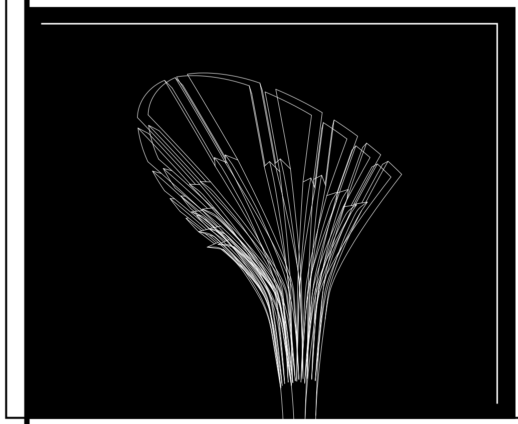


NEST

02. Appendix booklet
MSc. 4 / 2012
Department of Architecture
Aalborg University

NEST

authors : **Anders Ogstrup**

Kenn Clausen

academic advisors : **Peter Lind Bonderup //** Architect MAA

Poul Henning Kirkegaard // Civilengineer, PH.D, Associate Professor

submission : **May 23, 2012**

university of Aalborg : **Department of Architecture**

folder type : **02 // Appendix - Design process**

number of pages : **58**

number of copies : **05**

extra : ** This folder contains a cd-rom.*

TABLE OF CONTENT

The overview.

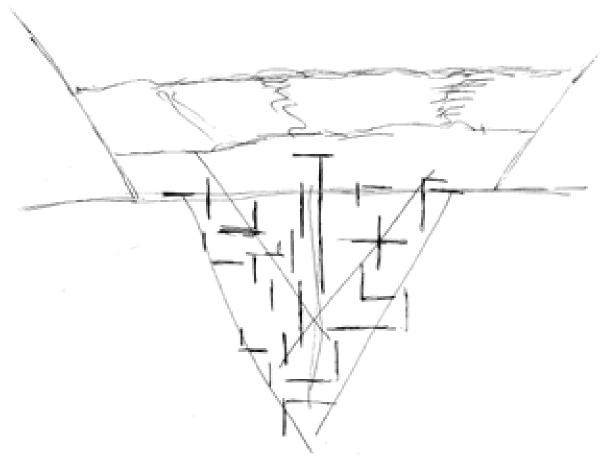
ill. 01 // Dome-shell structure covers concrete elements (light vs. heavy).

CONCEPTUAL STUDIES

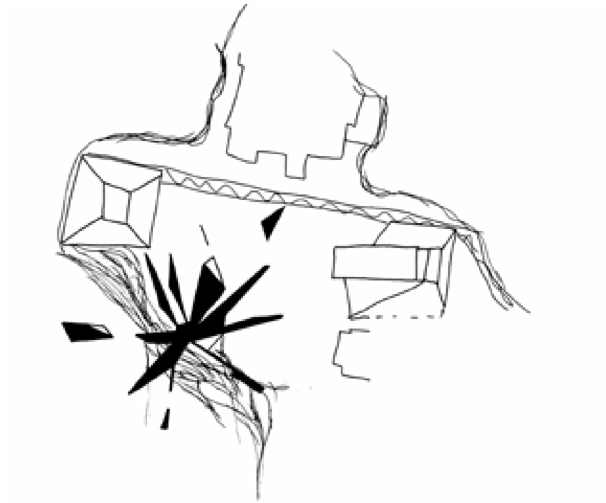
The ideas are born.

Here we abstract our ideas in sketches and models. We discuss possibilities and define our problems; we study large building structures and small hidden elements, how do we define a spatial structure that implements both structural and aesthetical qualities that both define and interconnect with the temples and plaza?

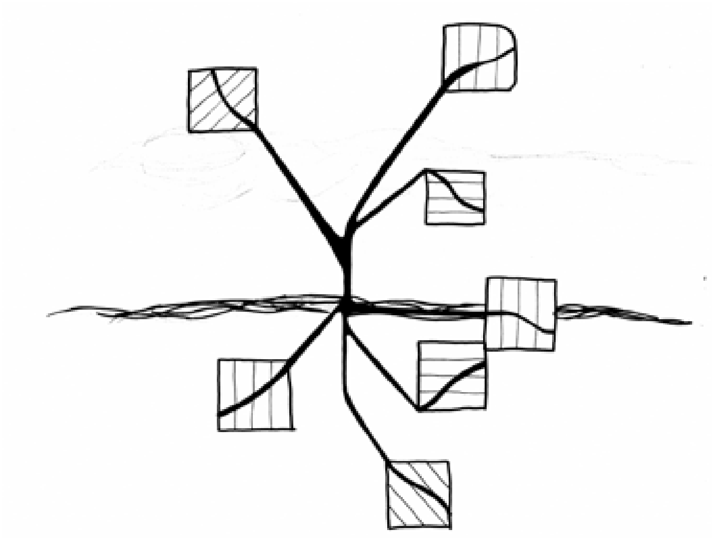
ill. 02 // Dome structure vs. triangular temples.



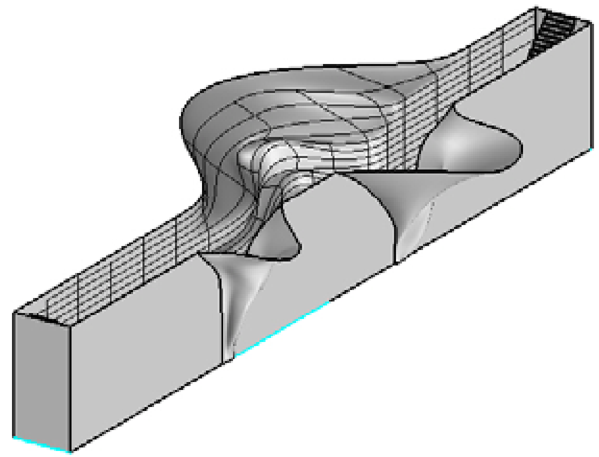
ill. 03 // Surfaces dissolve into ground adapting to the temple geometries.



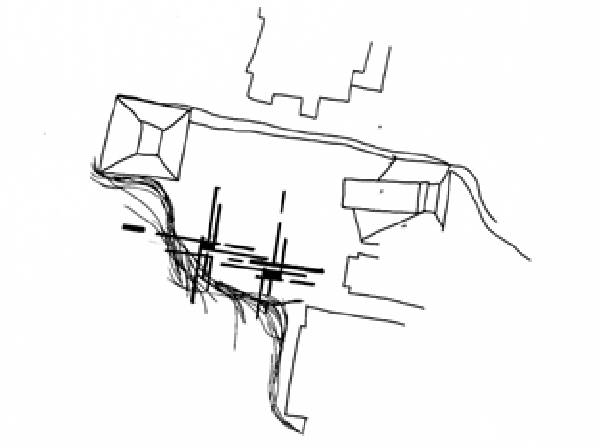
ill. 04 // Building located south from the plaza, dissolving from one point into space.



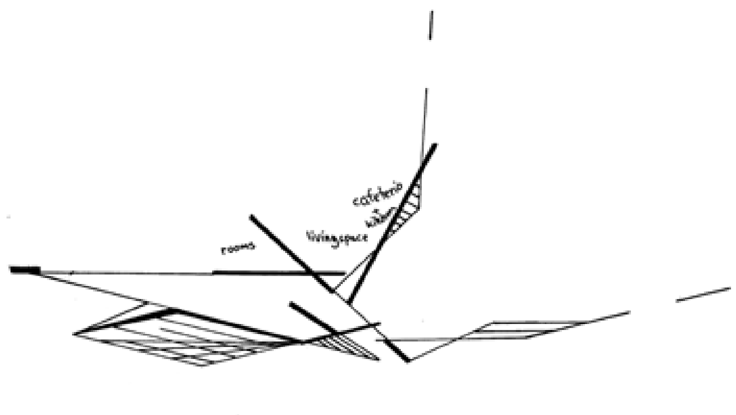
ill. 05 // Small huts adapts to a tree-structure.



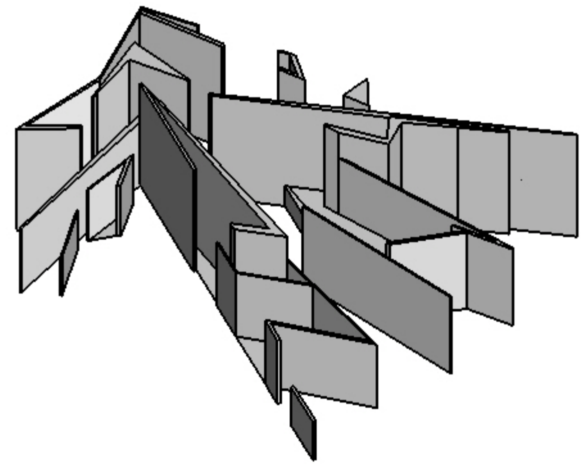
ill. 06 // Organic shapes dissolve a rectangular linear space.



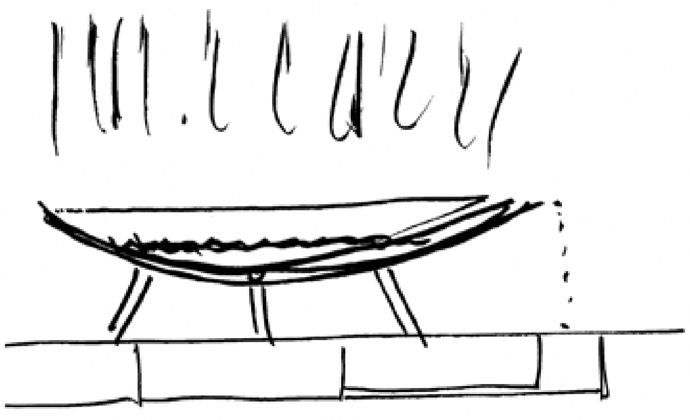
ill. 07 // Two building structures interfere with each other.



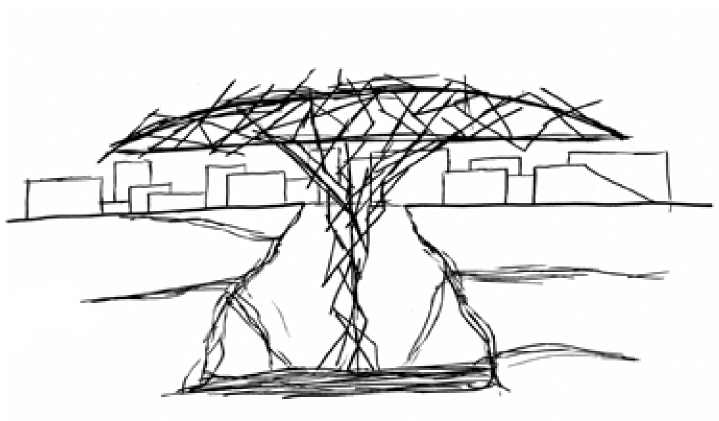
ill. 08 // Small huts adapts to a tree-structure.



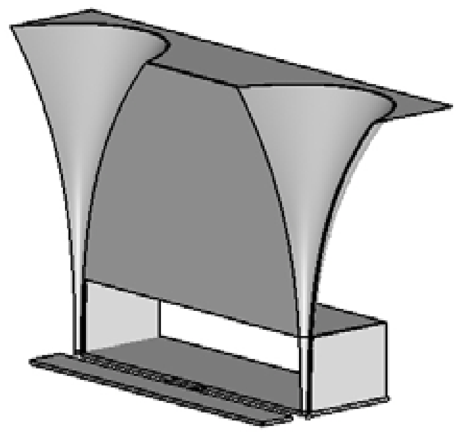
ill. 09 // Shifting wall heights generate diverse spaces.



ill. 10 // Rotated dome structure collects water and allows sunrays in the space.



ill. 11 // Structure transforms from an underground spatial element to a light roof structure.

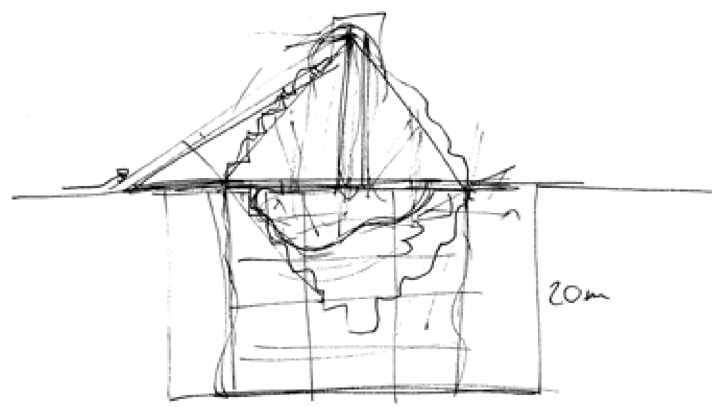


ill. 12 // Columns define an open space.

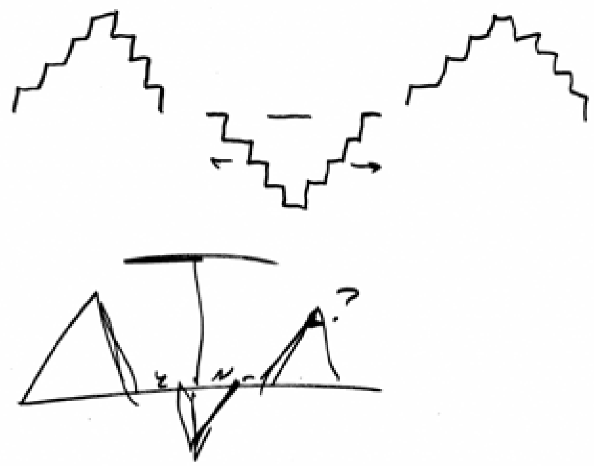
UNDERGROUND STUDIES

We develop our ideas further.

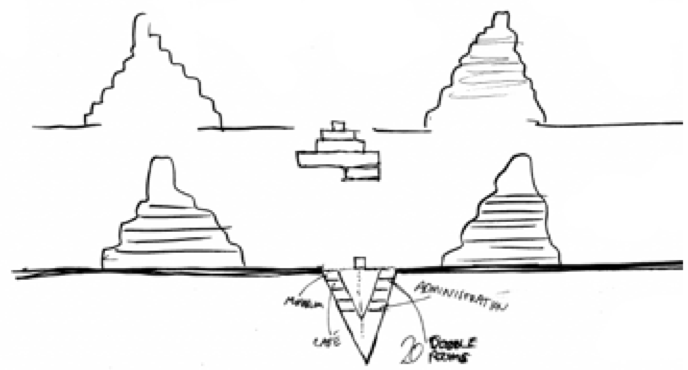
Building underground intrigues us because it creates climatic advantages; we hide away and respect the site at Tikal. We study interplays between landscape and element, ruins and building, building and visitors, ideas that respects the ruins and plaza but also marks a contemporary addition to the site.



ill. 13 // Temple 01 is lifted on columns and an organism is growing underneath.



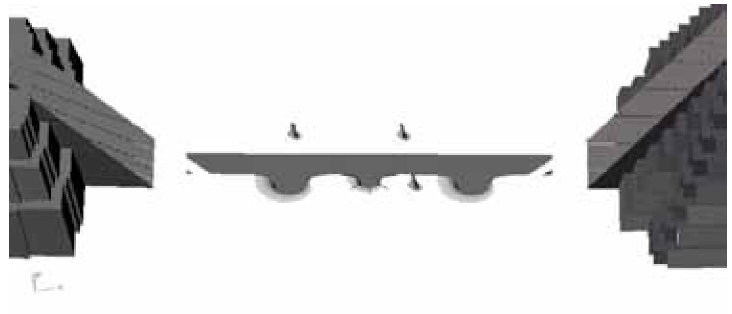
ill. 14 // The temple stepping is extended underground.



ill. 15 //Temples define the hostel layout and hidden underground.

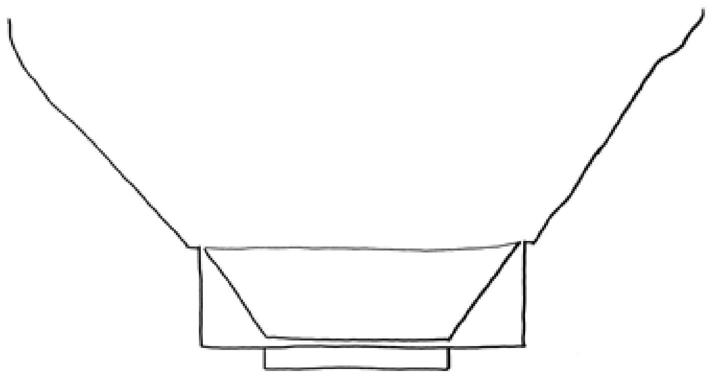
ill. 16 // A cut define the boundary for the space, a smaller fragmented structure allows ventilation circulation.

ill. 17 // A cut define the position of the functions and collects rainwater in the centre point.

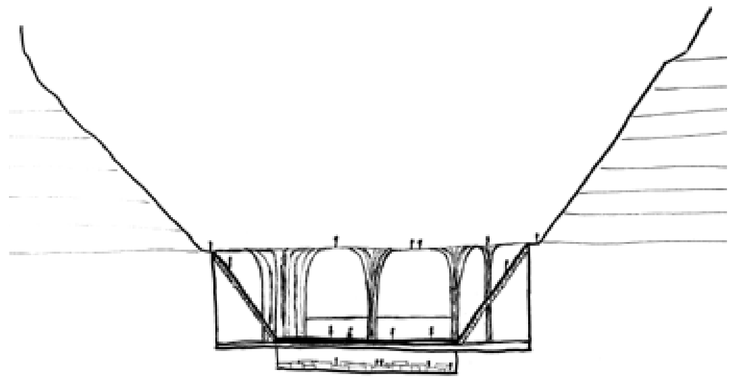


ill. 18 // Ground-level surface drawn underground.

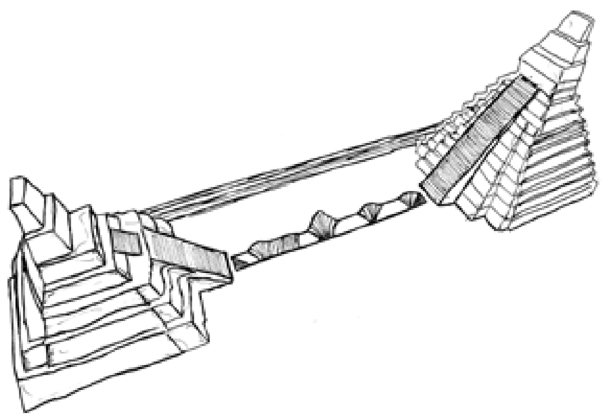
ill. 19 // Building elements cut through the landscape.



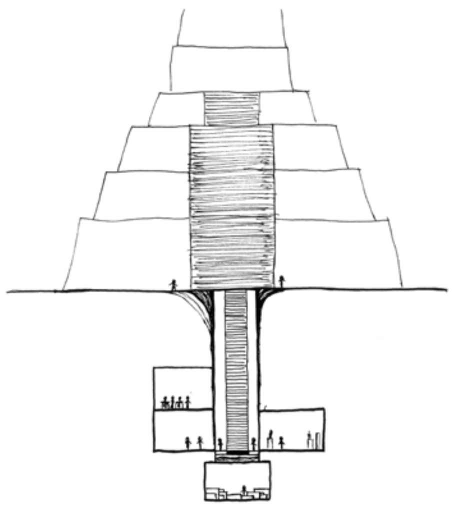
ill. 20 // Temple angles are extended underground.



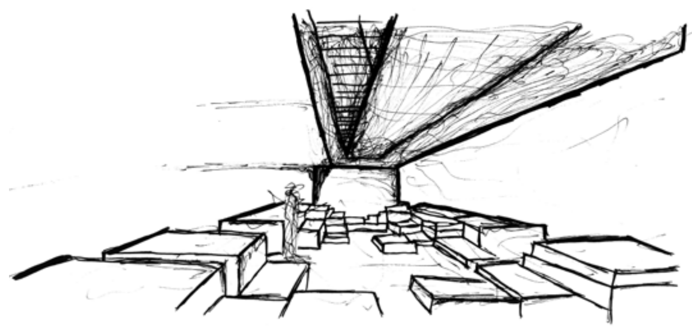
ill. 21 // Functions and temples are merged in a design proposal.



ill. 22 // A linear cut adapts to the organic landscape.



ill. 23 // The staircase extends from the temple top to the building ground.

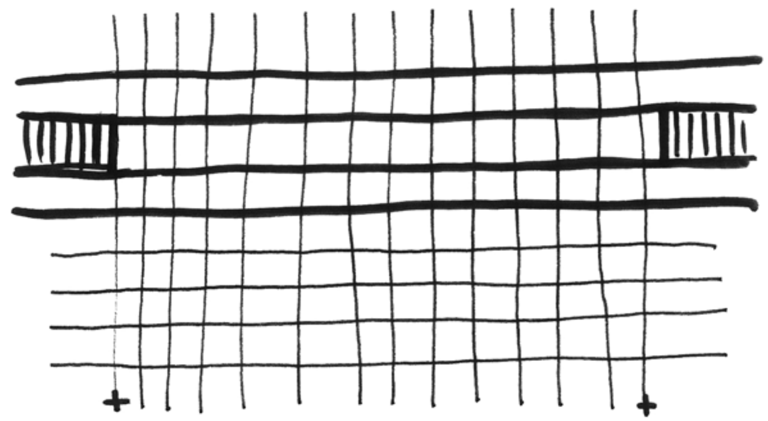


ill. 24 // Extruded plateaus define spaces in a spatial configuration.

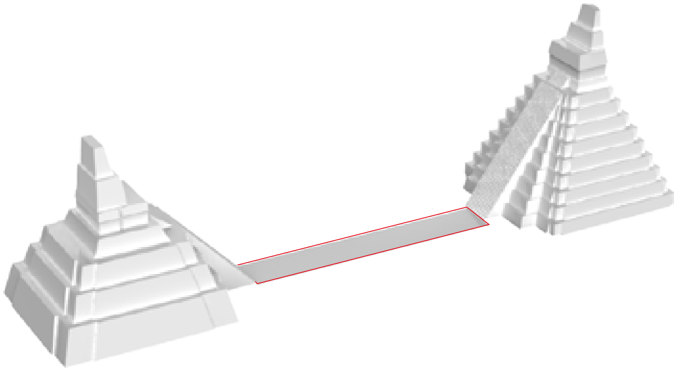
MASTERPLAN STUDIES 0.1

The hybrid between landscape and element.

The concrete surface defines the building boundaries and here we investigate proportion, interplay with landscape and flows. We study the interplay with the concrete surface, the two temples and the circulation on the plaza.

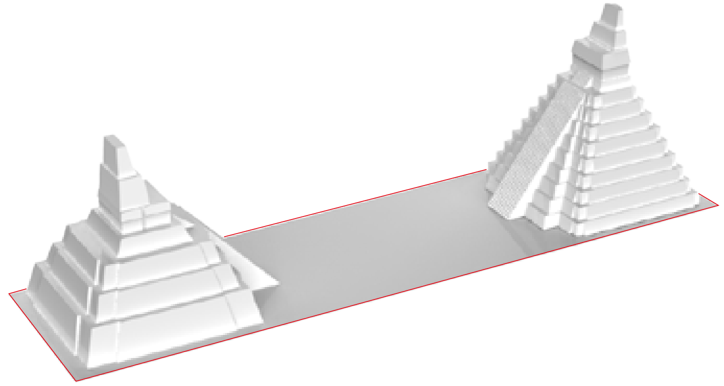


ill. 01 // Define the contextual geometry.



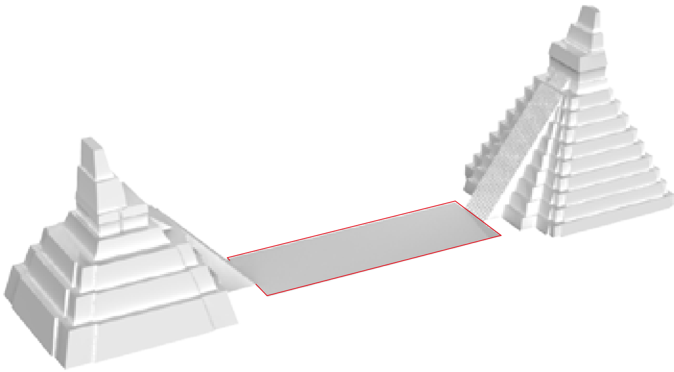
// **iteration 01.**

The surface follows the width of the temple stairs. It connects the temples, but creates a small green space on the left site.



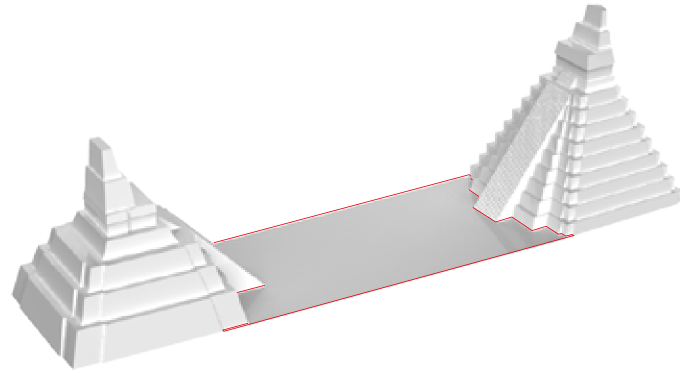
// **iteration 04**.

The surface marks the location of the temples. It creates an extension to the temples.



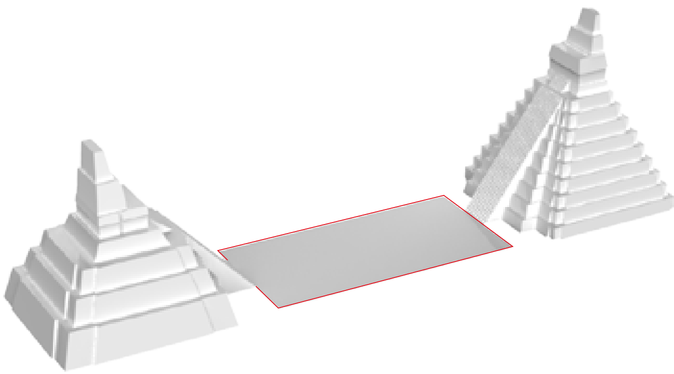
// **iteration 02.**

The surface is defined through temple corners from each temple. The element and context are not merged.



// iteration 05.

The surface adapts to the inner outlines from the temples. It defines the space between them and connects the plaza with a contemporary extension.



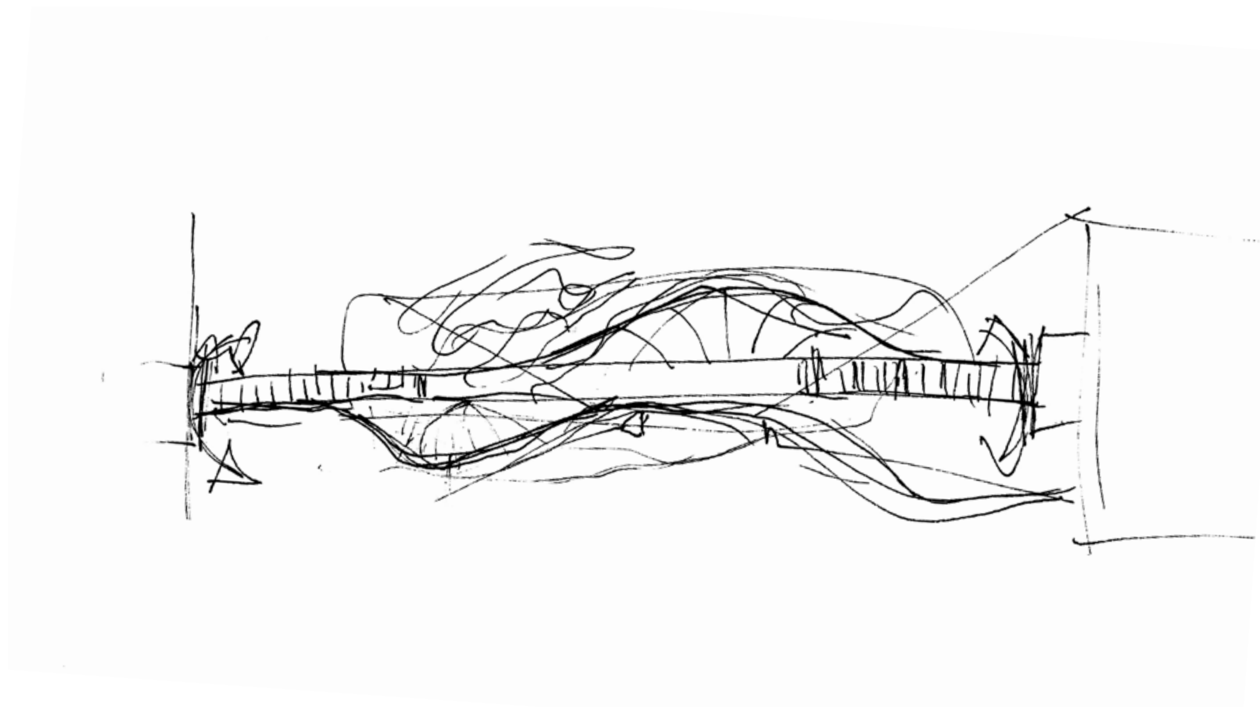
// **iteration 03**.

The size of the surface is defined by the width of the temples. The space on the left are defined, but the spots close to the temple stairs are unclear.

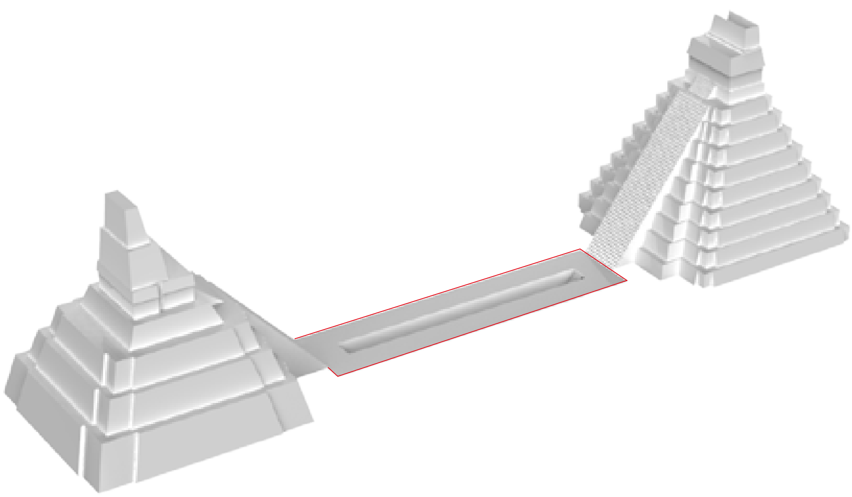
MASTERPLAN STUDIES 0.2

The bridge between two worlds , above- and under-ground.

The interplay between the concrete surface and the opening investigates flow, contrasts and coherence. We study the contrast between over- and underground and how the interplay between temples, plaza and landscape are defined.

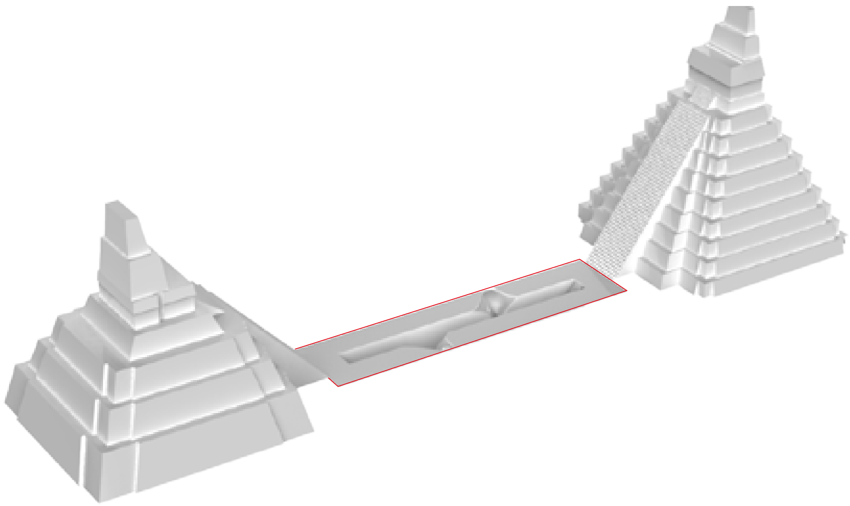


ill. 02 // Organic and rectangular cuts.



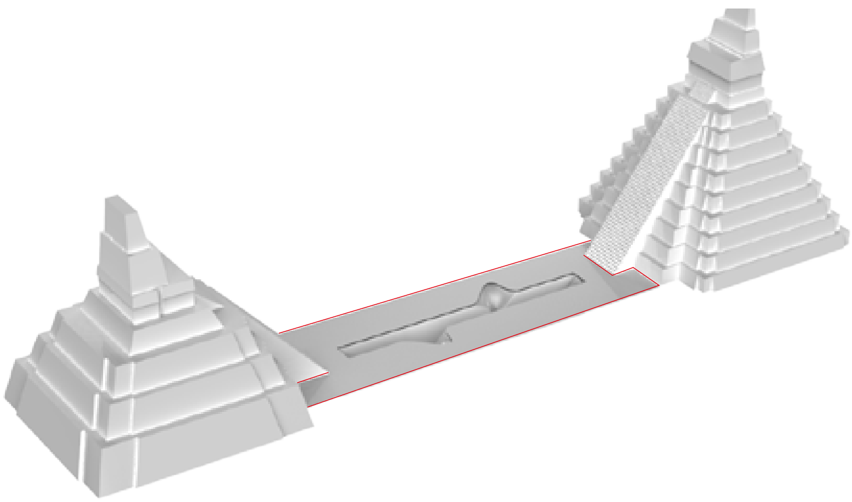
// **iteration 01.**

Cut and surface are similar; the flow is dense close to the temples.



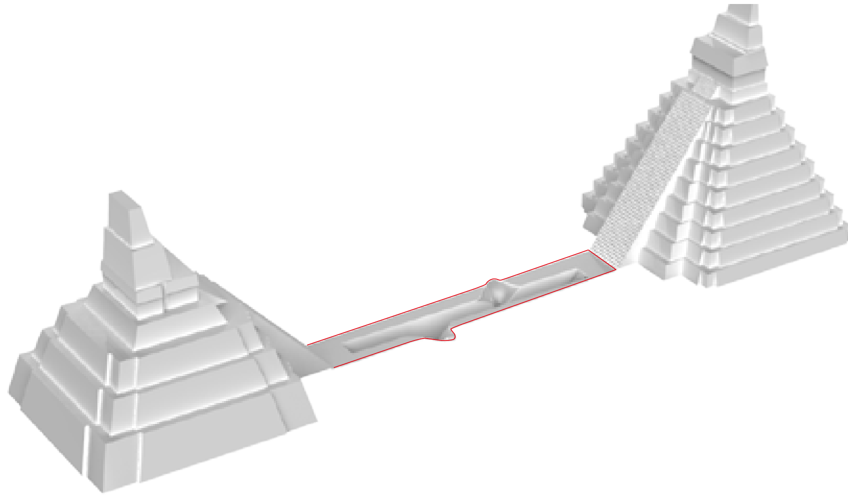
// **iteration 02.**

The linear opening merges with organic shapes; the contrast to the rectangular surface frame is interesting. The flow is sub-divided in to smaller zones.



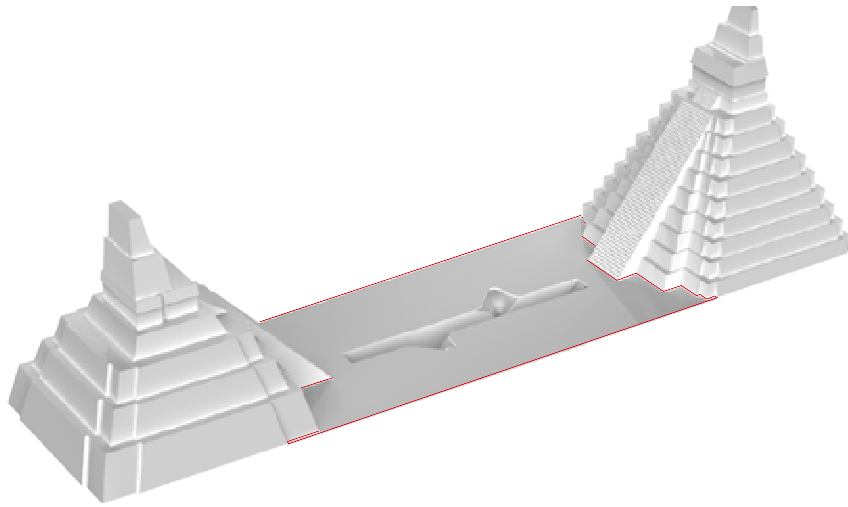
// **iteration 03.**

Keeping the organic shapes but the surface is extended and connected to the temples. It emphasizes the coherence with the temples and creates more space around the organic lines.



// **iteration 04.**

The surface follows the temple stairs and decreases around the organic shapes. It emphasises the organic areas but divides the plaza into small pieces.



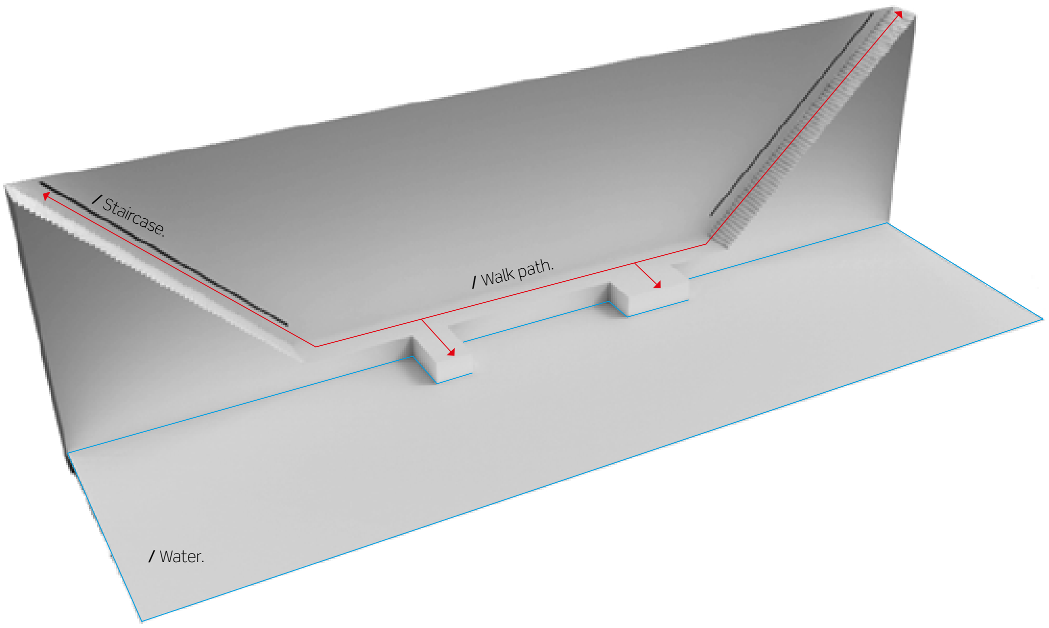
// **iteration 05.**

The coherence with the temples is interesting and the plaza is defined with a similar pavement connecting the whole plaza. The cut becomes too transparent.

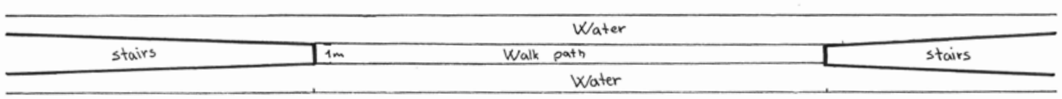
STAIRCASE / WALK PATH

Studies underground.

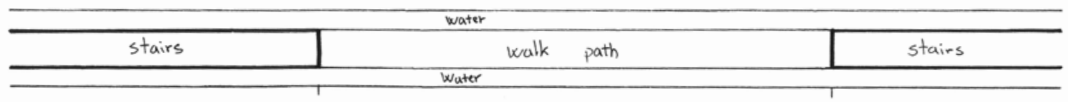
We study the movement from ground-level to walking path, how one element merges with another. We investigate position, step degree and expression to define the staircase element and furthermore we study proportion and light access of the opening to set the boundaries for the cut in the surface. The staircase-entrances are similar in expression and connected with a walking path in the middle.



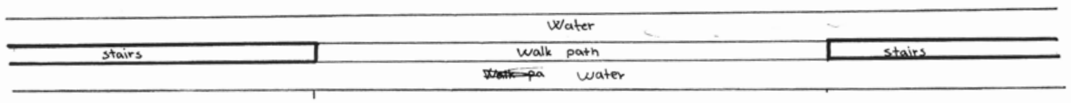
ill. 03 // The concrete staircase defines the movement towards the museum plateau.



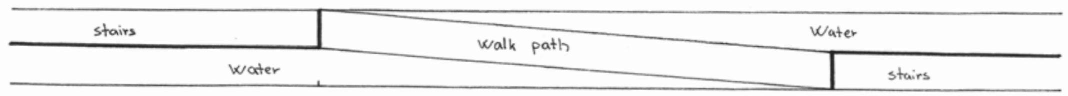
// **iteraion 01.** The staircase increases towards the bottom; it emphasises the direction.



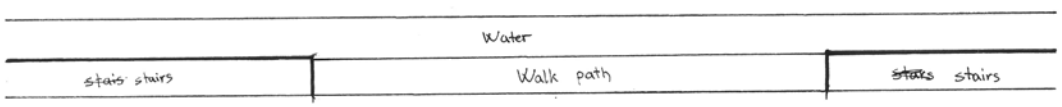
// **iteration 04.** The staircase is located in the centre; it divides the water canal into two and emphasizes the walk path.



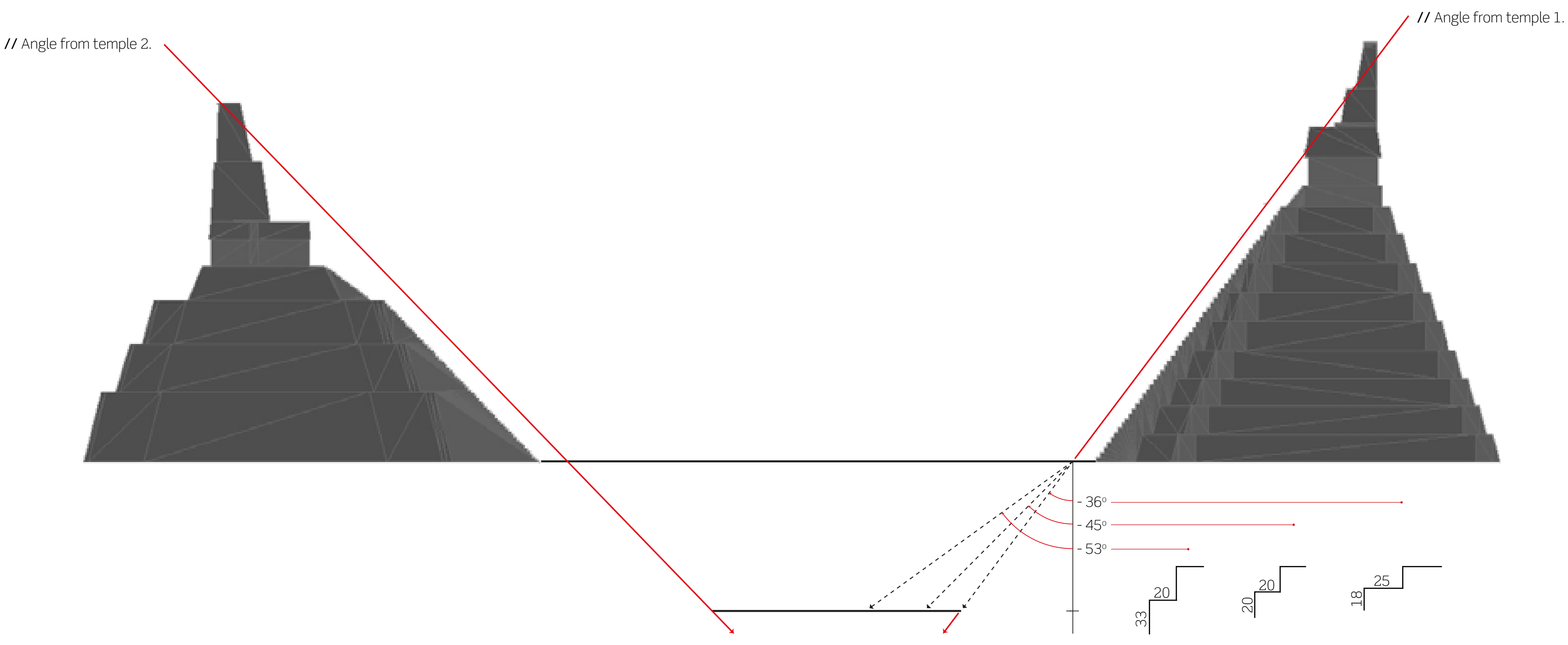
// **iteration 02.** The staircase is thin with water on both sides; only one person can walk at the time.



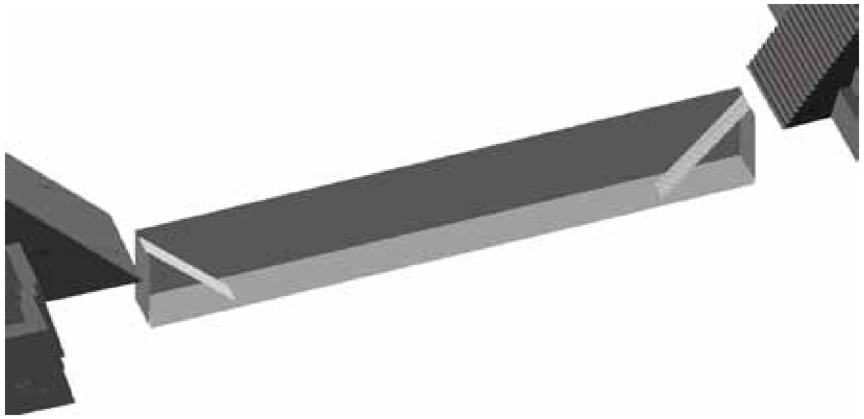
// iteration 05. The staircase is shifts from one side to the other; it generates an interesting expression, but an unbalance in the clear direction.



// **iteration 03.** The staircase is located at one side; a clear boundary between water and walk-path.



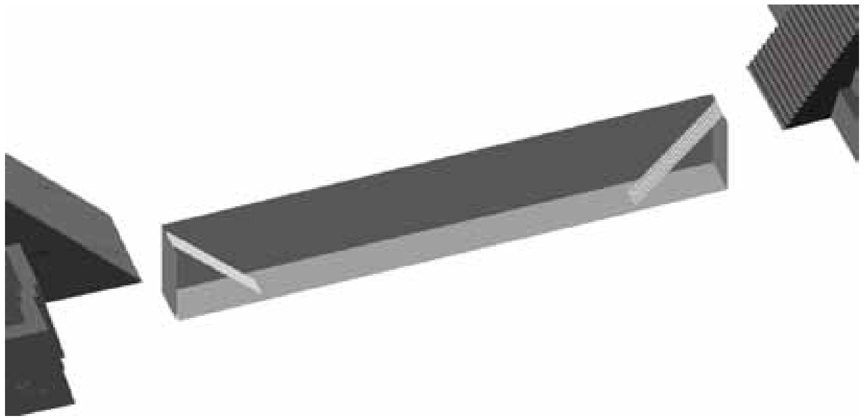
ill. 04 // Step-size and staircase degree: 20x20 and 45 degrees.



// **iteration 01.**

height // 8 m.
distance stairs // 39 m.

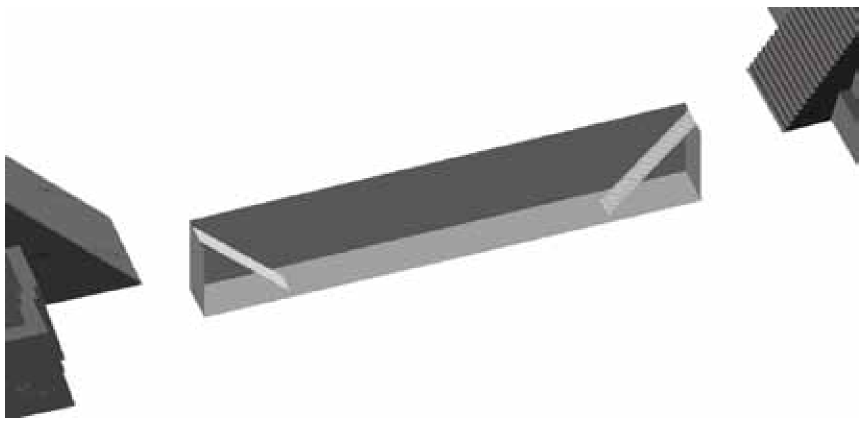
The underground cut is narrow and the distance between the stairs are too small.



// **iteration 02.**

height // 8 m.
distance stairs // 34 m.

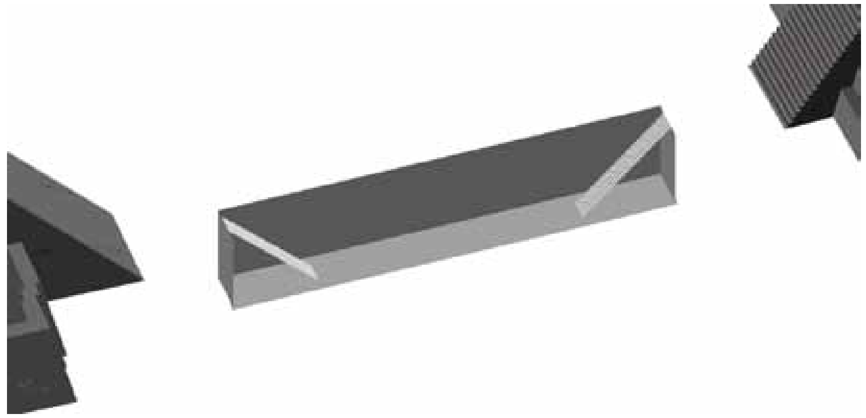
The proportions leave a horizontal expression and the length between the stairs is too big.



// **iteration 03.**

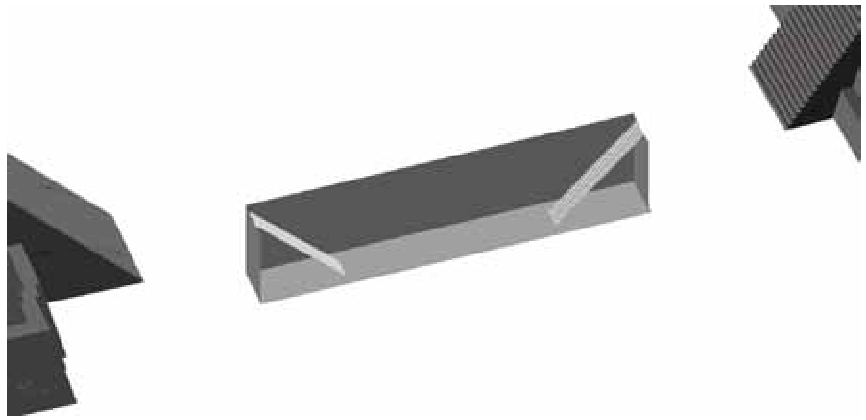
height // 8 m.
distance stairs // 29 m.

The proportions leave a horizontal expression, but it generates a larger space in front of the stairs.



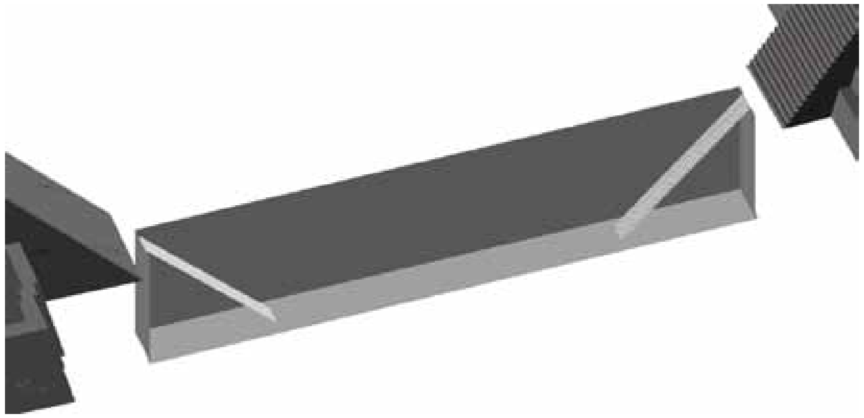
// **iteration 04.**

height // 8 m.
distance stairs // 24 m.



// **iteration 05.**

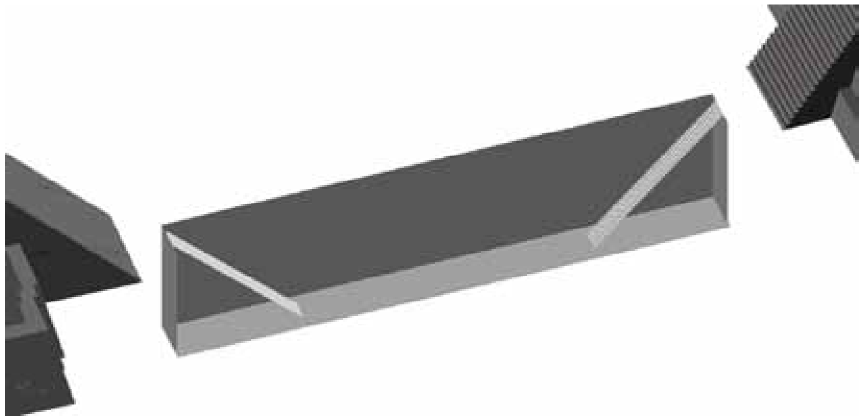
height // 8 m.
distance stairs // 19 m.



// **iteration 06.**

height // 12 m.
distance stairs // 31 m.

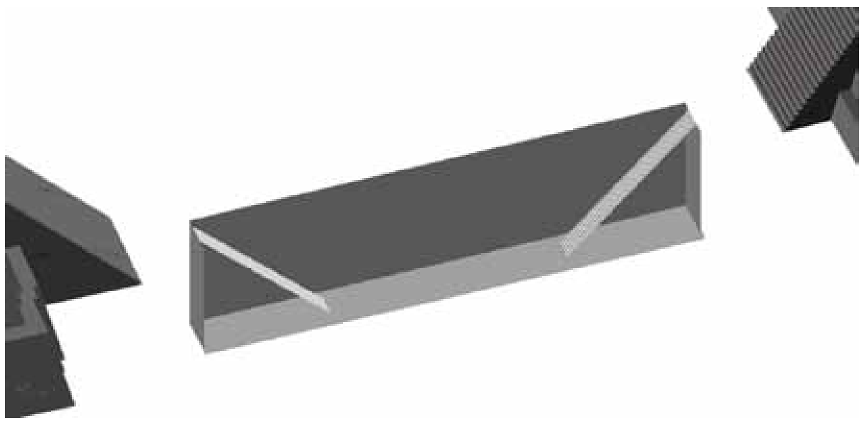
The space between the temple stairs and underground cut is narrow and the length of the walk-path is too big.



// **iteration 07.**

height // 12 m.
distance stairs // 26 m.

The space height and length of the walk path is good and the space between the temples and underground cut creates two plateaus.



// **iteration 08.**

height // 12 m.
distance stairs // 21 m.

Observation /

The underground proportions is 50m x 4m x 12m (L-W-H) from the ground-level down to the walk path. Coherence between temple stairs and underground staircases are emphasised in the movement and direction from the temple top towards the underground bottom.

LIGHT STUDIES

Light access undeground.

To ensure proper lighting levels in the interior, we used Autodesk Ecotect Analysis. The calculated results is measured in Lux and we have investigated lighting levels for three various spatial height settings. The different heights are 4, 8 and 12 meters. The last one matches the one we have built.

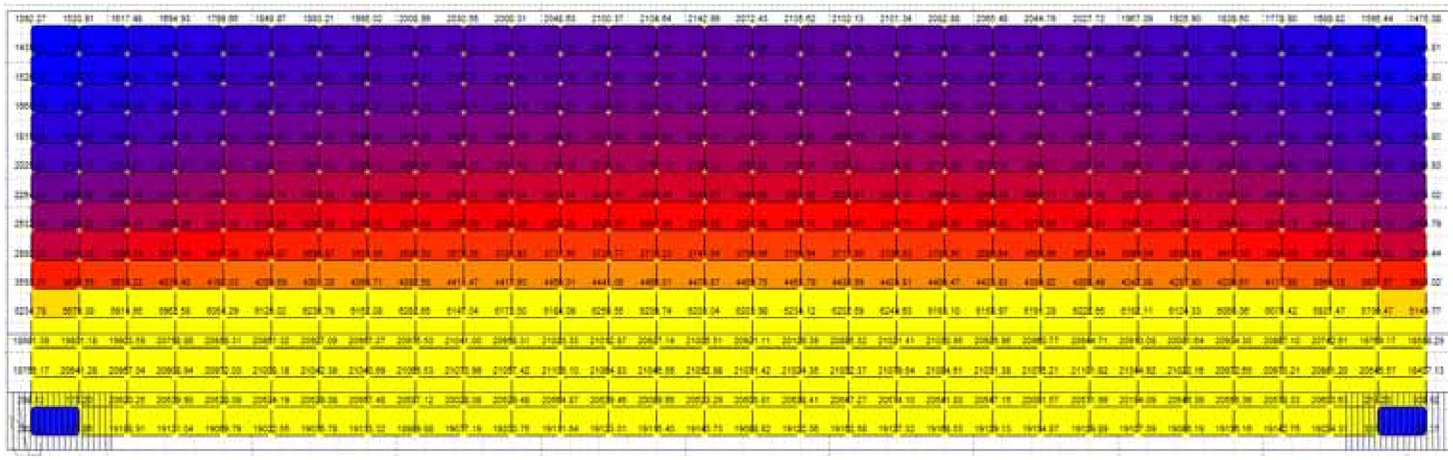
Input data:
Heights: 4m, 8m, 12m (Selected height)
Date: April 19th
Time 12.00

* Intermediate sky with sun.
* All results are calculated using Desktop Radiance for Ecotect.

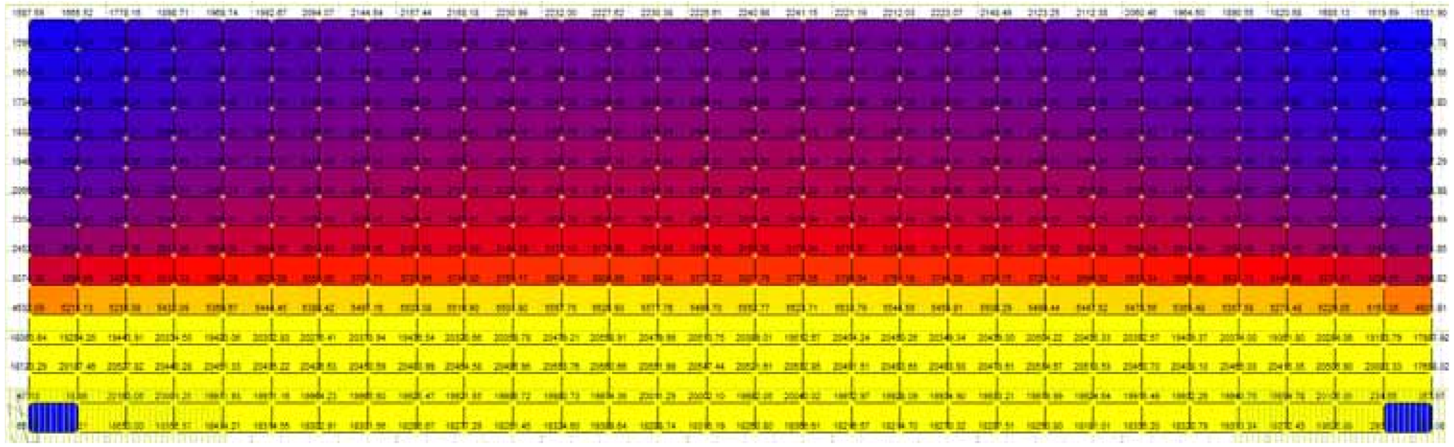
Lux:	**Surface illuminated by:**
1	Full moon at tropical latitudes
50	Family living room
80	Office building lights
100	Dark overcast day
400	Sunrise on a clear day
1000	Overcast day
10.000-25.000	Full daylight(not direct sun)
32.000-130.000	Direct sunlight

(http://en.wikipedia.org/wiki/Lux)

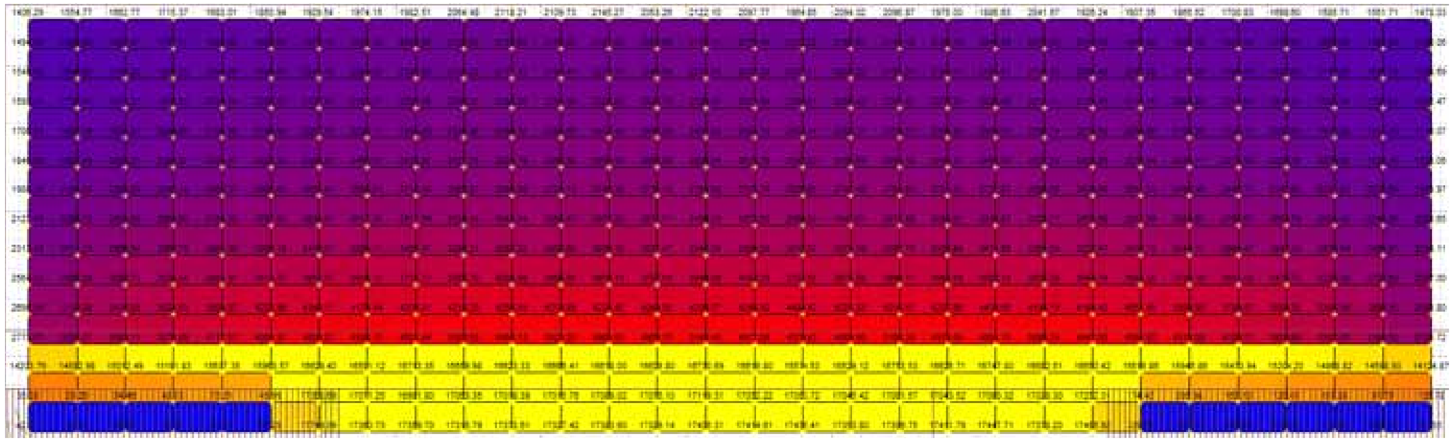
Height of room: 4 meters
Average value: 7226 Lux
Lowest value: 1392 Lux
Highest value: 20980 Lux
Approximate value(living and dining): 2500 Lux



Height of room: 8 meters
Average value: 6906 Lux
Lowest value: 1530 Lux
Highest value: 21048 Lux
Approximate value(living and dining): 2300 Lux



Height of room: 12 meters
Average value: 4568 Lux
Lowest value: 1400 Lux
Highest value: 18028 Lux
Approximate value(living and dining): 2200 Lux



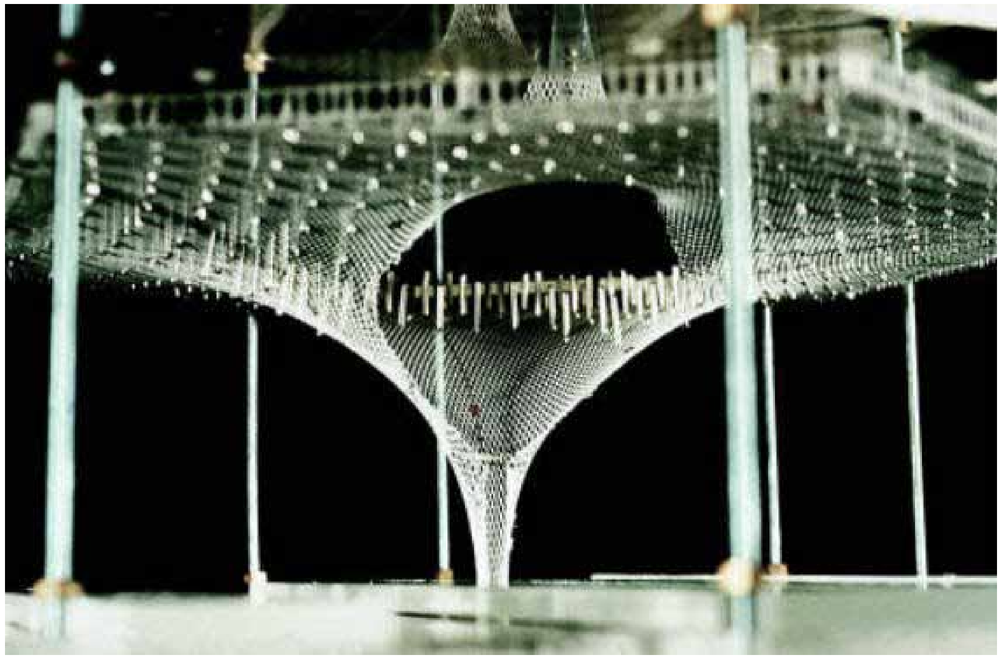
Conclusion /

The investigation shows that there's sufficient light in all areas of the interior space. The lowest value is around 1400 Lux, which matches the diffuse light of a very light overcast day. All results are very similar, but for spatial reasons, we choose the 12 meter high room.

COLUMNS

Defining a structural space.

The following references contribute to what column type will suit the space. The idea is that the columns, not only act as structural elements, but also help define and characterize our spaces. They will become mediators between above- and underground. We define and analyze the structural behaviours in the columns but a tectonic solution also influences the visual an aesthetical parameter. Do the roof rest on the columns or do the columns extend and continue through the deck, making a significant impact at ground level?

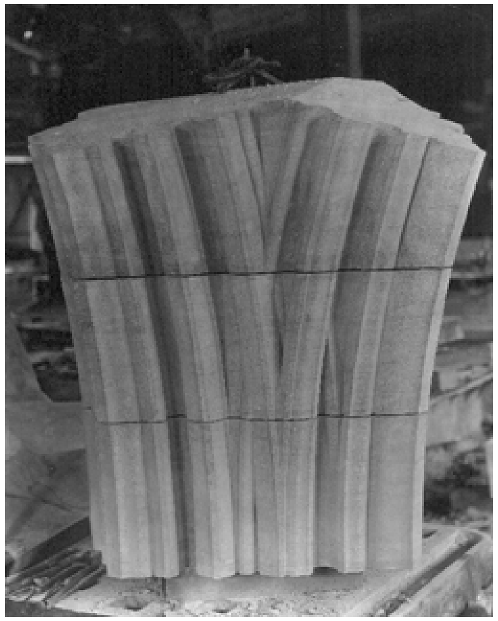


ill. 01 // Stuttgart 21 train station, Frei Otto.

- Fluent
- Daylight collector
- Organic

ill. 03 // La Bibliothèque de l'INHA.

- Open space
- Thin columns
- Linear position
- Similarity
- Spatial objects



ill. 04 // Part of column with interlacing curves.

- Fabrication techniques
- Building blocks
- Verticality
- Concrete

ill. 02 // The Grand Resort Bad Ragaz.

- Heavy
- Connected
- Curvature
- Detail between column and bottom
- Open

ill. 05 // Exeter Cathedral, London.

- Verticality
- Variation
- Direction
- Connected
- Even distribution of loads

ill. 06 // Kyaoi Garden University.

- Organic
- Fluent
- Spatial structure
- Variation in materials

SPATIAL COLUMN

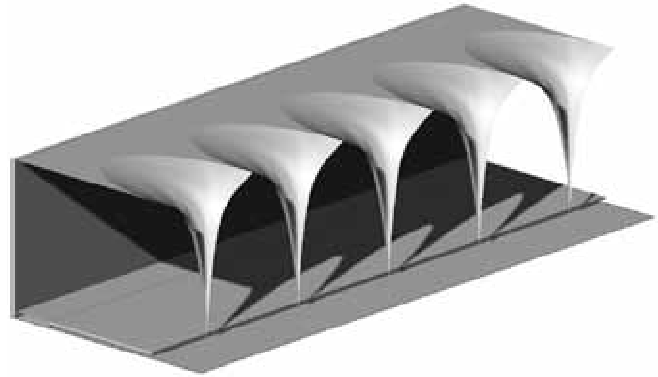
The search for verticality.

The first conceptual ideas only had the large linear cut implemented. We wanted a structure that created interplay between cut and structure, something that made the cut seem more transparent. The initial ideas contained organic curtains, floating down the walls and defining a clash between linear and organic. The interplay was interesting but implementing functions became more an attachment than an integration. But using the structural elements to define space had potential and developed into breaking down walls behind the structural elemenents.
The concept transformed from being organic structures drawn down to bearing columns that not only acted as a counterpart to the linear cut but also defined a tectonic element in the building. The columns developed from small transparent shapes to defining the archectural space.

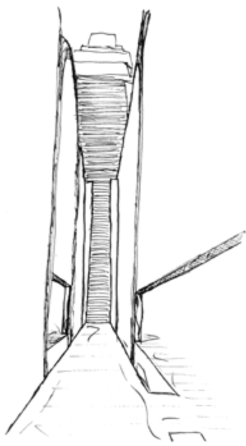
The columns define strength, scale and fluent circulation, but we added complexity to enhance the hybrid between functions underground and spatial elements above. The columns should define verticality and lead the perception upwards to the sky and ancient site.

The cut is open to the outside and create a physical interplay between climate and space. High humidity, hot temperatures and extreme rainfalls are some of the climatic obstacles when designing in Tikal. We decided to enhance the climatic change and allow rainfall in parts of the interior spaces and designed our columns to become water collectors. The interaction between columns and climate will change the surface and perception of an adaptable and transformable column structure.

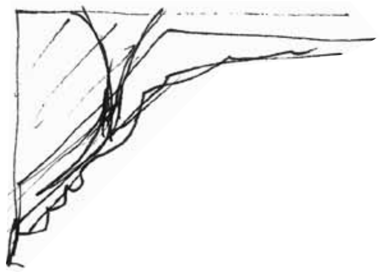
ill. 07 // Main curves for columns.



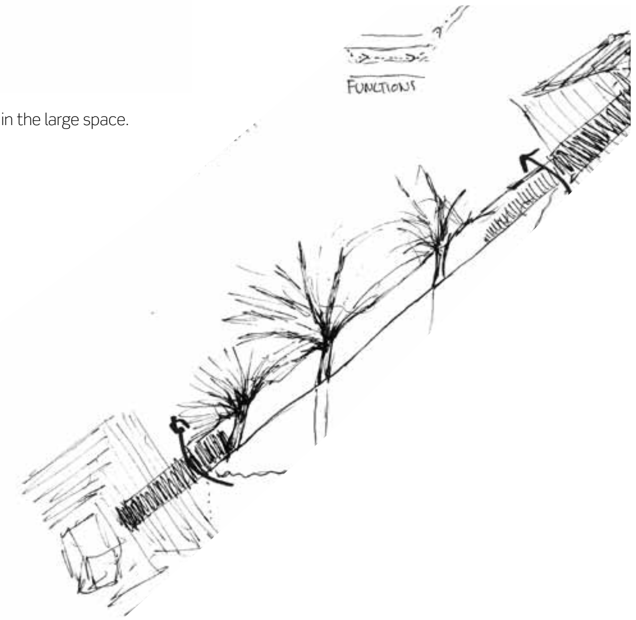
ill. 10 // Thin structure allows daylight, rain and ventilation in the large space.



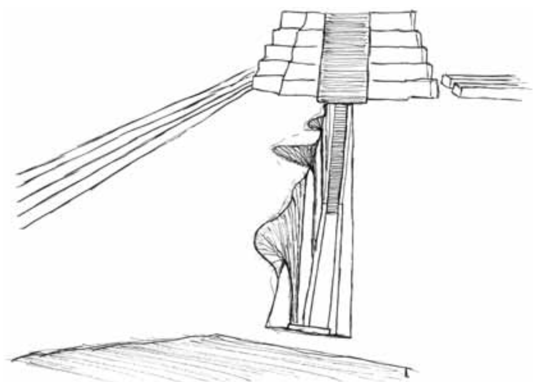
ill. 08 // Columns on both sides of the linear cut.



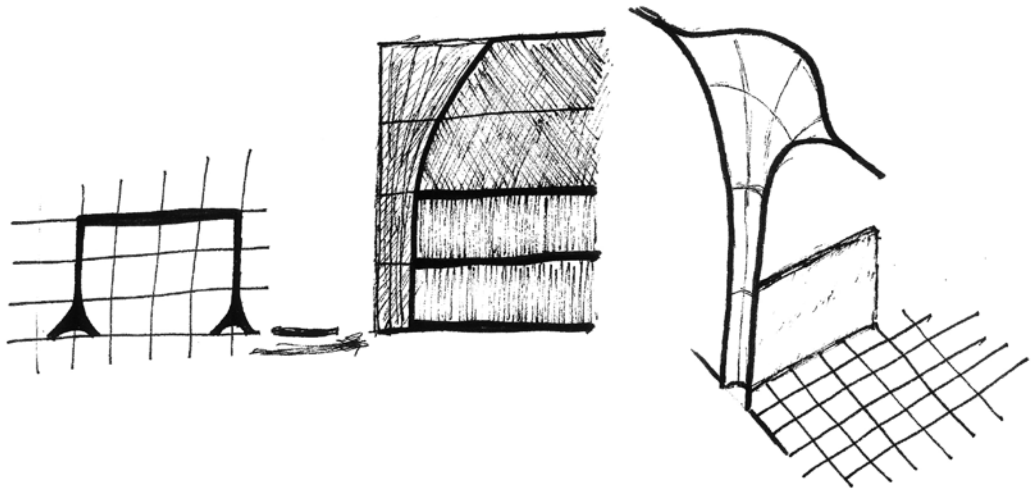
ill. 11 // Staircase and column.



ill. 12 // Column structure floats into the landscape and create a fragmented linear cut to the underground.



ill. 09 // Columns dissolve from ground level surface into the underground structure.



ill. 13 // Columns define a spatial layout.

COLUMN DEFINITION

A dynamic form-generating system.

A parametric definition is set up in Grasshopper, a plugin for Rhinoceros. The purpose is to control the column structure from input to output. Grasshopper is used to keep the geometrical constraints through a set of form studies and output data about the geometry, later load and deformation calculations will be added. The parametric approach to design creates a fluent workflow that effectively generates column studies.

We want to define a workflow that establishes a relationship between aesthetical form parameters and structural load calculations to ensure an integrated design process. We iterate through a set of aesthetical parameters to ensure a vertical and upward going expression in our columns while simultaneously calculating the load definition for a specific output.
Column and extracted data will be tested through a FEM program to understand the interplay between form, material and structure. The loop will continue until the designer extracts the spatial column structure for the design proposals' needs.

The system is defined in Grasshopper and allows the user to explore column typologies through a set of parameters.

Parameters //

/ input

Sel. pt:	Location of the column study.
Thickness roof (mm):	Define roof thickness (load-parameter).

/ column

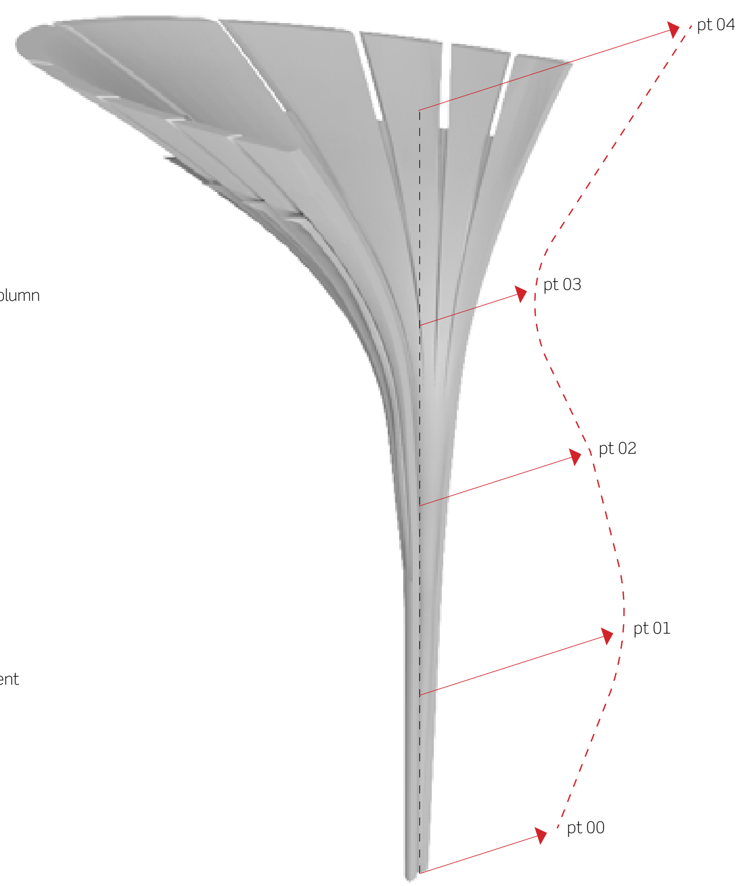
Height column (mm):	Define height of space.
Thickness column (mm):	Thicknes of the column/shell.
Ellipse width (mm):	Width of the shell (radius).
Ellipse depth (mm):	Depth of the shell (radius).

/ rail

Height rail (mm):	Heigh of the rail, defines the physical element over-ground.
Rail. sub-division:	Number of water openings in the shell.
Thickness cuts (mm):	Water openings.

/ form-generating points

Pt 00:
Pt 01:
Pt 02:
Pt 03:
Pt 04:



// **iteration 01**.

height column: 14000
thickness column: 200
ellipse width: 4000
ellipse depth: 9000

height rail: 1200
rail. sub-division: 0
thickness cuts: 0

pt.01: 2000
pt.01: 500
pt.02: 1500
pt.03: 100
pt.04: 1500

// An organic shape with a large shell in bottom and top. It removes the verticality expression.

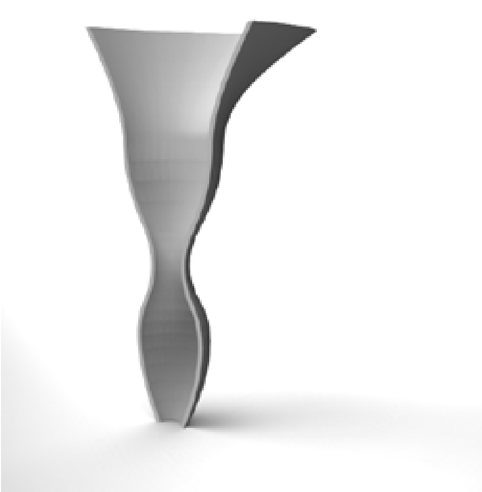
// **iteration 02.**

height column: 14000
thickness column: 200
ellipse width: 4000
ellipse depth: 9000

height rail: 1200
rail. sub-division: 0
thickness cuts: 0

pt.01: 500
pt.01: 200
pt.02: 200
pt.03: 2000
pt.04: 1000

// The shell moves from thin to big. The part in the middle distorts the verticality.



// **iteration 03.**

height column: 14000
thickness column: 200
ellipse width: 4000
ellipse depth: 9000

height rail: 1200
rail. sub-division: 0
thickness cuts: 0

pt.01: 500
pt.01: 2000
pt.02: 200
pt.03: 2000
pt.04: 2000

// The shell is split in two, a top and bottom part.

// **iteration 04.**

height column: 14000
thickness column: 200
ellipse width: 4000
ellipse depth: 9000

height rail: 1200
rail. sub-division: 0
thickness cuts: 0

pt.01: 100
pt.01: 500
pt.02: 1500
pt.03: 500
pt.04: 100

// The shell seems thin and elegant but the structural movement in the shell is difficult.

// **iteration 05**.

height column: 14000
thickness column: 200
ellipse width: 4000
ellipse depth: 9000

height rail: 1200
rail. sub-division: 0
thickness cuts: 0

pt.01: 1000
pt.01: 500
pt.02: 200
pt.03: 500
pt.04: 2000

// A linear curve moves from bottom to top and leaves a vertical impression.

// **iteration 06.**

height column: 14000
thickness column: 200
ellipse width: 4000
ellipse depth: 9000

height rail: 1200
rail. sub-division: 0
thickness cuts: 0

pt.01: 100
pt.01: 200
pt.02: 200
pt.03: 500
pt.04: 1000

// The shell transforms from small to big, the verticality is more visual now.

// **iteration 07**.

height column: 14000
thickness column: 200
ellipse width: 4000
ellipse depth: 9000

height rail: 1200
rail. sub-division: 5
thickness cuts: 400

pt.01: 100
pt.01: 200
pt.02: 200
pt.03: 500
pt.04: 1000

// A rail with five sub-divisions, the water-cuts and rails are too big.

// **iteration 08.**

height column: 14000
thickness column: 200
ellipse width: 4000
ellipse depth: 9000

height rail: 1200
rail. sub-division: 10
thickness cuts: 400

pt.01: 100
pt.01: 200
pt.02: 200
pt.03: 500
pt.04: 1000

// A rail with ten sub-divisions, the rails have a good size, but the water-cuts are still too big.

// **iteration 09.**

height column: 14000
thickness column: 200
ellipse width: 4000
ellipse depth: 9000

height rail: 1200
rail. sub-division: 20
thickness cuts: 200

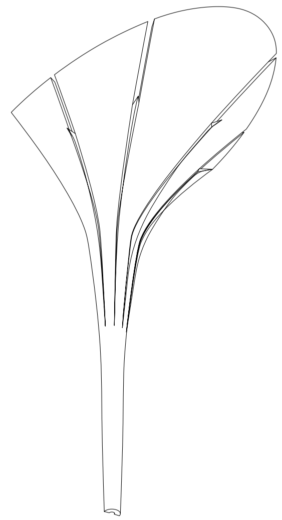
pt.01: 100
pt.01: 200
pt.02: 200
pt.03: 500
pt.04: 1000

// A rail with the sub-divisions, the water-cuts have a good proportion, but there are too many rails.

DETAIL STUDY

A junction between column and heaven.

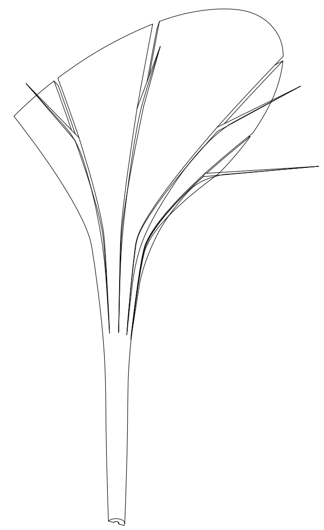
Various detail studies to how the columns could emphasize the verticality. The structures are connected to the overall Grasshopper definition and allows an effective exploration of forms.



// **iteration 01**.

water cuts:	05
cut thickness:	200
length crvs:	250

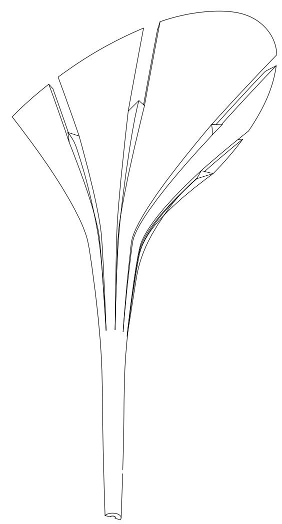
// The verticality is not there - Number of curves is too low.



// **iteration 02**.

water cuts:	05
cut thickness:	200
length crvs:	4000

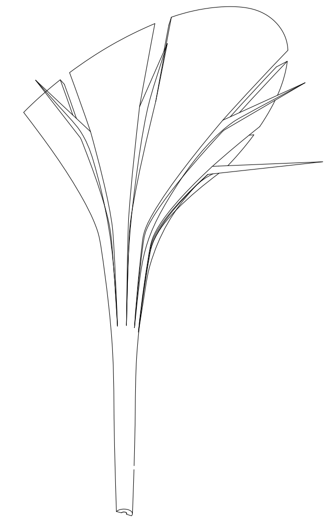
// Length of the elements is changed - they become too distant from the main column direction.



// **iteration 03**.

water cuts:	05
cut thickness:	500
length crvs:	250

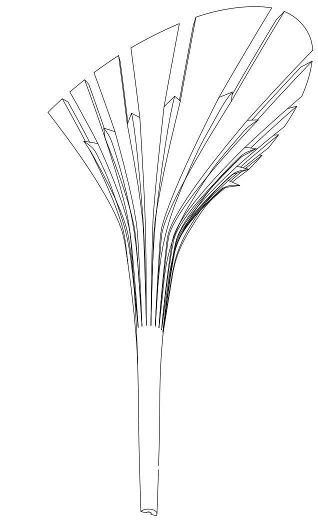
// The column is too divided.



// **iteration 04**.

water cuts: 05
cut thickness: 500
length crvs: 4000

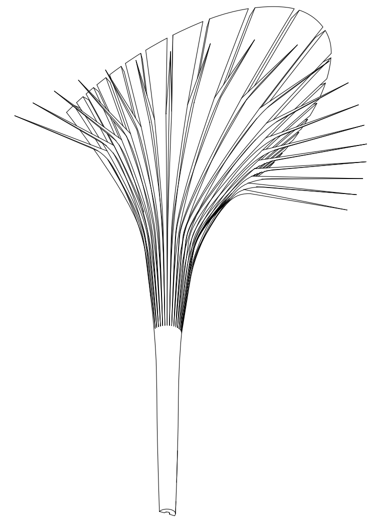
// Larger water cuts make the curve connections smaller.



// **iteration 07**.

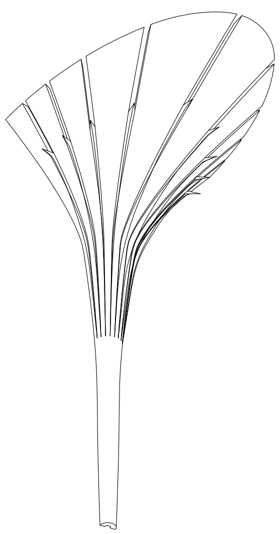
water cuts: 10
cut thickness: 500
length crvs: 250

// The balance between number of water cuts, width and length is good.



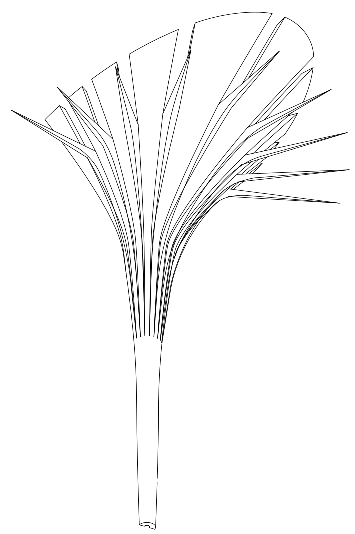
// **iteration 10**.

water cuts: 20
cut thickness: 200
length crvs: 4000



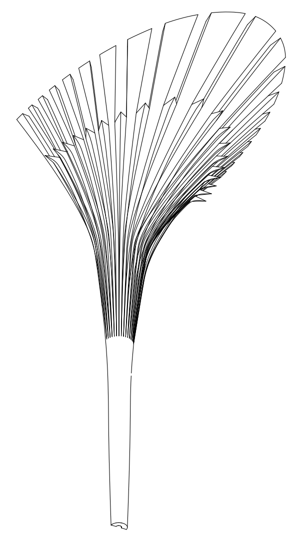
// **iteration 05**.

water cuts: 10
cut thickness: 200
length crvs: 250



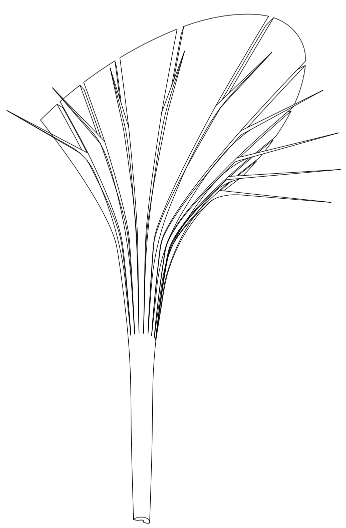
// **iteration 08**.

water cuts: 10
cut thickness: 500
length crvs: 4000



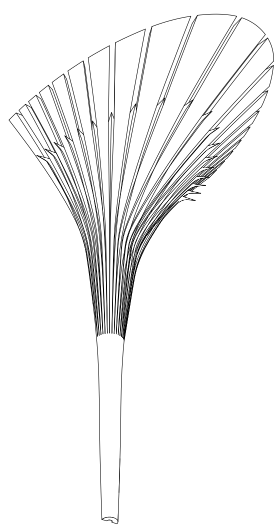
// **iteration 11**.

water cuts: 20
cut thickness: 400
length crvs: 250



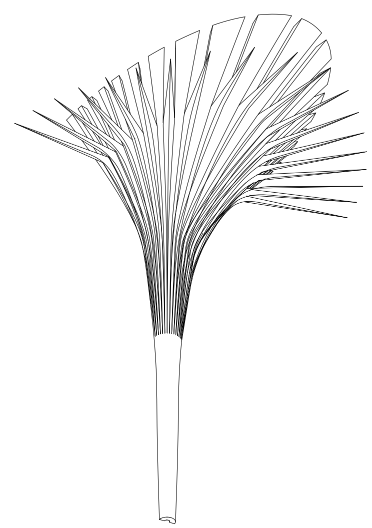
// **iteration 06**.

water cuts: 10
cut thickness: 200
length crvs: 4000



// **iteration 09**.

water cuts: 20
cut thickness: 200
length crvs: 250



// **iteration 12**.

water cuts: 20
cut thickness: 400
length crvs: 4000

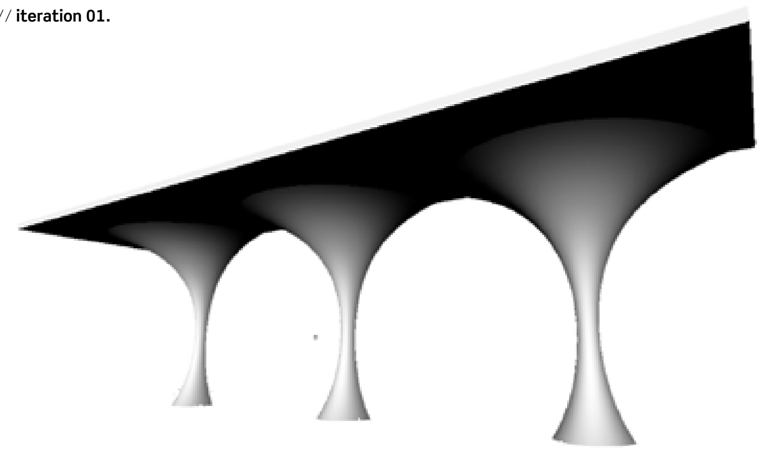
// The width and number of water cuts is too high – It's difficult to read the column

COLUMNS IN FORMATION

An aesthetical search for a structural system.

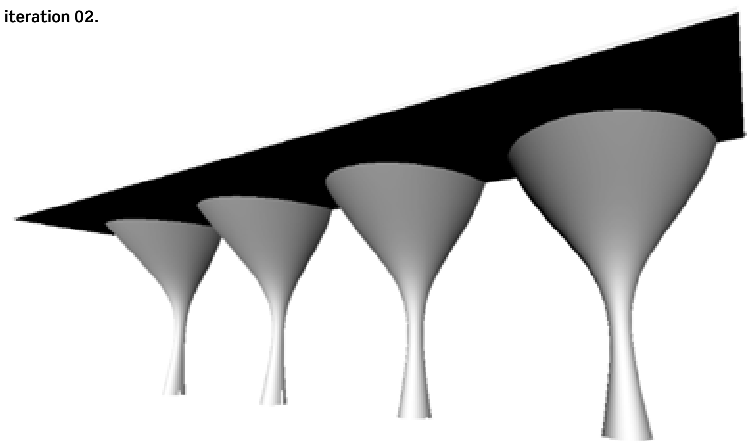
The iterations explore the relationship between columns and space, which is parametrically controlled. Each configuration is thoroughly investigated for its not only structural properties but also the aesthetical qualities regarding our vision to design a structure that articulates a vertical direction and an open space.

// **iteration 01.**



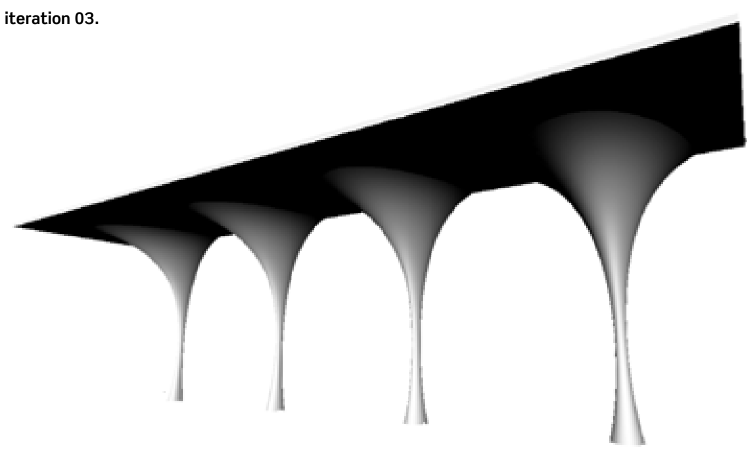
The columns create circular outlines in between them. The verticality from column to space is not defined.

// **iteration 02.**



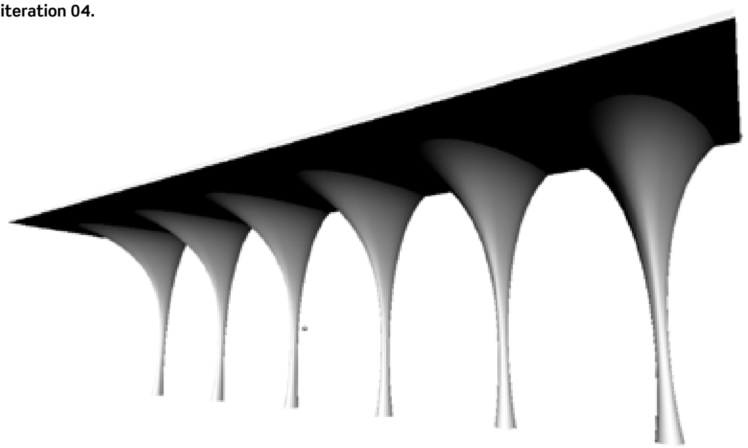
Four columns define the spatial framework. They transform from dense shapes in top to light and thin column structures in the bottom. The arch from bottom to top should be more linear.

// **iteration 03.**



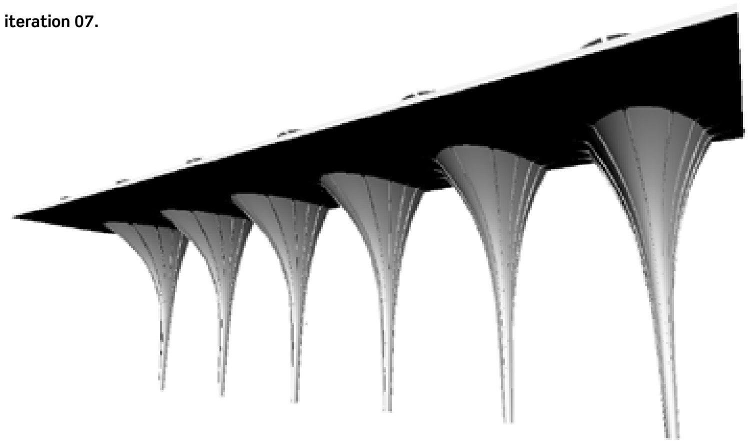
The columns are further developed here; the column curve is more linear and vertical.

// **iteration 04.**



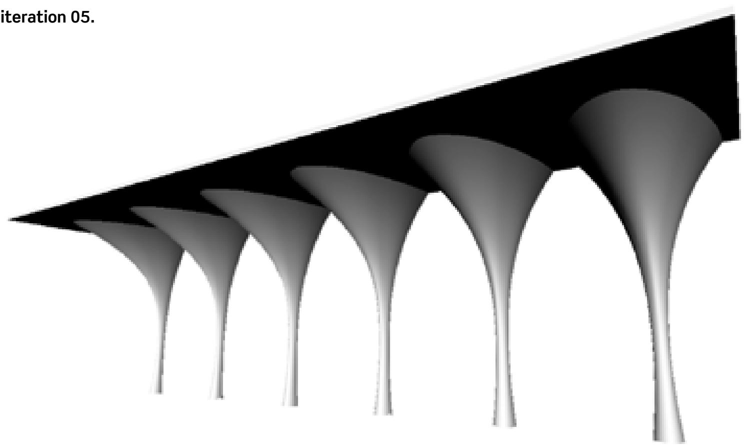
Six columns define the structure, it emphasises the verticality of the columns and reduces the curve radius.

// **iteration 07.**



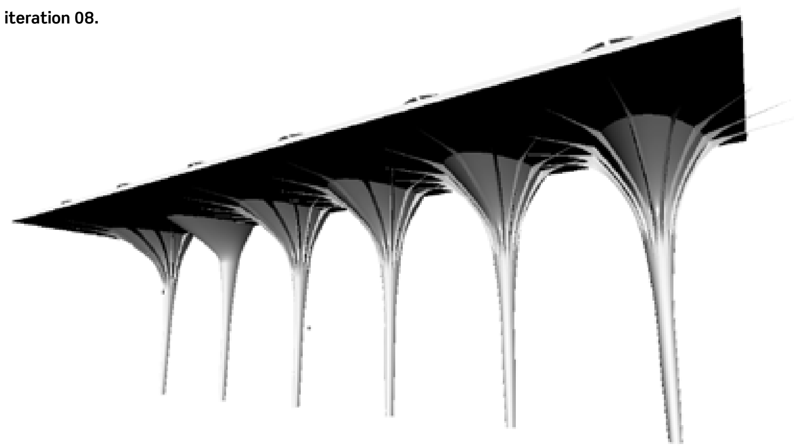
The verticality is emphasised by adding curve extrusions on the column. It enhances the strength around the column structure.

// **iteration 05.**



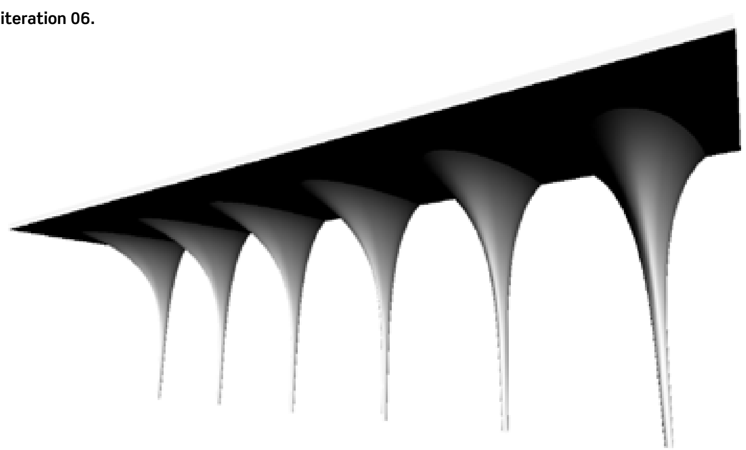
Adding more width to the top and bottom part of the columns. The roundness and bending of the outlines are increased.

// **iteration 08.**



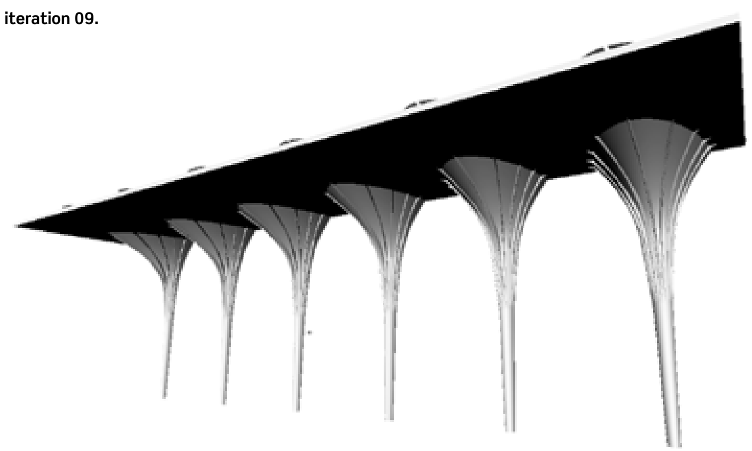
The extrusion-surfaces are emphasised and extended in the space. They overlap and generate a sub-pattern.

// **iteration 06.**



Reducing width in bottom. It enhances the verticality of the columns and increases the width between them.

// **iteration 09.**



The extrusions are decreased and reduced in length and they create a unity with the column.

STRUCTURAL PROPERTIES

Loads and deformations.

The column is analyzed in the finite element program Autodesk Robot Analysis. We investigate the relationship between column and structural analysis calculations to ensure that various columns can withstand the load.
To ensure an effective process between Rhino-Grasshopper and Robot we implement load calculations in our form-making definition. If we change the number of columns, height or other form-making parameters we develop a new column solution with updated data calculations to import into the finite element program. The variable data are the top outline of the column, roof area and roof volume. They are automatically updated and a new linear load property is calculated and applied on the developed column.

The structural components are: One concrete roof, one concrete wall, six concrete columns. Extra additional load factors are 18 hanging structures and concrete rails from the columns.
Loads are linear distributed on the surface and divided equally between columns and back wall. Calculations are only done on one column from each formation to compare expression and data.

The column is evaluated for deformation in SLS (Serviceability limit state) and compared with the max displacement variable, L/250 (eurocode 02). The column height is constant at 14200mm in the structural analysis iterations and the max deformation is **56,8mm.**

The column is made of reinforced concrete and obtains loads from 300mm. concrete roof, 18 hanging nest structures of birch and coated steel and concrete rails. (ill. 13)

Characteristic loads //

Materials:

Reinforced concrete:	24 [kN/m^3]
Plan concrete:	23 [kN/m^3]
Birch strips:	6,5 [kN/m^3]
Coated steel:	70 [kN/m^3]

Variable parameters:

Volume roof	$= x_{vol}$
Area roof	$= x_{area}$
Outline length	$= x_{length}$

Dead load:
(dead load) = (volume)*(density)
(dead load) = (x_{vol}) + (concrete rails) + (structure nests) + (cover nests)

dead load$_{all}$ = (x_{vol}*24) + (40,8*23) + (1,8*70) + (9*6,5) = 4377,3 [kN/m]

Pay load:
(pay load) = (area)*(pay load coefficient)
**pay load coefficient: 5 [kN/m^2] (category C3, eurocode 01)

pay load$_{concrete\ roof}$ = (x_{area}*5)

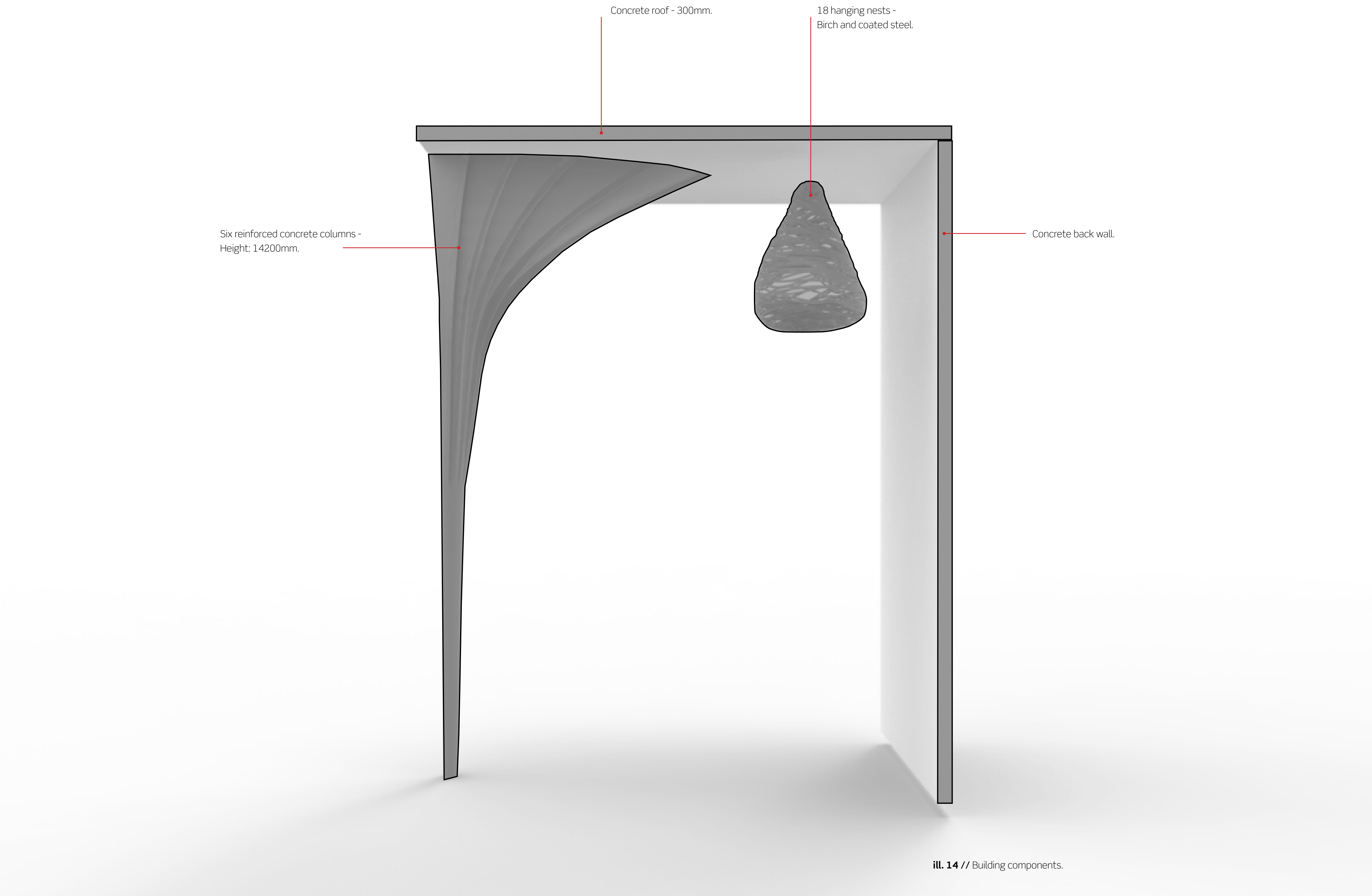
Load combination (SLS):
$P_d = (y_g g_k) + (y_Q q_{k,1})$
P_d = 1*dead load$_{all}$ [kN/m] + 1*pay load [kN/m]

Equal distribution to wall and columns: $P_{d/2} = (P_d / 2)$ [kN/m]

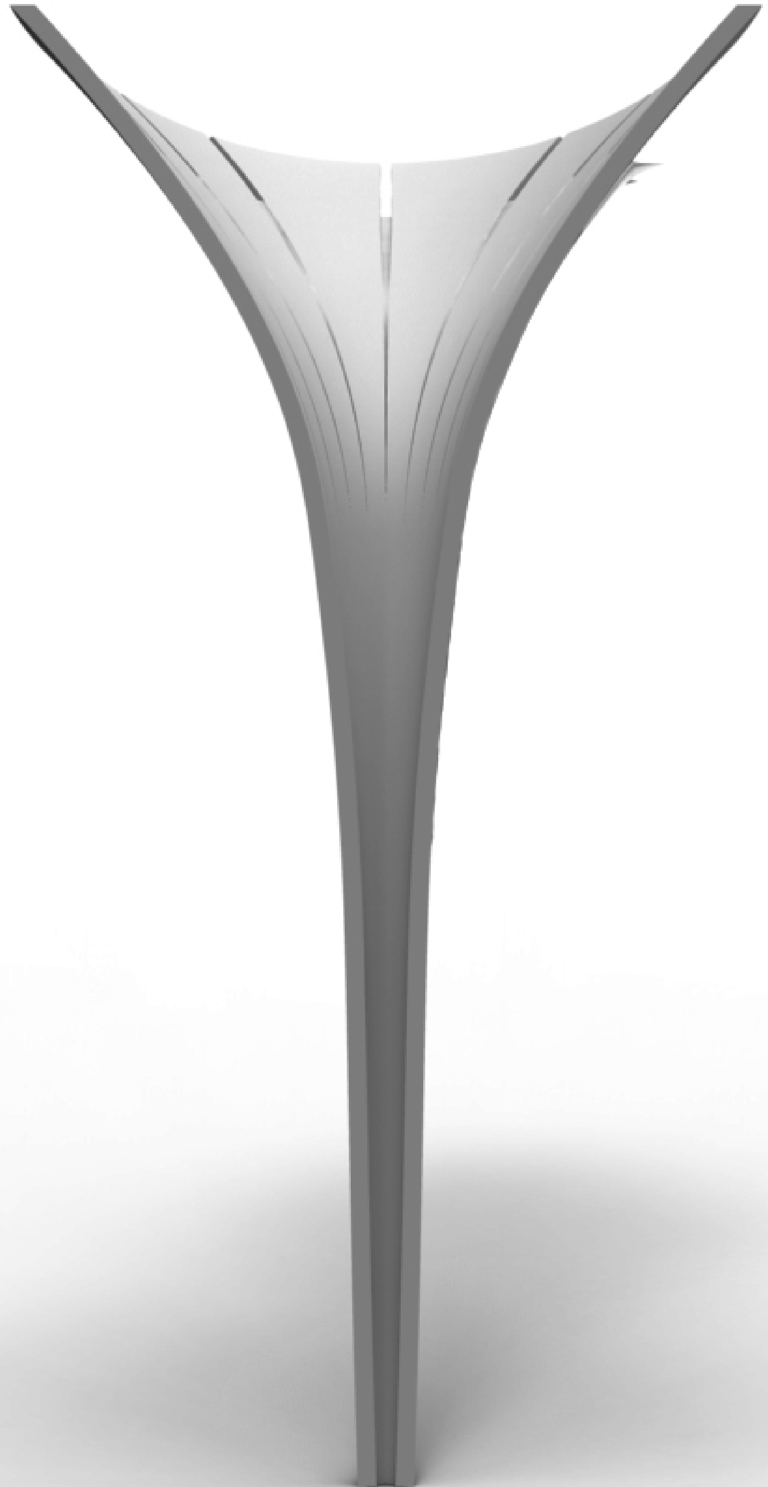
Equal distribution to each column: $P_{d\text{-}column} = P_{d/2}$ / number of columns) [kN/m]

Load pr. meter:
The outline length is variable: x_{length}

Load pr. m = ($P_{d\text{-}column} / x_{length}$)



ill. 14 // Building components.



STRUCTURAL ANALYSIS

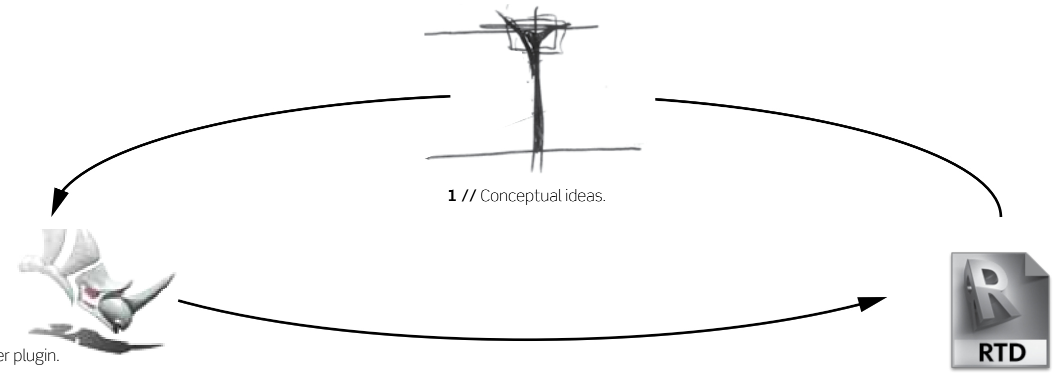
Analysis of different column structures using Robot Structural Analysis

Conceptual column ideas are verified and analyzed using the finite element program, Robot Structural Analysis. A loop ensures a fluent workflow between sketching, 3D modelling and analysis. The iterations are deviations from the initial column concept and analyzed for displacement in the finite element program.
The study reveals the strength and deformation of one column from each formation.

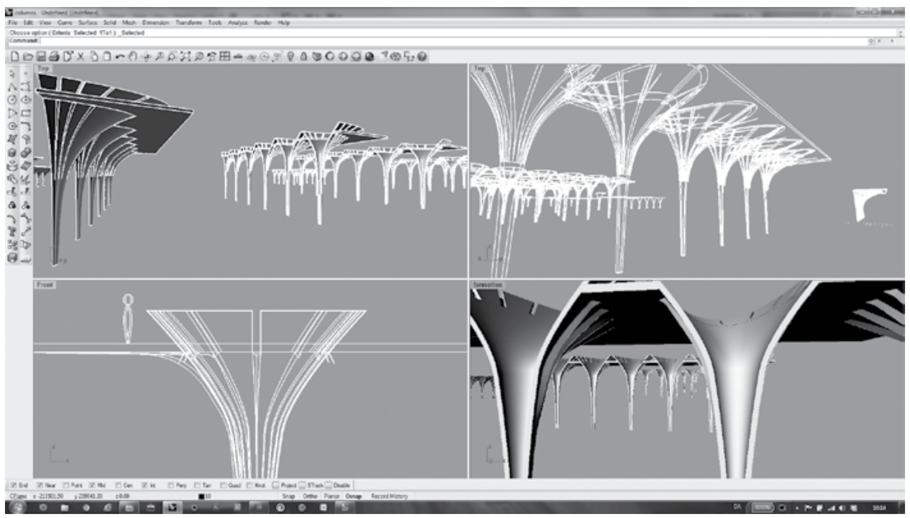
Input data: A column is fixed at the base and pinned along the edges. The thickness of the columns are investigated for 100mm, 200mm and 300mm and reinforced concrete with strength C35 is the material used.

Data /

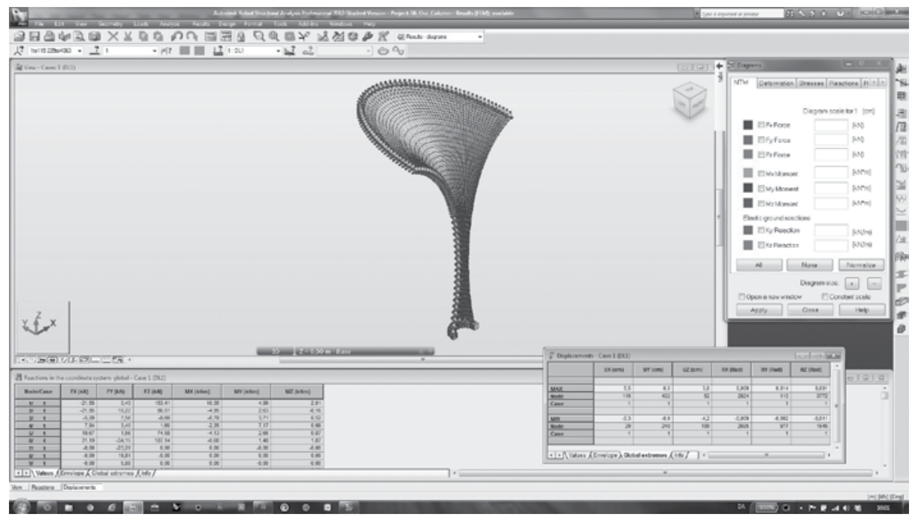
Concrete type: C35
Concrete thickness: 100mm, 200mm, 300mm.



ill. 15 // A loop generating workflow.



ill. 16 // Modeling of columns in Rhino using Grasshopper.



ill. 17 // Calculation of deformation values using Robot Structural Analysis.

// iteration 01.

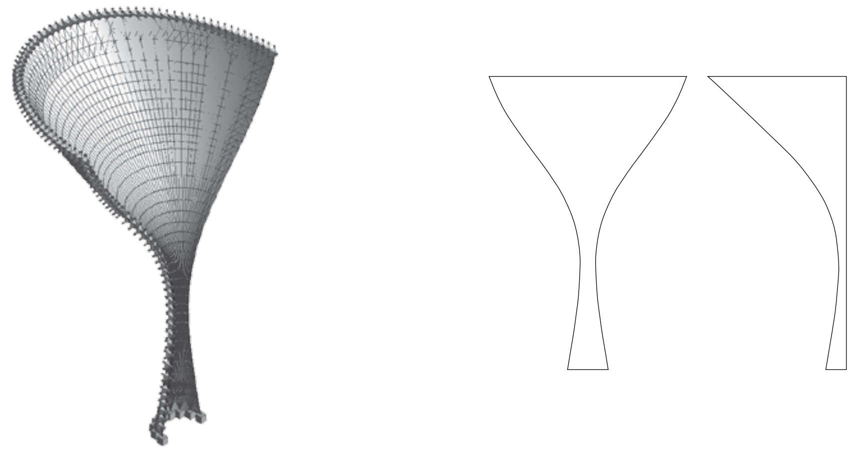
Aesthetics
It has a slight deviation in the curve, traveling from the top corner to the base. The span from corner to corner in top is significantly wider than the remaining iterations. Besides bump in the curvature, it also has a very dominant incline, and therefore it isn't as elegant as the curve in the original column design.

Load: 21 [kN/m]

Structural Analysis
Concrete thickness: 100 mm.
Deformation: Z-direction = 84 mm. X-direction(corner-corner) = 149 mm.

Concrete thickness: 200 mm.
Deformation: Z-direction = 19 mm. X-direction(corner-corner) = 37 mm.

Concrete thickness: 300 mm.
Deformation: Z-direction = 10 mm. X-direction(corner-corner) = 20 mm.



// iteration 02.

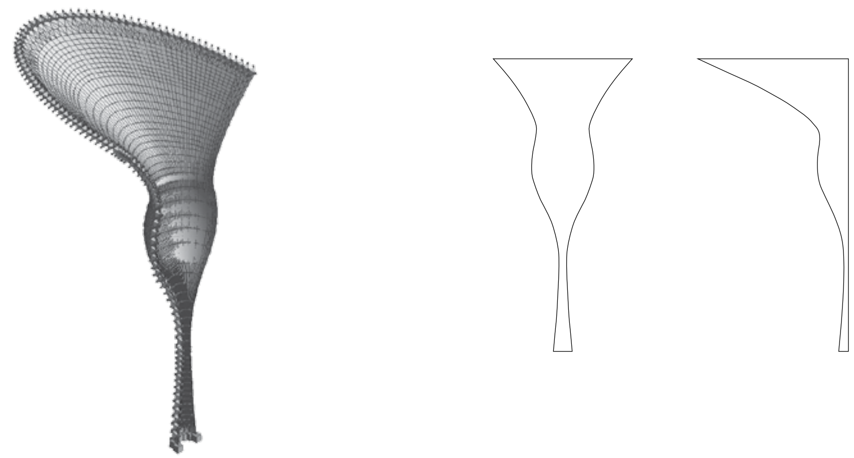
Aesthetics
The column has a significant bump near the centre. The column is noticeable more slim at the top and the base also has a smaller footprint, than in iteration 01.

Load: 26 [kN/m]

Structural Analysis
Concrete thickness: 100 mm.
Deformation: Z-direction = 150 mm. X-direction(corner-corner) = 261 mm.

Concrete thickness: 200 mm.
Deformation: Z-direction = 26 mm. X-direction(corner-corner) = 54 mm.

Concrete thickness: 300 mm.
Deformation: Z-direction = 10 mm. X-direction(corner-corner) = 25 mm.



// iteration 03.

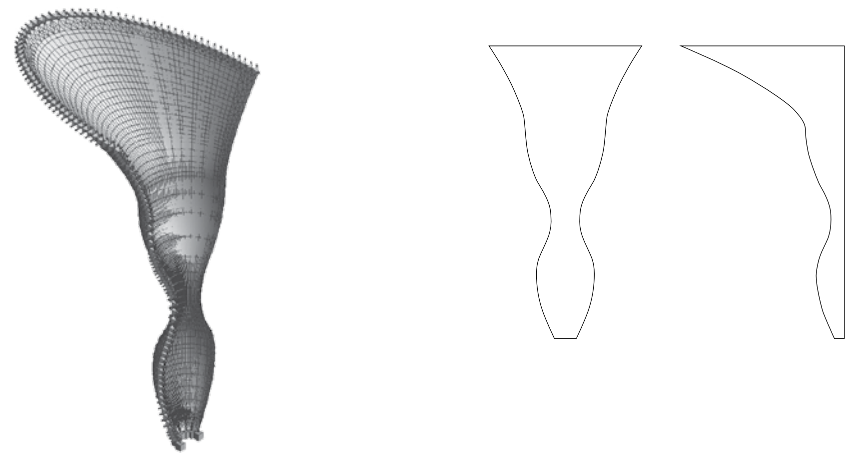
Aesthetics
This column has the same touch at the base and at the top, but with two very dominant bumps, which almost eliminates the perception of a slim column, unfolding in a canopy shape.

Load: 26 [kN/m]

Structural Analysis
Concrete thickness: 100 mm.
Deformation: Z-direction = 100 mm. X-direction(corner-corner) = 279 mm.

Concrete thickness: 200 mm.
Deformation: Z-direction = 19 mm. X-direction(corner-corner) = 59 mm.

Concrete thickness: 300 mm.
Deformation: Z-direction = 8 mm. X-direction(corner-corner) = 26 mm.



// iteration 04.

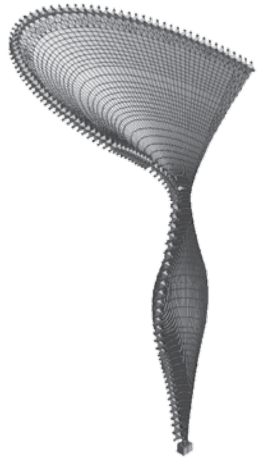
Aesthetics
The slim section of the column has been stretched and only one, more delicate bump, is present. The column is more balanced in form and correlation. The bump doesn't seem out of place, the same way as previous iterations.

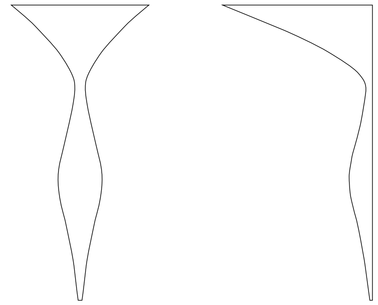
Load: 55 [kN/m]

Structural Analysis
Concrete thickness: 100 mm.
Deformation: Z-direction = 263 mm. X-direction(corner-corner) = 471 mm.

Concrete thickness: 200 mm.
Deformation: Z-direction = 51 mm. X-direction(corner-corner) = 94 mm.

Concrete thickness: 300 mm.
Deformation: Z-direction = 21 mm. X-direction(corner-corner) = 38 mm.





// iteration 05.

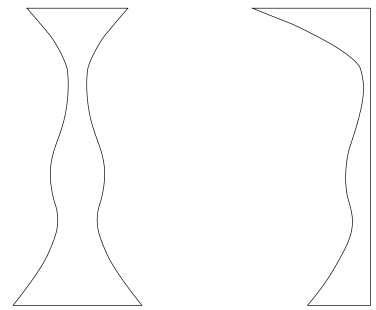
Aesthetics
The column has a wider bump near the centre. The base is significantly larger than all previous columns, and will therefore seem more heavy and dominant near the pathways at the lowest level.

Load: 46 [kN/m]

Structural Analysis
Concrete thickness: 100 mm.
Deformation: Z-direction = 165 mm. X-direction(corner-corner) = 272 mm.

Concrete thickness: 200 mm.
Deformation: Z-direction = 34 mm. X-direction(corner-corner) = 63 mm.

Concrete thickness: 300 mm.
Deformation: Z-direction = 13 mm. X-direction(corner-corner) = 27 mm.



// iteration 06.

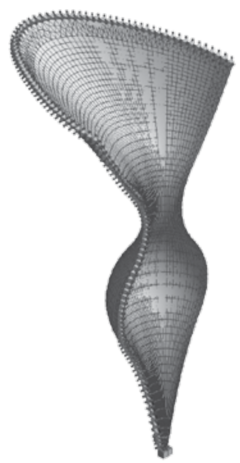
Aesthetics
The middle bump has been increased in size and the base at the bottom changed into a minimal size. Even though a solution like this could seem interesting to work with, the middle bump decreases the amount of daylight entering the interior space, and the vertical expression isn't present the same way, as if the column had a more slender appearance.

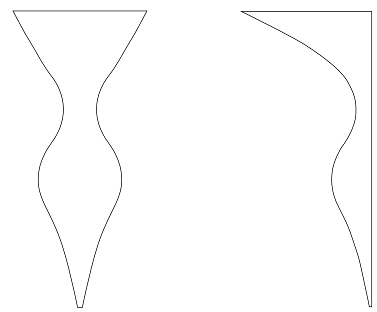
Load: 35 [kN/m]

Structural Analysis
Concrete thickness: 100 mm.
Deformation: Z-direction = 224 mm. X-direction(corner-corner) = 62 mm.

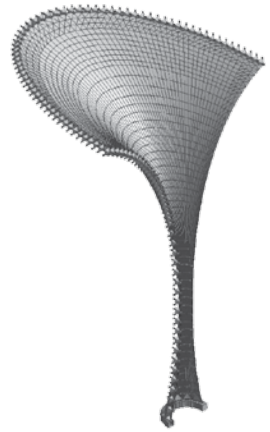
Concrete thickness: 200 mm.
Deformation: Z-direction = 10 mm. X-direction(corner-corner) = 37 mm.

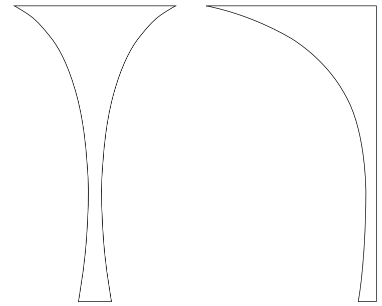
Concrete thickness: 300 mm.
Deformation: Z-direction = 3 mm. X-direction(corner-corner) = 14 mm.





// iteration 07.





Aesthetics
Eliminating unnecessary deviations in the form and simply connect the touch at the top and base, with a natural curve to it, the form reaches an elegant expression. The inclination of the curve, especially at the top half of the column, will determine the amount of diffuse sunlight entering the space under ground.

Load: 26 [kN/m]

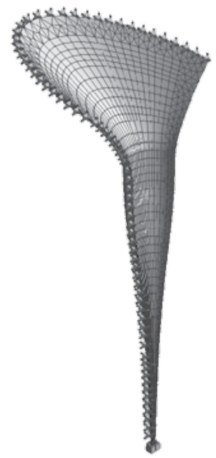
Structural Analysis
Concrete thickness: 100 mm.
Deformation: Z-direction = 429 mm. X-direction(corner-corner) = 252 mm.

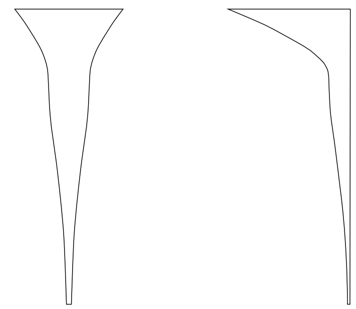
Concrete thickness: 200 mm.
Deformation: Z-direction = 59 mm. X-direction(corner-corner) = 108 mm.

Concrete thickness: 300 mm.
Deformation: Z-direction = 30 mm. X-direction(corner-corner) = 57 mm.

Initial observation /
We will investigate this column further. It will need further development to reach an acceptable displacement value. From the earlier iterations, we know that the critical area in the column is the lower narrow part. This is the area that will be tweaked further, according to deformation values.

// iteration 08.





Aesthetics
This is a developed version of iteration 07, the incline has been adjusted. It is very much like the previous version, with the same touch at the top and base, only now the curve inclination at the upper half, is lower than before, and therefore more remarkable.

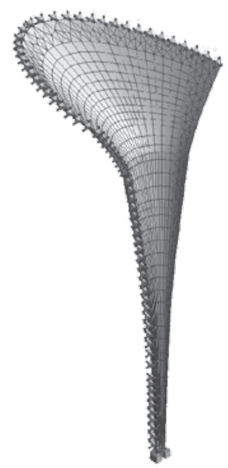
Load: 43 [kN/m]

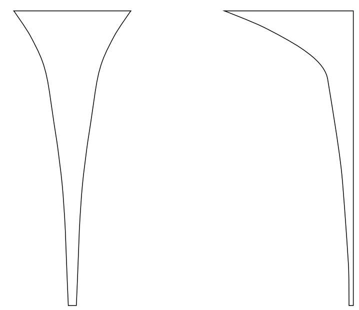
Structural Analysis
Concrete thickness: 100 mm.
Deformation: Z-direction = 93 mm. X-direction(corner-corner) = 158 mm.

Concrete thickness: 200 mm.
Deformation: Z-direction = 19 mm. X-direction(corner-corner) = 41 mm.

Concrete thickness: 300 mm.
Deformation: Z-direction = 8 mm. X-direction(corner-corner) = 22 mm.

// iteration 09.





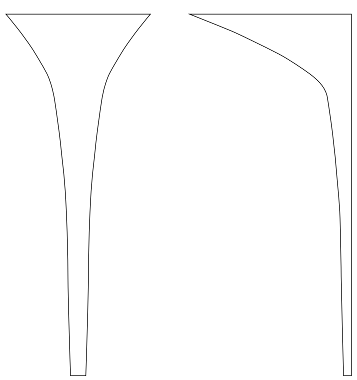
Aesthetics
This column is almost the same as iteration 08. The top is the same, but from where it starts to move very vertical downwards, the width of the section is wider and deeper. From earlier examples we've discovered that a wider section at this part will provide additional strength to the column. The structural deformations, also determine this.

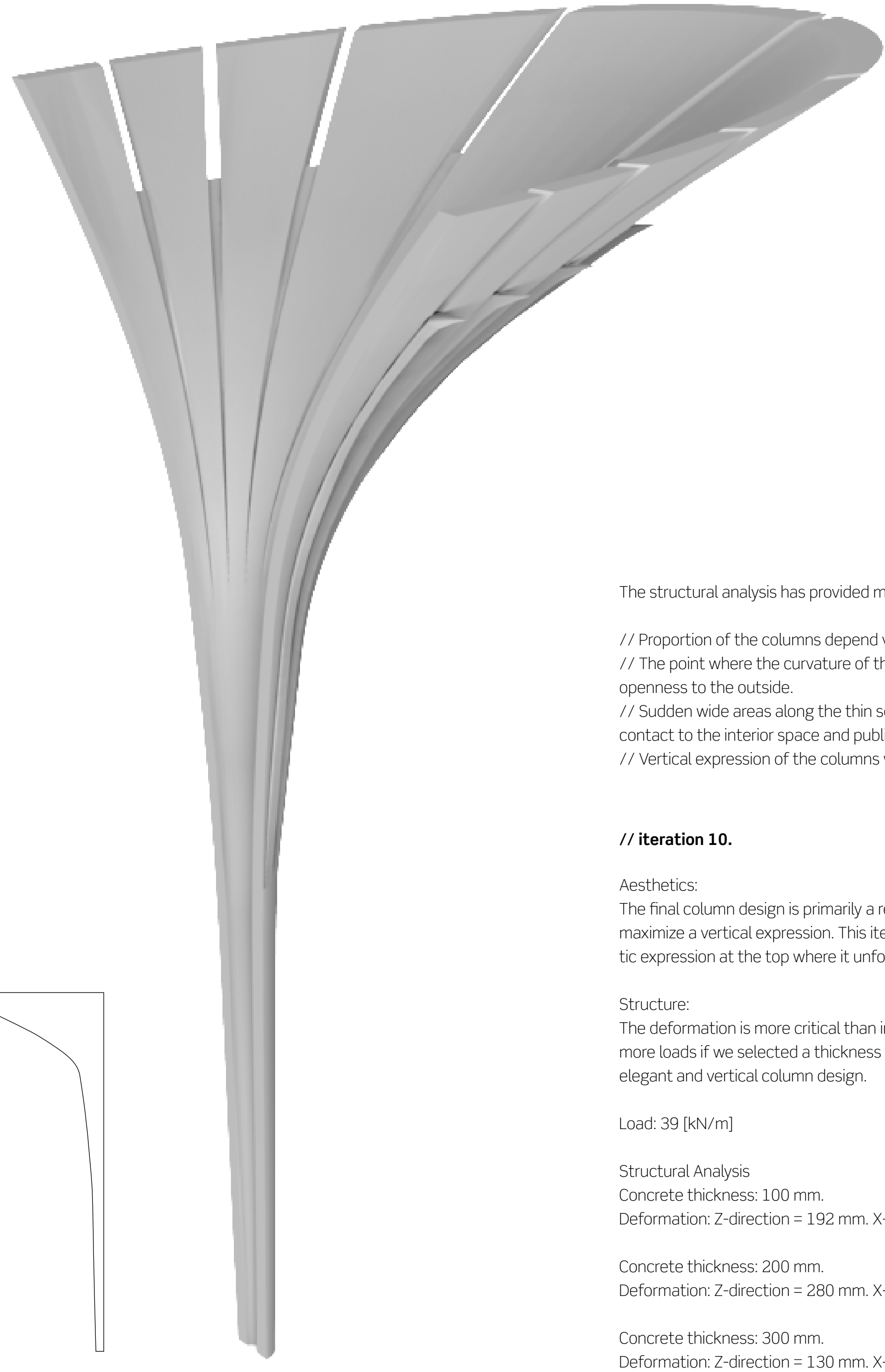
Load: 39 [kN/m]

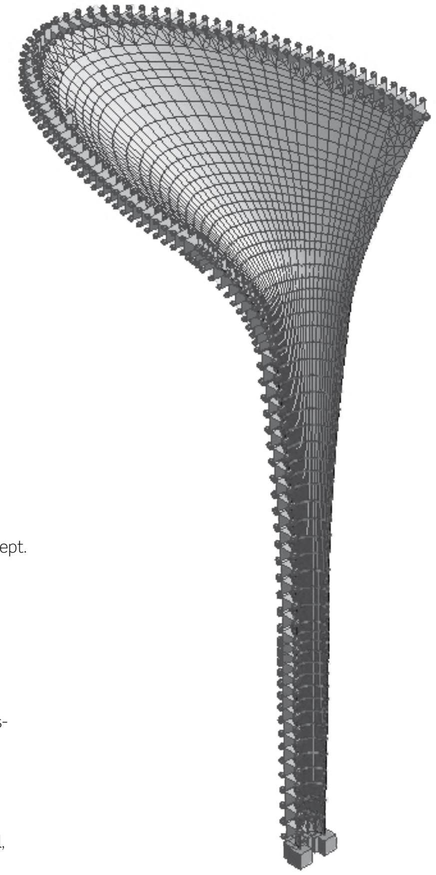
Structural Analysis
Concrete thickness: 100 mm.
Deformation: Z-direction = 79 mm. X-direction(corner-corner) = 171 mm.

Concrete thickness: 200 mm.
Deformation: Z-direction = 15 mm. X-direction(corner-corner) = 39 mm.

Concrete thickness: 300 mm.
Deformation: Z-direction = 7 mm. X-direction(corner-corner) = 20 mm.







The structural analysis has provided much information on how to study and design columns:

// Proportion of the columns depend very much on the width of the lowest part.
// The point where the curvature of the column breaks and turns vertical has a huge impact on the openness to the outside.
// Sudden wide areas along the thin section, is to be avoided, even though they enhance the visual contact to the interior space and public space remains intact.
// Vertical expression of the columns will remain stronger if the simplicity and smooth curvature is kept.

// iteration 10.

Aesthetics:
The final column design is primarily a redevelopment of iteration 09. The lowest part is thinner, to maximize a vertical expression. This iteration contains a lot of qualities; a thin base and a characteristic expression at the top where it unfolds.

Structure:
The deformation is more critical than in iteration 09, but still acceptable. The column could carry more loads if we selected a thickness of 200mm but a thin expression enhanced a more aesthetical, elegant and vertical column design.

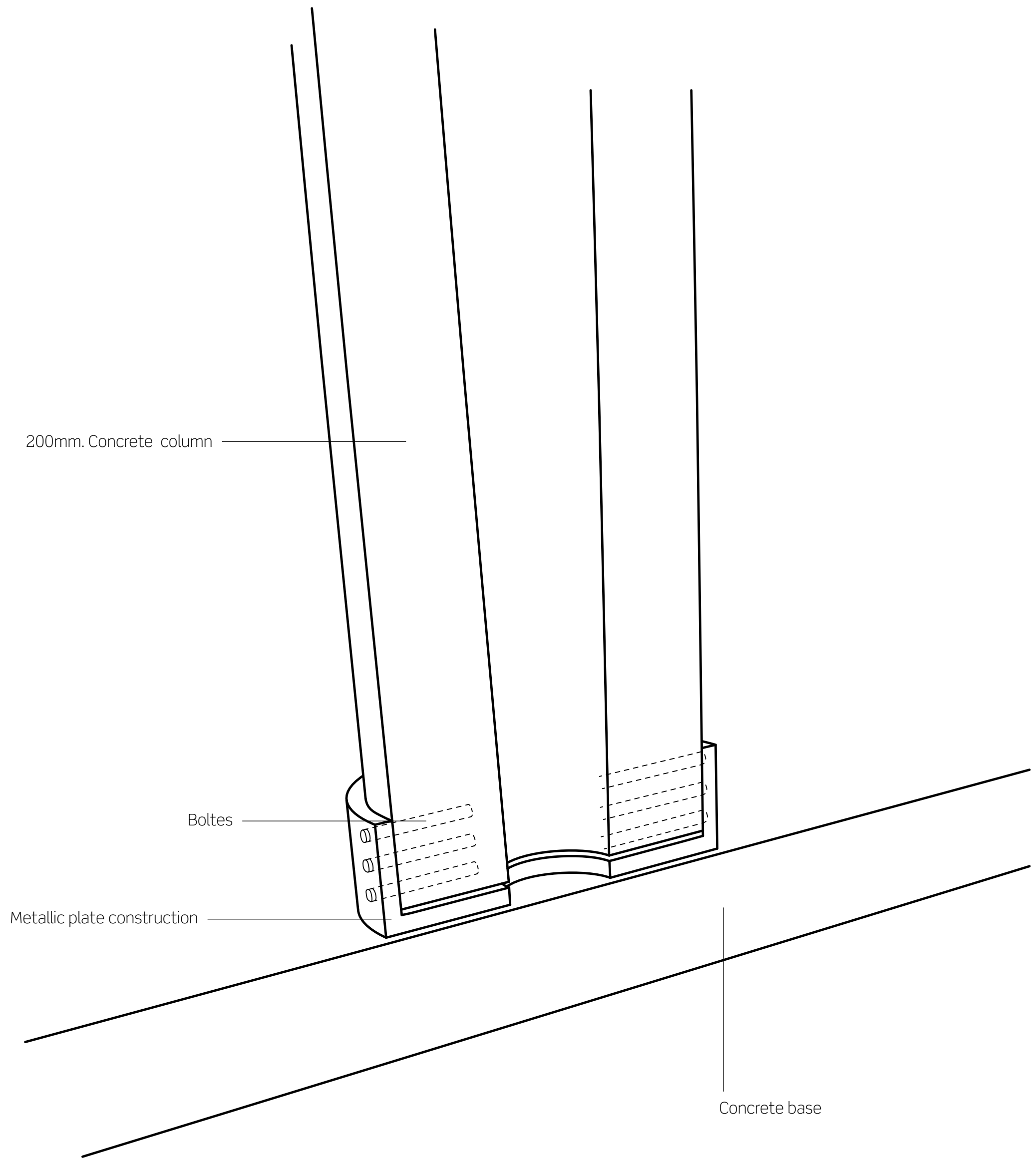
Load: 39 [kN/m]

Structural Analysis
Concrete thickness: 100 mm.
Deformation: Z-direction = 192 mm. X-direction(corner-corner) = 120 mm.

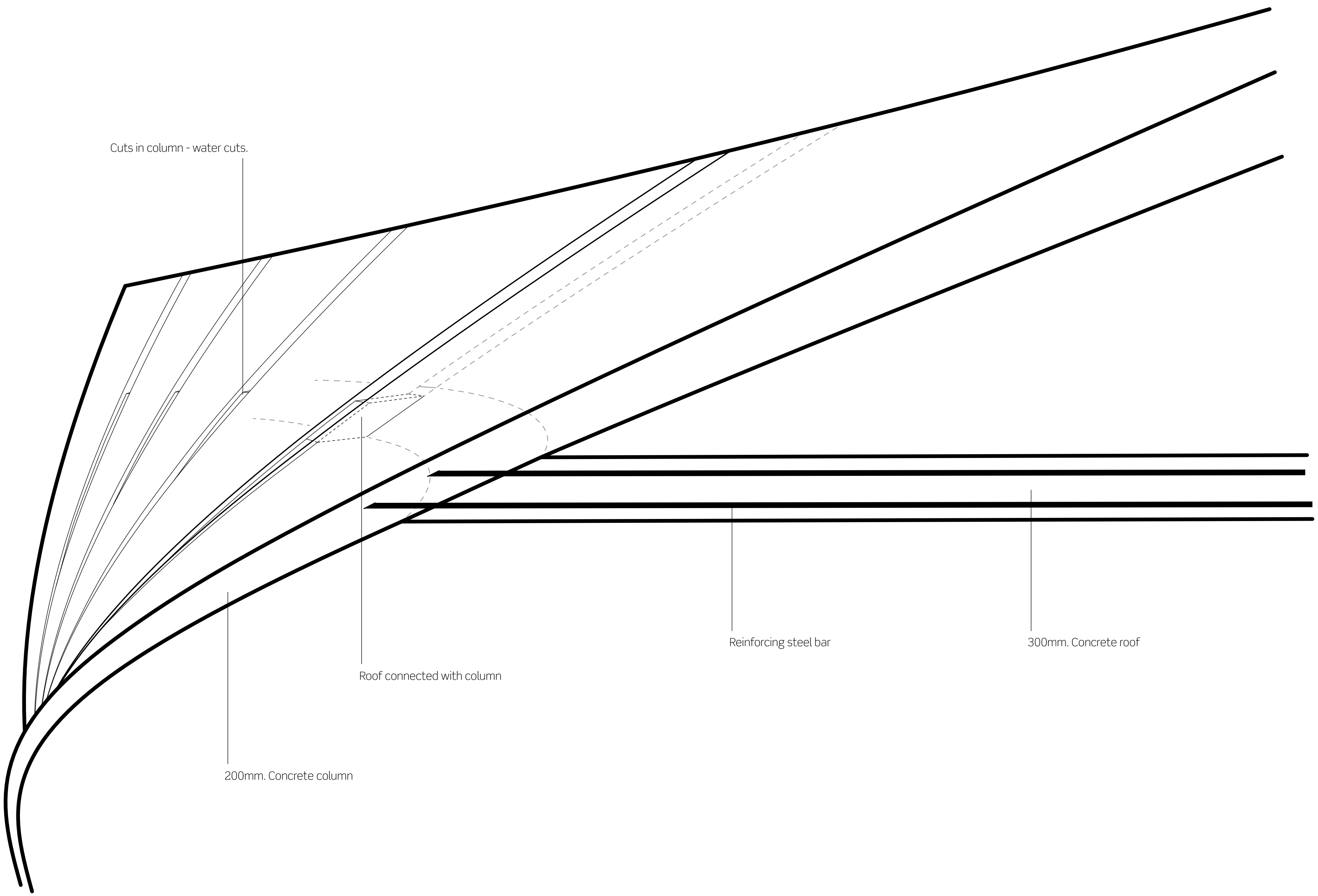
Concrete thickness: 200 mm.
Deformation: Z-direction = 280 mm. X-direction(corner-corner) = 49 mm.

Concrete thickness: 300 mm.
Deformation: Z-direction = 130 mm. X-direction(corner-corner) = 26 mm.

DETAIL DRAWINGS



ill. 18 // Column and base.

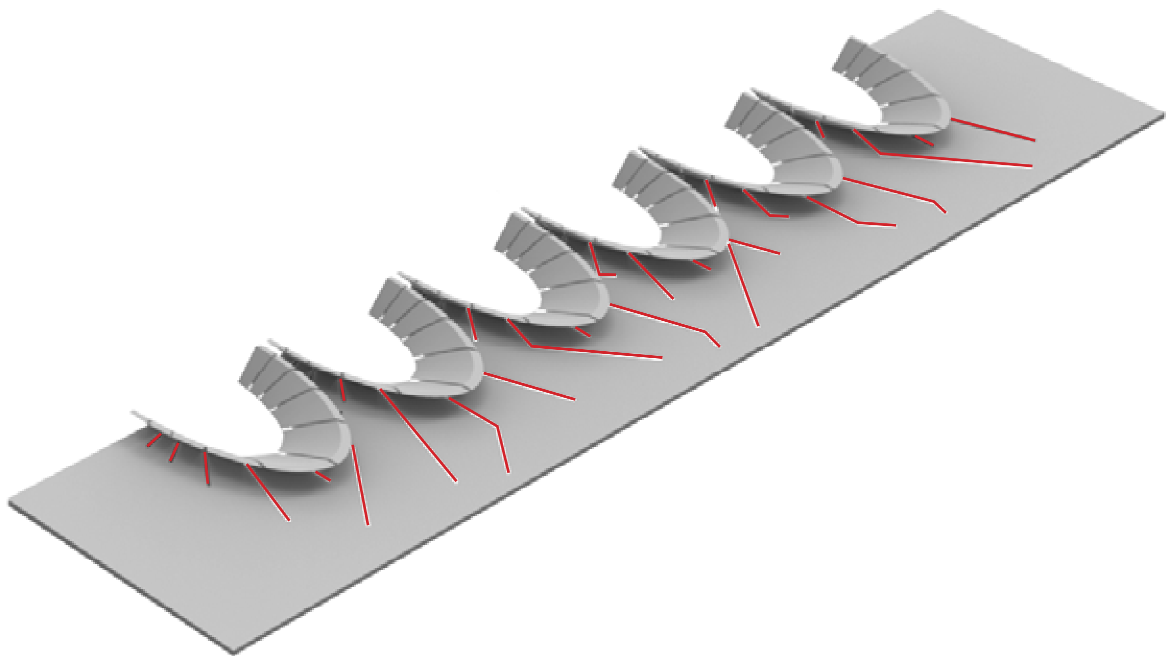


ill. 19 // Columns and ground level.

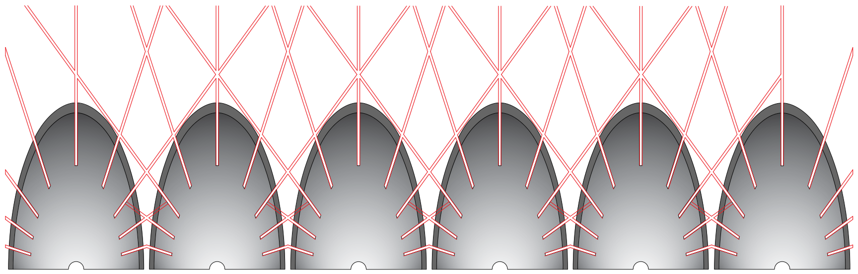
WATER CANAL SYSTEM

Sub-division of the masterplan.

The water canals collect water and are part of the flow around the columns. They are inspired by the excavated Maya canals that distributed water around the cities. We want to collect water and use that in a cooling system underneath. The canals express diversity in formation and emphasize the other elements in the ground-plan. The studies develop from a straight and linear flow towards a pattern that express movement, diversity and direction.

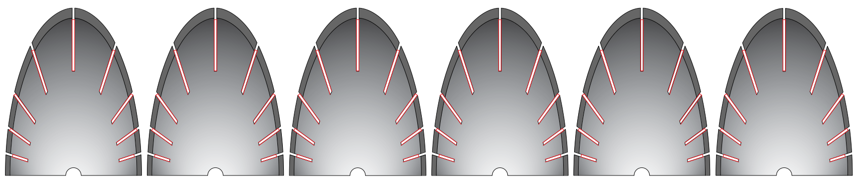


ill. 01 // Water canals in formation.



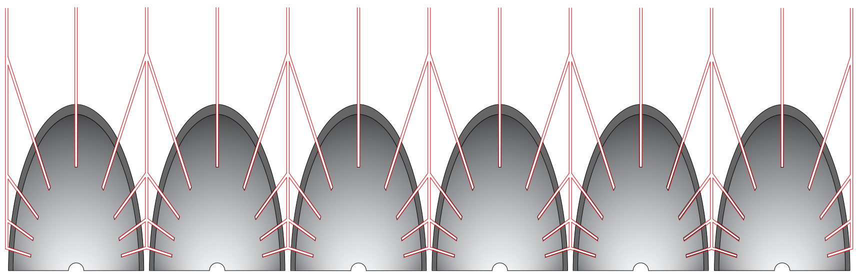
// **iteration 01.**

All water canals generate a pattern on the site; it divides the flow into fragments.



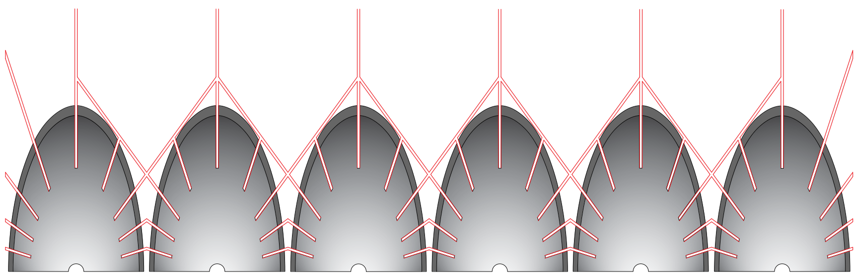
// **iteration 02.**

The water canals are subtracted at the column outline; they become too transparent.



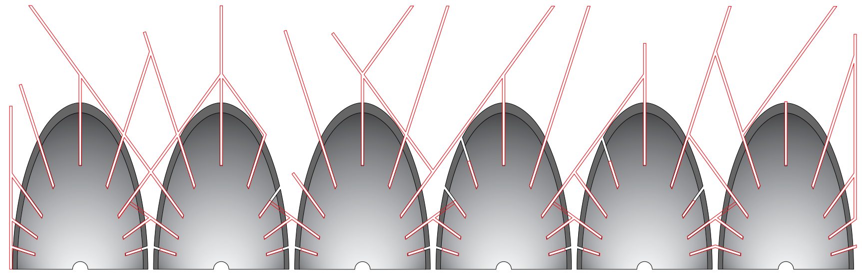
// **iteration 03.**

Water canals are interconnected with each other; they divide the flow in one direction, but leads visitors towards the columns.



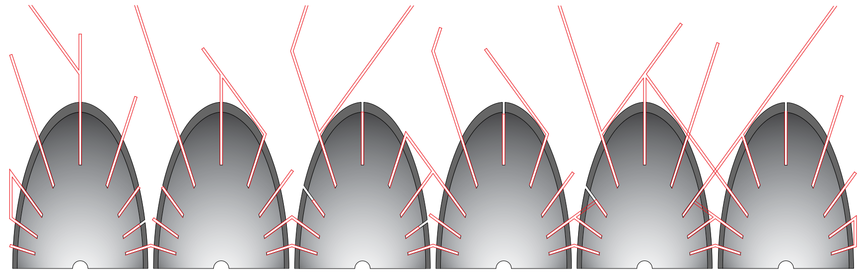
// **iteration 04.**

Another interconnection; the sizes of the water canals vary, but their direction are blurred.



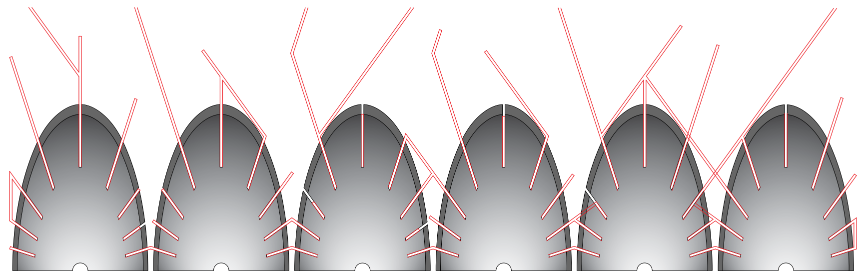
// **iteration 05.**

Interconnections and directions vary; they variation define an interesting expression.



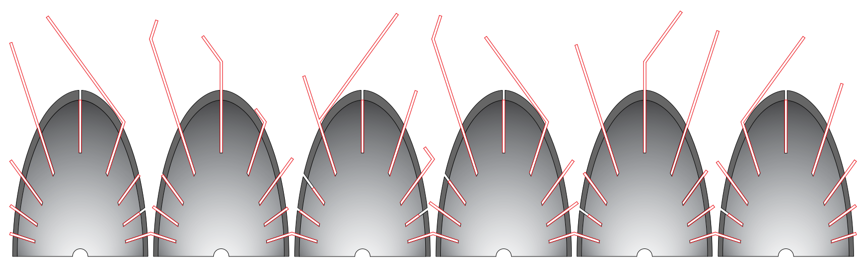
// **iteration 06.**

Variations are lowered, but the interconnections are still high.



// **iteration 07.**

Variations are lowered, but the interconnections are still high.



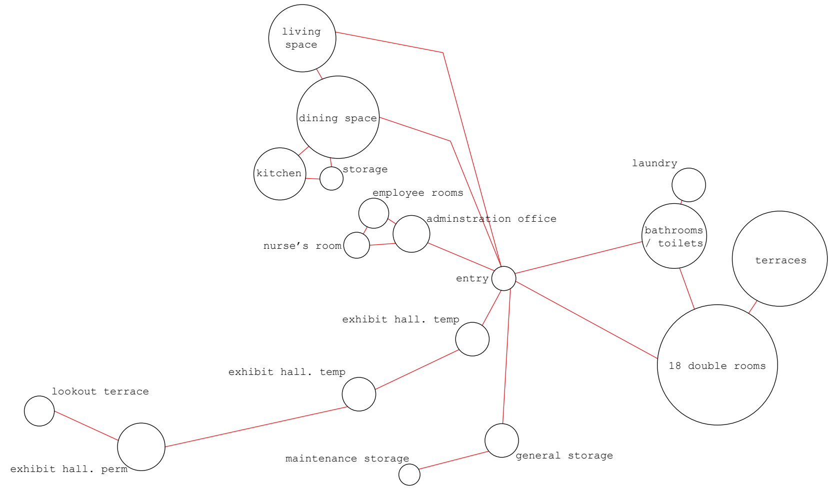
// **iteration 08.**

The water canals have a good balance between direction and variation.

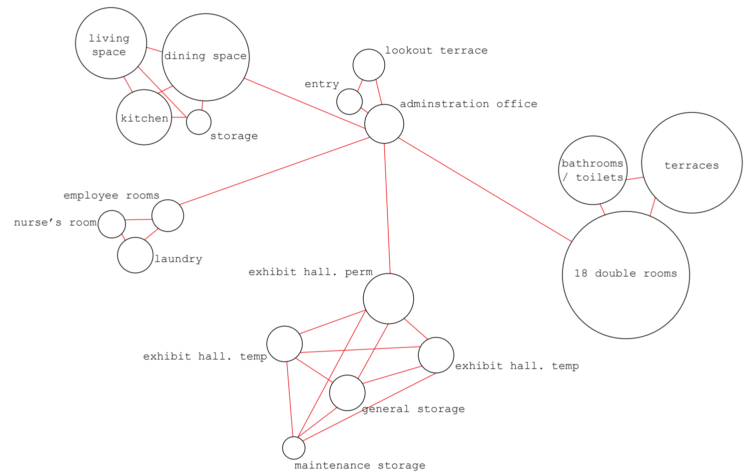
ROOM PROGRAM STUDIES

Internal connectivity.

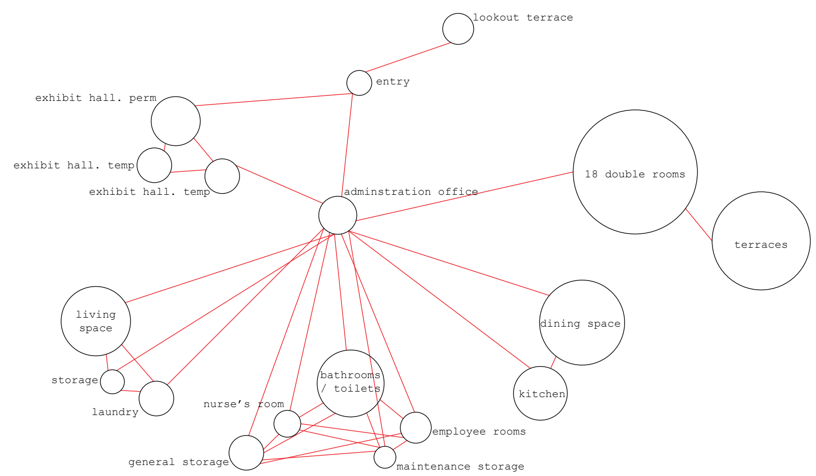
The room program has evolved through studies in different ways of compiling the functions. One of the common parameters in the initial studies was to cluster suited functions together. By separating the functions we could determine the internal connectivity and define differentiated experience in the building proposal.



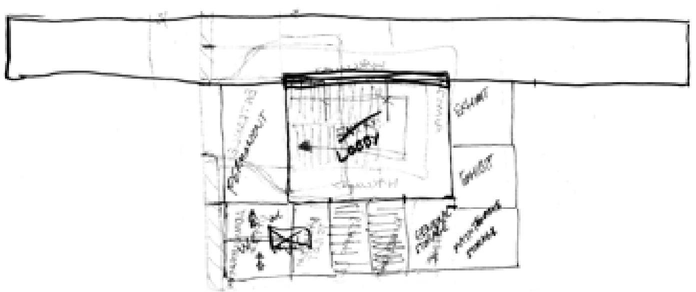
// layout 01.
Clusters of mutual functions are distributed and connected to one mutual entrance area. The layout creates a good overview because you always return to a main area.



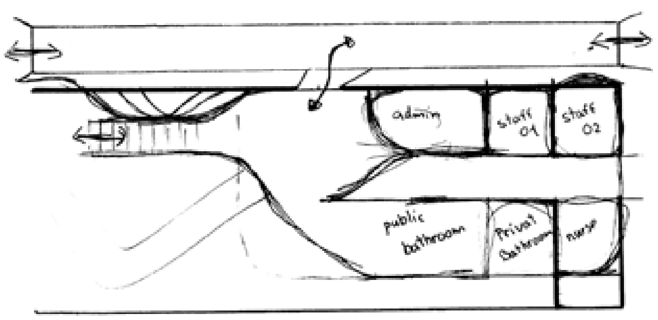
// layout 02.
The entrance cluster is interconnected with the other clusters. It gives a clear boundary between the various clusters.



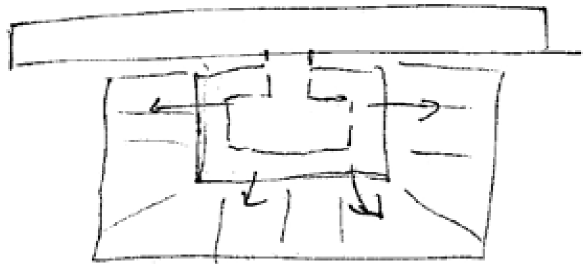
// layout 03.
The museum and hostel share a cluster of functions with the administration office as the main hub.

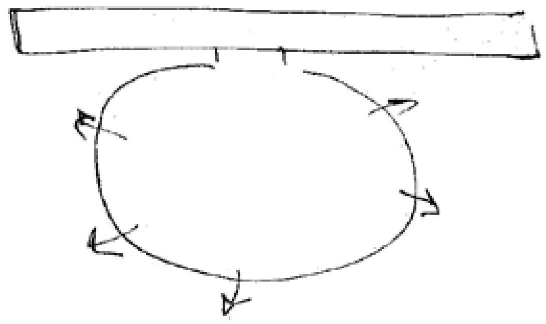


ill. 01 // Open space in the middle defines the other functions.

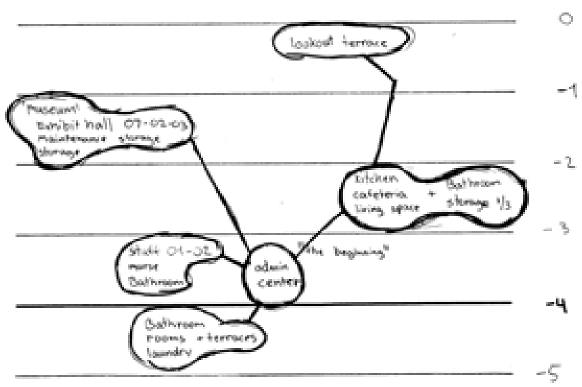


ill. 02 // Layout with functions divided - Vertical connections is left and other functions are right.

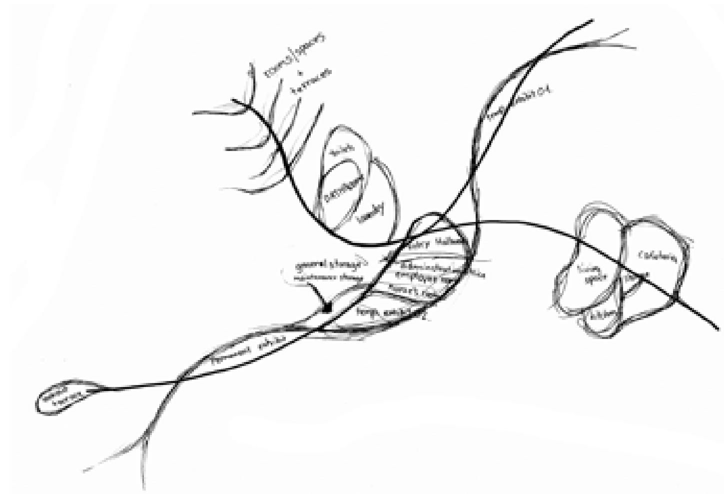




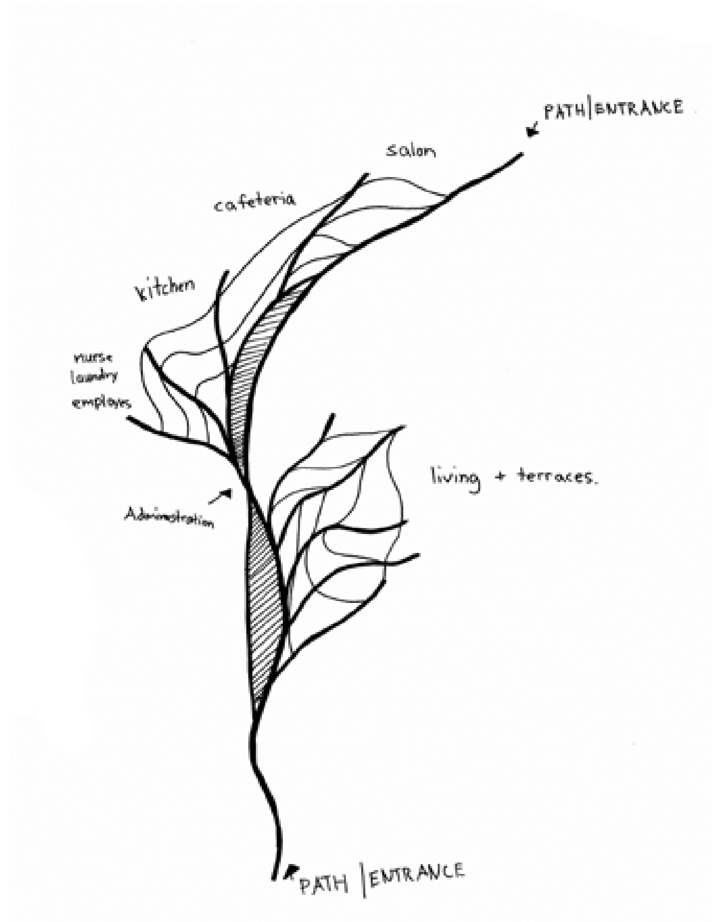
ill. 03 // Circular flows.



ill. 04 // Room-program divided in several levels.



ill. 05 // Organic flows interconnect with each other.

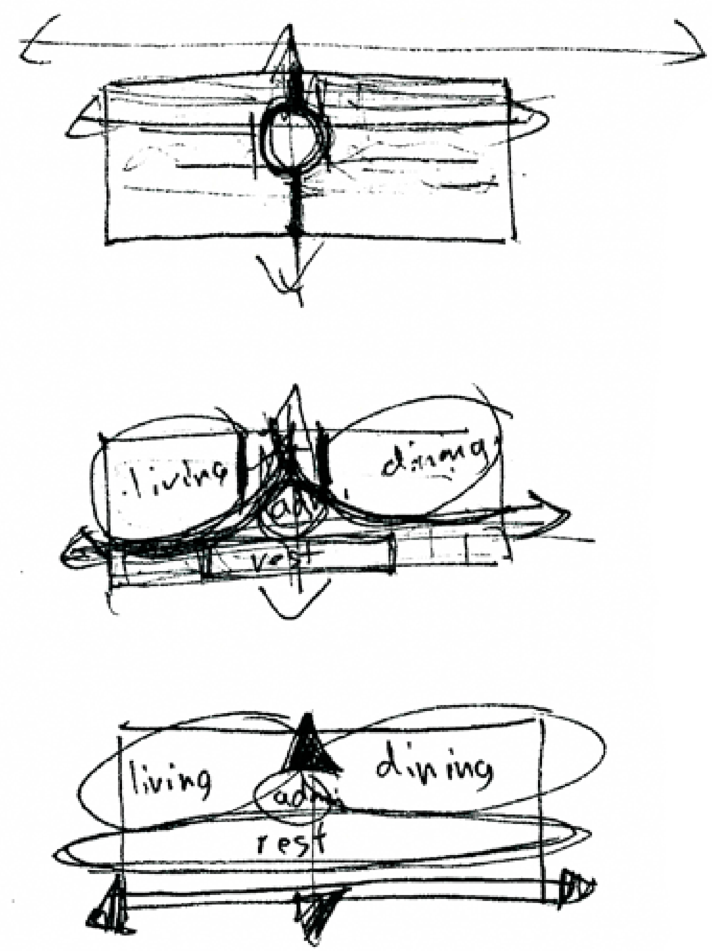


ill. 06 // Several entrances are connected to one main path.

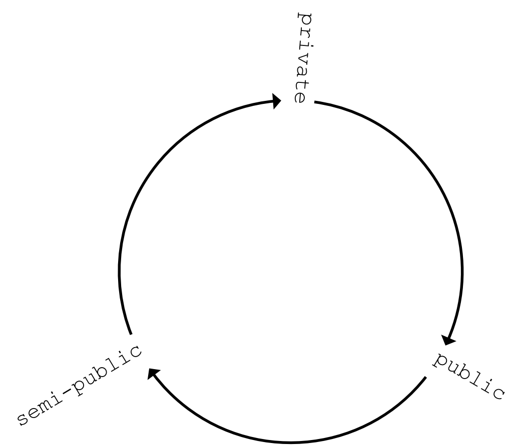
FLOW STUDIES

Internal movement.

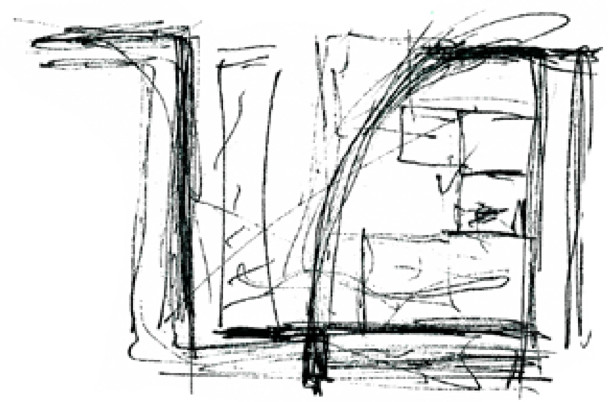
The internal movement was developed through a flow diagram to experience inside the building. One parameter was to define the public, semi-private and private concept layout through initial sketches. By determine the internal flow concept various sketches were studied to develop a 3dimensional building flow.



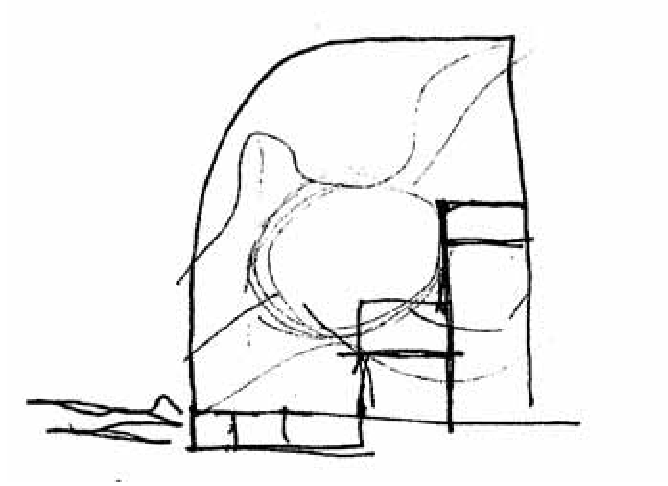
ill. 01 // Room-program layout is divided into three main clusters and three main flows, they all circle around the administration centre.



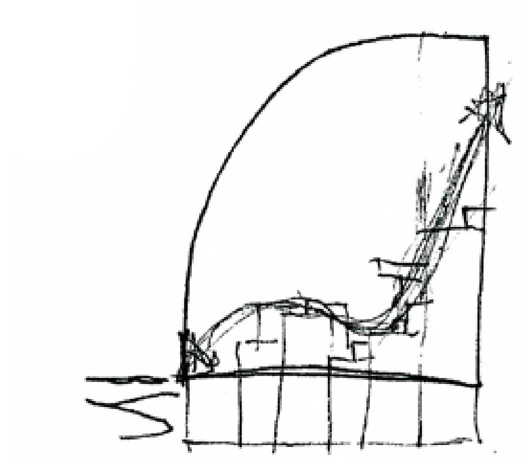
ill. 02 // Internal flow diagram.



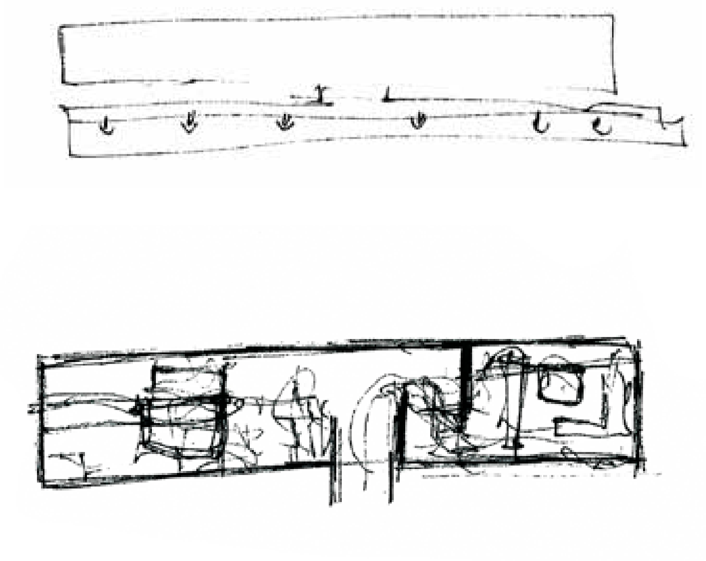
ill. 03 // A section studies the possibility of stacking the functions.



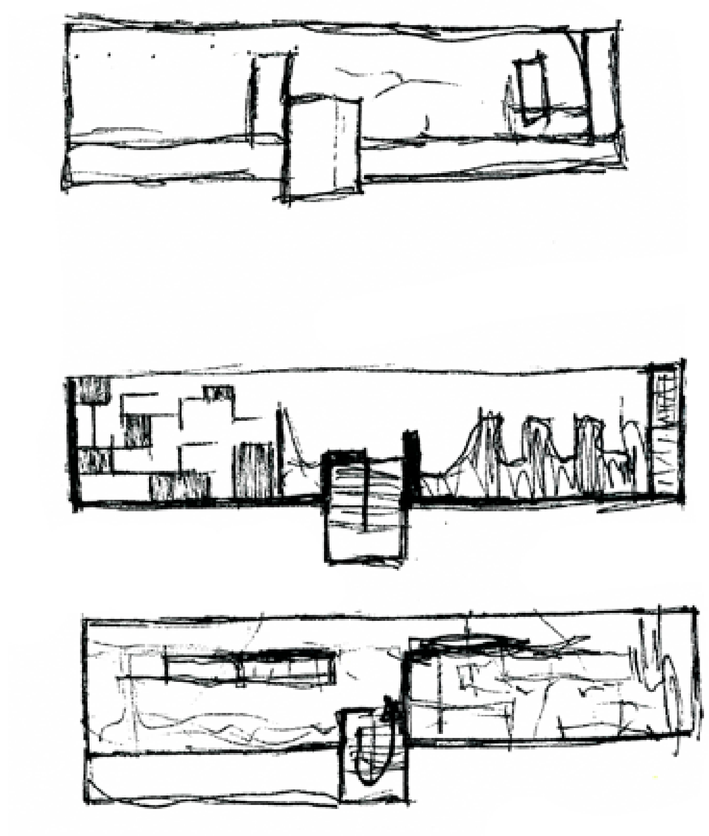
ill. 04 // A section studies the possibility of an open centre space with the functions hidden away.



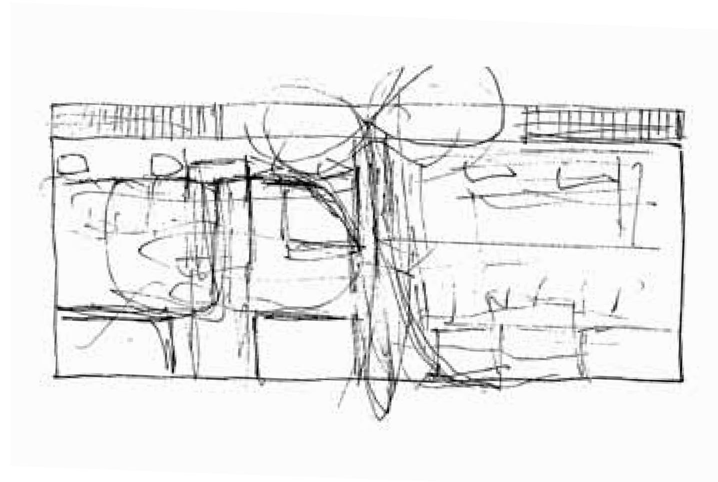
ill. 05 // A section investigates an open layout with extruded spaces.



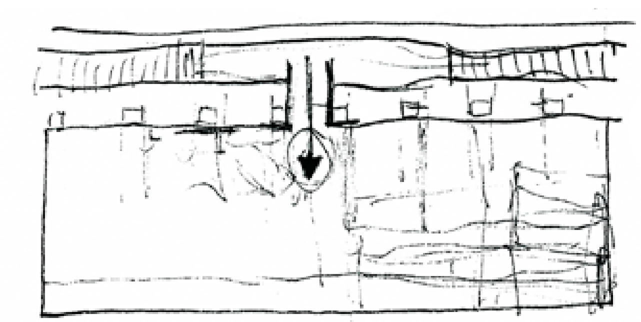
ill. 06 // Internal building layouts.



ill. 07 // Interior spaces are defined by geometry.



ill. 08 // A fluent layout allows for diversity.



ill. 09 // The layout has a clear boundary.

NESTS

Defining a refuge - a place to rest.

We want to design spaces that vary during the day and transform to small living clusters during the night. Nature inspire us, birds construct a safe internal layout and cover it with a light structure. We want our spaces to become spherical nests with a structural cover that incorporate interplay between open and closed areas to ensure a 360 degree light and ventilation strategy. We want our spaces to interpret hanging structures that are not connected to the ground-level, but floating in space.

ill. 01 // Animal nests, Tikal.

- Nature
- Organism
- Poetic
- Materials
- Local

ill. 02 // Nest chair, Nina Bruun.

- Weaving structure
- Dense vs. open
- Clear function
- Contrasts
- Structural wood element

ill. 06 // Birdnest.

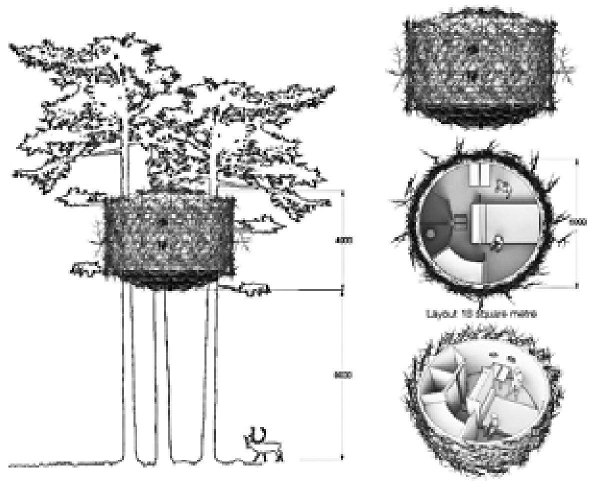
- Nature
- Various materials
- light structure
- Safe
- Home

ill. 03 // NestRest, Dedon.

- Resting place
- Hide
- Light materials
- Interior vs. exterior
- Geometry

ill. 04 // Weave your lighting, Kwangho Lee.

- Hanging elements
- Complex
- Chaotic
- Controlled
- Contrasts



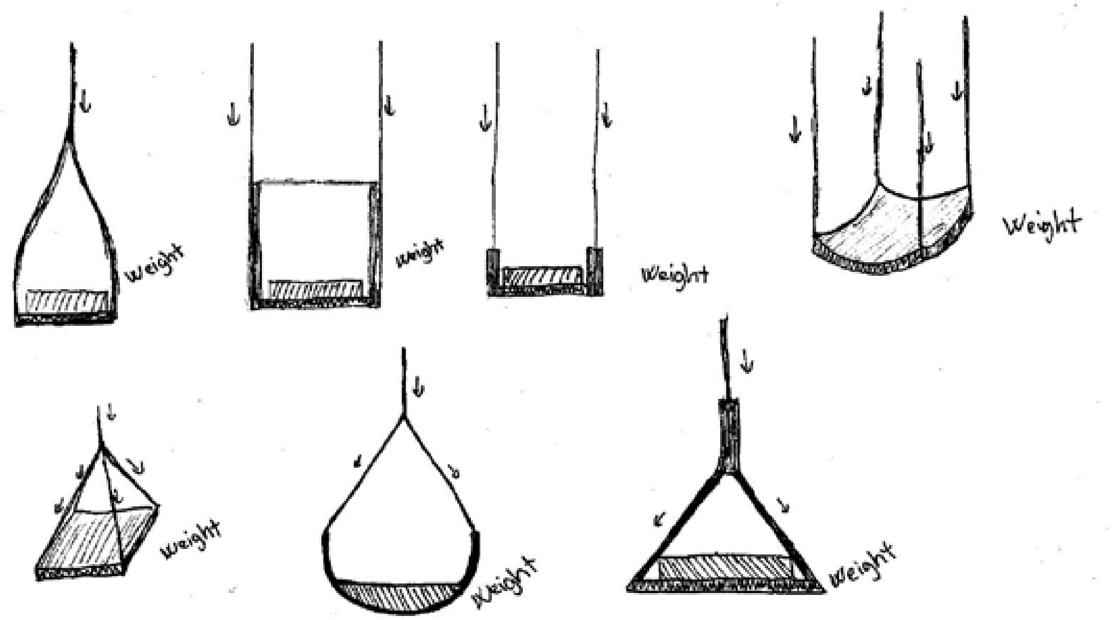
ill. 05 // Tree-house.

- Nature
- Cover
- Dense structure
- Entrance hidden

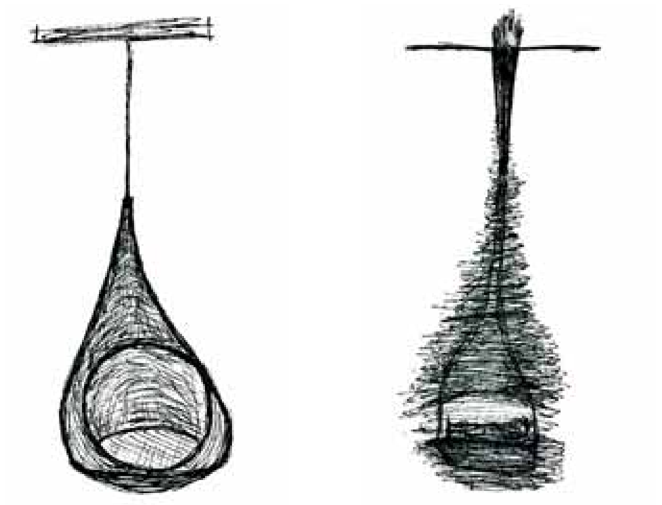
HANGING STRUCTURES

Spatial tension structures.

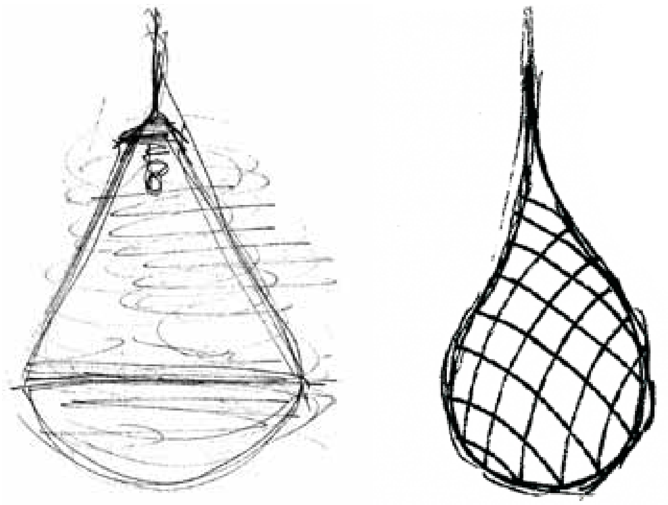
We study hanging structures in space and determine the parameters to change. We want our nests to float in space and obtain another aesthetical expression than the spatial framework that surrounds them. A structural core and a light cover define the nest with a small entrance grown in the cover.



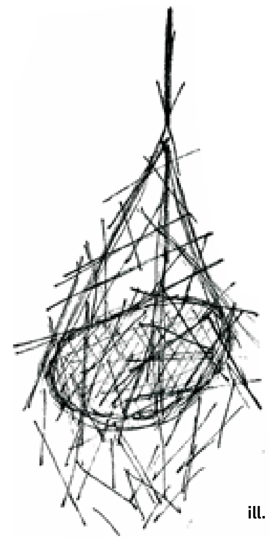
ill. 07 // Geometry and tension principles.



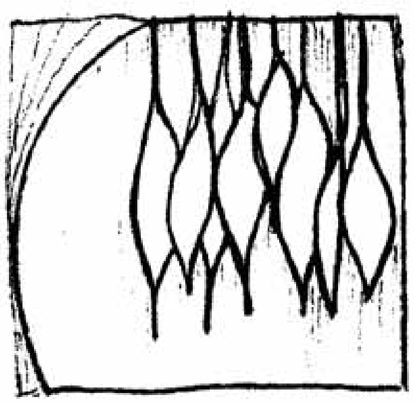
ill. 08 // Dense structures define the spaces.



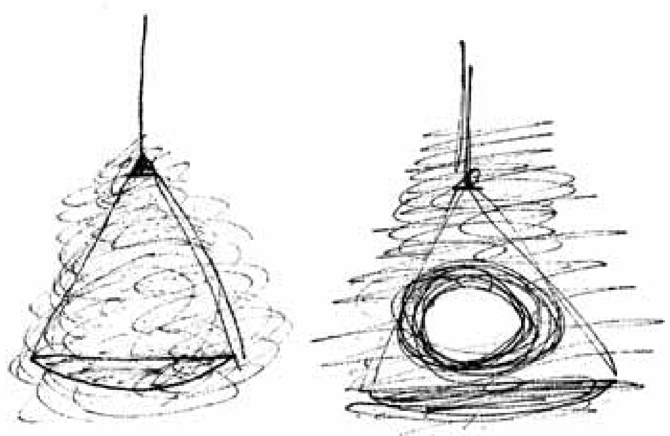
ill. 11 // Open structure that allows light from inside and outside.



ill. 14 // Component structure defines the space.

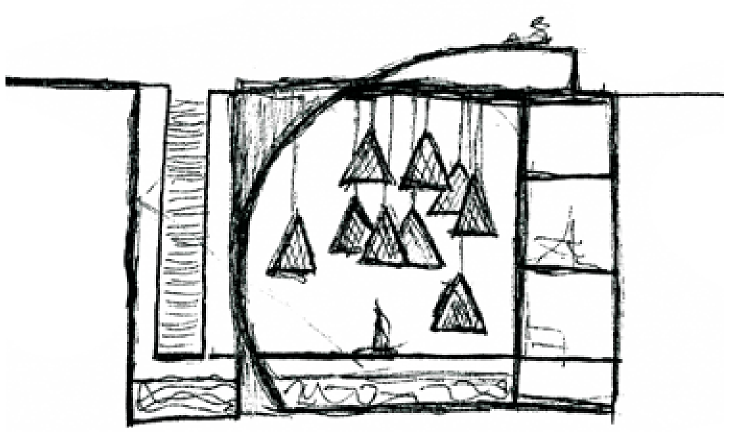


ill. 09 // Organic structures vs. regtangular space.

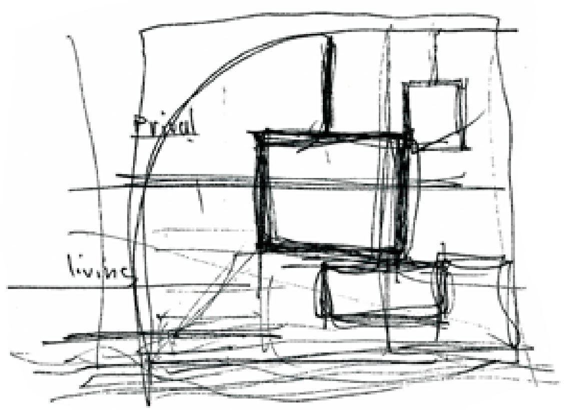


ill. 12 // Circular entrance (contrast).

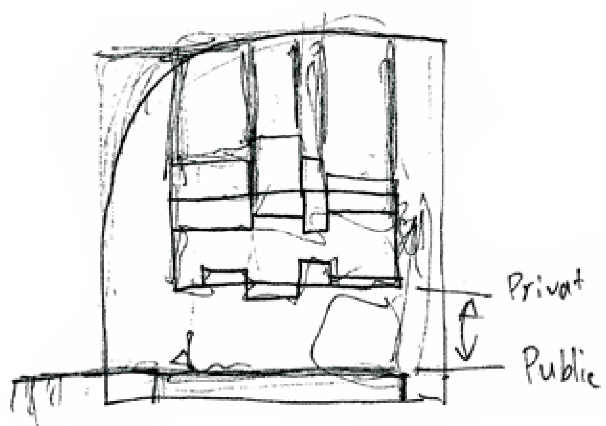
ill. 15 // Chaotic structure vs. Mathematical structure.



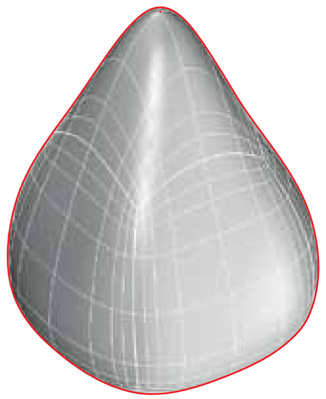
ill. 10 // Nest's randomly distributed in the space.



ill. 13 // Private and public spaces are divided.



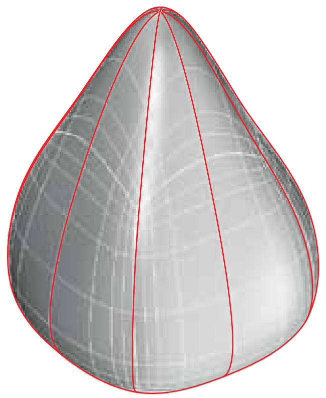
ill. 16 // Private and public spaces are divided.



// step 01.
Polygon-model is defined - it defines the boundaries for the structure.

WEAVING STRUCTURE

Grasshopper exploration - defining a covered space.



// step 02.
Curves follow the polygon-model - they define the directions for the growth curves.

A parametric definition is set up in Grasshopper, a plugin for Rhinoceros. The purpose is to control the weaving curves around the space. Grasshopper is used to keep the geometrical constraints through a set of form studies and to output data about the geometry. The parametric approach to design gives the designer a creative workflow that effectively generates various design options.

Through our design process we define the relationships between the geometrical parts and tweak different parameters to understand the interplay between them.

We iterate through a set of criteria's that determine the aesthetical expression of the nests. We seek a structure that balance between open and dense areas, furthermore we study the element proportions of the nest.

The Grasshopper definition explores various nest options - A polygon model defines the spatial cover and the curve-structure is defined by changeable parameters. The investigation searches for a balance between an open and closed structure. The open parameter values generate transparency for ventilation, views and light while the closed parameters define covered spatial areas.

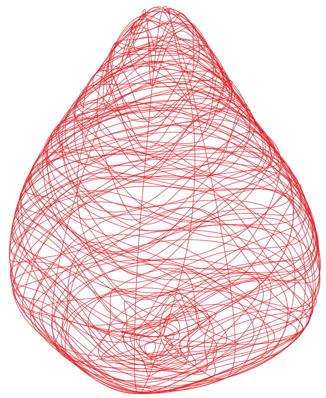
Parameters //

Number crvs: Density of the system.

Random domain: Variation of the curves.

Element thickness: Dimension of the material.

Element height: Dimension of the material.

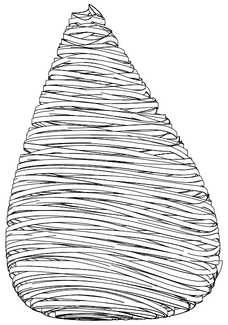


// step 03.
Growth curves define the cover - They develop the spatial cover for the nest.

// **form a - iteration 01.**

The cover is smooth with similar openings around the space – random domain is low.

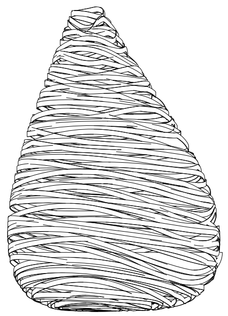
number crvs // 90.
random domain // 0.03.
Element thickness // 5mm.
Element height // 50mm.




// form a - iteration 02.

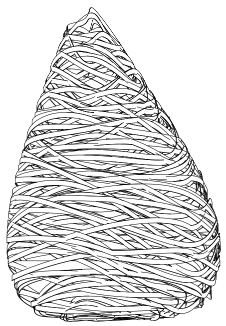
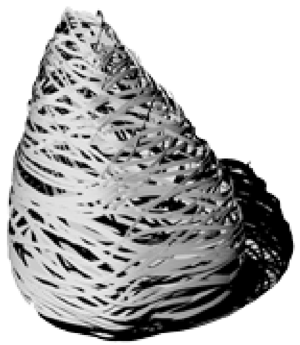
The random domain is increased – Openings are more diverse, but not dense enough around the bottom.

number crvs // 90.
random domain // 0.05.
Element thickness // 5mm.
Element height // 50mm.




// form a - iteration 03.

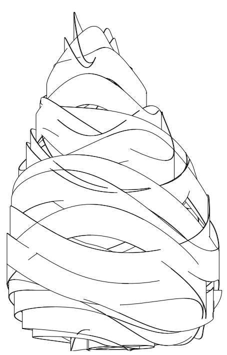
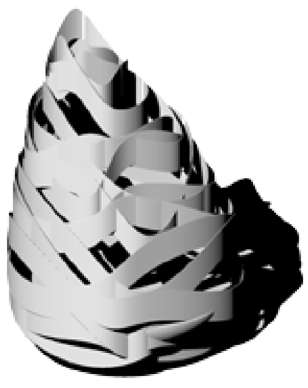
number crvs // 90.
random domain // 0.07.
Element thickness // 5mm.
Element height // 50mm.

// form a - iteration 04.

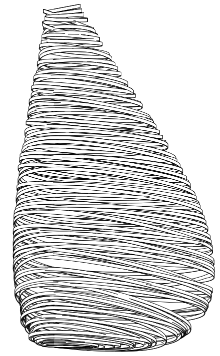
Surfaces are decreased – the cover is dense and faceted.

number crvs // 25.
random domain // 0.05.
Element thickness // 5mm.
Element height // 300mm.

// form a - iteration 05.

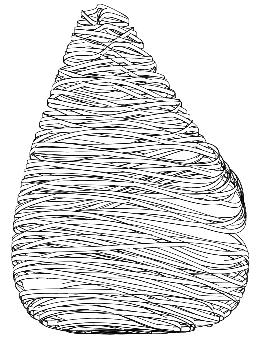
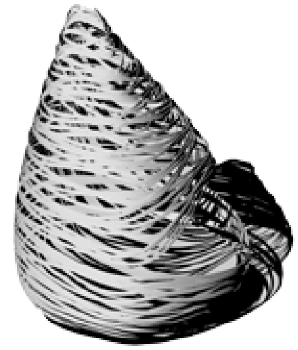
number crvs // 100.
random domain // 0.02.
Element thickness // 5mm.
Element height // 50mm.




// form b - iteration 01.

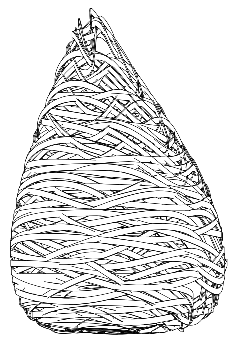
The surface variation has a good interplay with the entrance.

number crvs // 90.
random domain // 0.03.
Element thickness // 5mm.
Element height // 50mm.

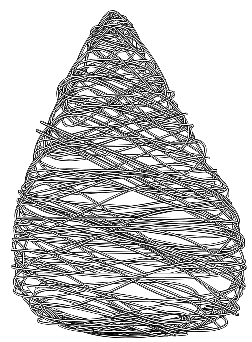
// form b - iteration 02.

number crvs // 90.
random domain // 0.05.
Element thickness // 5mm.
Element height // 50mm.



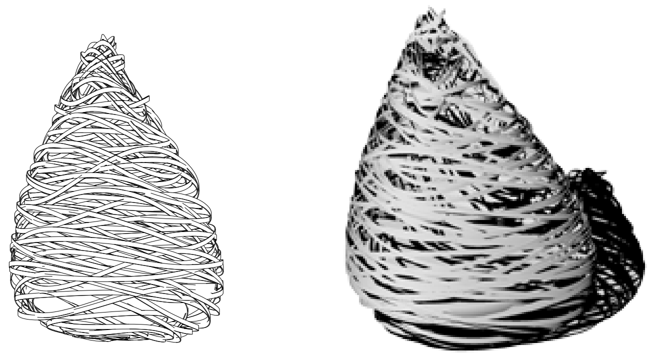

// form c - iteration 01.

number crvs // 90.
random domain // 0.06.
Element thickness // 15mm.
Element height // 15mm.



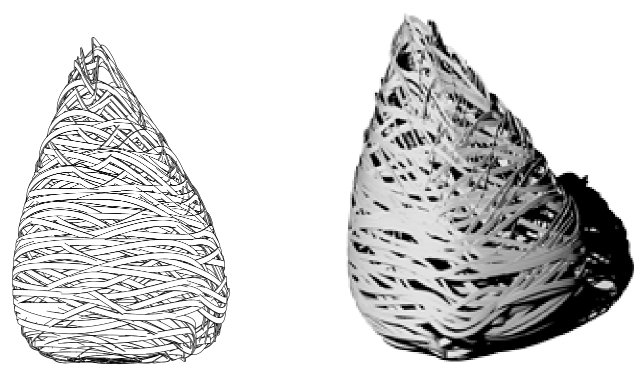

// form c - iteration 02.

number crvs // 75.
random domain // 0.06.
Element thickness // 5mm.
Element height // 50mm.



// form c - iteration 03.

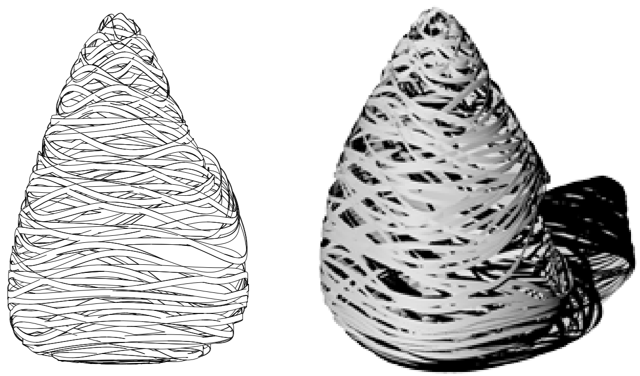
number crvs // 100.
random domain // 0.06.
Element thickness // 5mm.
Element height // 50mm.



// form d - iteration 01.

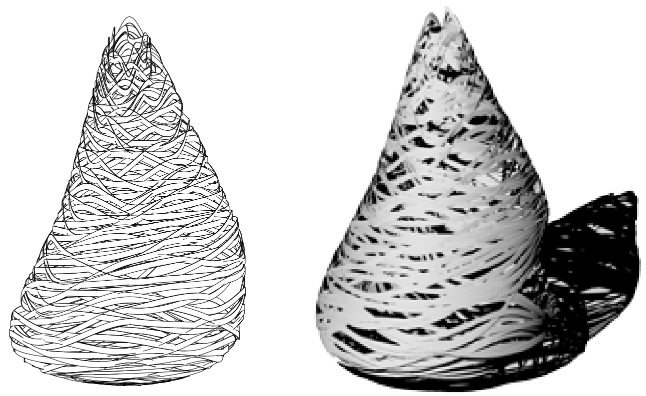
The shape transforms from a central pivot point towards a varied space. The random domain is good but the surface height is too big.

number crvs // 70.
random domain // 0.04.
Element thickness // 5mm.
Element height // 60mm.



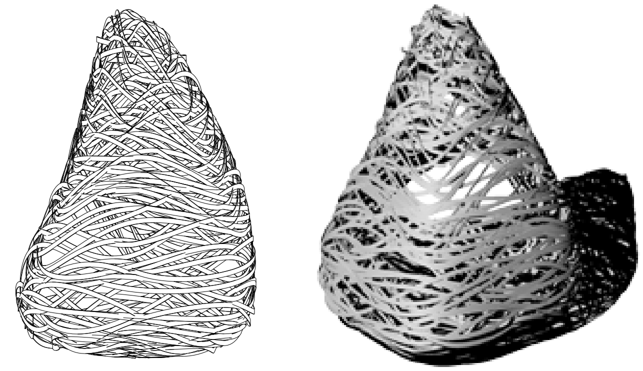
// form e - iteration 01.

number crvs // 100.
random domain // 0.05.
Element thickness // 5mm.
Element height // 60mm.



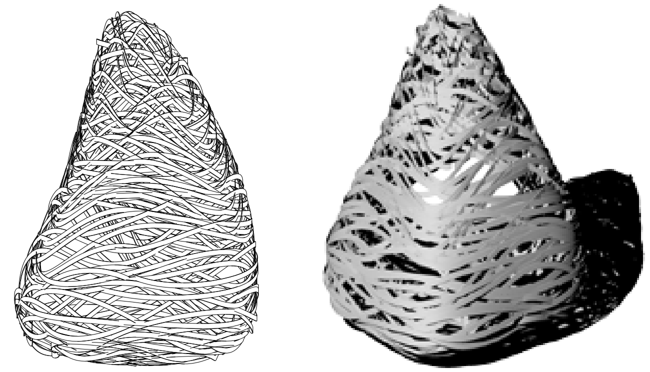
// form f - iteration 01.

number crvs // 100.
random domain // 0.09.
Element thickness // 5mm.
Element height // 50mm.



// form f - iteration 02.

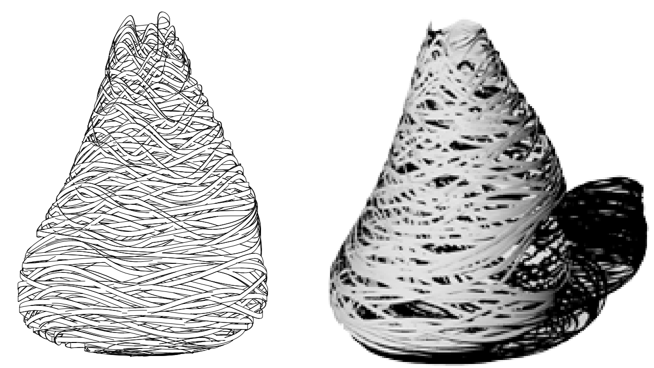
number crvs // 100.
random domain // 0.09.
Element thickness // 5mm.
Element height // 70mm.



// form g - iteration 01.

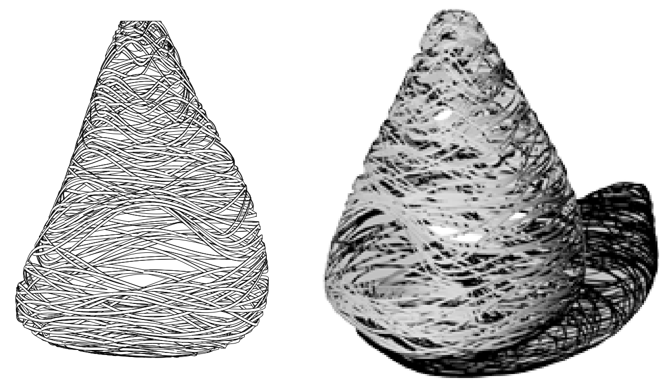
The random domain and surface proportions have an interesting coherence.

number crvs // 100.
random domain // 0.05.
Element thickness // 5mm.
Element height // 50mm.



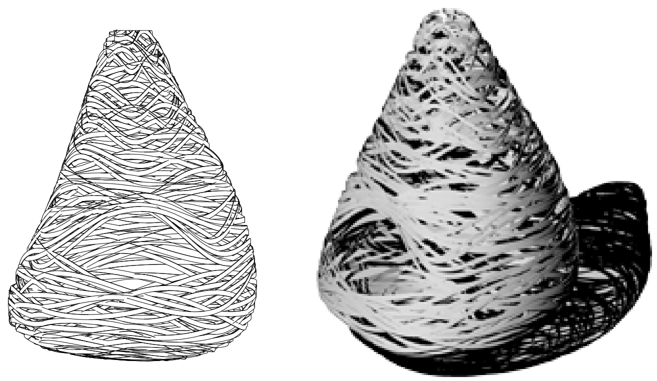
// form h - iteration 01.

number crvs // 100.
random domain // 0.05.
Element thickness // 5mm.
Element height // 30mm.



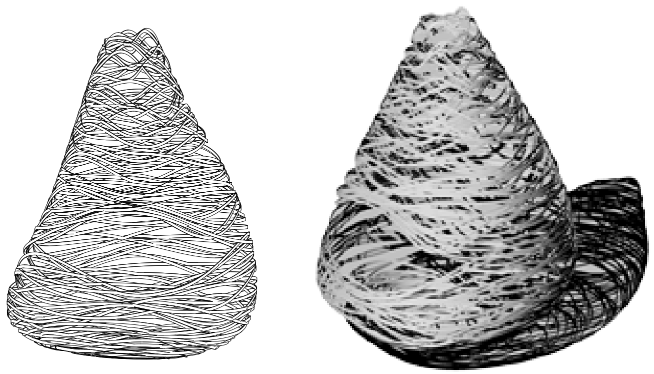
// form h - iteration 02.

number crvs // 100.
random domain // 0.05.
Element thickness // 5mm.
Element height // 50mm.



// form h - iteration 03.

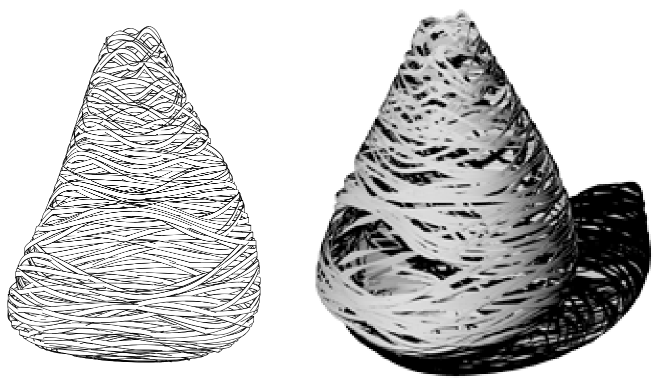
number crvs // 100.
random domain // 0.04.
Element thickness // 5mm.
Element height // 30mm.



// form h - iteration 04.

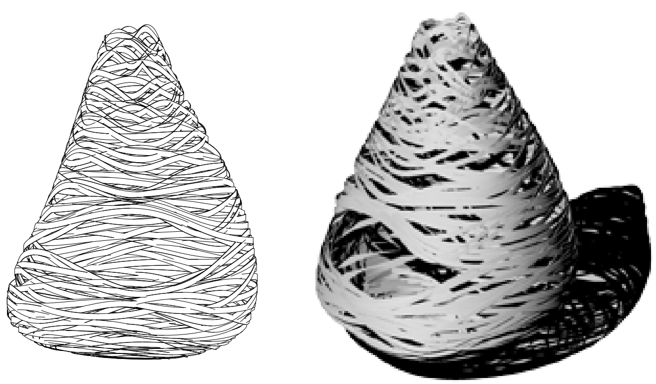
The shape, random domain and surface proportions define a spatial interior.

number crvs // 100.
random domain // 0.04.
Element thickness // 5mm.
Element height // 50mm.



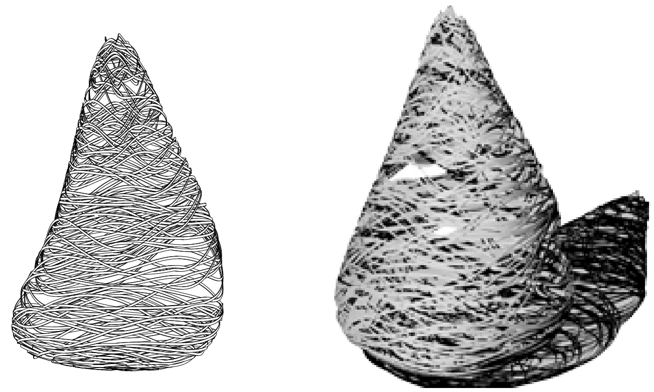
// form h - iteration 05.

number crvs // 100.
random domain // 0.04.
Element thickness // 5mm.
Element height // 60mm.



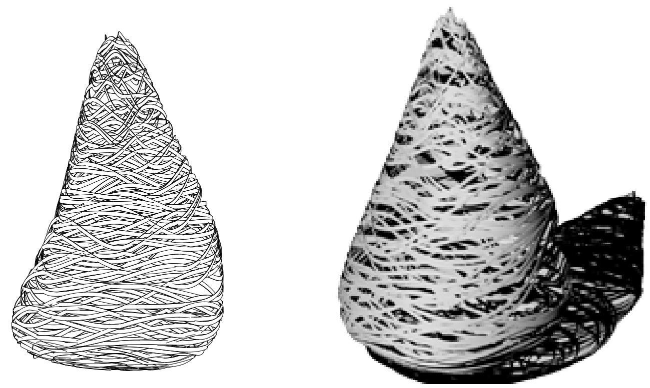
// form i - iteration 01.

number crvs // 100.
random domain // 0.05.
Element thickness // 5mm.
Element height // 30mm.



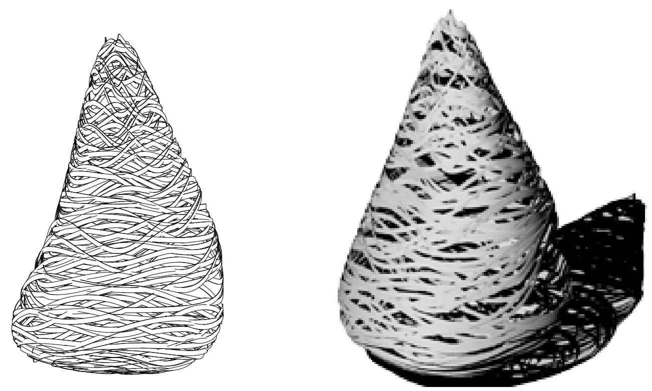
// form i - iteration 02.

number crvs // 100.
random domain // 0.05.
Element thickness // 5mm.
Element height // 50mm.



// form i - iteration 03.

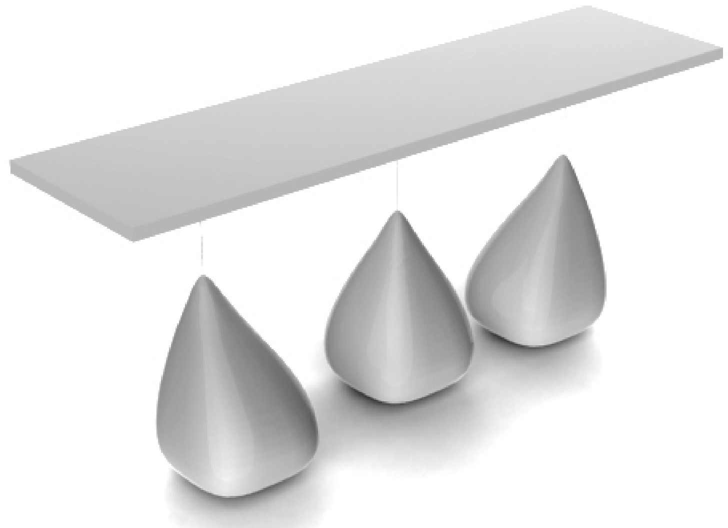
number crvs // 100.
random domain // 0.05.
Element thickness // 5mm.
Element height // 60mm.



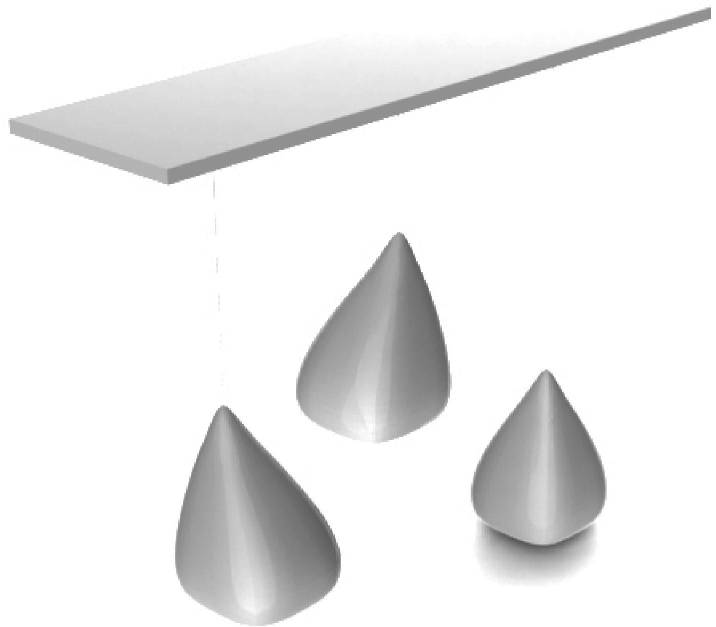
NEST PROPERTIES

Specifications and scenarios.

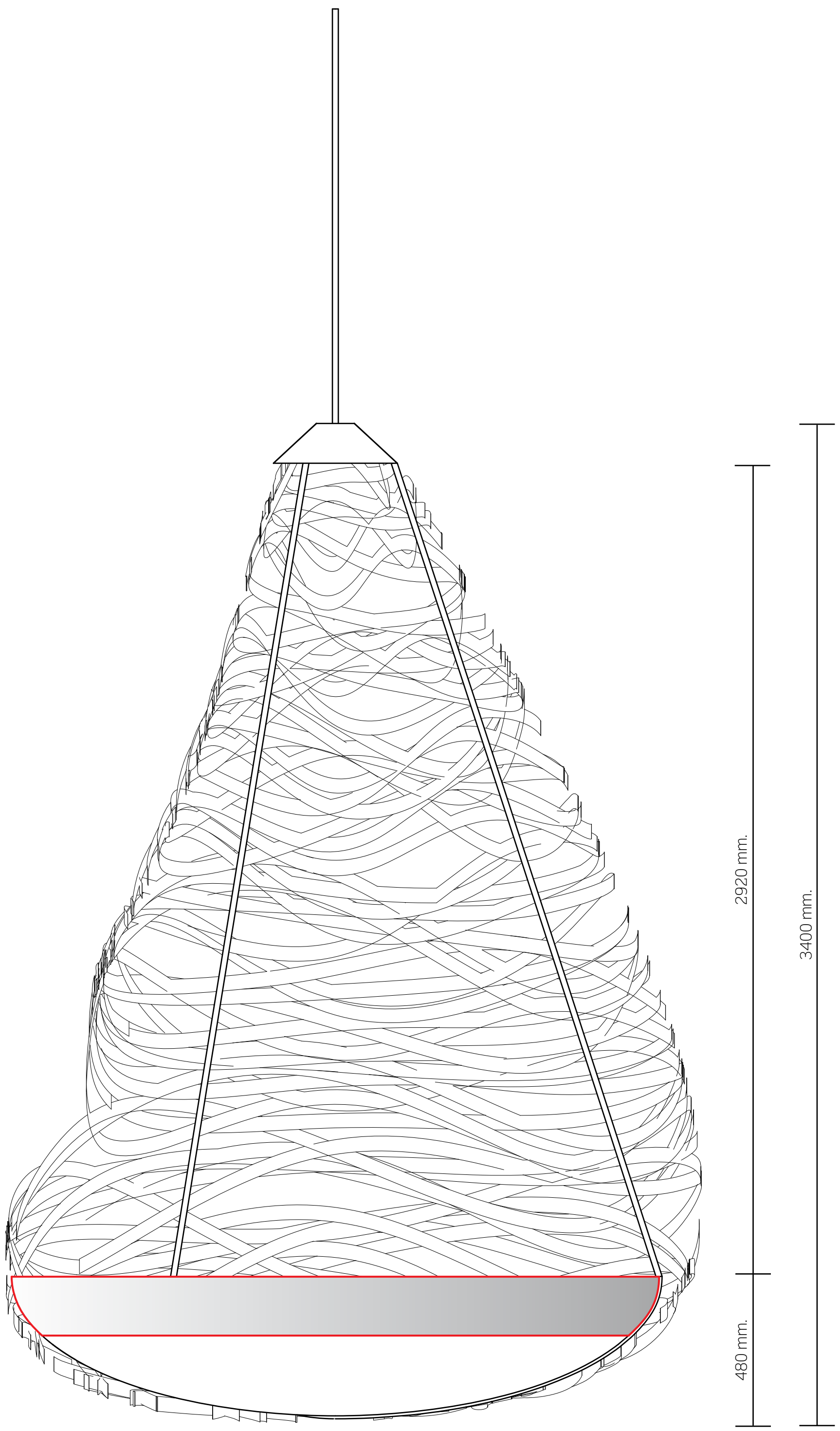
The nests are hanging in a row following the walk-path, from here visitors are able to enter the nests and select a position in space. At day-time the nests are hanging close to the roof, but at night-time they individually adapt to various positions in the space and become local floating light bulbs.



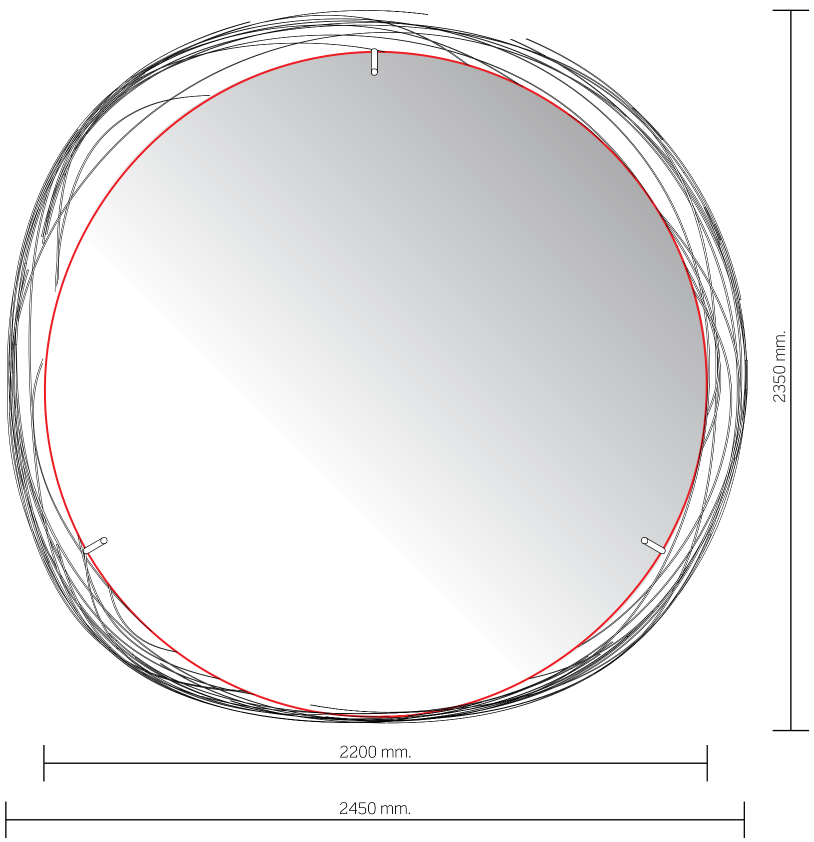
ill. 17 // Day scenario.



ill. 18 // Night scenario.



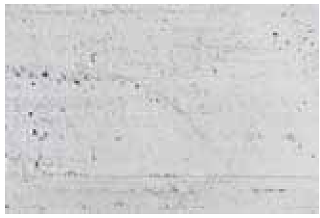
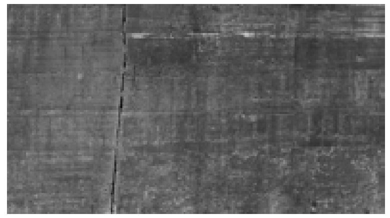
ill. 19 // Section - Nest.



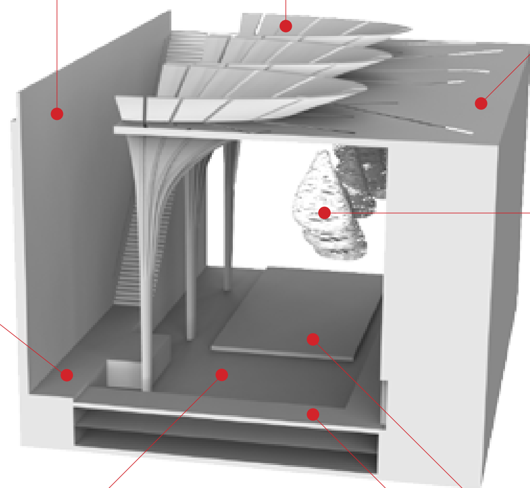
ill. 20 // Plan - Nest.

MATERIALS

Considerations regarding materials.

The main material used in Tikal is limestone. Limestone is a stone material that resembles concrete in many cases. We selected concrete because of the stone similarity and is suitable for our structural demands. We wanted a low variety of materials used in the building; therefore all bearing walls and decks are made of concrete.



The aspect of having rain enter naturally in the actual museum, will result in a much more intense and authentic experience. Since it is nearly raining 15 mm. pr. Day in five month, it's necessary with a drainage system for all the rain entering the interior spaces. We merged both parts having a constant filled reservoir of water. This ensures a flooding safety and the interior and exterior are both physical, visual and technical connected.

Wood resembles the surrounding trees of the rainforest. We use wood to mark the transition between the public and the semi-private zone. The coating for the walkway in the semi-private zone will be wood planks. The two platforms representing dining- and living area will also be coated with wood planks. Finally the nests are made by wood. They resemble the trees in the rainforest, as they are located high above ground.






ILLUSTRATION LIST

ill **links**

Appendix C

01. http://3.bp.blogspot.com/_d042CW4fZzk/TKoZlFN2vwI/AAAAAAAAAlY/45WQJT2jJvM/s1600/ModellOtto.jpg

02. http://www.obsessionarchitecture.com/upload/article/31/2-smolenicky-partner-tamina-therme-grand-resort-bad-ragaz-bad-ragaz-switzerland.jpg?PHPSESSID=3a9cb4a078130a212d7dc837d05b32f7

03. http://www.inha.fr/centenaire/images/centenaire-bibliotheque-39.jpg

04. http://www.newchurchhistory.org/articles/cathedral/pictures/106Blg.jpg

05. http://www.essential-architecture.com/IMAGES2/Exeter_cathedral.JPG

06. http://inhabitat.com/wp-content/blogs.dir/1/files/2010/08/green-roof-univ-japan-interior-render.jpg

Appendix G

01. http://3.bp.blogspot.com/-C7z88-XjdTg/TaoXlxUMGMI/AAAAAAAAAIw/ogZZGMdrWxk/s1600/IMG_3536.JPG

02. http://thedesignhome.com/wp-content/uploads/2011/03/nest-chair-nina-bruun-1.jpg

03. http://2.bp.blogspot.com/_afa6V6KzaAs/TNjtNFvh4KI/AAAAAAAAAfE/w0-G_dxrKFI/s1600/nestrest.jpg

04. http://static.dezeen.com/uploads/2008/01/weaveyourlighting-black-edition.jpg

05. http://www.markneville.co.uk/images/039Magpie-nest-132-Barrowfield-Street039-from-the-slide-installation-039Animal-Architecture039.jpg

06. http://1.bp.blogspot.com/-Gmiyp_x5MdQ/Ti3SP-GetVI/AAAAAAAAAmQ/j-EbVEup3og/s1600/IMG_1162+-+Kopia.JPG

Appendix H

01. http://imgon.net/di-HLD2.jpg

02. http://openwalls.com/image/7973/heavy_rain_1440x900.jpg

03. http://i305.photobucket.com/albums/nn227/fishpastehill/th_Rain_Forest_Tropic-1-1.jpg

04. http://upload.wikimedia.org/wikipedia/commons/thumb/0/0b/Taxus_wood.jpg/300px-Taxus_wood.jpg

05. http://ipwalls.com/wp-content/uploads/2010/06/pevide-dark-brown-wood-ipad-wallpaper.jpg

06. http://www.freestockimages.org/wp-content/uploads/2010/09/free-stock-images-old-wood-textures-01.jpg

07. http://farm6.staticflickr.com/5065/5683918619_57e76148f8_z.jpg

08. Concrete texture 01

09. Concrete texture 02