

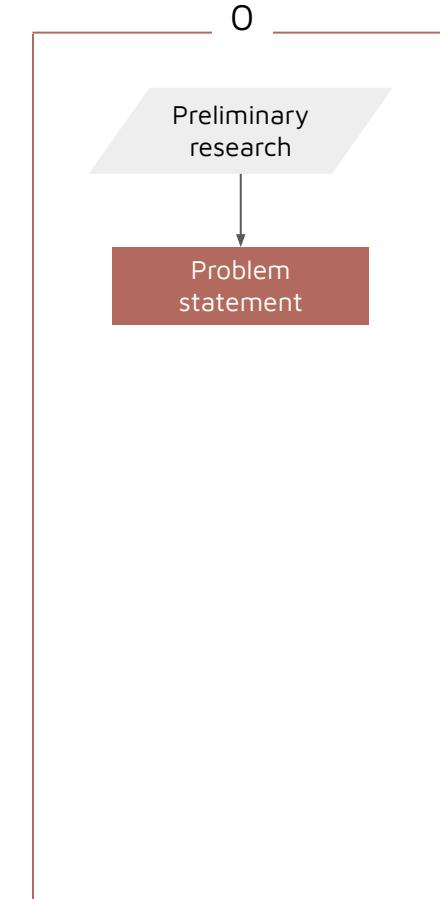


RAHA

راحة

Recreational Activity Hub Actuator

Problem statement



Intervention

SOLUTION



Informal
Counselling



Recreation
Hub



Human
interaction

PROBLEM



Population
influx



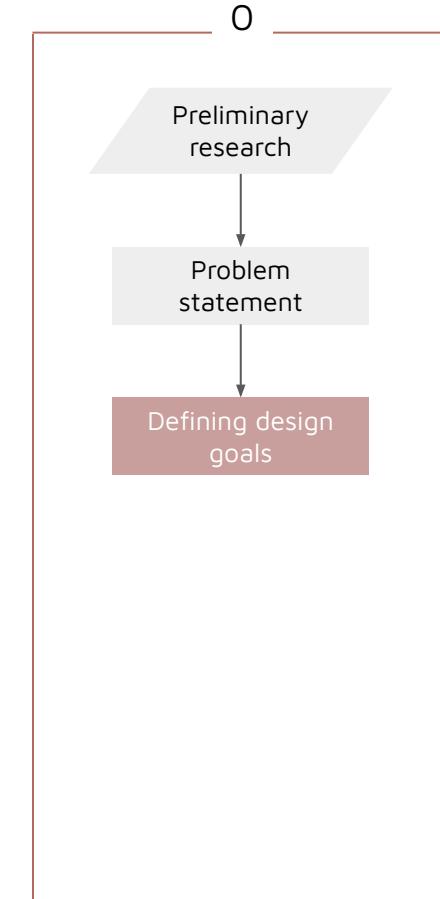
Permanent
settlement



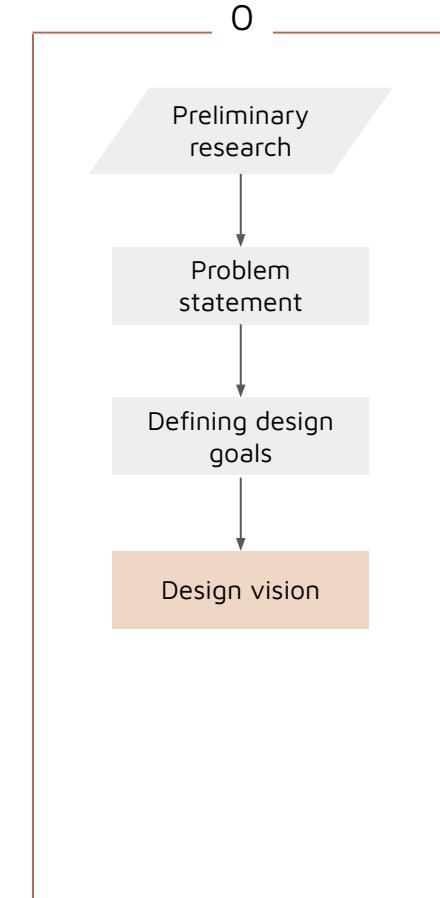
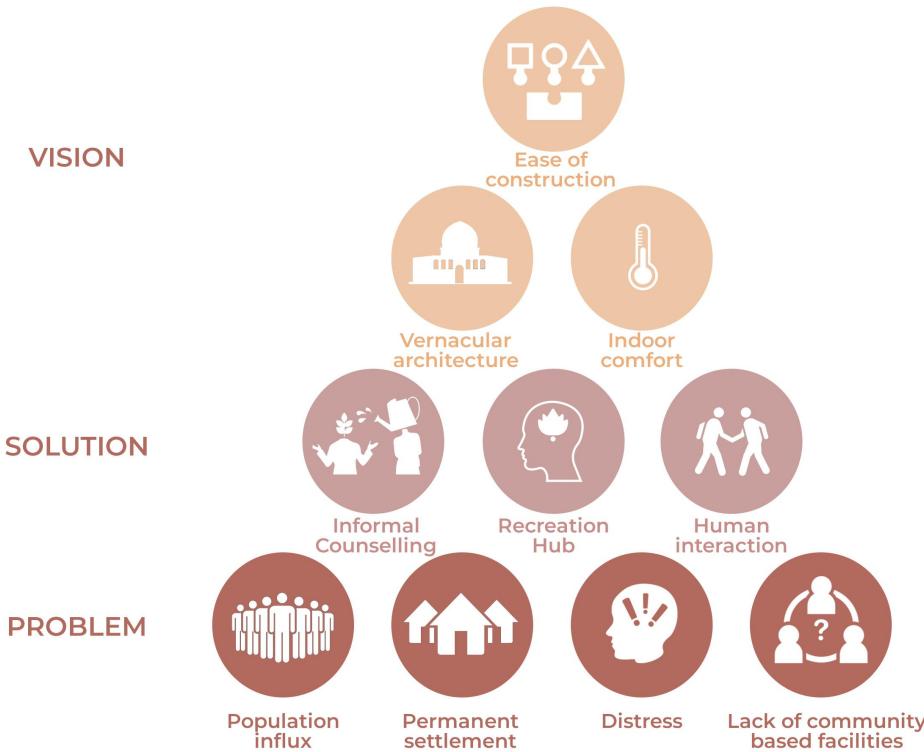
Distress



Lack of community
based facilities



Design Vision





رها

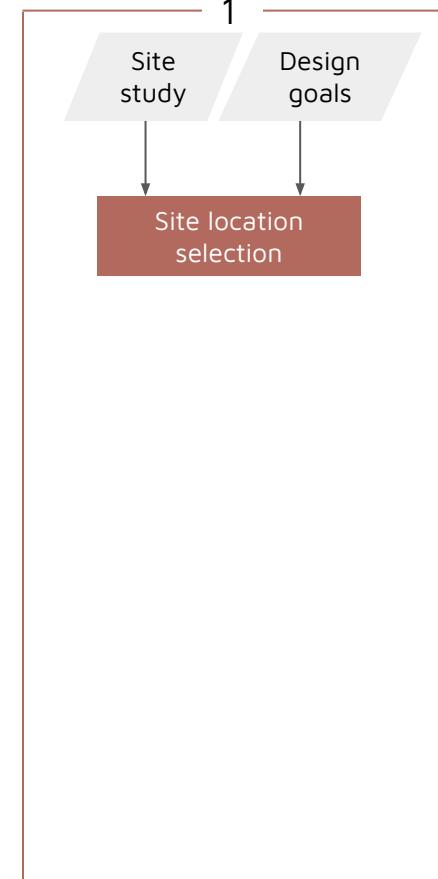
RAHA

1 - Configuring

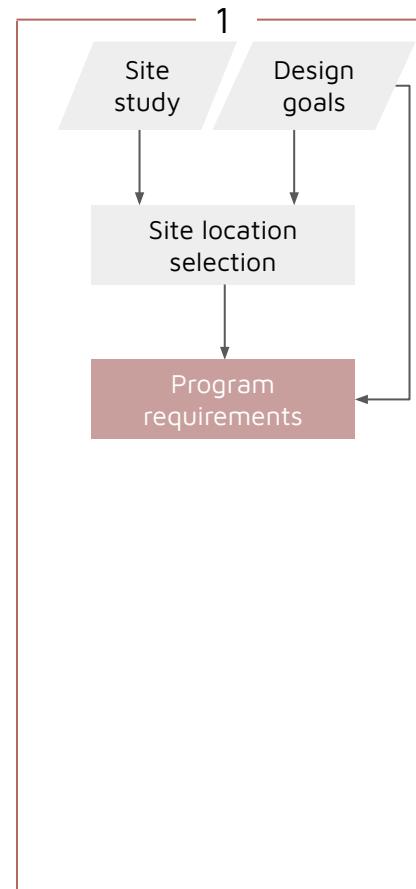


LOCATION SELECTION

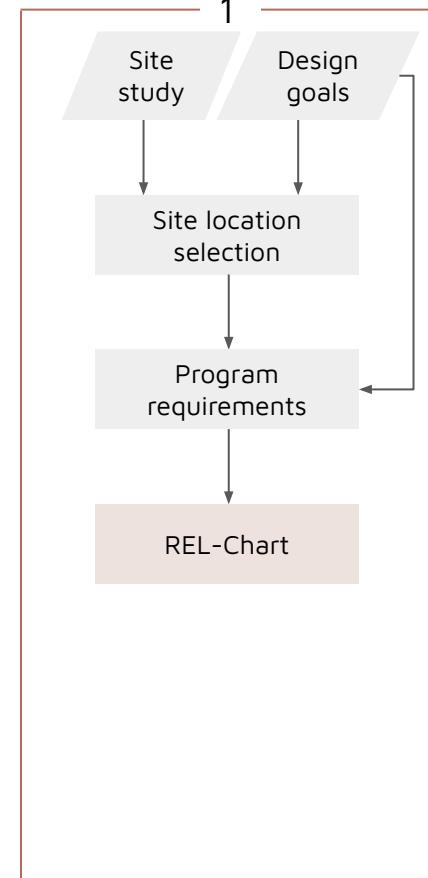
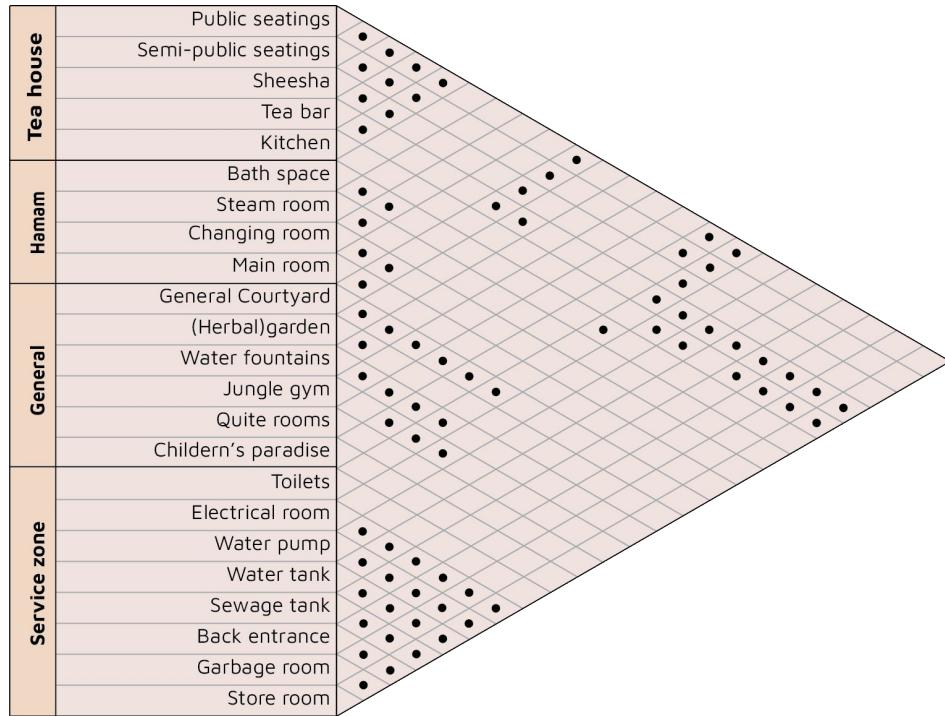
Built-Unbuilt space



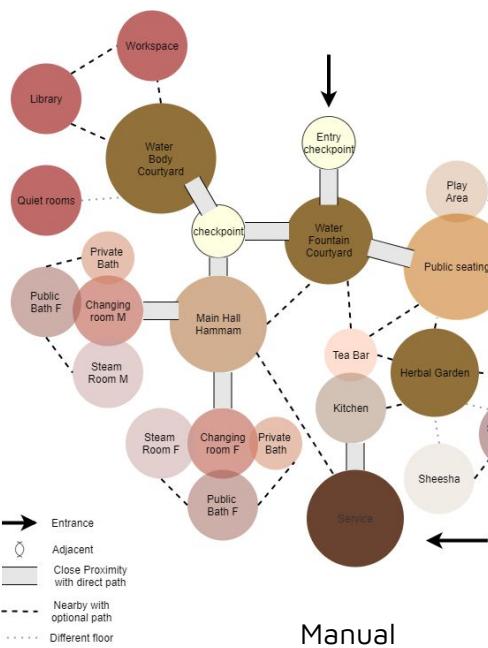
Space	Functions	Nature of the space		Area (sqm)	Capacity	Net Area (sq.m)	Quantity	Total Area (sq.m)	Min Clear heights (m)	Daylight	
				Total Area:				655		Necessity	Orientation
Tea house	Seating spaces	semi-public	closed	1.5-2 m2 / person	50	100	1	100	3	Yes	South-East
		public	semi-open	1.5-2 m2 / person	100	200	1	200			
	Sheesha	semi-public	semi-open	1.5-2 m2 / person	70	180	1	180			
	Tea bar	public	closed	5-10 m2 / service table	4	40	1	40			
	kitchen	private	closed	15-25% of total area	-	135	1	135			
Hamam house	Main Hall	public	closed	150 m2	50	150	1	150	4.5	Yes	West
	Bath space (male)	public	closed	4.5-6 m2 / person	30	140	1	140	4.5		
	Bath space (female)	public	closed	4.5-6 m2 / person	30	140	1	140	4.5		
	steam room	private	closed	1.5-2 m2 / person	15	30	2	60	4.5		
	changing room (male)	private	closed	50 m2	-	50	1	50	2.7		
	changing room (female)	private	closed	50 m2	-	50	1	50	2.7		
	Courtyard							908			
Multi-purpose Hall	Connector to multiple spaces	public	open	120 m2	-	120	1	120	-	Yes	Varies
	Herbal garden	public	open	60 m2	-	60	1	60	-		
	Water fountains	public	open	60 m2	-	60	1	60	-		
Play area	Quiet Room	private	closed	1.5-2 m2 / person	30	30	2	60	3-4.5	Yes	North
	Workspaces	private	closed	1.5-2 m2 / person	24	8	6	48	3-4.5		
	Library	semi - public	closed	1.5-2 m2 / person	90	180	1	180	3-4.5		
Toilets	Children's play area	visually connected (public)	semi-open	1.5-2 m2 / person	30	60	1	60	3	Yes	North-East
	Earth Castle	visually connected (public)	open	1.1-1.3m2 / person	35	50	1	50	-		
	Sand Pit	visually connected (public)	open	1.1-1.3m2 / person	35	50	1	50	-		
Service zone	male	private	closed	10m2	-	20	2	40	2.7	No	Varies
	female	private	closed	10m2	-	20	2	40	2.7		
	electrical room	private	closed	20m2	-	20	1	20	2.7		
	Water pump	private	closed	25m2	-	20	1	20	2.7		
	Water tank (UGT/DHT)	private	closed	25m2	-	20	1	20	2.7		
	Sewage tank (septic)	private	closed	25m2	-	20	1	20	2.7		
	Back entrance (loading/unloading)	private	closed	20m2	-	20	1	20	2.7		
	Garbage room	private	closed	20m2	-	20	1	20	2.7		
	Store rooms	private	closed	20m2	-	20	1	20	2.7		



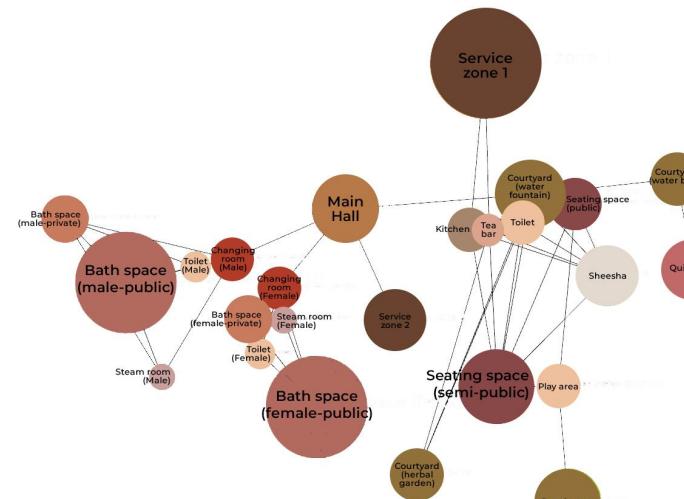
REL - Chart



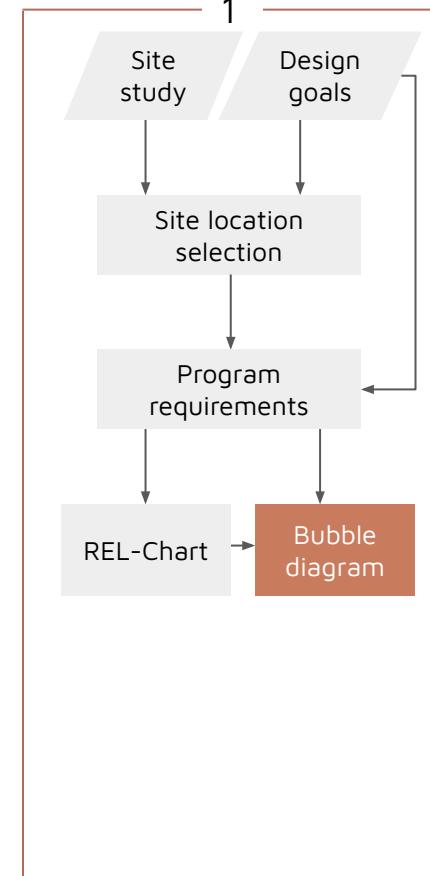
Bubble Diagram - Manual and Syntactic



Manual



Syntactic tool



Hierarchy of Space- Depth chart

Viewpoint

depth 1

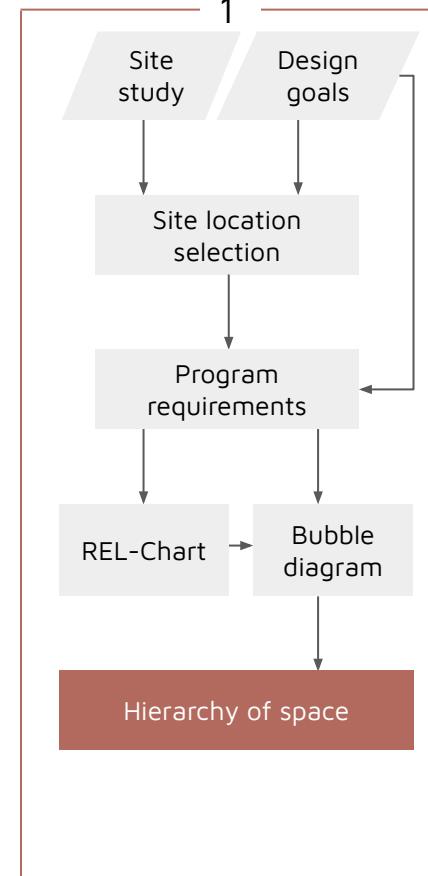
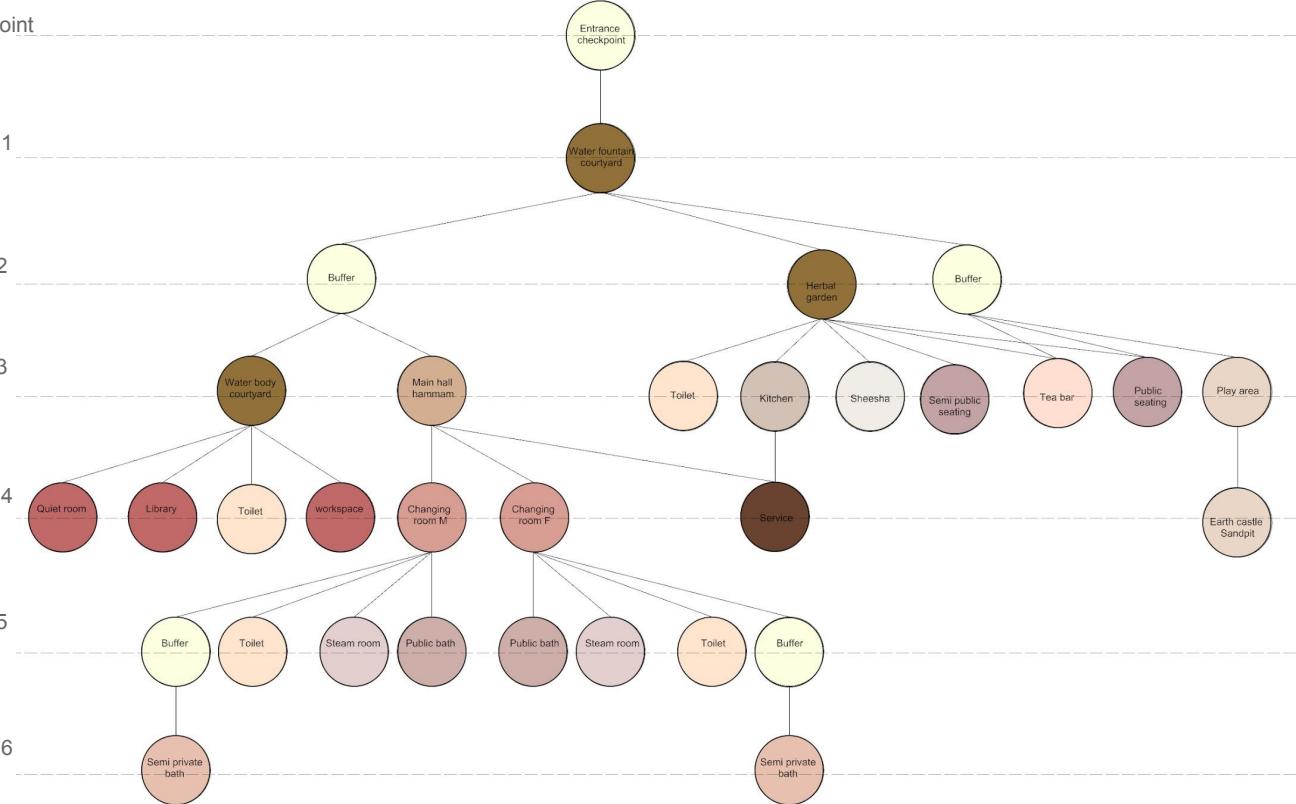
depth 2

depth 3

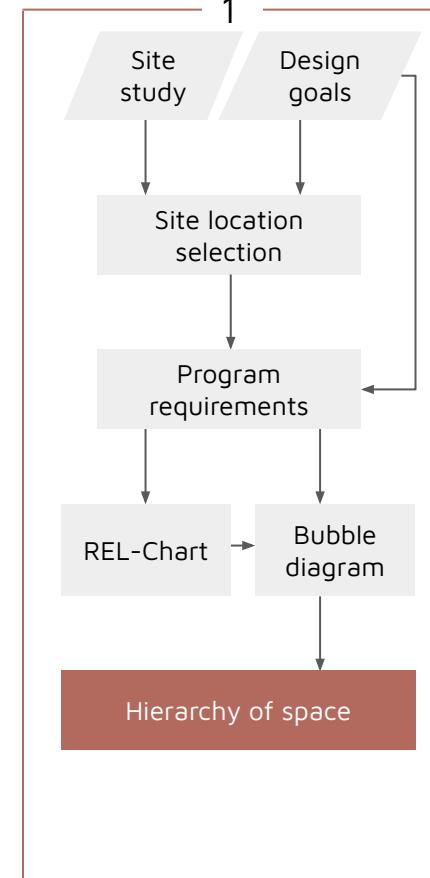
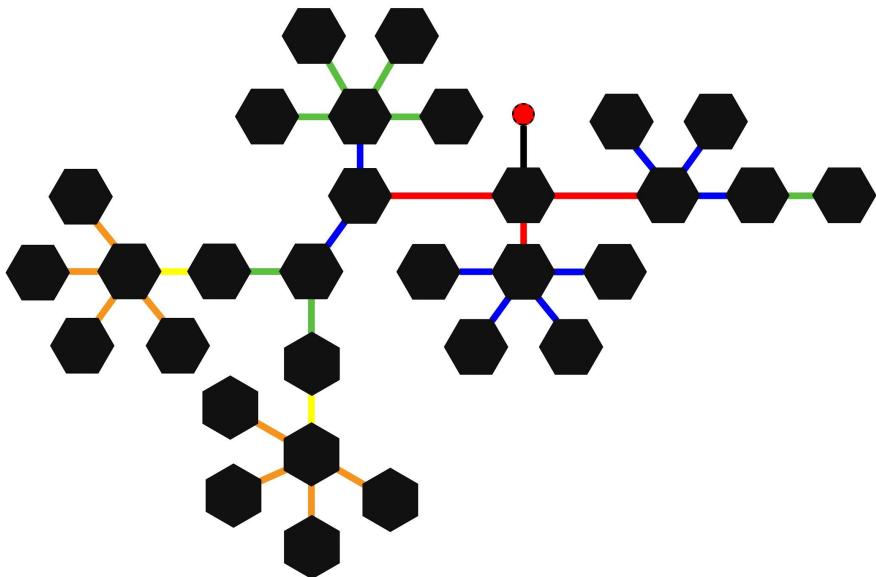
depth 4

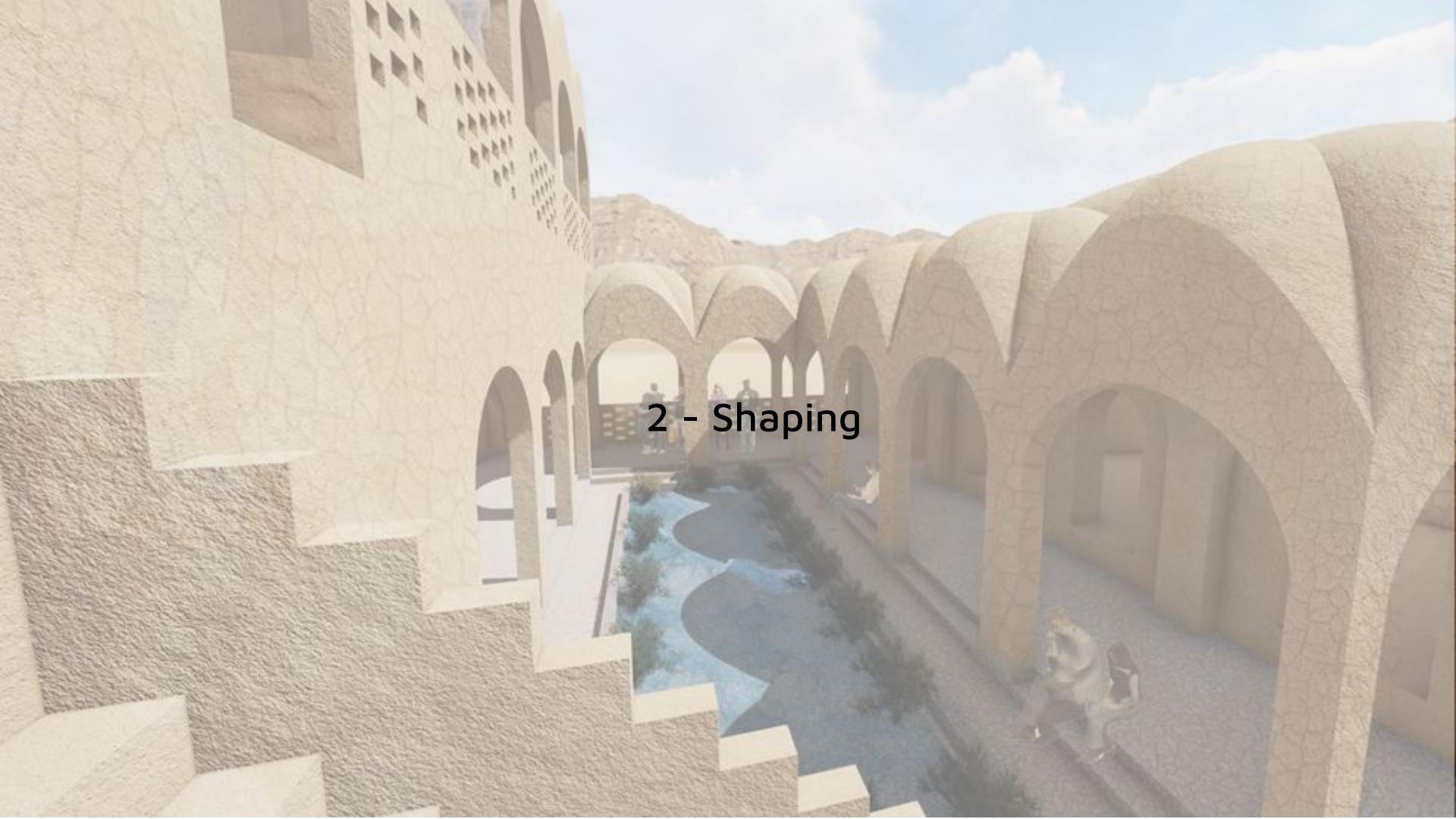
depth 5

depth 6



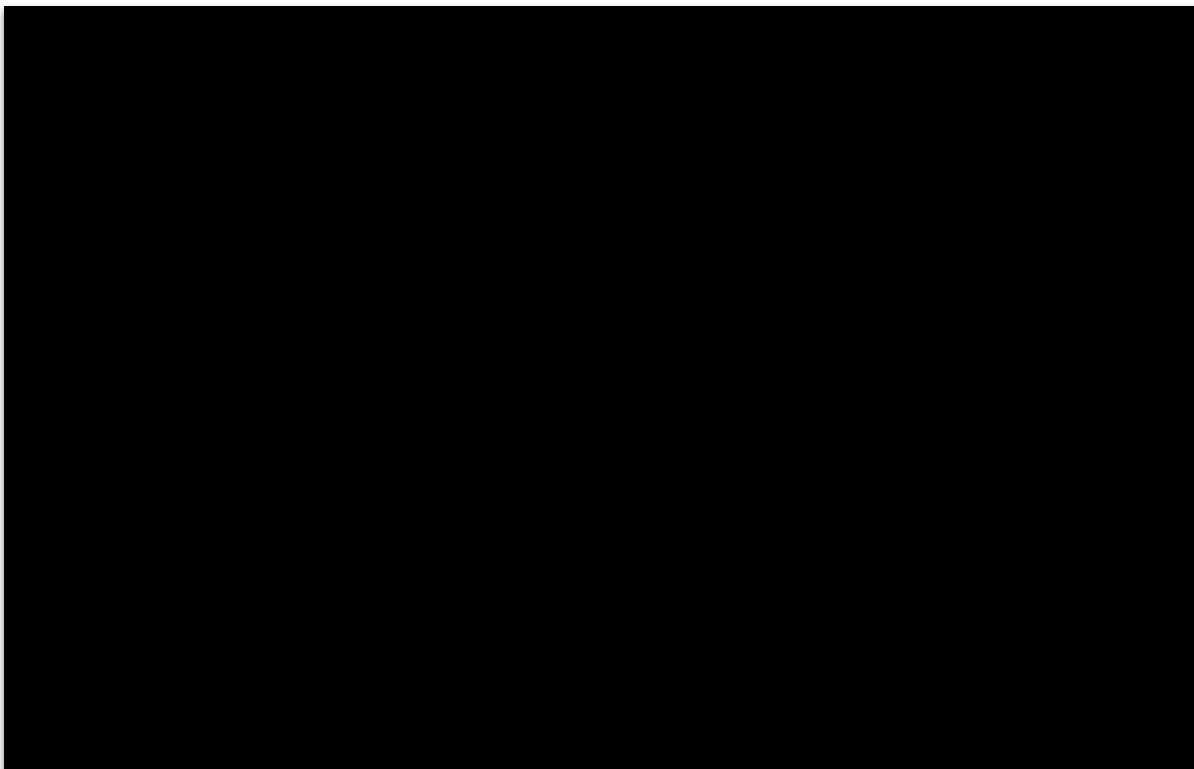
Hierarchy of Space





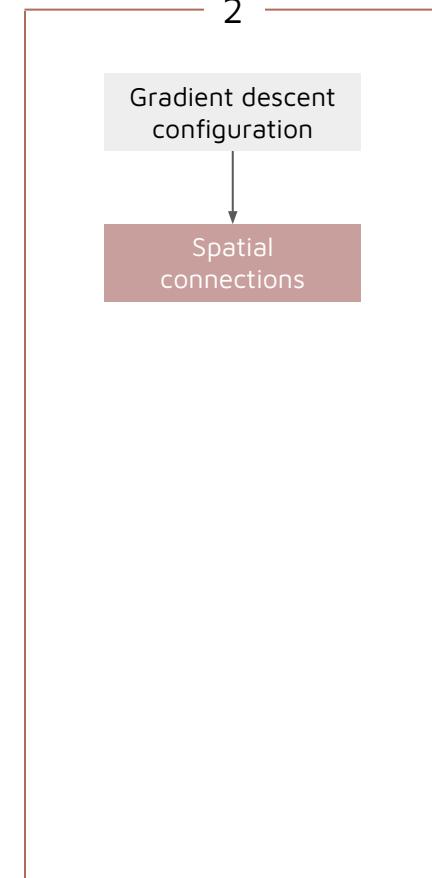
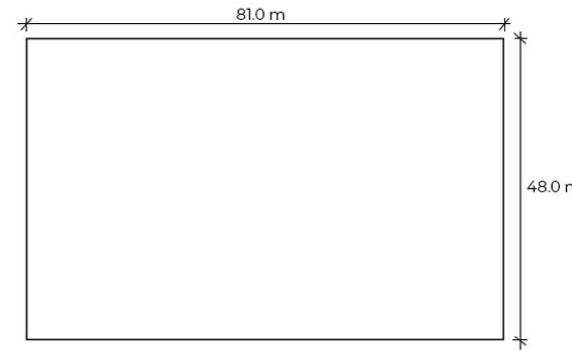
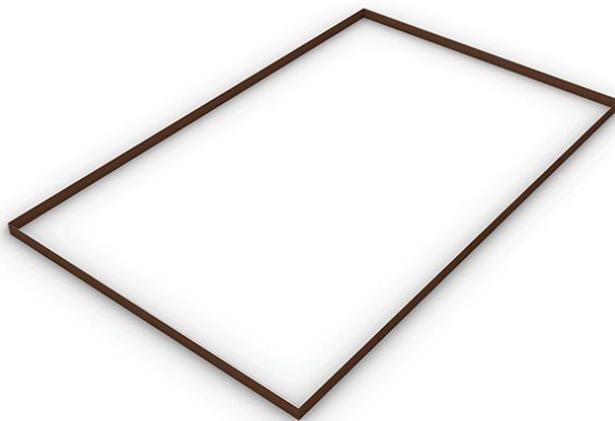
2 - Shaping

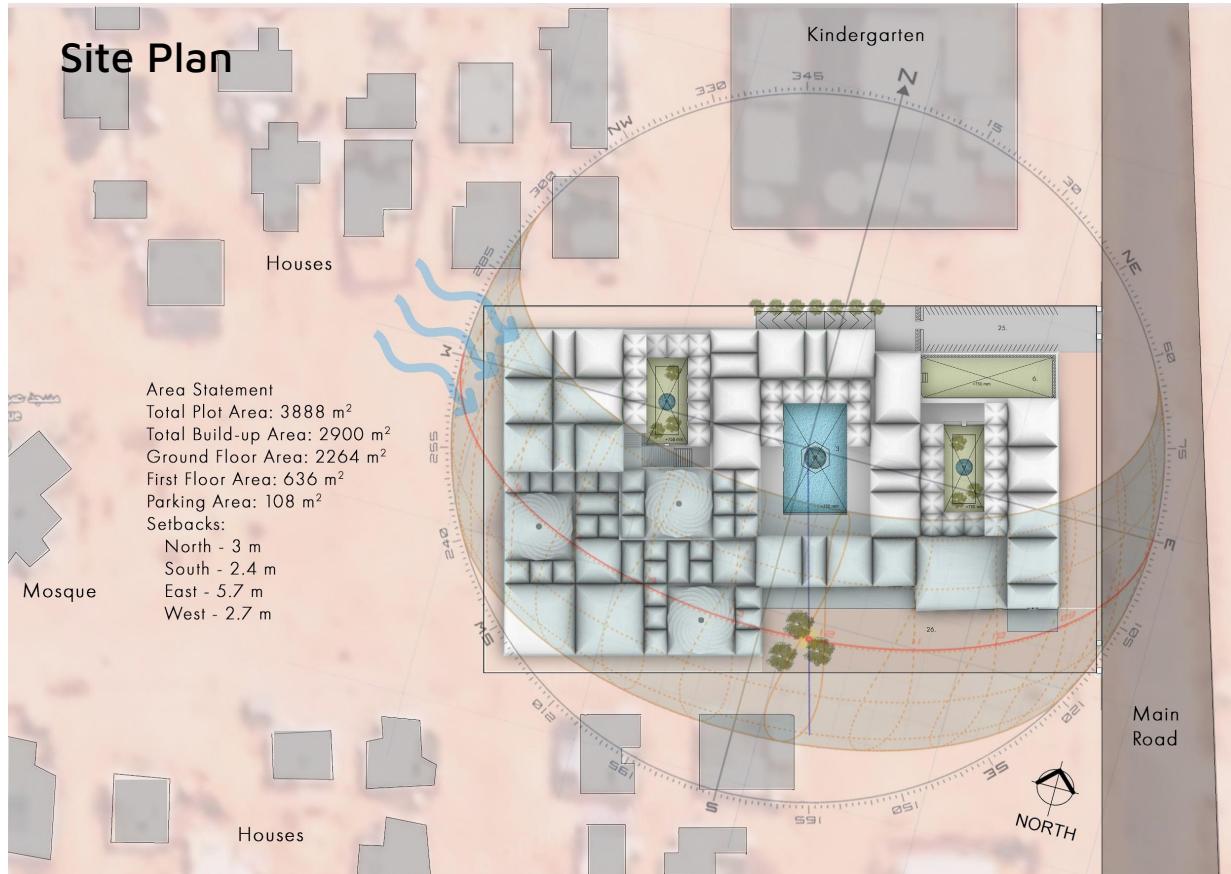
Gradient Descent Optimization



Hierarchy Depths	Spaces	Direction of Spaces	Length of Spaces	Width of Spaces
1	Courtyard water fountain	S	10.8	18.6
2	Buffer	E	4.8	4.8
2	Buffer	W	4.8	4.8
2	Herbal Garden	E	8.4	14.4
3	Hammam Main Hall	S	8.4	8.4
3	Waterbody courtyard	W	6	10.2
3	Teabar	E	4.8	4.8
3	Kitchen	E	4.8	8.4
3	Public seating	E	9.7	10.8
3	semi-public seating	E	9.7	10.8
3	sheesha	E	9.7	10.8
3	teahouse toilets	E	4.8	2.4
3	play area	NE	6	4.8
4	library	W	12	7.8
4	workspaces	W	9.6	7.8
4	quiet rooms	W	9.6	7.8
4	changing room male	SW	4.8	4.8
4	changing room female	S	4.8	4.8
4	Service zone	S	6	19.2
4	sand pit and earth castle	NE	10.8	6
5	private bath male	SW	3.6	3.6
5	public bath male	SW	6	4.8
5	steamroom male	SW	3.6	3.6
5	private bath female	S	3.6	3.6
5	public bath female	S	6	4.8
5	steamroom female	S	3.6	3.6

Connectivity of Space





2

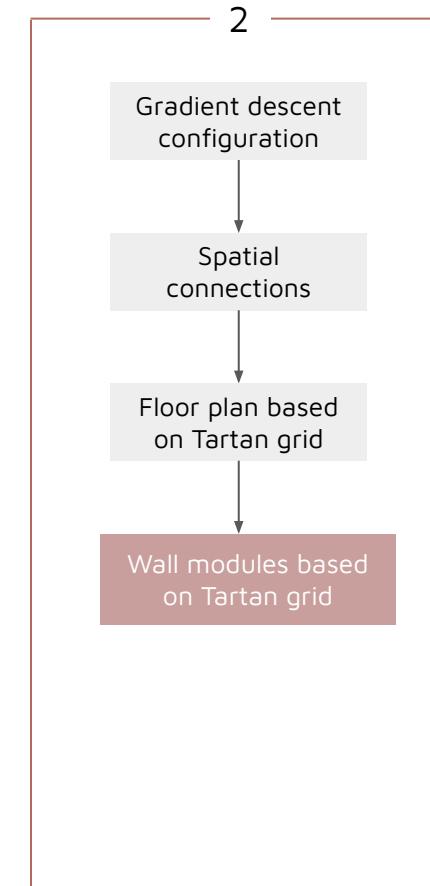
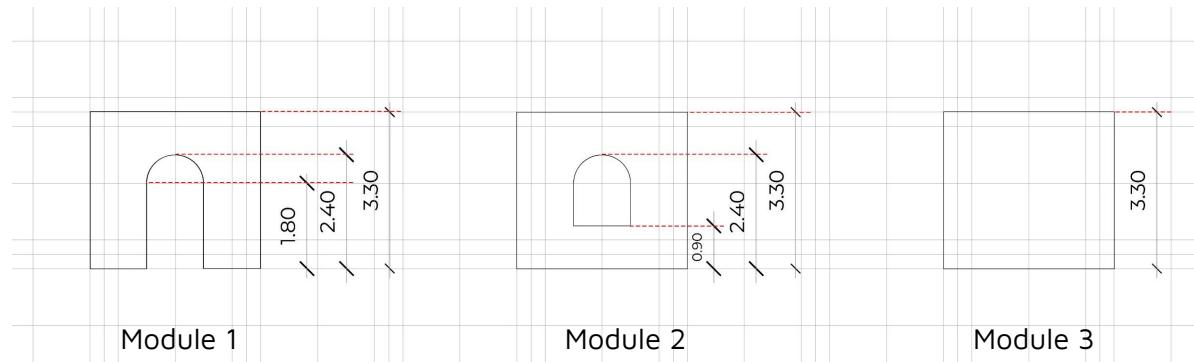
Gradient descent configuration

Spatial connections

Floor plan based on Tartan grid

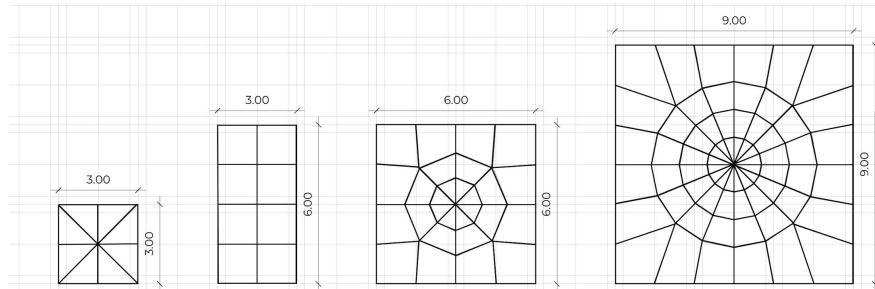
Modularity - Tartan Grid

Wall Modules



Modularity - Tartan Grid

Roof Modules

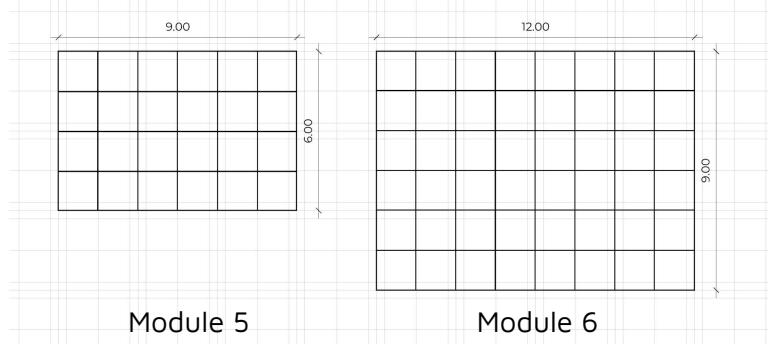


Module 1

Module 2

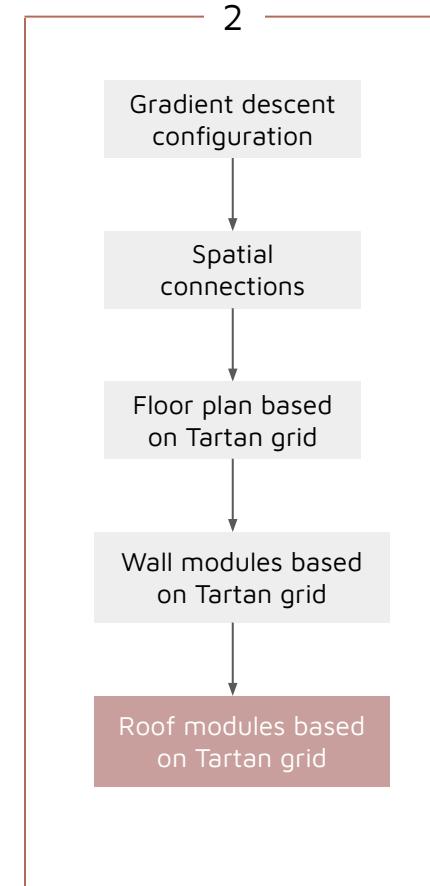
Module 3

Module 4



Module 5

Module 6



Floor Plan - Ground floor



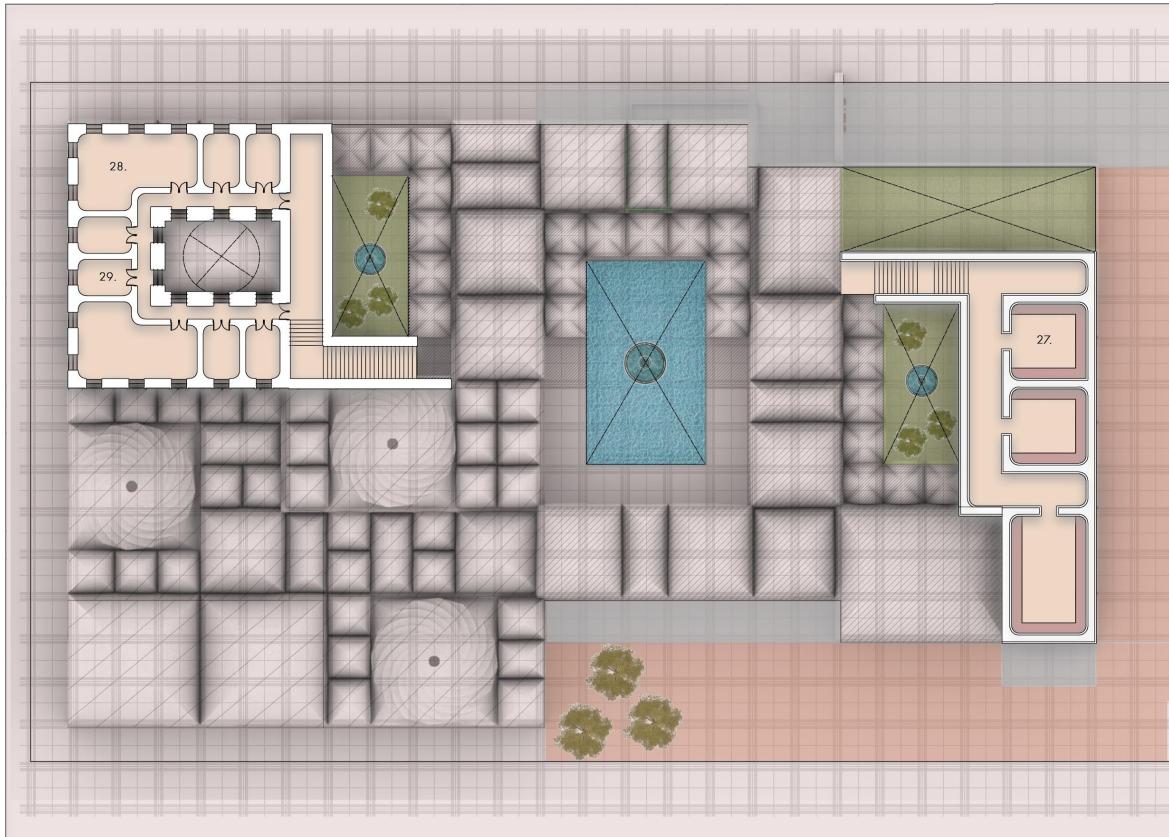
Legend

1. Entrance
 2. Entrance Vestibule
 3. Water-fountain
 - Courtyard
 4. Vestibule
 5. Play Area
 6. Sand-pit/ Earth Castle
 7. Herbal garden
 8. Public Seating
 9. Semi-public Seating
 10. Tea-bar
 11. Kitchen
 12. Store
 13. Water-body
 - Courtyard
 14. Main Hall
 - Hammam
 15. Changing Rooms
 16. Public Bath -1
 17. Public Bath- 2
 18. Private Bath
 19. Steam Room
 20. Administration
 21. Library
 22. Services
 23. Male Toilets
 24. Female Toilets
 25. Parking
 26. Loading/Unloading

Configured design



Floor Plan - First floor



Legend

- 27. Public Seating/Sheesha
- 28. Quiet Room
- 29. Workspace

Configured design

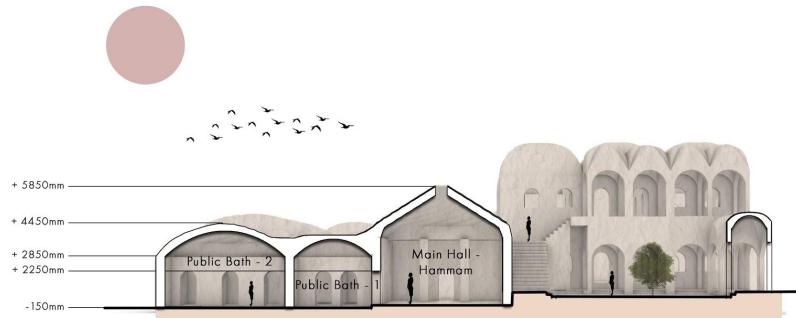
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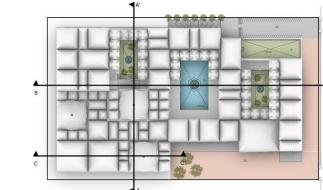
Section



Section BB'



Section AA'

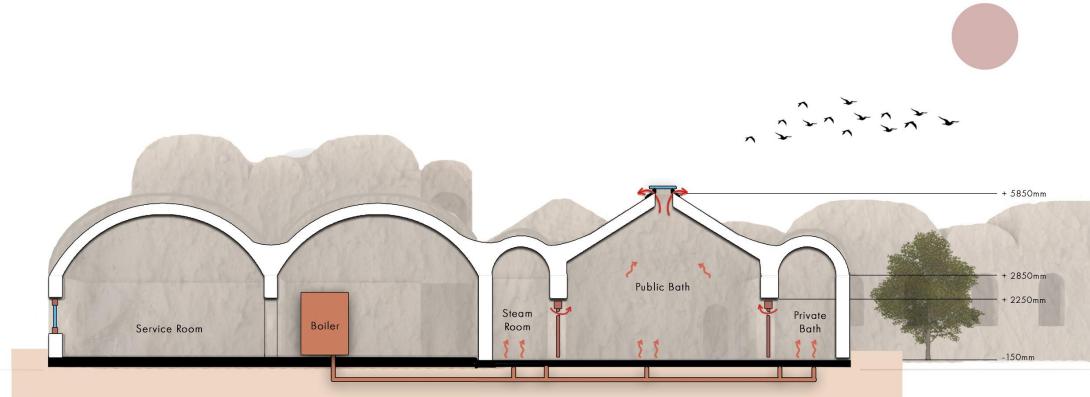
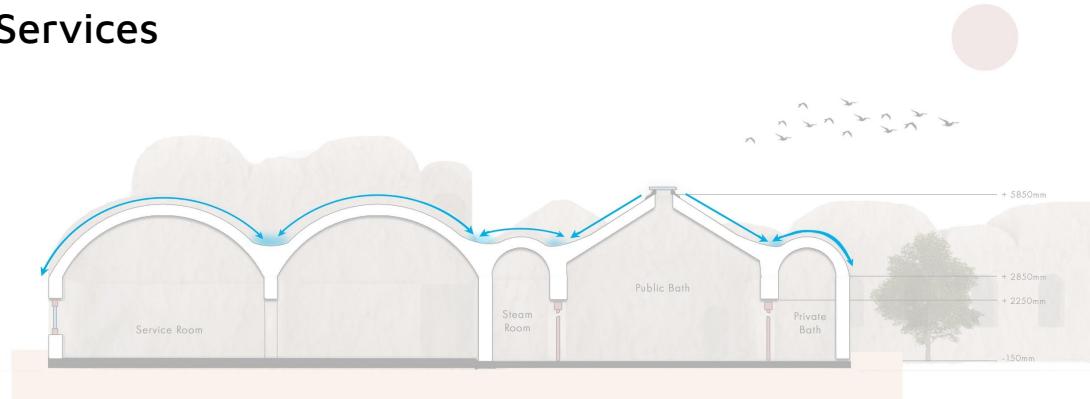


Key Plan

2

Configured design

Services

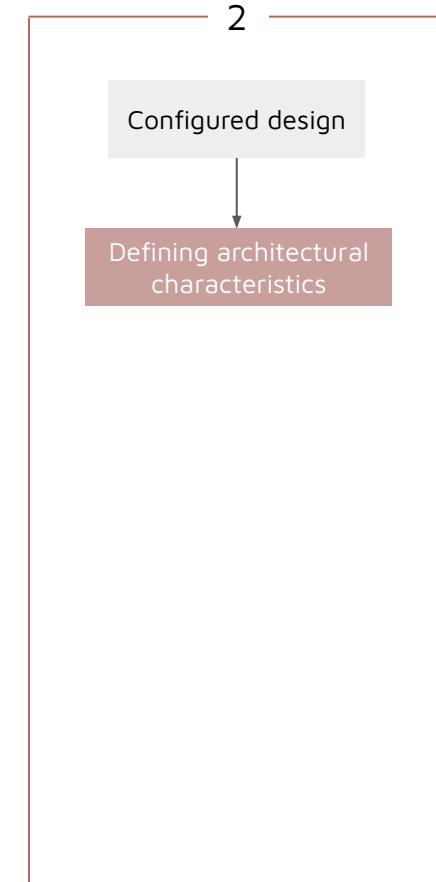
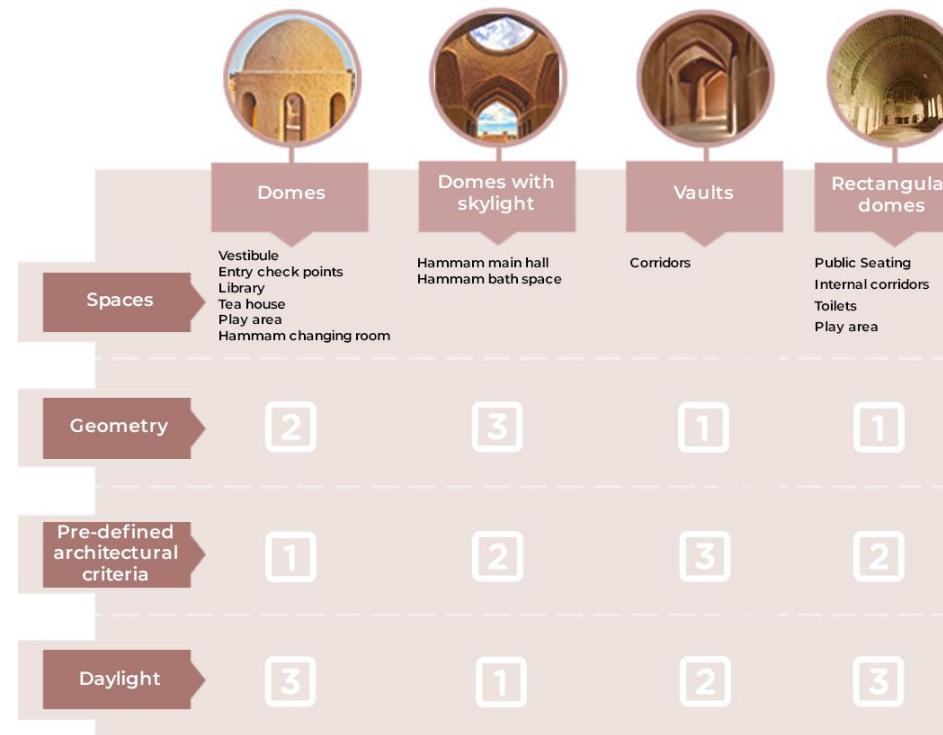


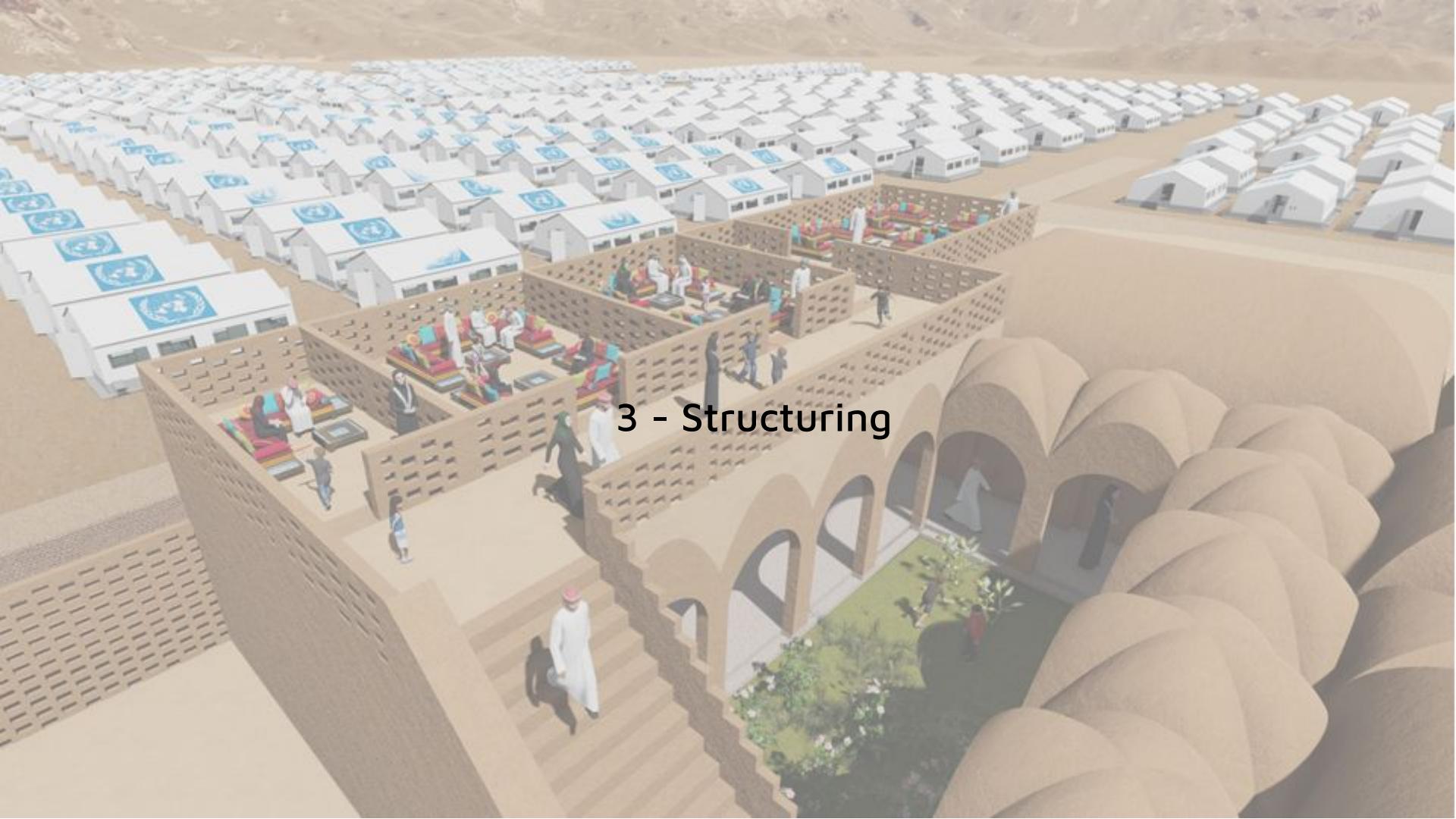
Section CC'

2

Configured design

Architectural Characteristics

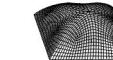
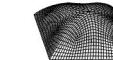




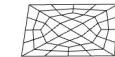
3 - Structuring

Tessellations

First triangulate then constant quad split



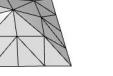
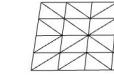
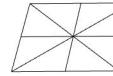
Constant quad split



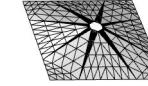
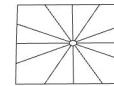
Triangulate edge then constant quad split



All triangulate



Triangulation with skylight

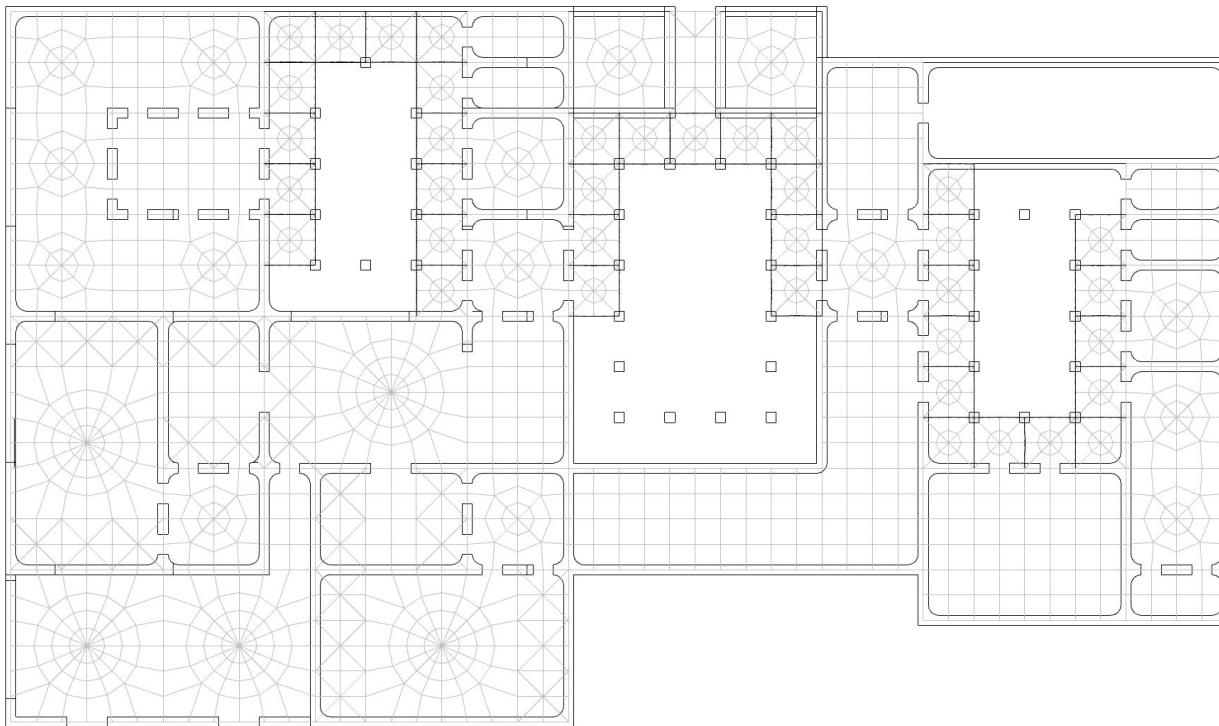


3

Defining architectural characteristics

Tessellations

Tessellations

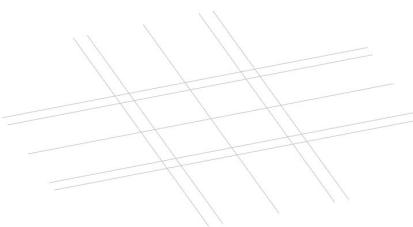


3

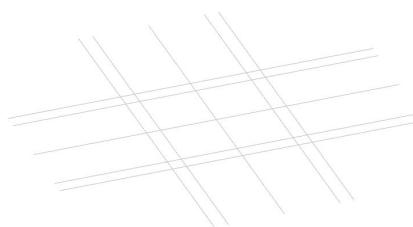
Defining architectural characteristics

Tessellations

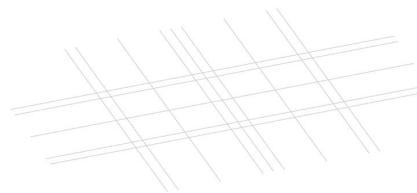
Tessellations



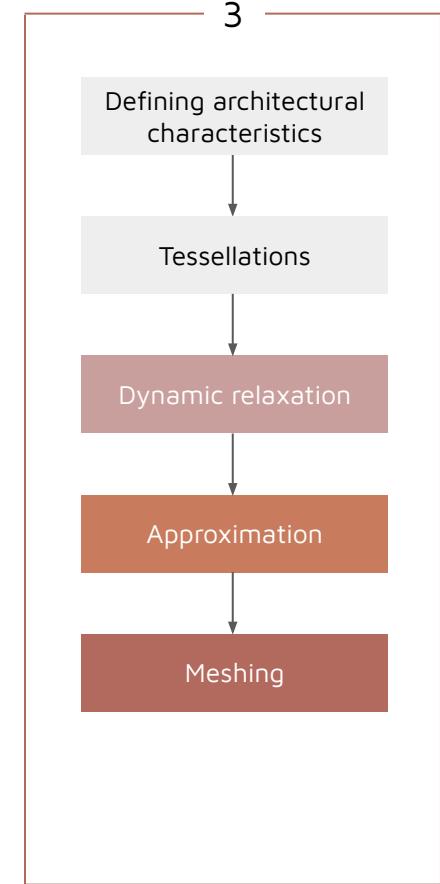
Tartan grid



Tartan grid

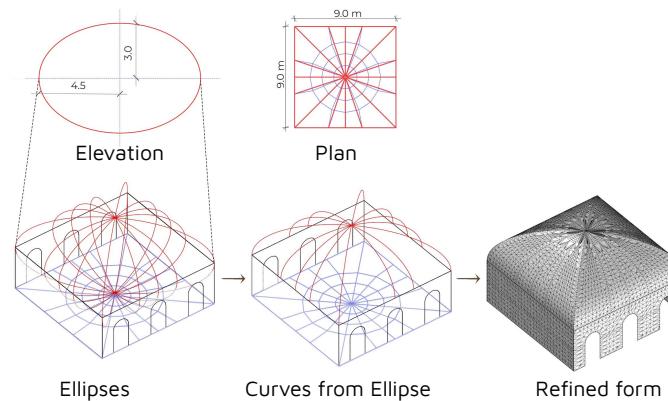


Tartan grid

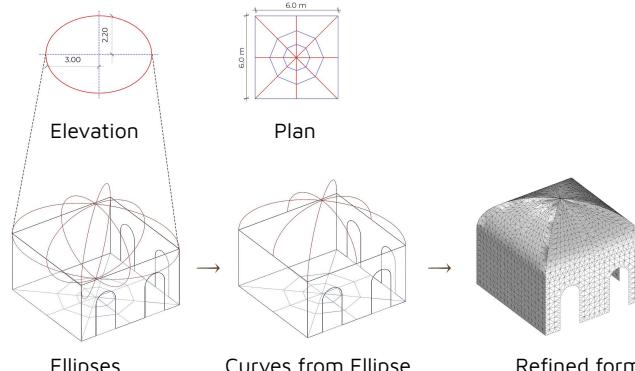


Simplification

9 x 9 M Dome



6 x 6 M Dome



3 Structuring

3

Defining architectural characteristics

Tessellations

Dynamic relaxation

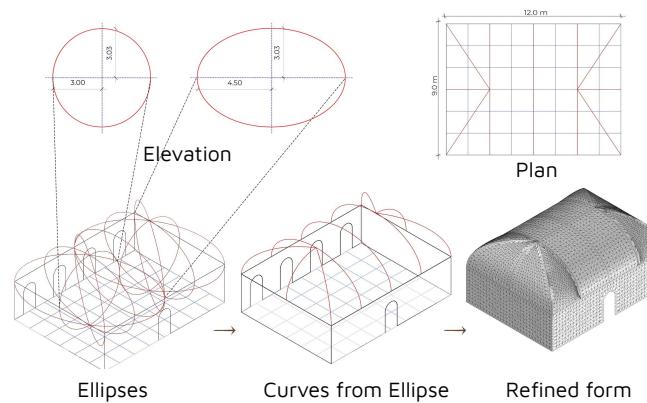
Approximation

Meshing

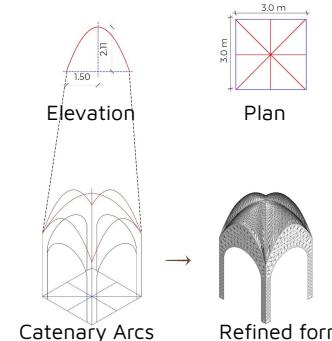
Refine mesh

Simplification

12 x 9 M Dome



3 x 3 M Cross vault



Defining architectural characteristics

Tessellations

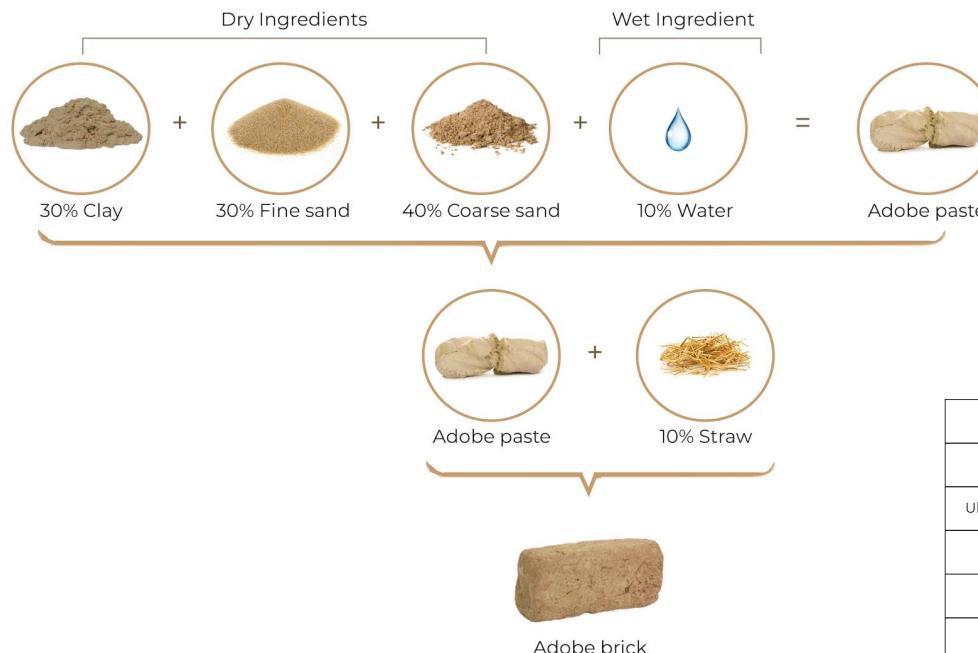
Dynamic relaxation

Approximation

Meshing

Refine mesh

Material

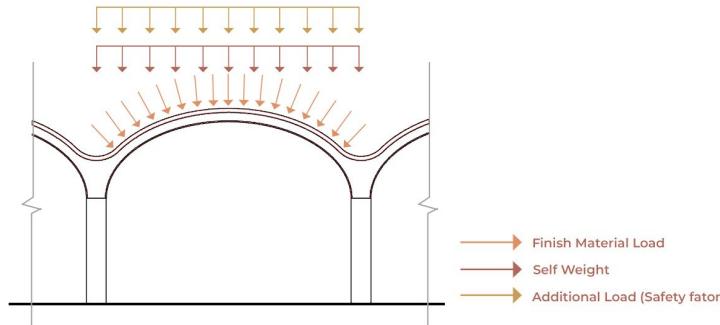


Limit States and values	
Brick type	Adobe + Straw
Ultimate Compressive Strength	1.3 MPa
Ultimate Tensile Strength	0.13 MPa
Young's Modulus	80 MPa
Specific weight	1200 kg/m ³

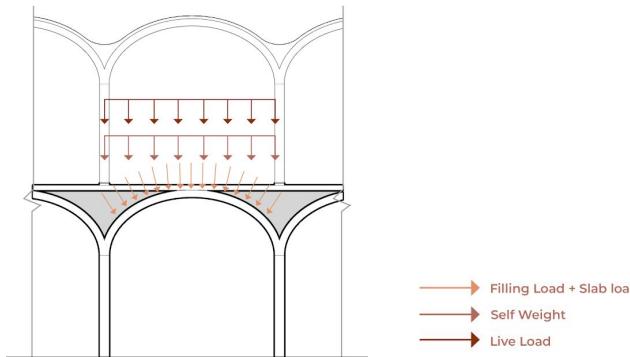
Refine mesh

Material selection

Structural Analysis - Load Factor



Finish material Load= 2 KN/m²
 Safety Factor= 1.2



Live Load= 4 KN/m²
 Filling Load= 150 kg/m³
 Slab Load= 1 KN/m²
 Finish material Load= 2 KN/m²
 Safety Factor= 4

Refine mesh

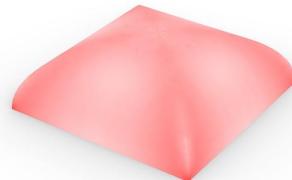
Material selection

Applied load cases

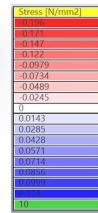
3

Structural Analysis - 9x9 m Square base Dome

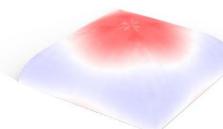
Limit States	
Ultimate Compressive stress (MPa)	1.3
Ultimate Tensile stress (MPa)	0.13
Displacement (mm) (span/400)	22.5



Combined stresses



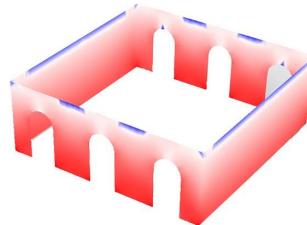
DOME (9000 mm x 9000 mm span)	
Thickness	300 mm
Peak Compressive stress (MPa)	-0.16
Peak Tensile stress (MPa)	0.11
Max displacement (mm)	14.8



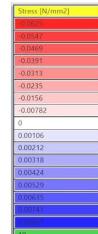
Principal stress 1



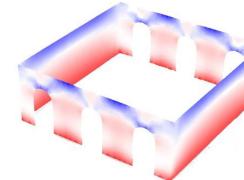
Principal stress 2



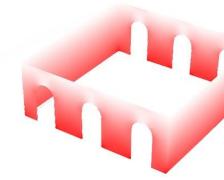
Combined stresses



WALL	
Thickness	450 mm
Peak Compressive stress (MPa)	-0.062
Peak Tensile stress (MPa)	0.008
Max displacement (mm)	1.4



Principal stress 1



Principal stress 2

Refine mesh

Material selection

Applied load cases

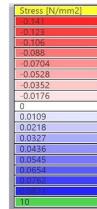
Structural Analysis

3

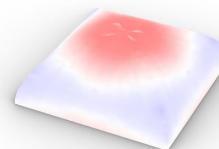
Structural Analysis - 6x6 m Square base Dome



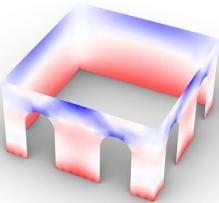
Combined stresses



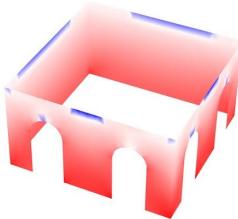
DOME (3000 mm x 3000 mm span)	
Thickness	225 mm
Peak Compressive stress (MPa)	-0.14
Peak Tensile stress (MPa)	0.08
Max displacement (mm)	7.5



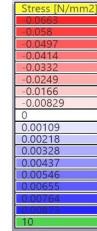
Principal stress 1



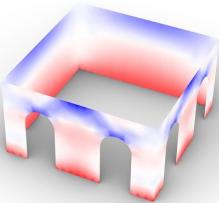
Principal stress 2



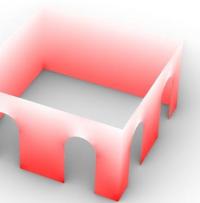
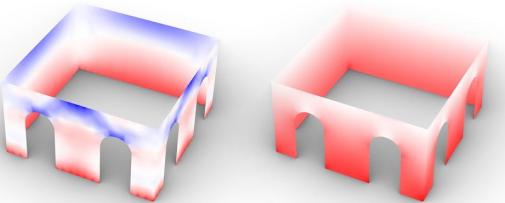
Combined stresses



WALL	
Thickness	300 mm
Peak Compressive stress (MPa)	-0.06
Peak Tensile stress (MPa)	0.008
Max displacement (mm)	1.4



Principal stress 1



Principal stress 2

Refine mesh

Material selection

Applied load cases

Structural Analysis

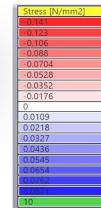
3

Structural Analysis - 3x3 m Square base Dome

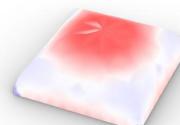
Limit States	
Ultimate Compressive stress (MPa)	1.3
Ultimate Tensile stress (MPa)	0.13
Displacement (mm) (span/400)	7.5



Combined stresses



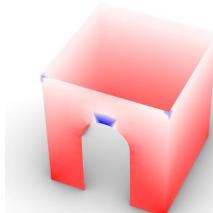
DOME (3000 mm x 3000 mm span)	
Thickness	150 mm
Peak Compressive stress (MPa)	-0.06
Peak Tensile stress (MPa)	0.03
Max displacement (mm)	1.4



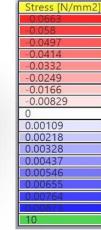
Principal stress 1



Principal stress 2



Combined stresses

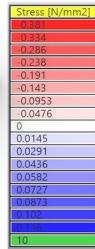


Structural Analysis - 12x9 m Rectangular base Dome

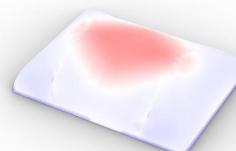
Limit States	
Ultimate Compressive stress (MPa)	1.3
Ultimate Tensile stress (MPa)	0.13
Displacement (mm) (span/400)	30



Combined stresses



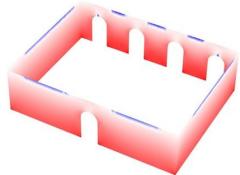
DOME (12000 mm x 9000 mm span)	
Thickness	300 mm
Peak Compressive stress (MPa)	-0.38
Peak Tensile stress (MPa)	0.11
Max displacement (mm)	23



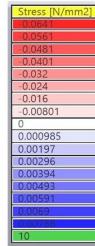
Principal stress 1



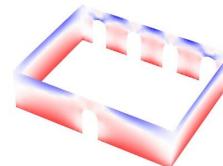
Principal stress 2



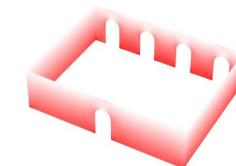
Combined stresses



WALL	
Thickness	600 mm
Peak Compressive stress (MPa)	-0.015
Peak Tensile stress (MPa)	0.006
Max displacement (mm)	10.4



Principal stress 1



Principal stress 2

3

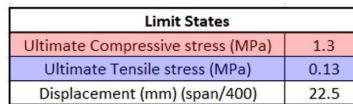
Refine mesh

Material selection

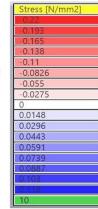
Applied load cases

Structural Analysis

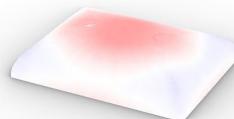
Structural Analysis - 9x6 m Rectangular base Dome



Combined stresses



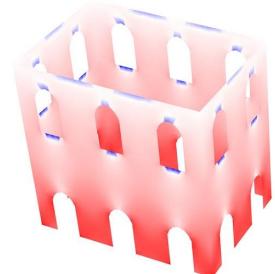
DOME (9000 mm x 6000 mm span) (double height Dome)	
Thickness	225 mm
Peak Compressive stress (MPa)	-0.22
Peak Tensile stress (MPa)	0.11
Max displacement (mm)	17.7



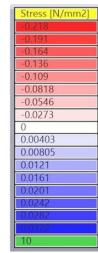
Principal stress



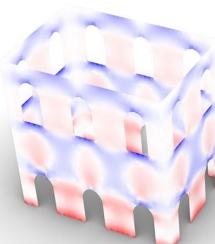
Principal stress 2



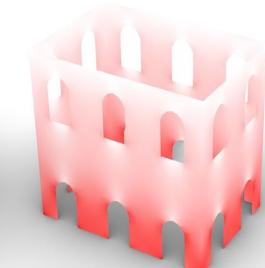
Combined stresses



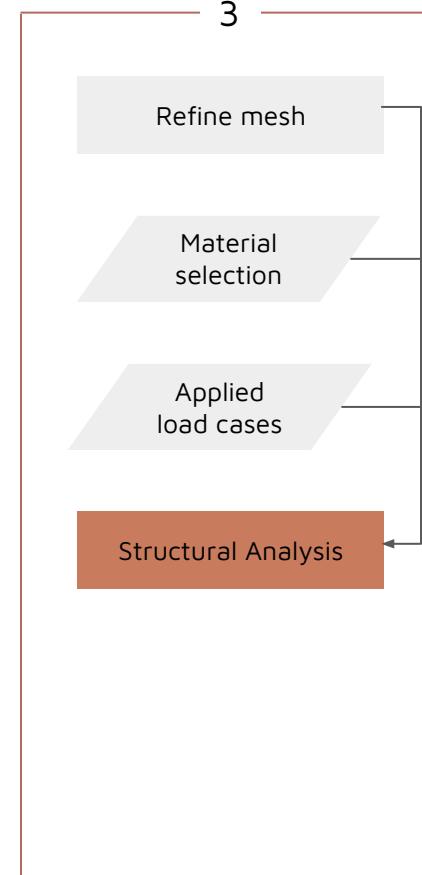
WALL	
Thickness	600mm
Peak Compressive stress (MPa)	-0.2
Peak Tensile stress (MPa)	0.03
Max displacement (mm)	8.5



Principal stress



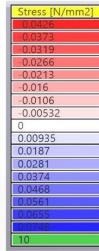
Principal stress 2



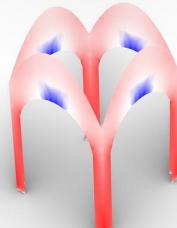
Structural Analysis - 3x3 m Cross Vaults



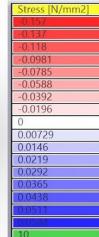
Combined stresses



CROSS VAULTS (3000 mm x 3000 mm span)	
Thickness	150 mm
Peak Compressive stress (MPa)	-0.06
Peak Tensile stress (MPa)	0.05
Max displacement (mm)	0.74



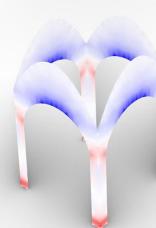
Combined stresses



WALL	
Thickness	300 mm
Peak Compressive stress (MPa)	-0.15
Peak Tensile stress (MPa)	0.08
Max displacement (mm)	5.26



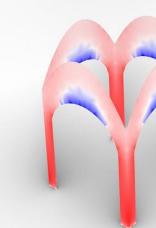
Principal stress 1



Principal stress 1



Principal stress 2



Principal stress 2

Refine mesh

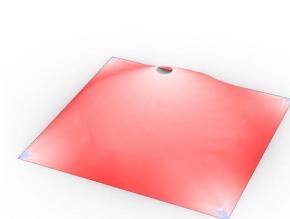
Material selection

Applied load cases

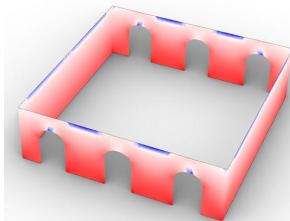
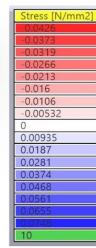
Structural Analysis

3

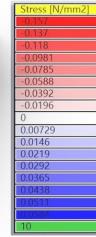
Structural Analysis -9 x 9 m Adobe 2.0 Dome



Combined stresses

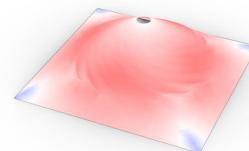


Combined stresses

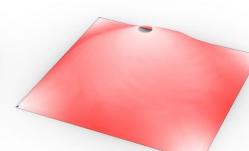


Limit States	
Ultimate Compressive stress (MPa)	1.3
Ultimate Tensile stress (MPa)	0.13
Displacement (mm) (span/400)	22.5

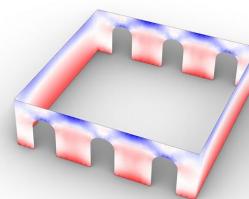
Adobe 2.0 (9000 mm x 9000 mm span)	
Thickness	300 mm
Peak Compressive stress (MPa)	-0.19
Peak Tensile stress (MPa)	0.11
Max displacement (mm)	12



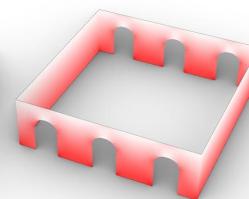
Principal stress 1



Principal stress 2



Principal stress 1



Principal stress 2

Refine mesh

Material selection

Applied load cases

Structural Analysis

3

Structural Analysis - Load Factor

Sum of total Reaction forces in Computational Model= **197.19 KN**

Hand Calculation:

Surface area of mesh= 91.28 m²

Thickness of mesh= 0.15 m

therefore, Volume of the mesh= 13.69 m³

Safety Factor= 1.2

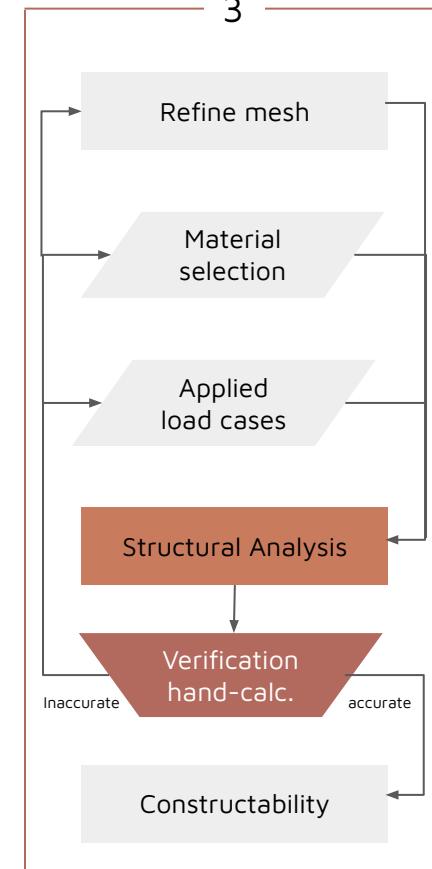
Specific weight = 12 KN/m³ (Adobe density = 1200 kg/m³)

Total reaction force= $13.69 \times 1.2 \times 12$

$$= \mathbf{197.16 \text{ KN}}$$

Thus, Computational model gives accurate results.

3



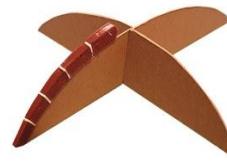


4 - Constructability

Experiment



Making the infill bricks



Assembling the 3D printed interlocking bricks with the help of cardboard formwork.



Assembling the infill bricks once all the ribs have been constructed.

4

Experimenting with the brick modules

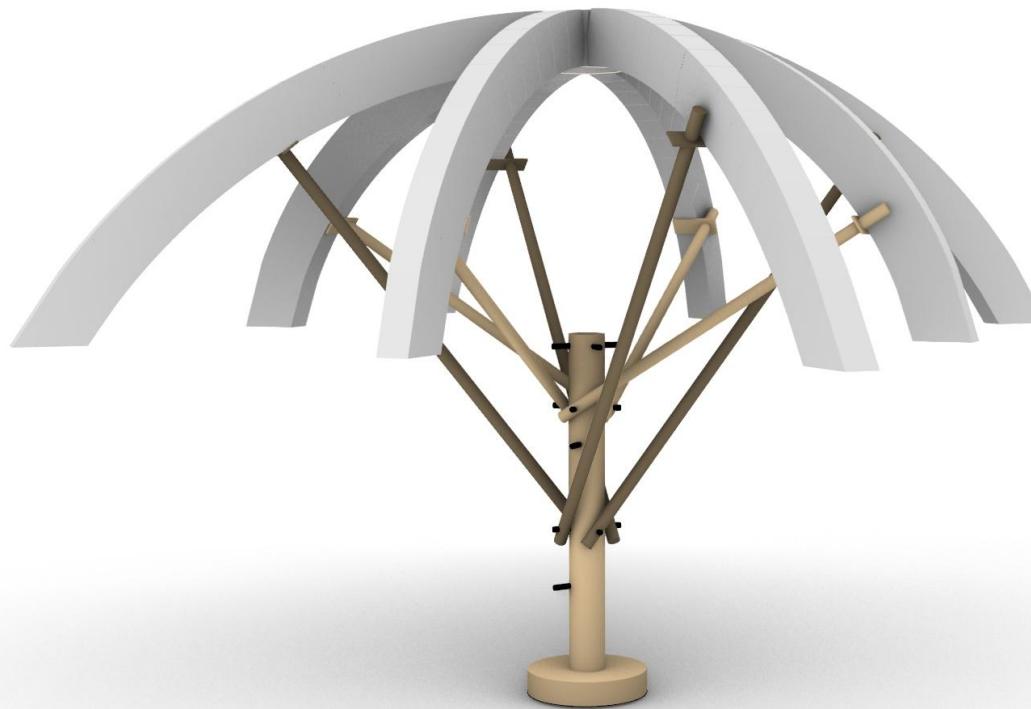
Experiment



4

Experimenting with
the brick modules

Instrument - A concept



4

Experimenting with
the brick modules

Materials used during
the construction
process

Materials

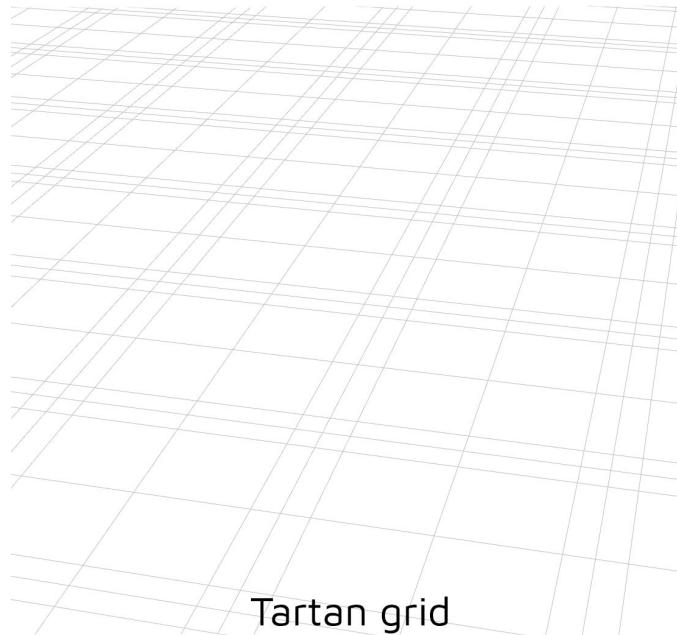
Materials	 SHOVEL AND BUCKET	 HAND MIXER	 SCRAPE WOOD	 ADOBE BRICKS	 PLUMBING PIPES	 NAILS, SCREWS & ROPE	 CLAMPS & HINGES
Application	Digging the site. Moving Earth	Mixing soil mixture	To make brick moulds	Corner-stones Key-stones Interlocking Bricks Infill Outdoor and Indoor Plaster	Formwork instrument Fathy's Compass	Attaching parts of the formwork instrument Guide for excavation	Formwork instrument Fathy's Compass
Sourcing	Hardware store UNHCR	Hardware store UNHCR	Waste on Camp	Moulded on site	Waste on camp Hardware store UNHCR	Hardware store UNHCR	Hardware store UNHCR
Re-usability	Used for other construction process	Used for other construction process	Used for all bricks in the project	Broken down and re-used again to make bricks	The formwork is re-used again to make other domes	The formwork is re-used again to make other domes	The formwork is re-used again to make other domes

4

Experimenting with the brick modules

Materials used during the construction process

Construction - Ribbed Dome script



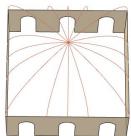
4

Experimenting with
the brick modules

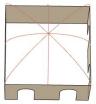
Materials used during
the construction
process

Generating a script
for the bricklaying of
the roof

Construction - Module 1 : Ribbed Dome



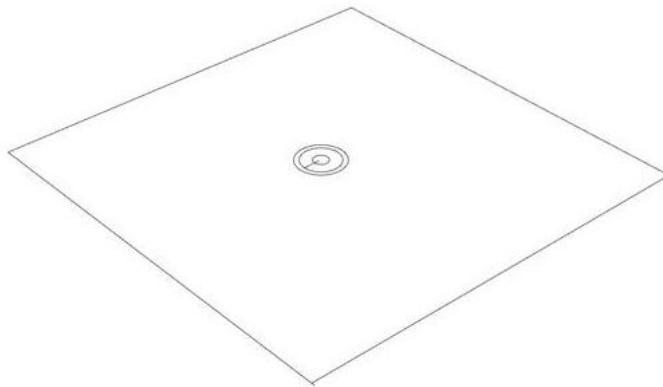
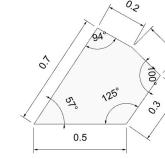
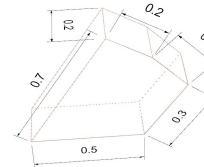
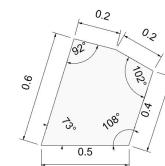
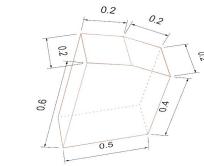
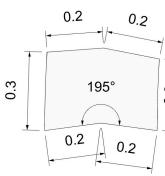
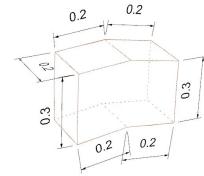
9x9 Dome



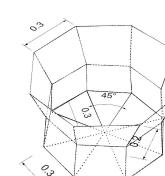
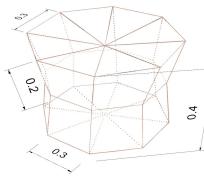
6x6 Dome



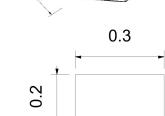
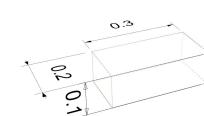
3x3 Dome

**Type****Size and Shape****Mould**Corner-stone
-diagonalCorner stone
-horizontal &
VerticalInterlocking
blocks

Key-stone



Infil



4

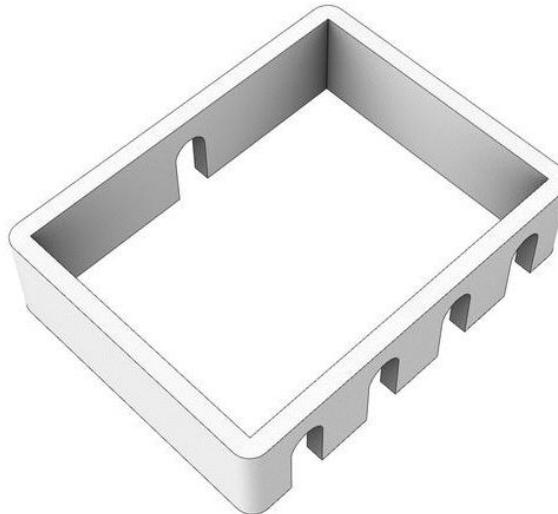
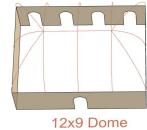
Experimenting with
the brick modulesMaterials used during
the construction
processGenerating a script
for the bricklaying of
the roof

Assembly sequence

Defining Brick sizes

Defining Mould sizes

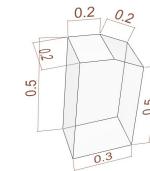
Construction - Module 2 : Vaulted Dome



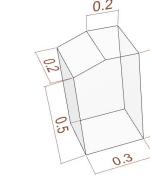
Type

Corner-stone
-diagonal

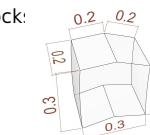
Size and Shape



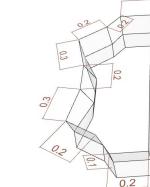
Corner stone
-horizontal &
Vertical



Interlocking block:



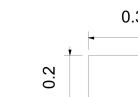
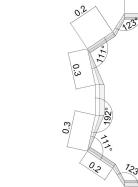
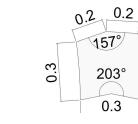
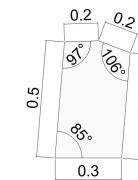
Key-stone



Infil



Mould



4

Experimenting with
the brick modules

Materials used during
the construction
process

Generating a script
for the bricklaying of
the roof

Assembly sequence

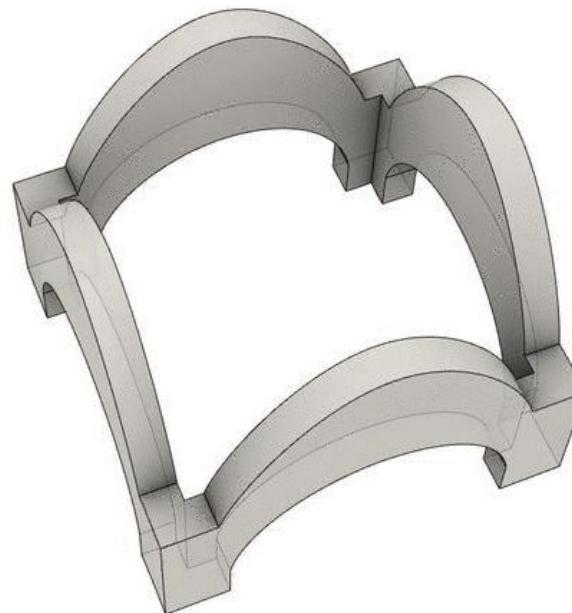
Defining Brick sizes

Defining Mould sizes

Construction - Module 3: Cross Vault



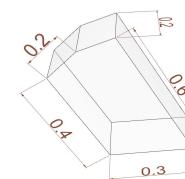
3x3 cross vault



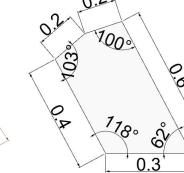
Type

Corner-stone
-diagonal

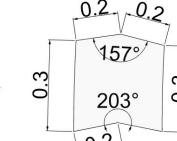
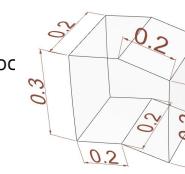
Size and Shape



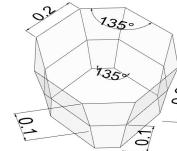
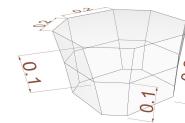
Mould



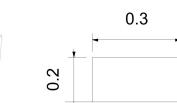
Interlocking bloc



Key-stone



Infil



Experimenting with the brick modules

Materials used during the construction process

Generating a script for the bricklaying of the roof

Assembly sequence

Defining Brick sizes

Defining Mould sizes

6 x 6 m square dome visualisation



4

Assembly sequence

Defining Brick sizes

Defining Mould sizes

3D visualisation

Construction - Module 4 script

Generating a script
for the bricklaying of
the adobe 2.0 roof



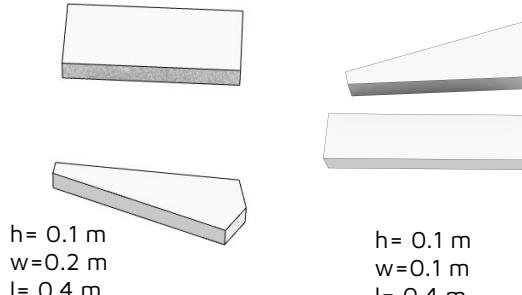
Divine Fibonacci points

Construction - Module 4: Adobe 2.0



Use of Fathy's compass for brick laying

Brick proportion 1:2:4



Generating a script
for the bricklaying of
the roof

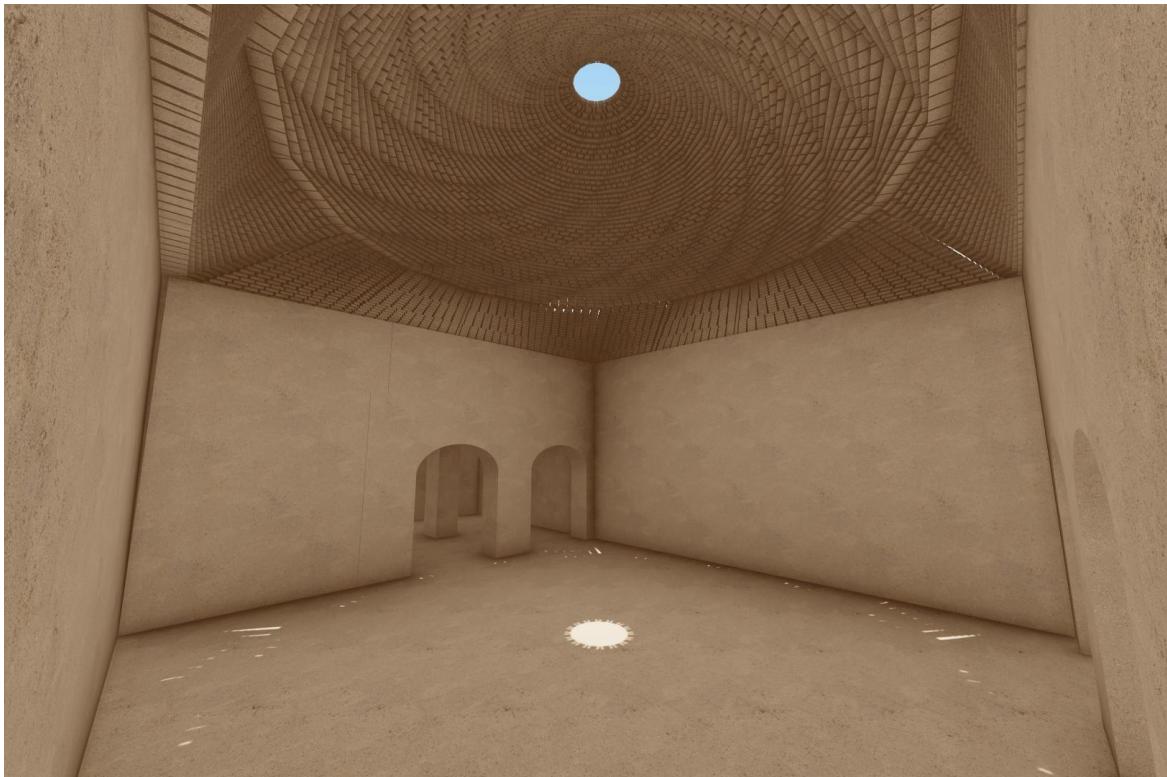
Assembly sequence

Defining Brick sizes

Defining Mould sizes

4

Adobe 2.0 dome visualisation



4

Assembly sequence

Defining Brick sizes

Defining Mould sizes

3D visualisation

Reflections

1. The overall design achieved is an agglomeration of a modular spaces and geometries.
2. The construction instrument is still conceptual and needs further development for accuracy in the construction process in case of adobe 2.0.
3. Computational and Human approach need to work in synergy in order to speed up the process with the required skills and accuracy.

Relaxing in the Hammam



Twinkle Nathani

Welcoming the visitors



Shivya Balakrishnan

Coordinating the gardening activities



Thijmen Pijnimers



Enjoying the cool breeze in the water fountain courtyard



Relaxing in the Hammam

3D Visualisations

Reflections

4



Thank you!

