Za'atari Earth Institute

Syria before war

Syria before war

Za’atari Camp

Za'atari: Camp or City?

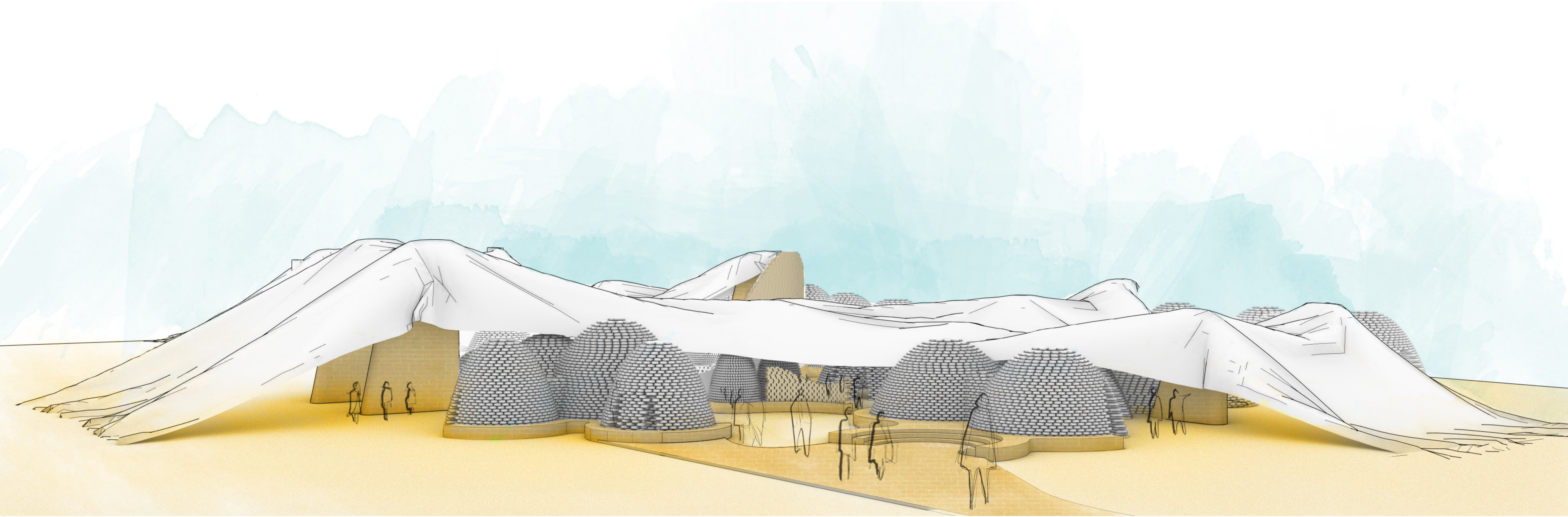
Za'atari: Refugees or People?

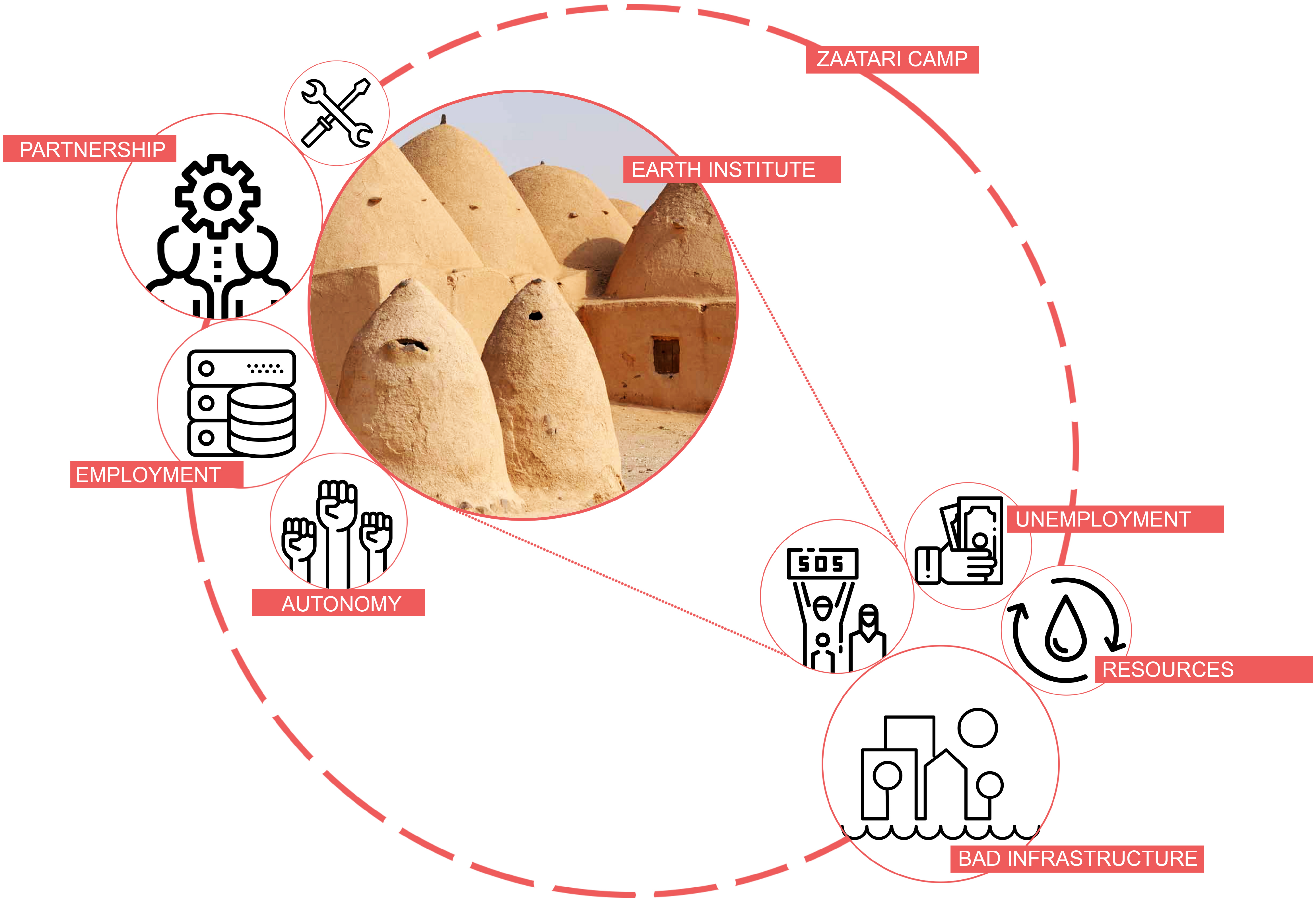
Za'atari City and its People

Despite all the infrastructural and resource challenges forcibly displaced people will continue to struggle in order to restore their daily habits and culture. This energy and cultural richness continues to raise questions.
Is this place a camp or a city? Are we dealing with refugees or citizens?

Looking at the situation, as a city and its people, we propose to empower the people of Za'atari with an Earth Institute to teach people how to build with earth by rethinking the use and management of the local resources. In the long term the project generates a place of work, a sense of place and will gradually decrease the infrastructural problems of Za'atari City.

"Teach a man how to build
and he will raise a city for his life."

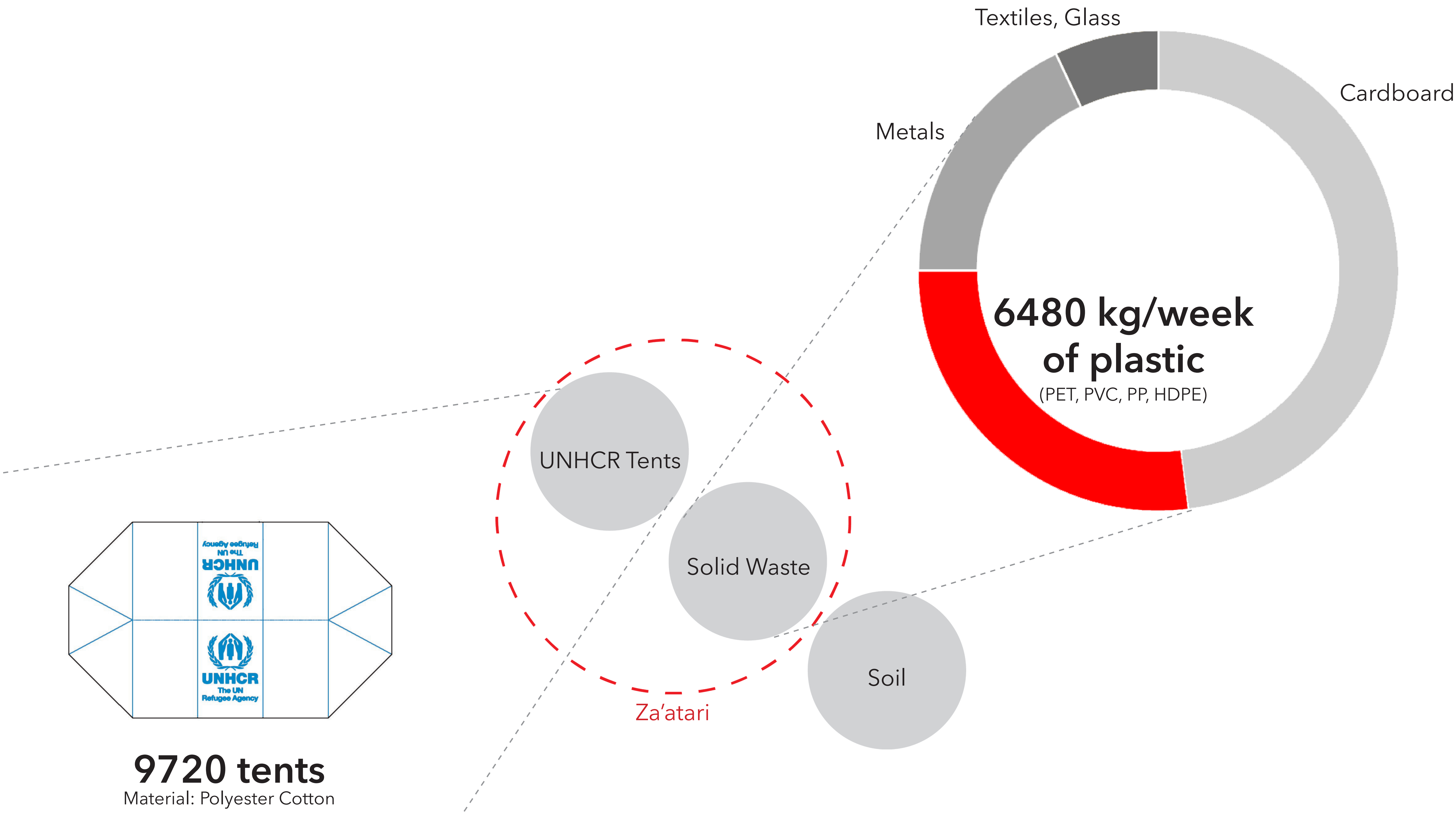




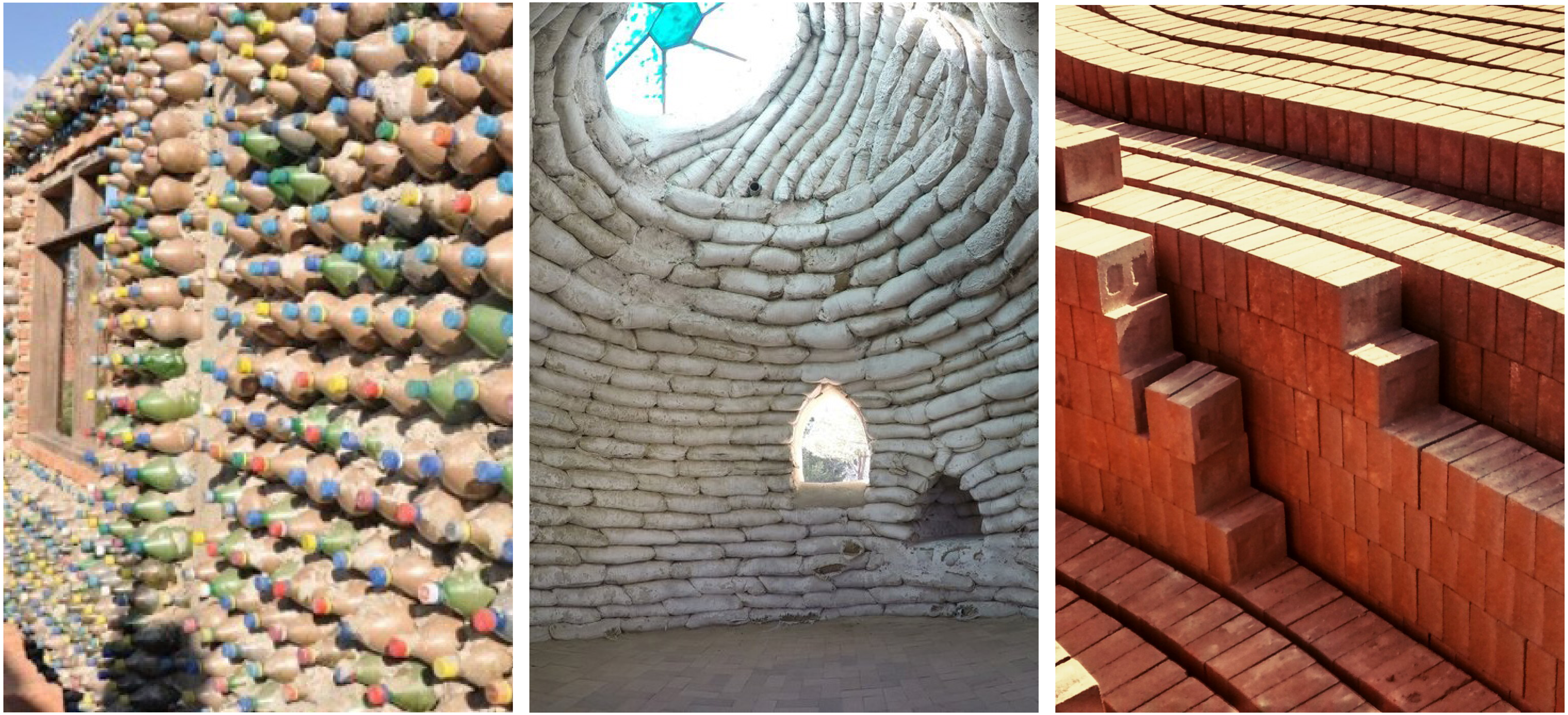
An Earth Institute for Za'atari


UNHCR
The UN Refugee Agency
UNHCR
The UN Refugee Agency
UNHCR
The UN Refugee Agency

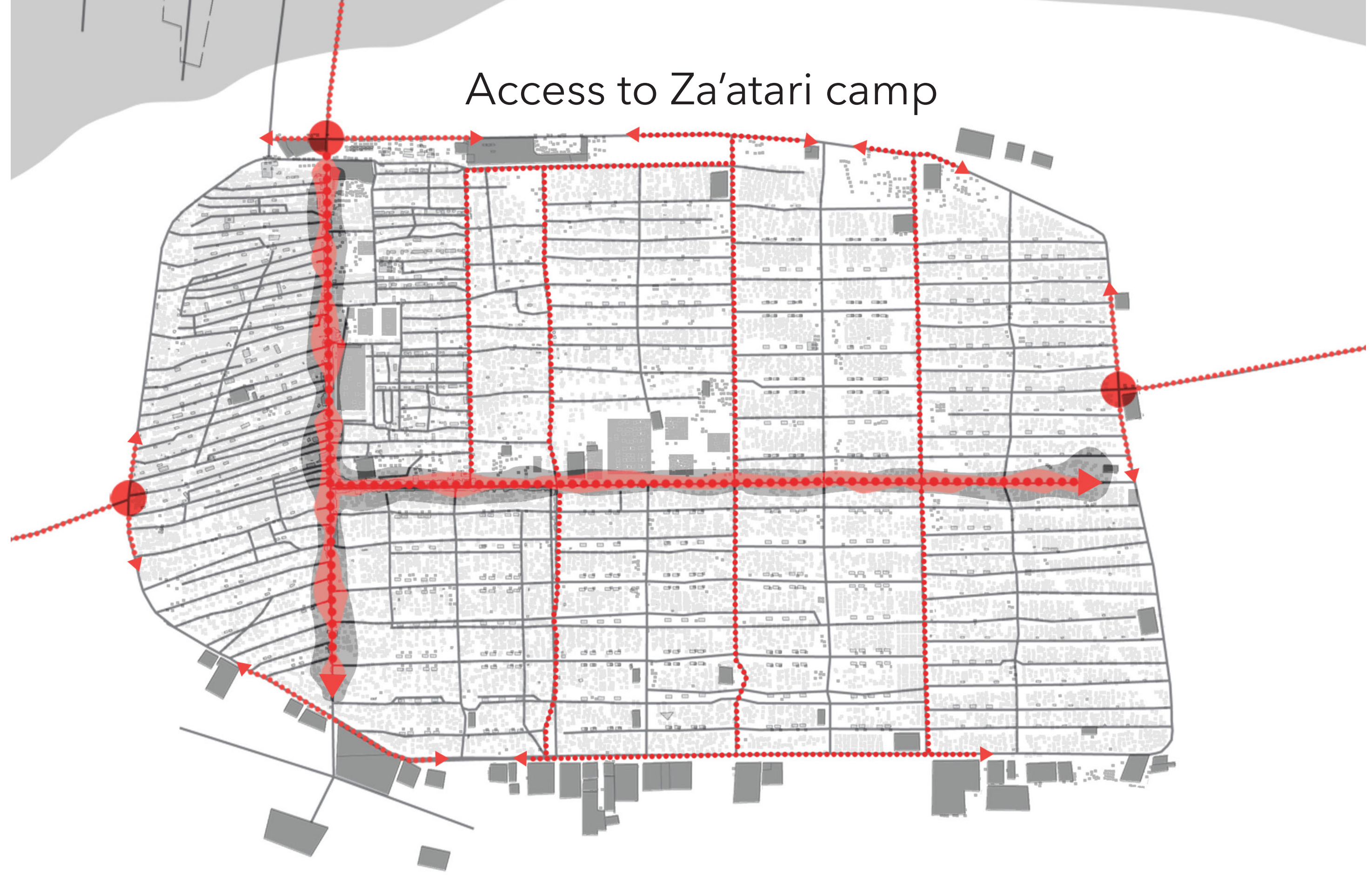

F-1

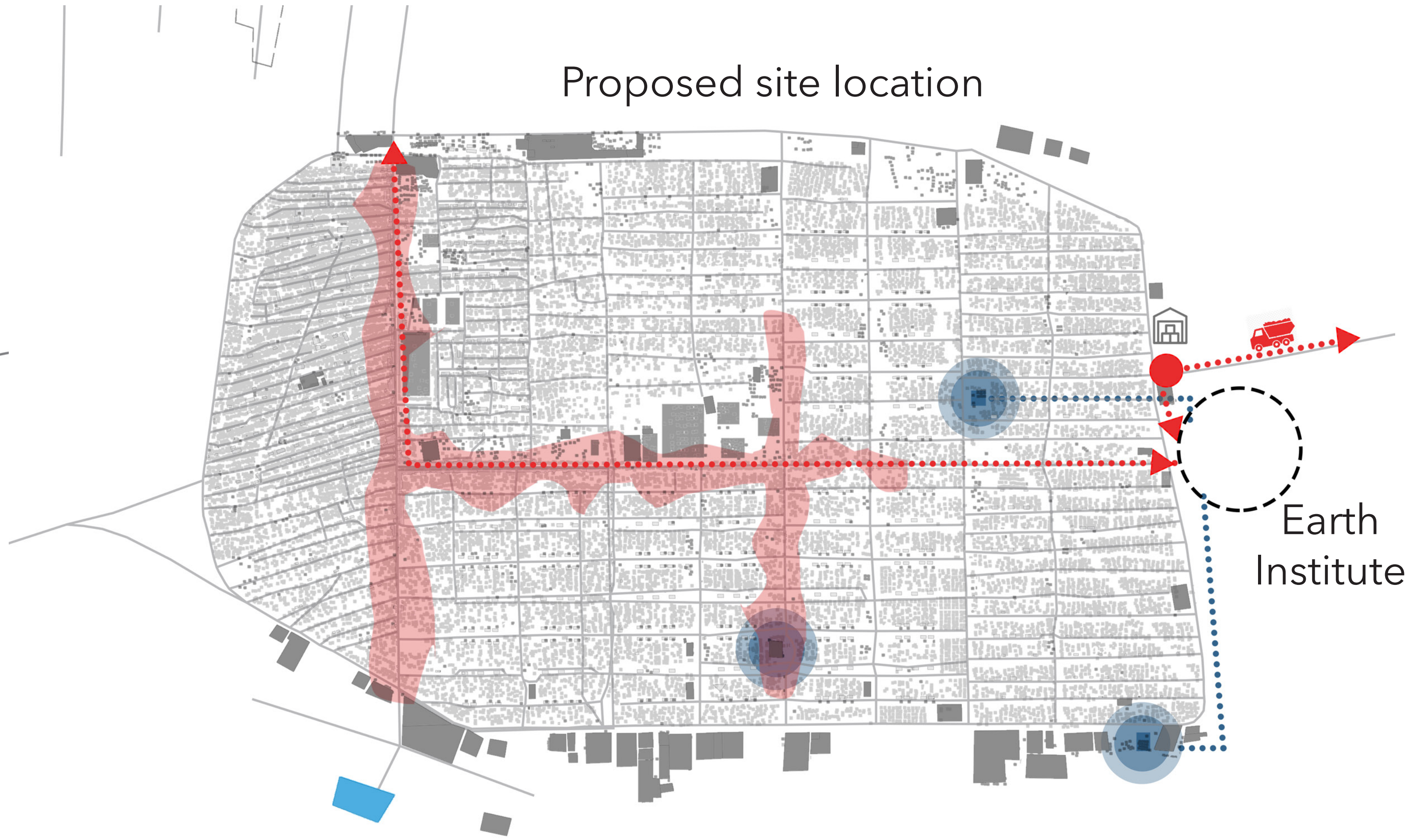


Available resources

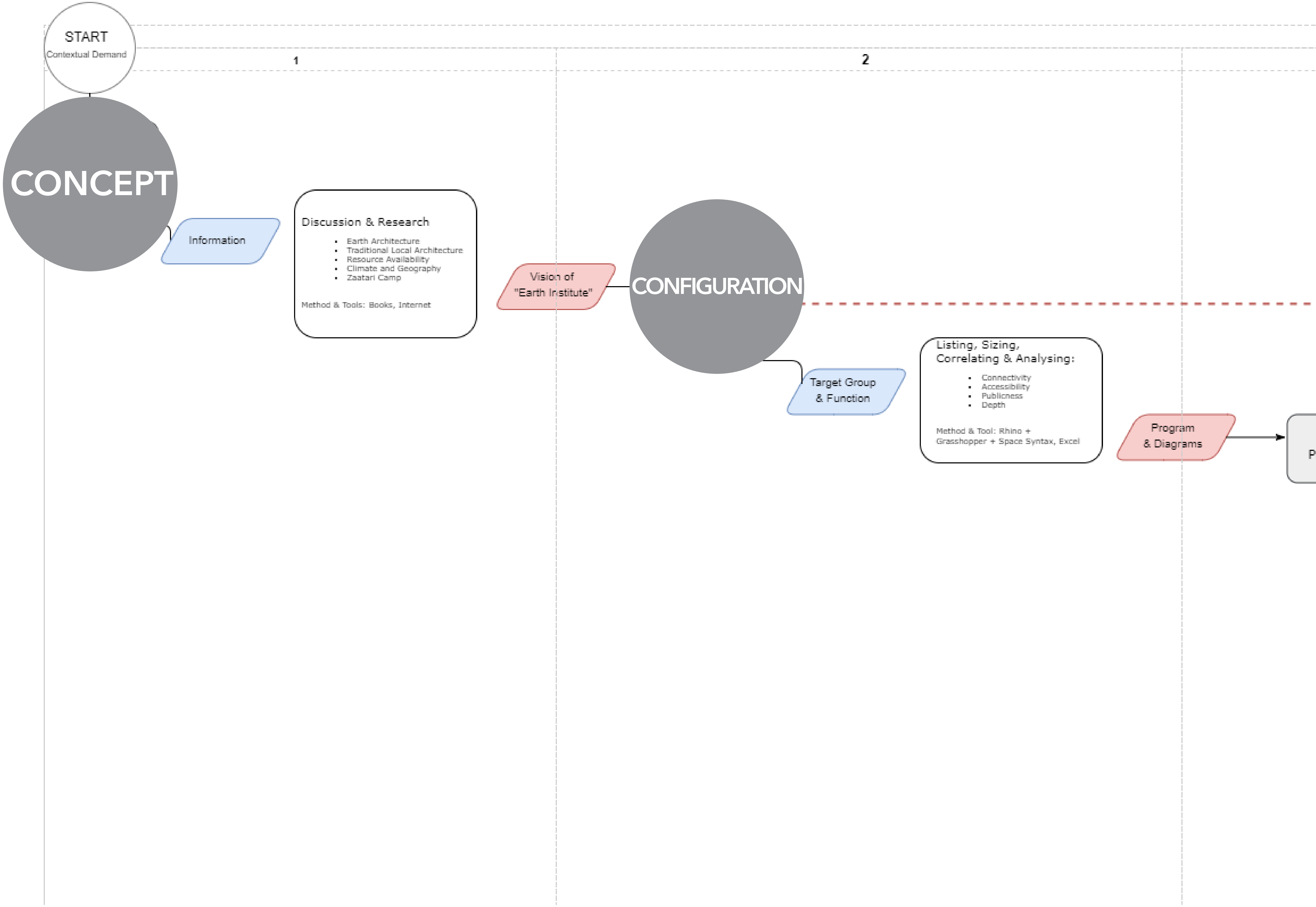


Proposed building materials

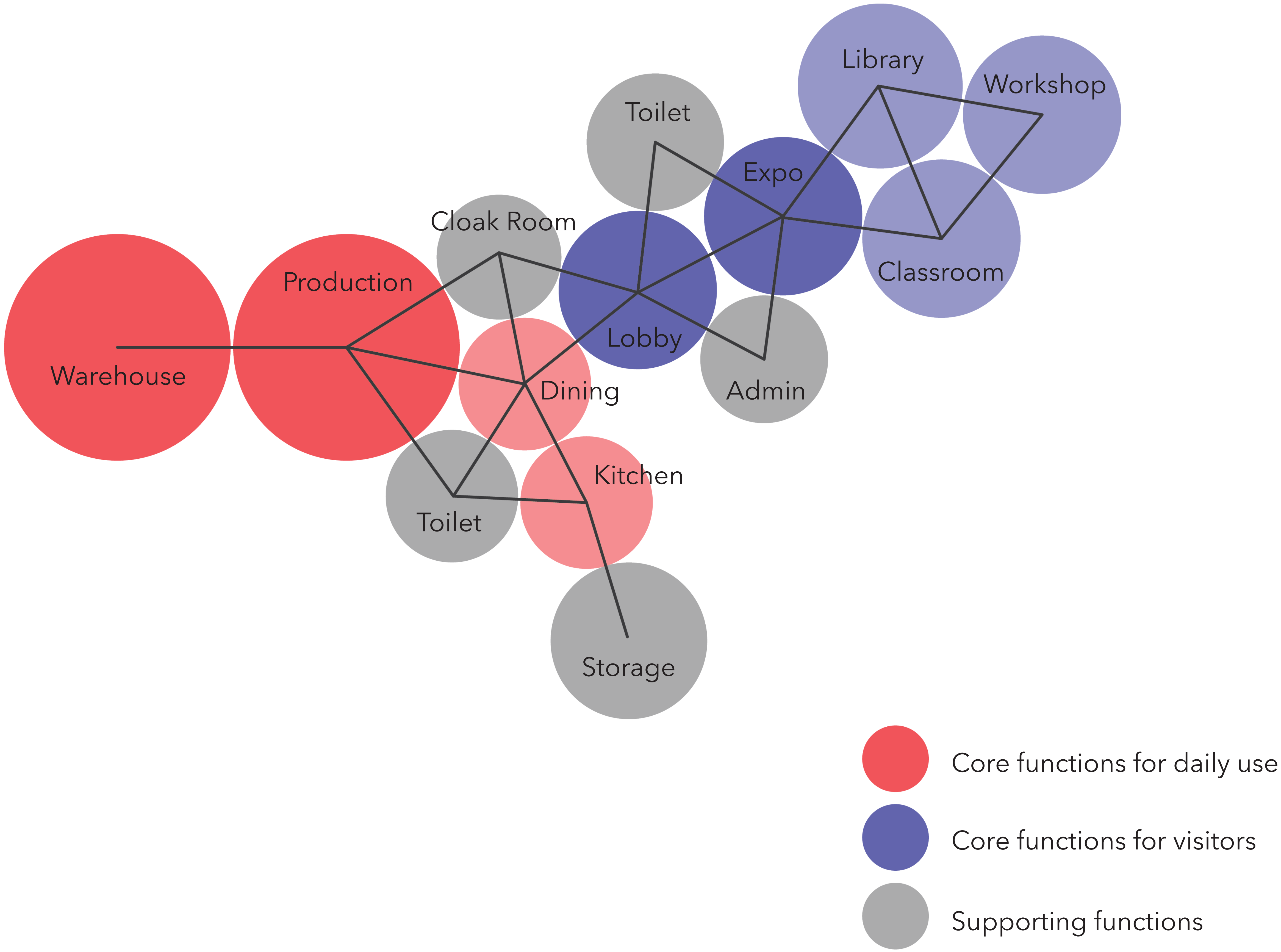




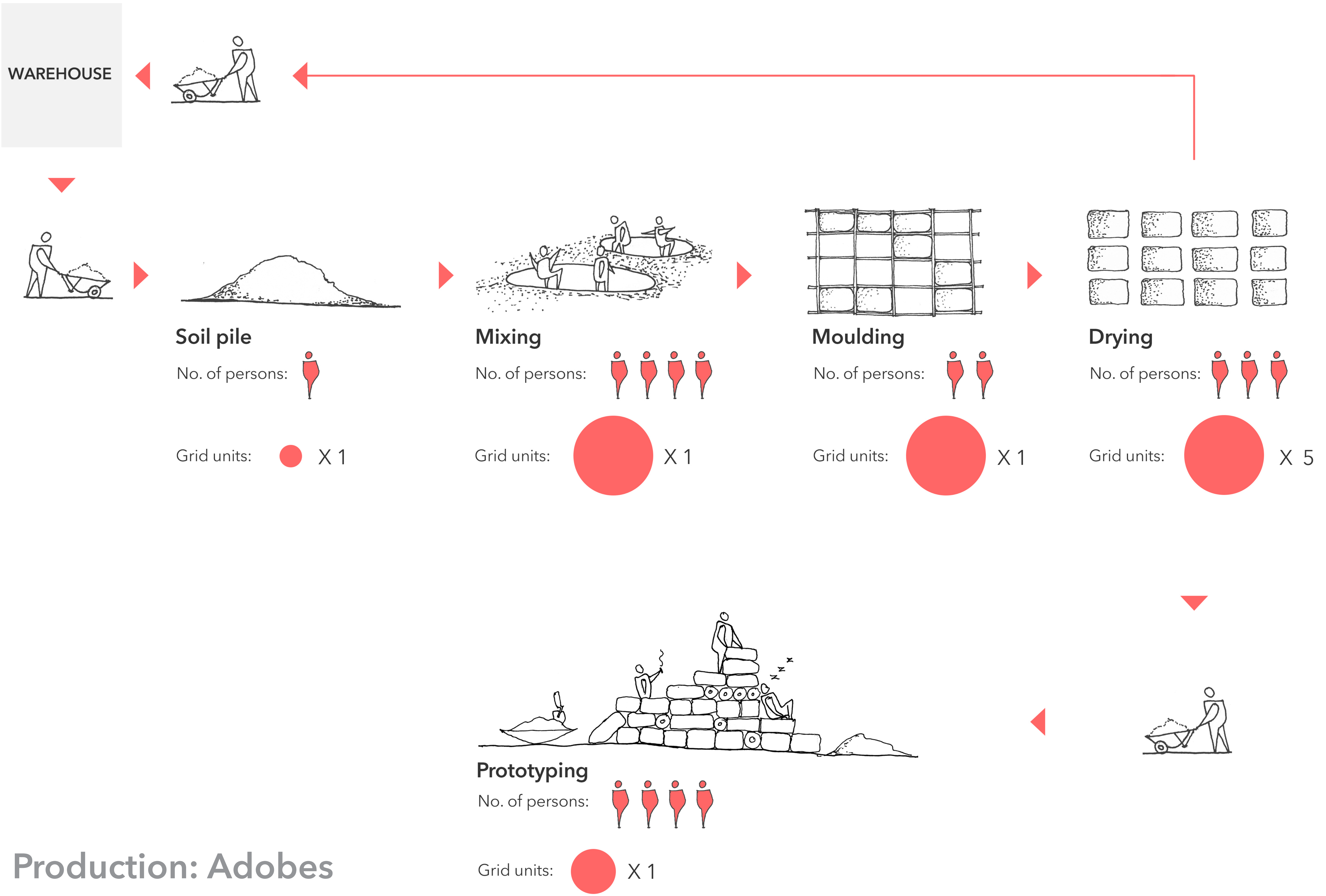
Urban analysis



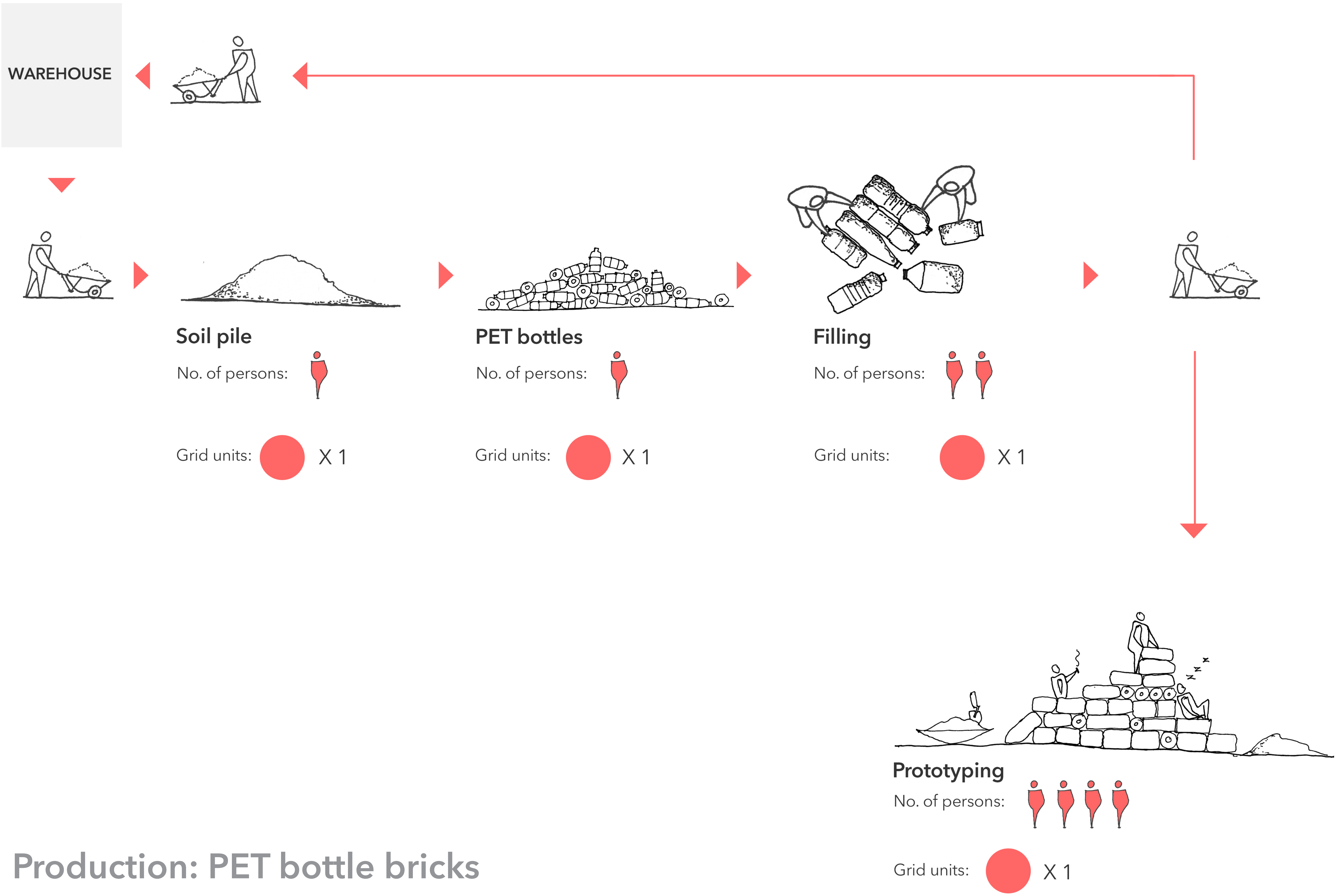
START
Contextual Demand
1
2
CONCEPT
Information
Discussion & Research
Earth Architecture
Traditional Local Architecture
Resource Availability
Climate and Geography
Zaatari Camp
Method & Tools: Books, Internet
Vision of "Earth Institute"
CONFIGURATION
Target Group & Function
Listing, Sizing, Correlating & Analysing:
Connectivity
Accessibility
Publicness
Depth
Method & Tool: Rhino + Grasshopper + Space Syntax, Excel
Program & Diagrams



Functional Organisation

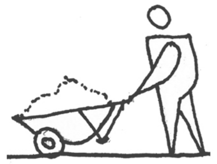


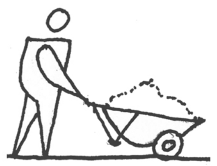
Production: Adobes



Production: PET bottle bricks

WAREHOUSE

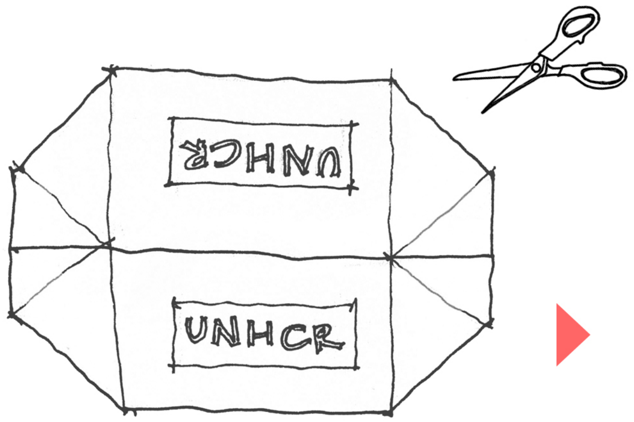




Raw material

No. of persons: 1

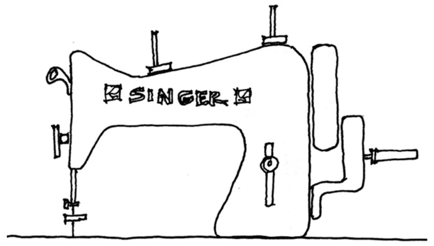
Grid units: X 1



Tent cutting

No. of persons: 2

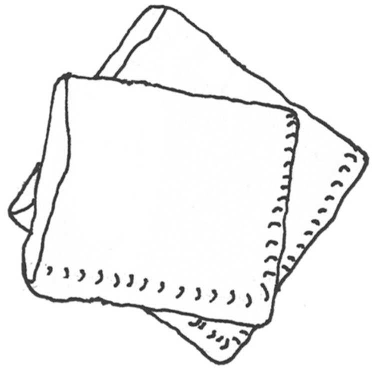
Grid units: X 2



Stitching

No. of persons: 4

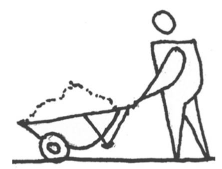
Grid units: X 2

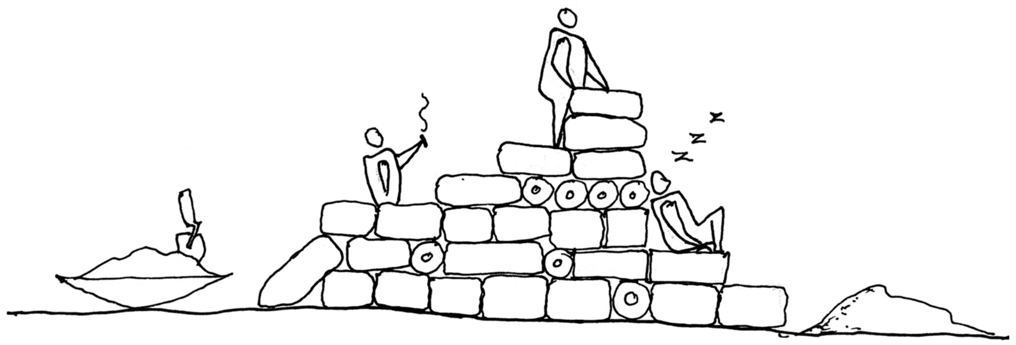


Finished bags

No. of persons: 1

Grid units: X 1



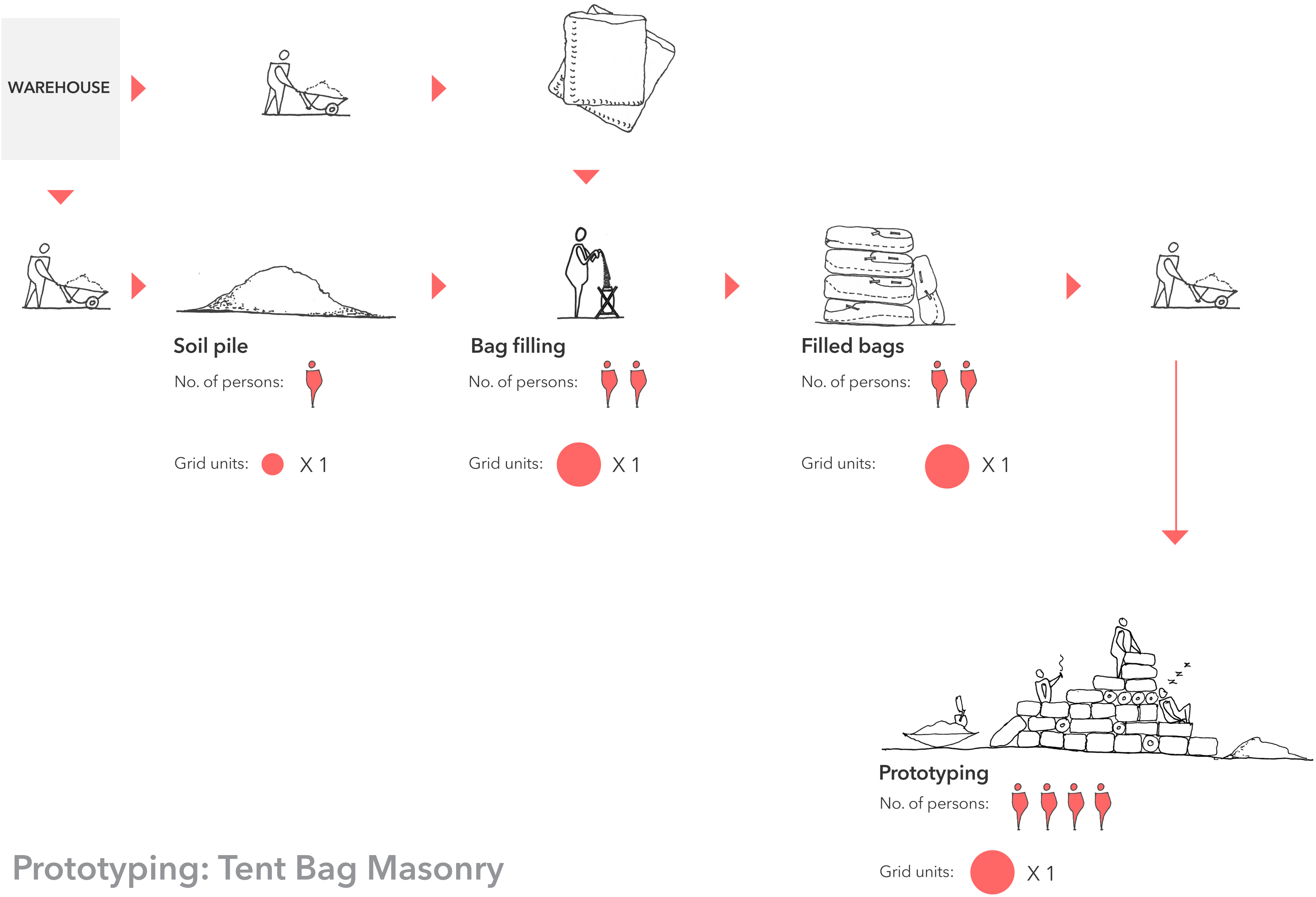


Prototyping

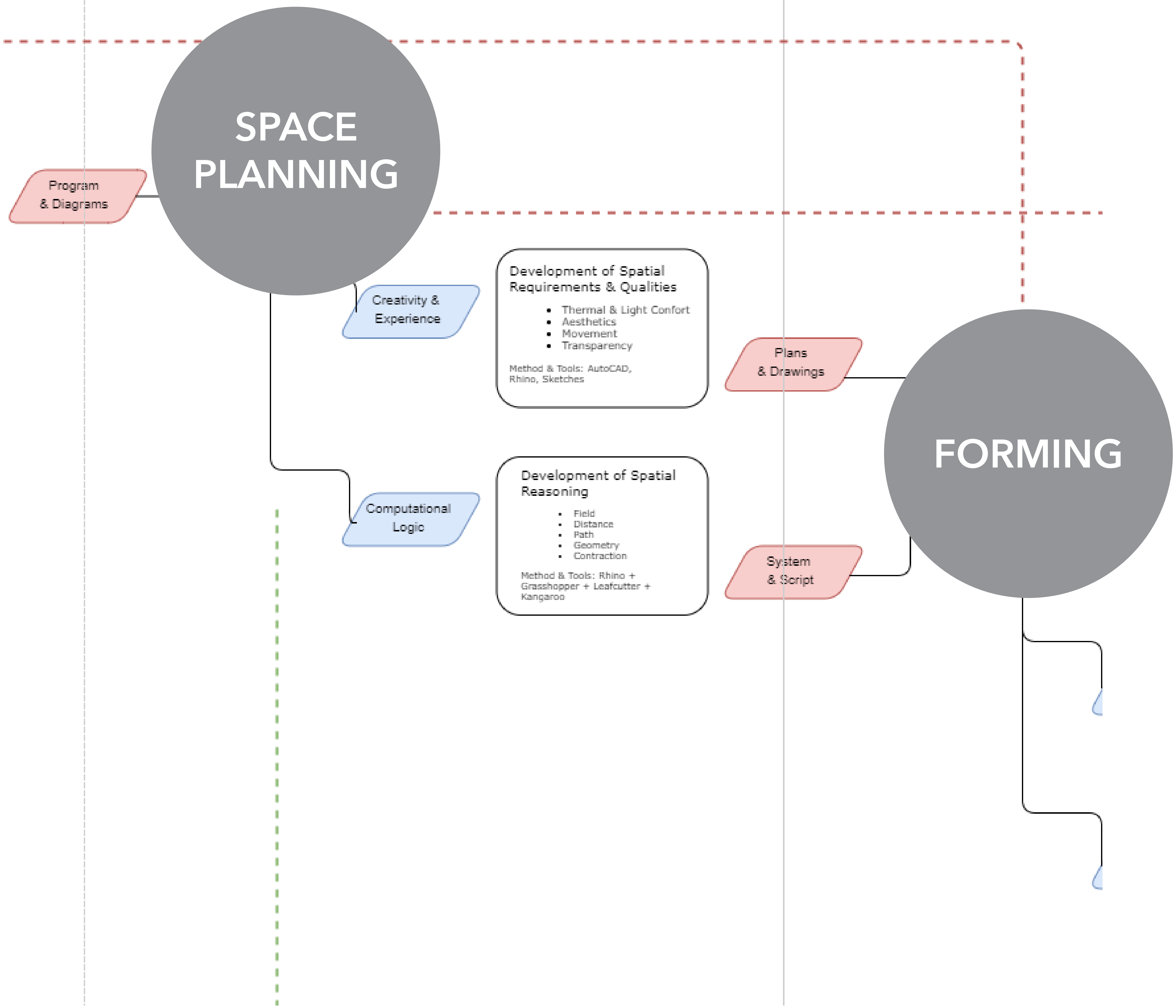
No. of persons: 4

Grid units: X 1

Production: Tent Bags



Prototyping: Tent Bag Masonry

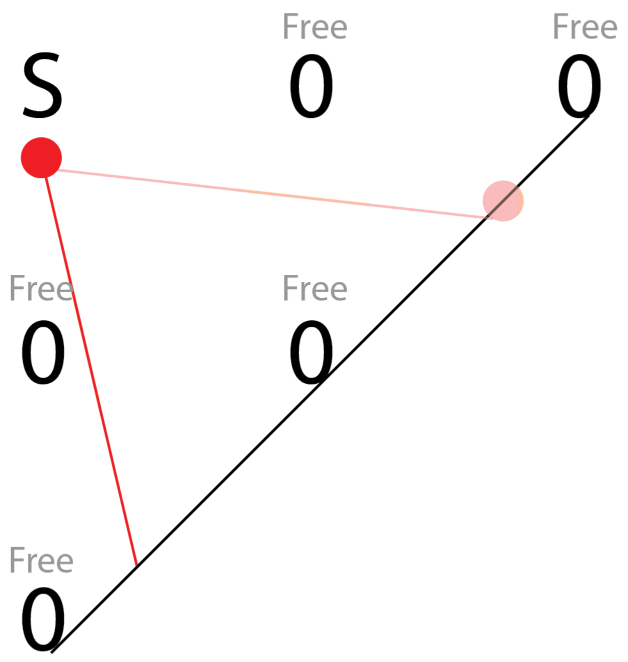


SPACE PLANNING
Program & Diagrams
Creativity & Experience
Computational Logic
Development of Spatial Requirements & Qualities
Thermal & Light Confort
Aesthetics
Movement
Transparency
Method & Tools: AutoCAD, Rhino, Sketches
Development of Spatial Reasoning
Field
Distance
Path
Geometry
Contraction
Method & Tools: Rhino + Grasshopper + Leafcutter + Kangaroo
Plans & Drawings
System & Script
FORMING

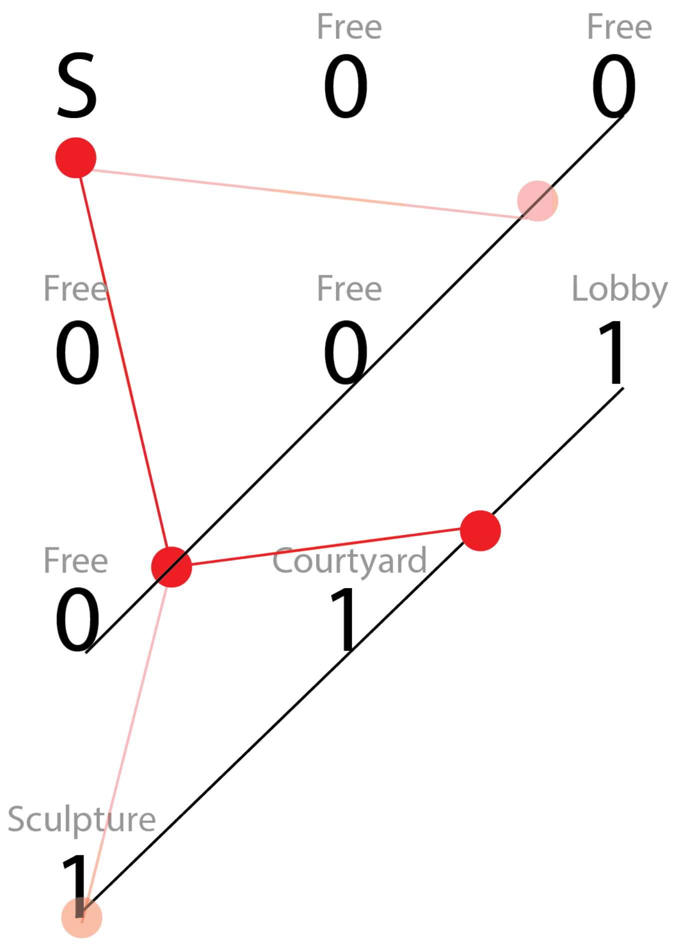
S	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-

Cellular Automaton is a discrete model of iterative arrays, which generates tesselating structures. The model is studied in different fields, as computer science or biology. Conceptually it originated in 1940s by Stanislaw Ulam and John von Neumann and became more popular in the 1970s, as base of the game Conway's Game of Life.

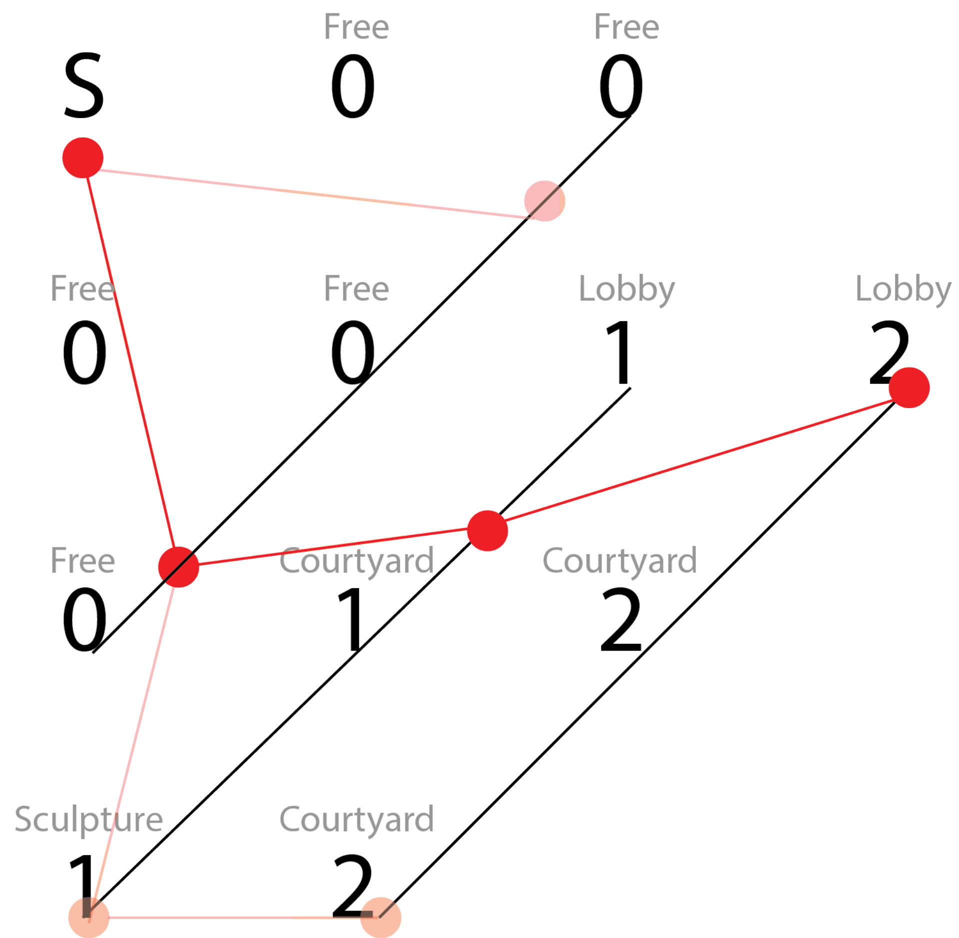
Cellular automaton



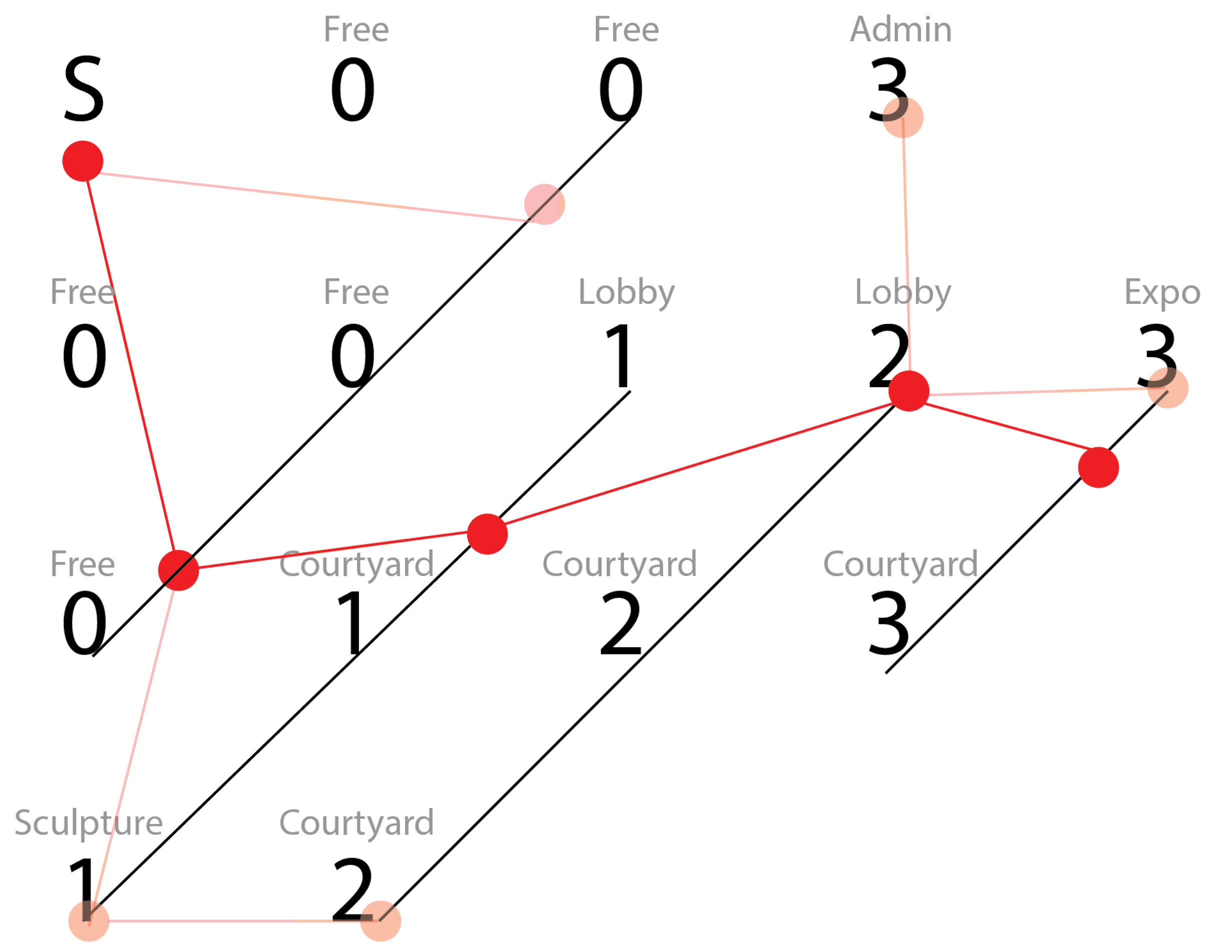
In a finite grid of cells, neighborhood cells or closest points are defined in relation to a specified cell. An initial state is defined, in this case the starting point S with an empty field. In the process of translating this logic into spatial architecture, the specified cell is seen as a person in the field. This person is taking a path with a specific direction. After each iteration the path is further defined and with it a new generation of cells is defined in relation to the persons position.



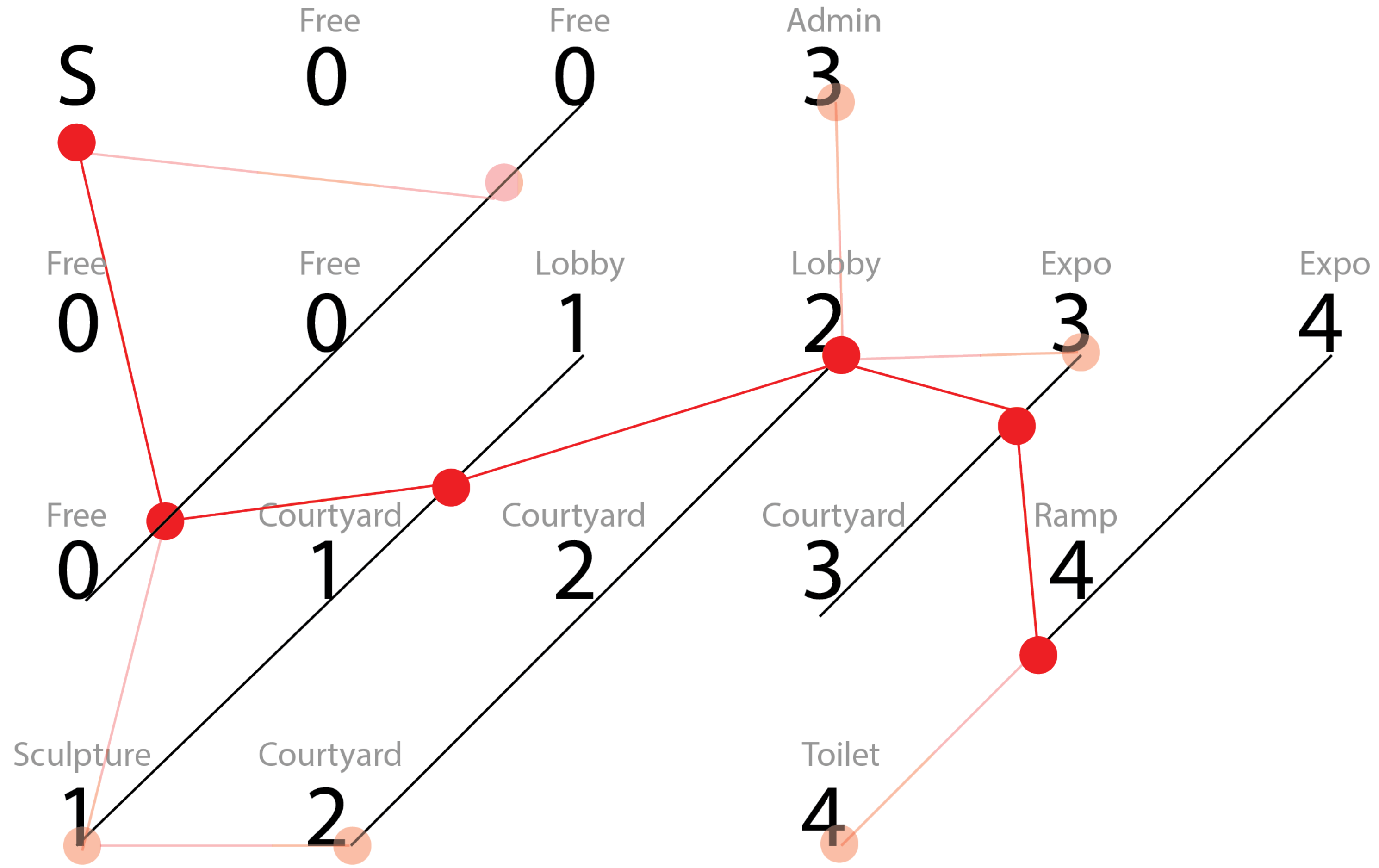
In this example, the person walks at iteration (0) from the starting point through five empty cells. By reaching the boundary of cells of this iteration (0), iteration (1) starts and the closest new cells are again defined. Here, the person is directed towards a sculpture and a courtyard getting closer to the lobby, invited to enter the building.



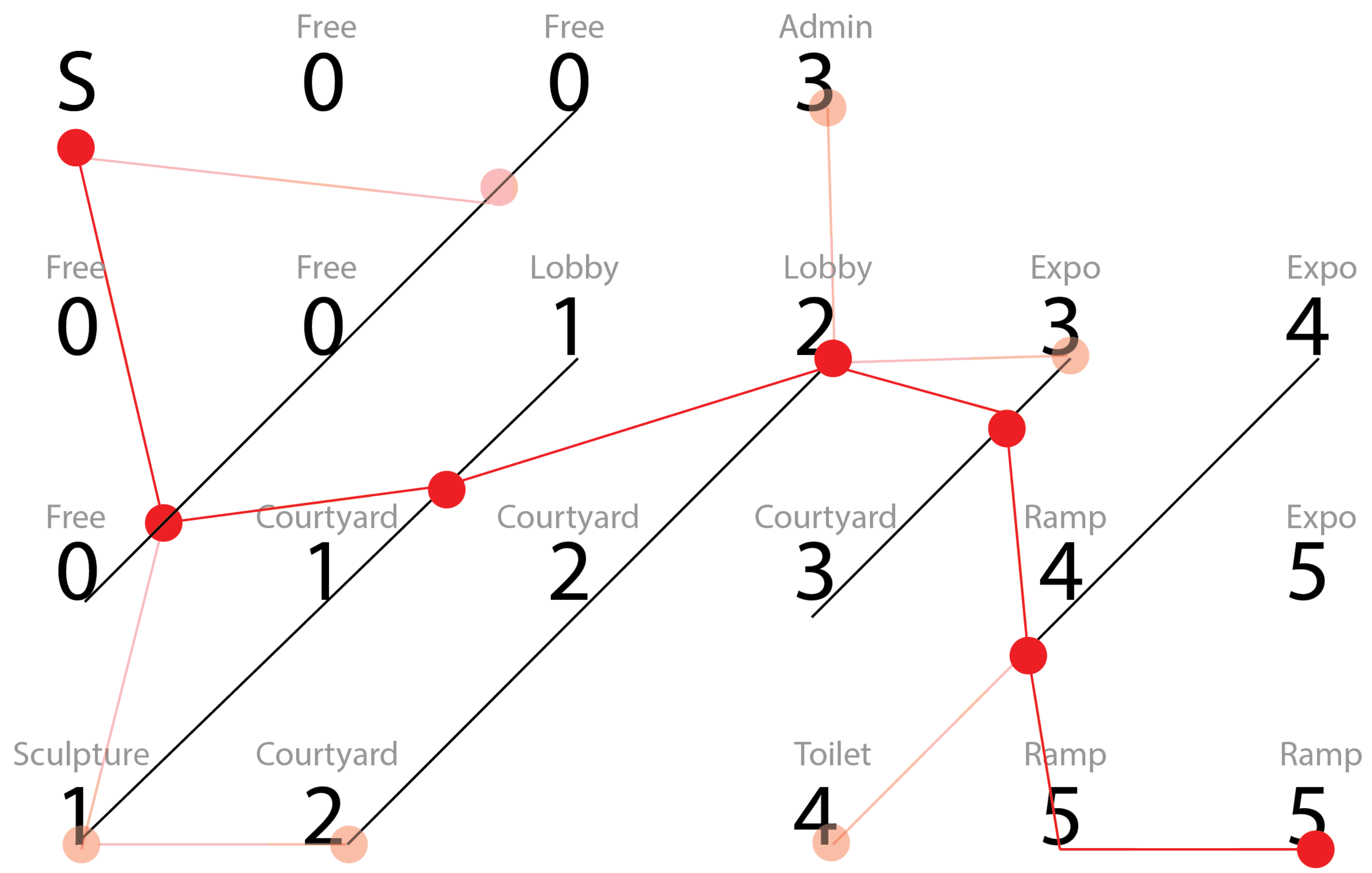
Afterwards, the person sees and walks towards the lobby, passing through the courtyard. The design process with this logic and script “5.11_Cellular Automata_SpacePlanning” requires parallel sketching, imagining the ideal path of the user and eventually creating an herarchy.



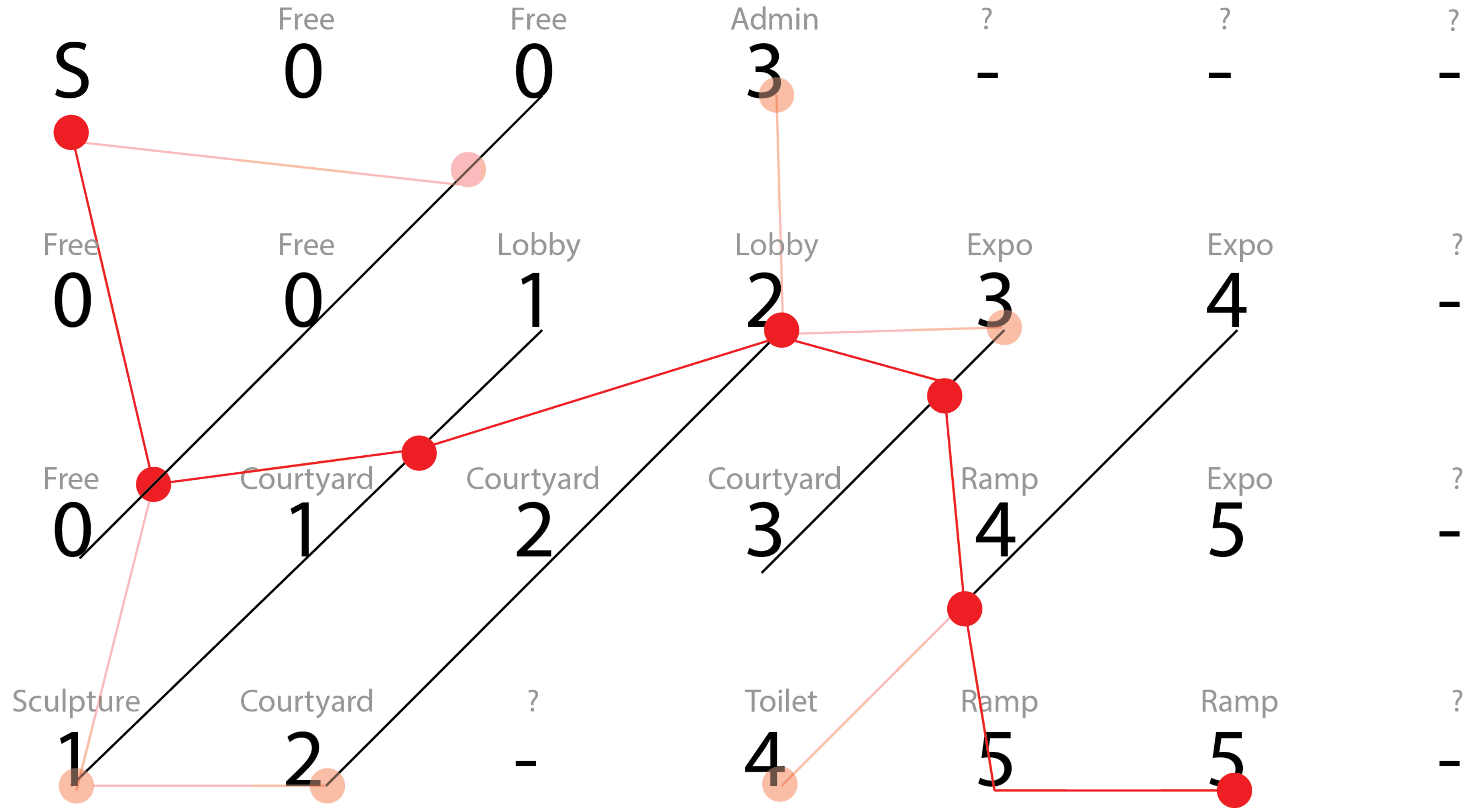
The chain continues and with it the further definition of spatial paths and relations, as far as the grid allows for.



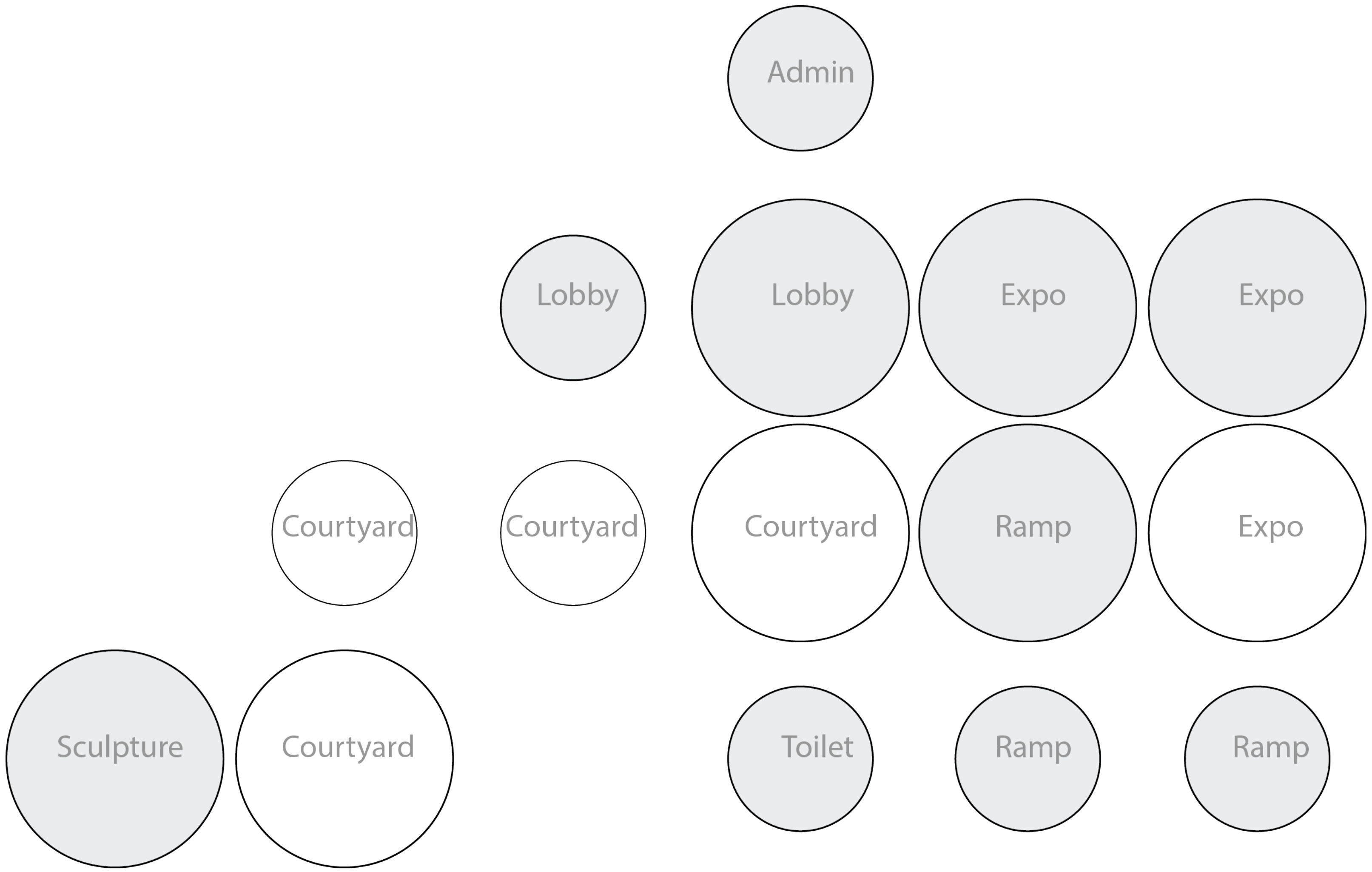
S
Free
0
Free
0
Admin
3
Free
0
Free
0
Lobby
1
Lobby
2
Expo
3
Expo
4
Free
0
Courtyard
1
Courtyard
2
Courtyard
3
Ramp
4
Sculpture
1
Courtyard
2
Toilet
4



The script allows for changes in the initial iterations, although with consequences on all the following iterations. The designer can change at any given moment, the location of the person at an iteration, by choosing two points creating a line and controlling the position of the person on that same line.

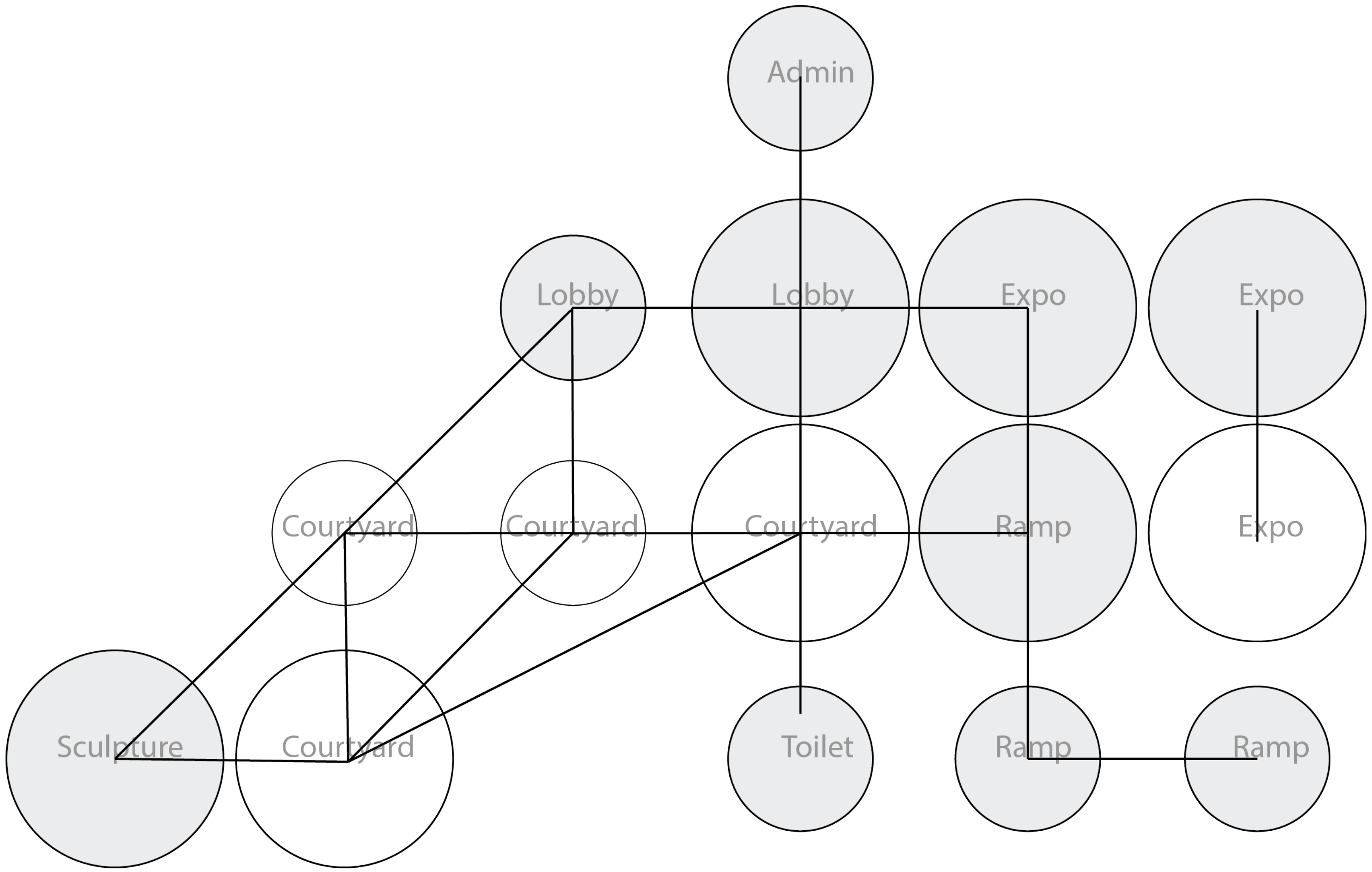


The more detailed the designer can define this space the better. Important is to keep rethinking the alternative required possibilities the person should have, as well as the orientation and position of each function in the field.



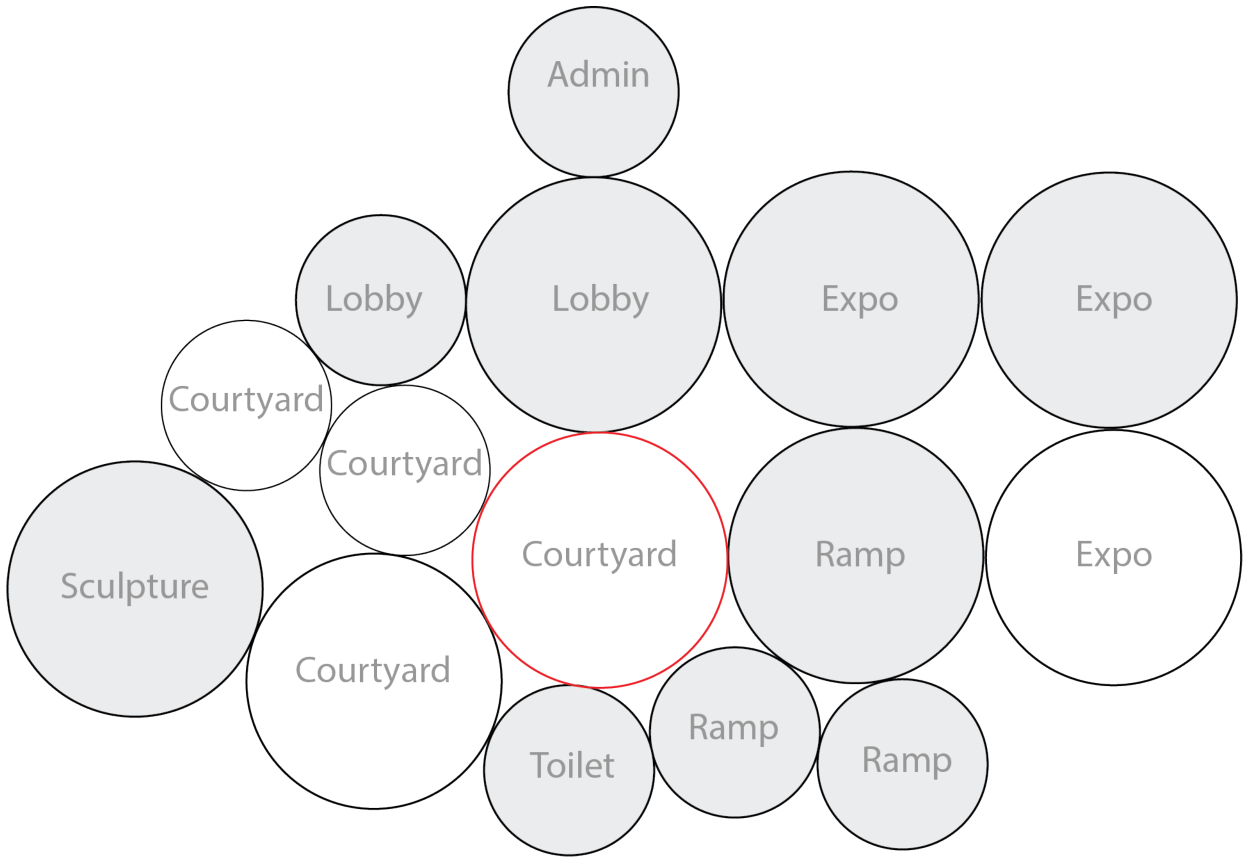
Each cell can then be assigned with a space boundary, which can again be systematised in modular units of different sizes. In this case, circles of 3, 2 and 1m radius, translated of the required space for each activity.

Spatial definition



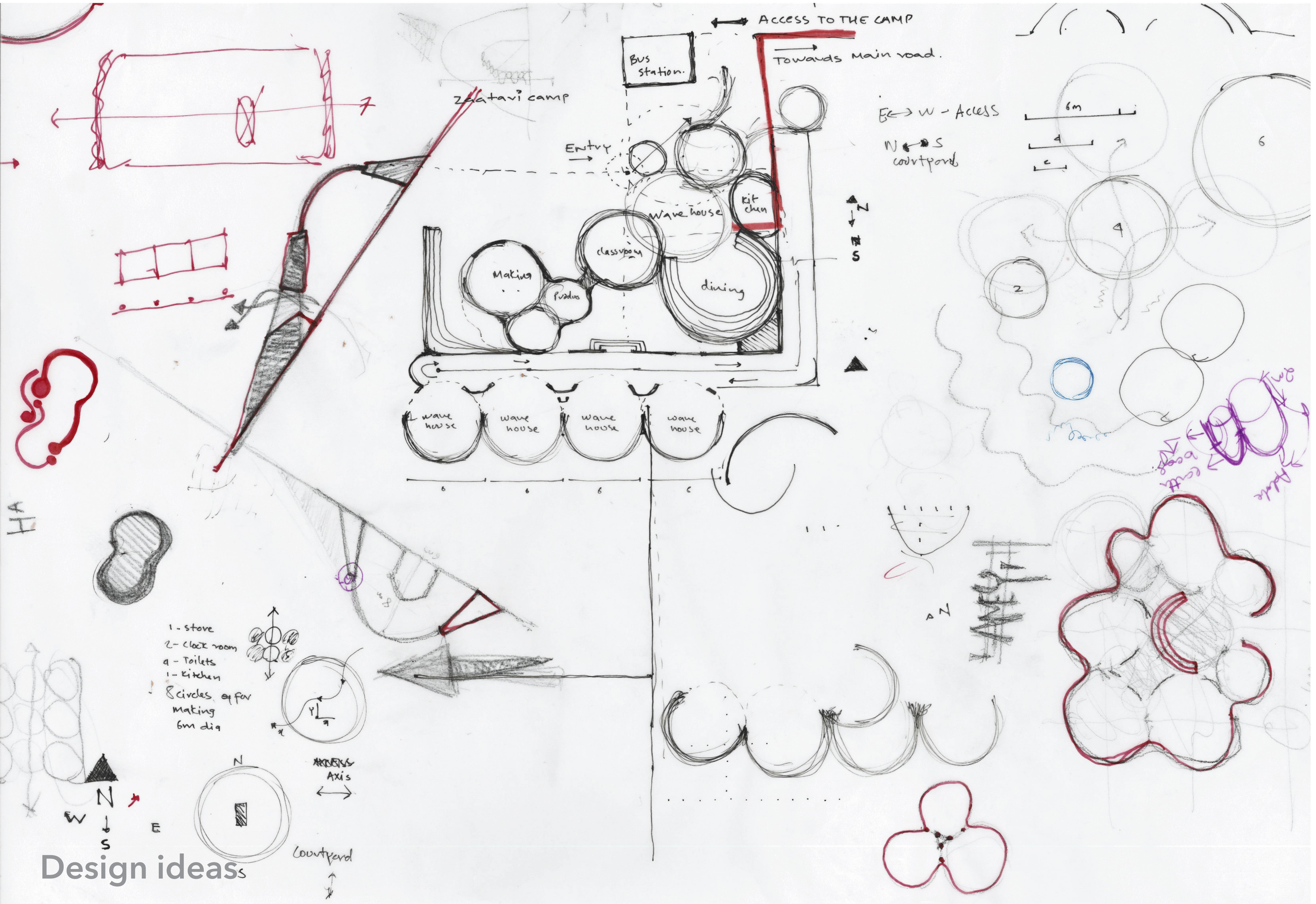
All connections can be derived from the relations of the generated spaces and so all possible paths can be visualized and confirmed.

Connections



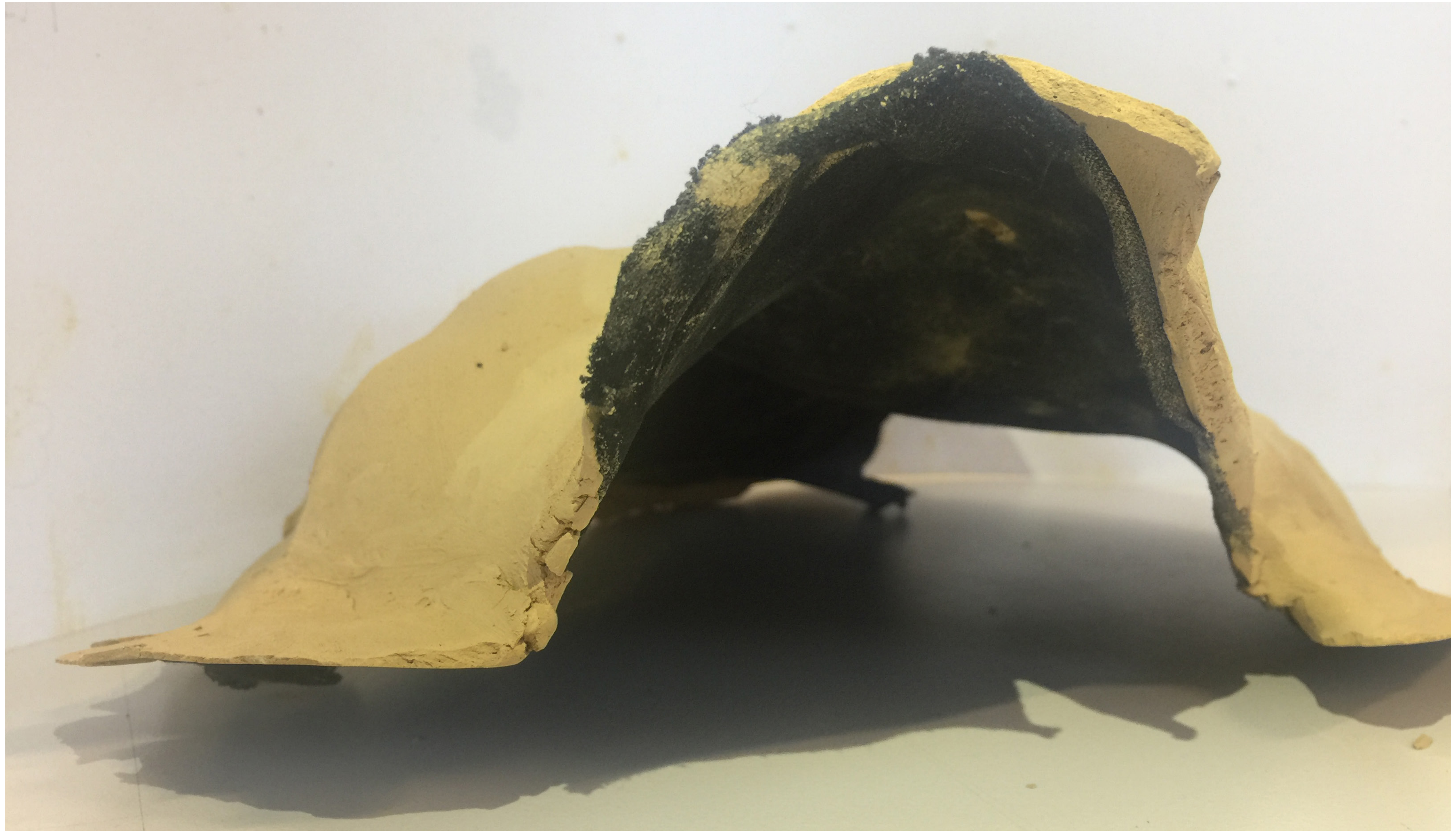
Finally, all spatial boundaries are then compacted together breaking the rigid grid structure. Furthermore, with the output and positioning of the curves, there is the further possibility of defining in more detail the boundary, inside spaces and openings. In this case, the logic was applied and further developed manually.

Compaction

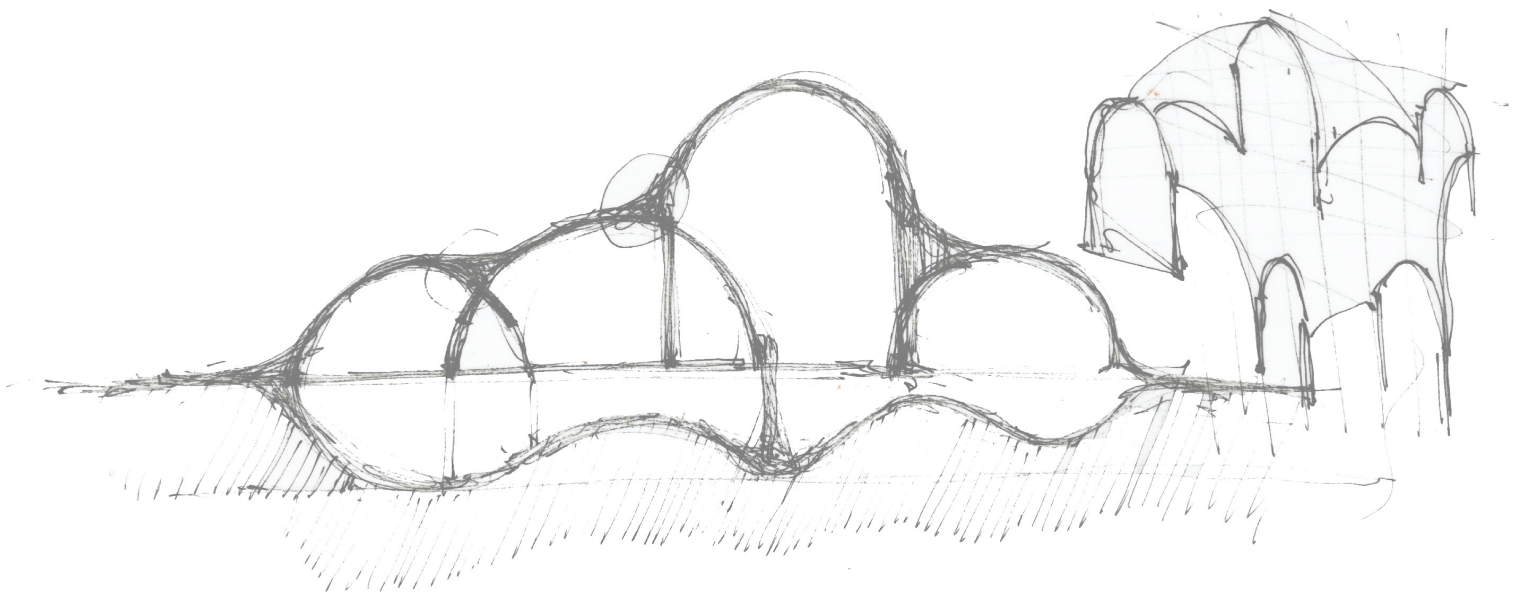


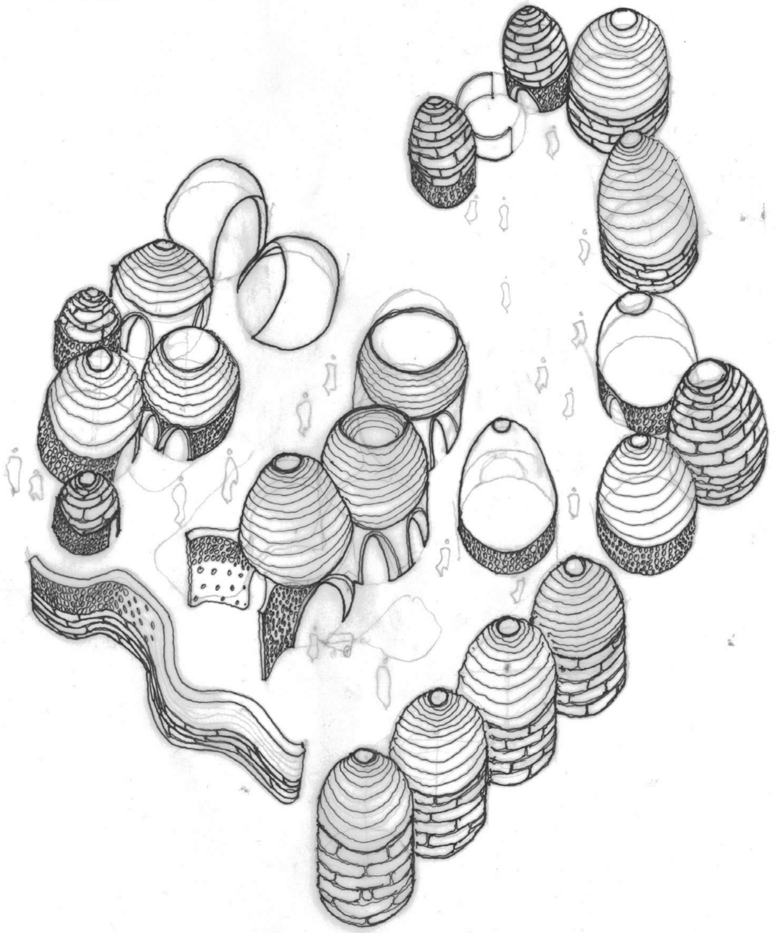
Design ideas

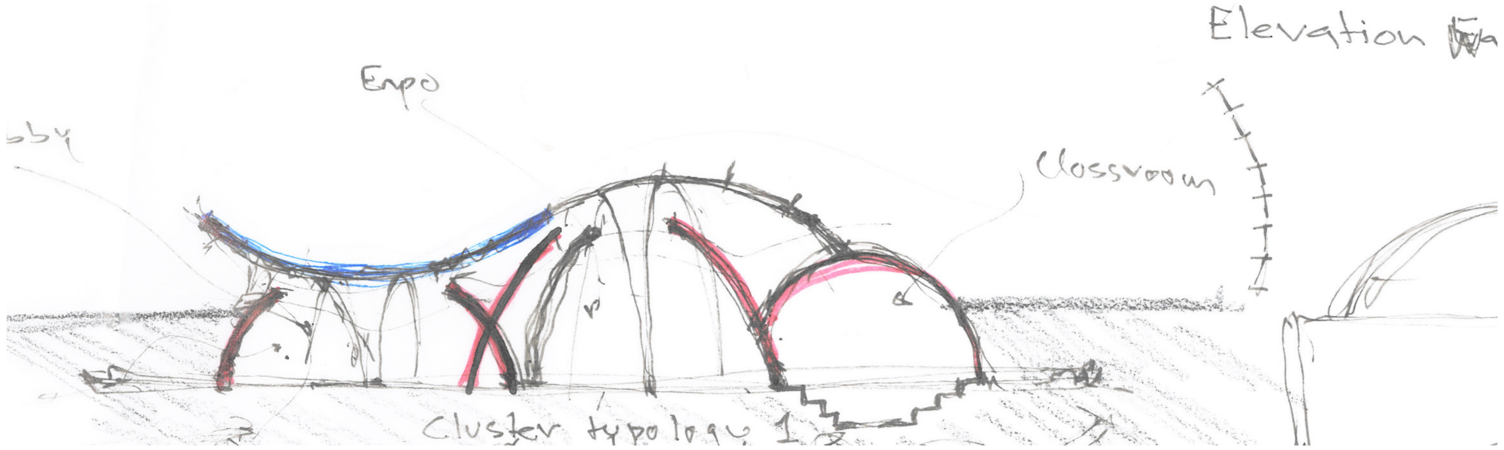
Process models

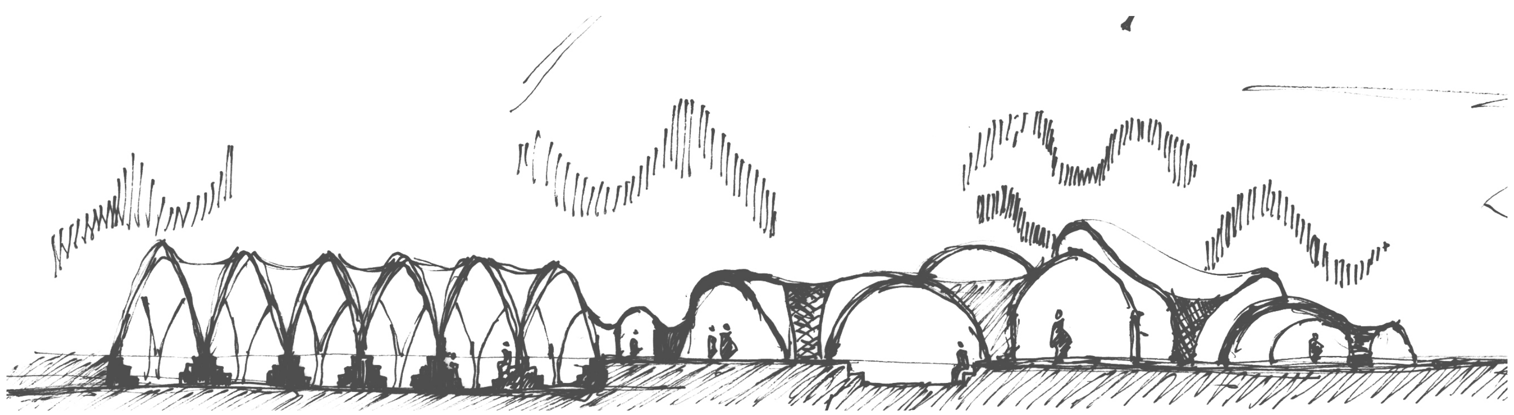


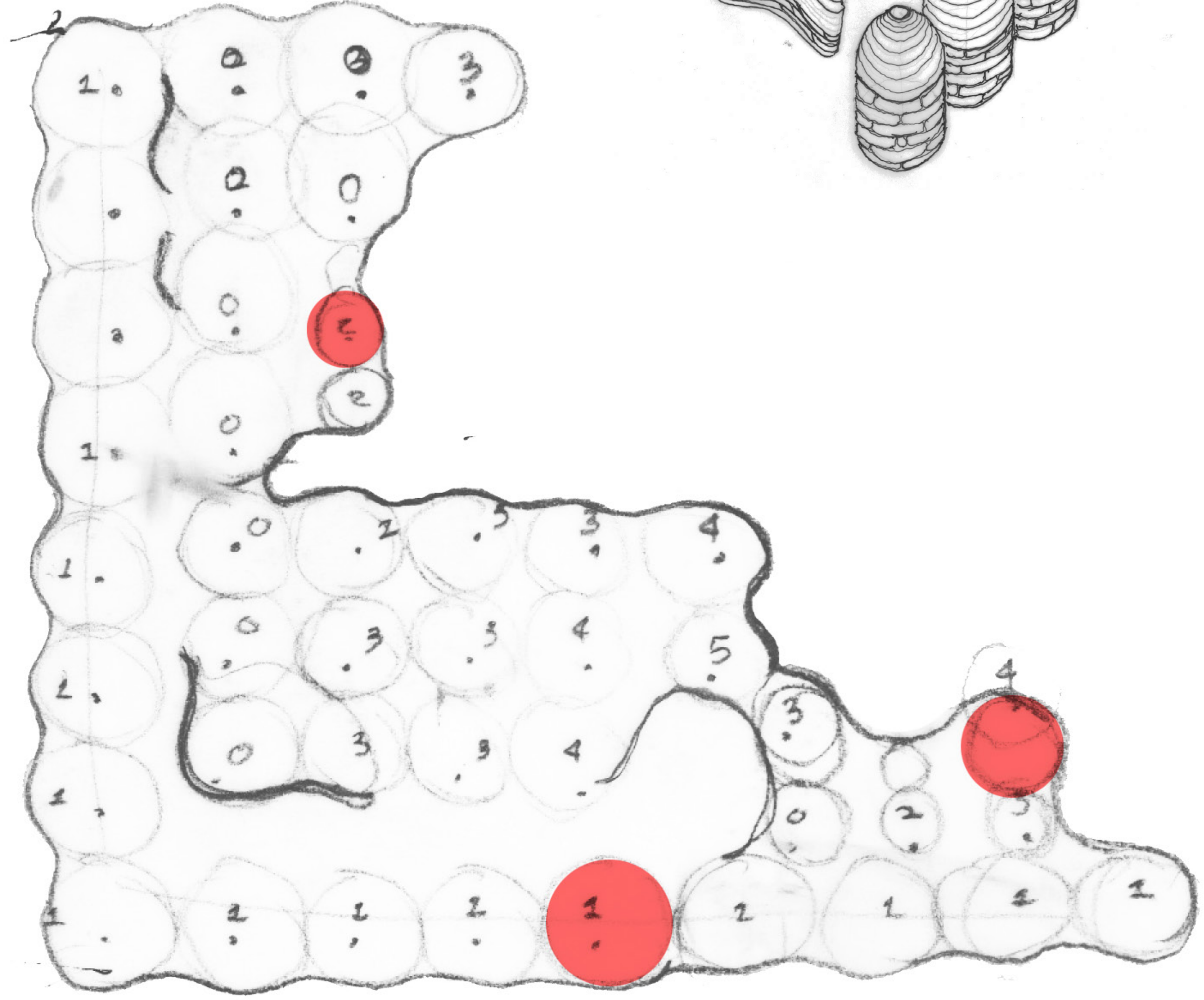
Process models



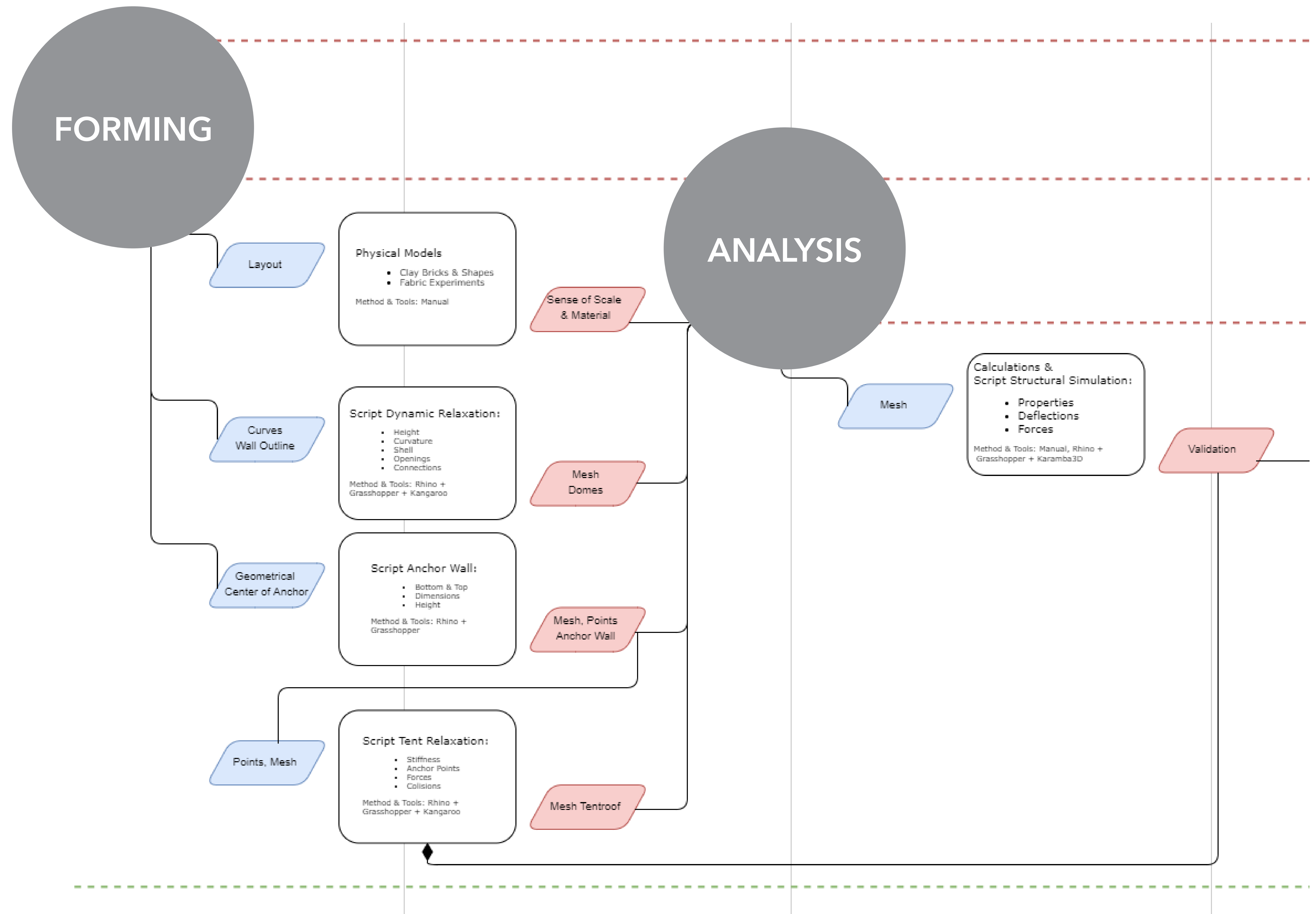


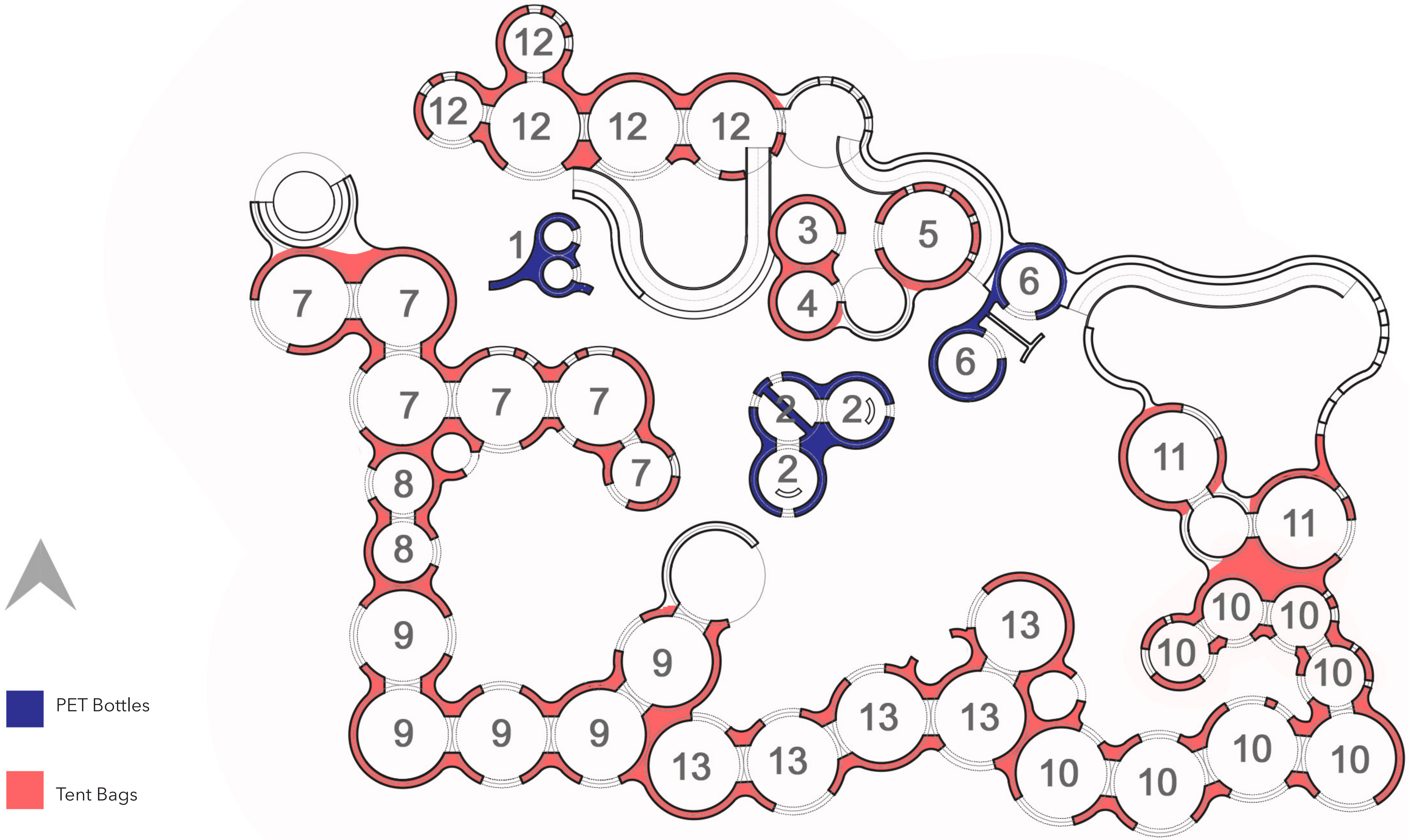






Conceptual sections


FORMING
ANALYSIS
Layout
Physical Models
Clay Bricks & Shapes
Fabric Experiments
Method & Tools: Manual
Sense of Scale & Material
Curves Wall Outline
Script Dynamic Relaxation:
Height
Curvature
Shell
Openings
Connections
Method & Tools: Rhino + Grasshopper + Kangaroo
Mesh Domes
Geometrical Center of Anchor
Script Anchor Wall:
Bottom & Top
Dimensions
Height
Method & Tools: Rhino + Grasshopper
Mesh, Points Anchor Wall
Points, Mesh
Script Tent Relaxation:
Stiffness
Anchor Points
Forces
Collisions
Method & Tools: Rhino + Grasshopper + Kangaroo
Mesh Tentroof
Mesh
Calculations & Script Structural Simulation:
Properties
Deflections
Forces
Method & Tools: Manual, Rhino + Grasshopper + Karamba3D
Validation



The plan has been developed on the basis of a grid. Since the plan is composed of multiple geometries (circles), a nomenclature system was set up depending upon the individuality or connectivity of the domes. Cluster of domes which were attached with the arches behaved as a single mesh and considered one unit for process of forming and structural analysis, while those that were separate were considered individually.
The plan shows the nomenclature for the 13 clusters of domes and the colour represents their construction material.

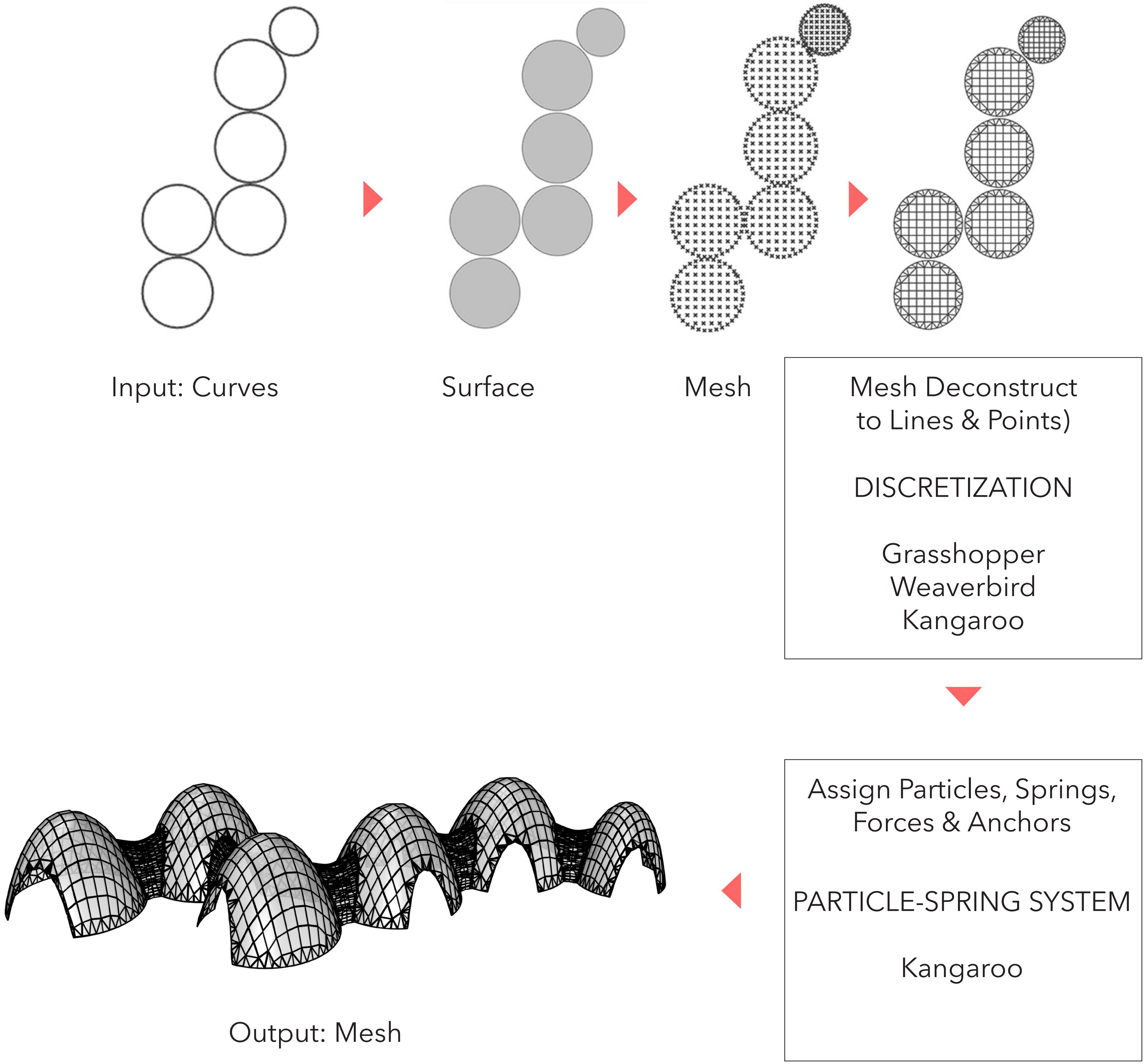
Structural Analysis: Domes

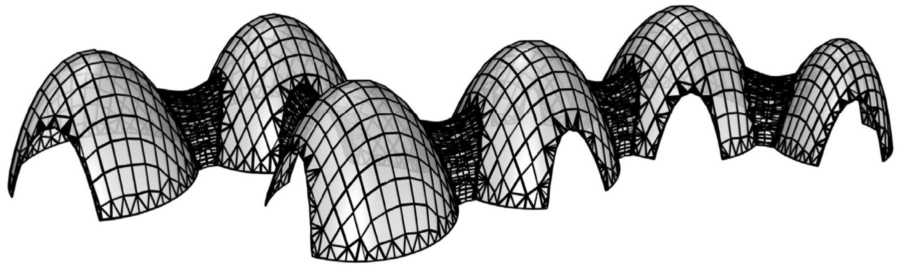
Dynamic Relaxation

The particle spring system has been used to form find the compression only dome structures. Hooke's law is the driving principle behind the simulations made by using Kangaroo (plugin for grasshopper).

Three elements were generated by kangaroo for the form generation, they include use of cable catenary-simulation for generation of arches and door openings and shell simulation for the domes.

An example of dome element of kangaroo workflow is illustrated herewith. Additionally, the different mesh configurations, i.e., mesh with or without diagonals can be tested for varying results. Also, the density of the vertices affects the smoothness of the mesh and the overall form.

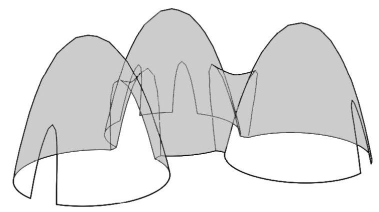




MATERIAL PROPERTIES

Density
Young's Modulus
Poisson's Ratio
Compressive Strength

Input: Mesh from Kangaroo



X 13 GROUPS

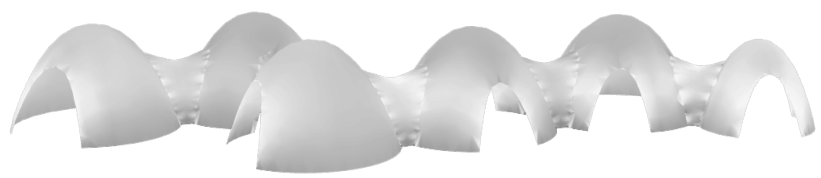
Analyse groups of domes for:

1. Deformation
2. Compressive Strength

Karamba

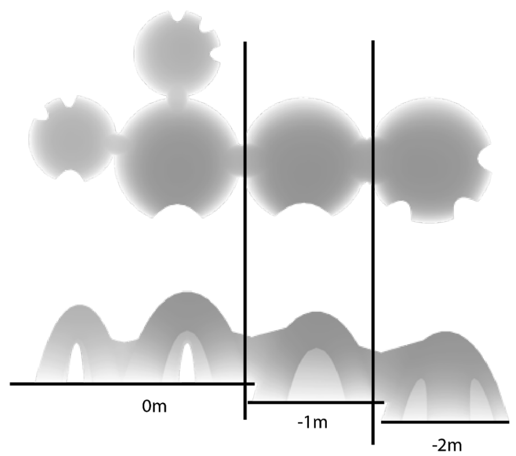
Pass — 9 GROUPS

Fail — 4 GROUPS



GROUPS 7, 9, 10:

Modify height & opening size



GROUP12:

Split group into separate domes

Modified Mesh

The finite element analysis (FEA) method has been used for the structural analysis using the grasshopper plugin Karamba.

The structural properties of the building materials- adobe and earth filled bottle have been used from the lab tests, while that for earth bag has been used from literature research.

The forms that was the output from dynamic relaxation of kangaroo was analysed for deformation and compressive strength. 9 out of 13 clusters passed the tests while the other 4 (group 7,9,10&12) had to be modified for structural stability.

Structural Analysis: Overview

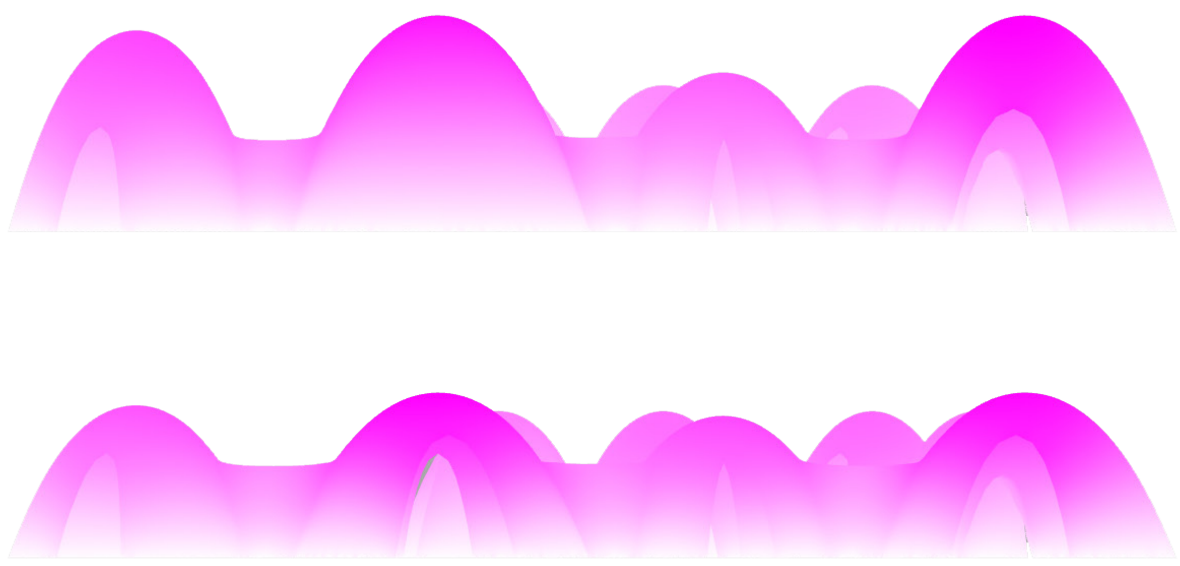
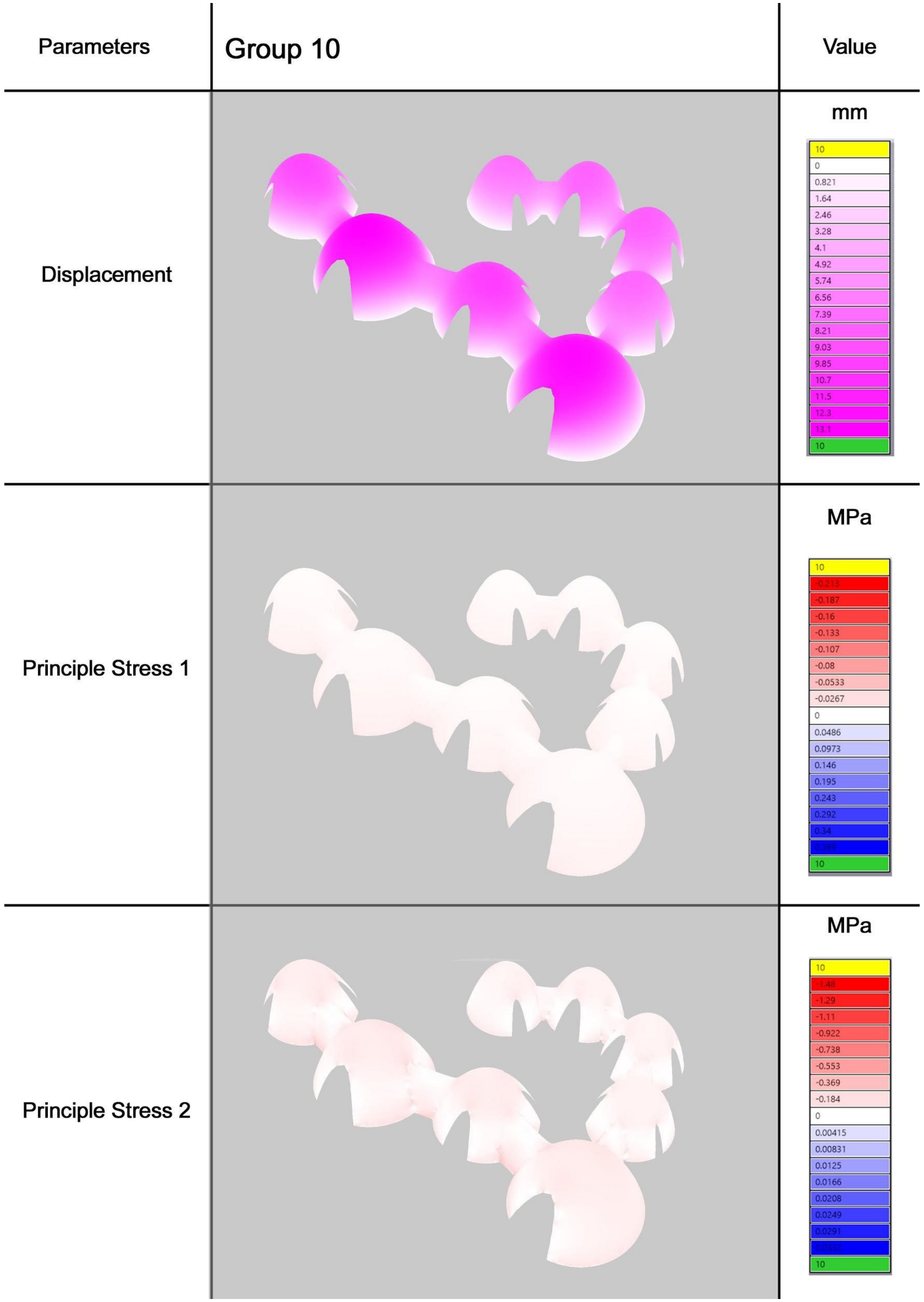


Table.2 Group 10 Optimisation

Varible	H [m]	Zd [mm]	XYd [mm]	Disp. Z [mm]	Disp. XY [mm]	σc,max [MPa]	σt,max [MPa]	ULS	SLS
(origin)	4.69	15.62	6.69	15.90	3.40	1.5566	0.6023	✓	×
Opening size	4.69	15.62	6.69	16.26	2.59	2.0300	0.8901	×	✓
Height	3.59	11.96	5.13	11.66	2.19	1.5582	0.5585	✓	✓

As in case of group 10, changing the opening sizes and adjusting the number of openings did not help in significant reduction in deformations. Thus, the overall height of the domes had to be reduced from 4.69m to 3.59m for the deformation results to fall within permissible limits.

Structural Optimization: Group 10



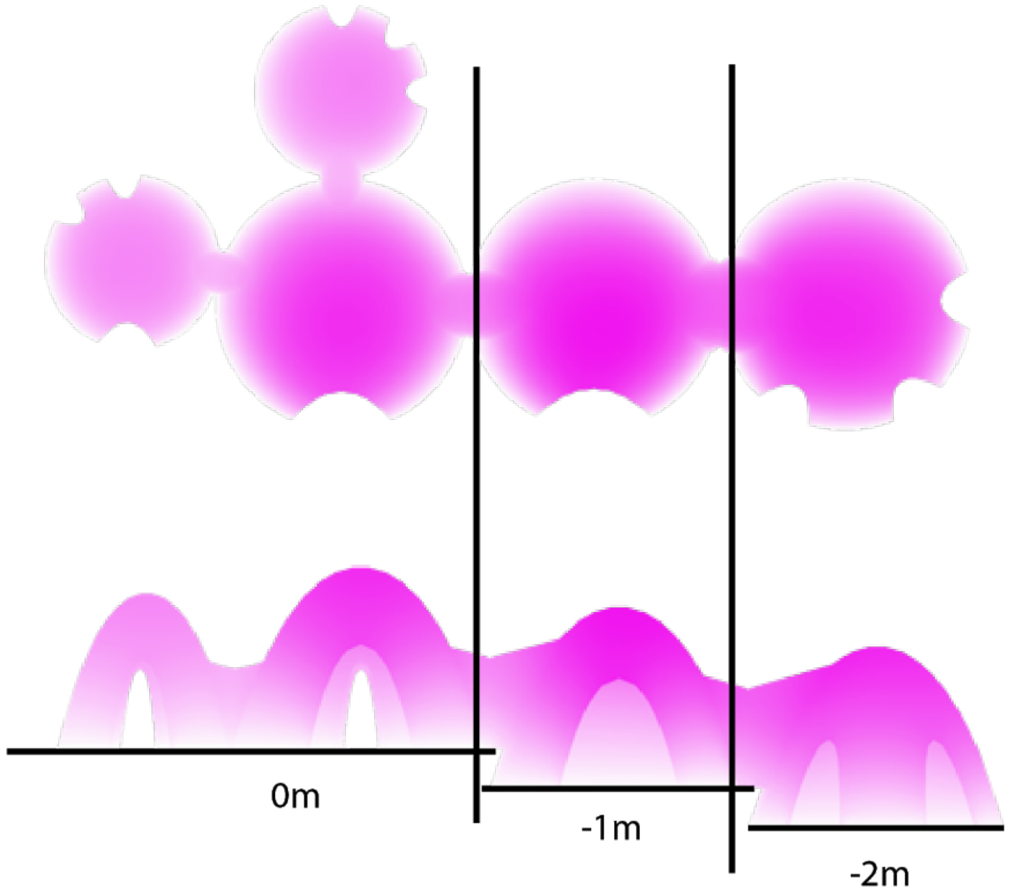
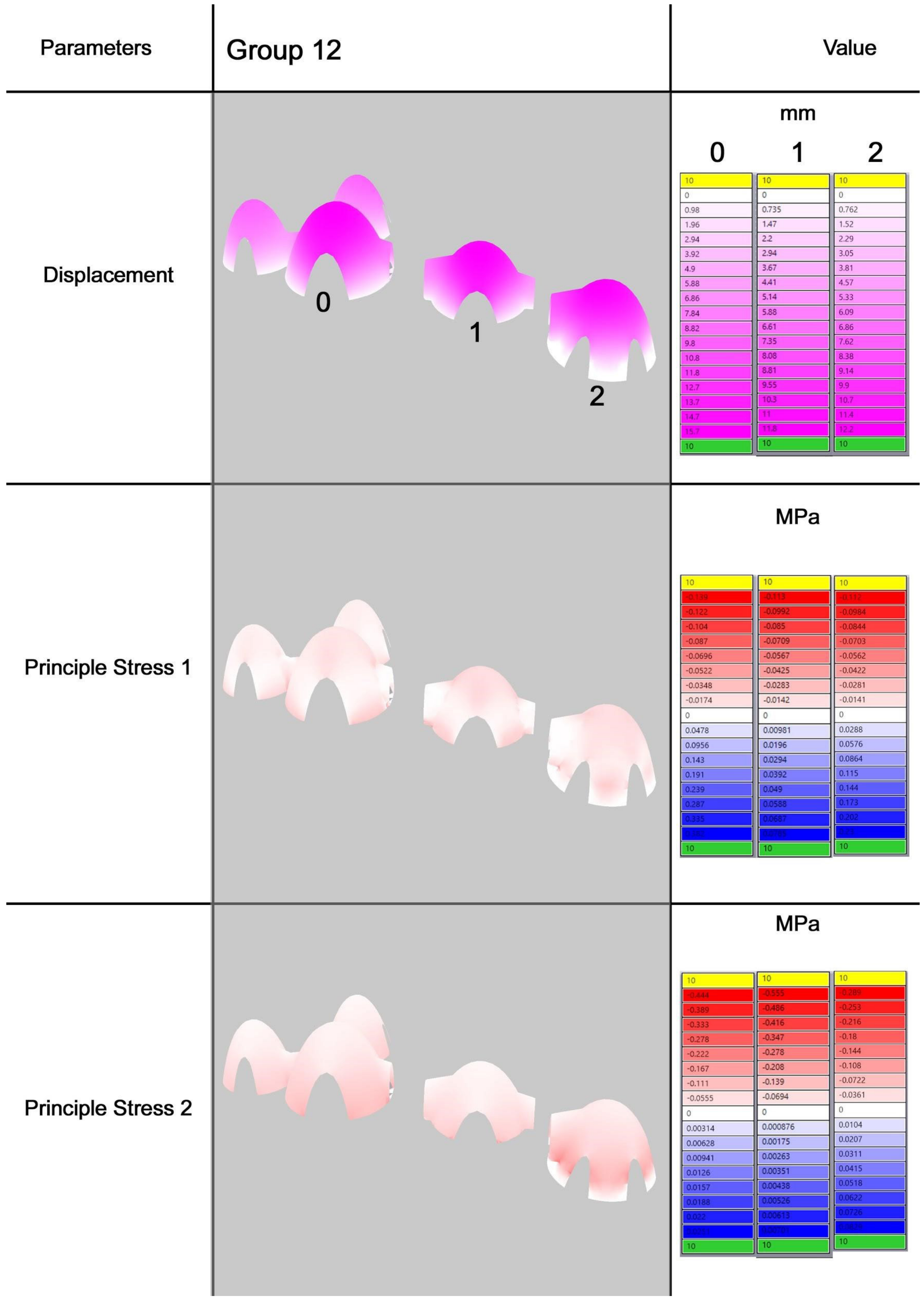
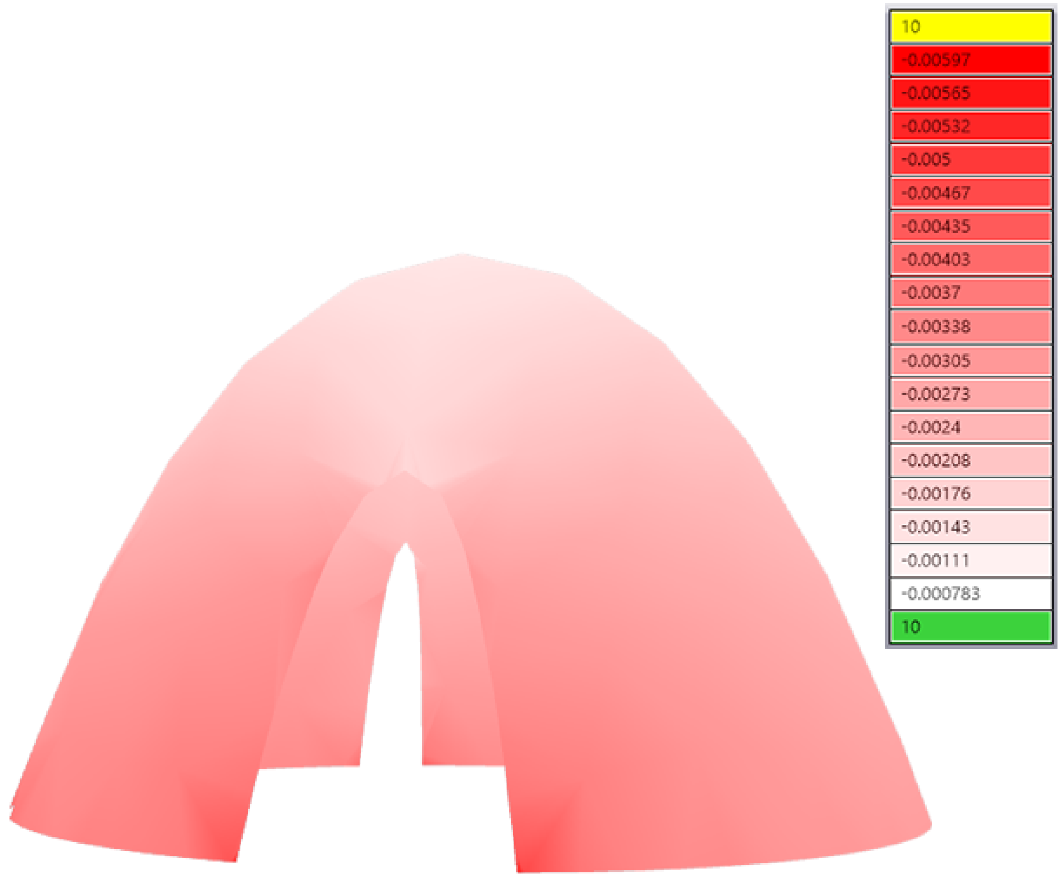


Table.3 Group 12 Optimisation									
Varible (Ground level)	H [m]	Zd [mm]	XYd [mm]	Disp. Z [mm]	Disp. XY [mm]	σc,max [MPa]	σt,max [MPa]	ULS	SLS
(origin)	4.57	15.23	6.53	16.62	5.65	1.9806	0.2907	×	×
0m	4.57	15.25	6.53	15.41	3.42	0.4759	0.4389	✓	✓
-1m	4.57	15.25	6.53	11.56	2.72	0.5027	0.0348	✓	✓
-2m	4.57	15.23	6.53	12.10	2.93	0.18	0.0702	✓	✓

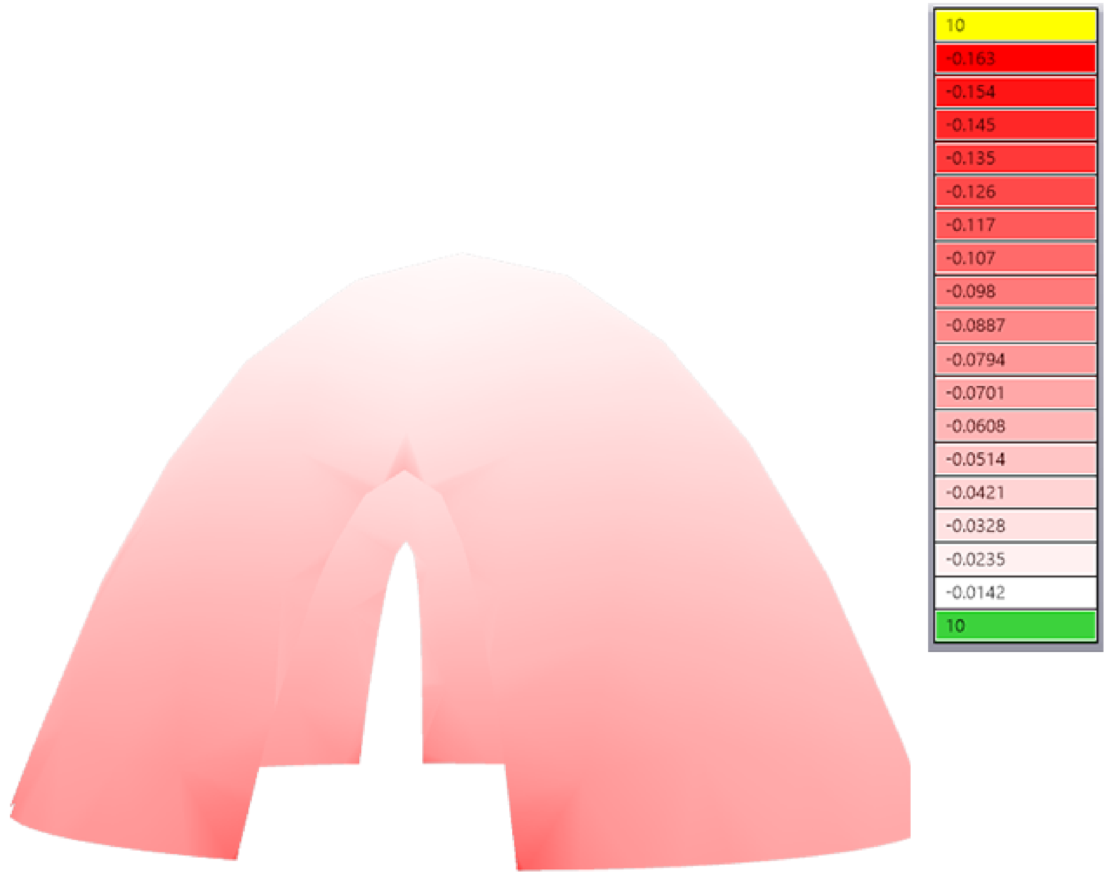
The domes in group 12 were located at three levels 0, -1 and -2m. Analyzing the three domes together at different levels for structural stability were creating stress concentrations and excessive deformations. Thus, the domes were split and analyzed separately.

Structural Optimization: Group 12





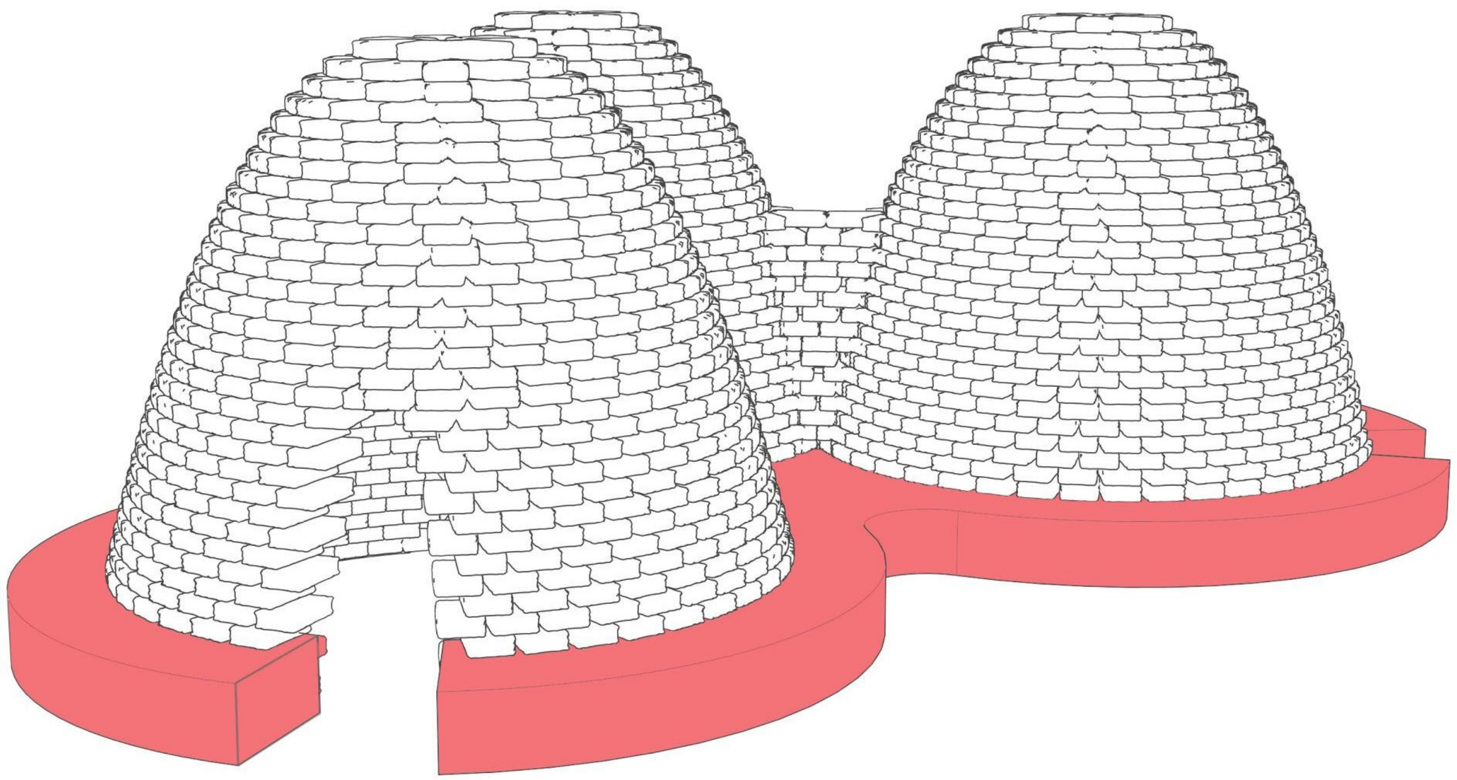
Principal Stress 2 under live load（MPa）
Group 5



Principal Stress 2 under self-weight（MPa）
Group 5

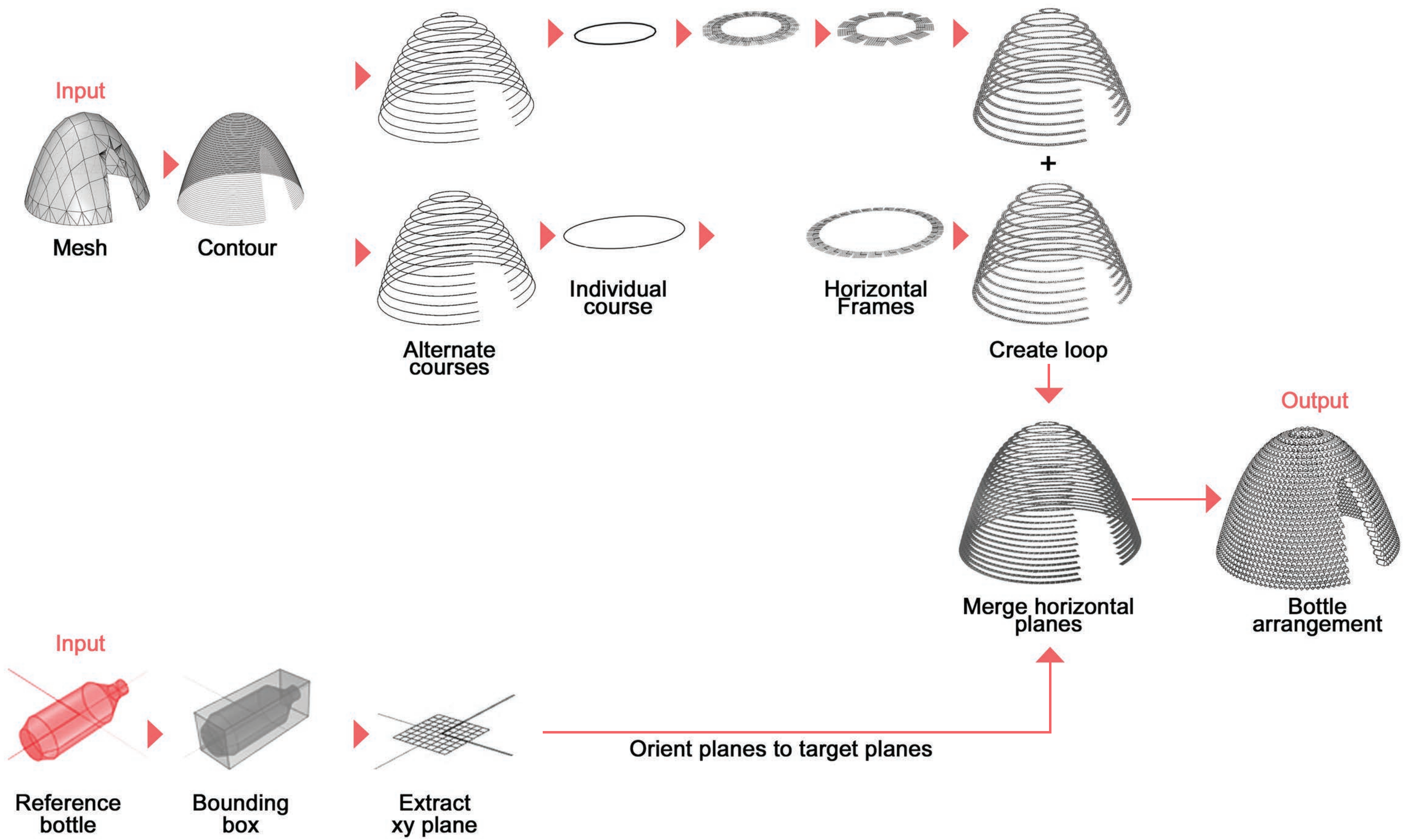
It can be seen from the image that the principle stress for self-weight is prominent than that for live loads in the domes. Thus, the stress concentrations were mainly due to self-weight, with concentrations at the bottom edge. This was because in the initial design the anchor points were located at the edge of the mesh.

Structural Results

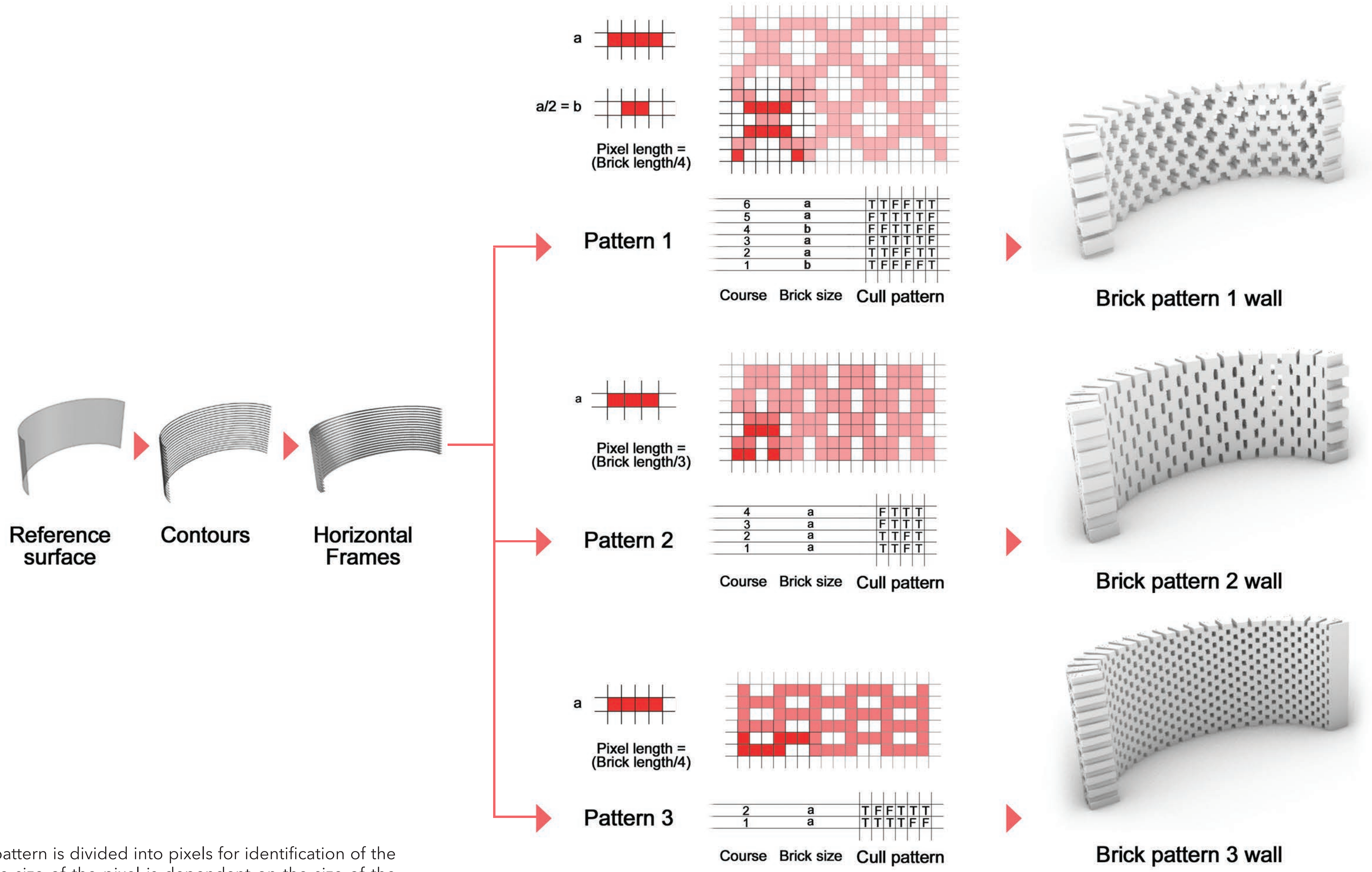


To increase the stability and reduce the problem of stress concentration at the edges, an extra 0.5m high plinth was added. This helped in distribution of loads on a larger surface area as compared to an edge. These plinths were then incorporated into the architectural concept for planning creating spaces for sitting and plantation.

Design Implication

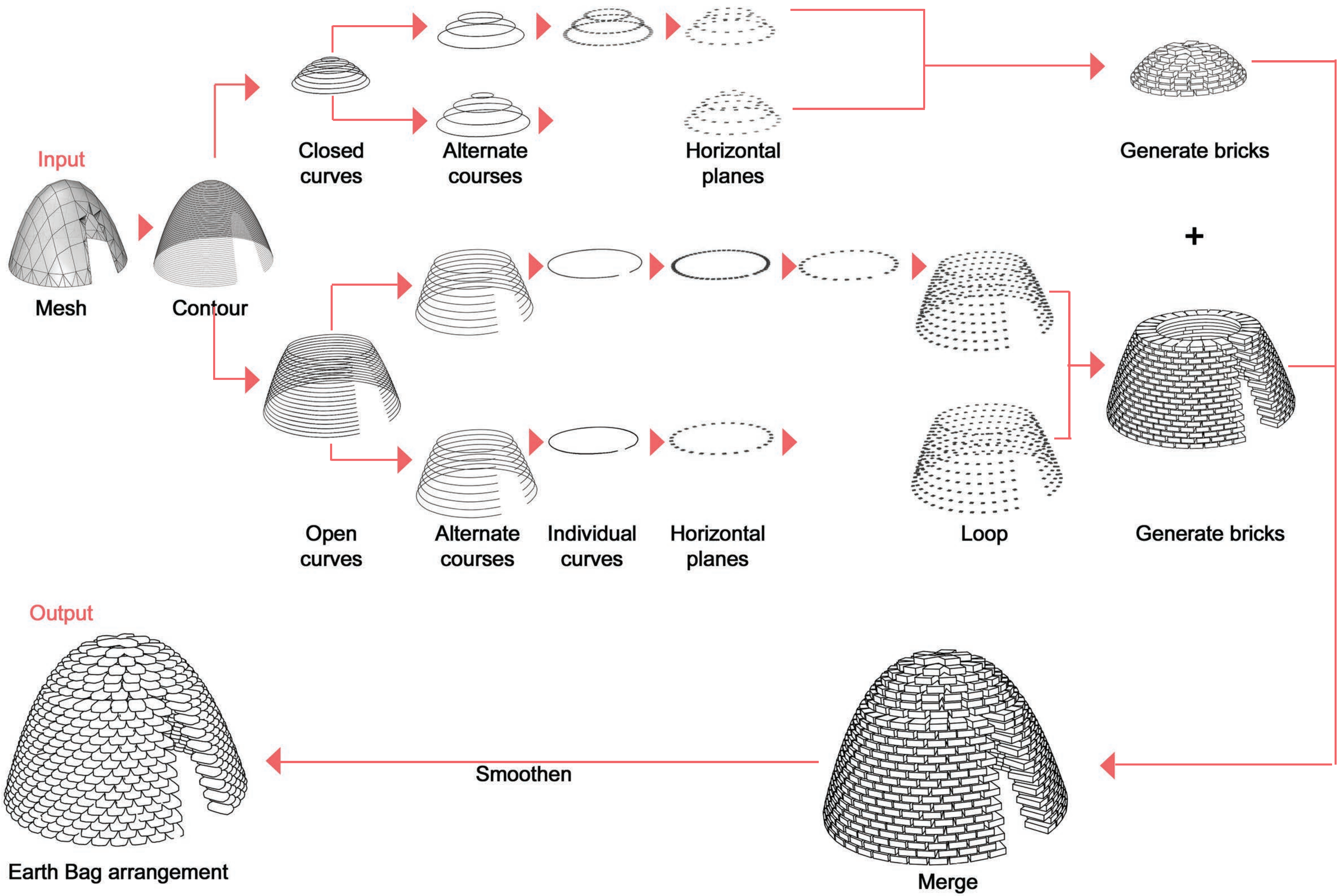


Masonry pattern: PET Bottles

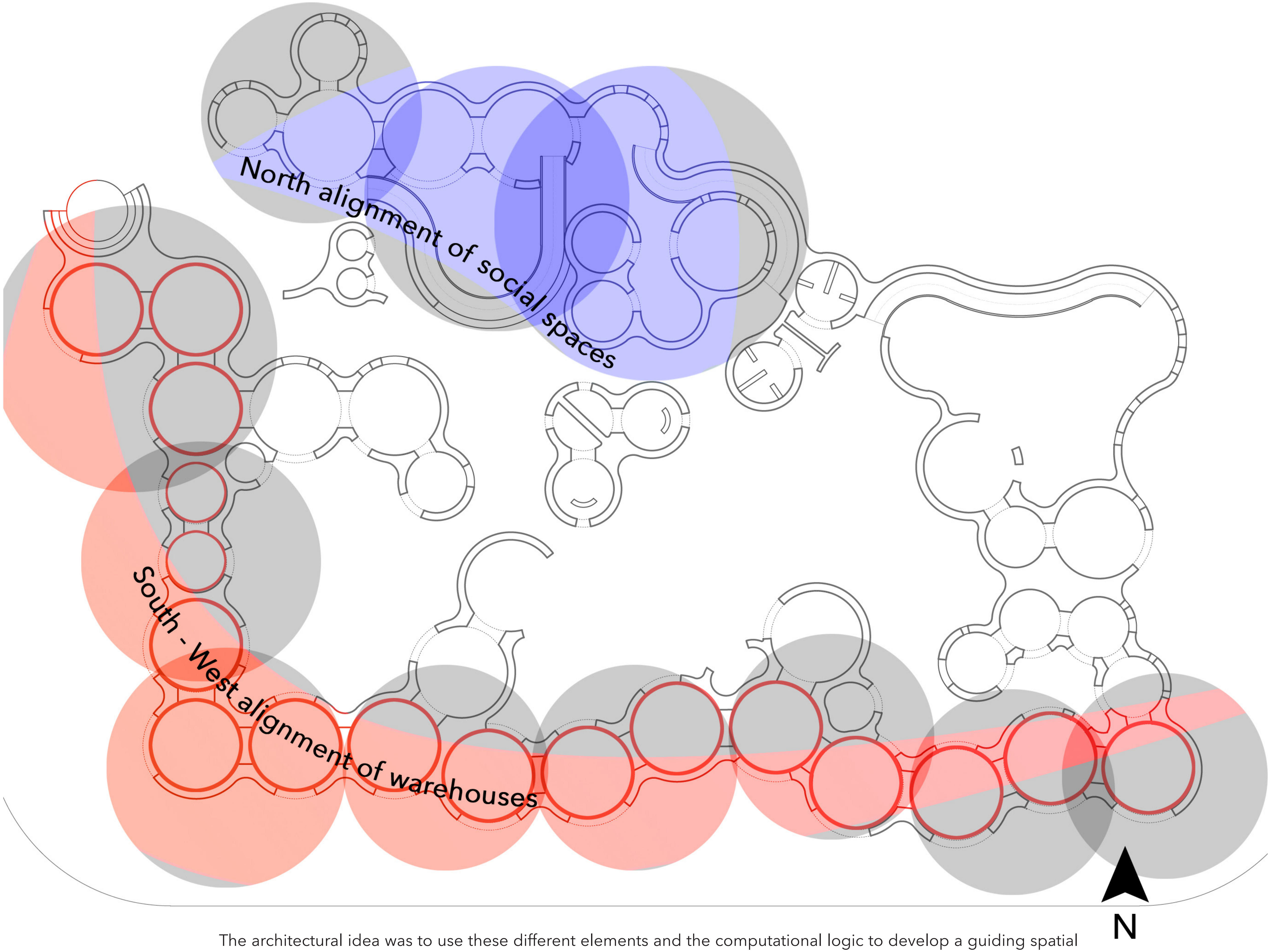


The brick pattern is divided into pixels for identification of the pattern. The size of the pixel is dependent on the size of the brick and pattern configuration. The combination of these pixels generate patterns. The pixels are combined to form a whole brick or half the size of the brick.

Masonry pattern: Adobe

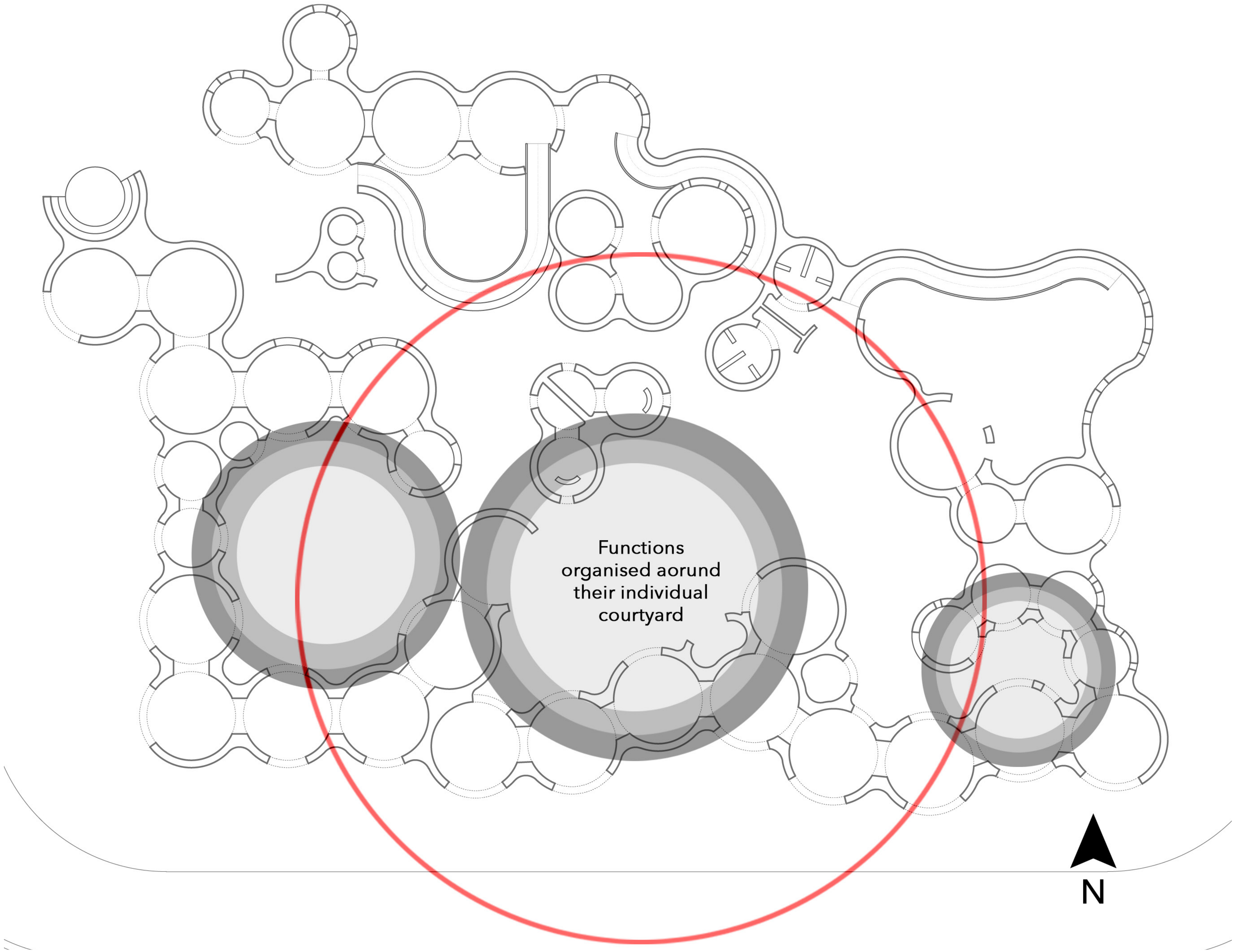


Masonry pattern: Earth Bags



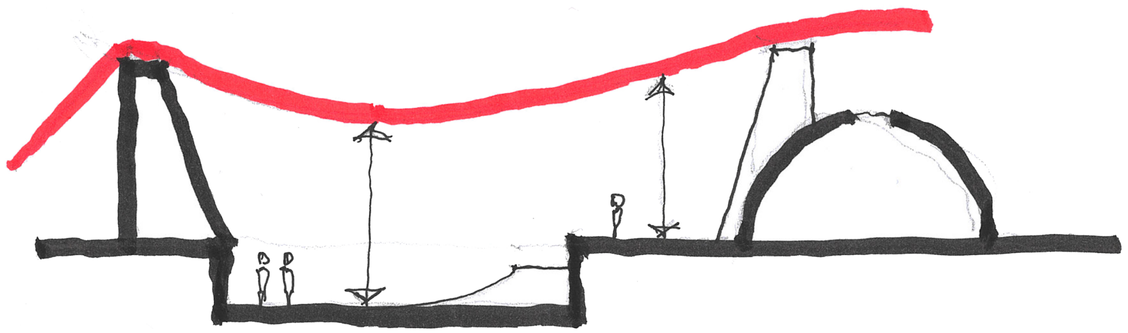
The architectural idea was to use these different elements and the computational logic to develop a guiding spatial flow for the people using different functions housed in our design. The functions, mainly the production areas/ warehouse and open to public spaces like exposition and library were strategically aligned to maintain optimum spatial conditions.
For example, spaces like the warehouses which would mostly be used for storage purposes were placed on the south-west to provide thermal buffering.

Space planning

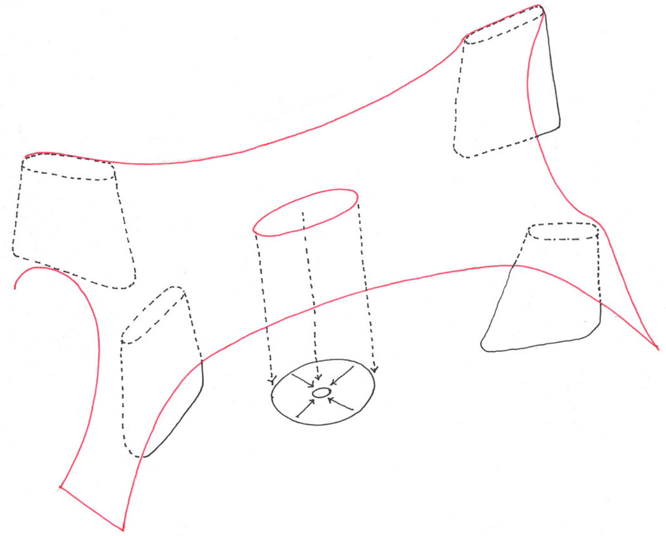


Space planning

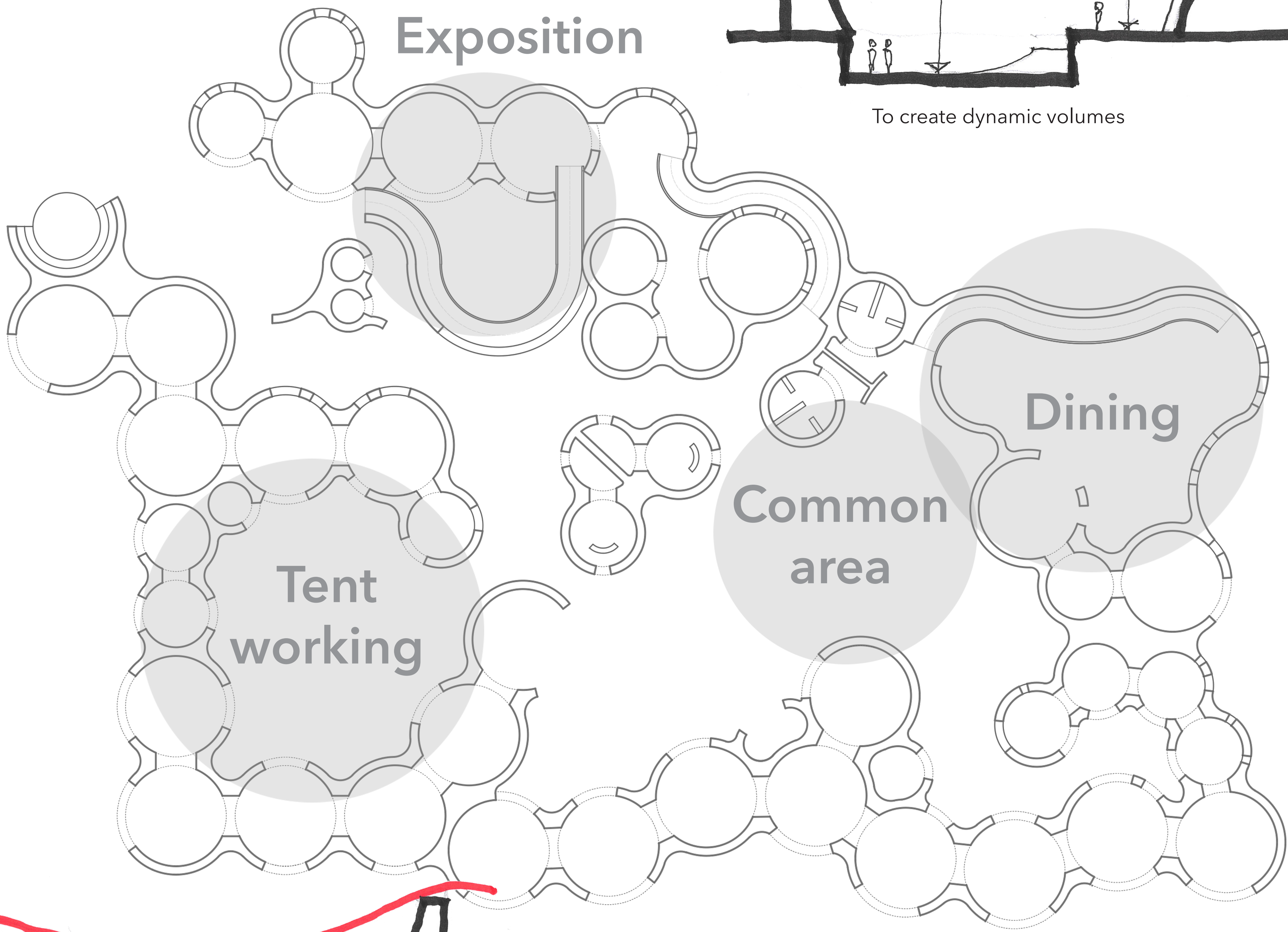
Design for production areas, that is, pet bottle filling, adobe brick making and tentbag cutting and stitching was greatly influenced by the logic of production process and were organised in such a way that each of those areas have their individual courtyard.

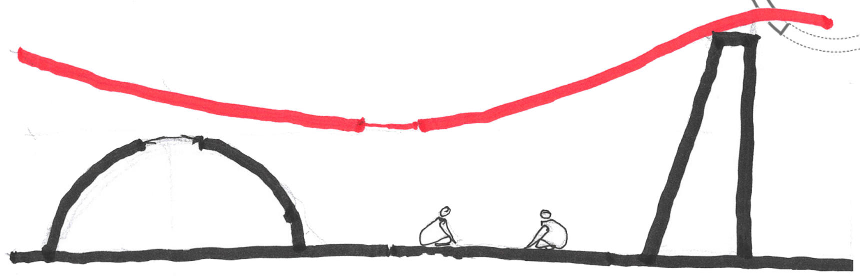


To create dynamic volumes

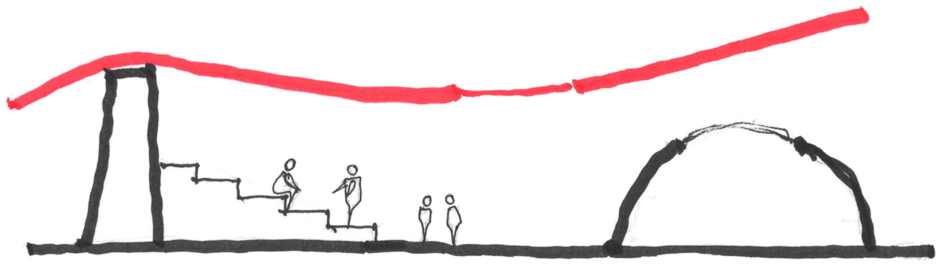


Rainwater is channeled through holes at the lowest points of the roof. The floor directly below each such opening is sloped radially to collect the water in the centre and drain it to a common tank.





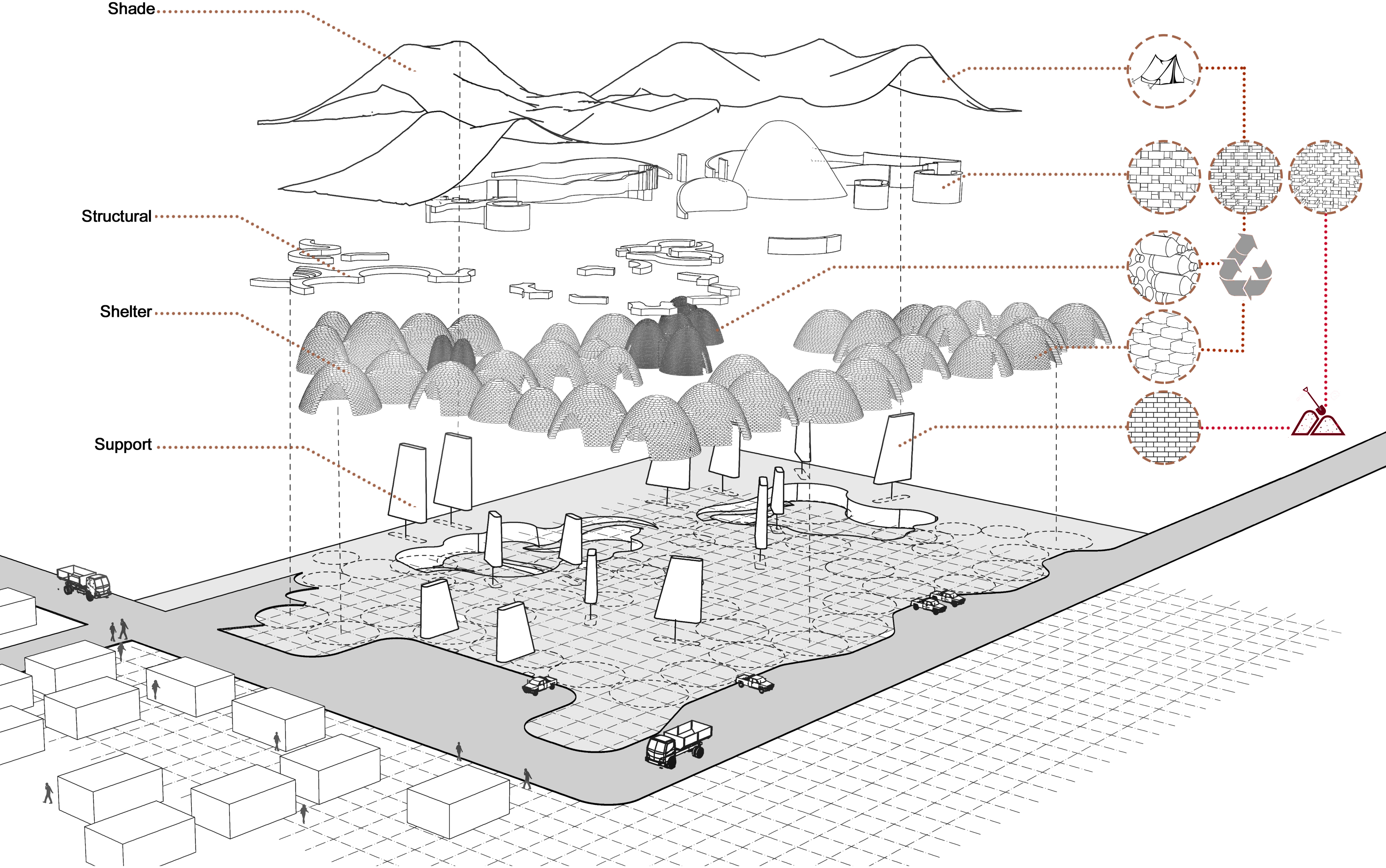
To shade a courtyard work space



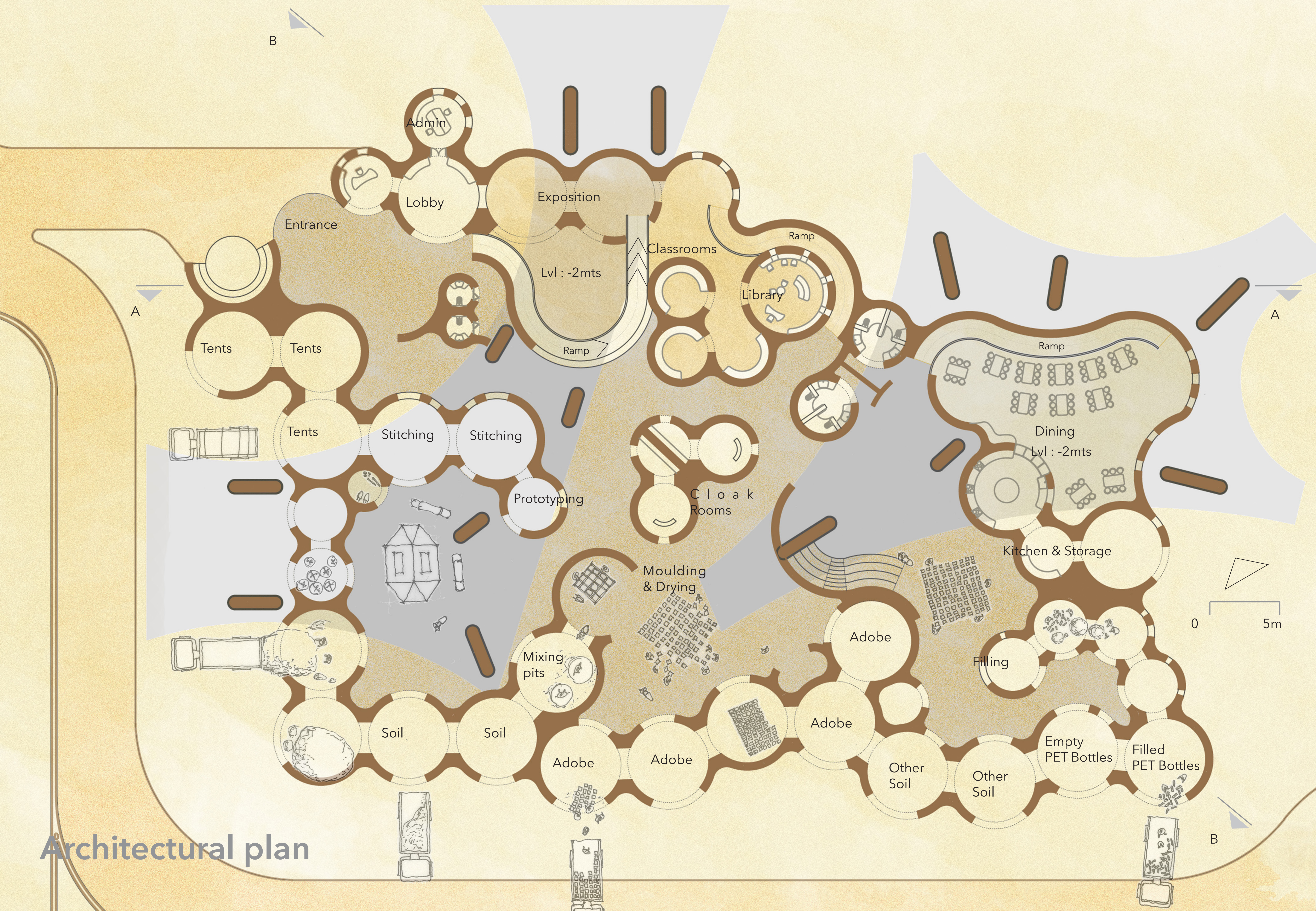
To shade a socialising space

An interesting element which was introduced in the design concept was the independent roof structure made of recycled tent bags, which was planned over different functions depending on the use.

Fabric roof planning



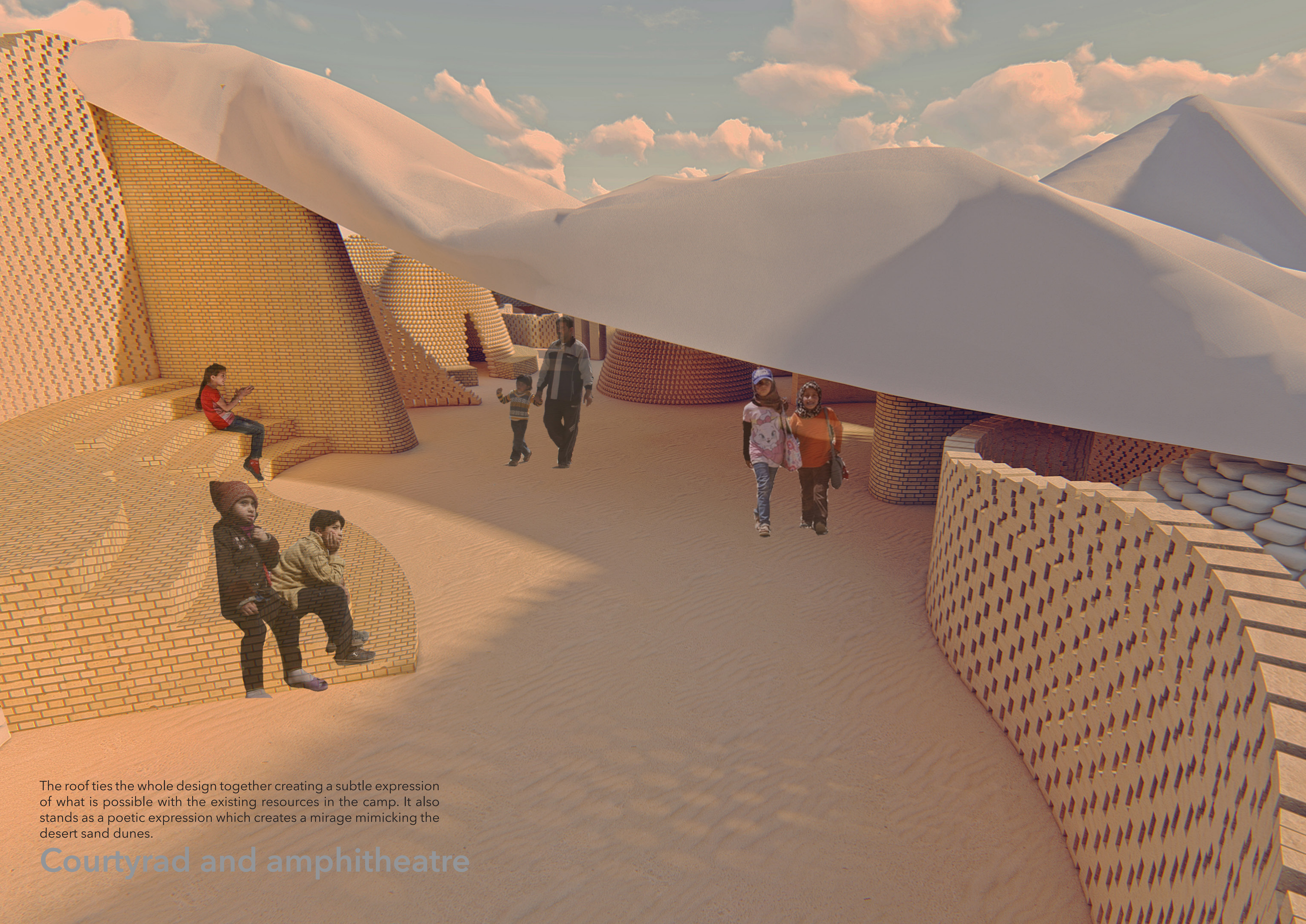
Elements of design



Architectural plan


Tentbag cutting and stitching area

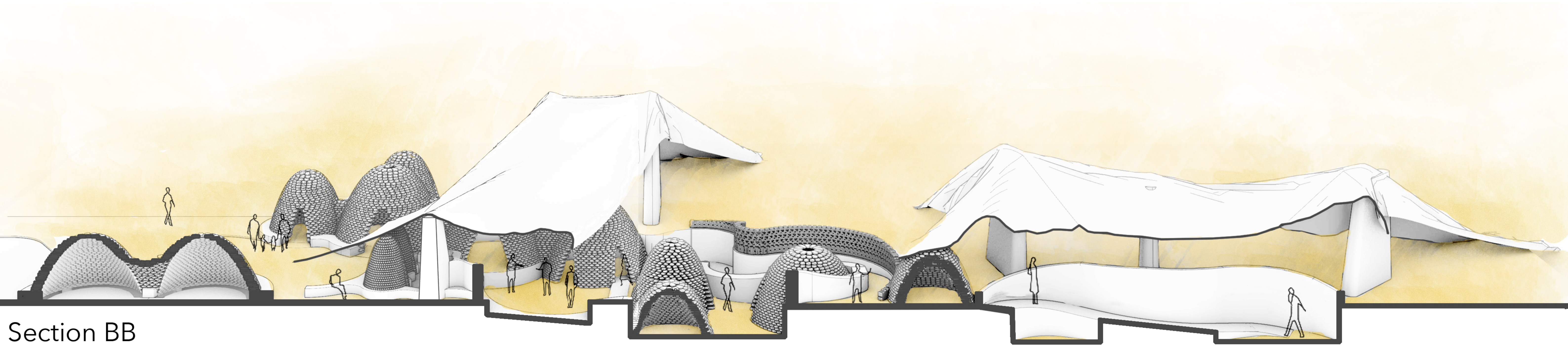

EXposition and classrooms



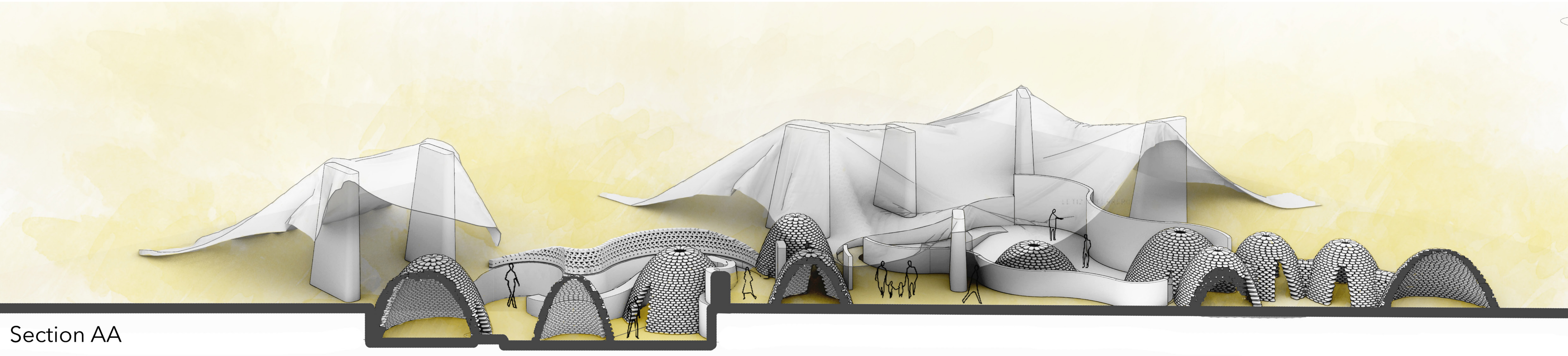
The roof ties the whole design together creating a subtle expression of what is possible with the existing resources in the camp. It also stands as a poetic expression which creates a mirage mimicking the desert sand dunes.

Courtyrad and amphitheatre

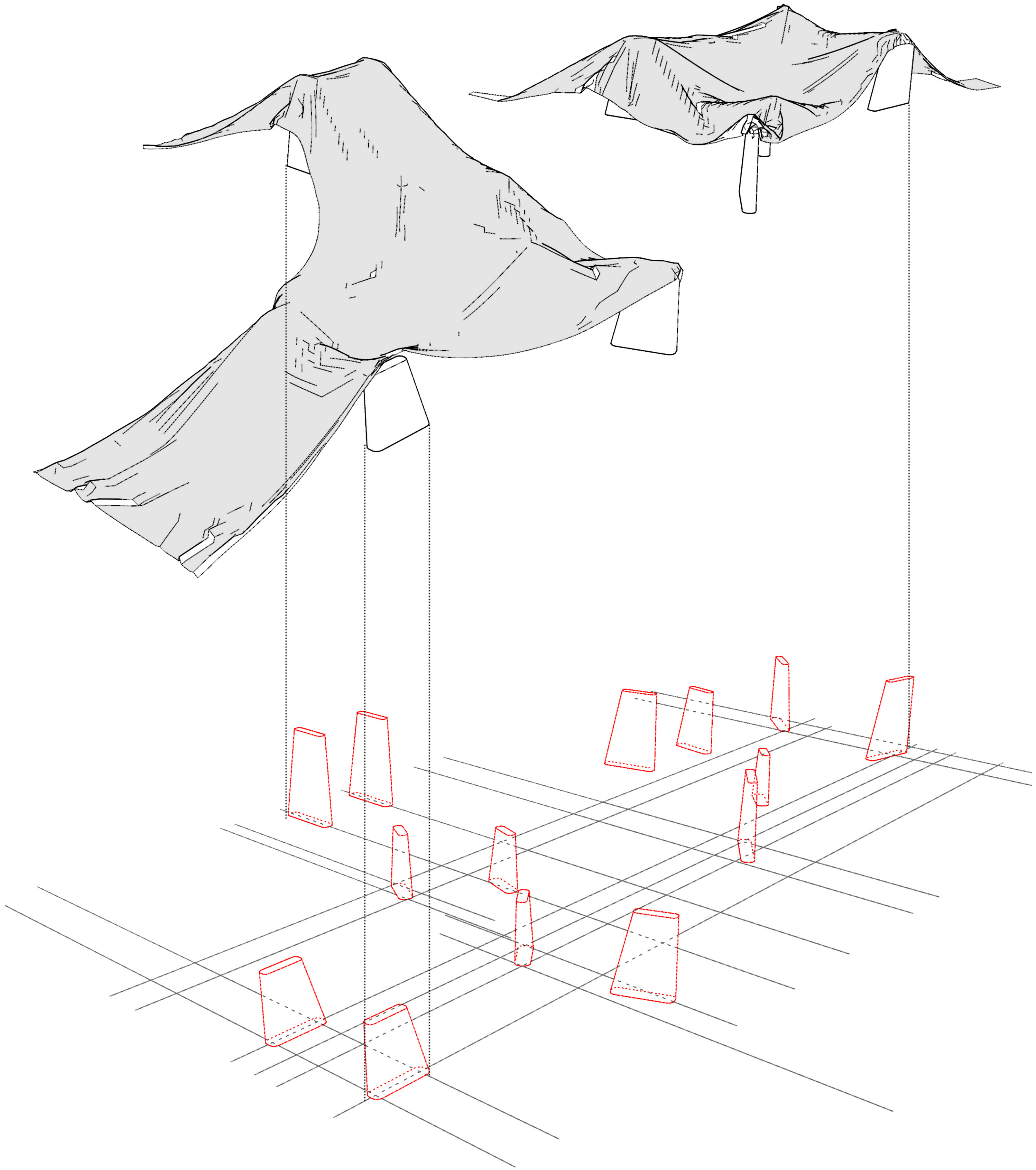
Dining space



Section BB

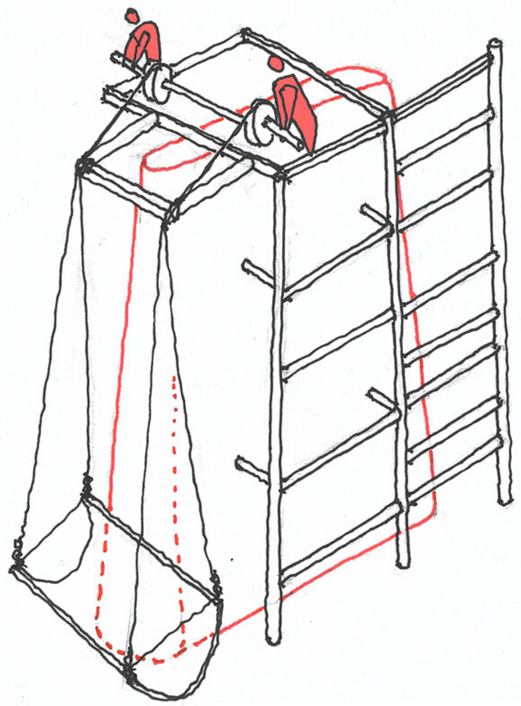


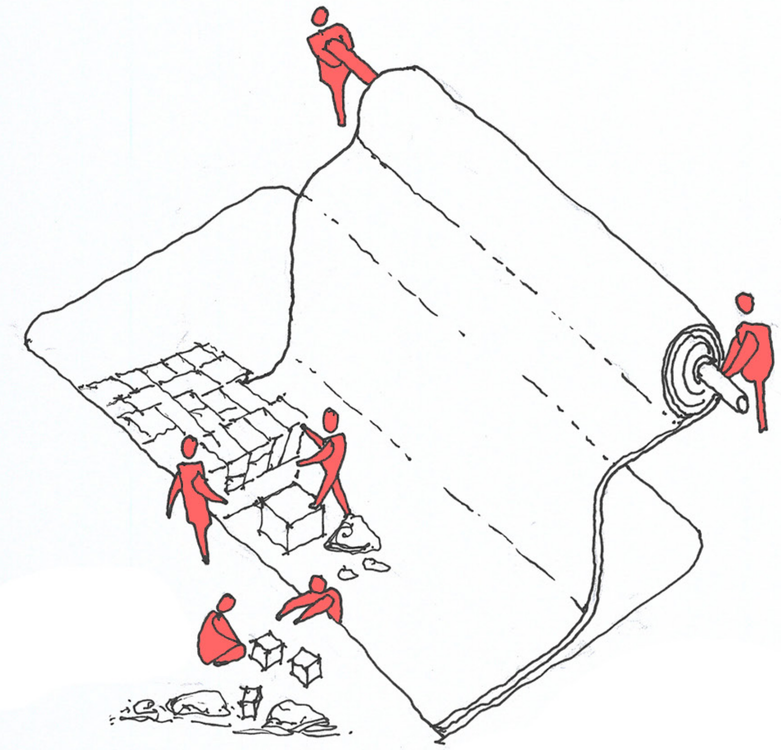
Section AA



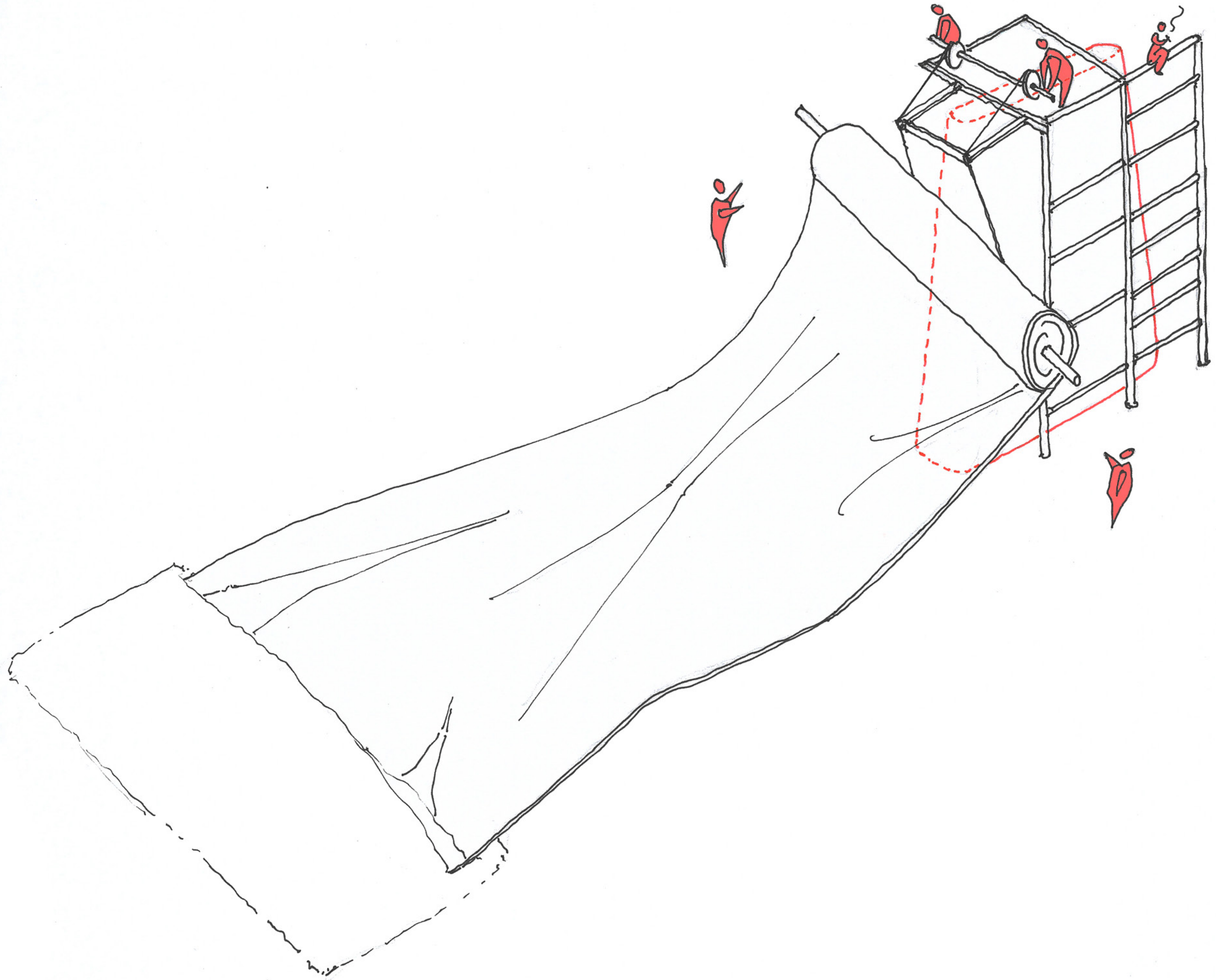
Construction process

01. Marking positions of the anchor walls using centrelines.

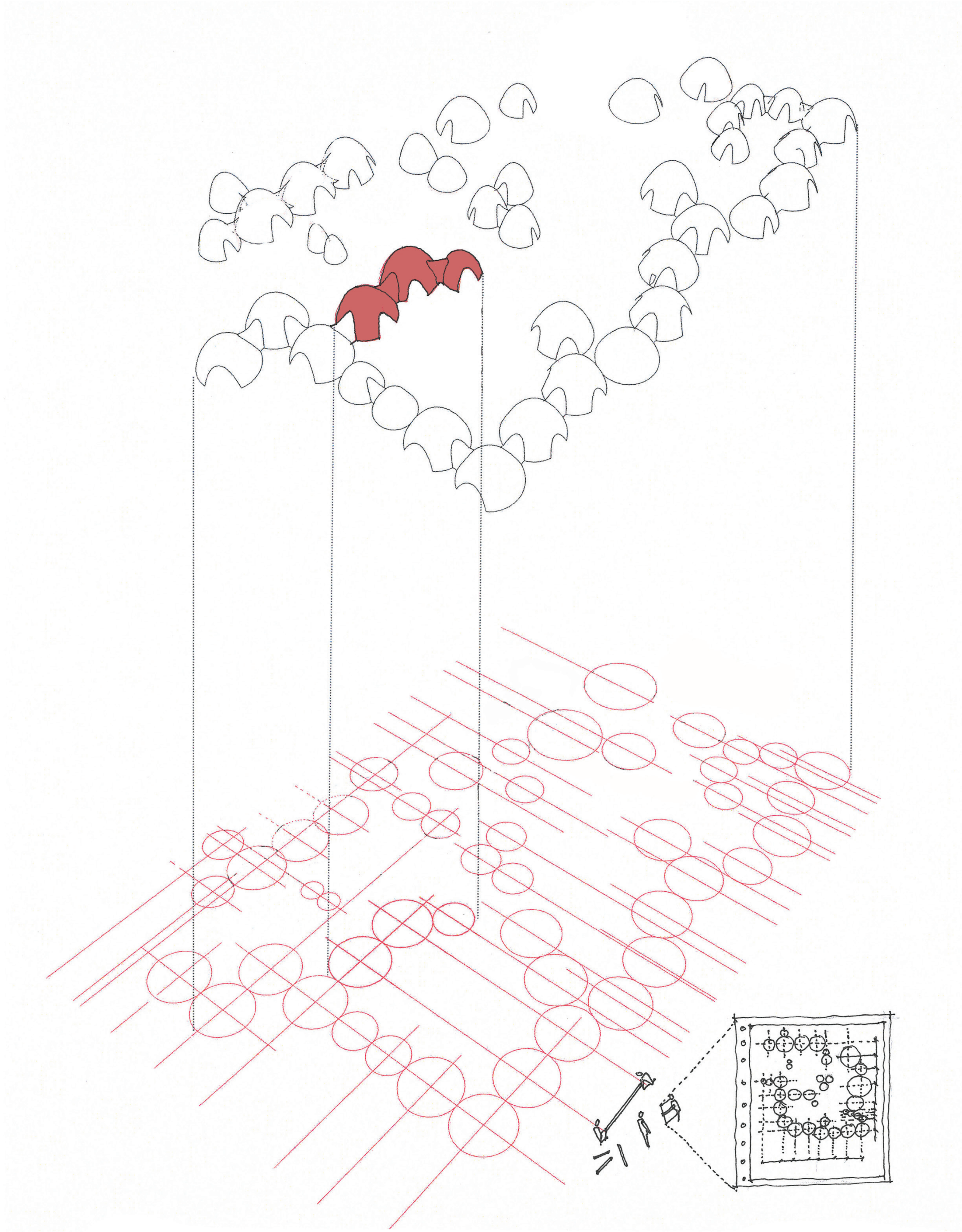




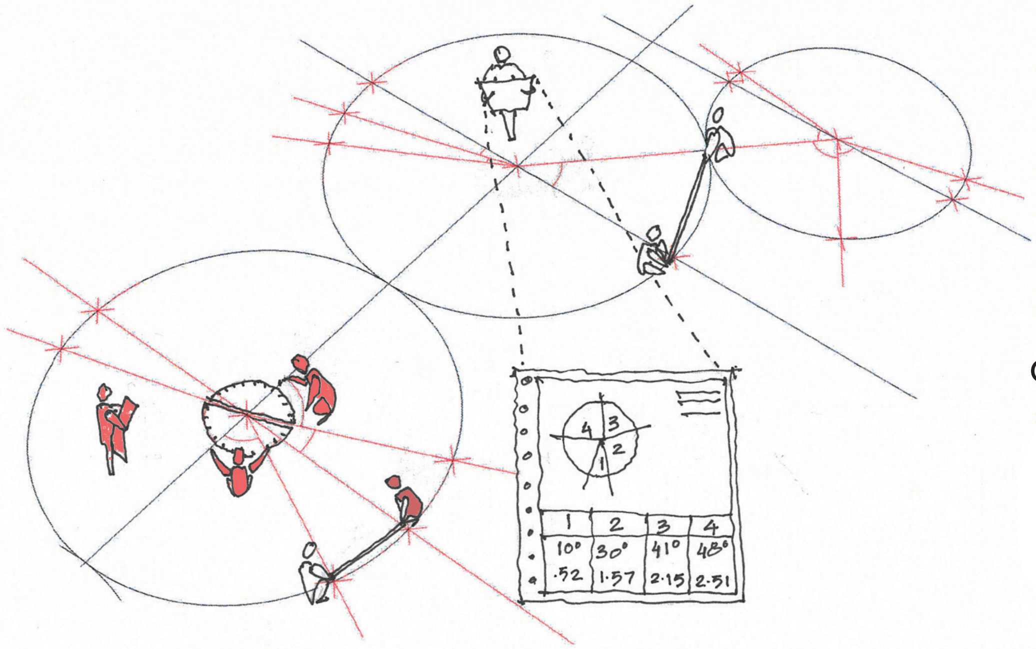
02. Anchoring the tent fabric in the ground



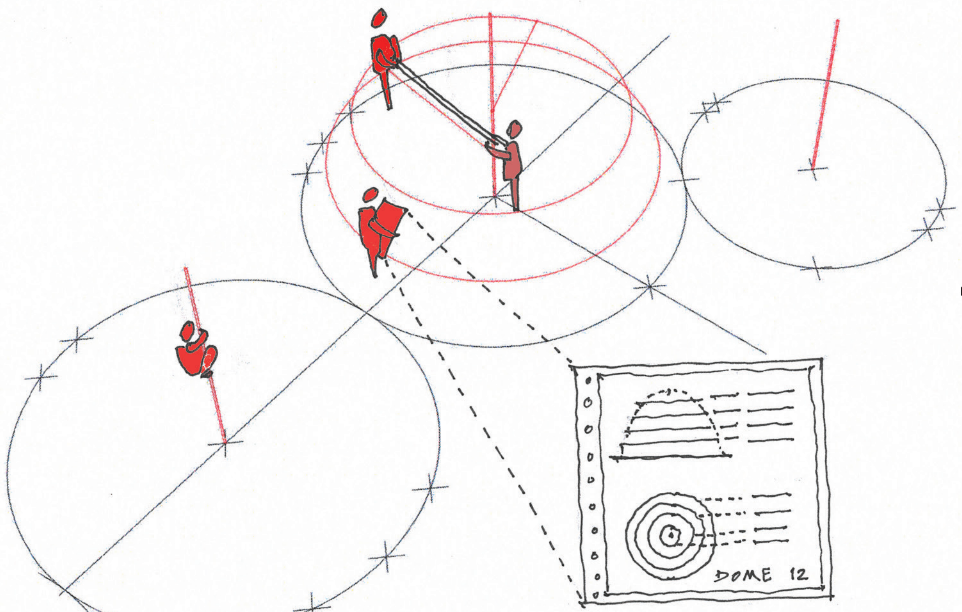
03. Hoisting the fabric up the anchor wall using a pulley system.



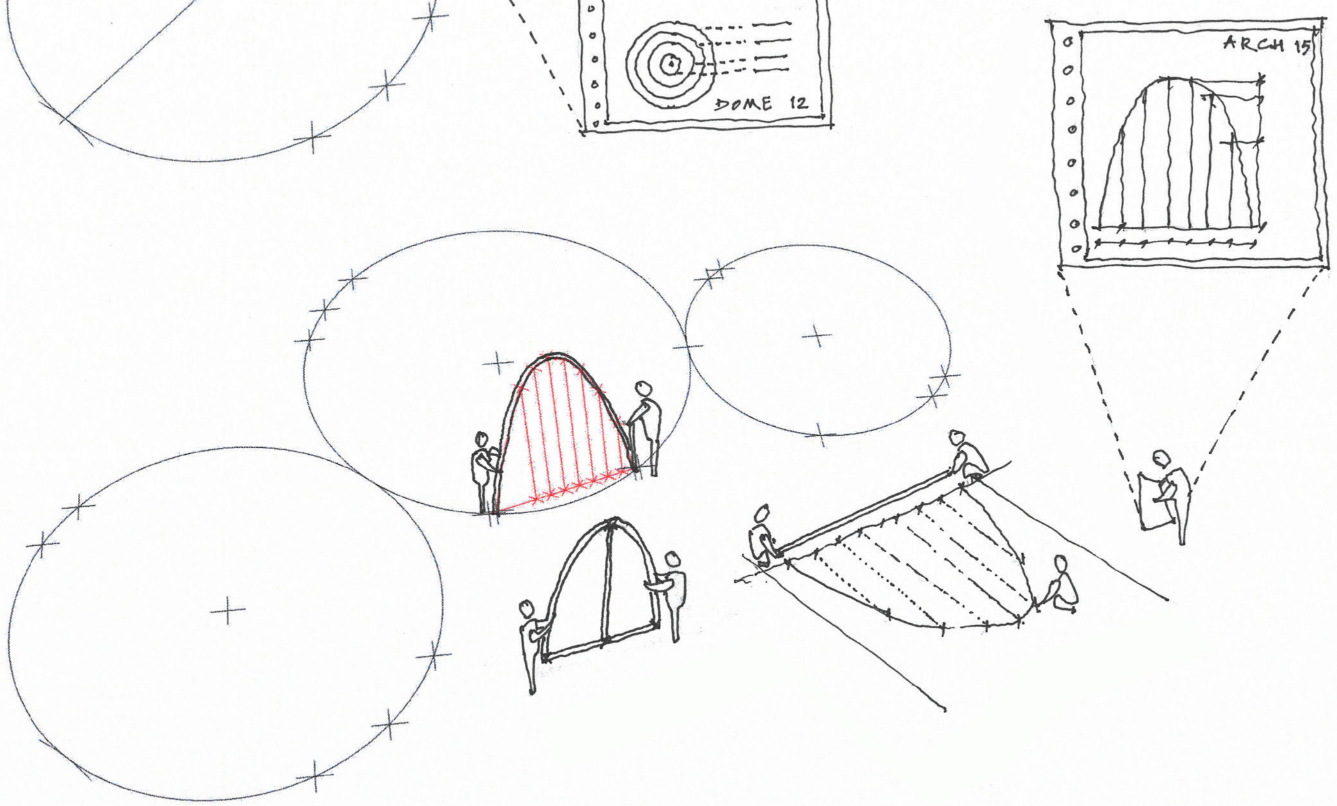
01. Marking positions of the domes and walls using centrelines.



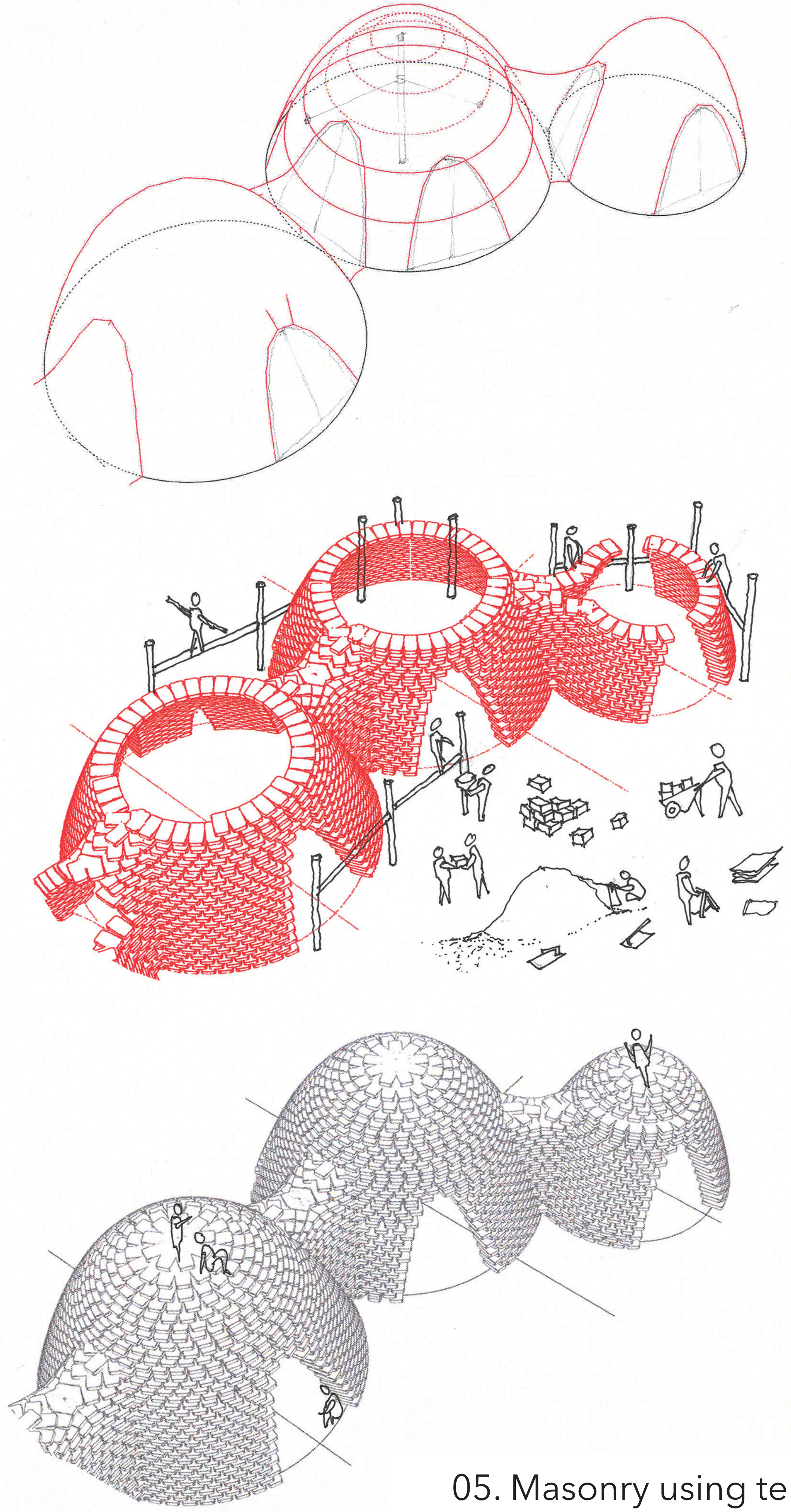
02. Marking of openings using angles and arc lengths.



03. Marking of courses using given radius for each course.



04. Marking arches, first on the ground and then transferred using flexible wire.



05. Masonry using tent bags.

Za'atari Earth Institute

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