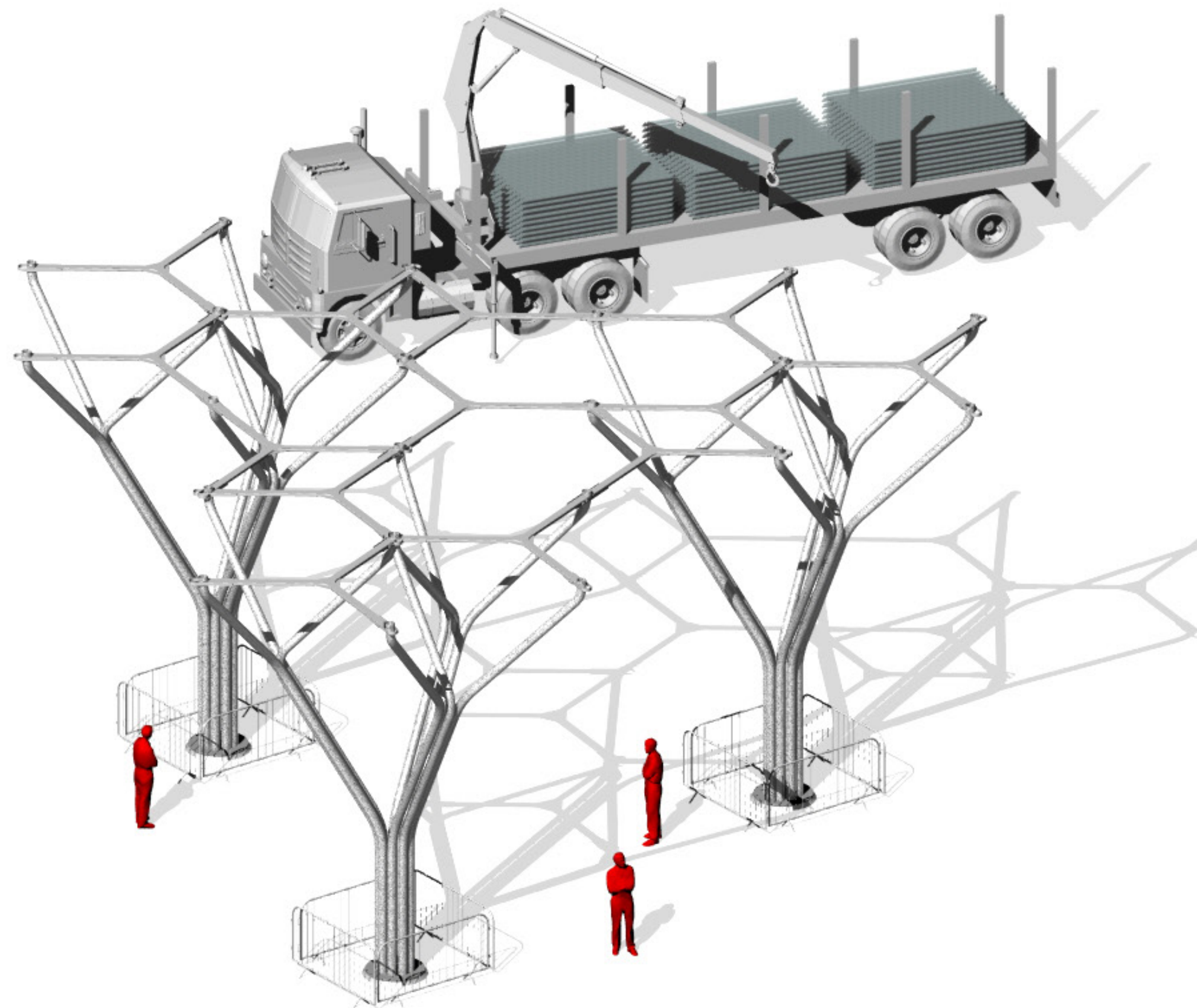
detailing - strapping tool



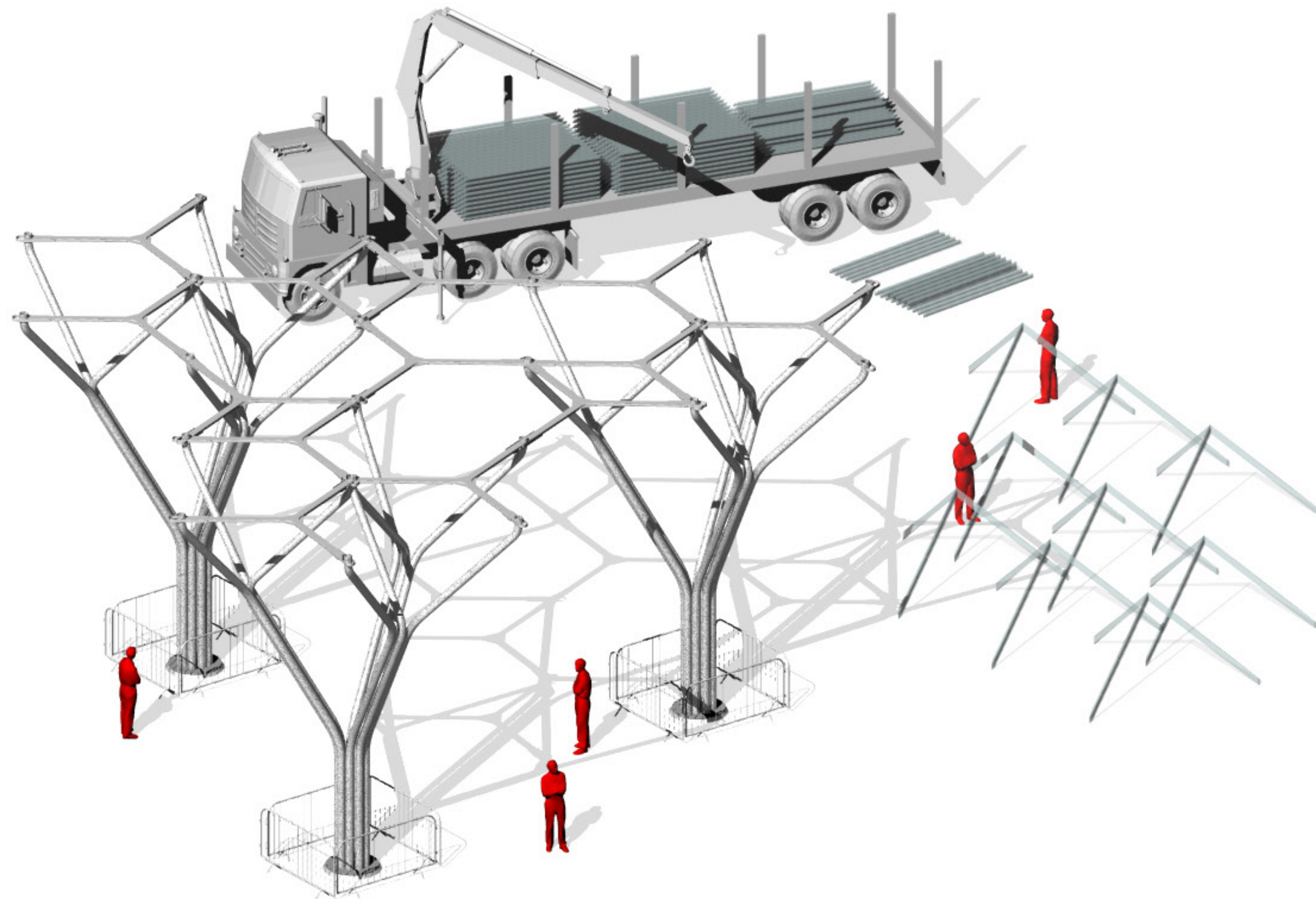
method statement



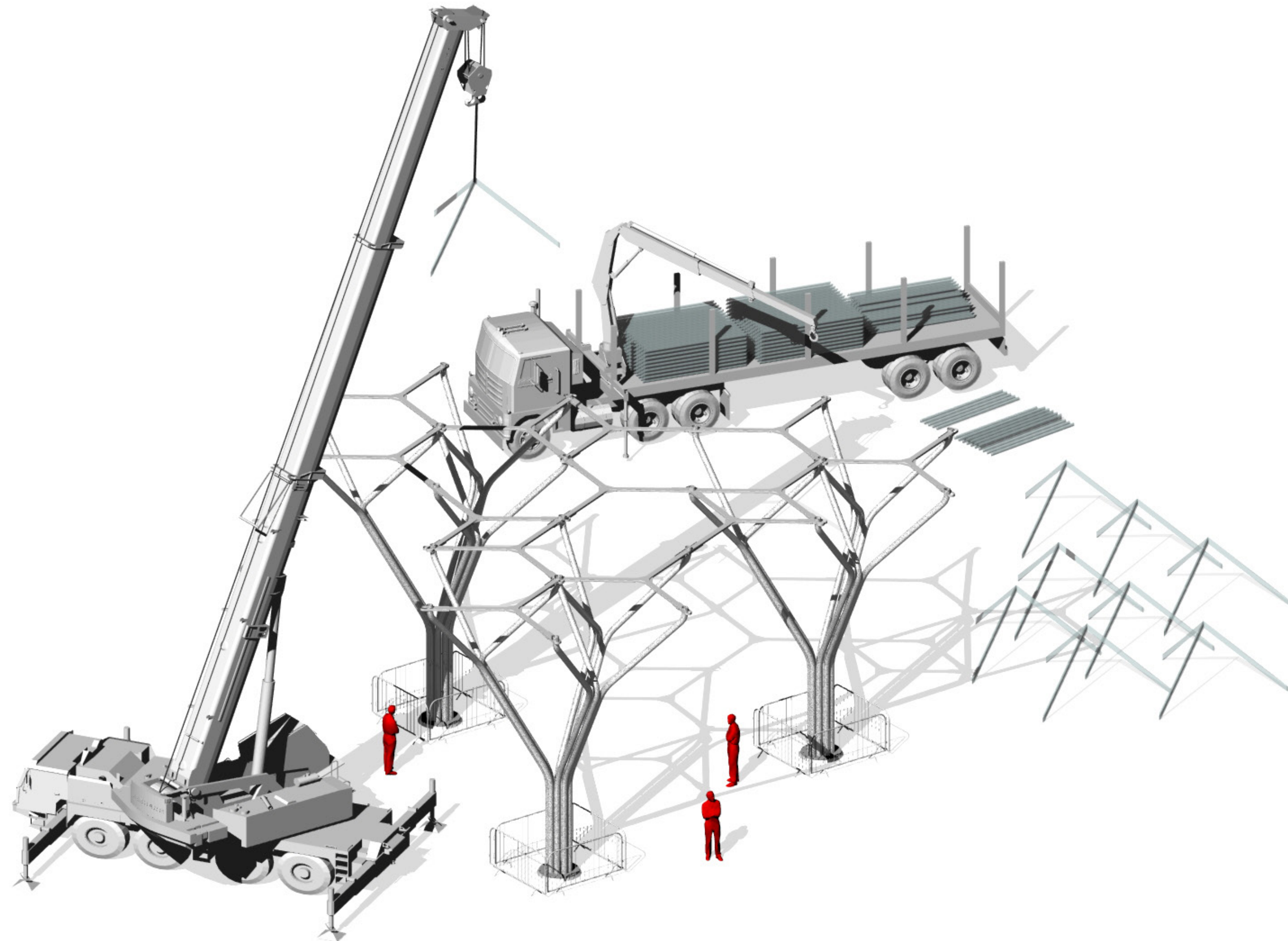
method statement



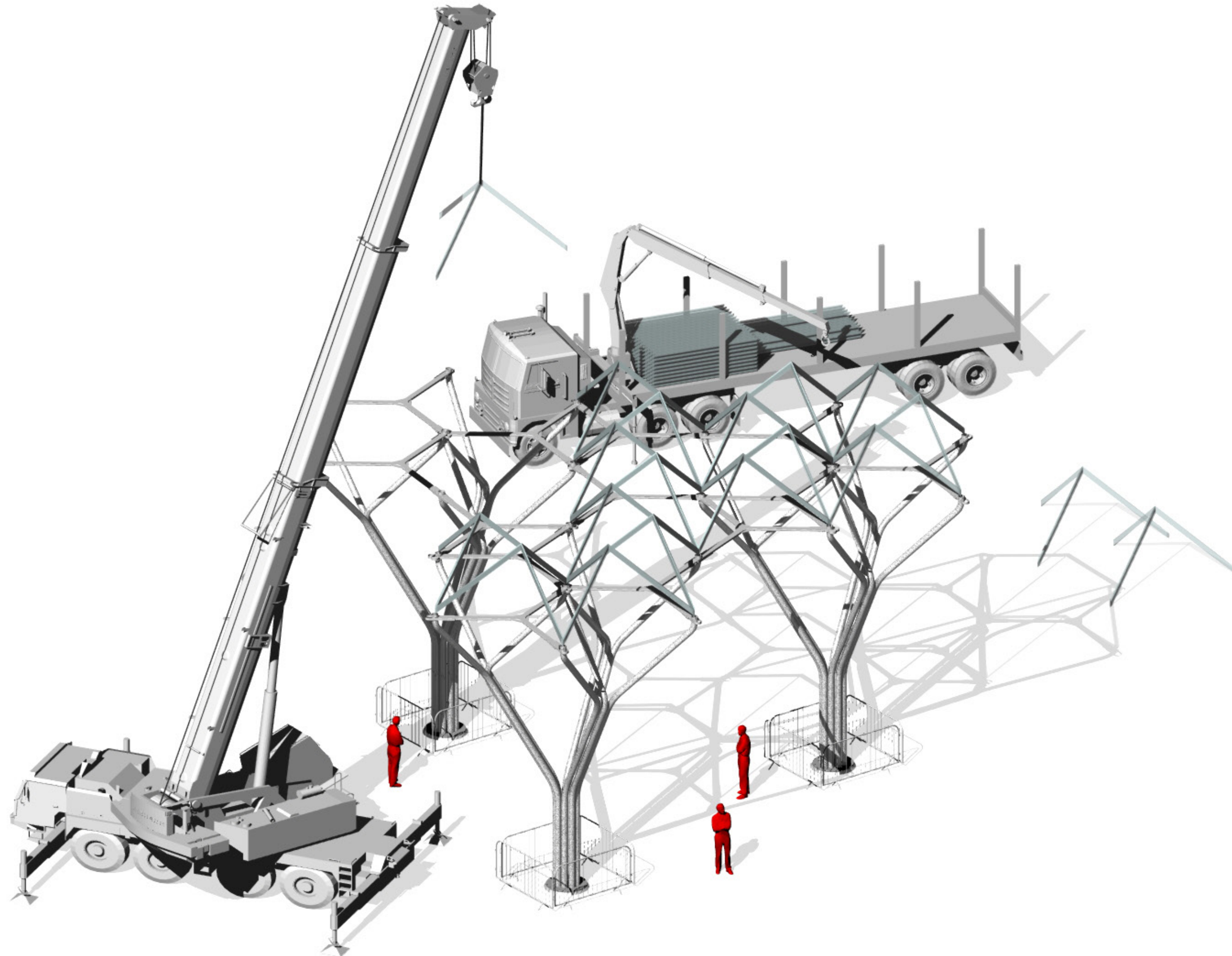
method statement



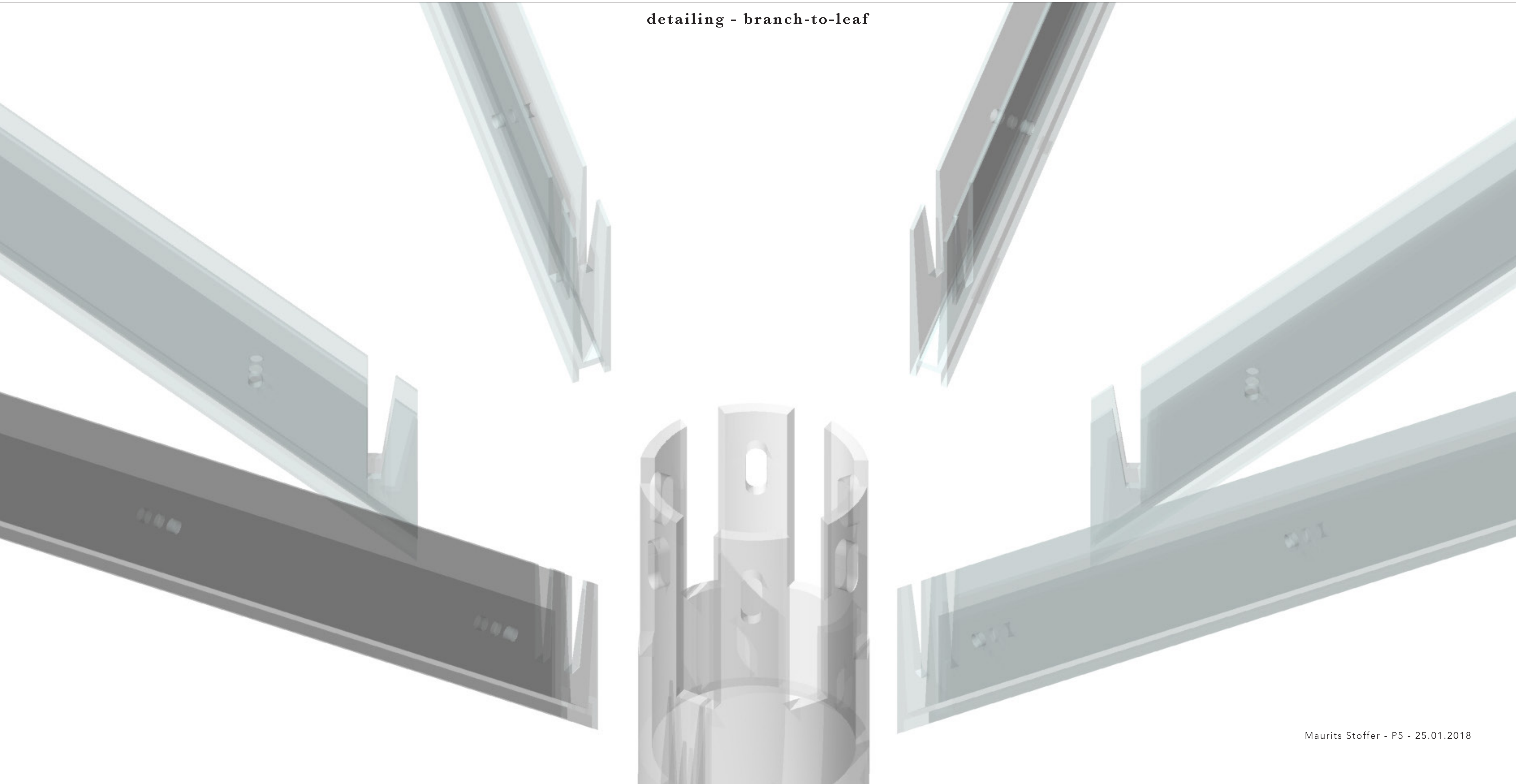
method statement



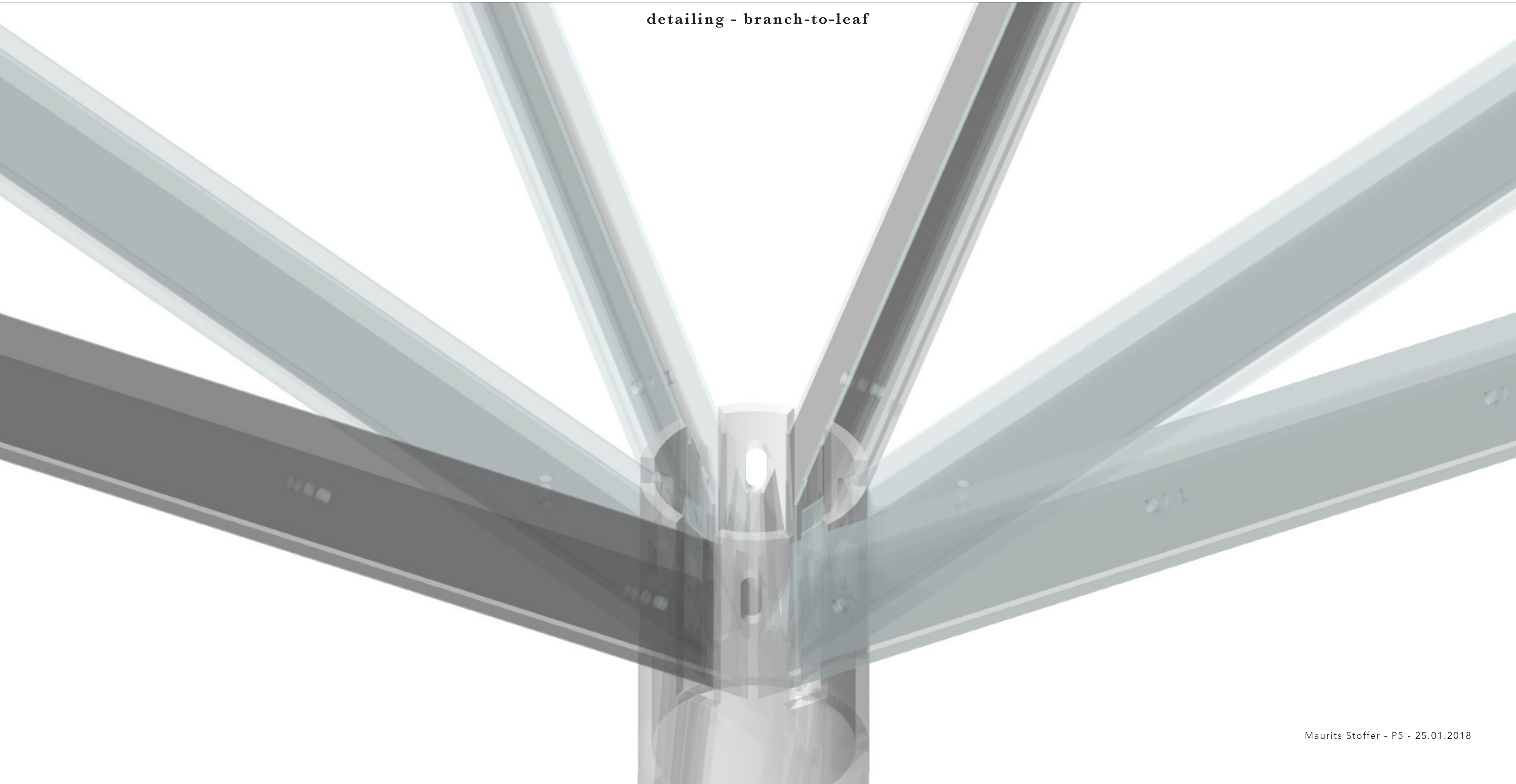
method statement



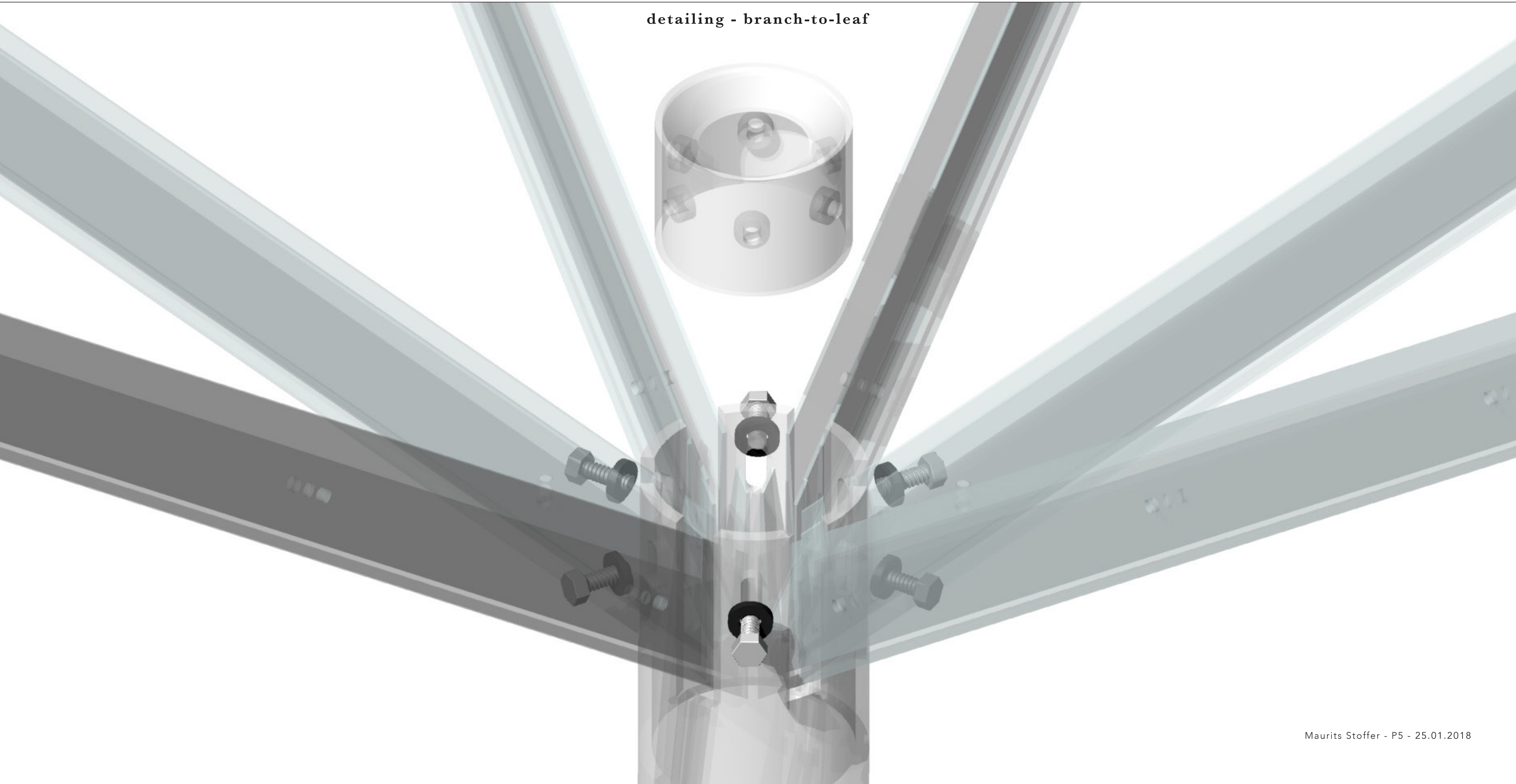
detailing - branch-to-leaf



detailing - branch-to-leaf

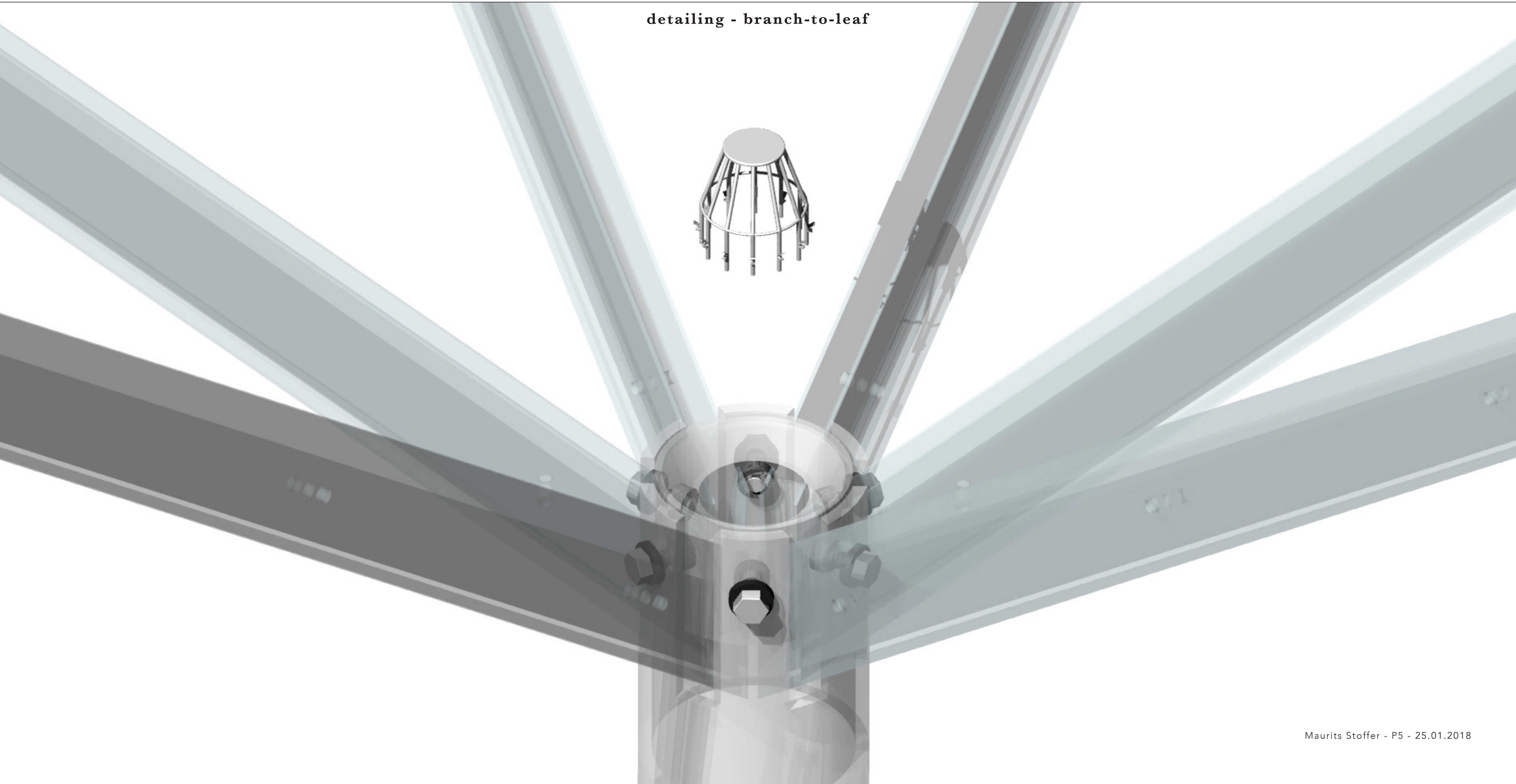


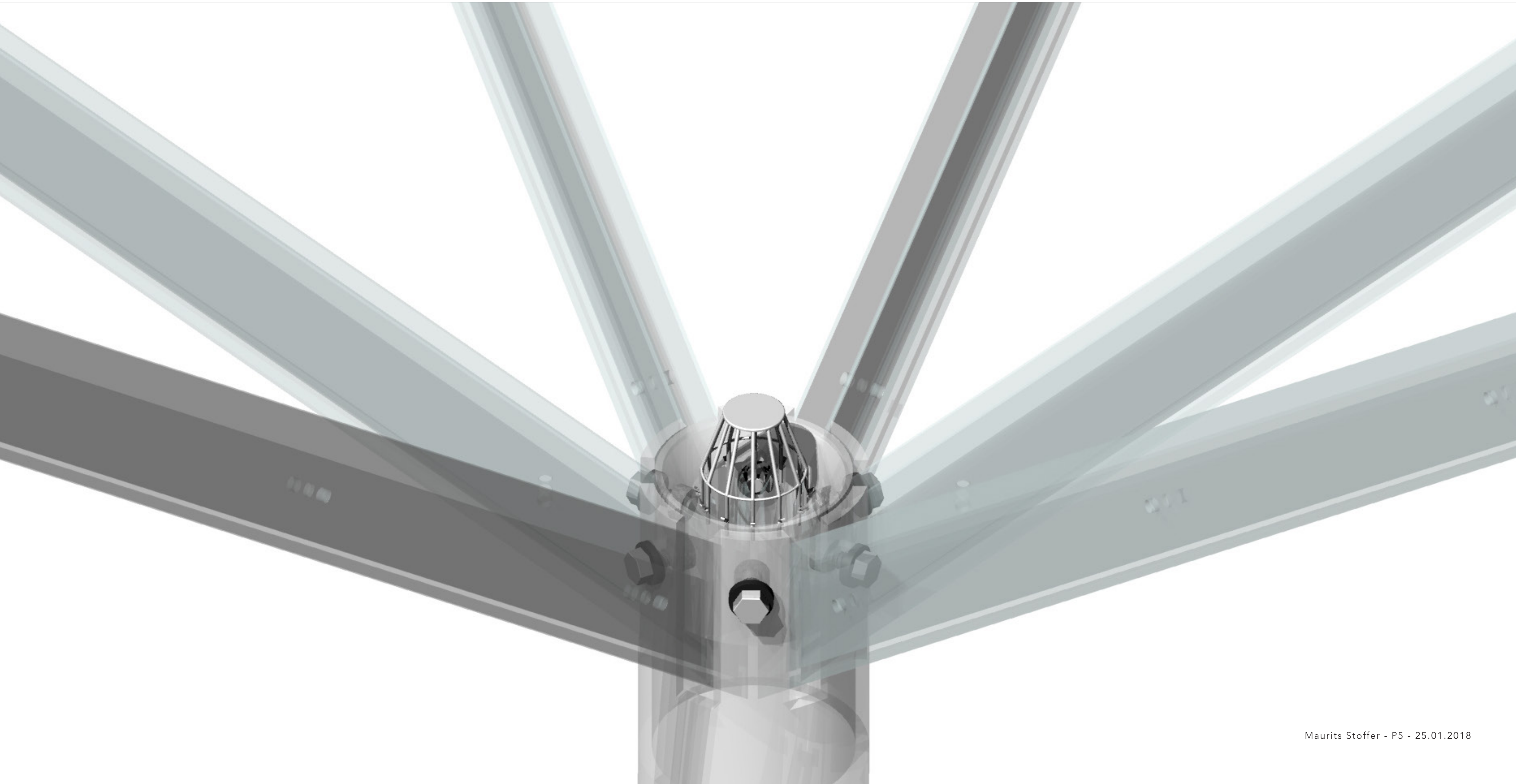
detailing - branch-to-leaf



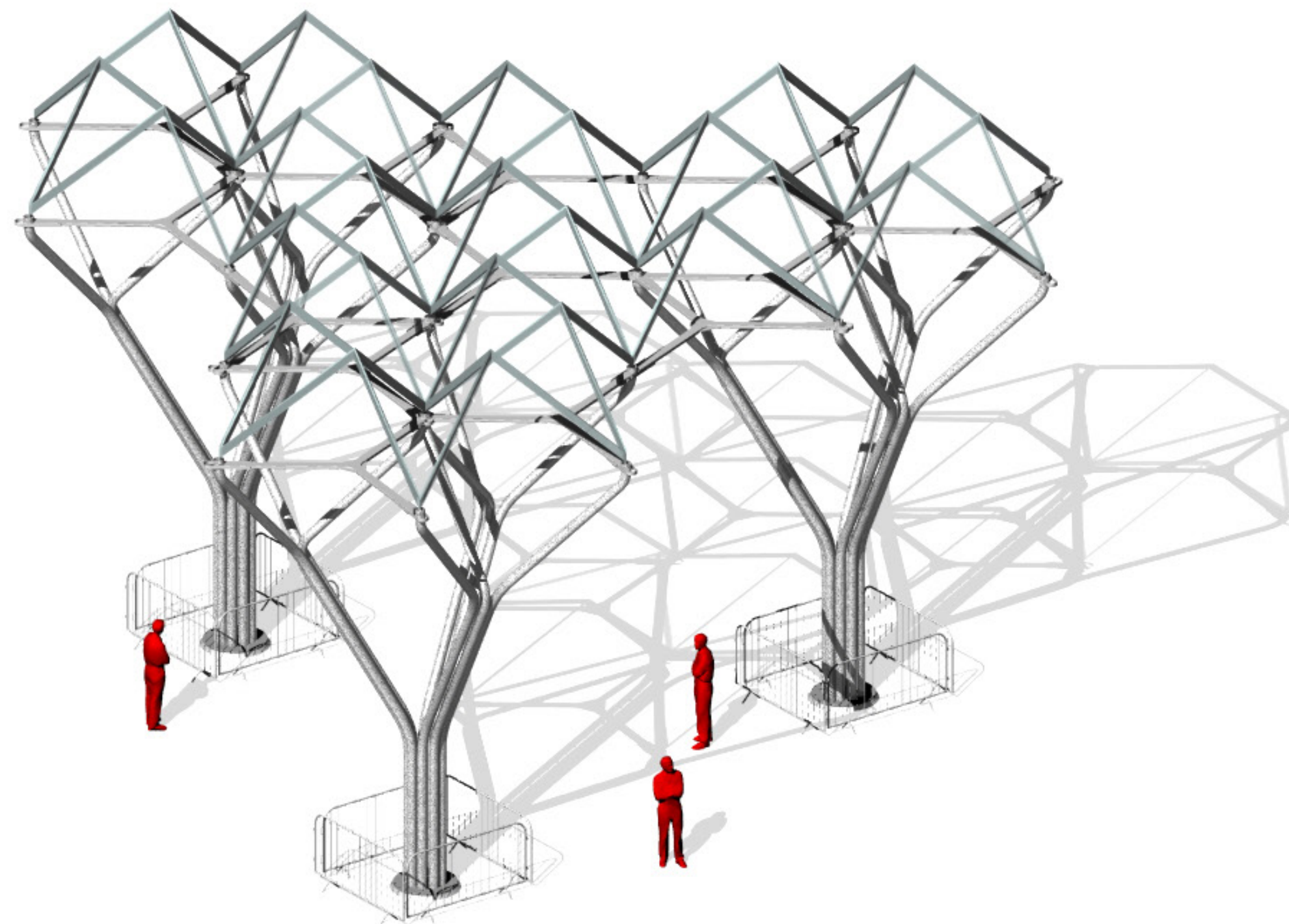
5. DESIGN DEVELOPMENT

detailing - branch-to-leaf

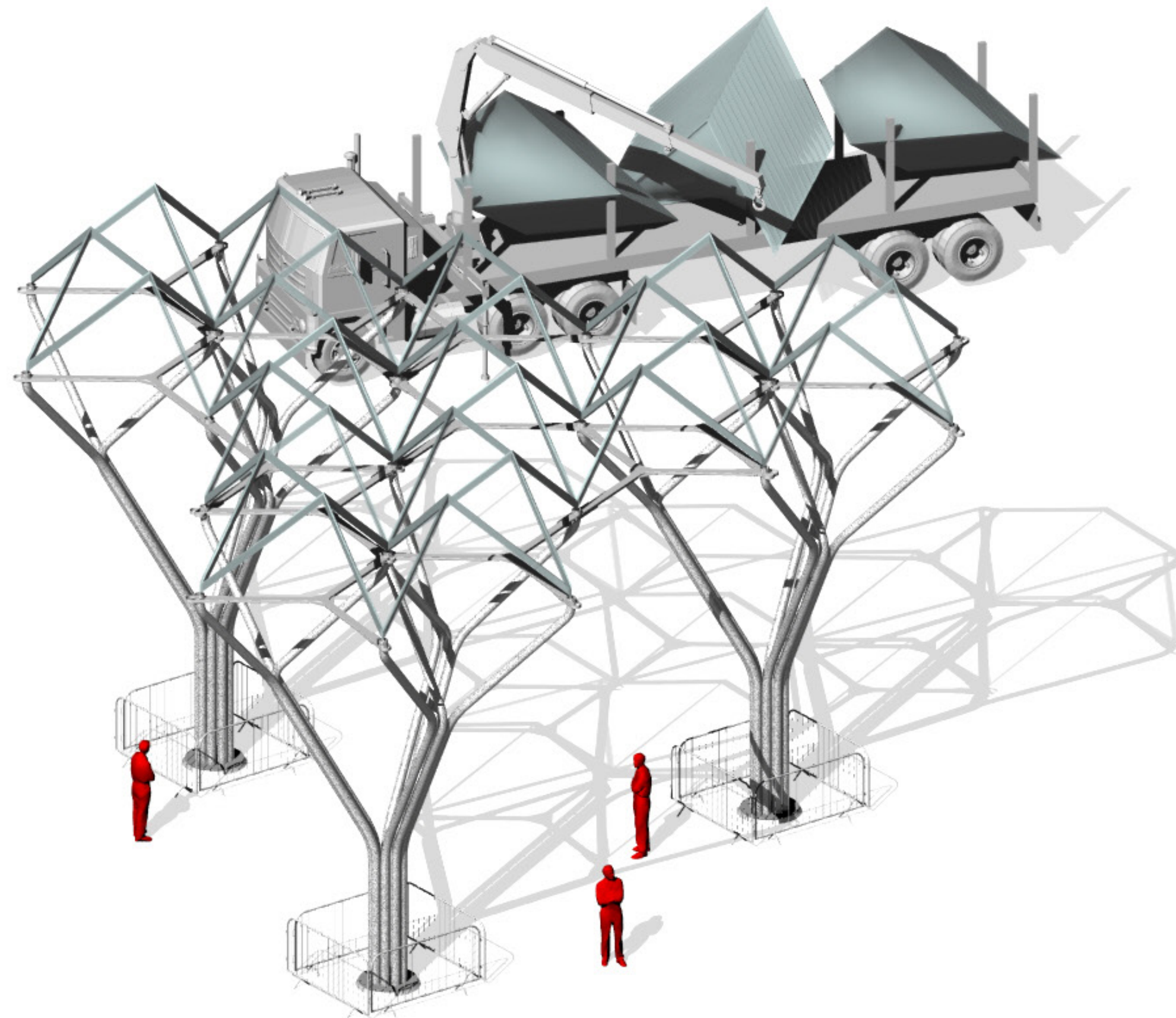




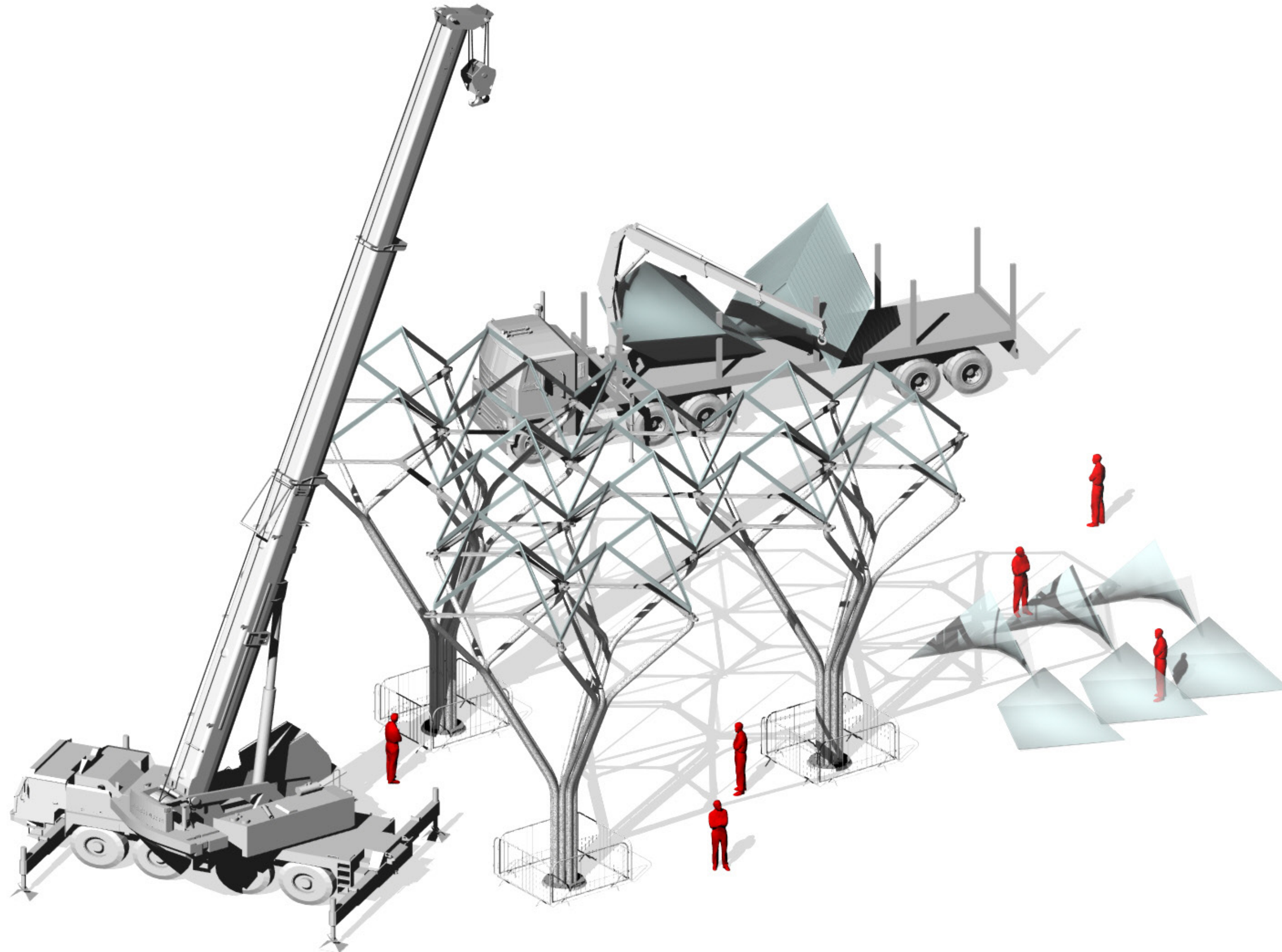
method statement



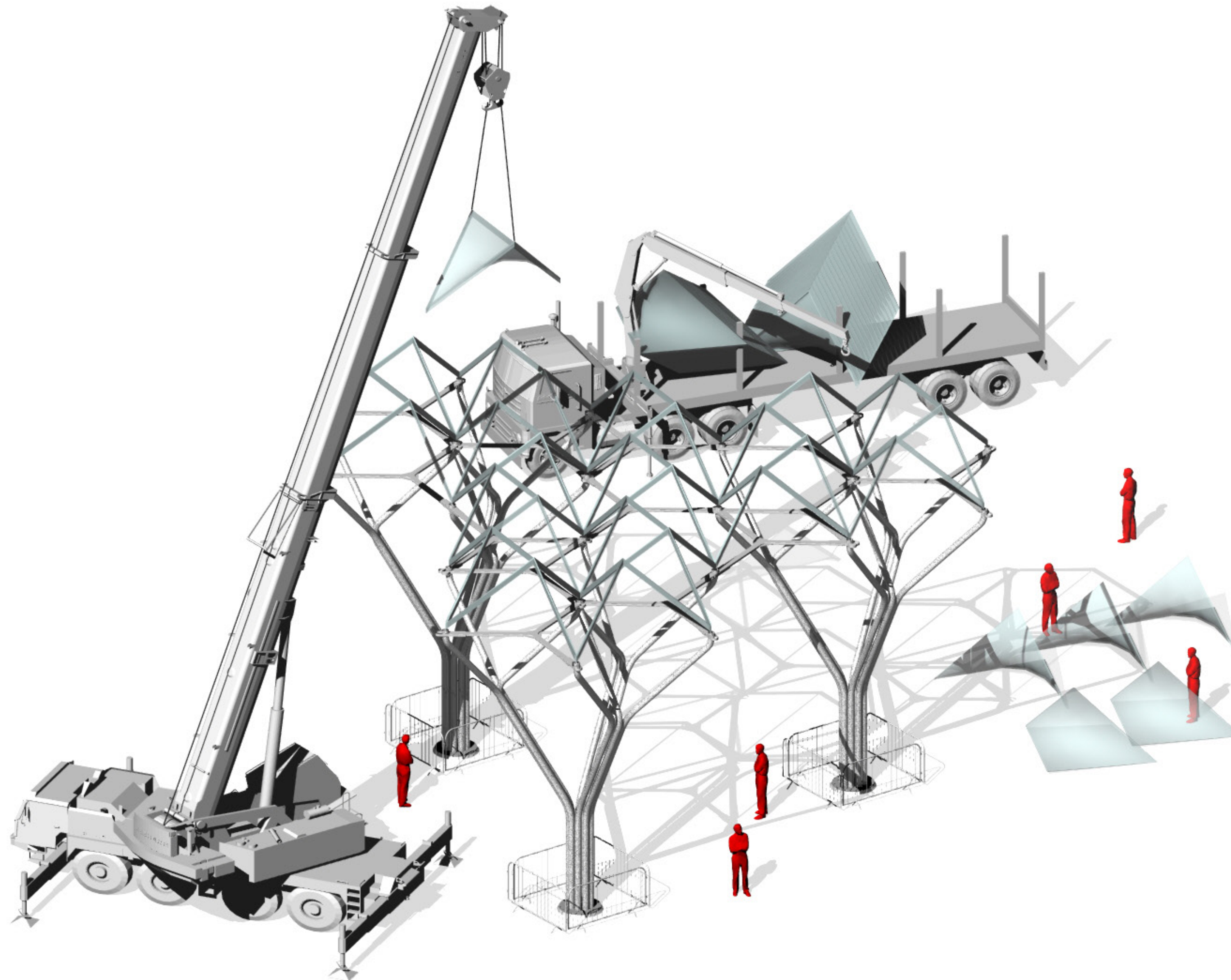
method statement



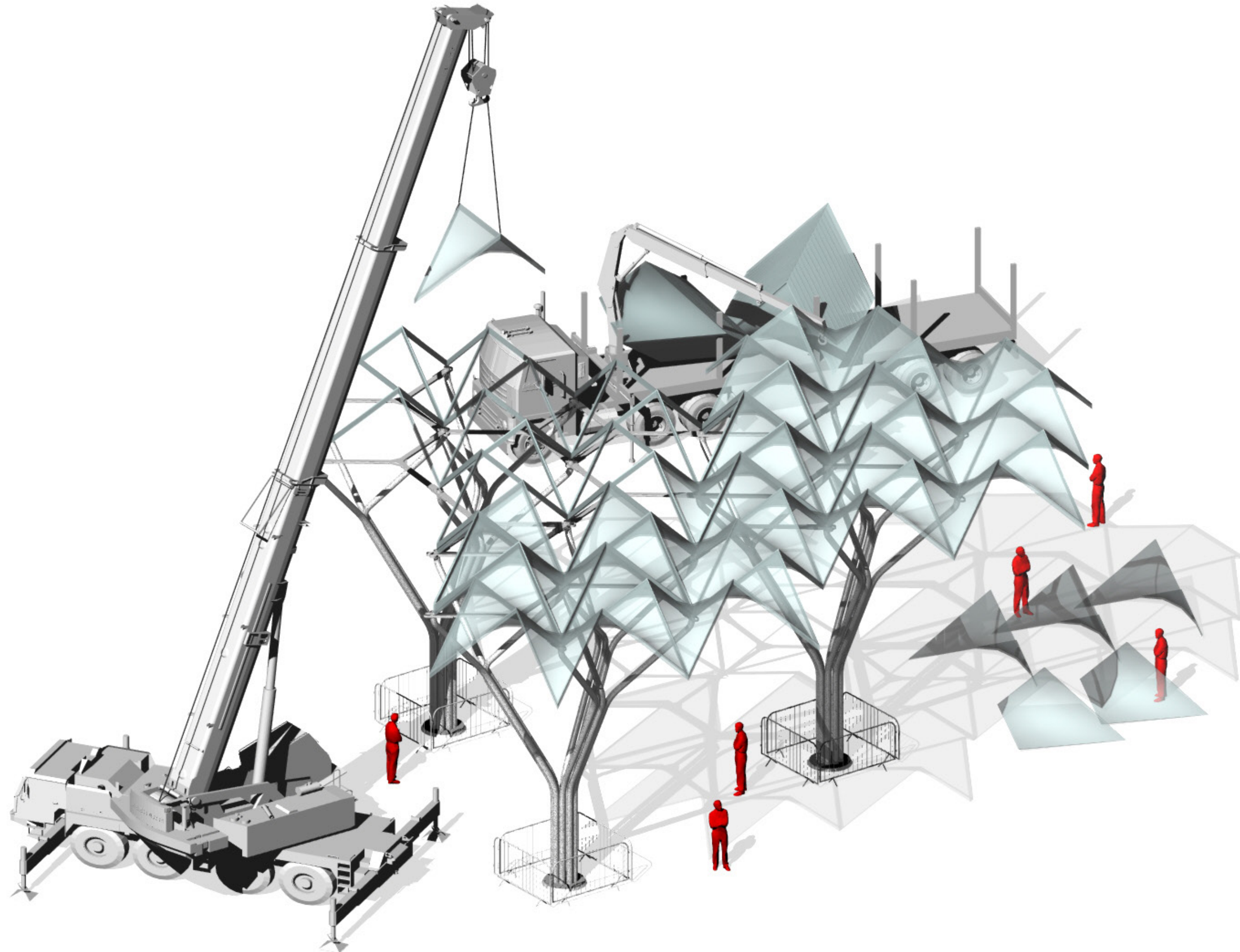
method statement



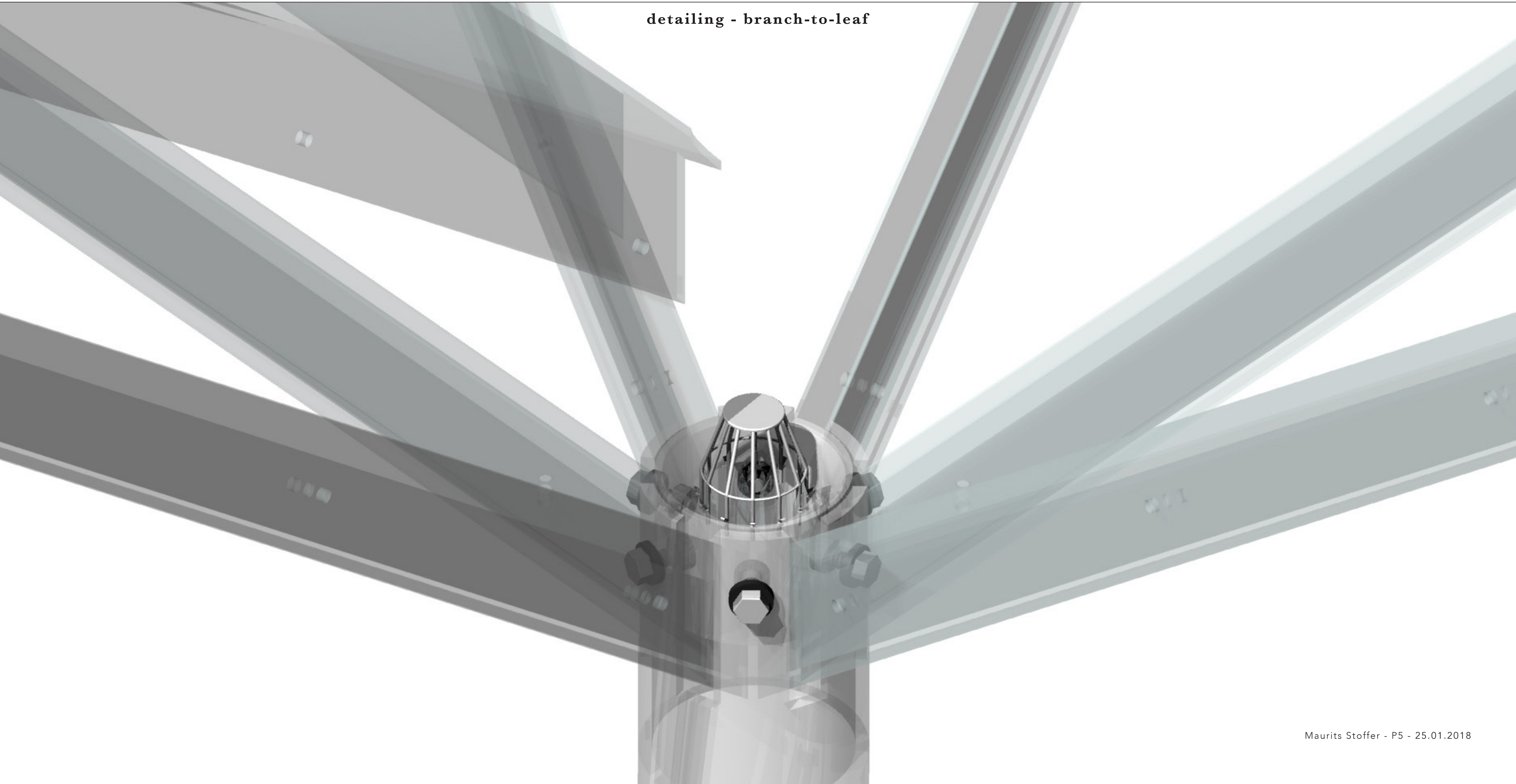
method statement



method statement

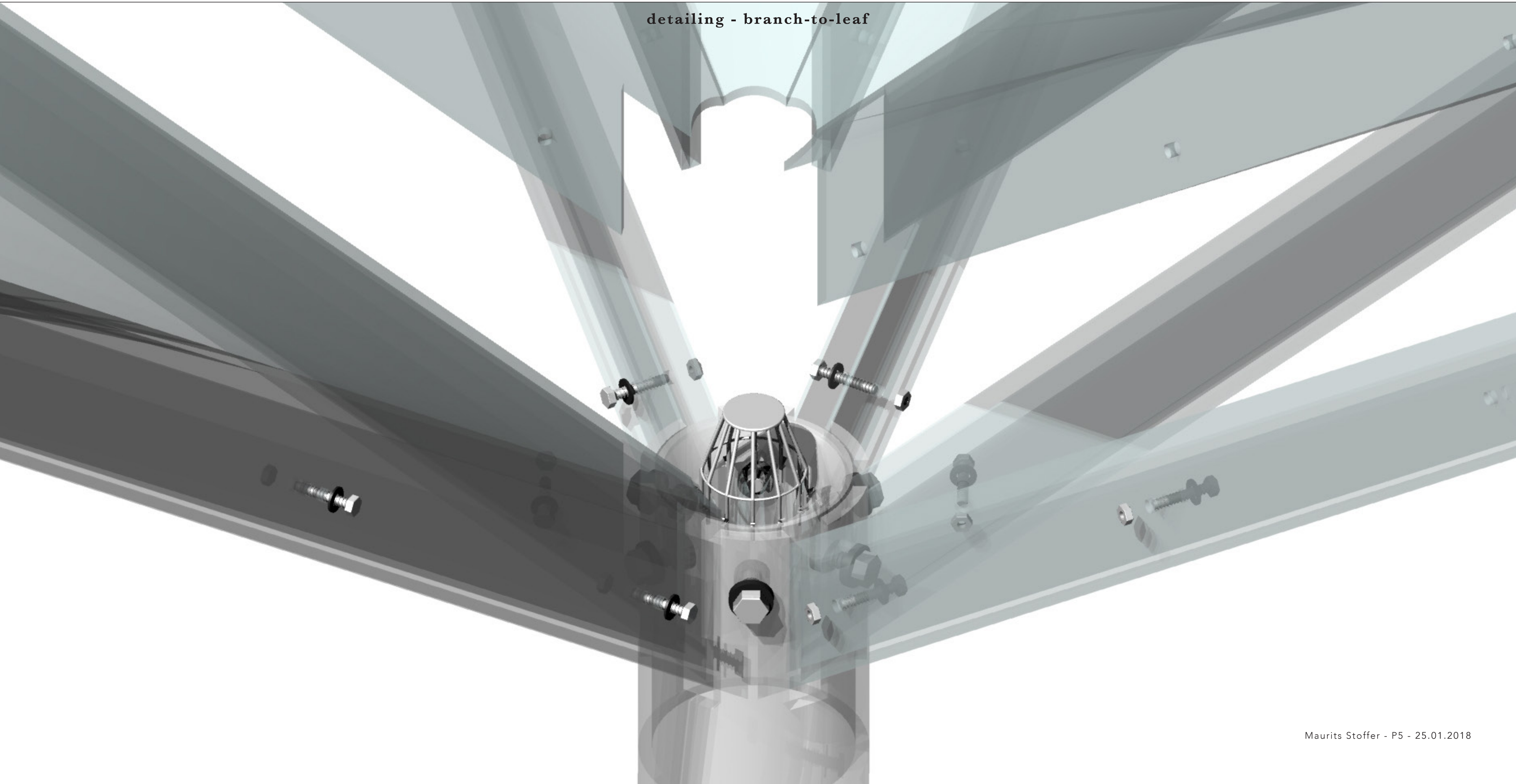


detailing - branch-to-leaf

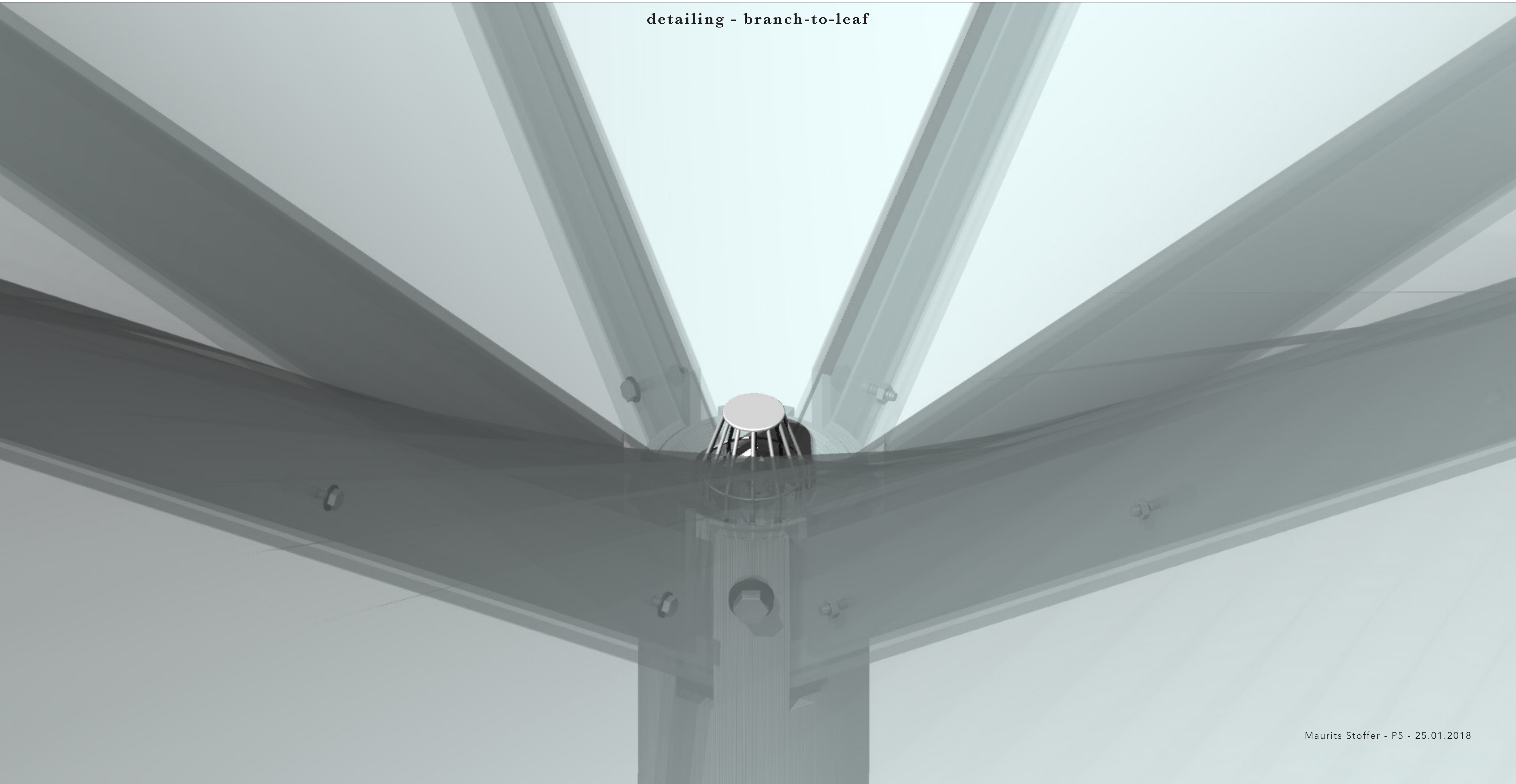


5. DESIGN DEVELOPMENT

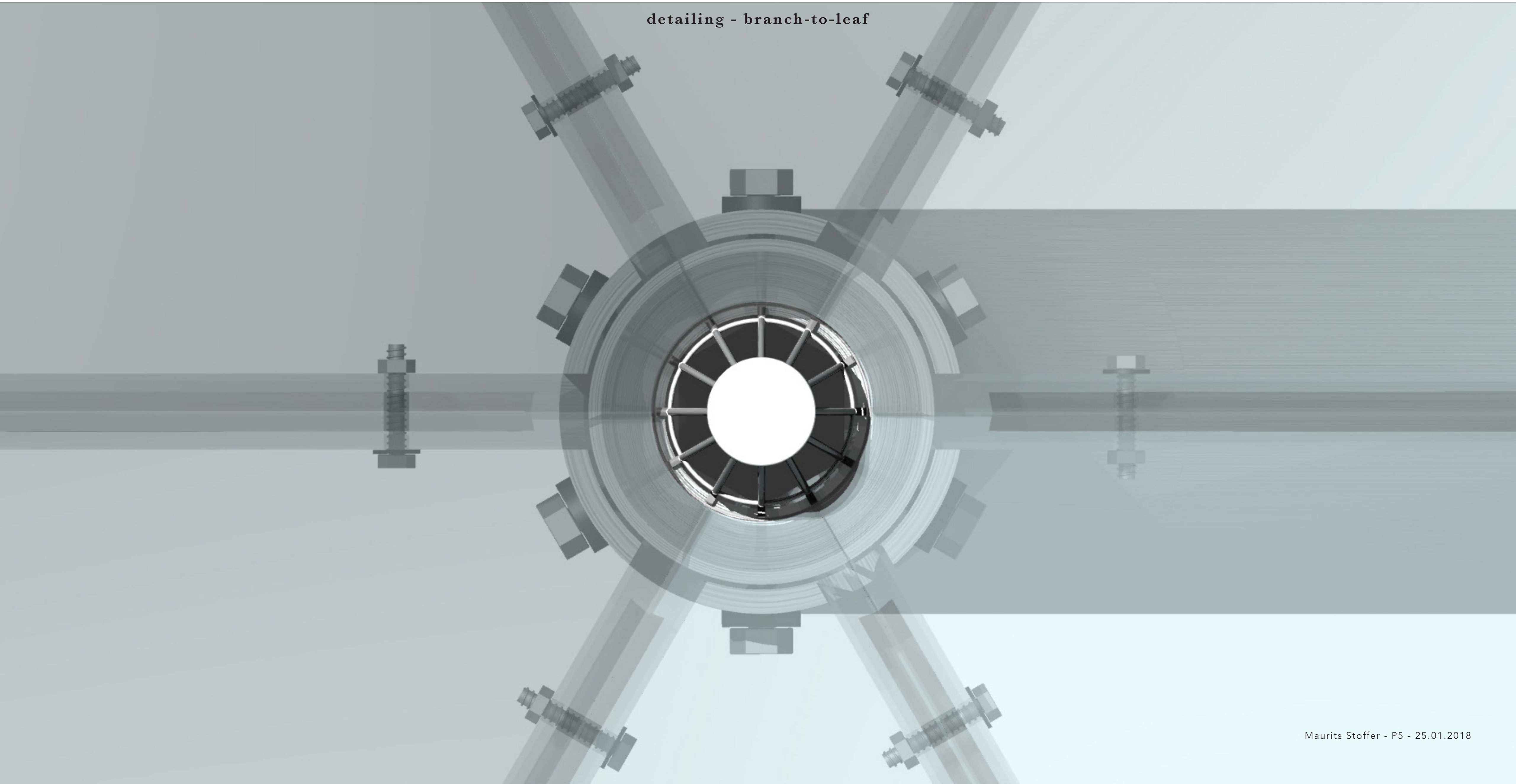
detailing - branch-to-leaf



detailing - branch-to-leaf

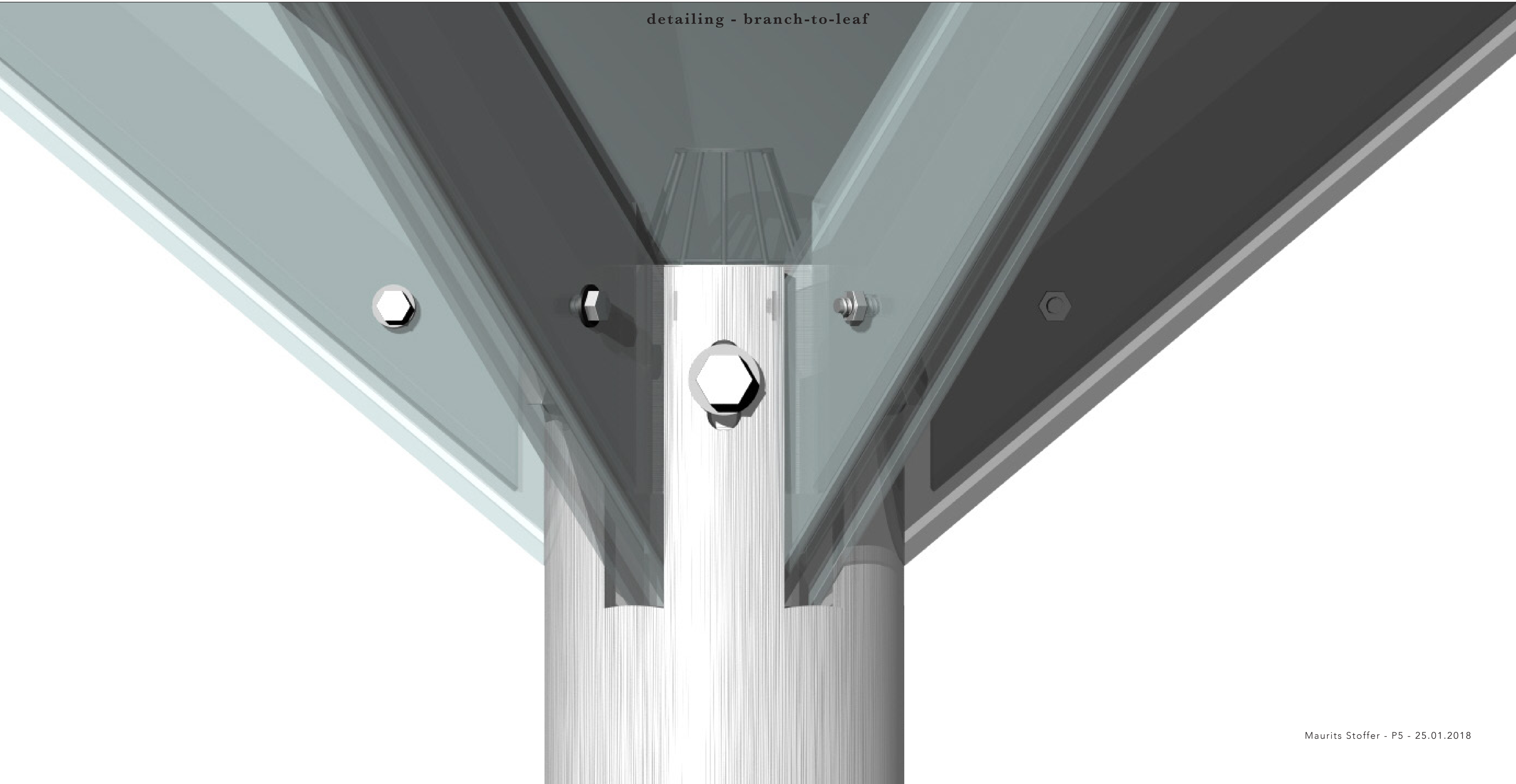


detailing - branch-to-leaf

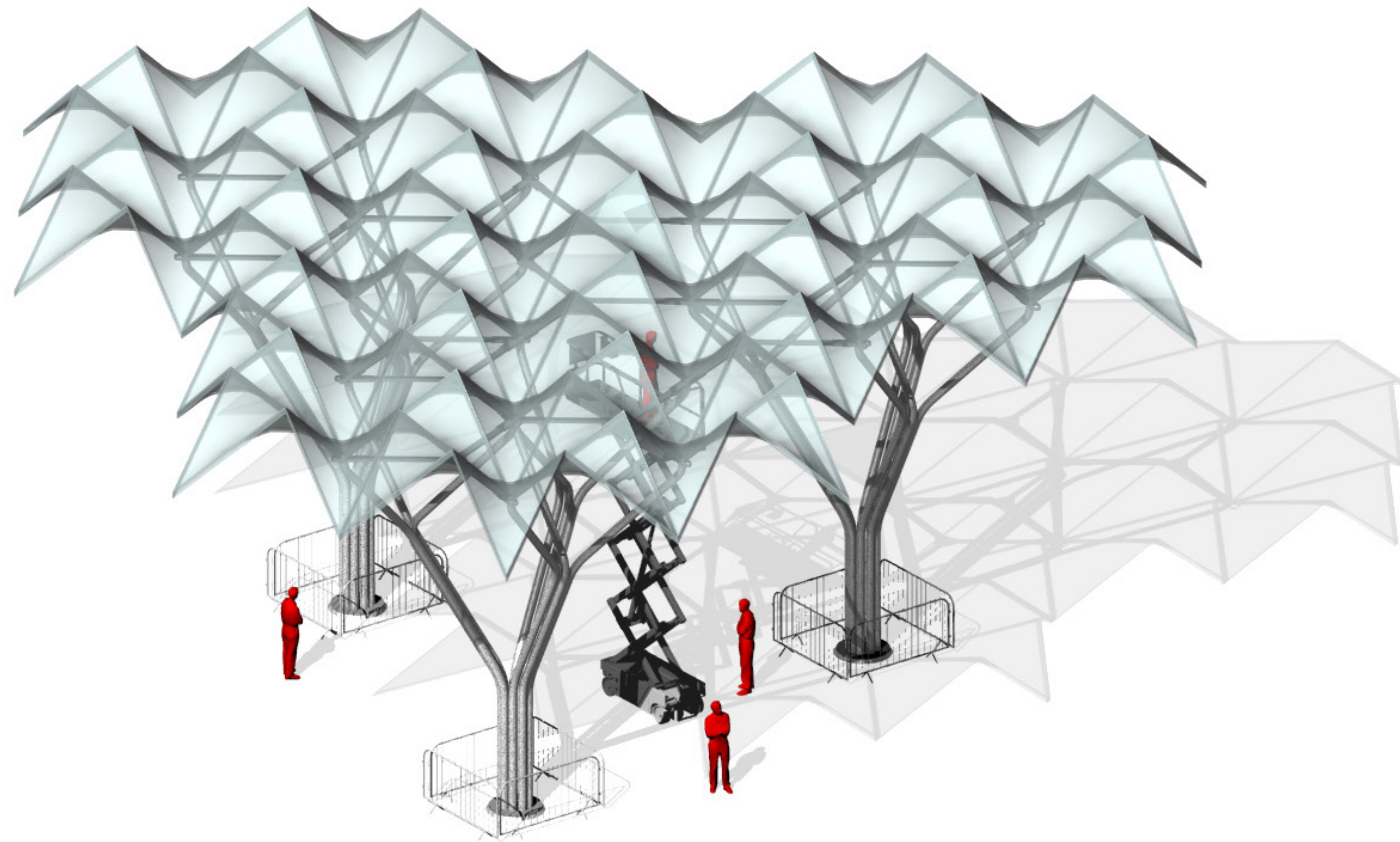


5. DESIGN DEVELOPMENT

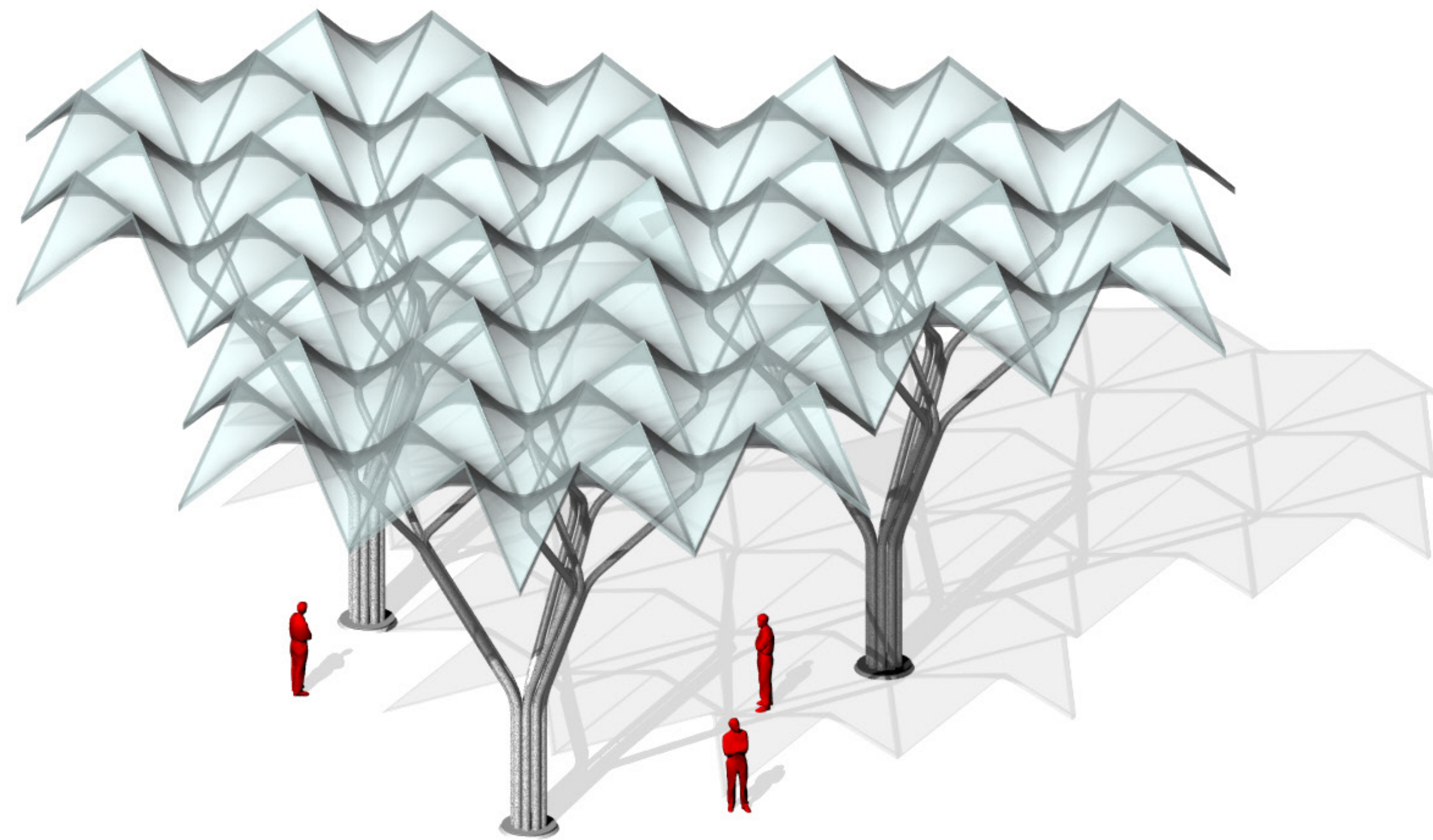
detailing - branch-to-leaf



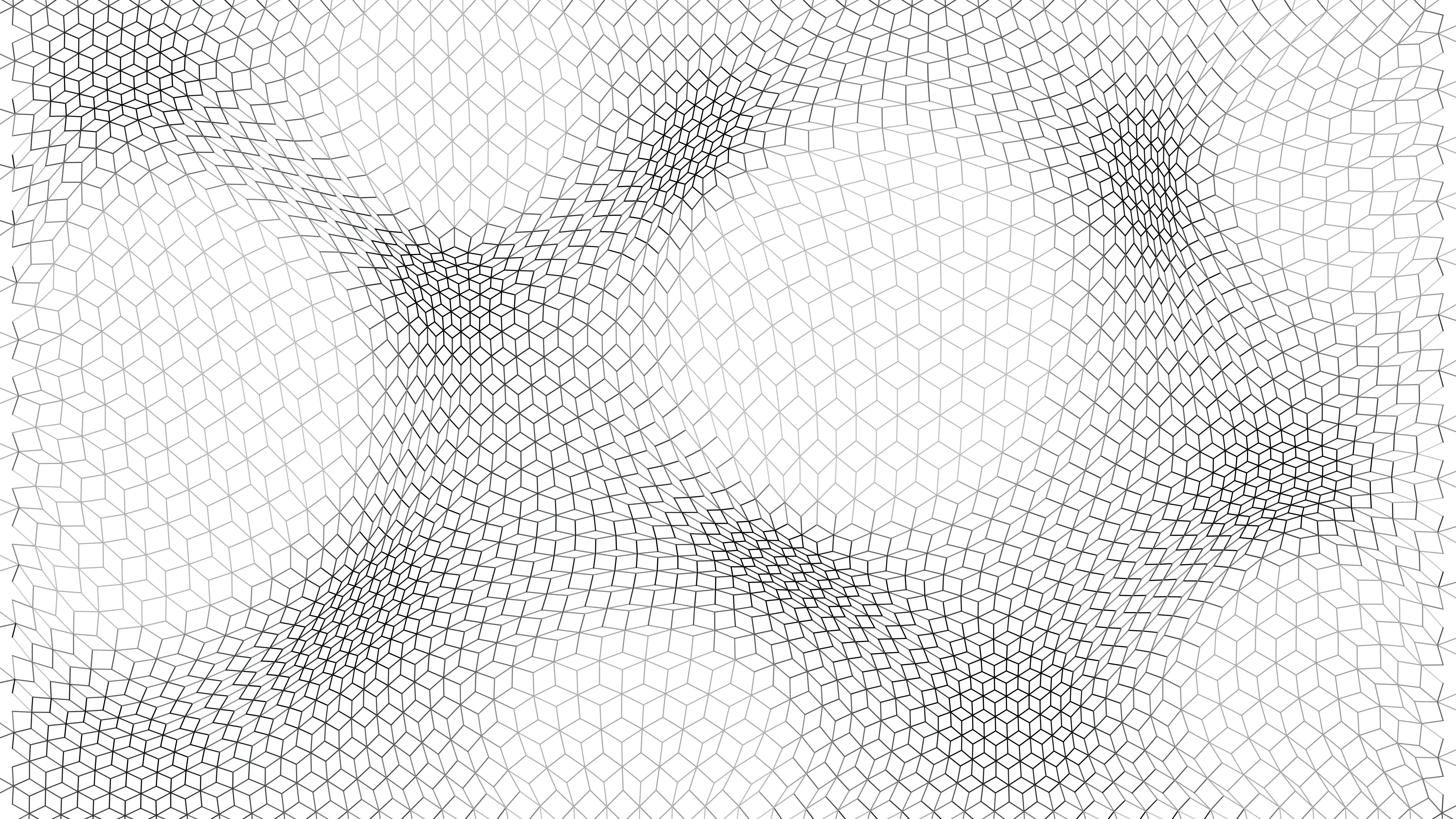
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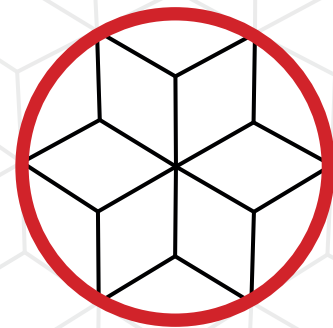
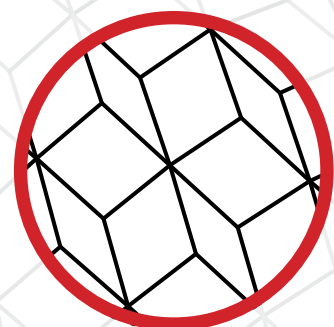
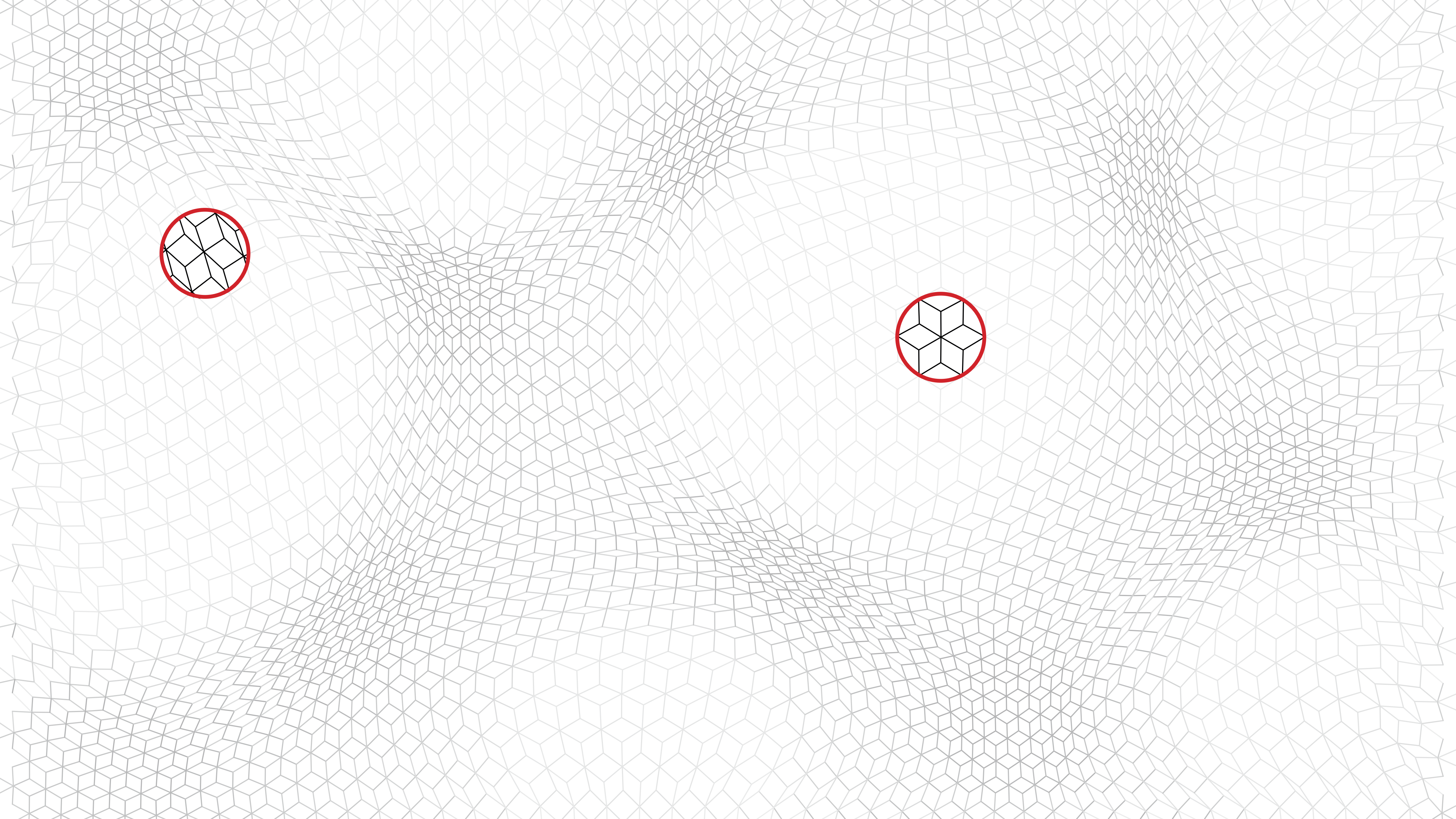


method statement

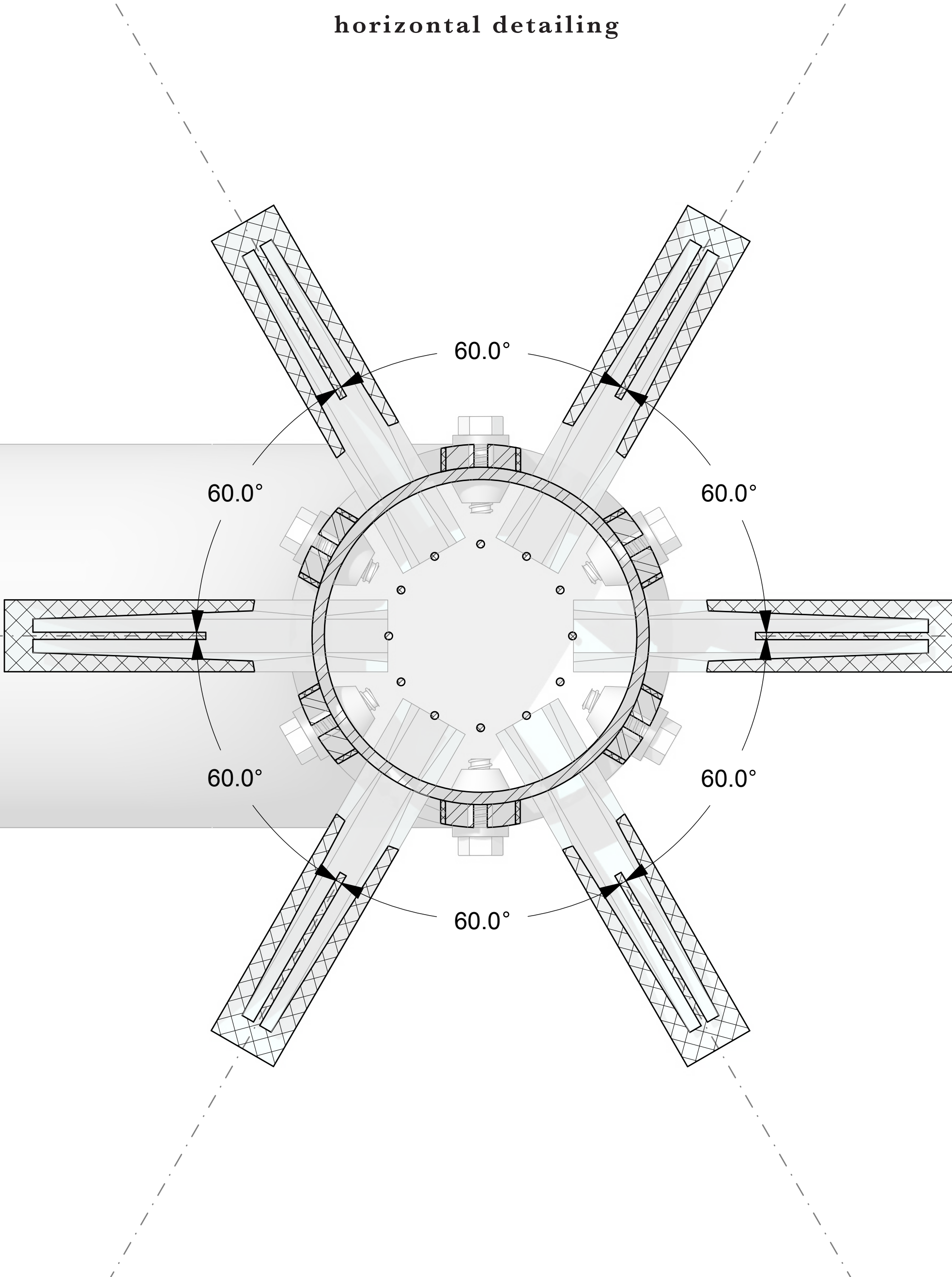


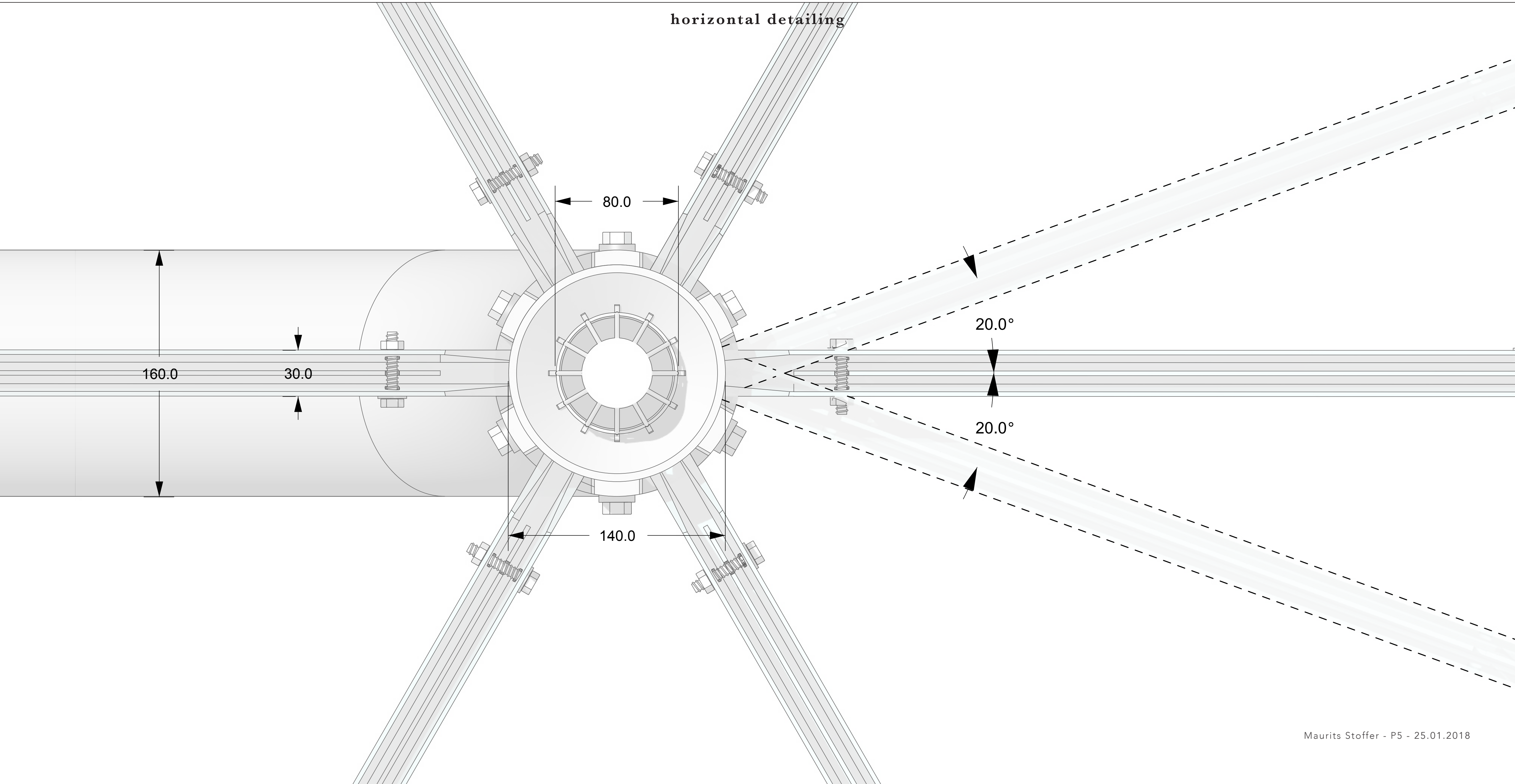
design functionality



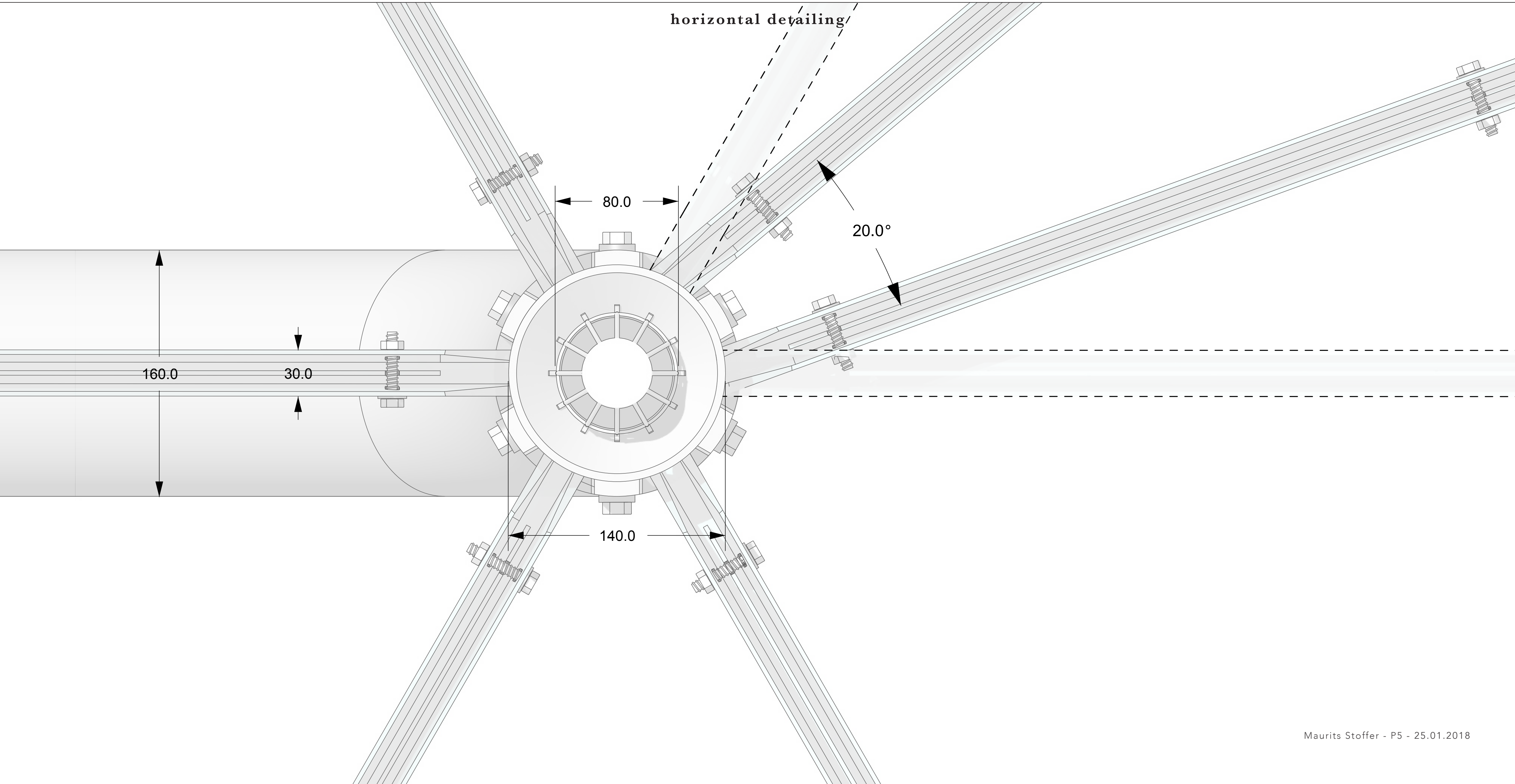


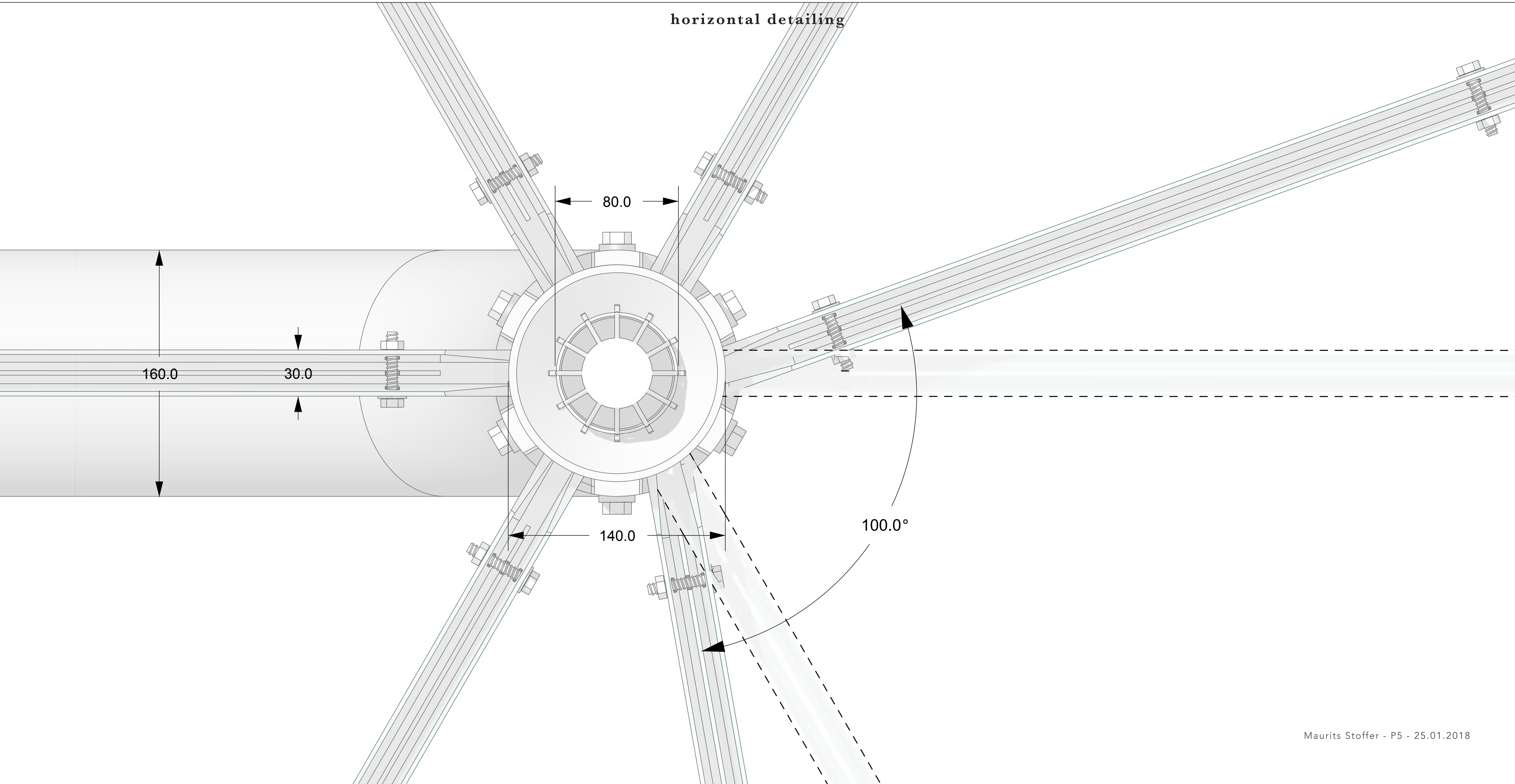
horizontal detailing



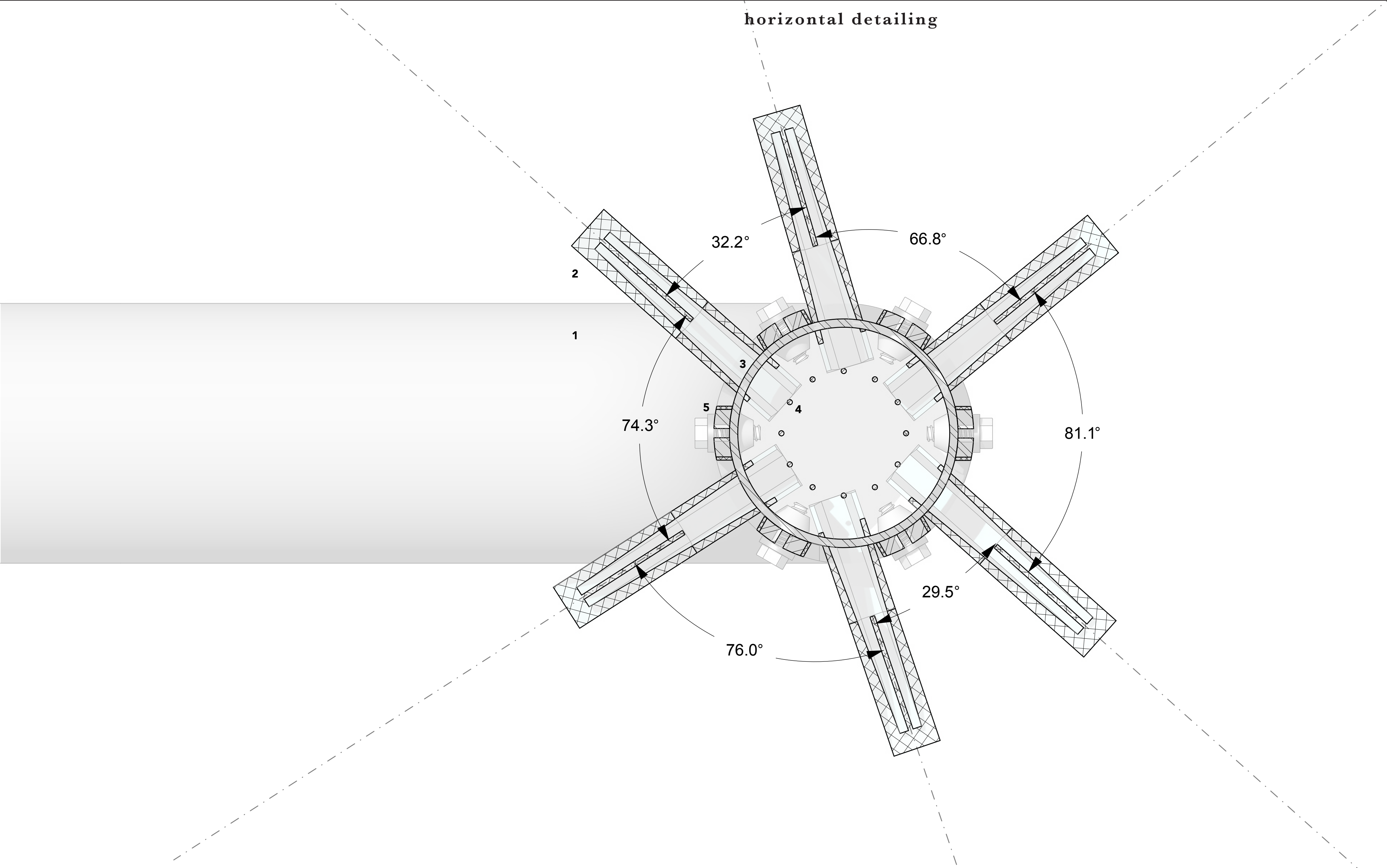


6. DESIGN FUNCTIONALITY

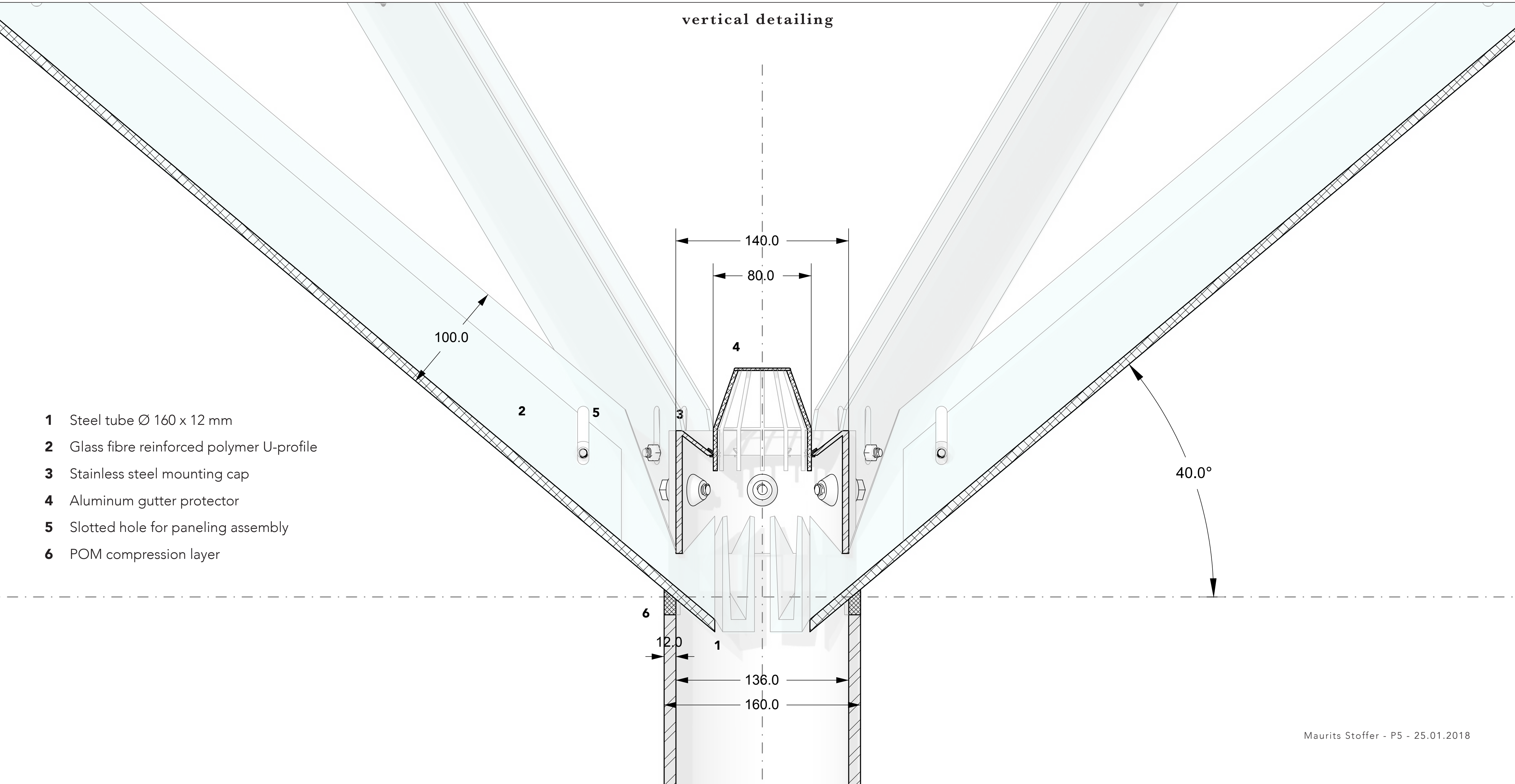




horizontal detailing

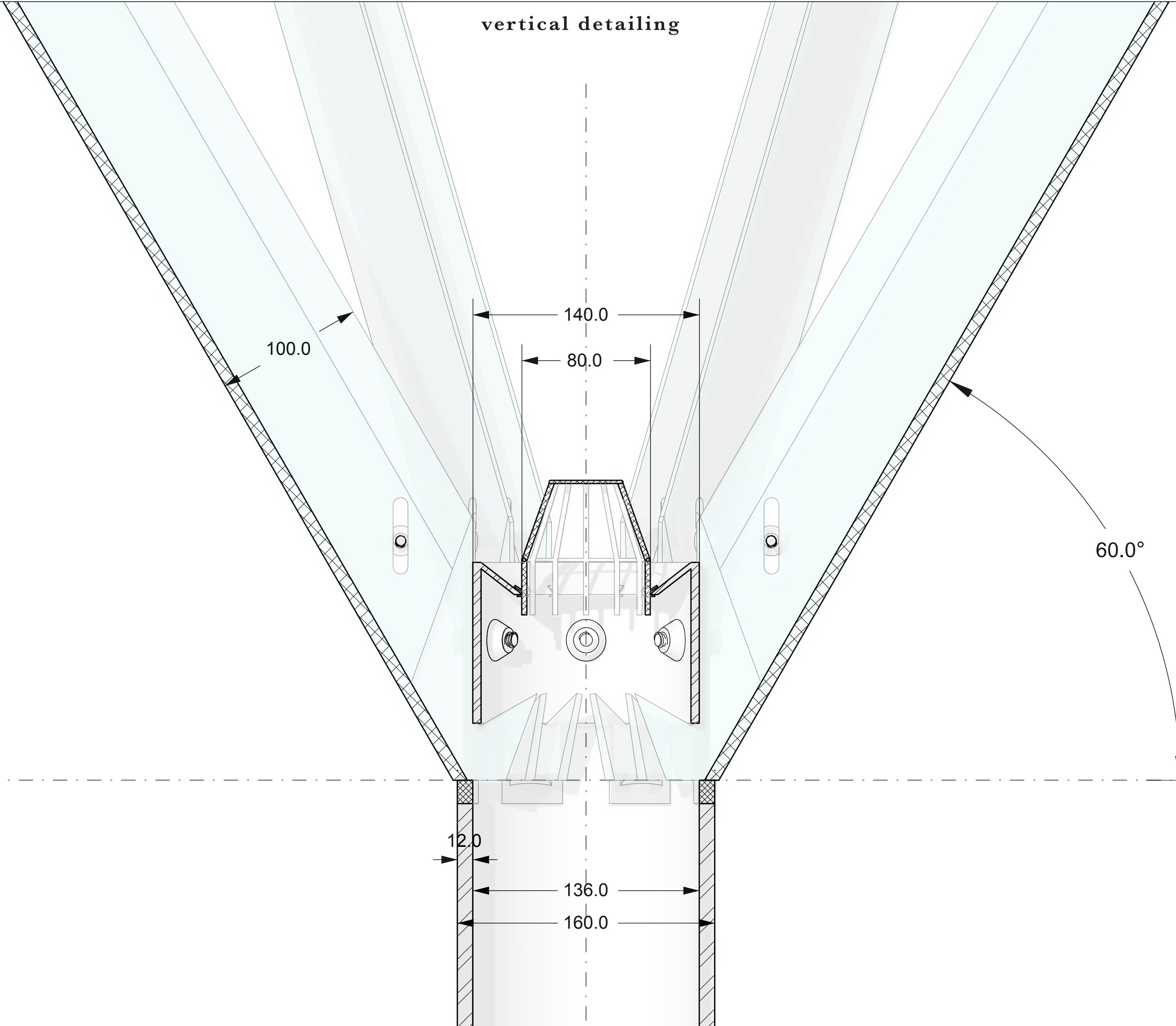


vertical detailing

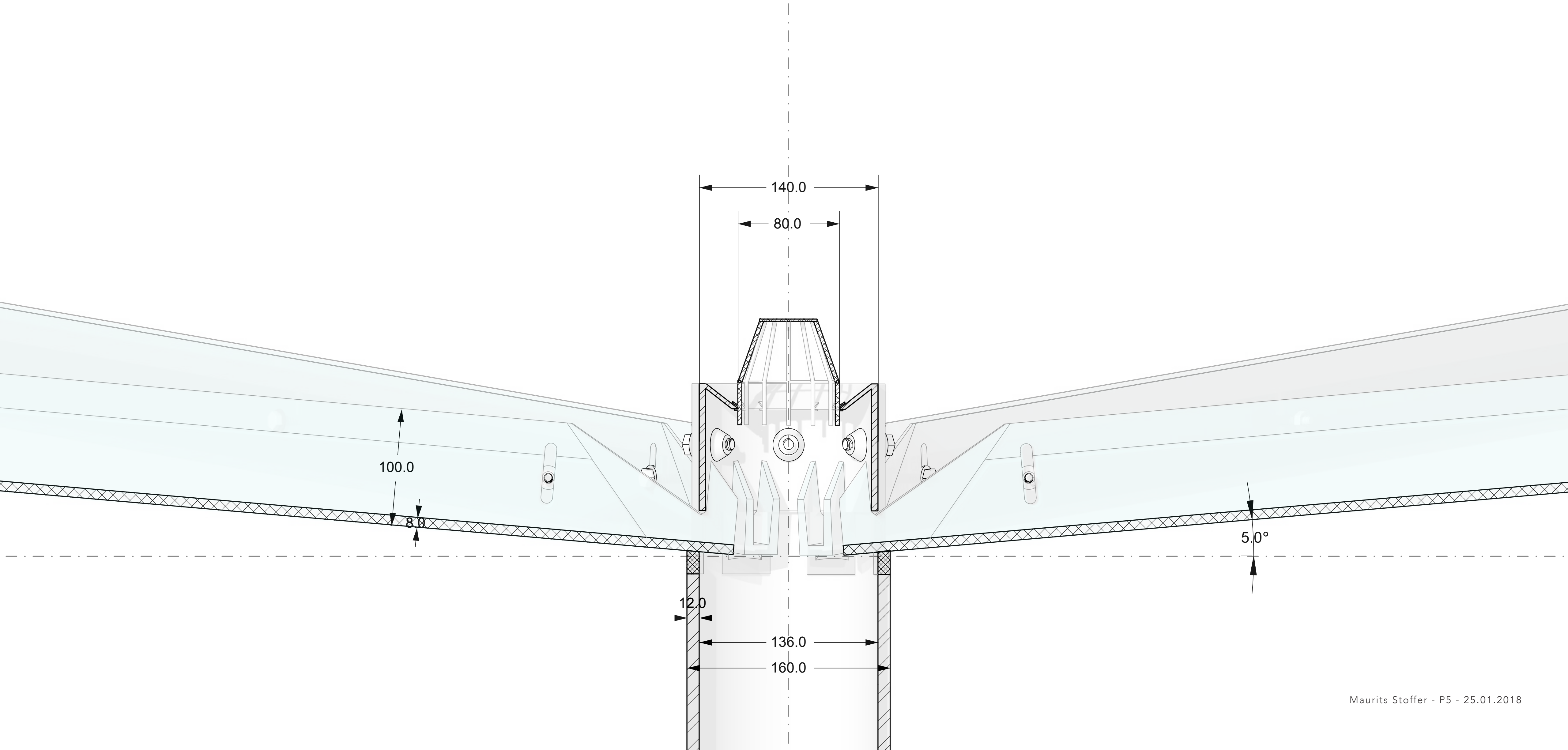


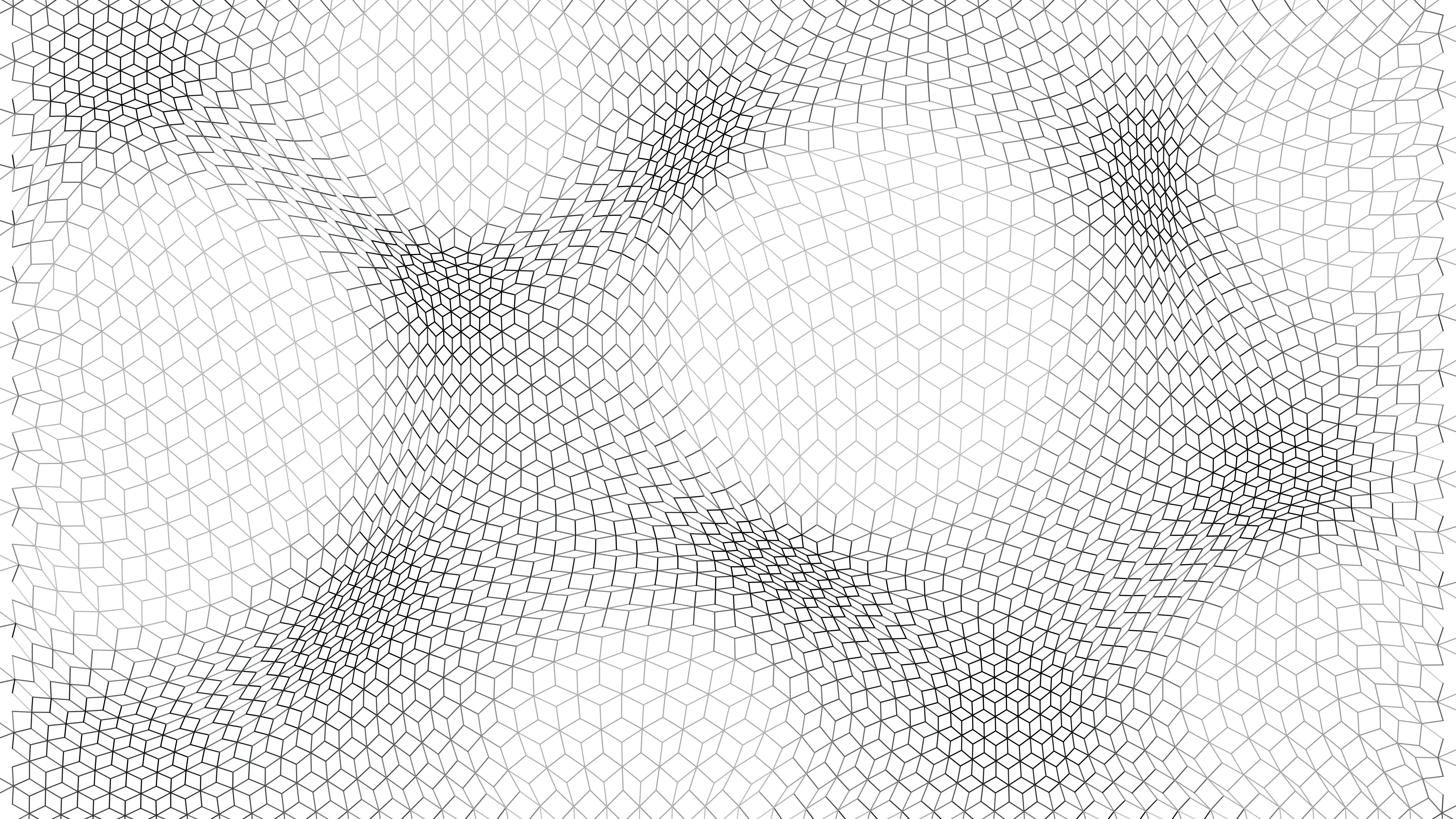
- 1 Steel tube Ø 160 x 12 mm
- 2 Glass fibre reinforced polymer U-profile
- 3 Stainless steel mounting cap
- 4 Aluminum gutter protector
- 5 Slotted hole for paneling assembly
- 6 POM compression layer

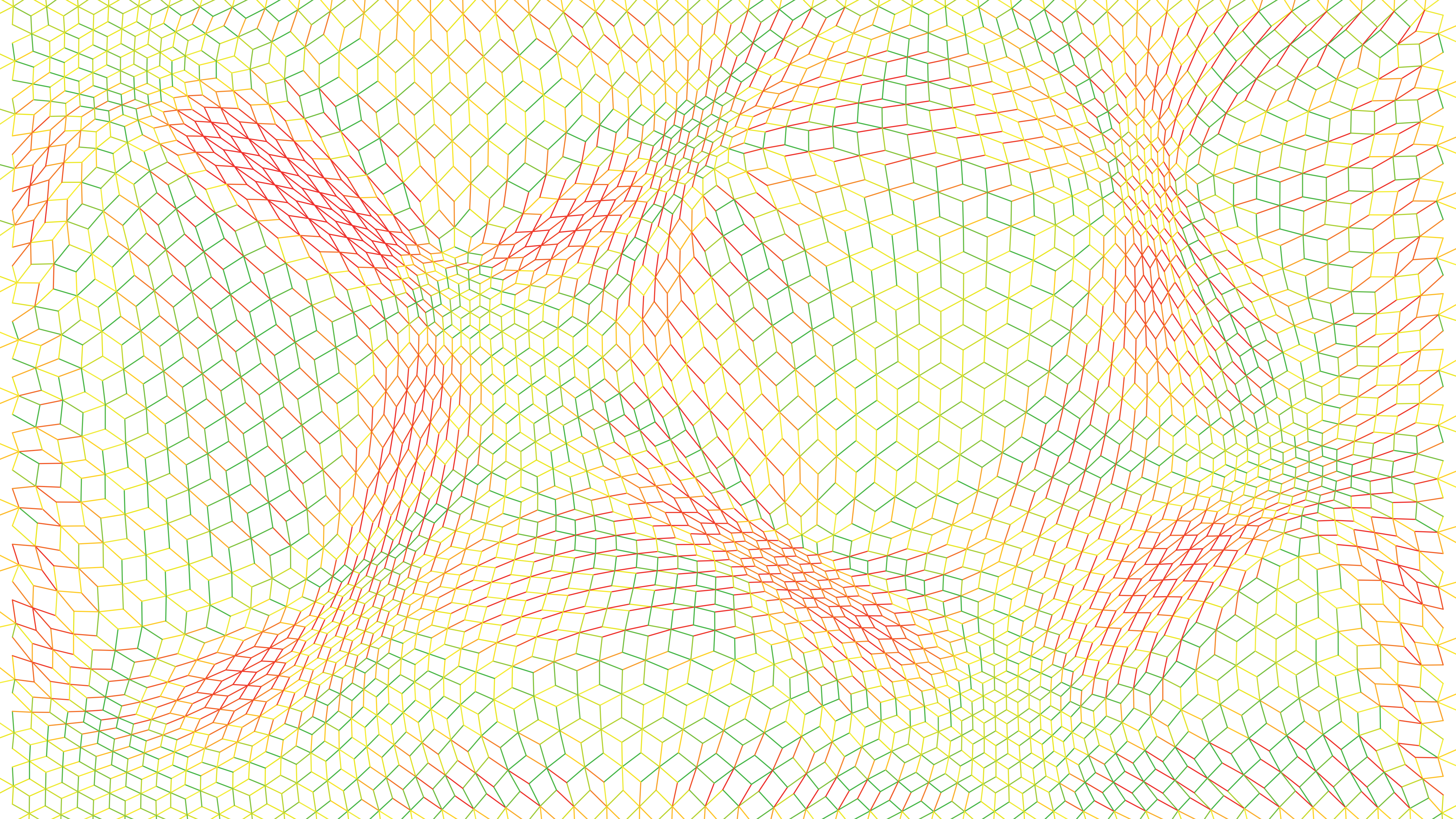
vertical detailing

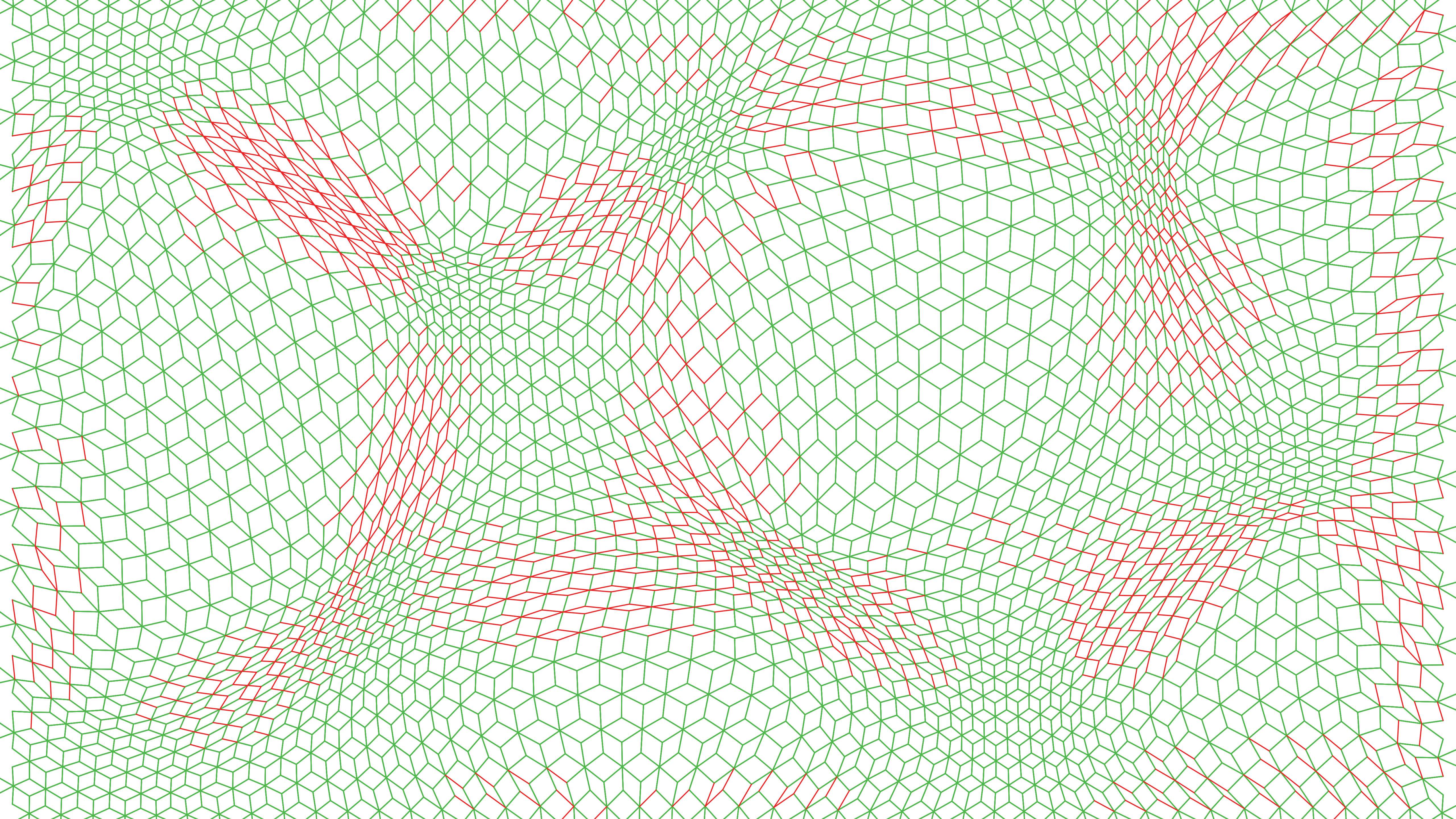


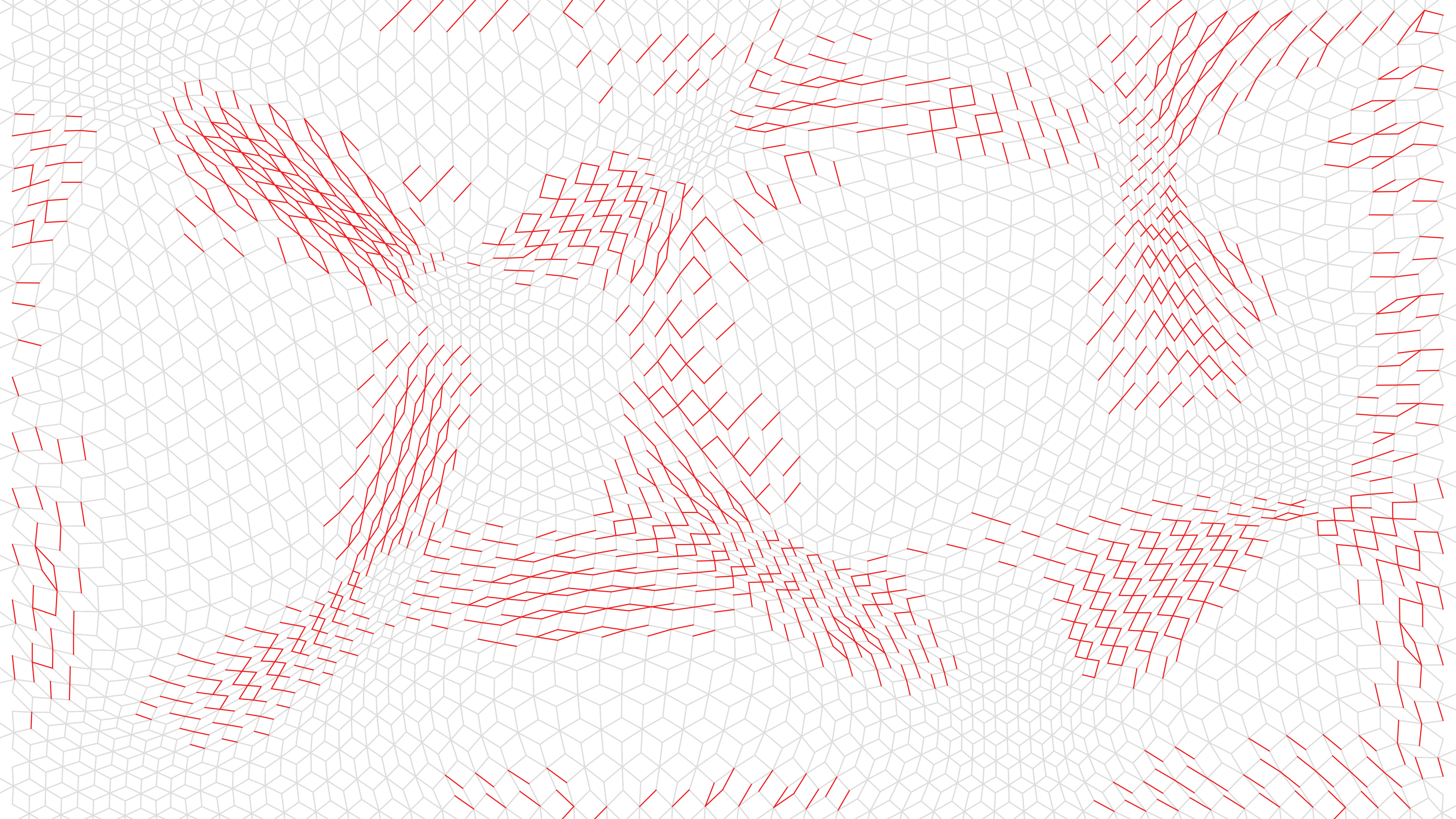
vertical detailing

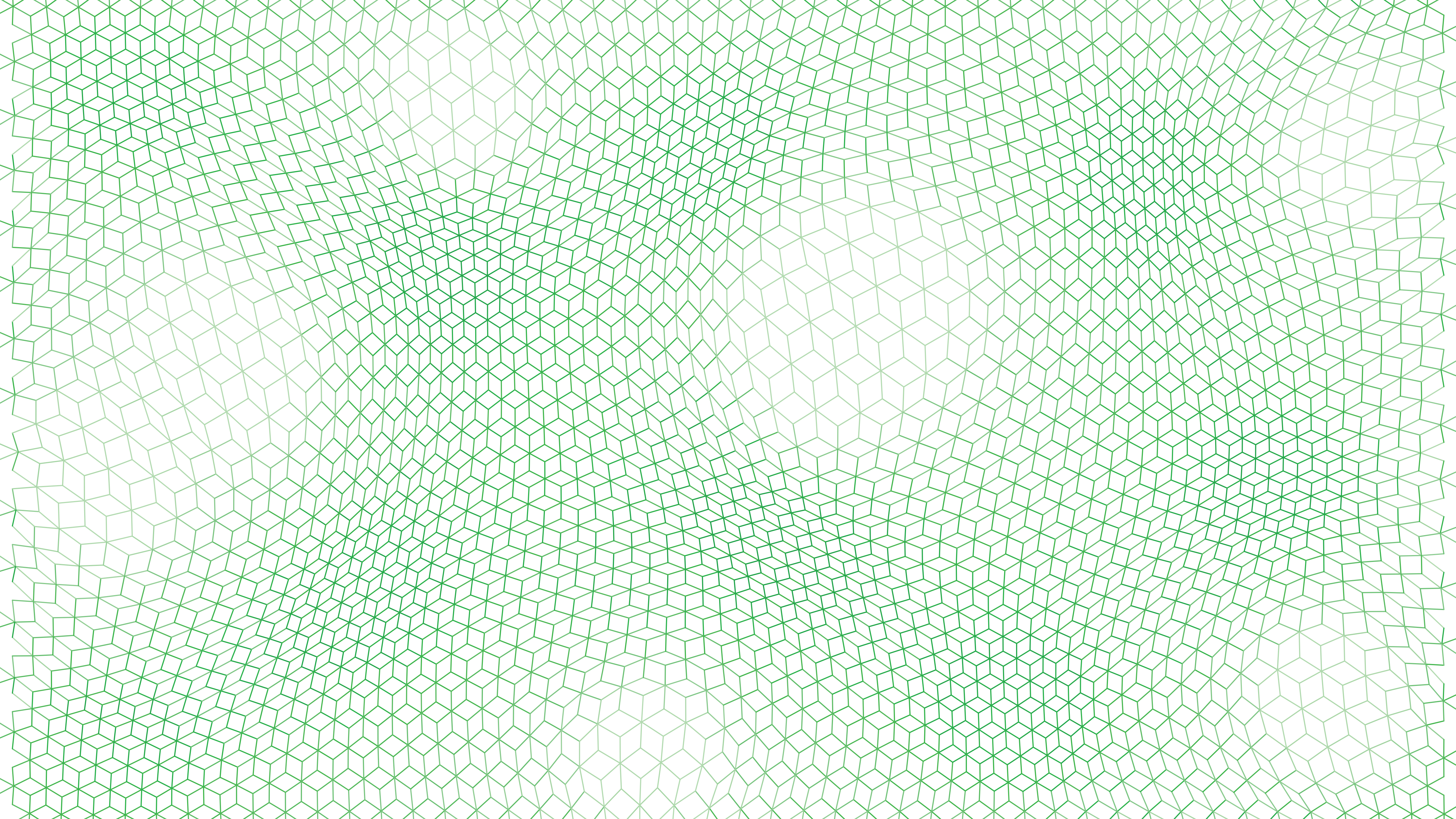








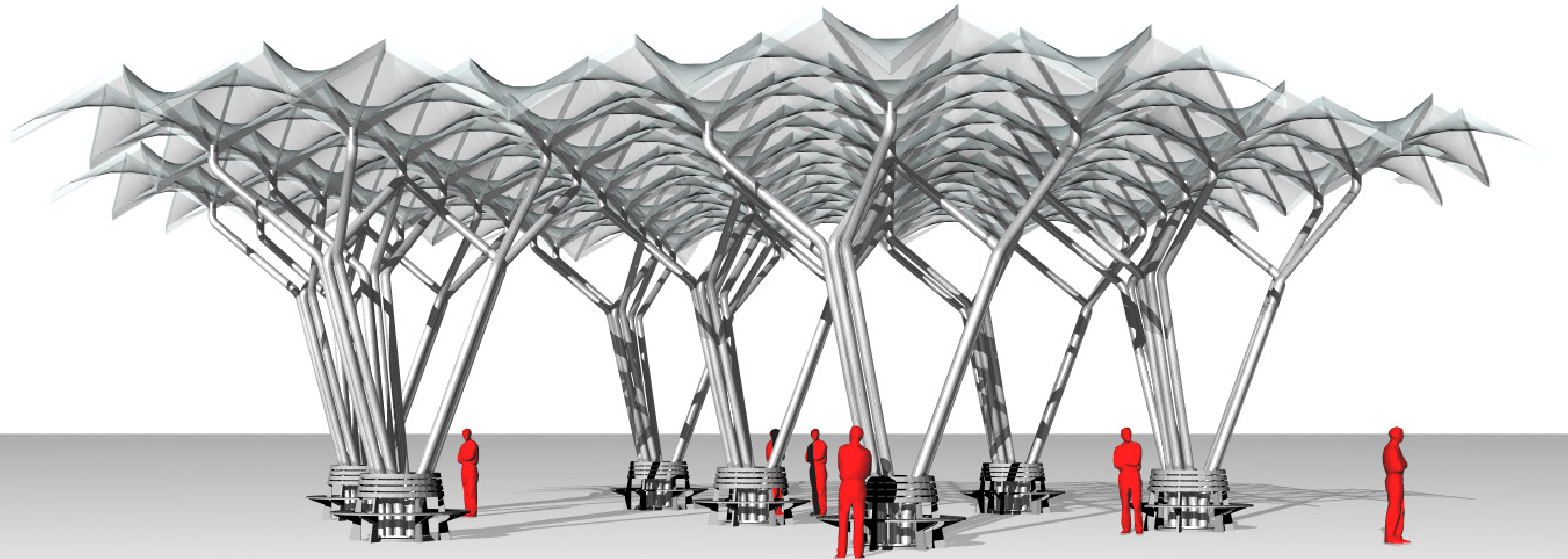




design intents

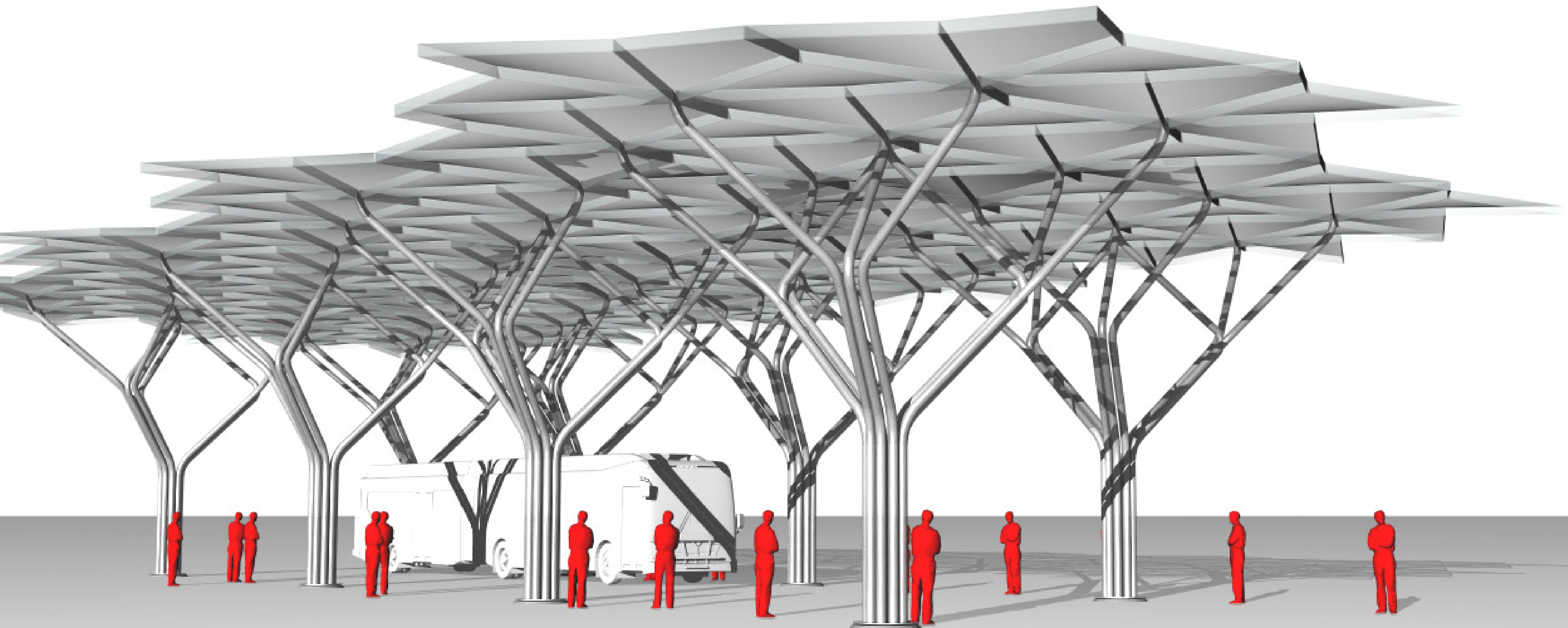
7. DESIGN INTENT

city's icon intent

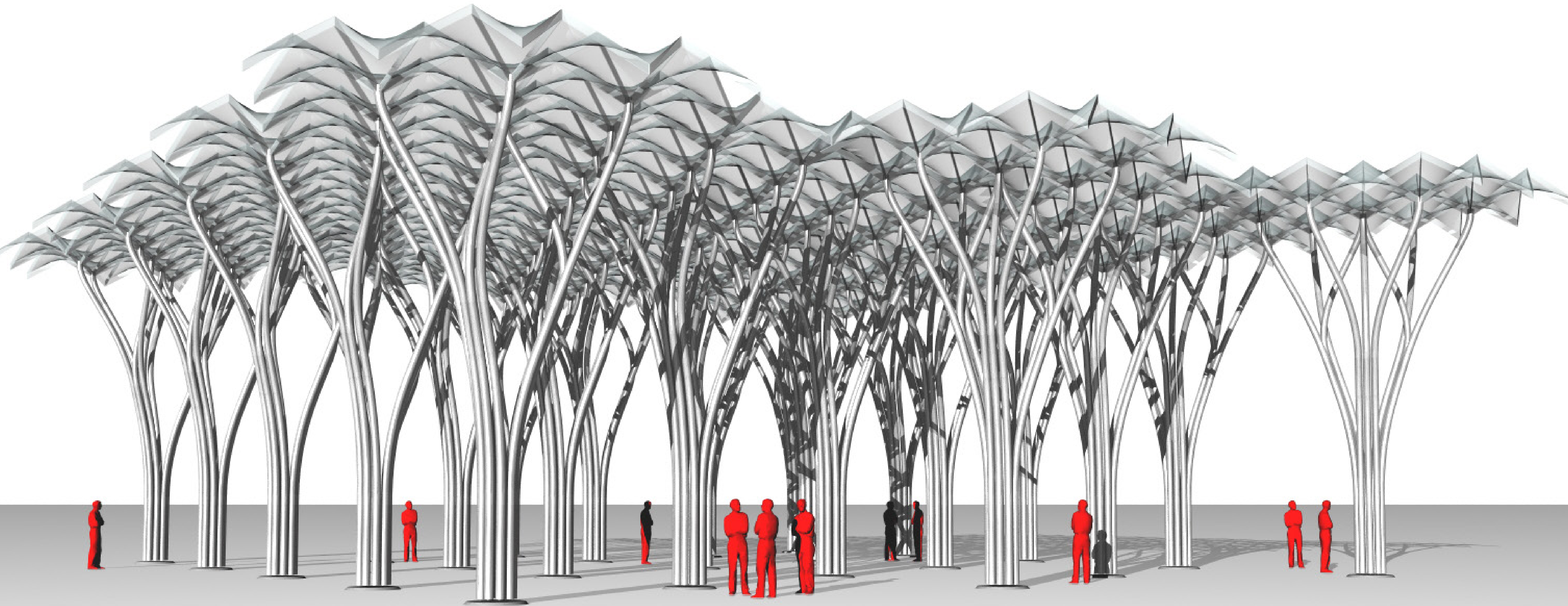


7. DESIGN INTENT

busstation intent



Gaudian intent



final remarks

Design by nature is because of its constant feedback loop much more integrative than architectural design

Using nature as inspiration combined with math enables us to come up with structurally rational designs

Natural designs are based on relentless and ruthless principles

For every designphase, nature has solution available

Thank you