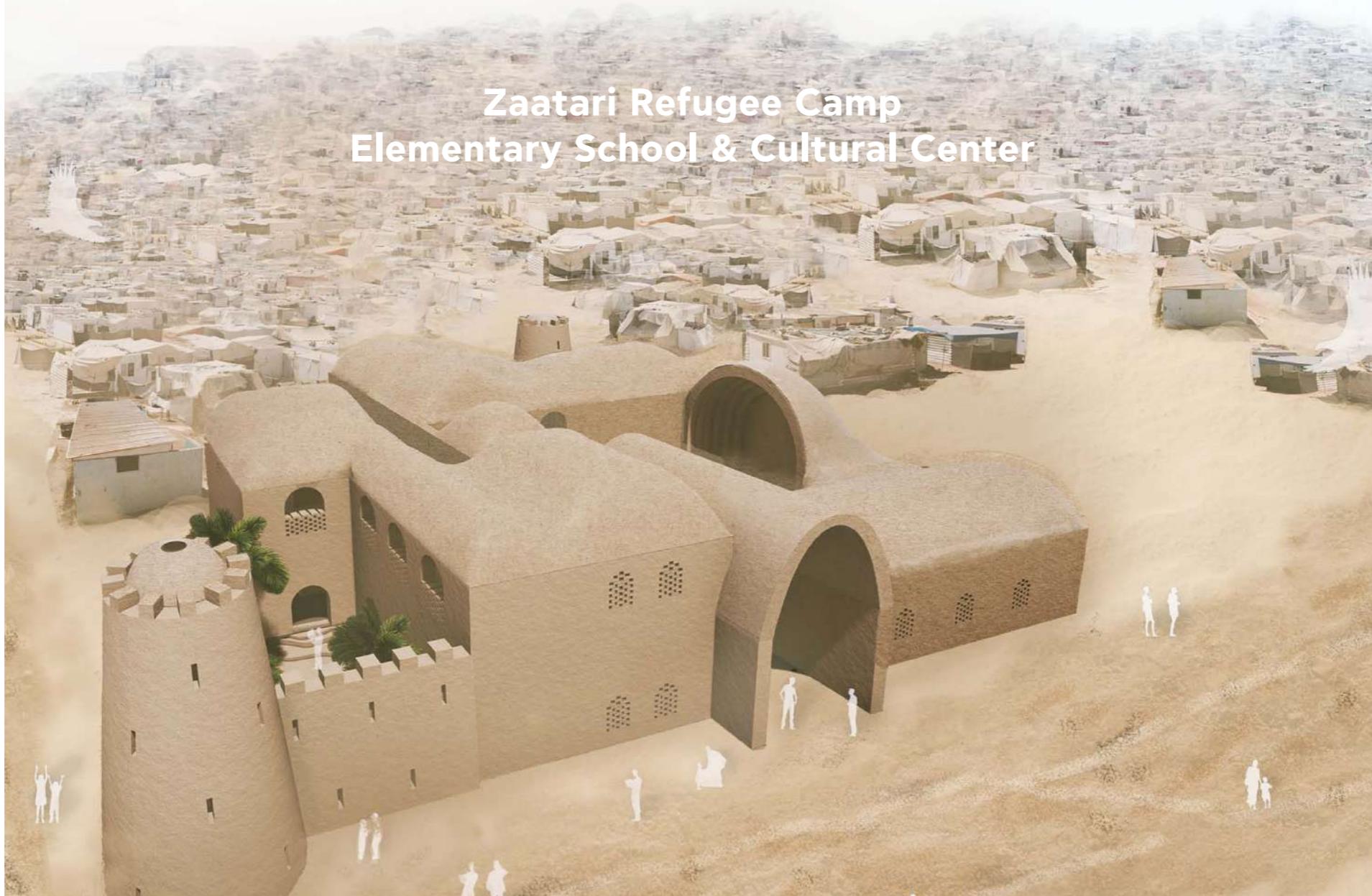


SANDCASTLE



Prof. Dr. Ir. Sevil Sariyildiz
Dr. Ir. Fred Veer
Dr. Ir. Pirouz Nourian
Ir. Hans Hoogenboom
Ir. Dirk Rinze Visser
Ir. Shervin Azadi
Ir. Frank Schnater

AR3B011 Earthy TU Delft Group_04

ANALYSIS

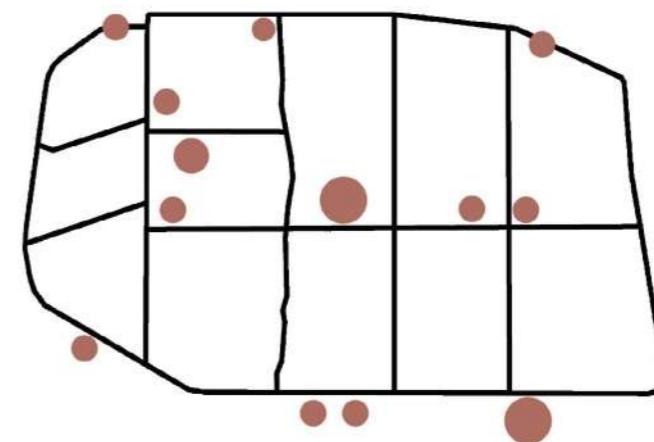
STATISTICS



18.493 children



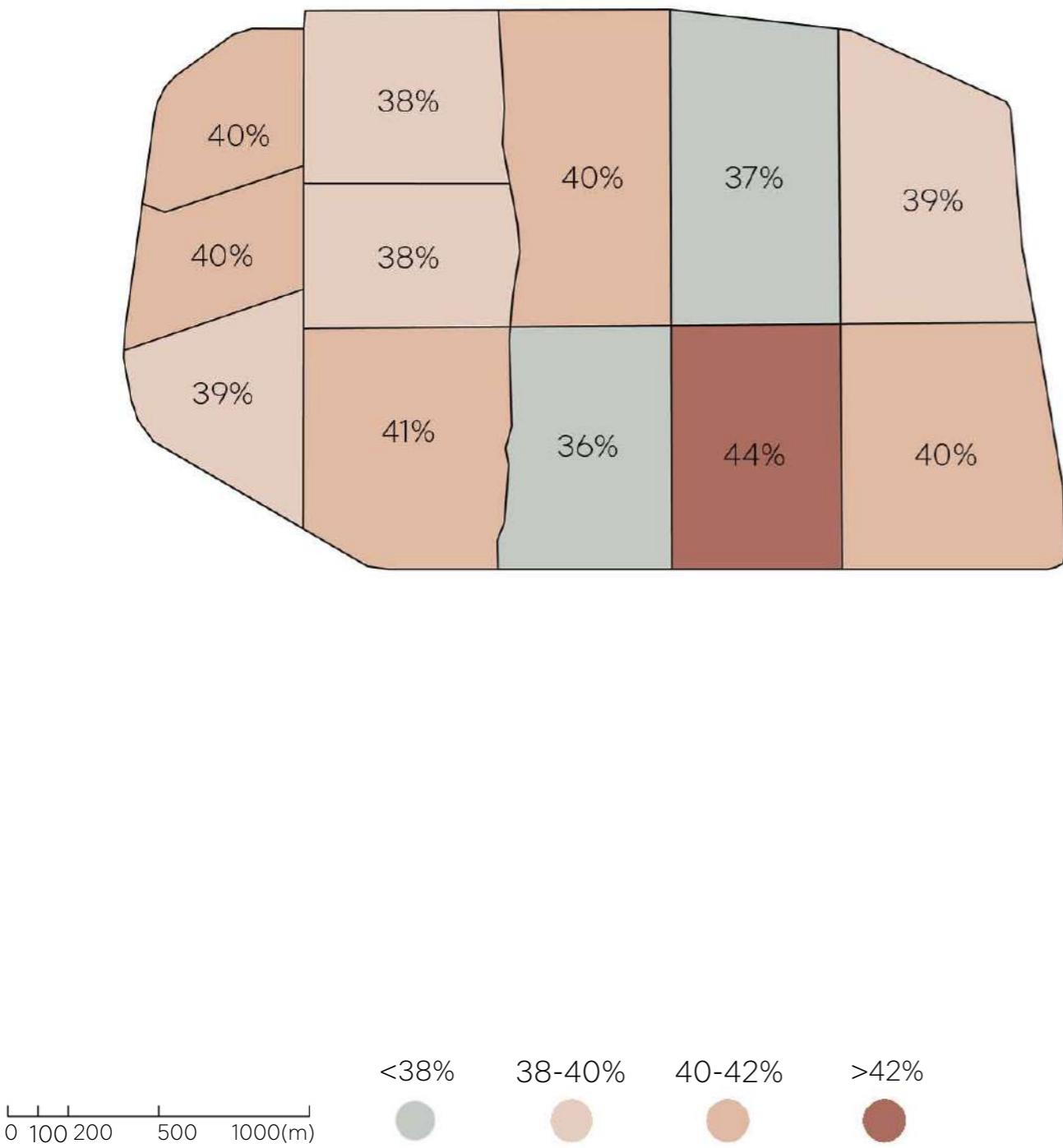
32 schools



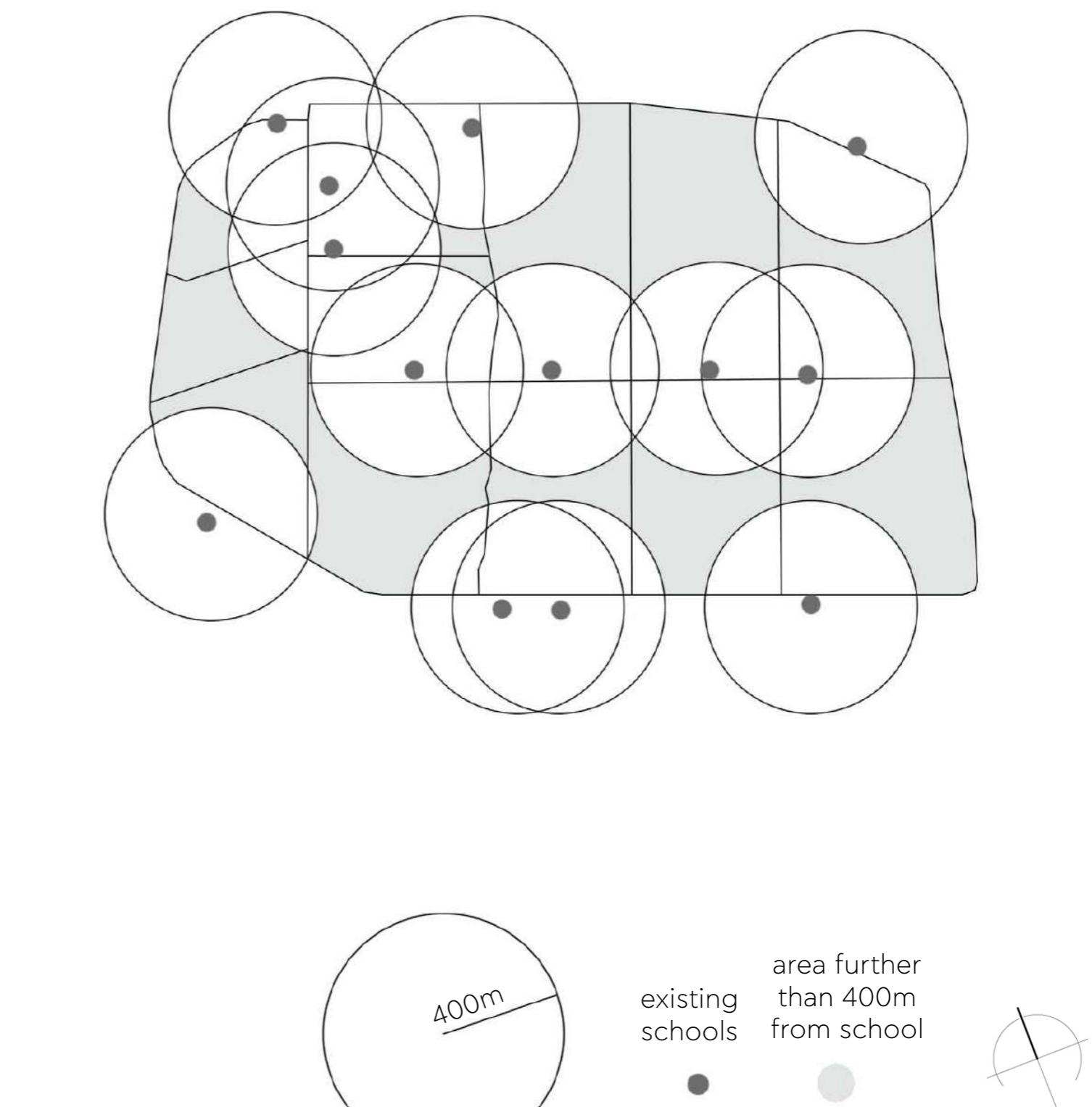
13 school locations

578 children per school?

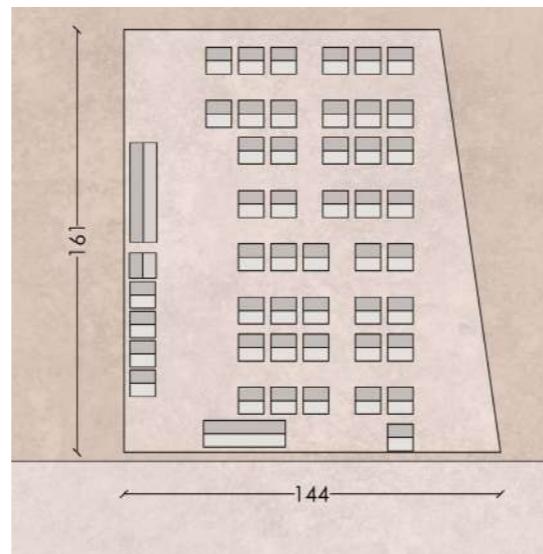
HOUSEHOLDS WITH CHILDREN
6 - 12 ENROLLED



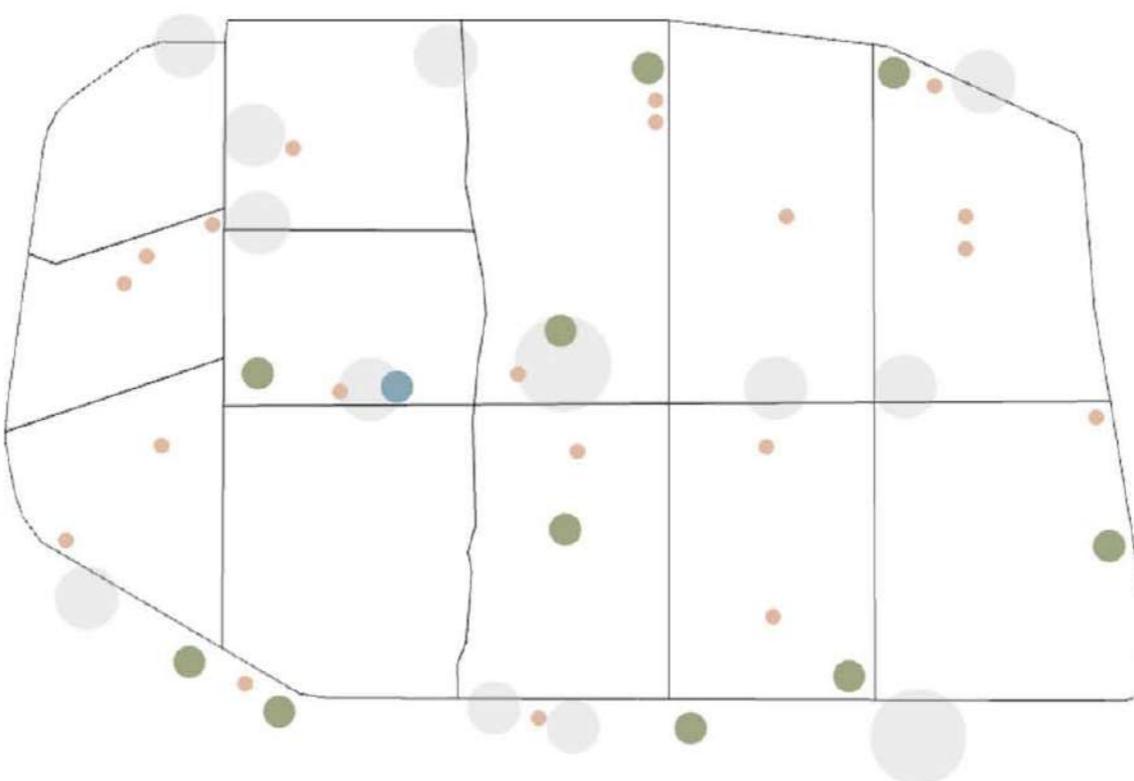
AREA 400M FROM A SCHOOL



EXISTING SCHOOLS



COMMUNAL ACTIVITIES



existing community
schools centers playground cinema

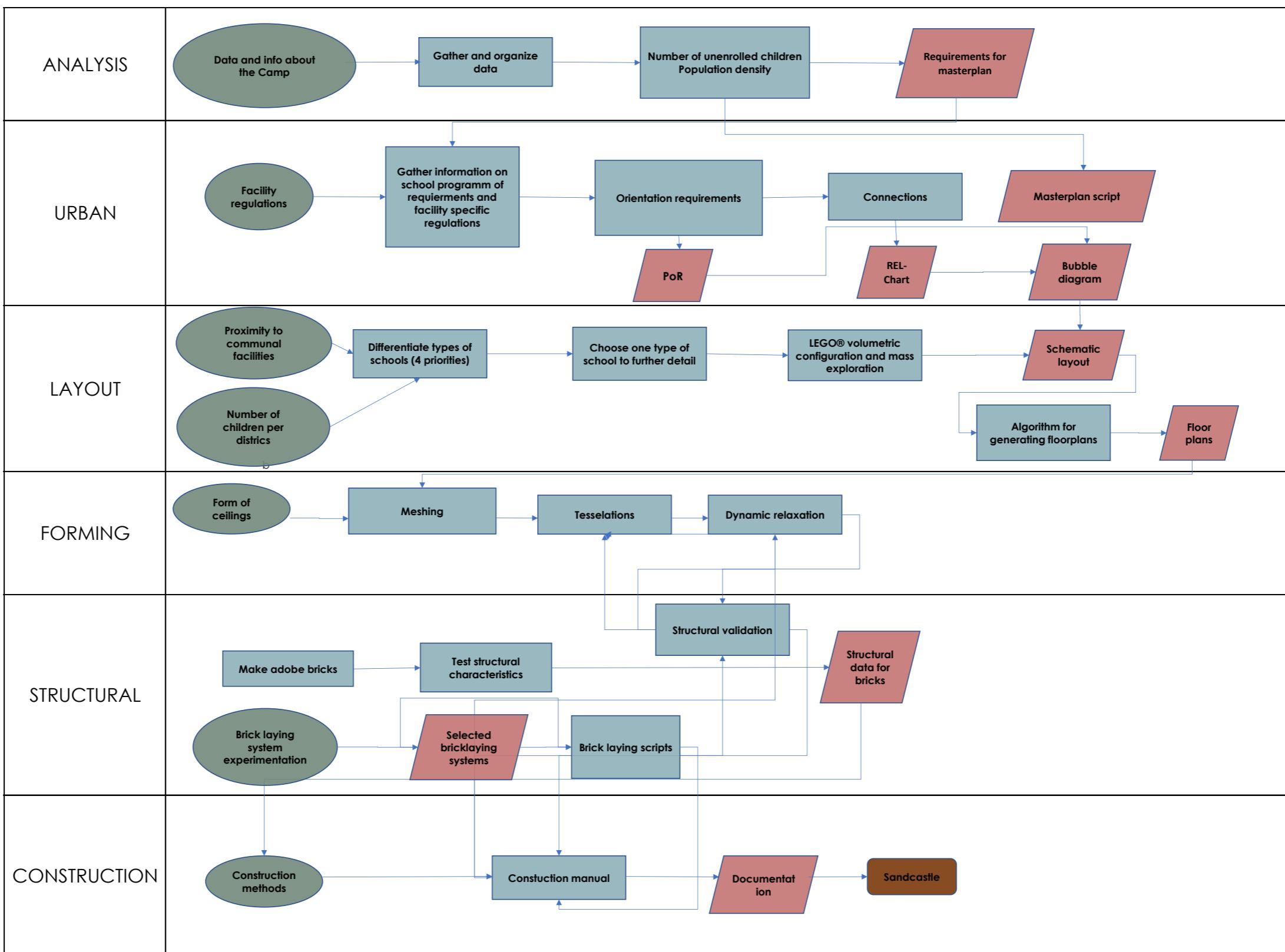


0 100 200 500 1000(m)



	PROBLEM	SOLUTION
ACCESSIBILITY	large walking distances for children paved street traffic	enhance school network avoid crossing paved streets
FACILITIES	uninspiring buildings no designated play space	make school appealing create a safe playing environment

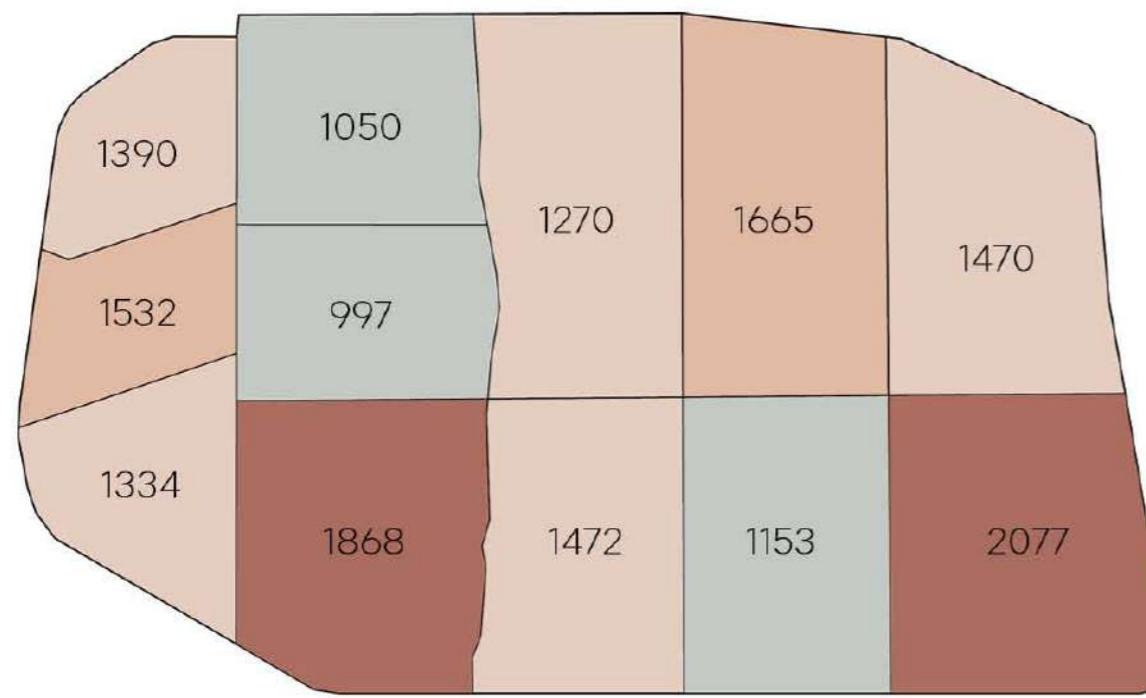
GLOBAL FLOWCHART



URBAN CONFIGURATION

	PROBLEM	SOLUTION
ACCESSIBILITY	large walking distances for children paved street traffic	enhance school network avoid crossing paved streets
FACILITIES	uninspiring buildings no designated play space	make school appealing create a safe playing environment

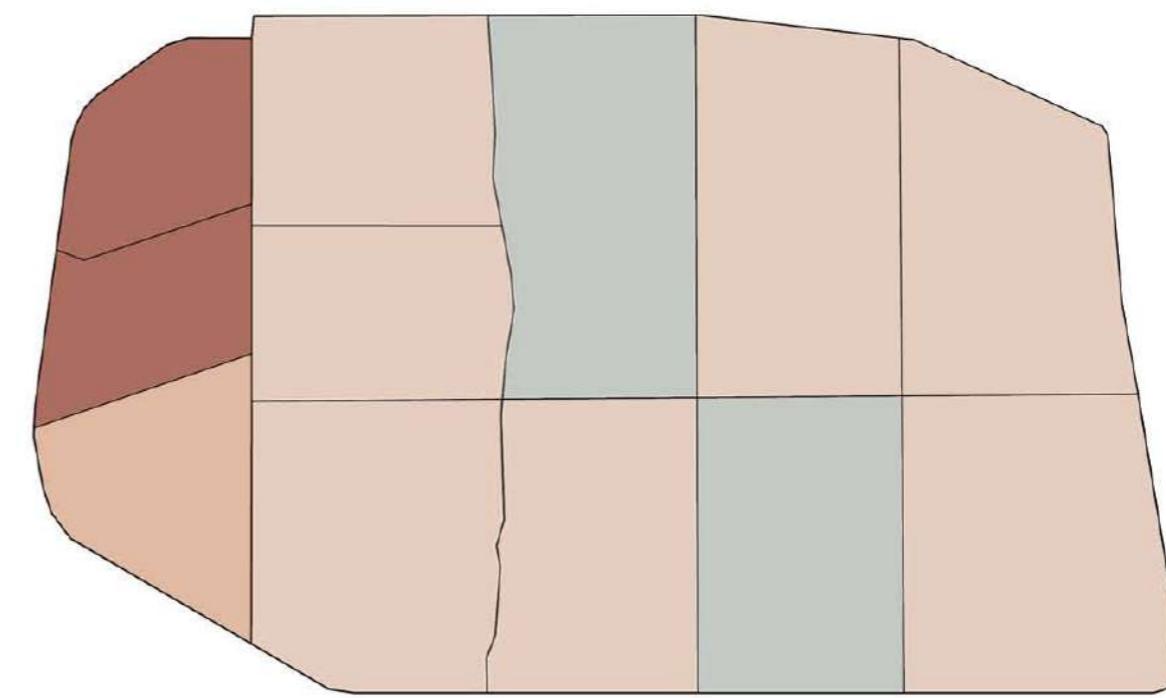
CHILD POPULATION



0 100 200 500 1000(m)

<1200 1200-1500 1500-1800 >800

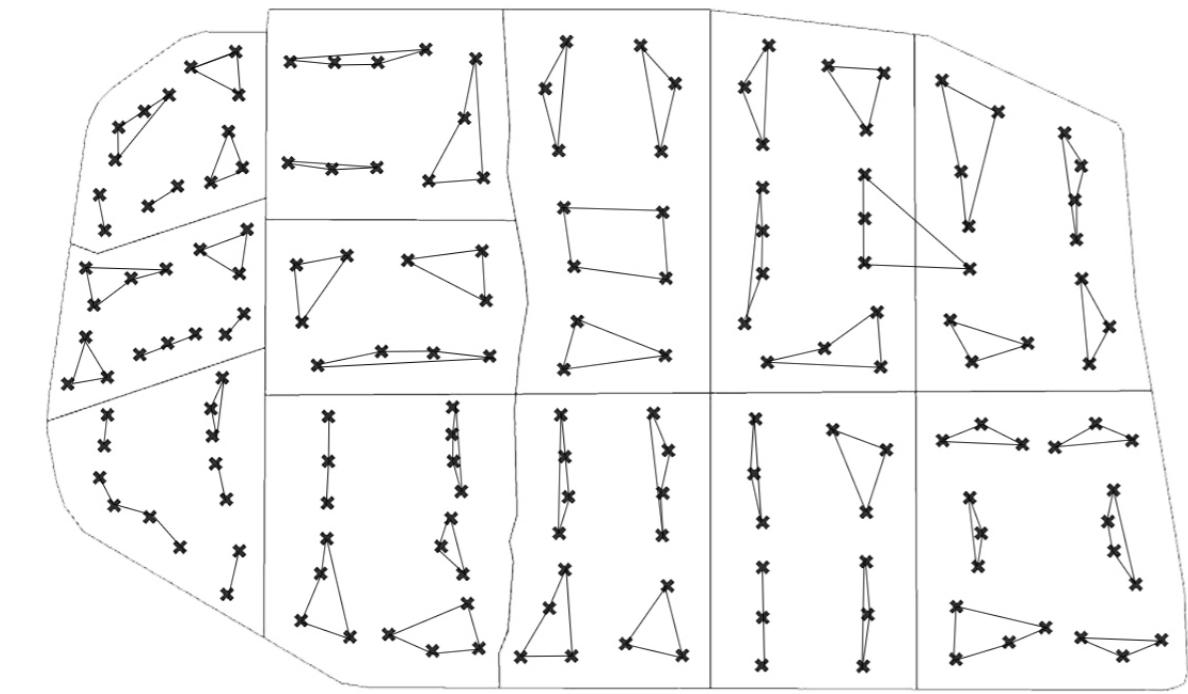
CHILD DENSITY



<2500 2500-4000 4000-5500 >5500
ppkm² ppkm² ppkm² ppkm²



CHILD DENSITY



0 100 200 500 1000(m)

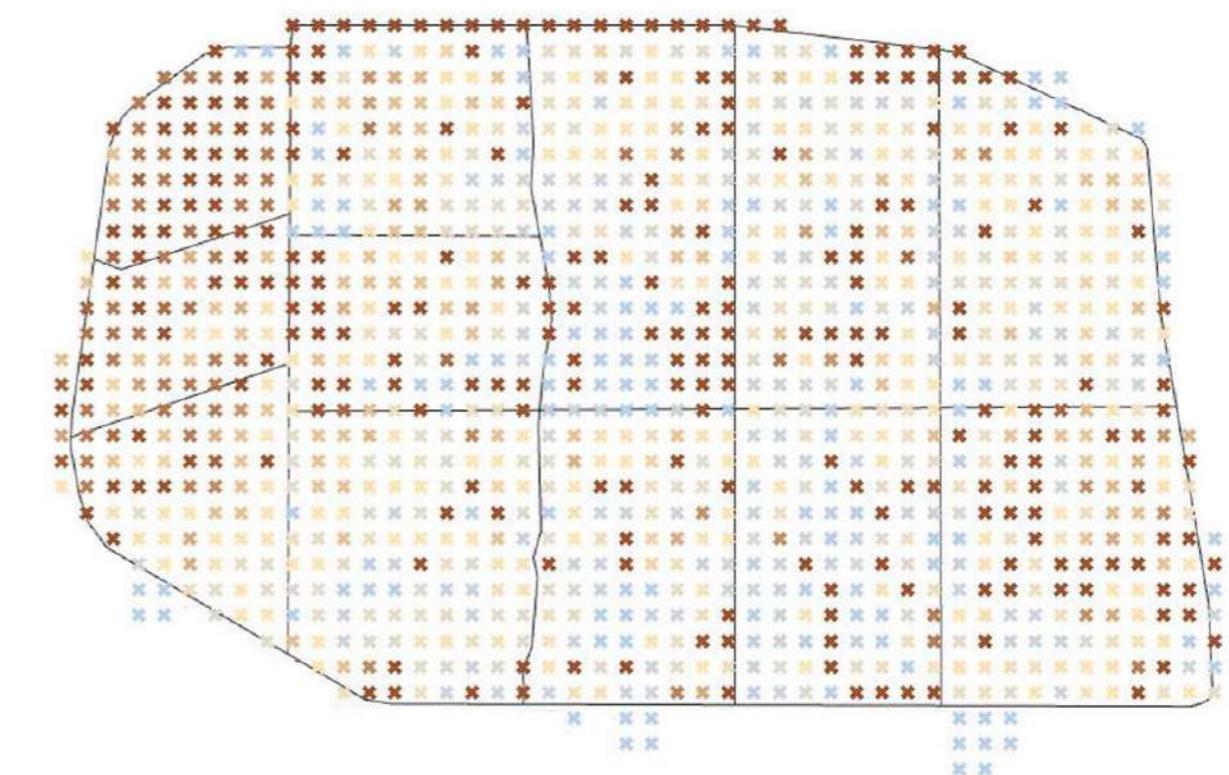
100
children
clusters

ANALYSIS

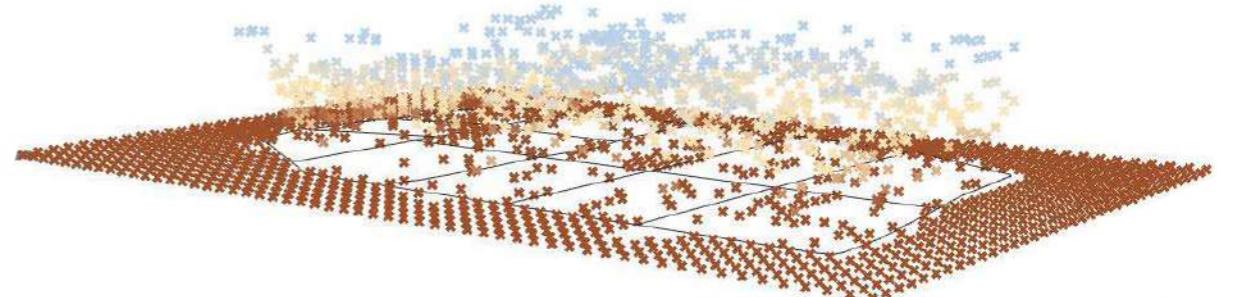
URBAN

LAYOUT

EMPTY SPACES



full empty

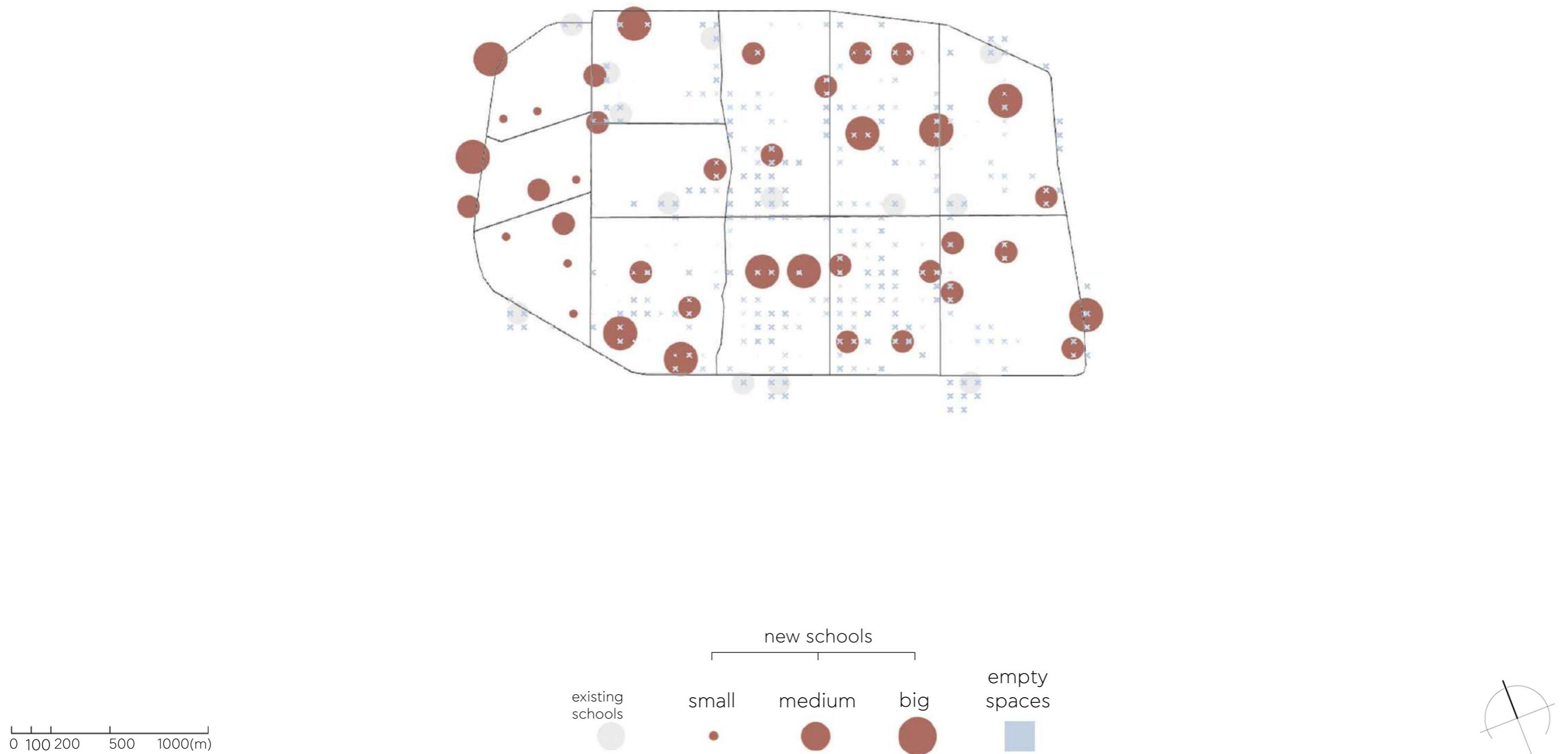


FORMING

STRUCTURAL

CONSTRUCTION

FINAL SCHOOL NETWORK



ANALYSIS

URBAN

LAYOUT

FORMING

STRUCTURAL

CONSTRUCTION

13

LAYOUT CONFIGURATION

	PROBLEM	SOLUTION
ACCESSIBILITY	large walking distances for children paved street traffic	enhance school network avoid crossing paved streets
FACILITIES	uninspiring buildings no designated play space	make school appealing create a safe playing environment

PROGRAM OF REQUIREMENTS

<100
STUDENTS

DISTRIBUTE TO NEIGHBOURING SCHOOLS

100-200
STUDENTS



CLASSROOM



COURTYARD



TEACHER ROOM

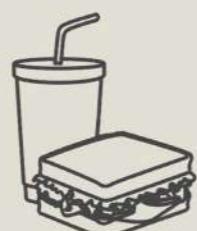


RESTROOMS

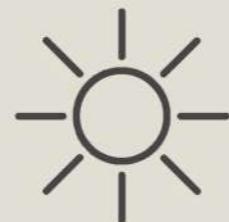
200-300
STUDENTS



MULTI-FUNCIONAL ROOM



CANTINE & KITCHEN



LIWAN



ADMINISTRATION



LIBRARY

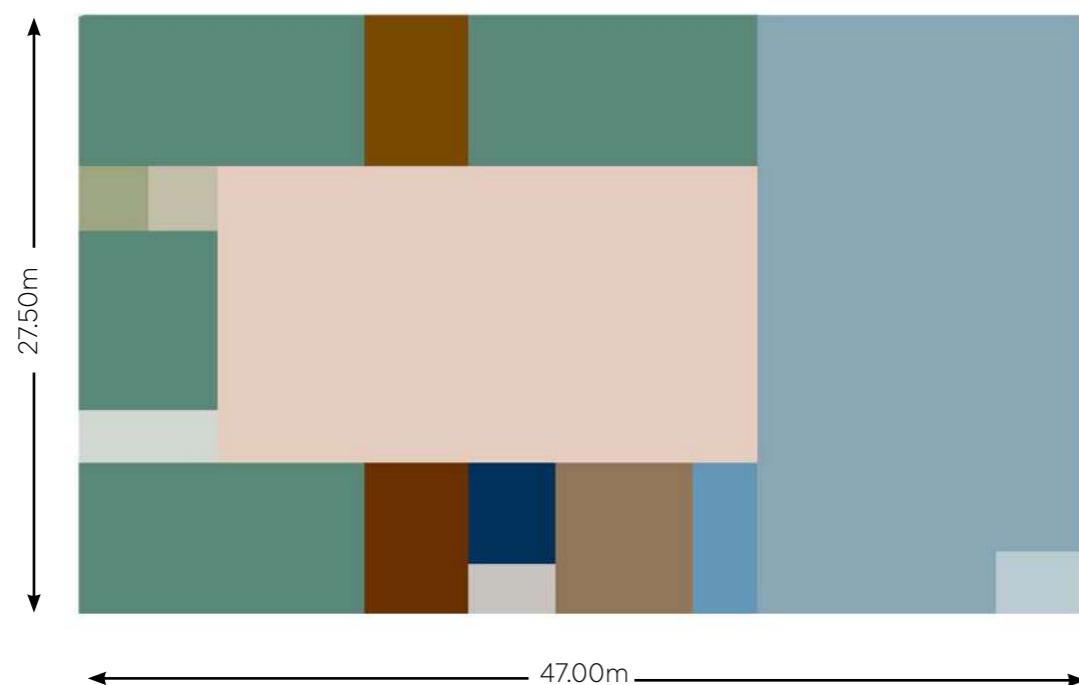


WINTER LIVING ROOM

>400
STUDENTS

ADD ANOTHER NEW SCHOOL

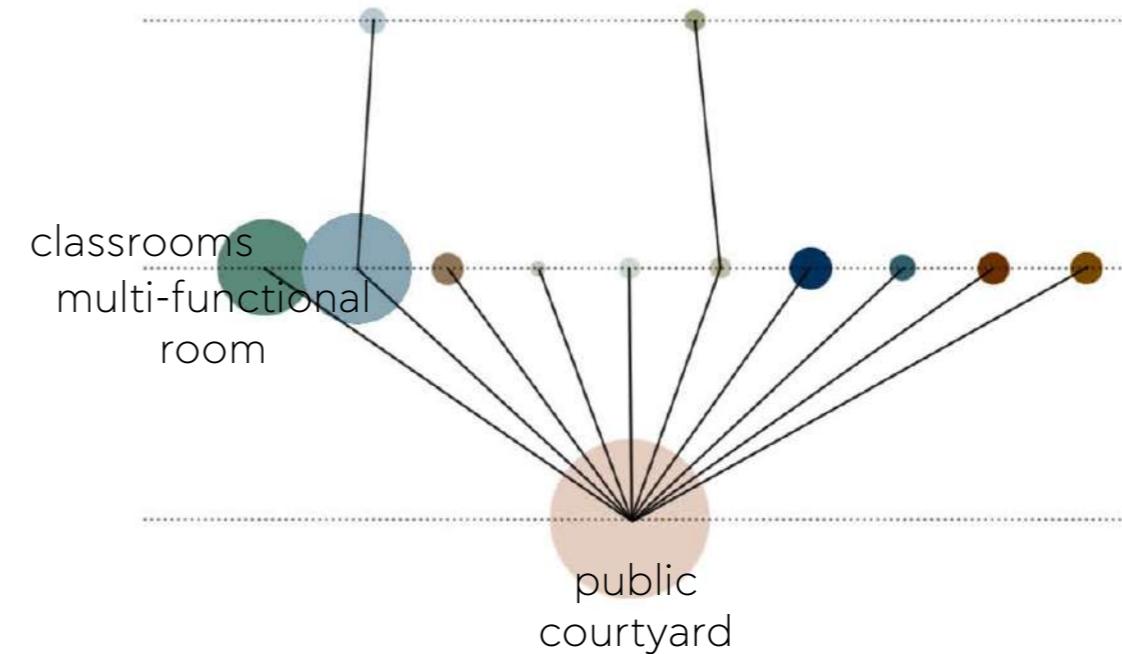
COURTYARD LAYOUT



+

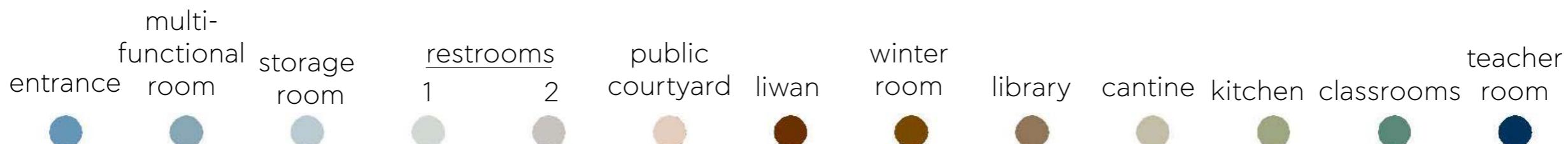
feeling of safety & property
familiar from vernacular architecture

JUSTIFIED GRAPH



-

too spread out
multi-functional room overshadows school
simple layout



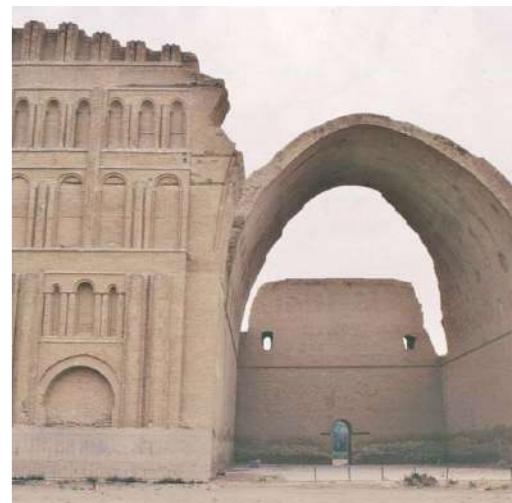
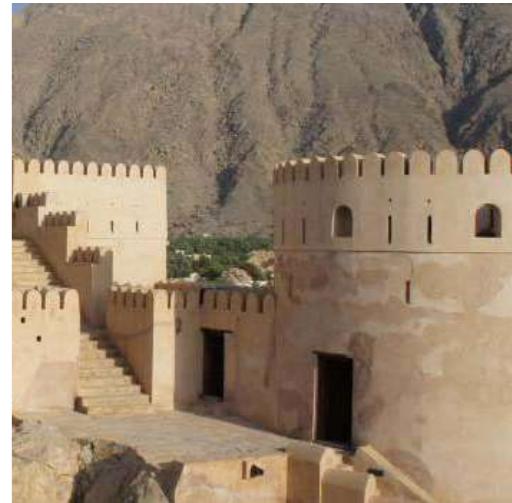
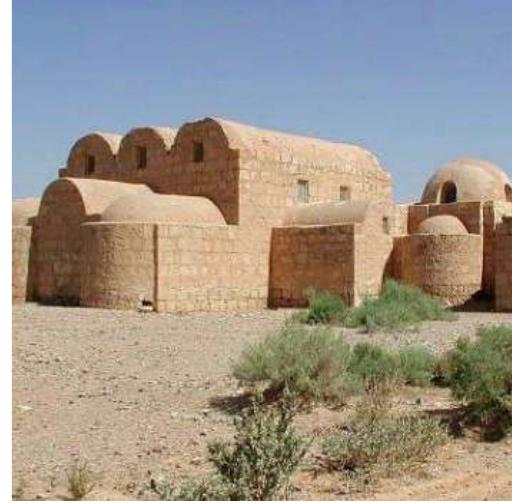
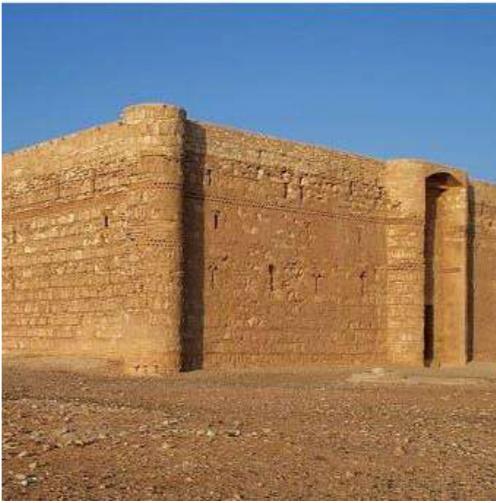
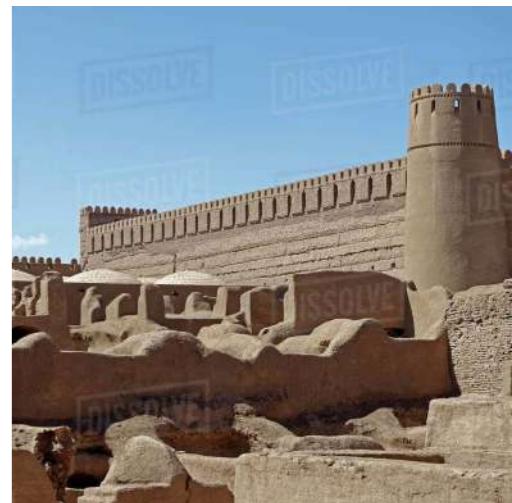
C A S T L E S

+

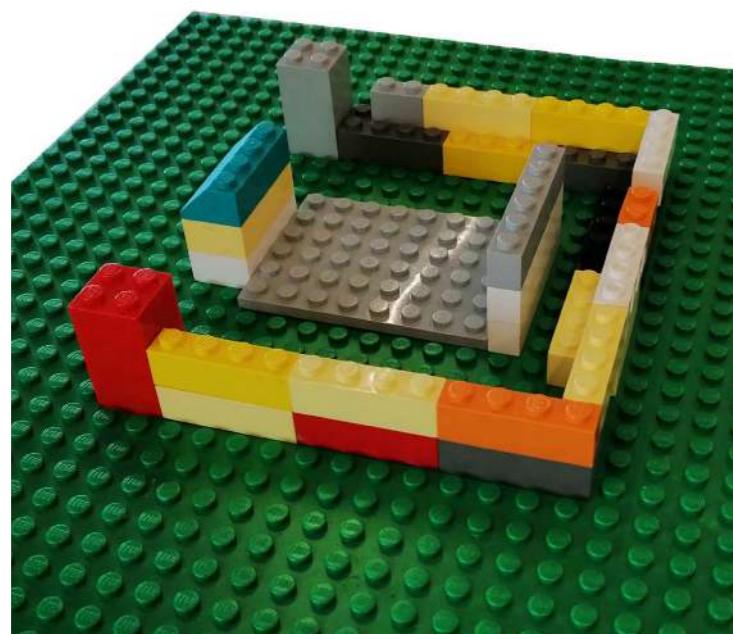
- feeling of safety
- feeling of property
- space saving
- appealing to children

WHAT MAKES A CASTLE

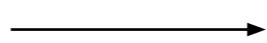
- single entrance
- surrounding wall
- maze-like layout
- different heights & towers



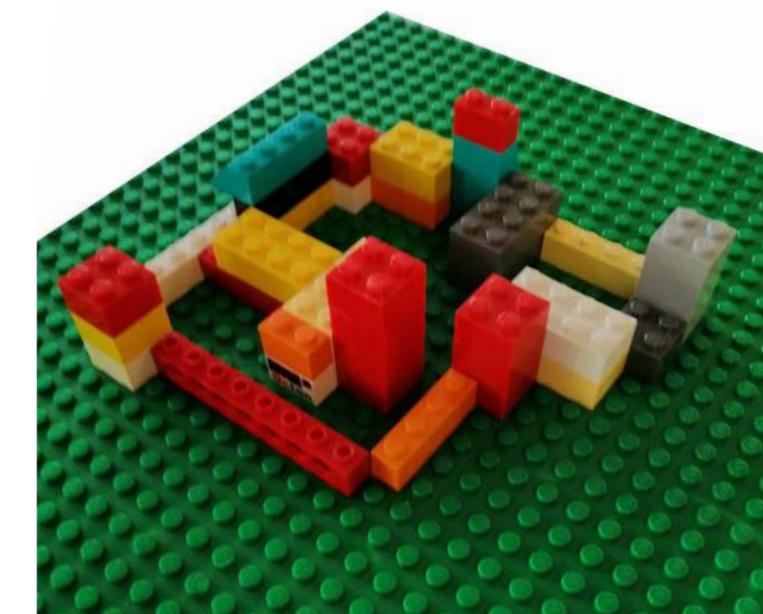
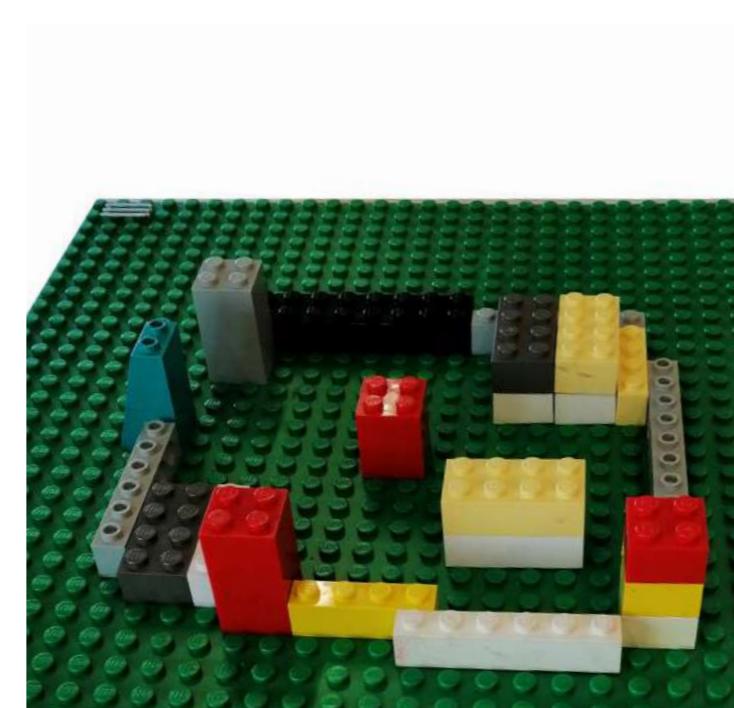
LEGO EXPERIMENTATION



single courtyard

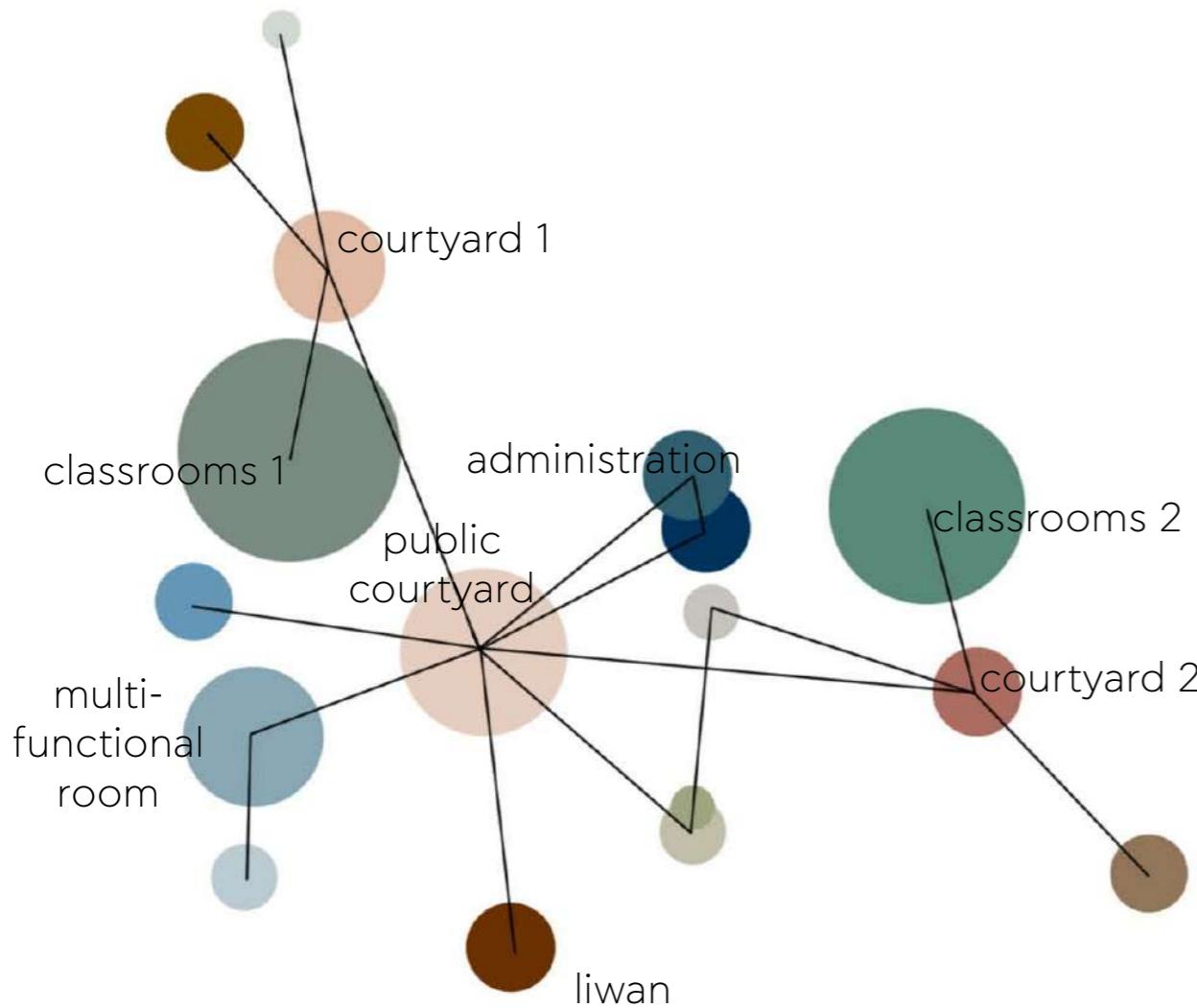


break up the space
more height variations

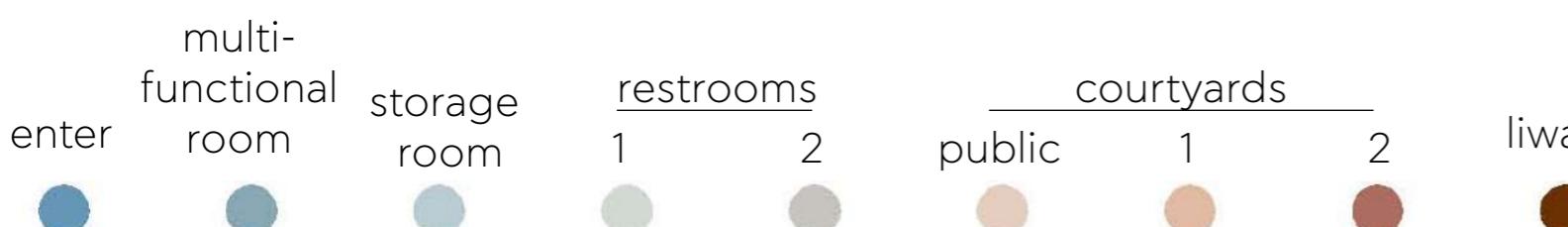
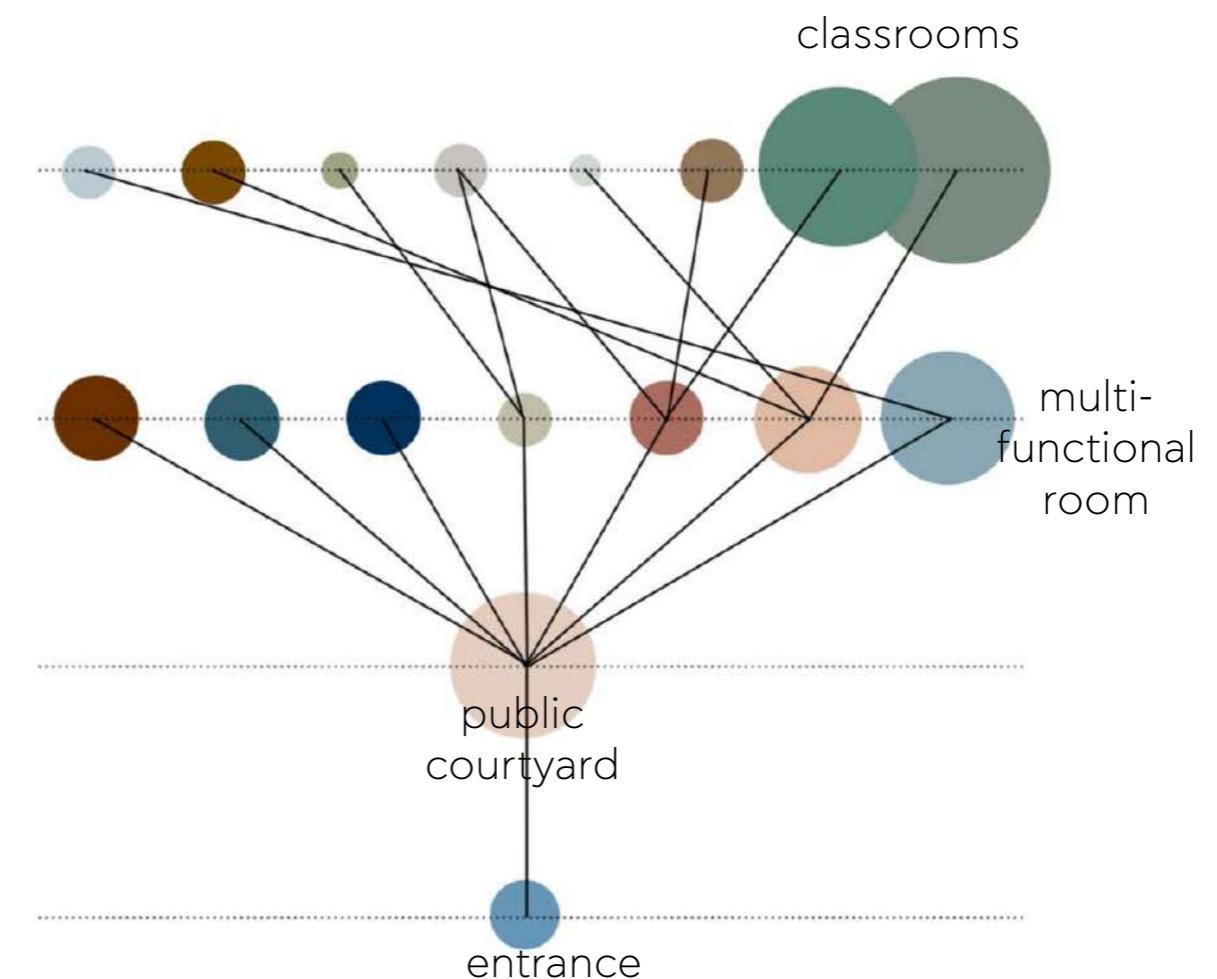


make dense

B U B B L E D I A G R A M



J U S T I F I E D G R A P H



ANALYSIS

URBAN

LAYOUT

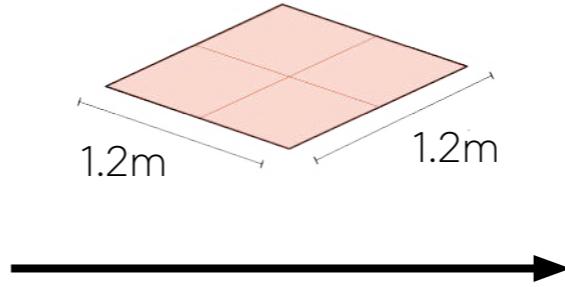
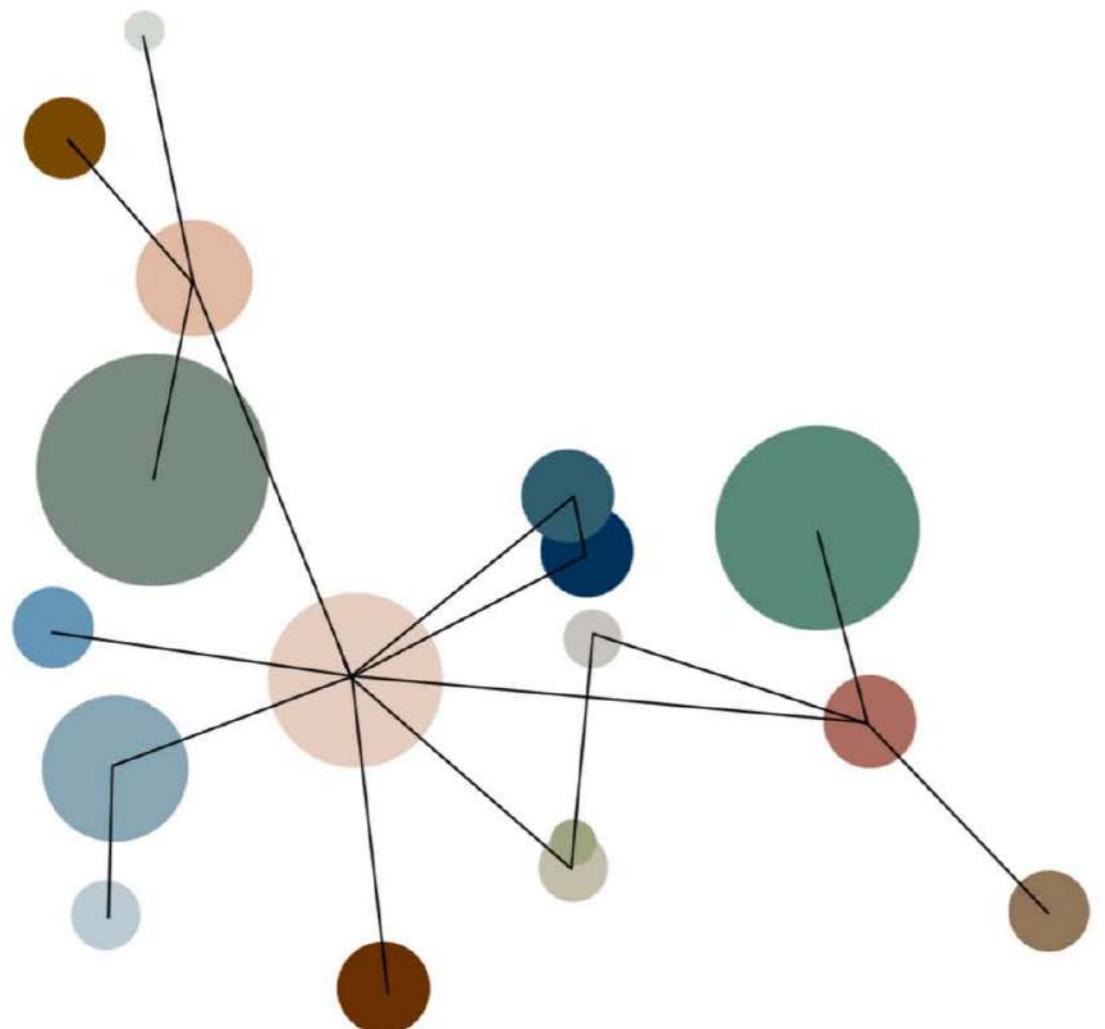
FORMING

STRUCTURAL

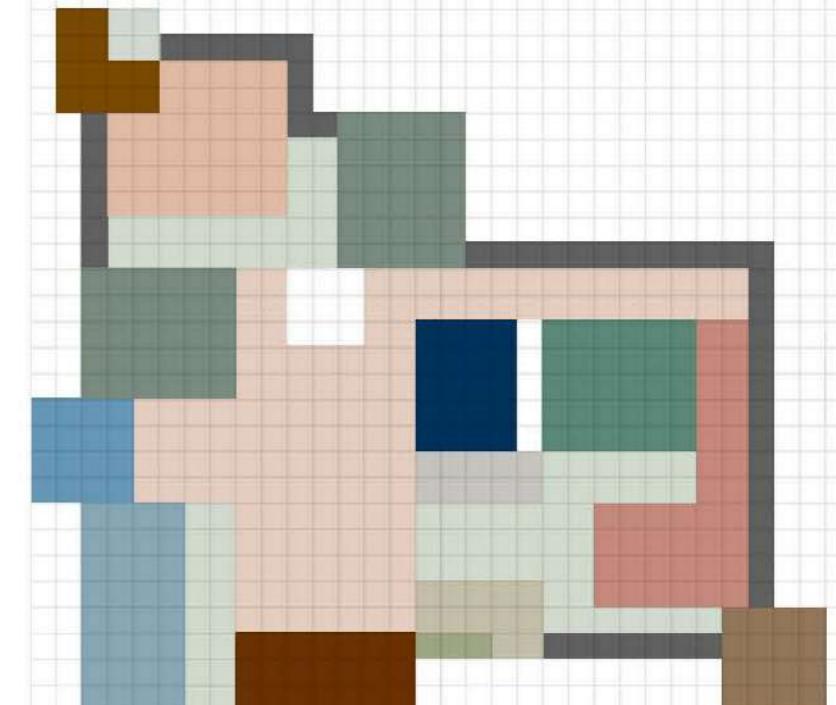
CONSTRUCTION

20

B U B B L E D I A G R A M



L A Y O U T



multifunctional room	storage room	<u>restrooms</u> 1	<u>restrooms</u> 2	<u>public courtyards</u> 1	<u>public courtyards</u> 2	liwan	winter room	library	cantine	kitchen	<u>classrooms</u> 1	<u>classrooms</u> 2	teacher room	admin
enter														

GROUND FLOOR



0 1 2 5 10m

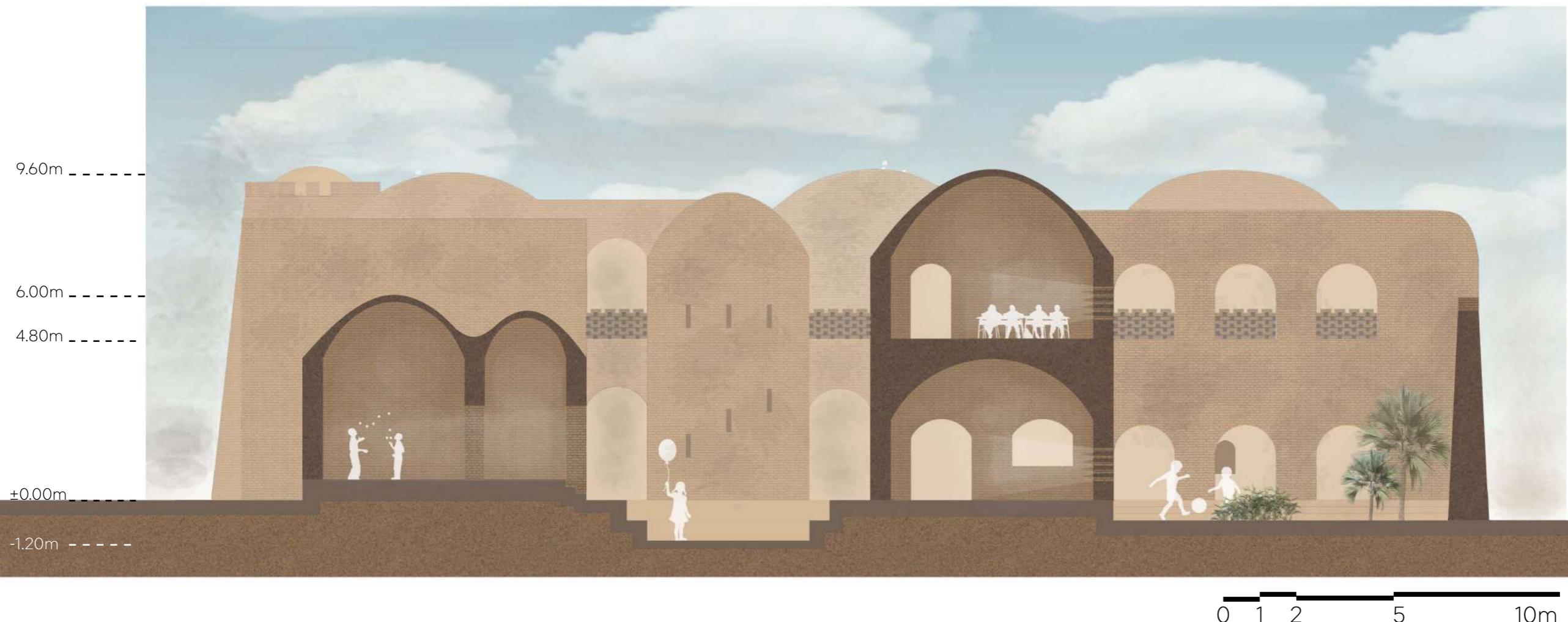
FIRST FLOOR



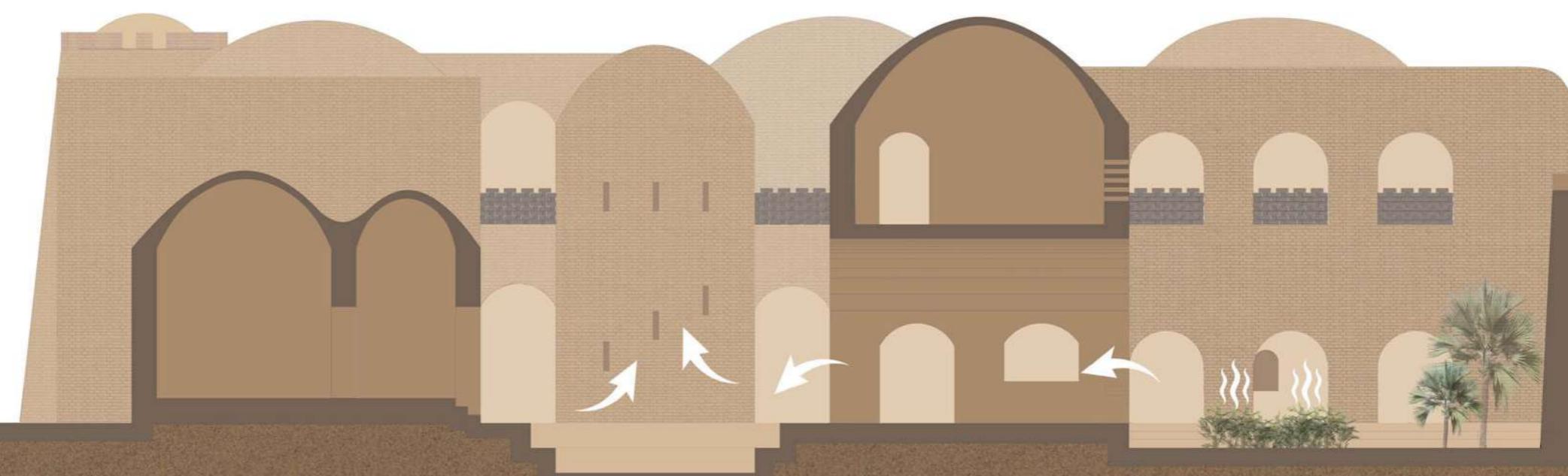
SECTION 1



S E C T I O N 2



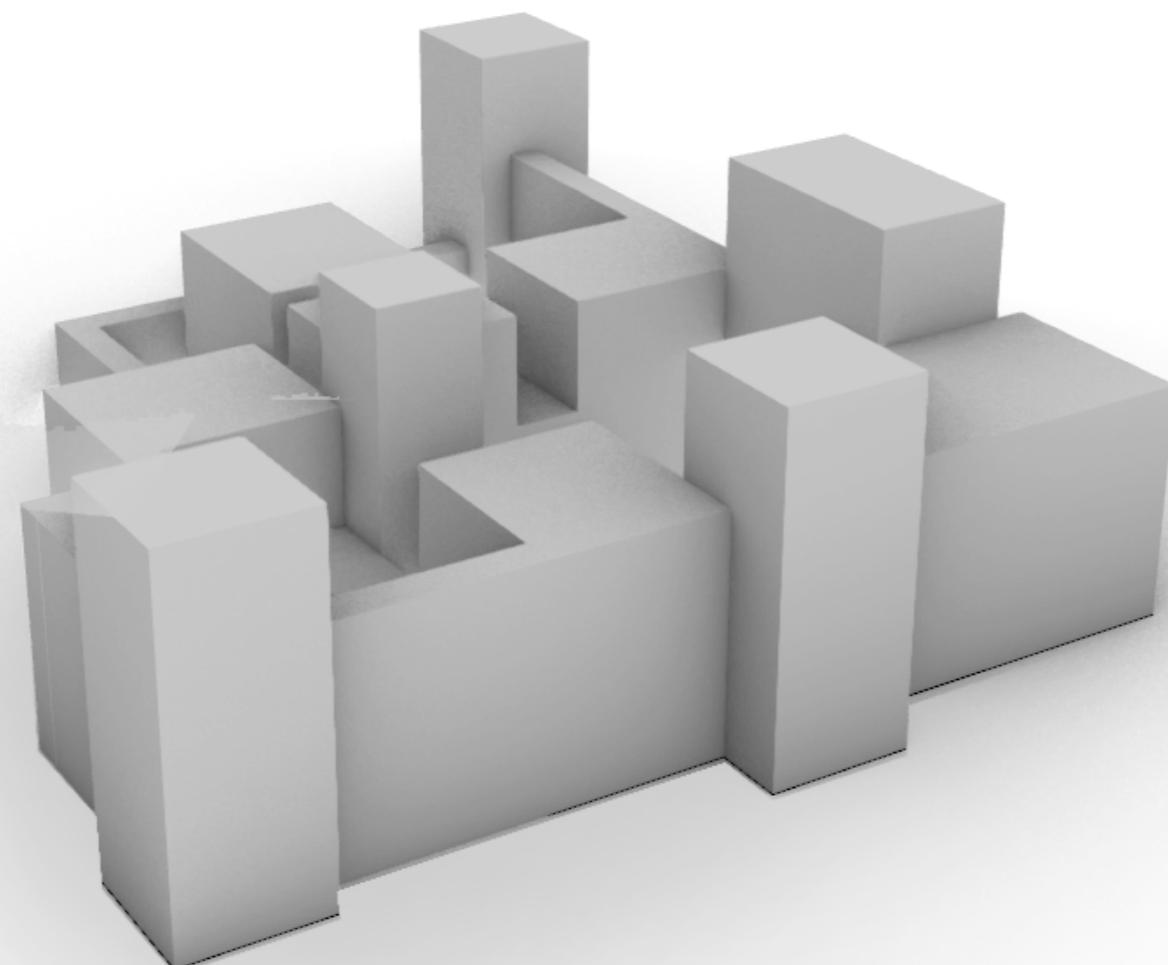
CLIMATE ASPECT



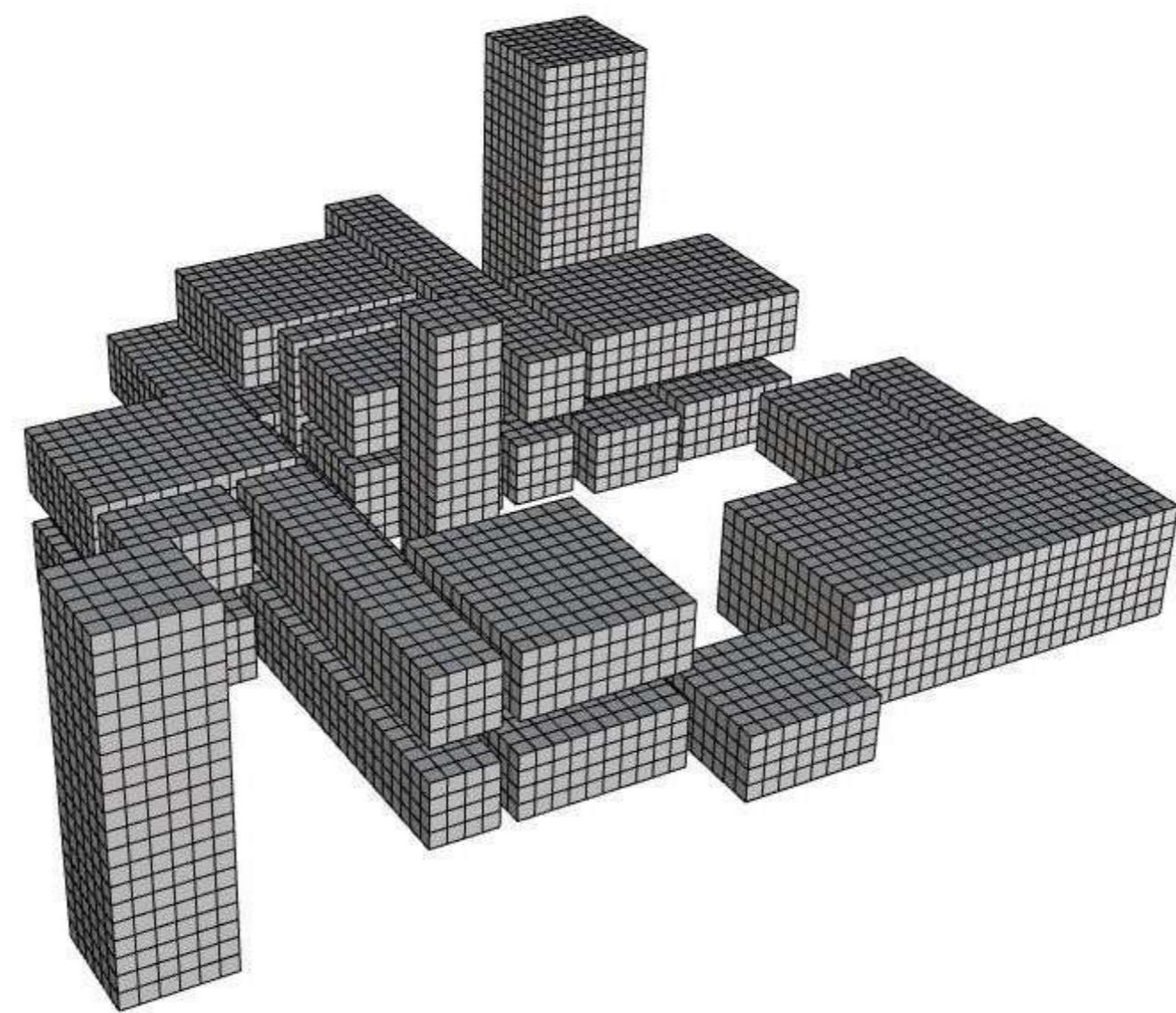
0 1 2 5 10m

FORMING

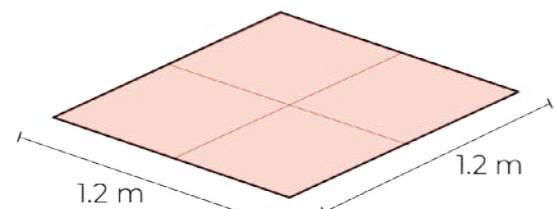
INITIAL MODEL



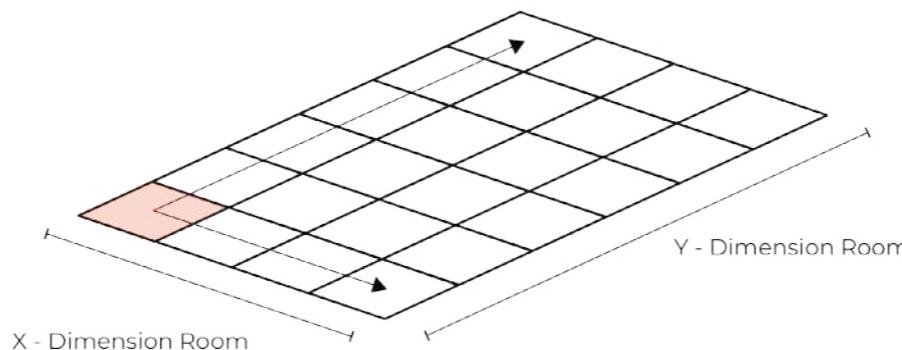
COMPUTATIONAL GRID



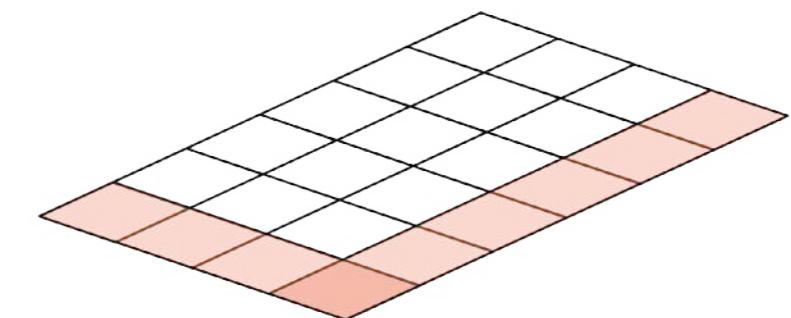
COMPUTATIONAL GRID



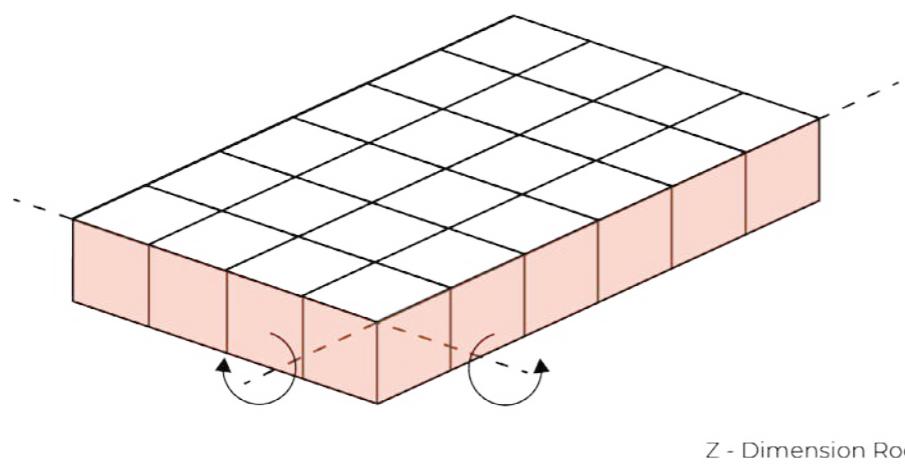
Step 1: Create the Module tile



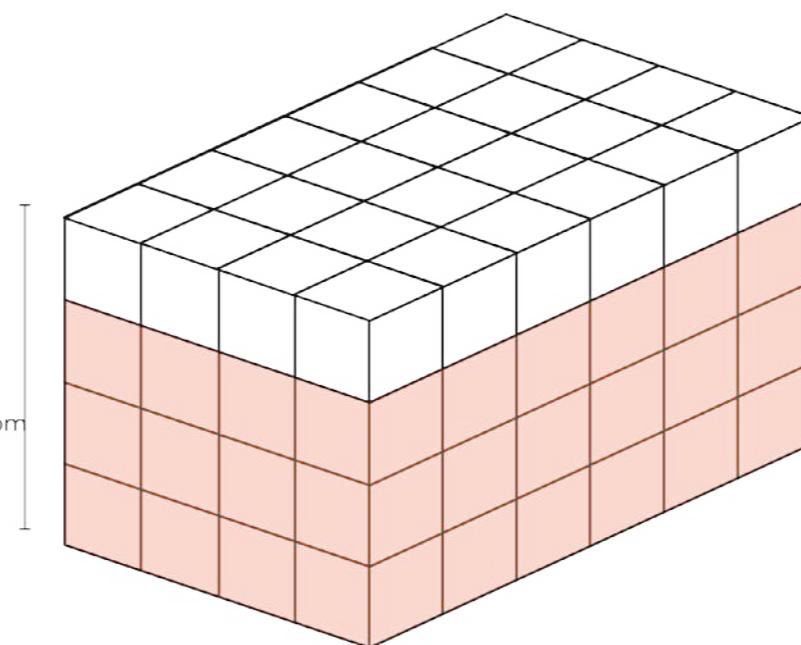
Step 2: Position the tile and duplicate in X and Y direction



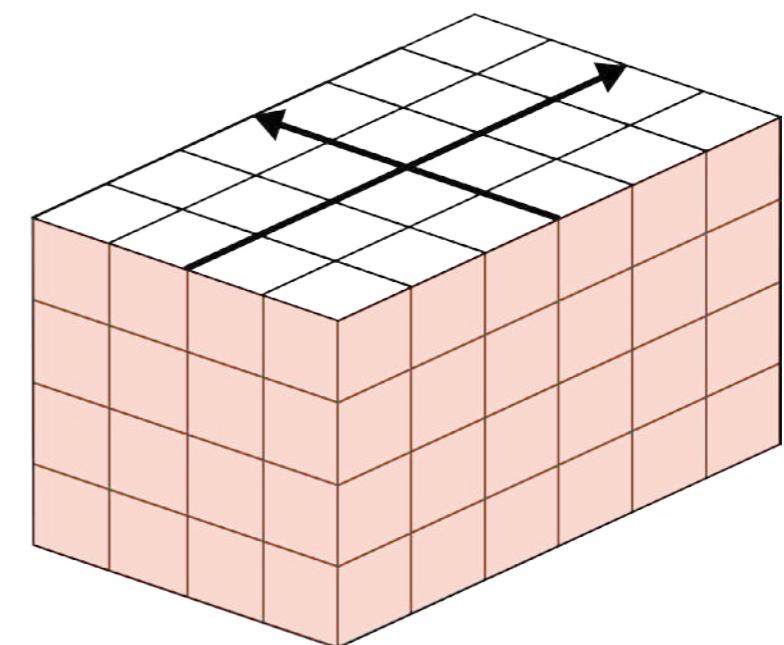
Step 3: Duplicate the edge tiles of two sides



Step 4: Rotate the duplicated tiles

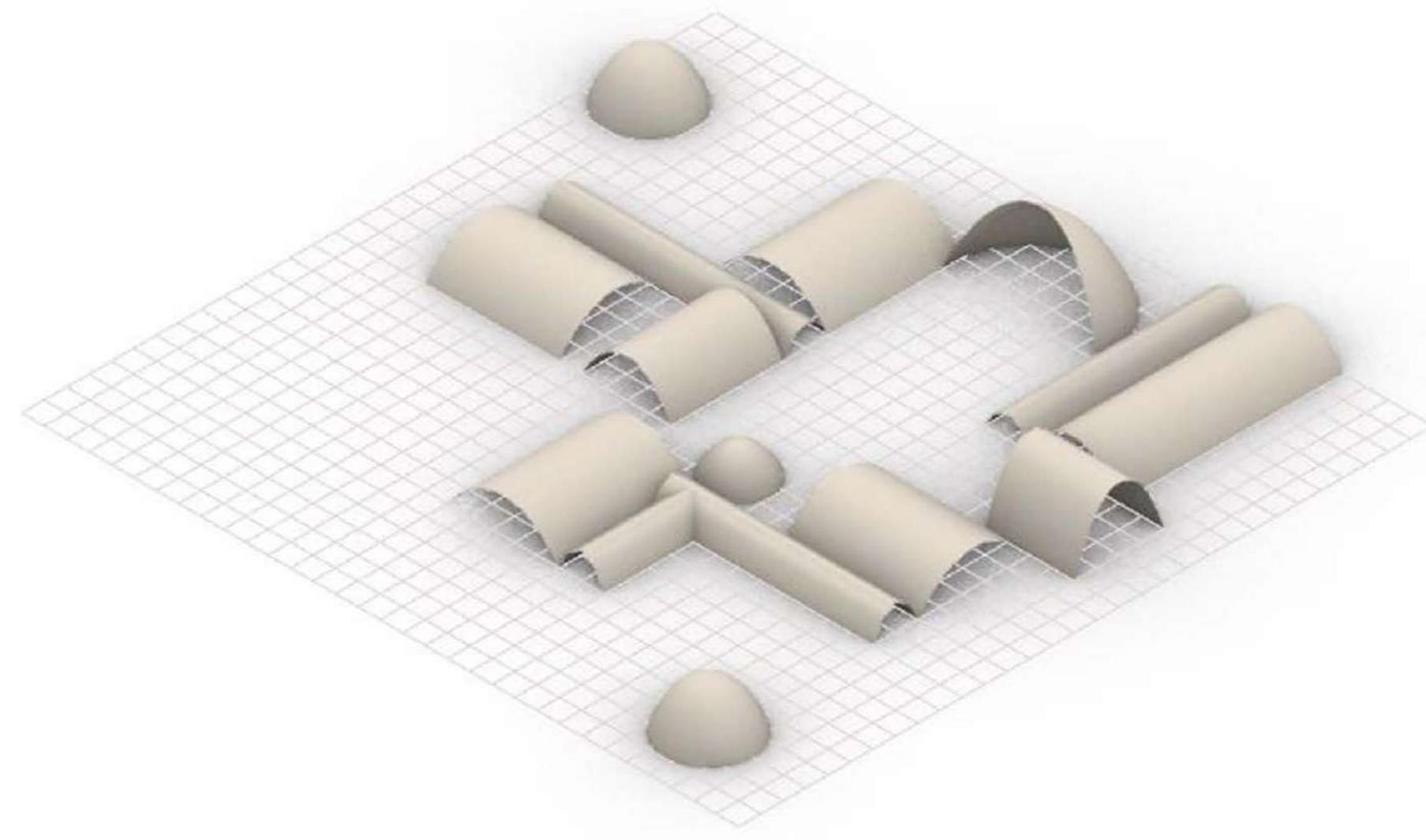


Step 5: Duplicate the rotated tiles in the Z direction

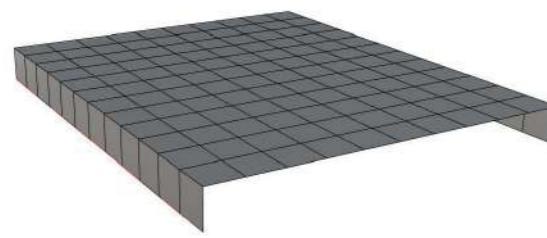


Step 6: Copy the walls to the other two sides of the room

C E I L I N G D E C I S I O N S



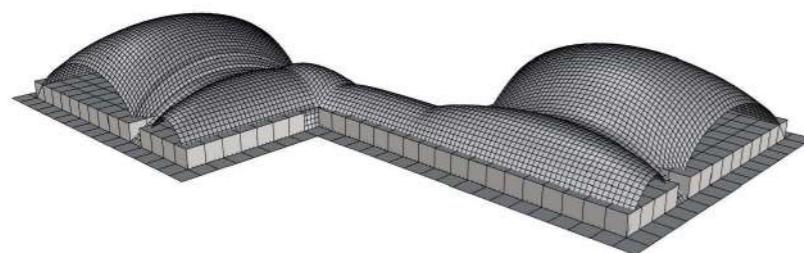
TESSELLATION - RELAXATION



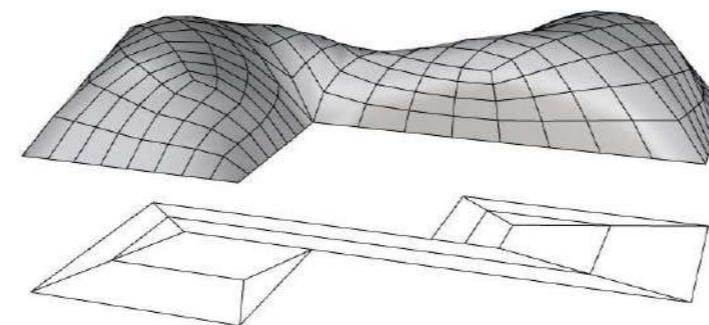
VAULTS

DOMES

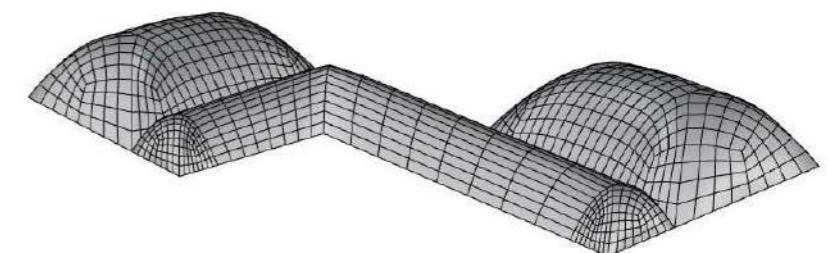
TESSELLATION - RELAXATION



MANIFOLD



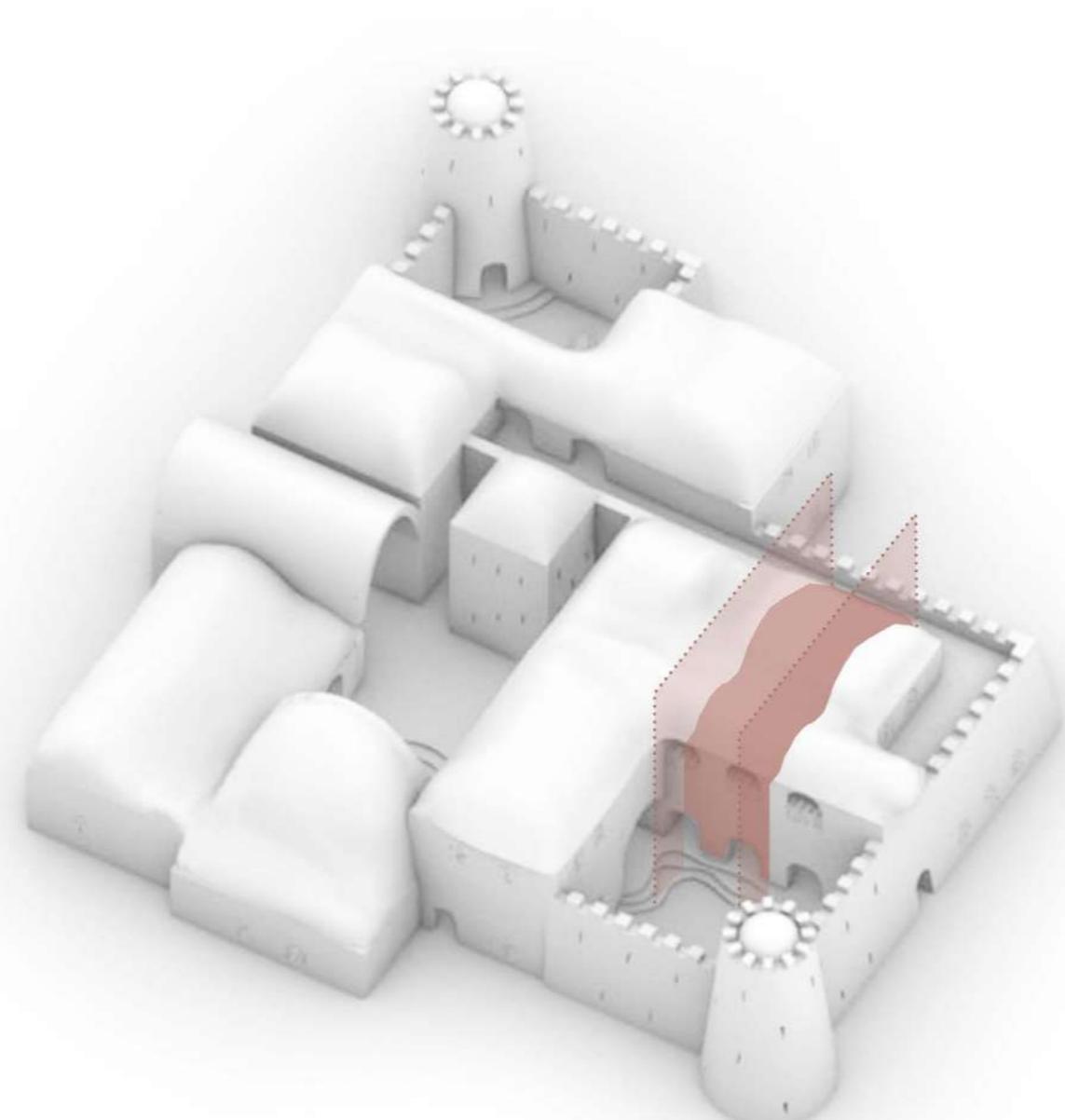
MANUAL TESSELLATION



FINAL GEOMETRY

STRUCTURAL

POINT OF FOCUS

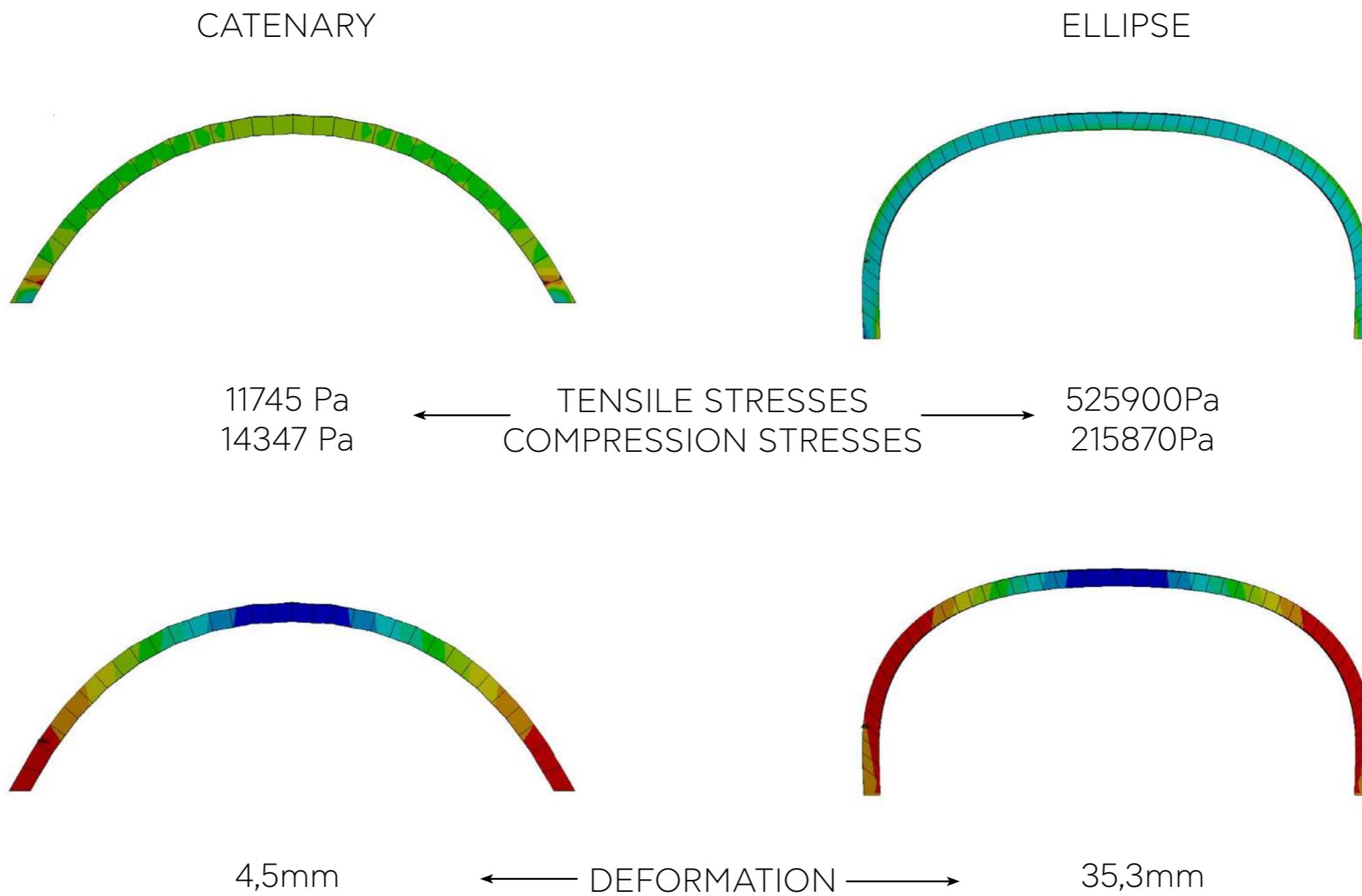


A N S Y S E X P E R I M E N T S



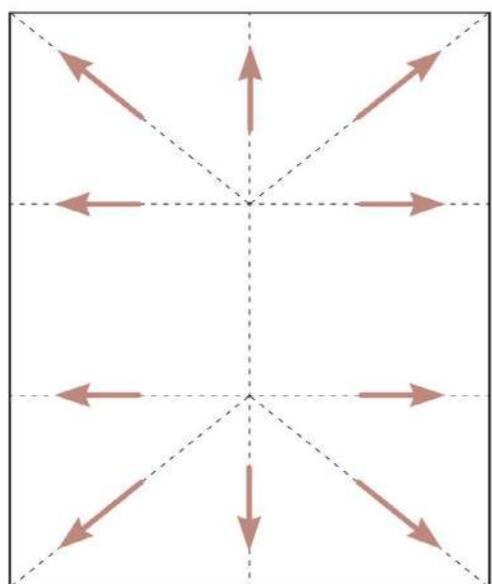
CATENARY OR ELLIPSE?

ANSYS EXPERIMENTS

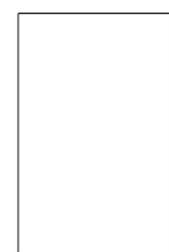


RIB STRUCTURE

FORCE DISTRIBUTION

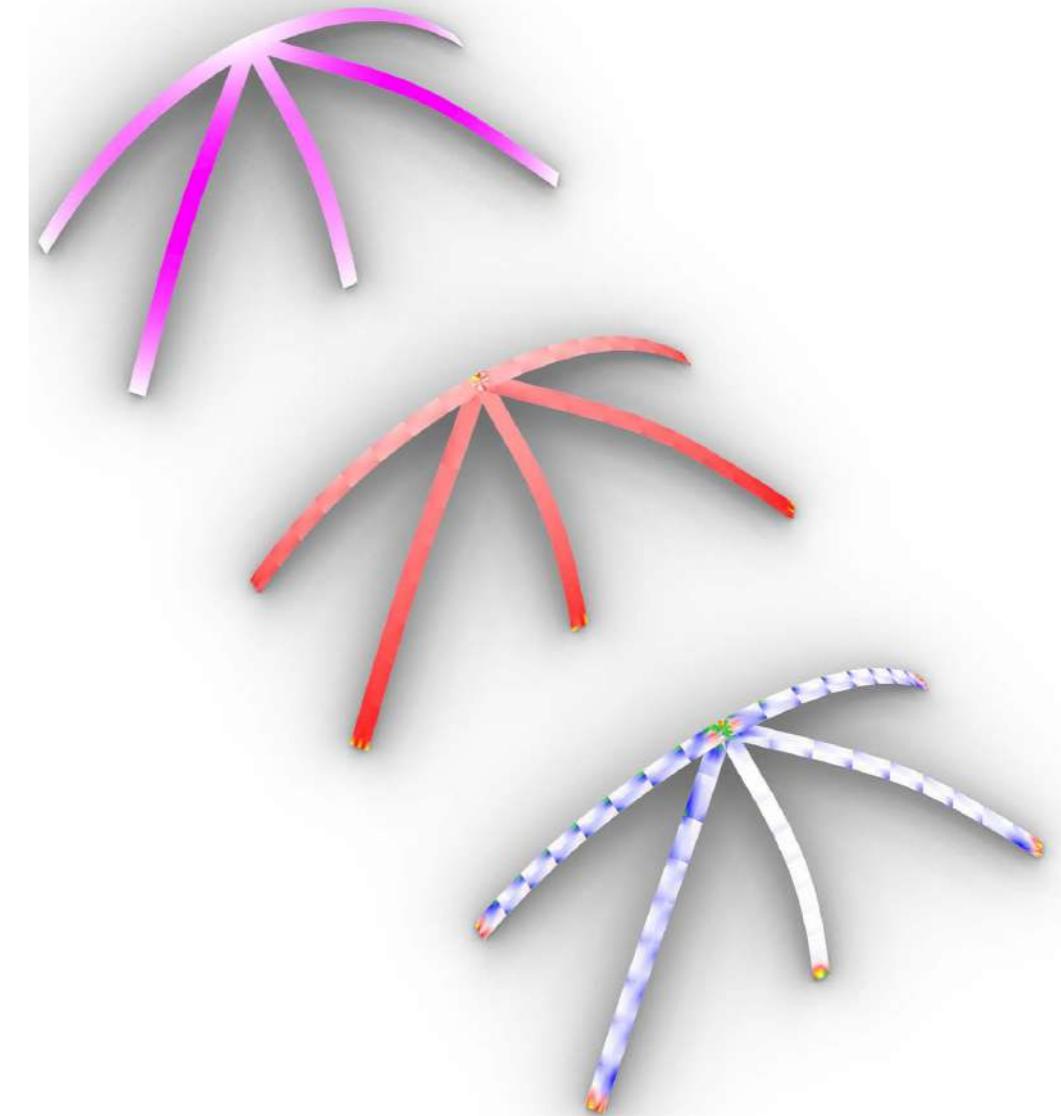


CROSS SECTION AREA



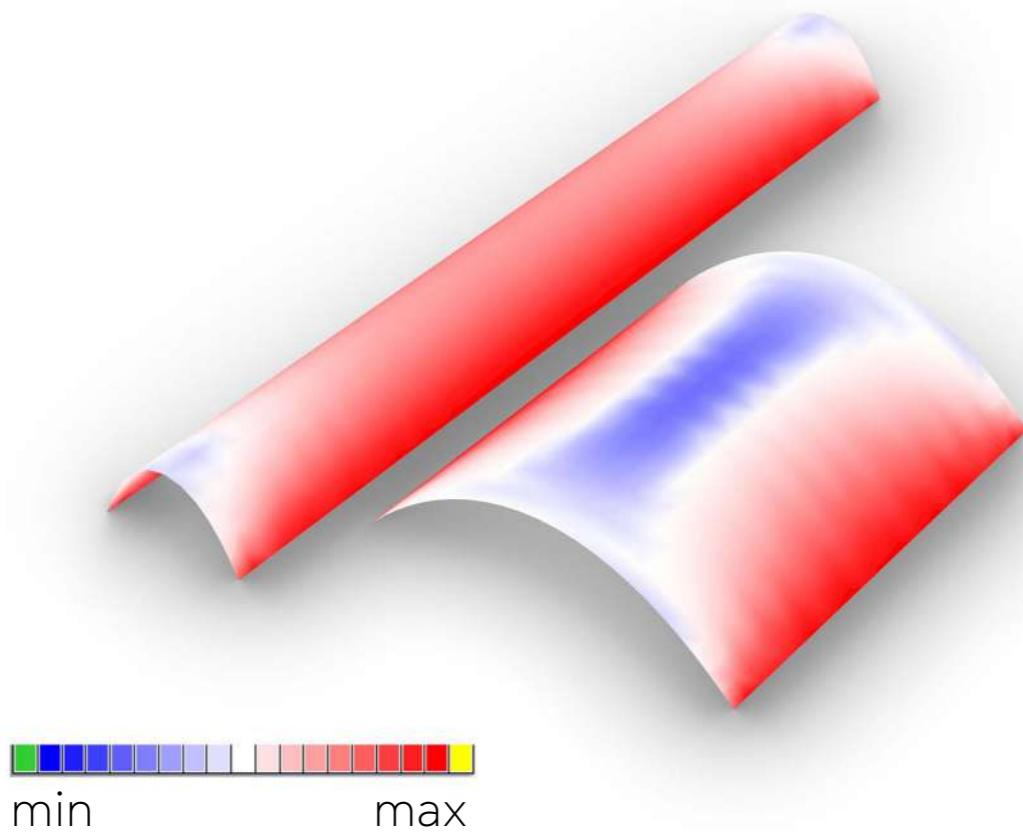
$$A=31500\text{mm}^2$$

RIBS	max Disp.	Prin.Stress1	Prin.Stress2
		max min	max min
	15.8mm	-0.116 0.234	-0.349 -0.151



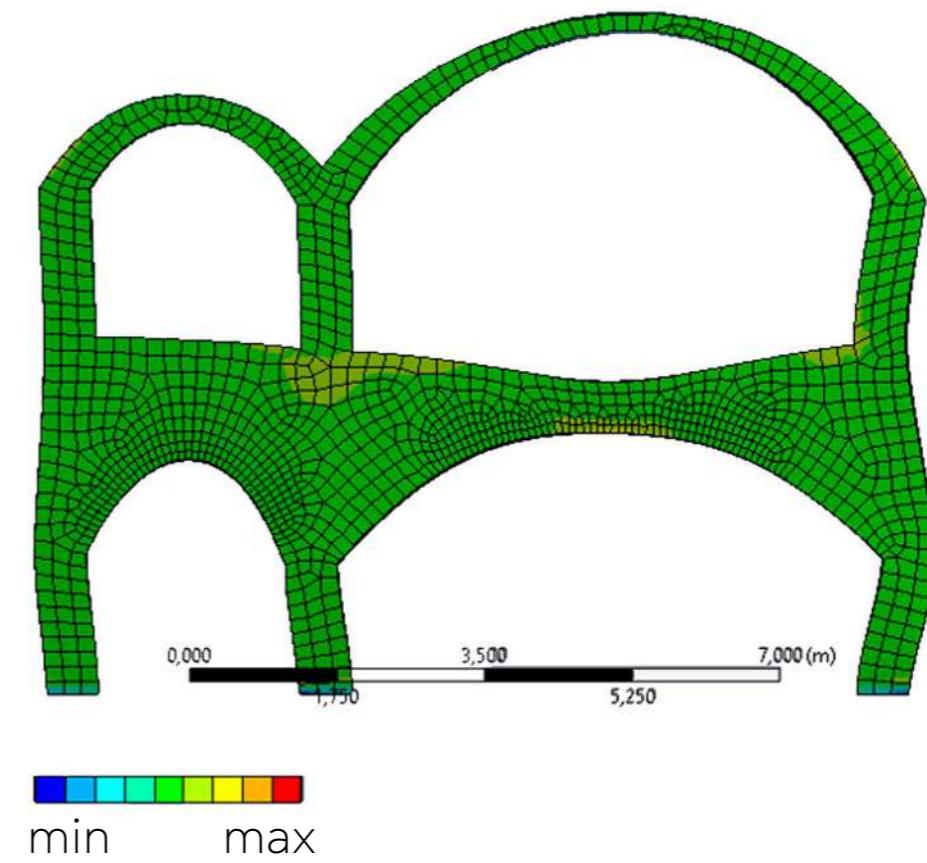
MAXIMUM STRESSES

K A R A M B A



	max Disp.	Prin.Stress1		Prin.Stress2	
		max	min	max	min
GALLERY	7.3mm	-0.09	0.001	-0.03	-0.09
CLASSROOM	15mm	-0.02	0.003	-0.125	0.043

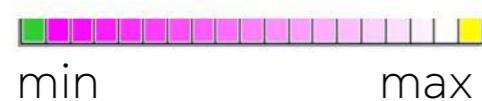
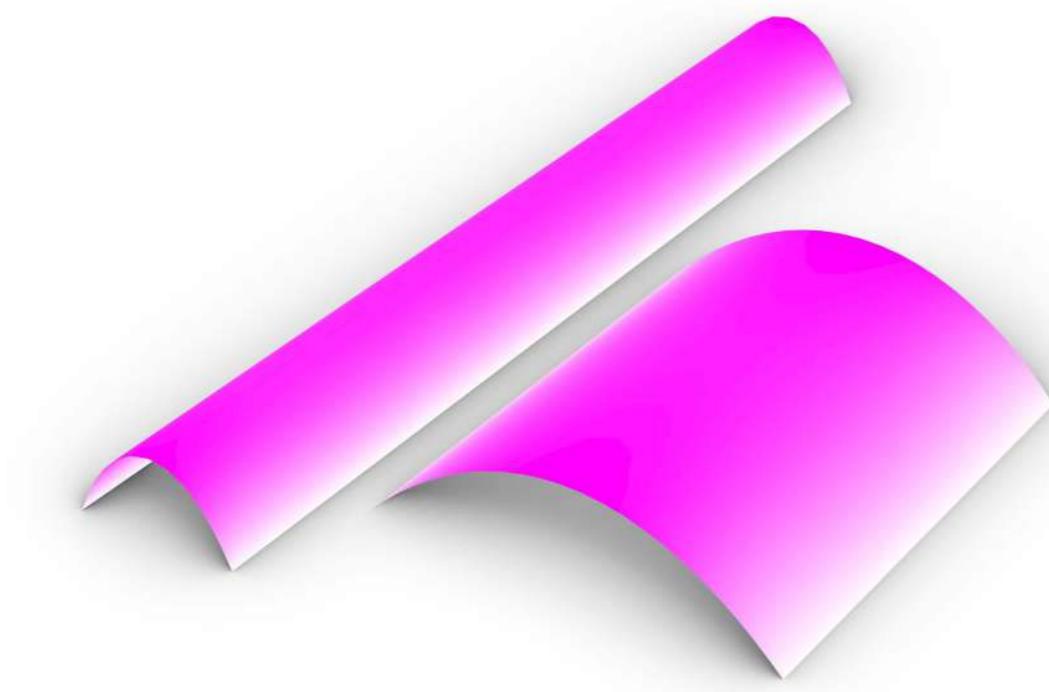
A N S Y S



	max Disp.	Prin.Stress1	
		max	min
GALLERY & CLASSROOM	18.7mm	-0.214	0.171

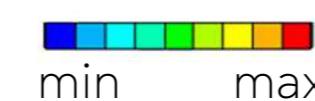
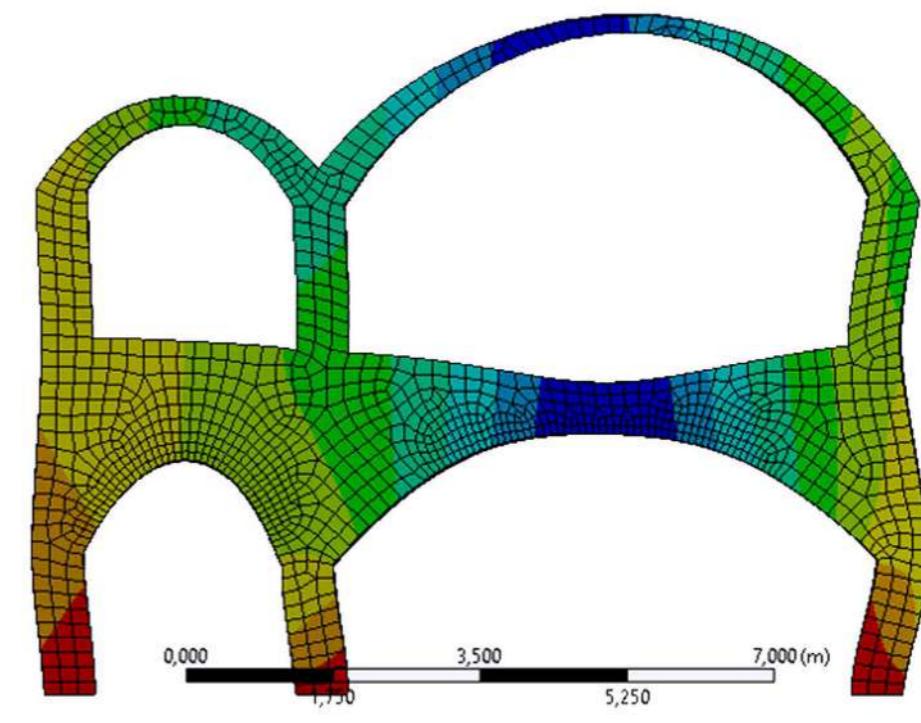
MAXIMUM DEFORMATION

K A R A M B A



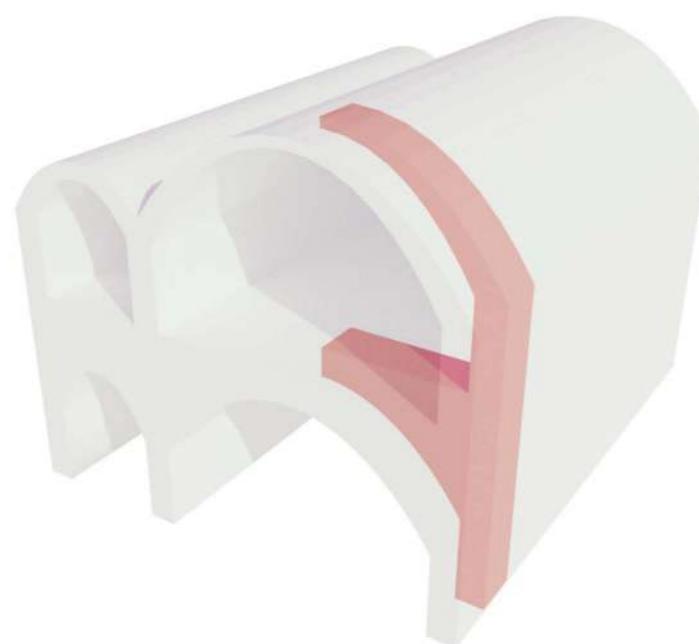
	max Disp.	Prin.Stress1		Prin.Stress2	
		max	min	max	min
GALLERY	7.3mm	-0.09	0.001	-0.03	-0.09-
CLASSROOM	15mm	-0.02	0.003	-0.125	0.043

A N S Y S



	max Disp.	Prin.Stress1	
		max	min
GALLERY & CLASSROOM	18.7mm	-0.214	0.171

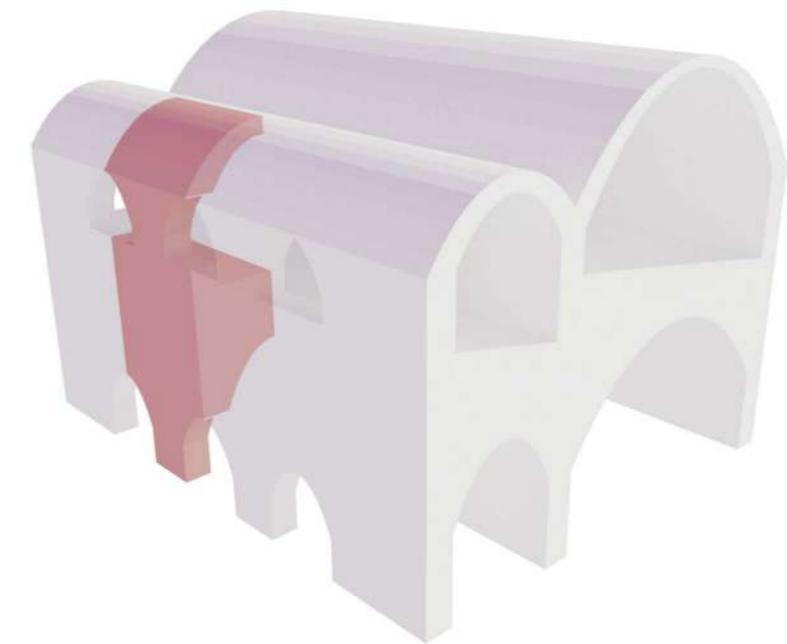
H A N D C A L C U L A T I O N S



EDGE WALL



WALL BETWEEN
CLASSROOM AND GALLERY



WALL BETWEEN
GALLERY OPENINGS

CONSTRUCTION

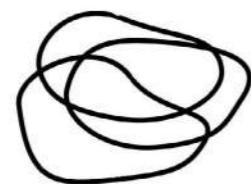
B R I C K M I X T U R E

BASIC MIXTURE

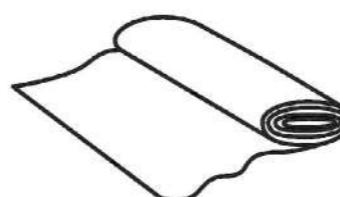


27.3% CLAY
27.3% FINE SAND
36.4% COARSE SAND
9.1% WATER

ALTERNATIVE ADDITIVES



RUBBER BANDS



COTTON FABRIC



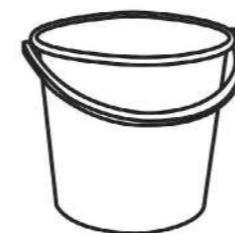
STRAW



WOODCHIPS

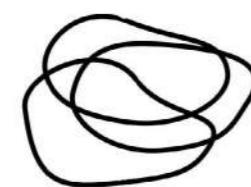
B R I C K M I X T U R E

BASIC MIXTURE

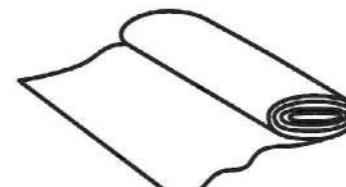


27.3% CLAY
27.3% FINE SAND
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ALTERNATIVE ADDITIVES



RUBBER BANDS



COTTON FABRIC

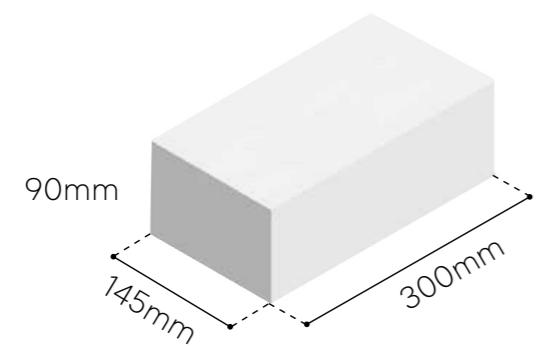


STRAW



WOODCHIPS

B R I C K T Y P E S



TYPE A

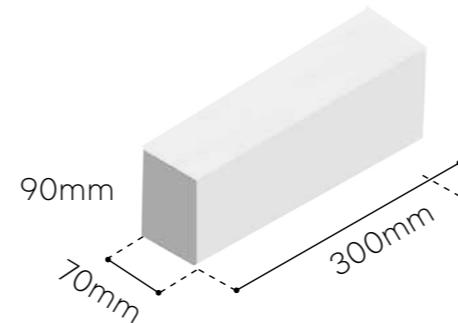
walls

subdivision of
architectural module

stretcher
=

2*header + mortar

8kg

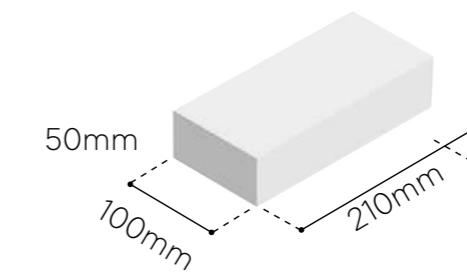


TYPE B

walls

for room corners

4kg



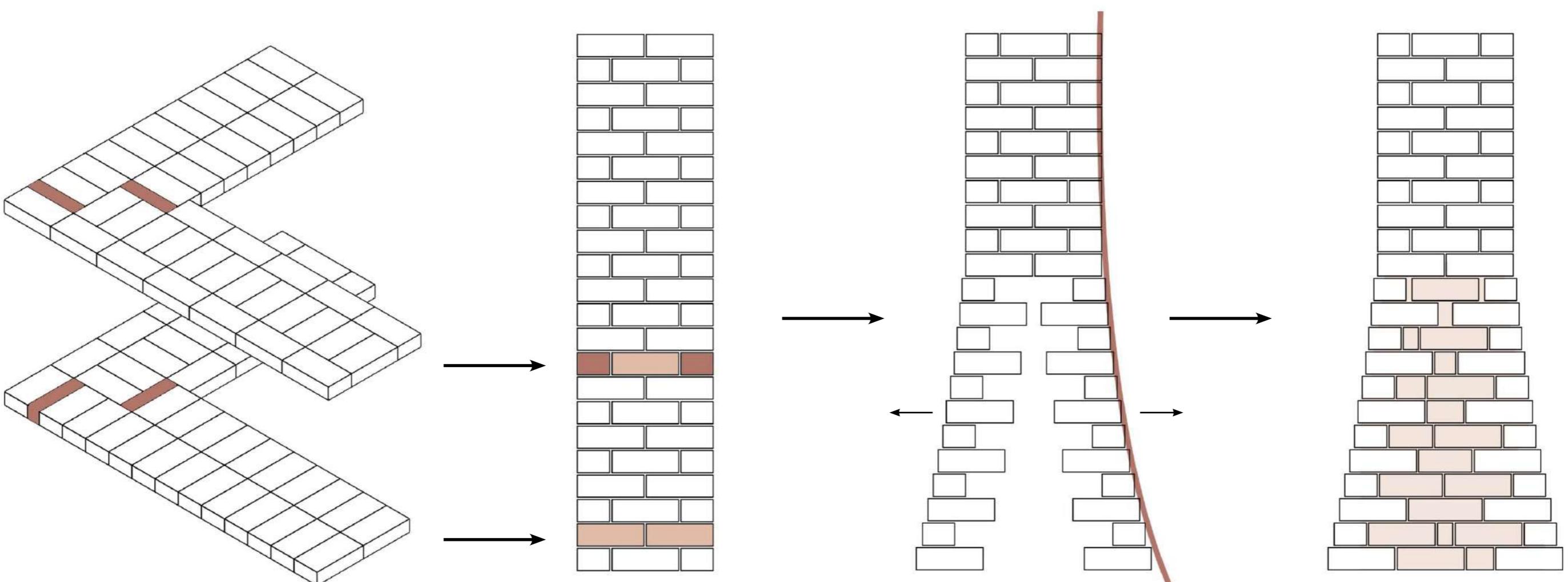
TYPE C

vaults & arches

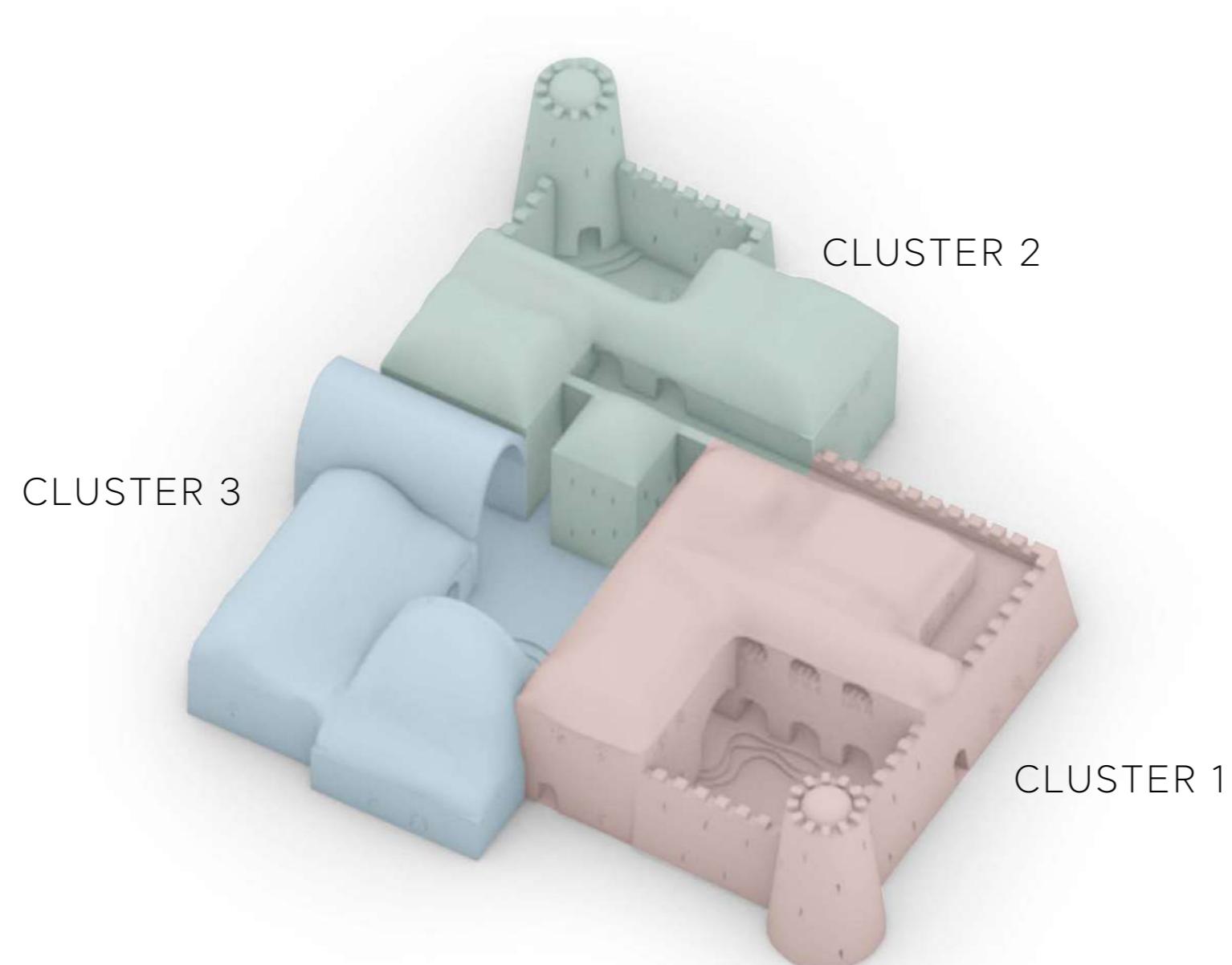
smaller
lighter

2kg

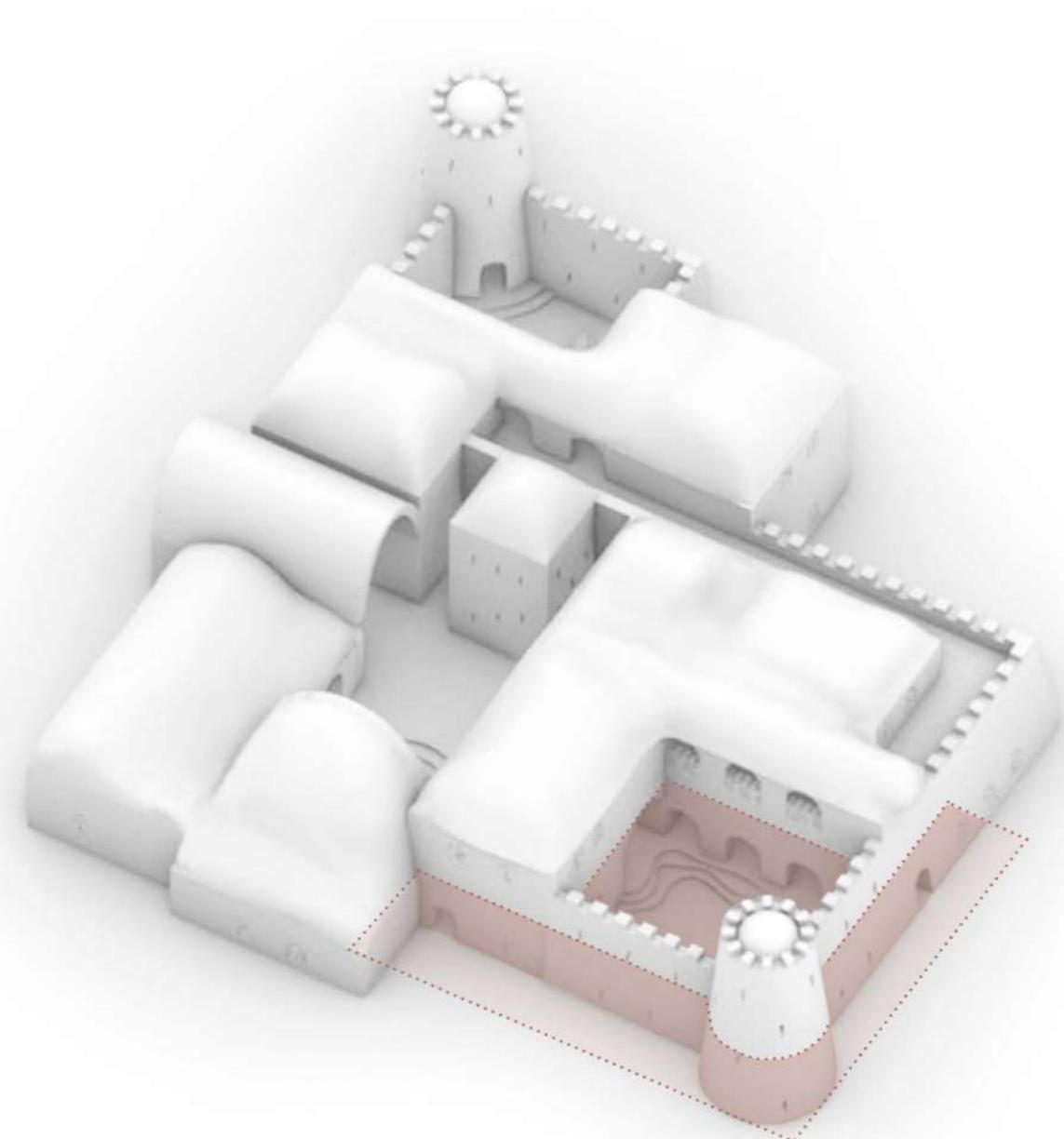
BRICKLAYING IN WALLS



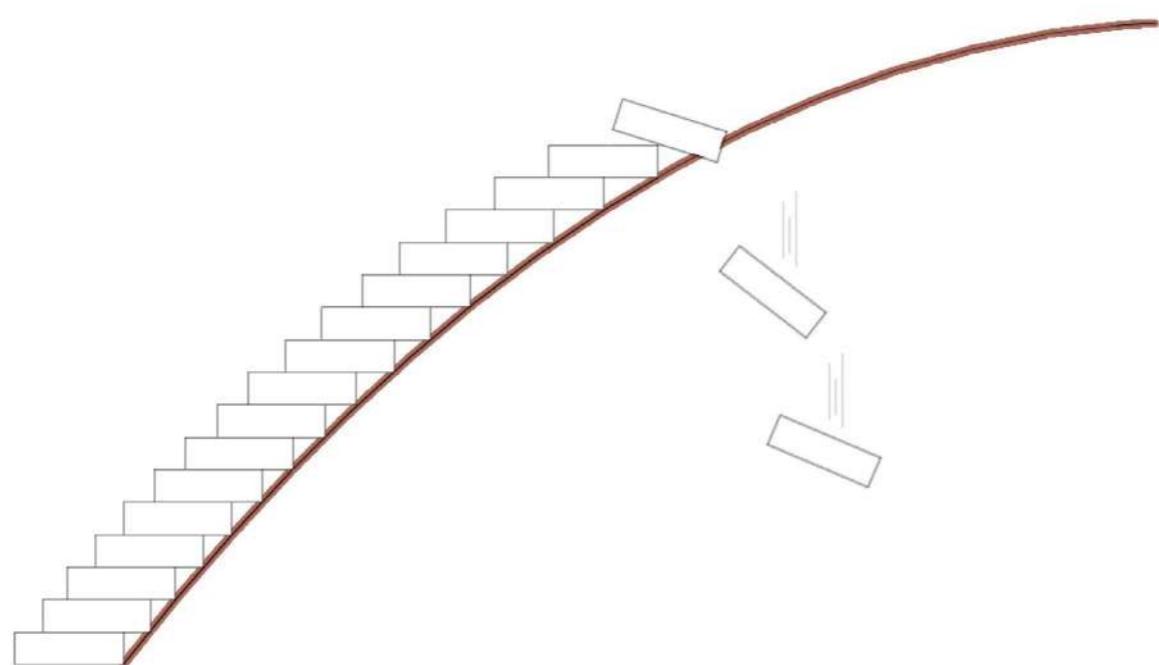
CONSTRUCTION PHASES



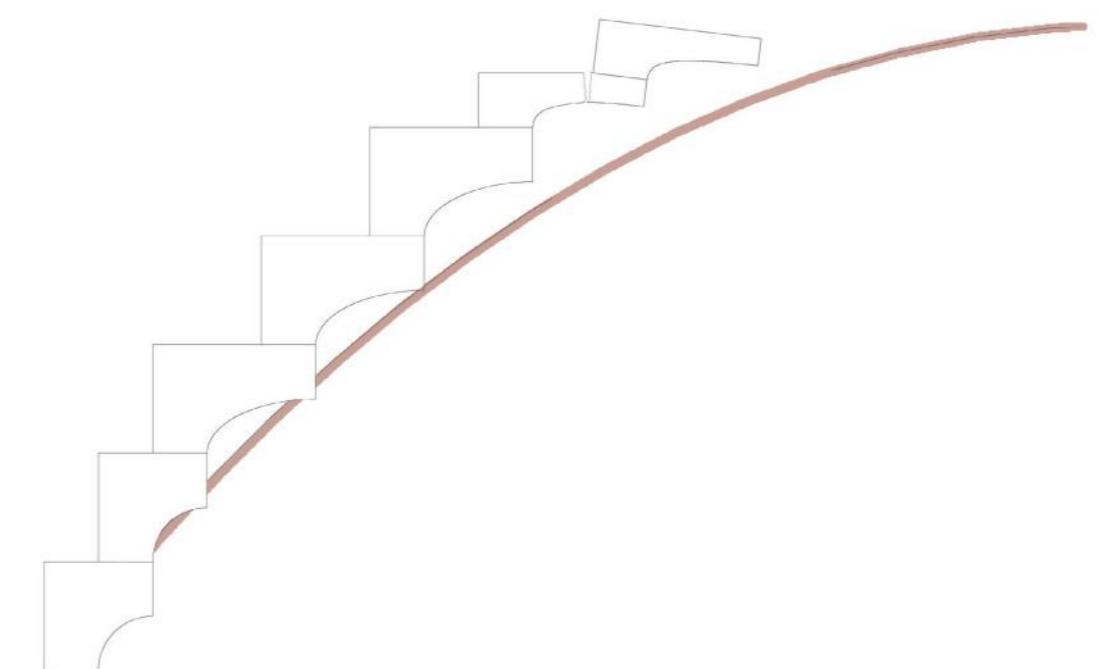
G R O U N D F L O O R



STACKING TRIALS

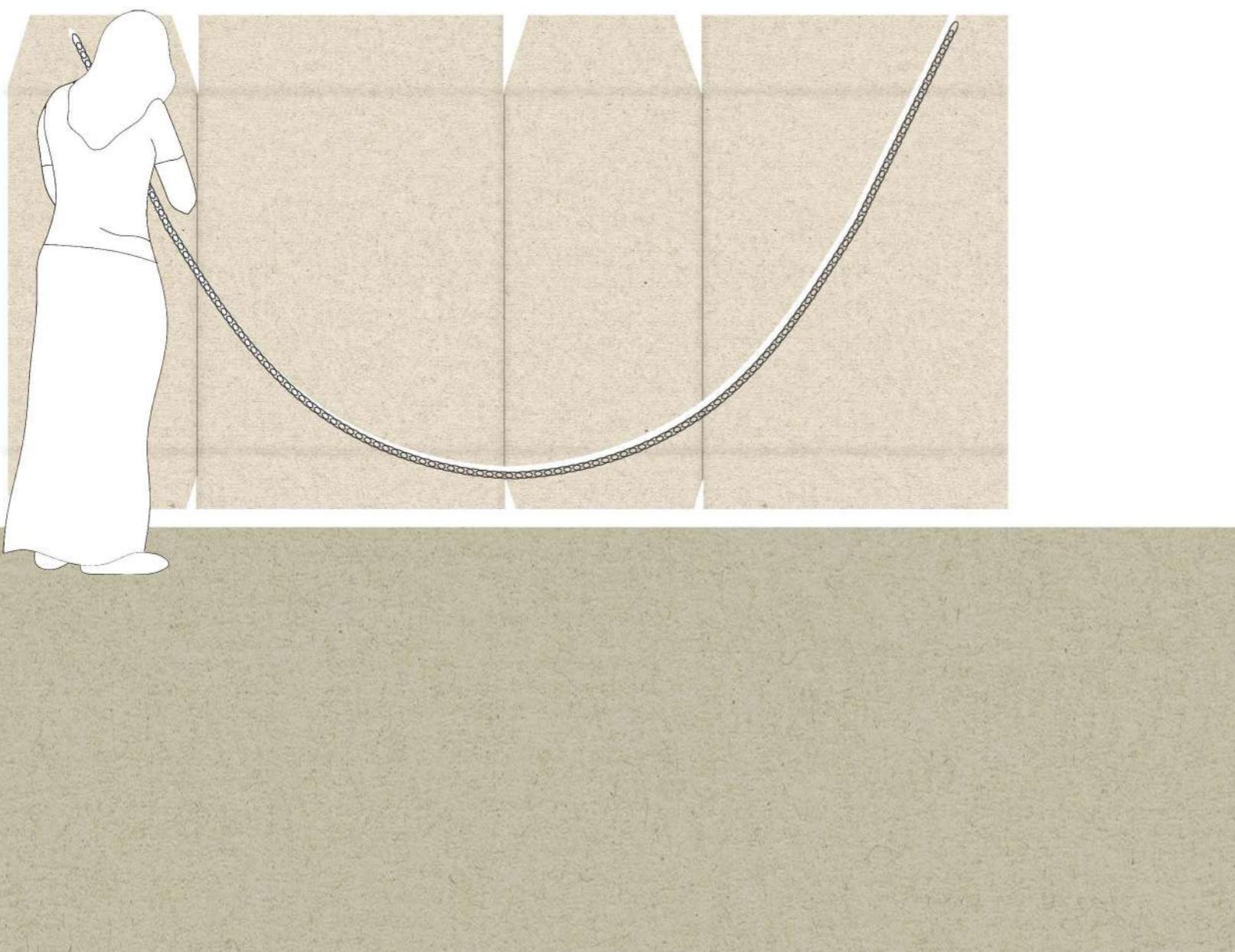


BRICKS

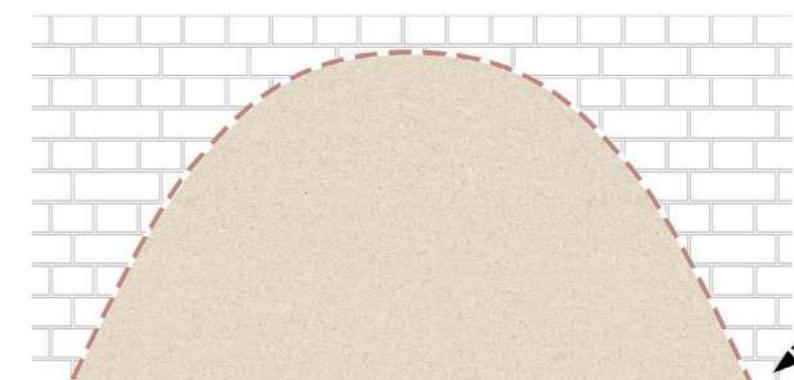
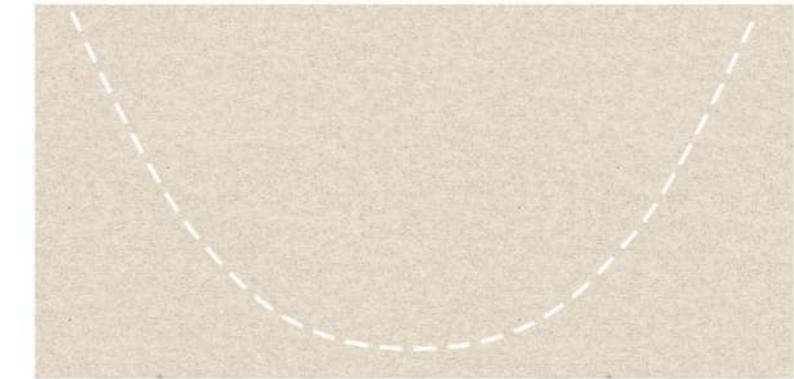
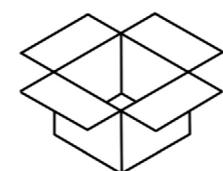


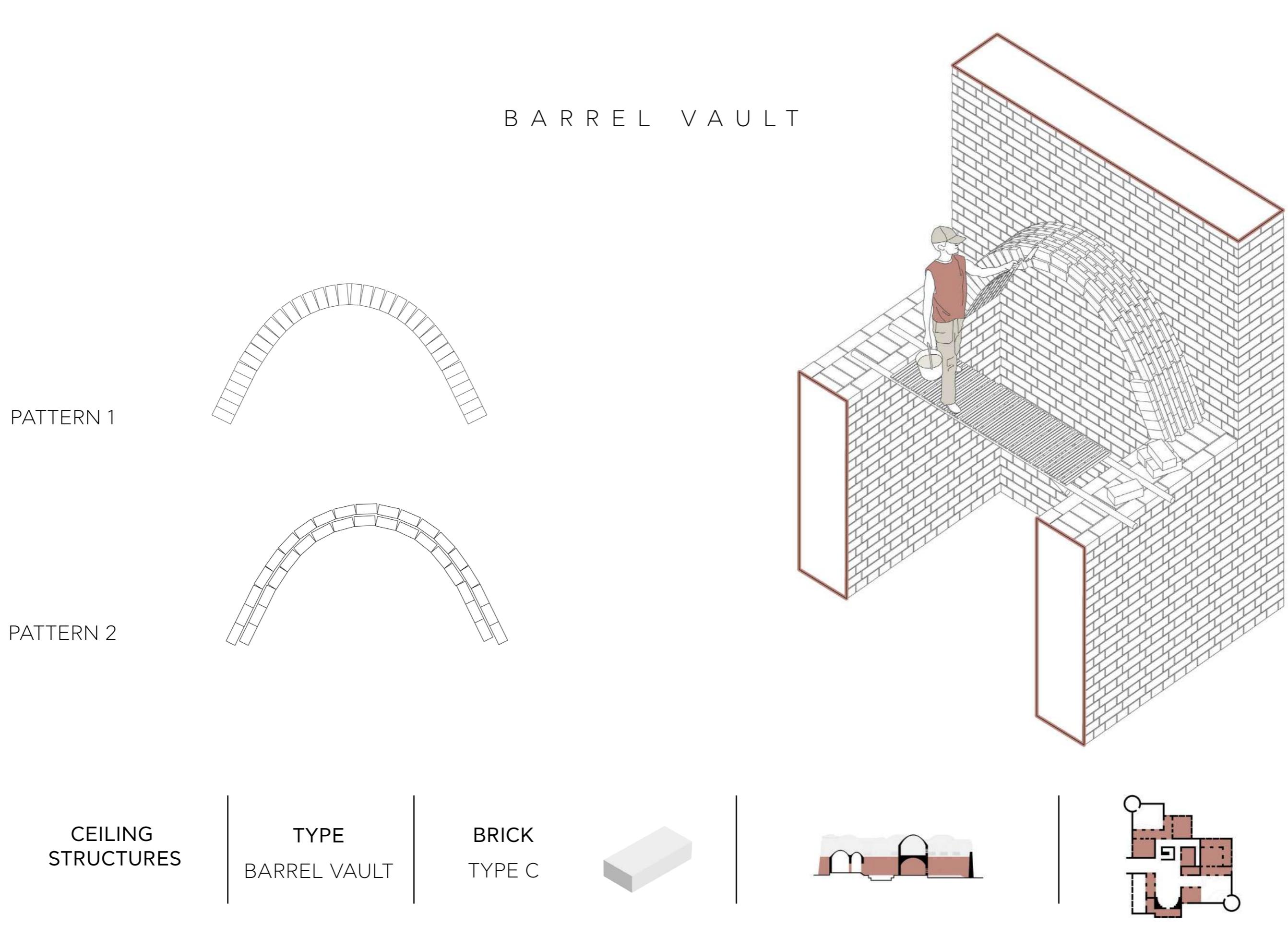
MUQARNAS

C A D _ C A R D B O A R D A I D E D D E S I G N

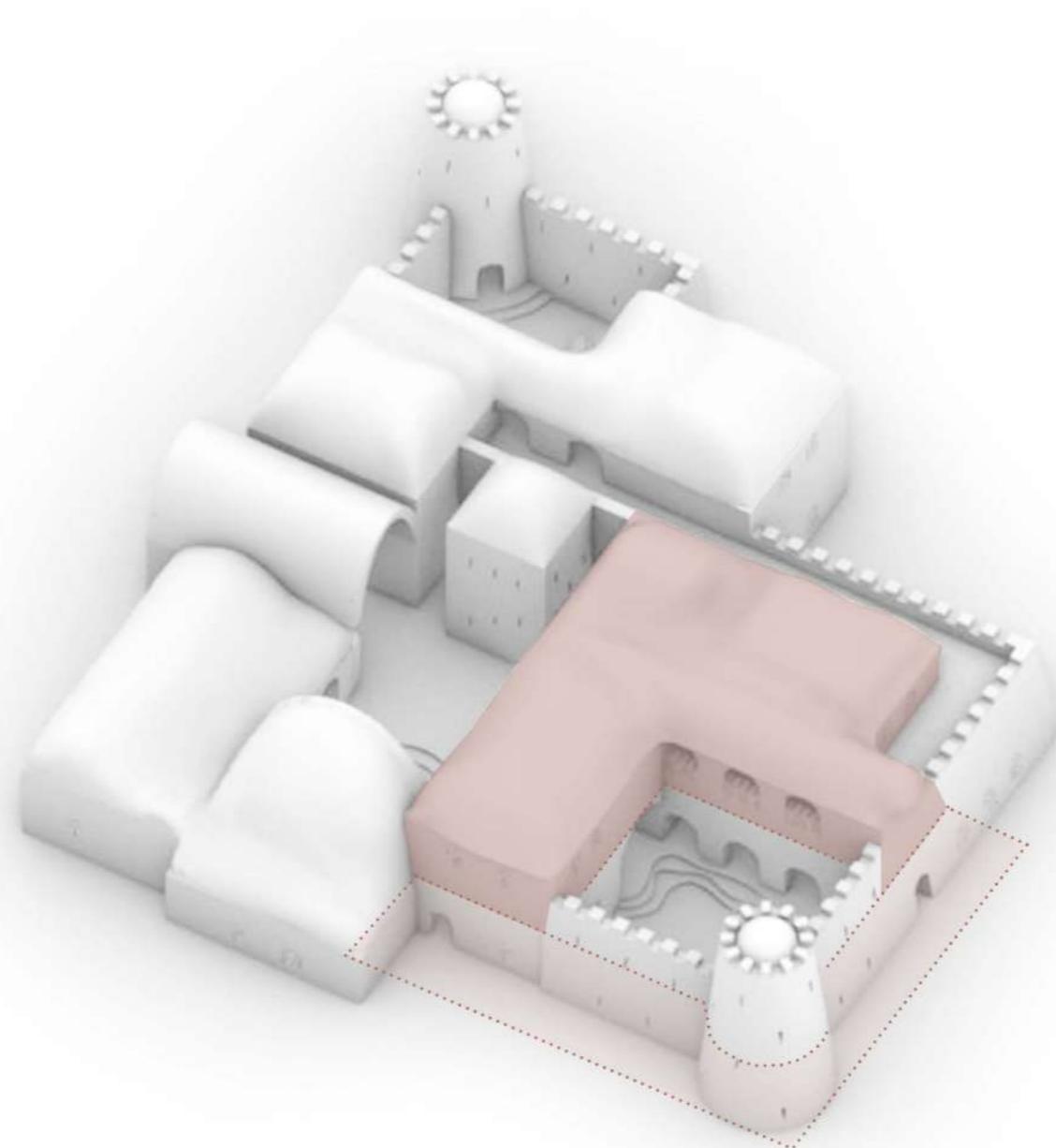


E Q U I P M E N T



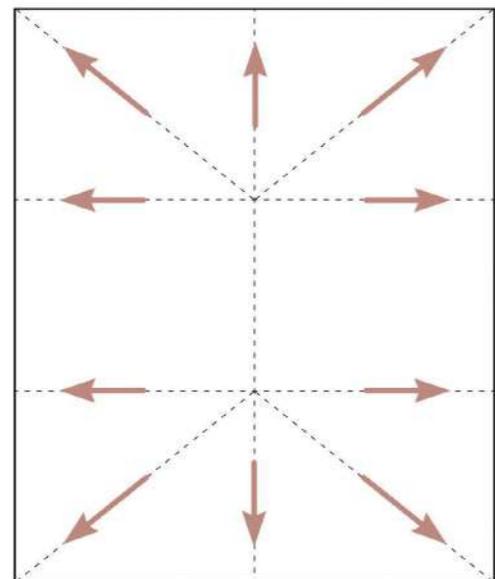


F I R S T F L O O R

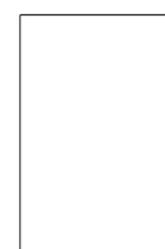


R I B S T R U C T U R E

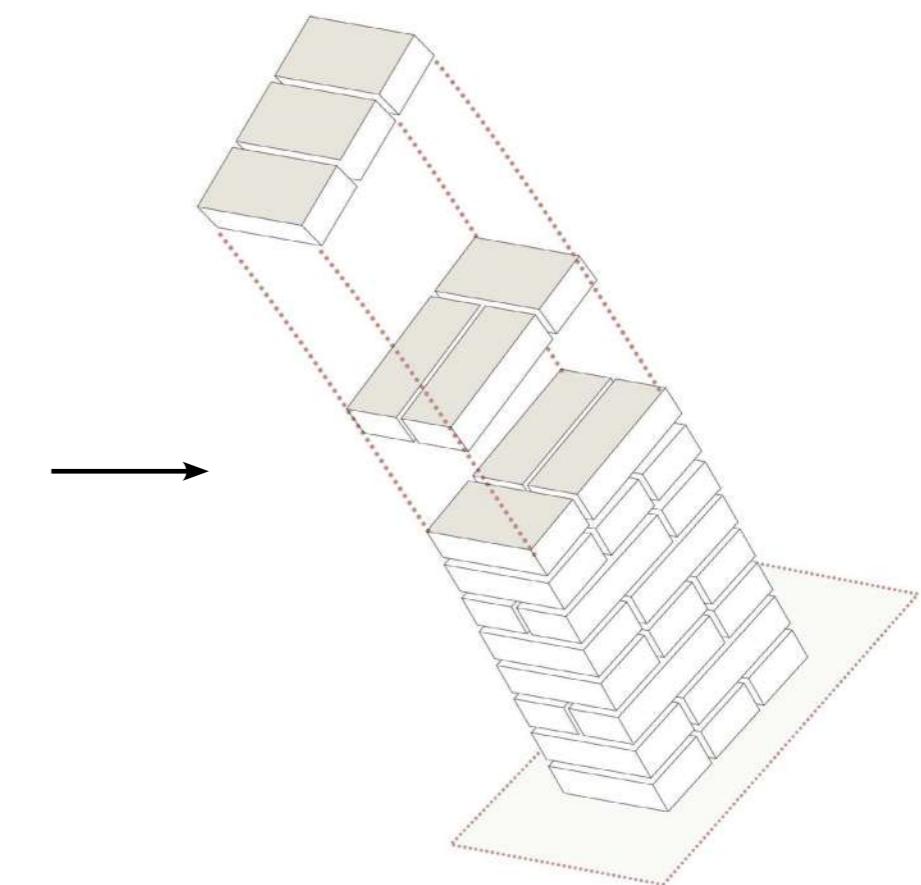
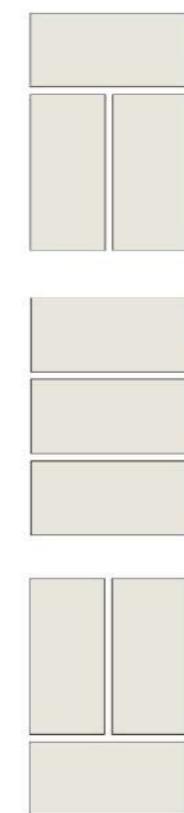
FORCE DISTRIBUTION



CROSS SECTION
AREA



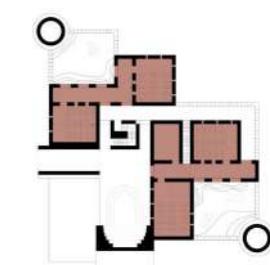
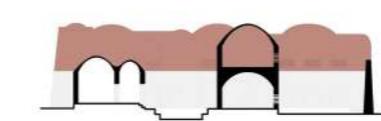
PATTERNS



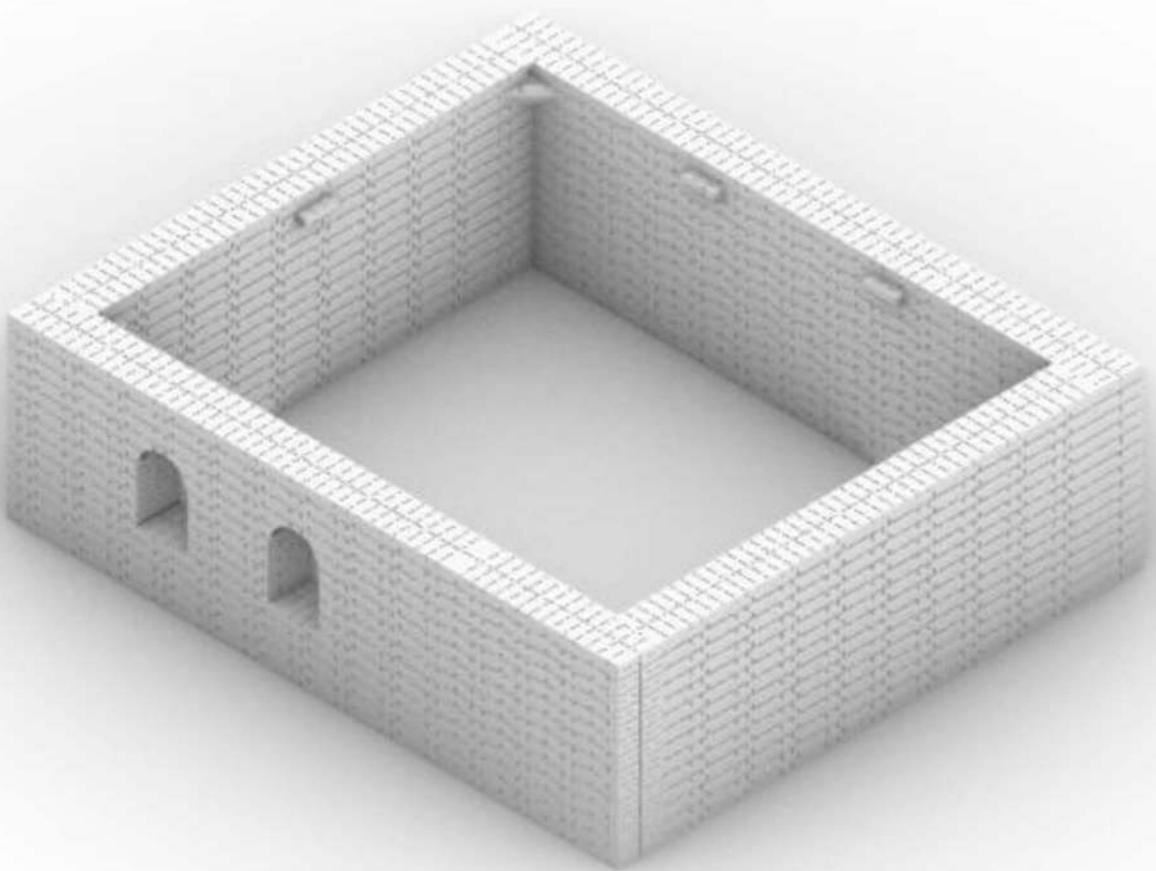
CEILING
STRUCTURES

TYPE
RIBBED VAULT

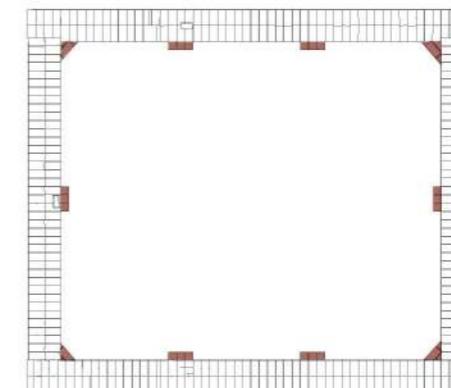
BRICK
TYPE C



RIB STRUCTURE



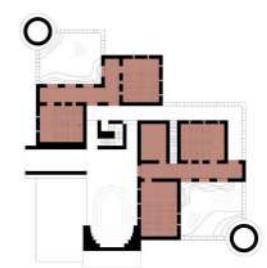
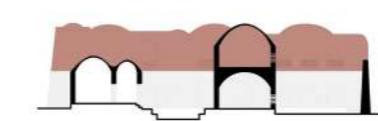
FORMWORK BASE



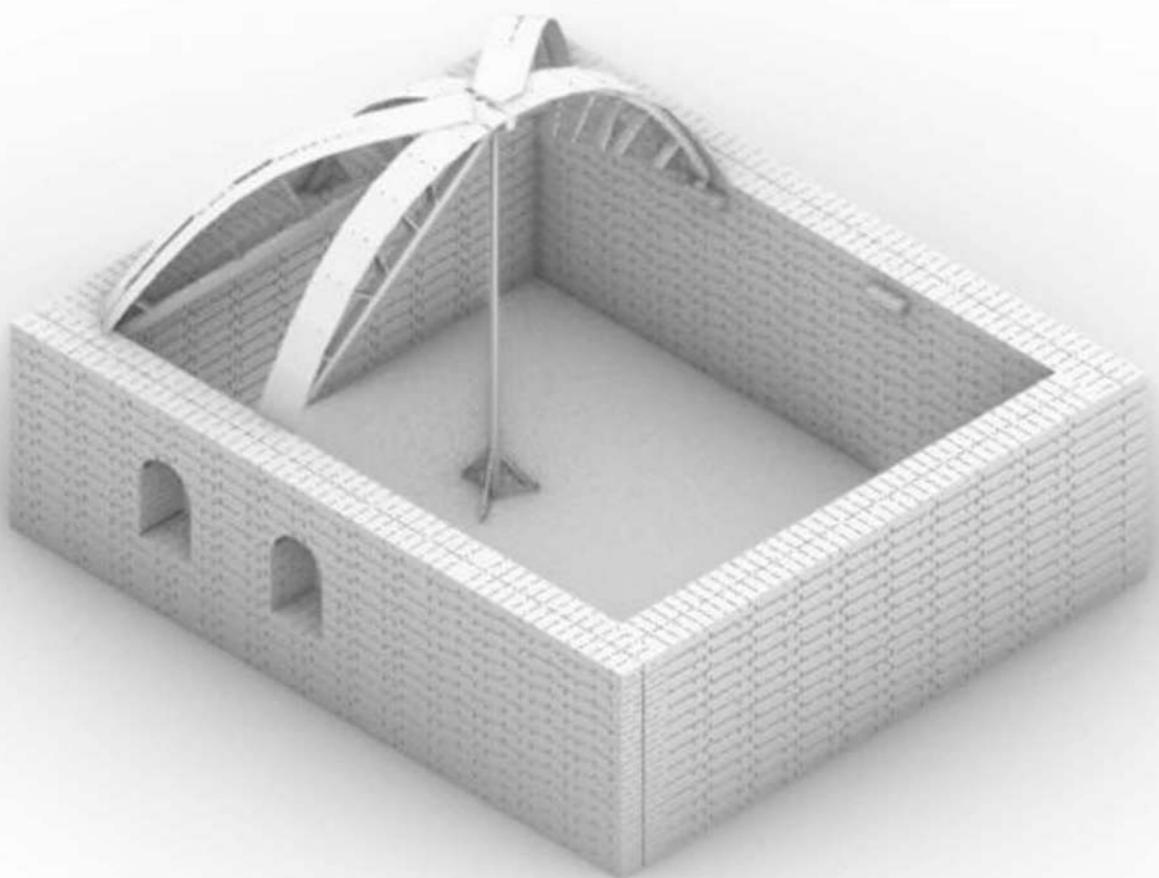
CEILING
STRUCTURES

TYPE
RIBBED VAULT

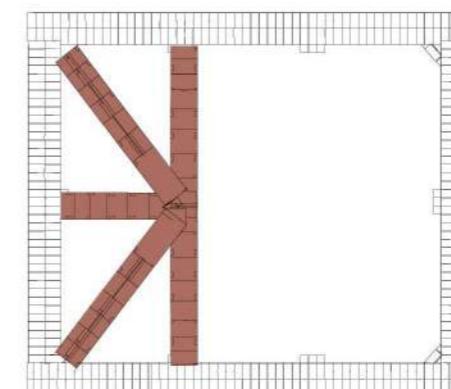
BRICK
TYPE C



RIB STRUCTURE



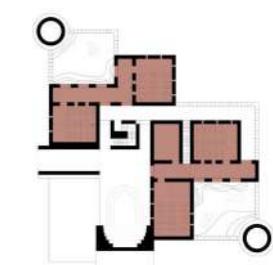
FORMWORK



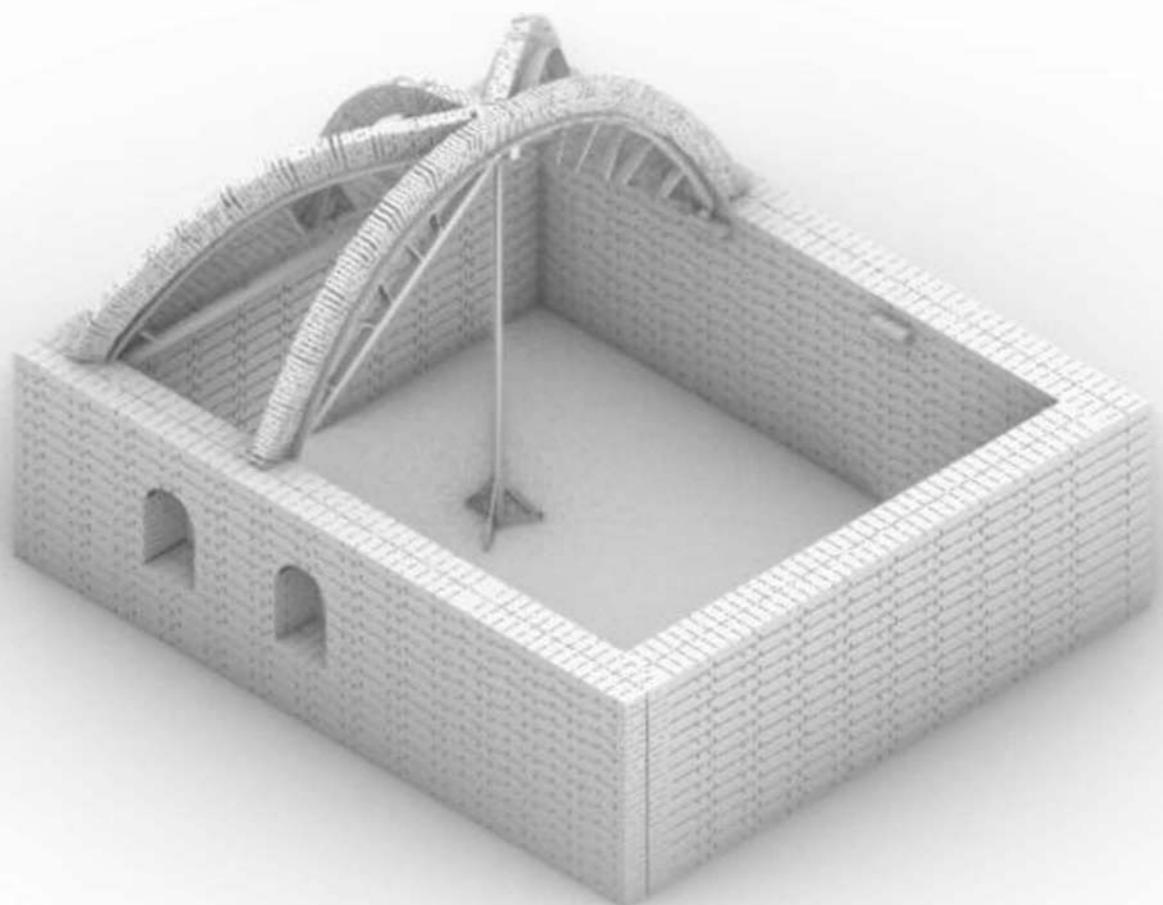
CEILING
STRUCTURES

TYPE
RIBBED VAULT

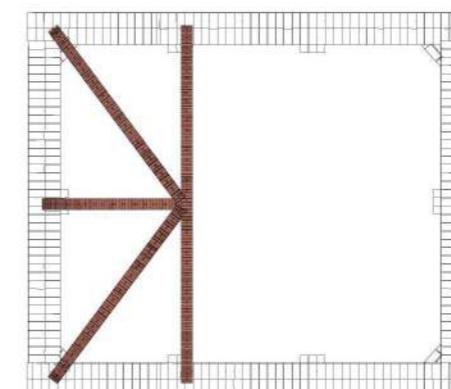
BRICK
TYPE C



RIB STRUCTURE



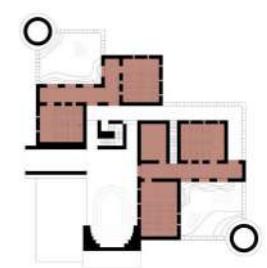
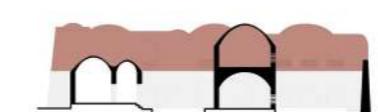
RIBS



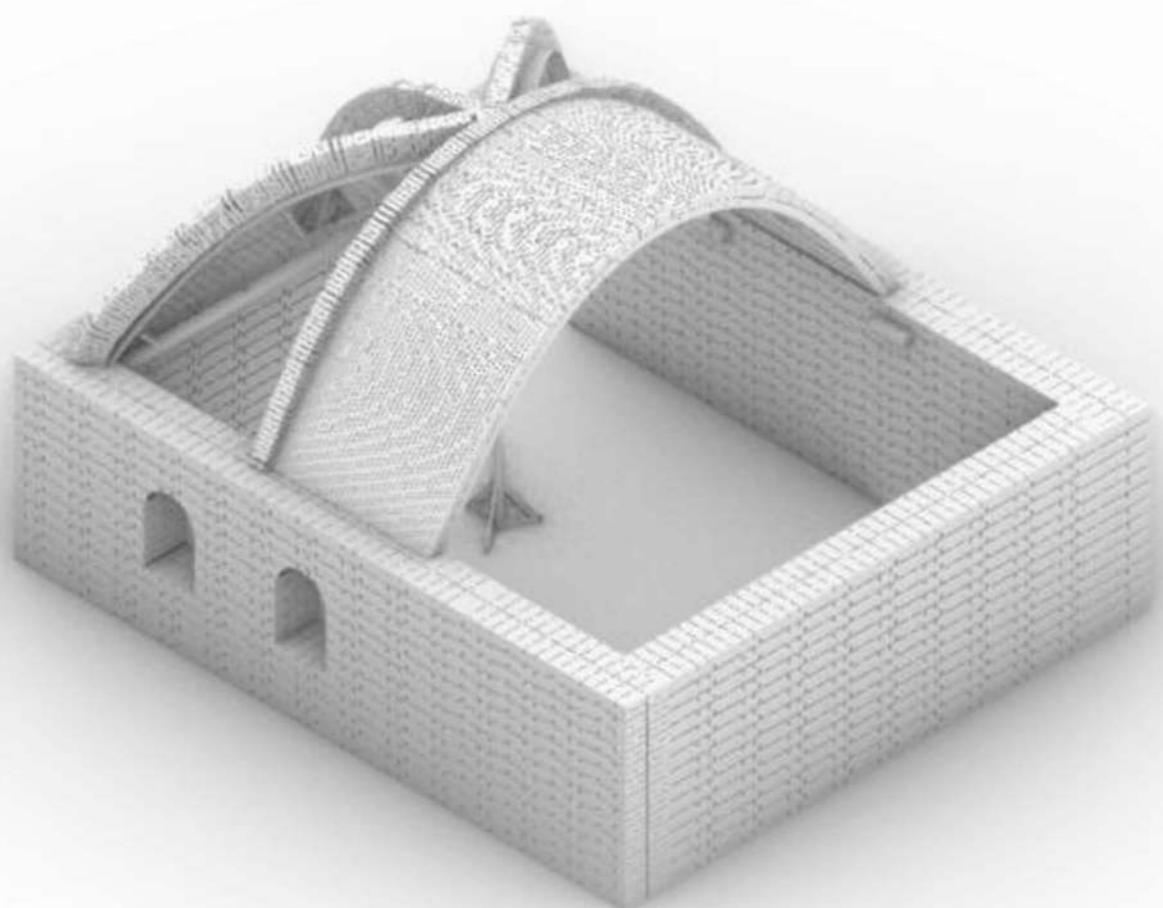
CEILING
STRUCTURES

TYPE
RIBBED VAULT

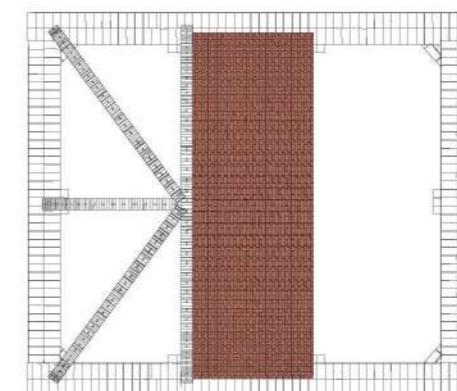
BRICK
TYPE C



RIB STRUCTURE



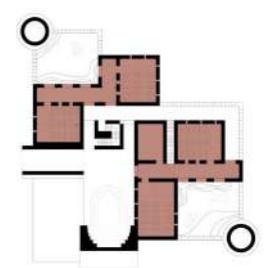
VAULT



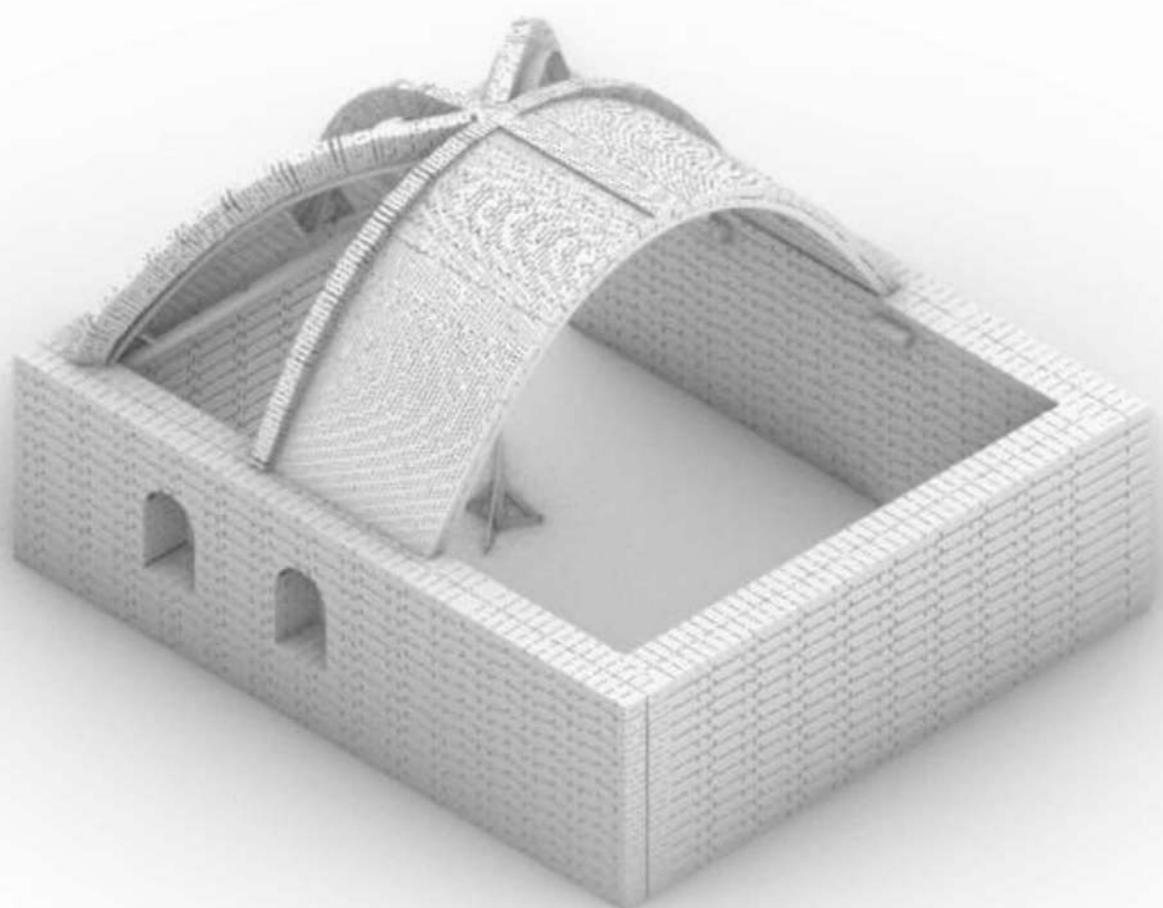
CEILING
STRUCTURES

TYPE
RIBBED VAULT

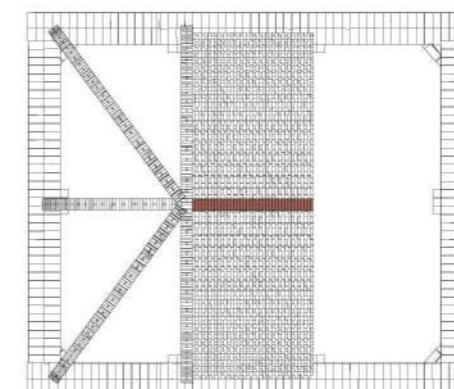
BRICK
TYPE C



RIB STRUCTURE



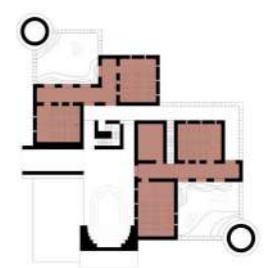
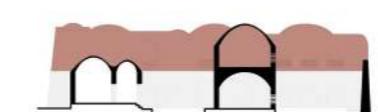
TOP RIB



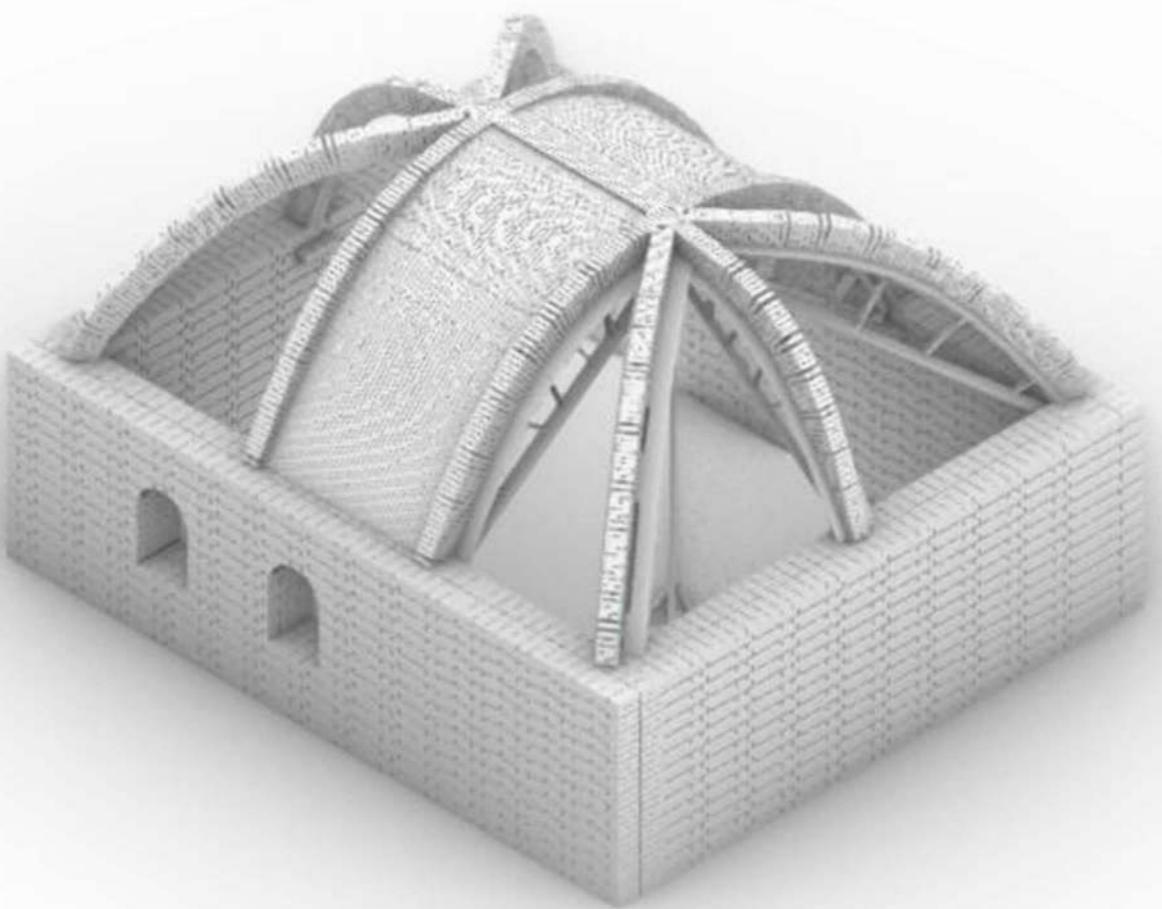
CEILING
STRUCTURES

TYPE
RIBBED VAULT

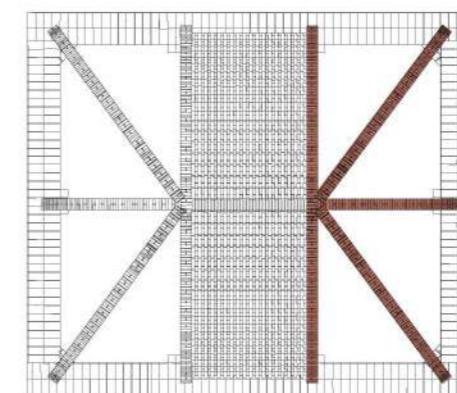
BRICK
TYPE C



RIB STRUCTURE



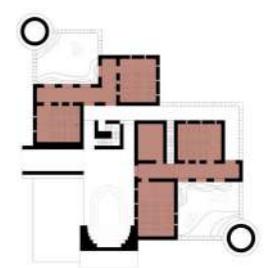
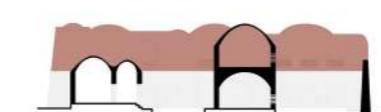
RIBS



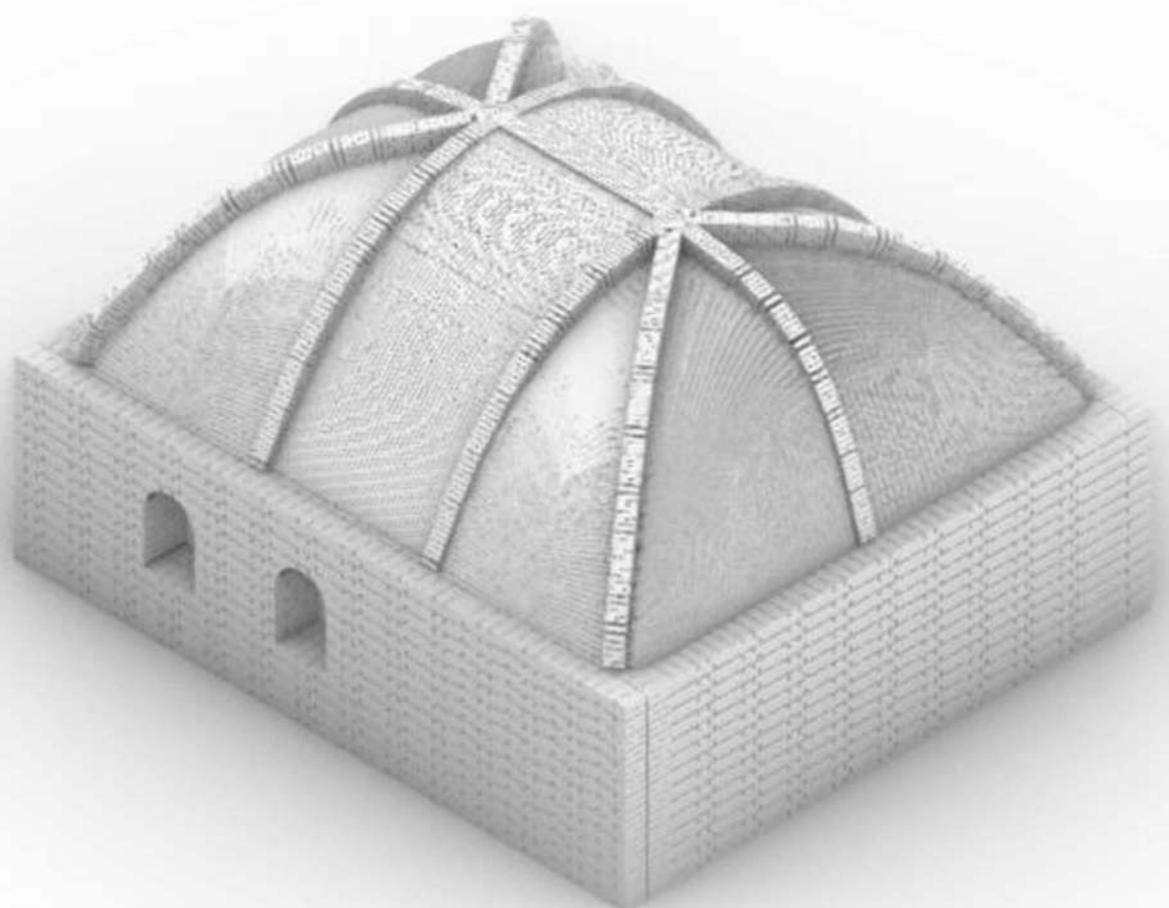
CEILING
STRUCTURES

TYPE
RIBBED VAULT

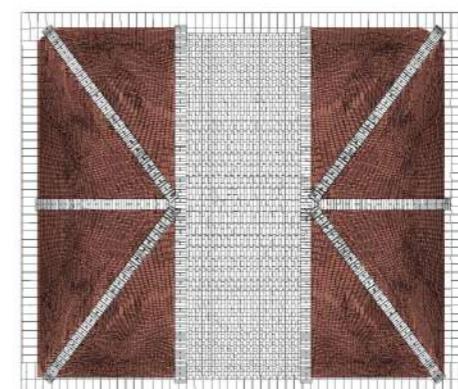
BRICK
TYPE C



RIB STRUCTURE



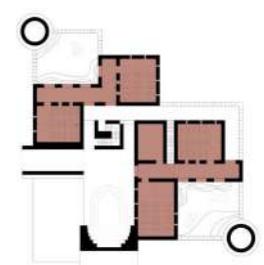
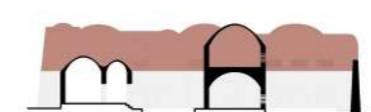
FILLING



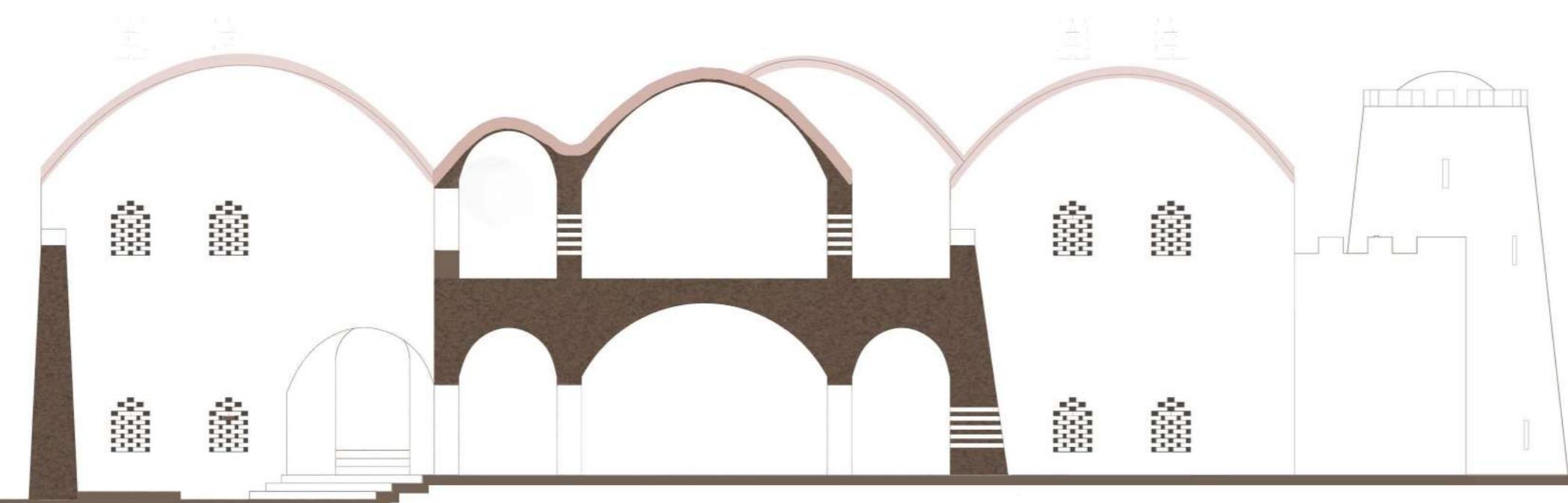
CEILING
STRUCTURES

TYPE
RIBBED VAULT

BRICK
TYPE C



EXTERIOR & ROOF



0 1 2 5 10(m)

ANALYSIS

URBAN

LAYOUT

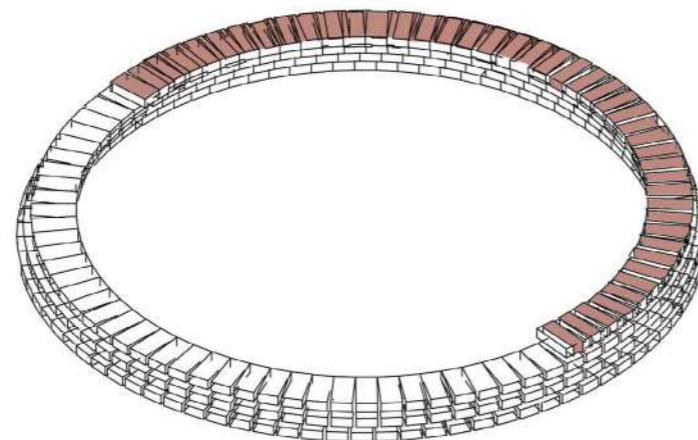
FORMING

STRUCTURAL

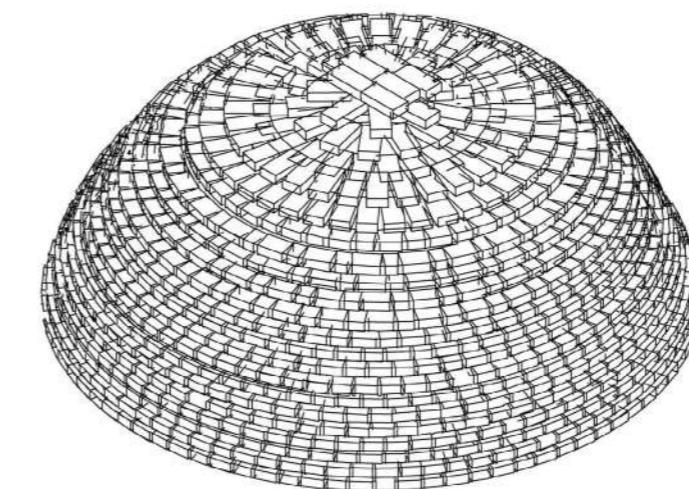
CONSTRUCTION

60

DOMES



BRICK LAYING

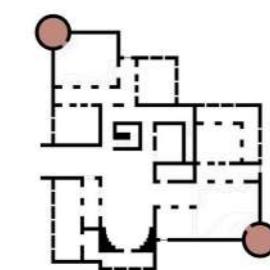
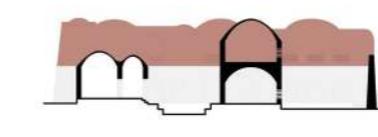


FULL DOME

CEILING
STRUCTURES

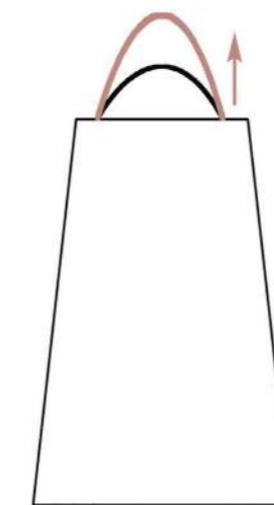
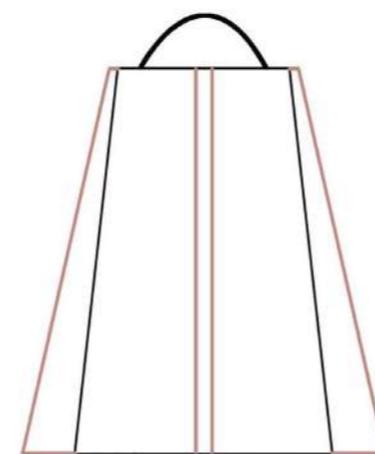
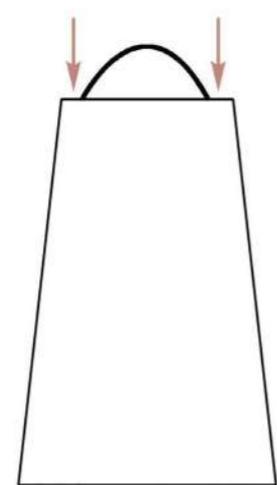
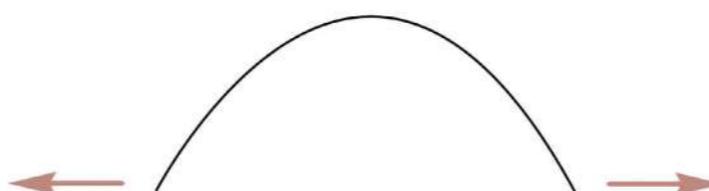
TYPE
DOME

BRICK
TYPE C



DOMES

PROBLEM

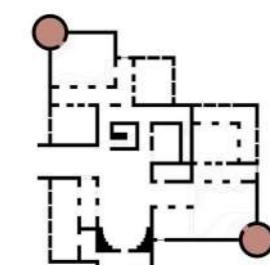
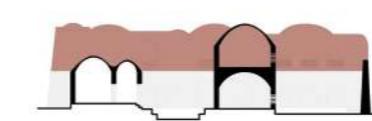


SOLUTIONS

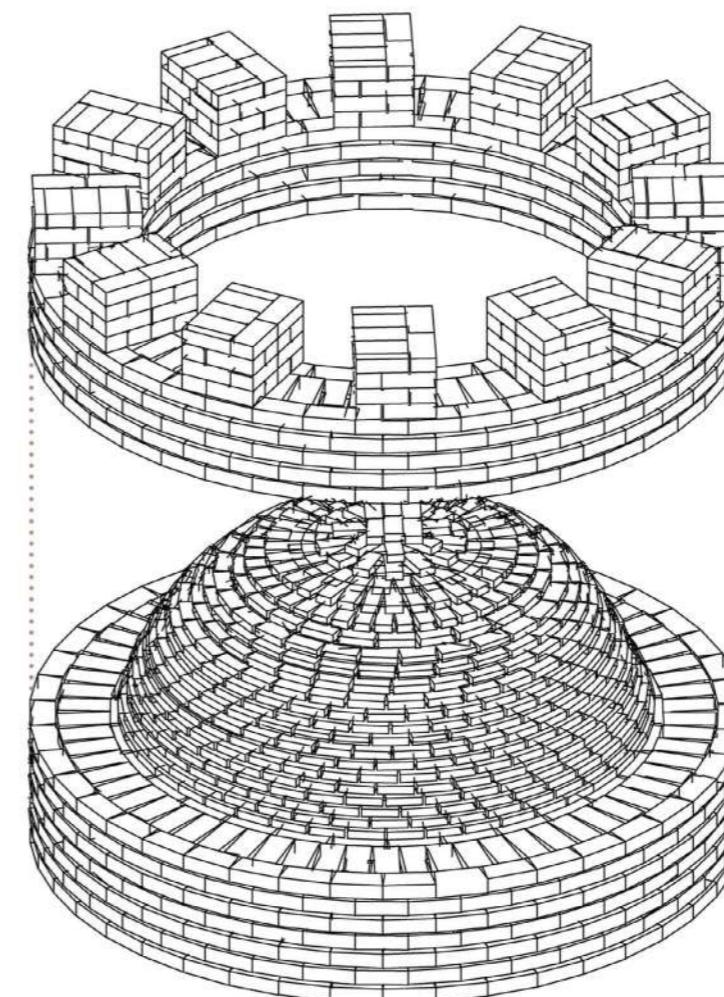
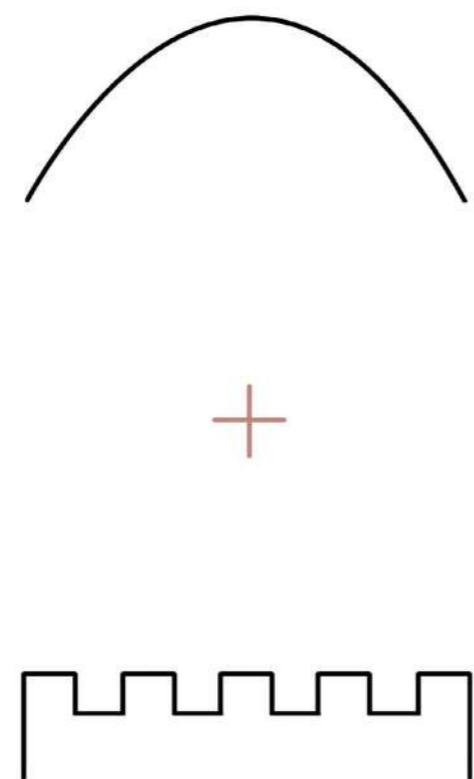
CEILING
STRUCTURES

TYPE
DOME

BRICK
TYPE C



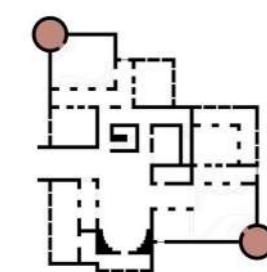
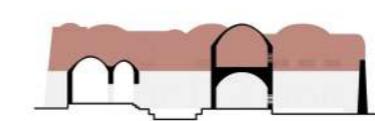
DOMES



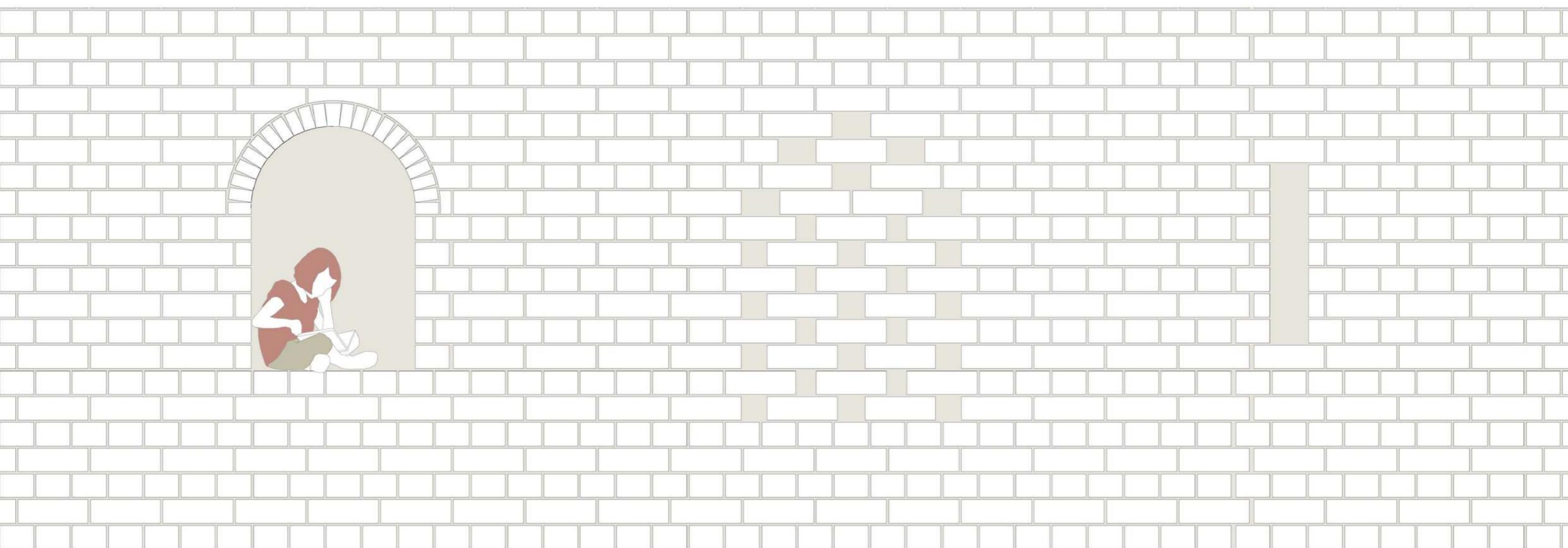
CEILING
STRUCTURES

TYPE
DOME

BRICK
TYPE C



W I N D O W S

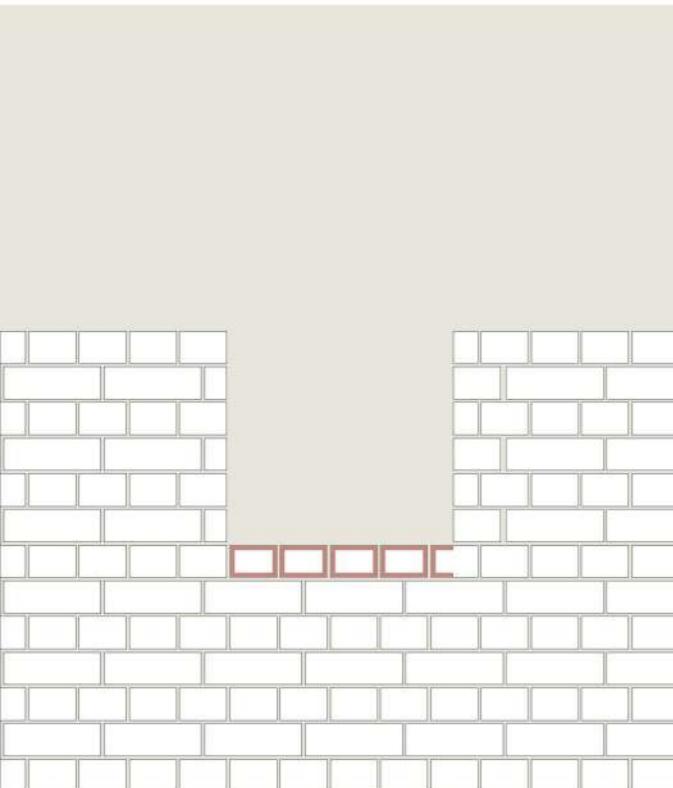


ARCH WINDOW

MASHRABIYA WINDOW

ARROW LOOP

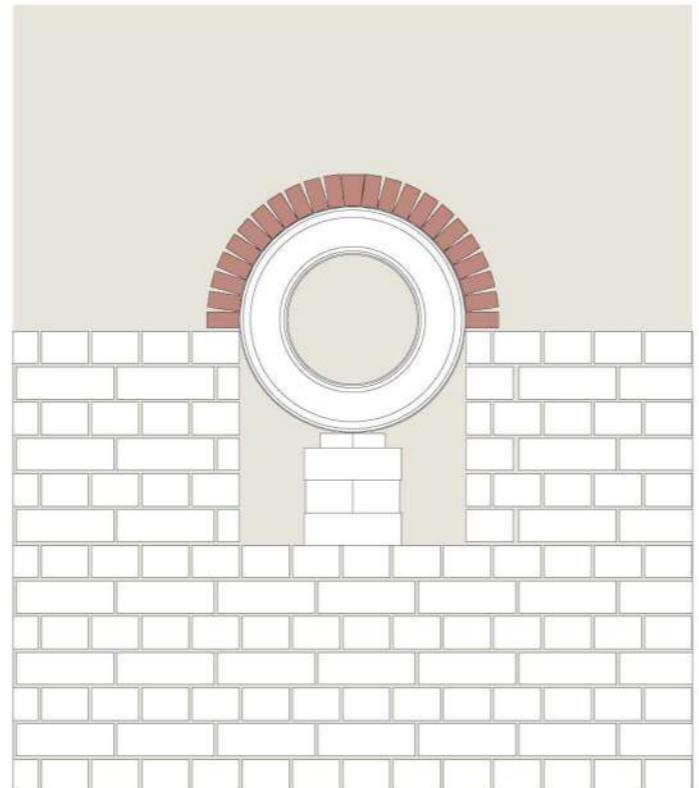
A R C H W I N D O W



DEFINE THE GAP

window width
=

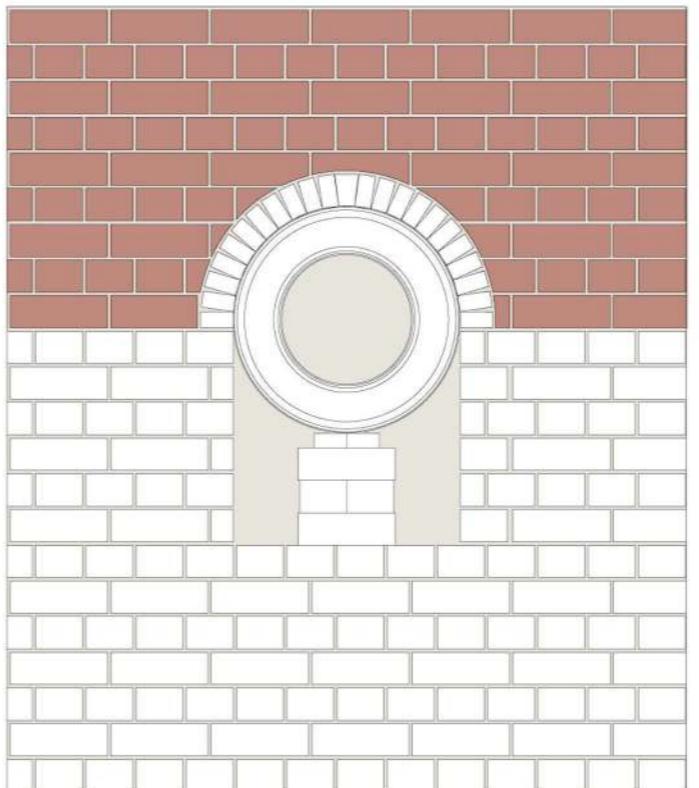
4 1/2 headers brick A



CREATE ARCH

temporarily place a truck tire
on bricks

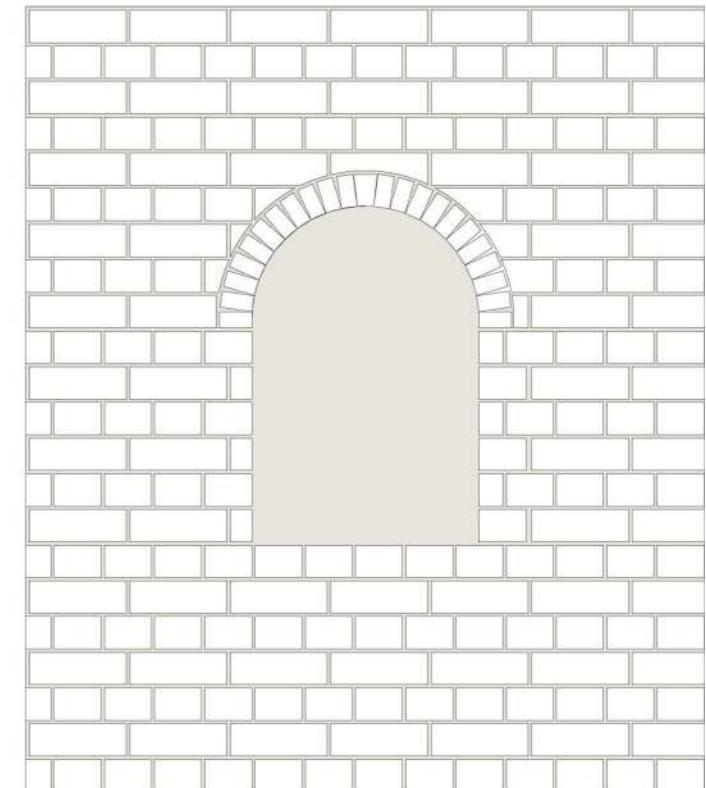
use brick B to create the arch
over the tire



FILL UP WALL

continue bricklaying as usual

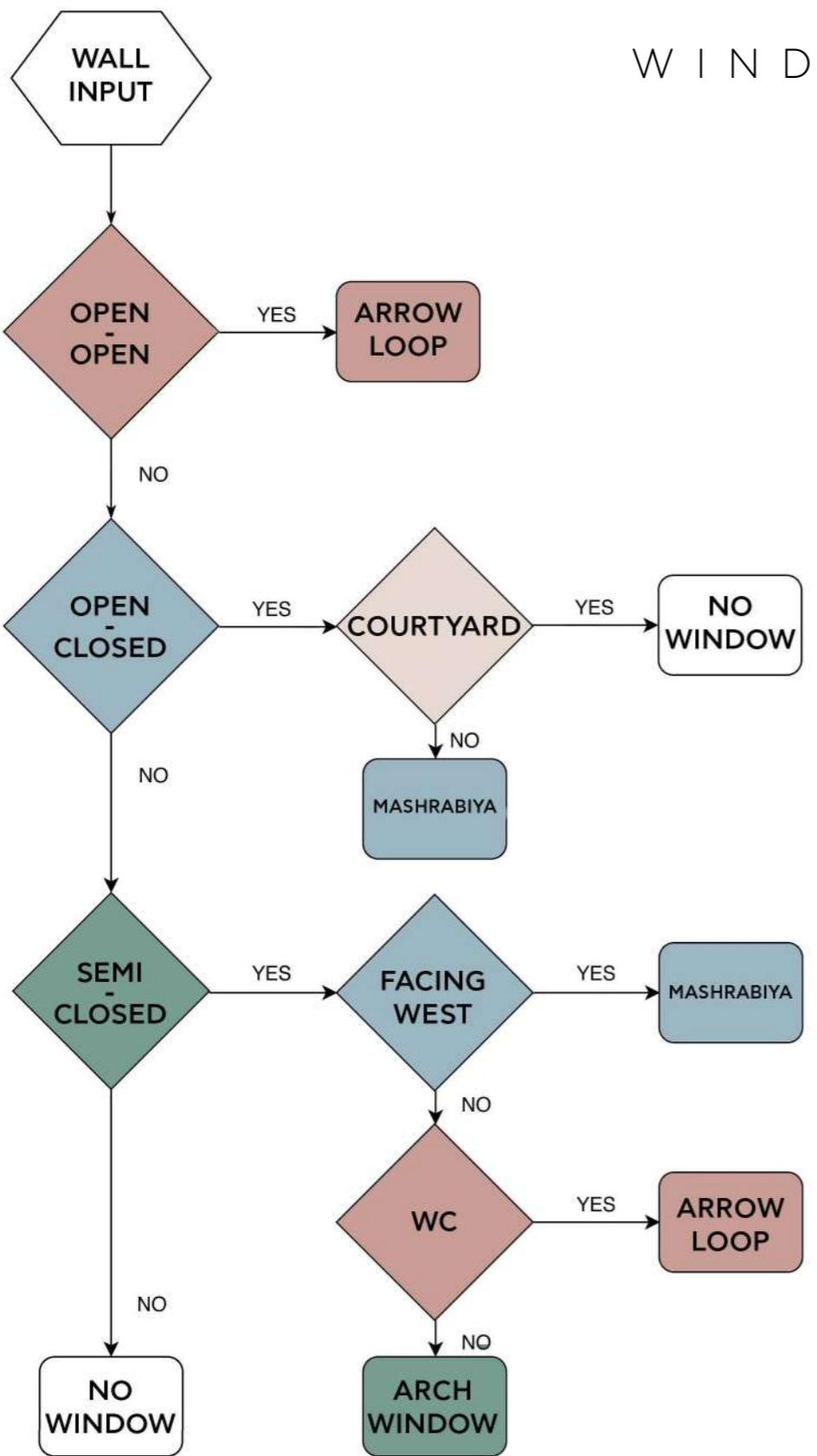
use broken bricks around the
arch



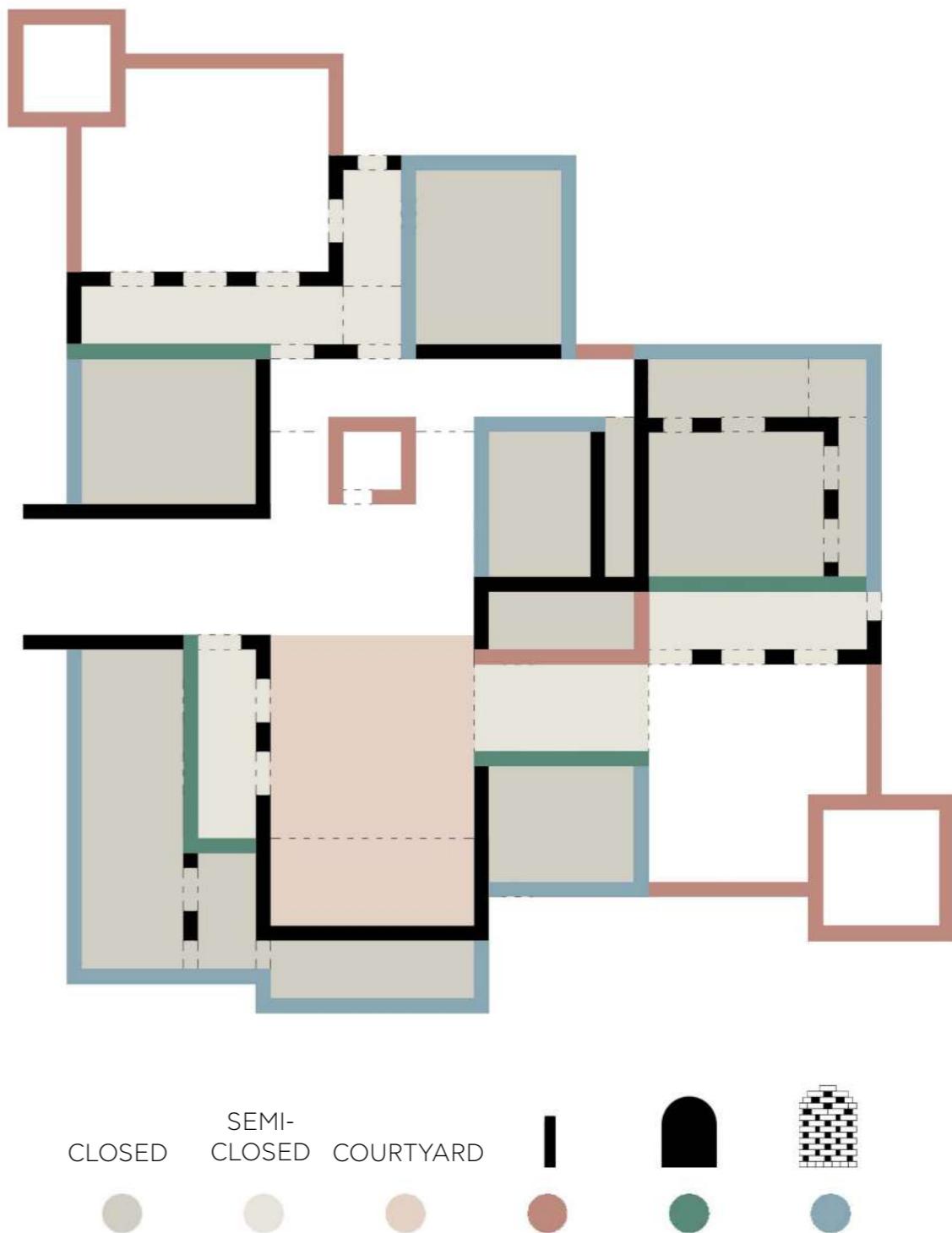
REMOVE TIRE

remove the tire

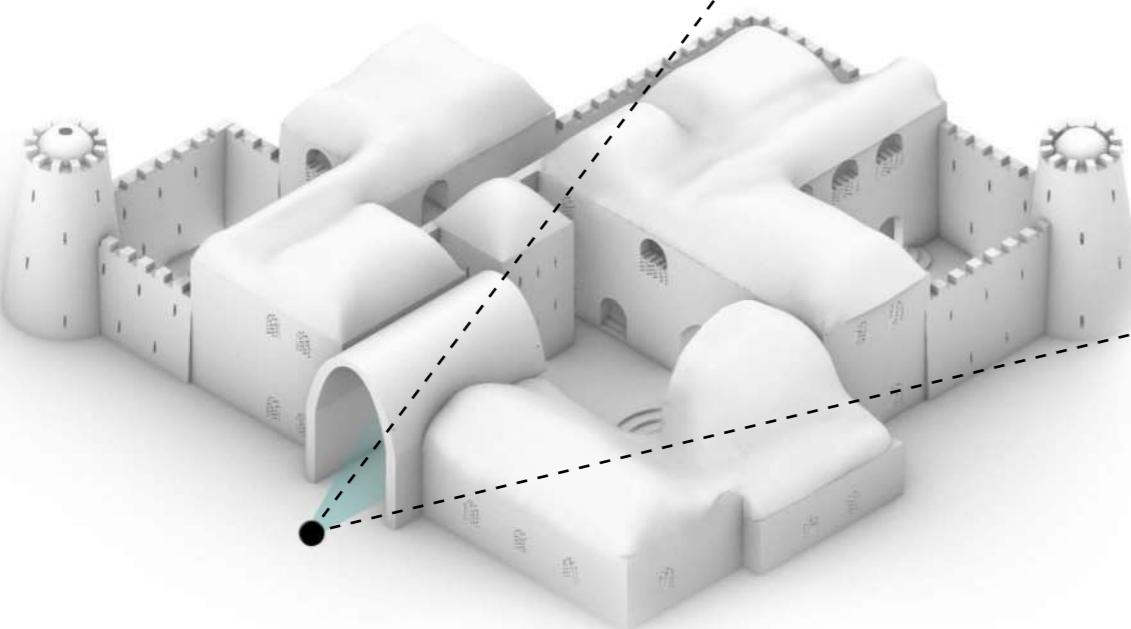
the window is ready!



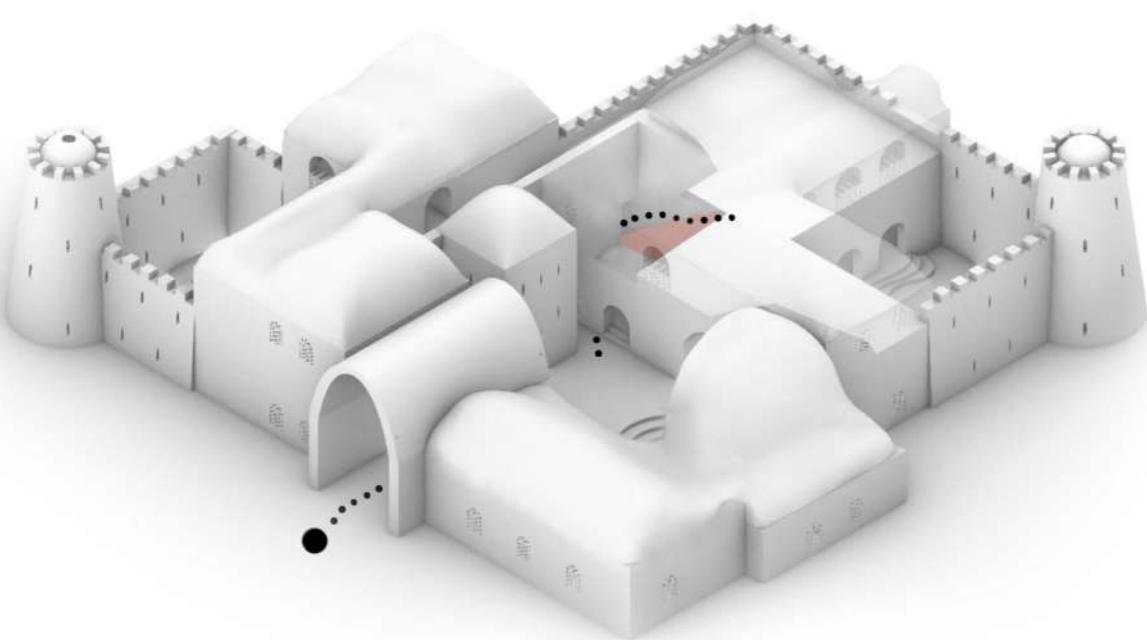
WINDOW PLACEMENT



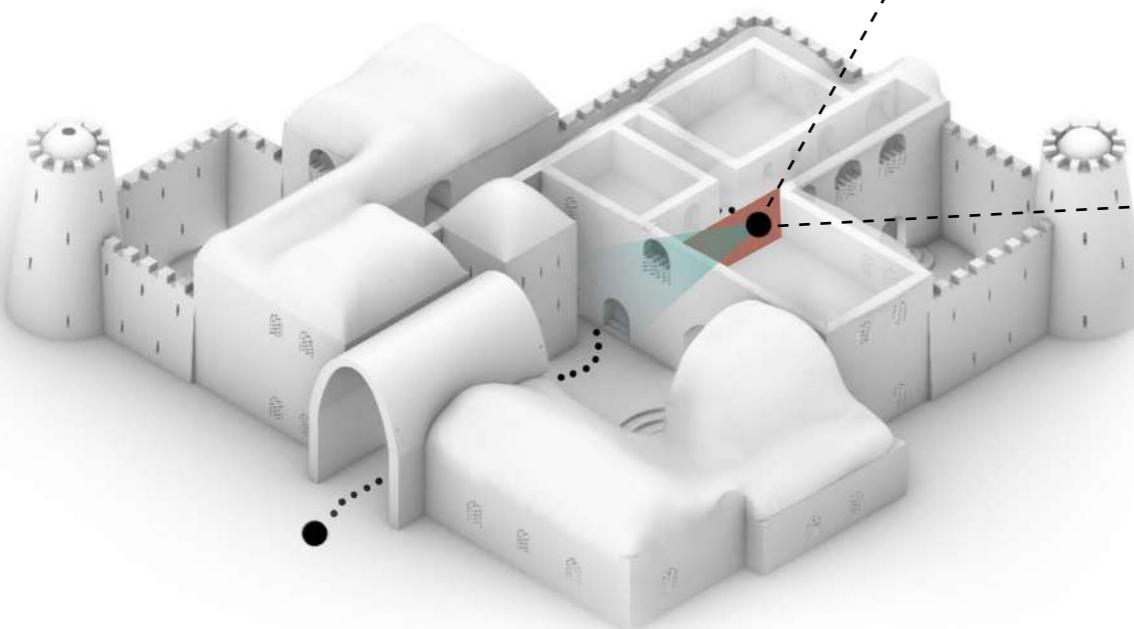
THE FLOW



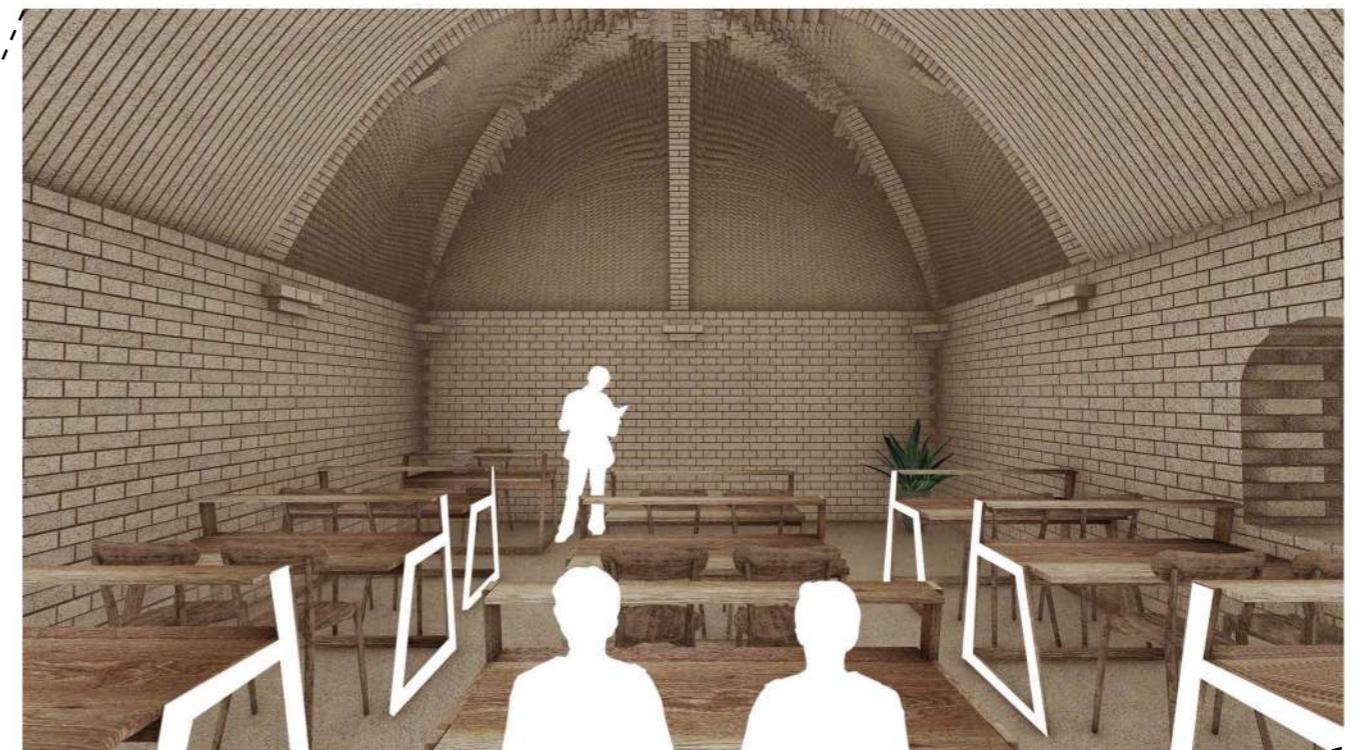
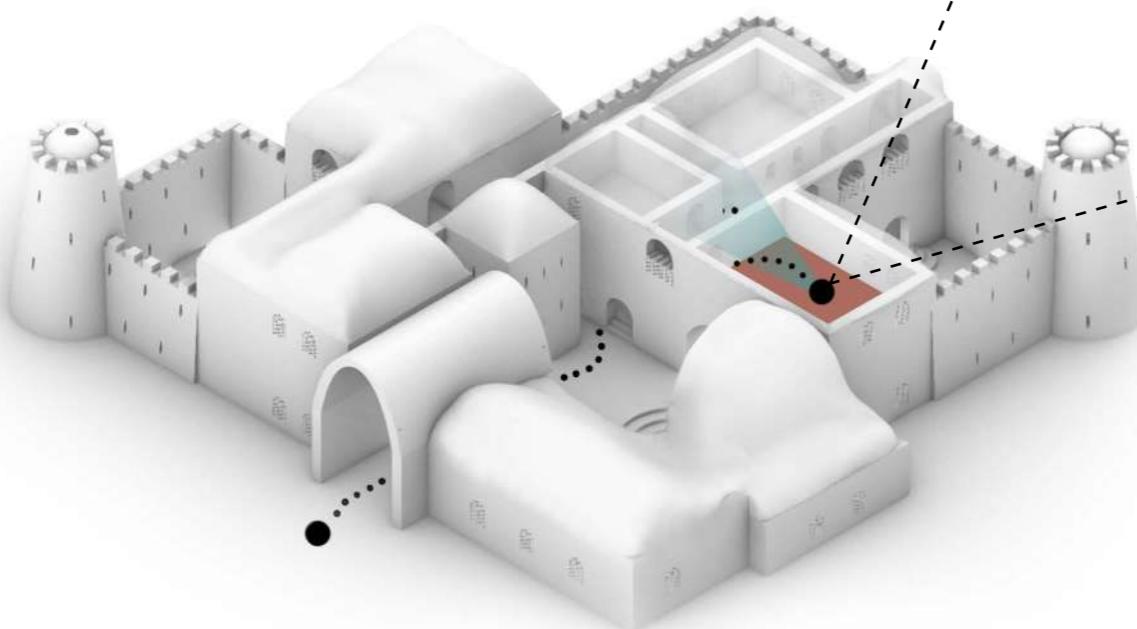
T H E F L O W



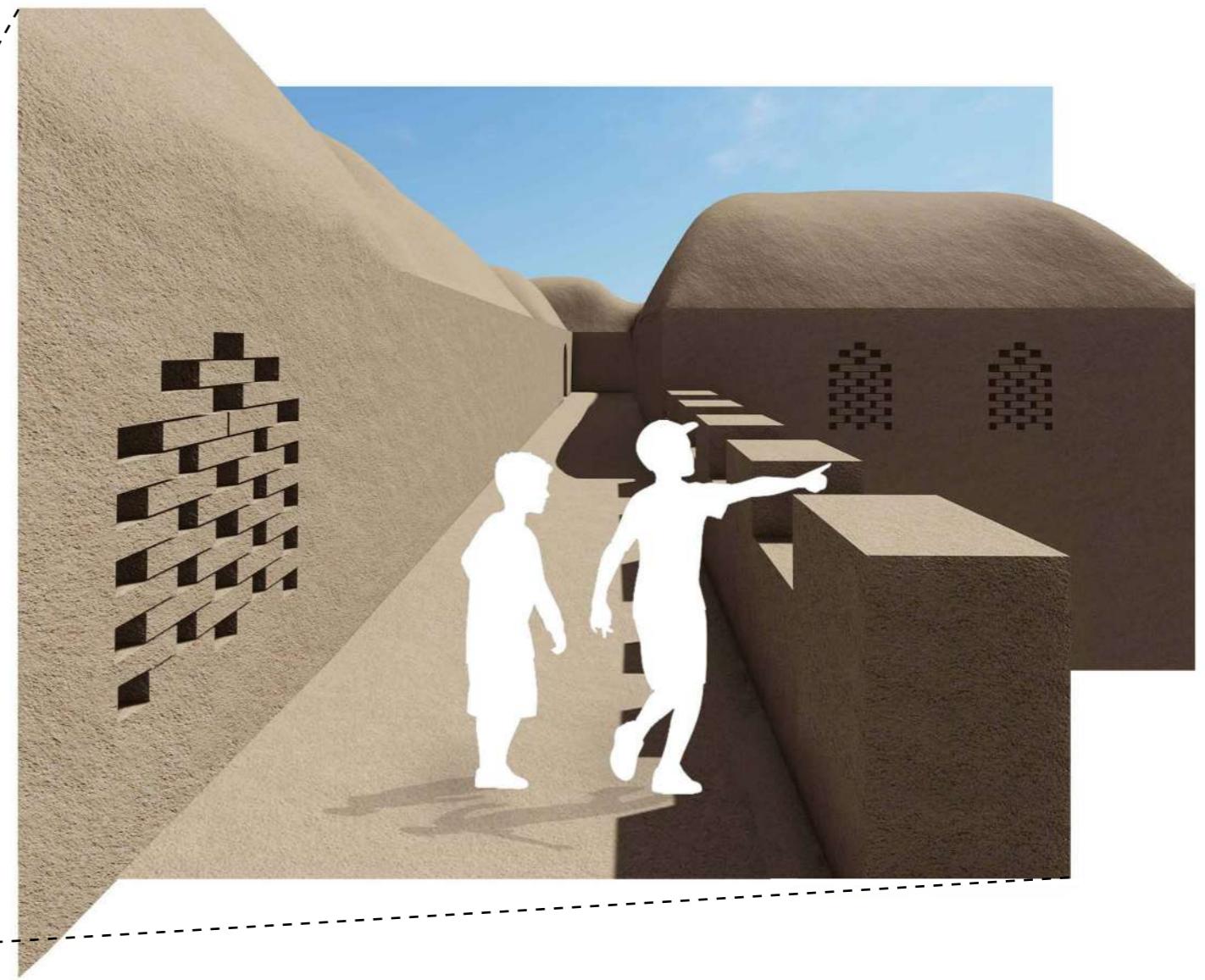
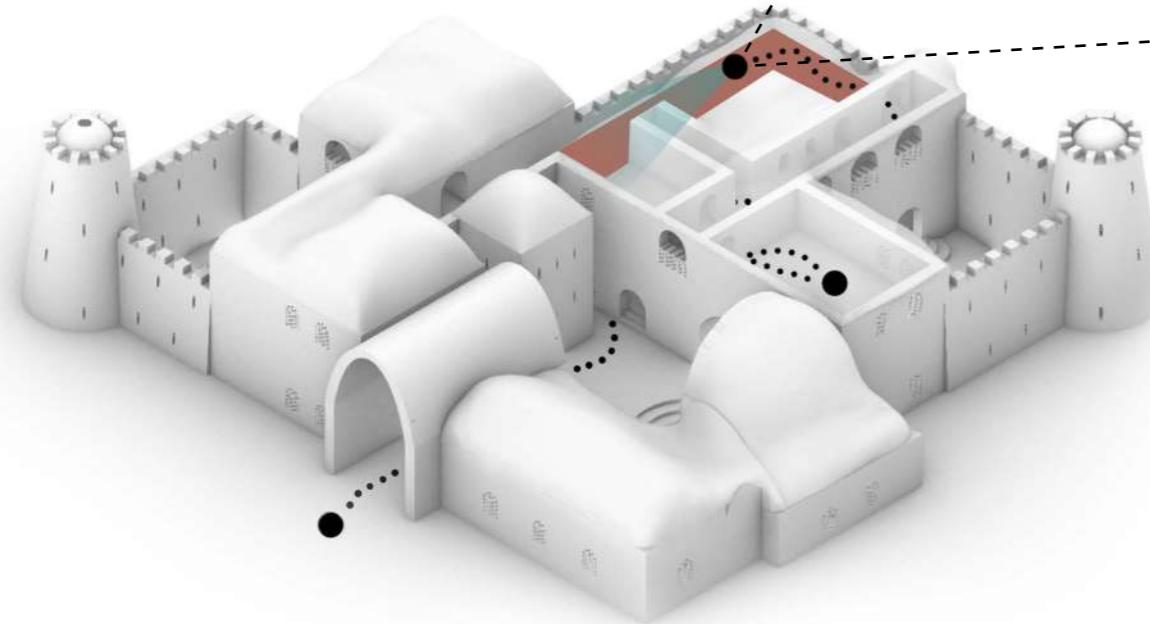
THE FLOW



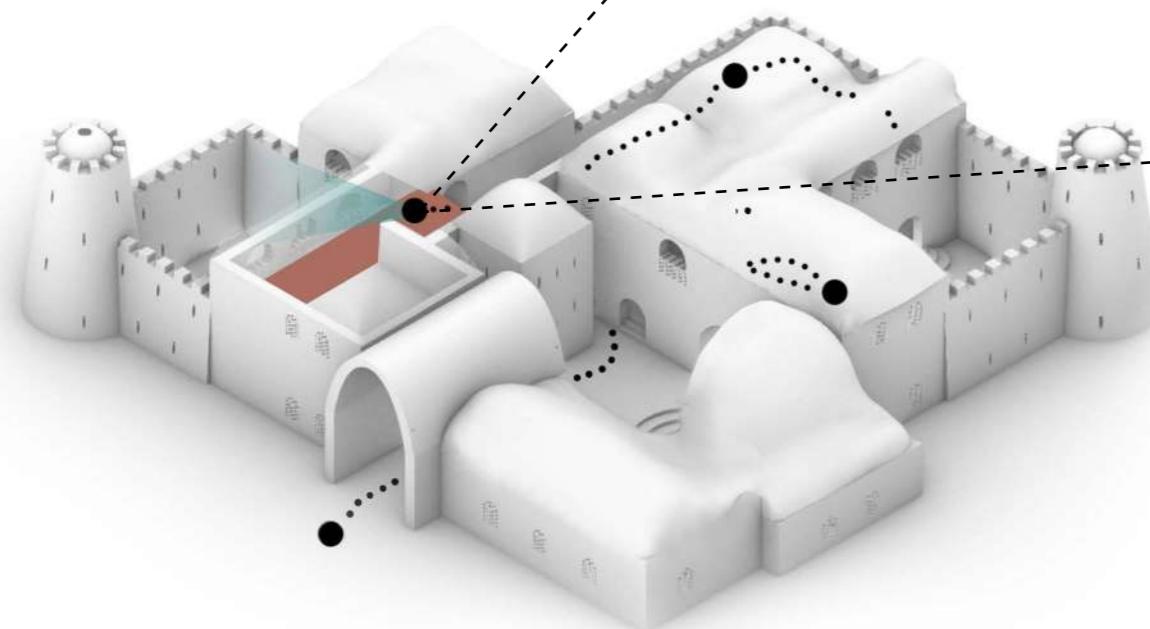
THE FLOW



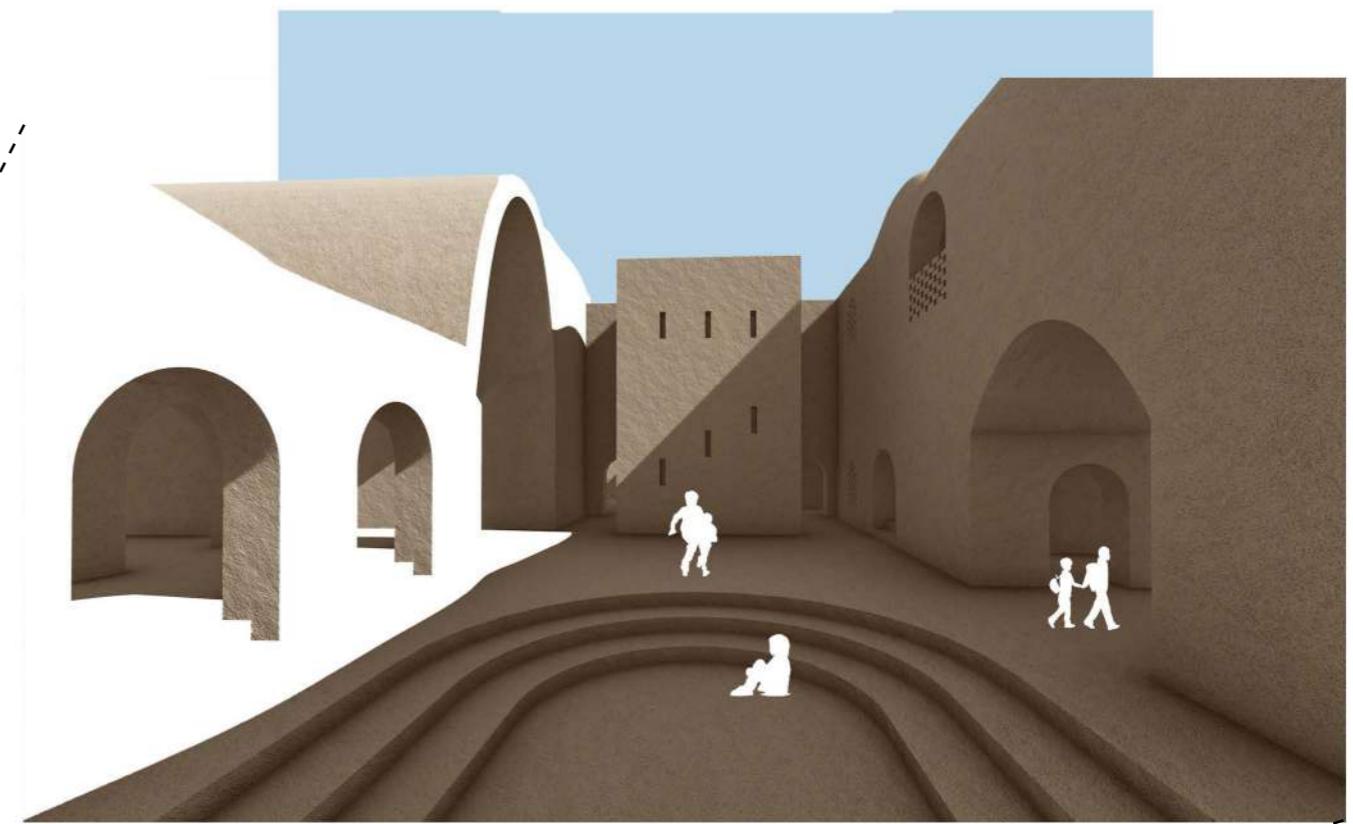
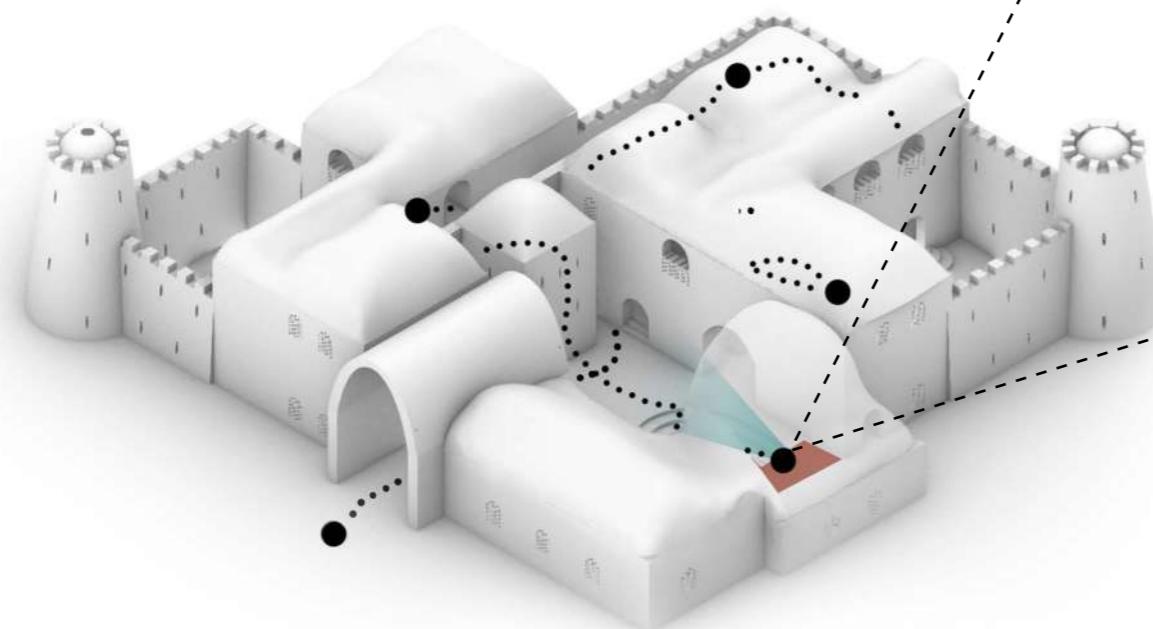
THE FLOW



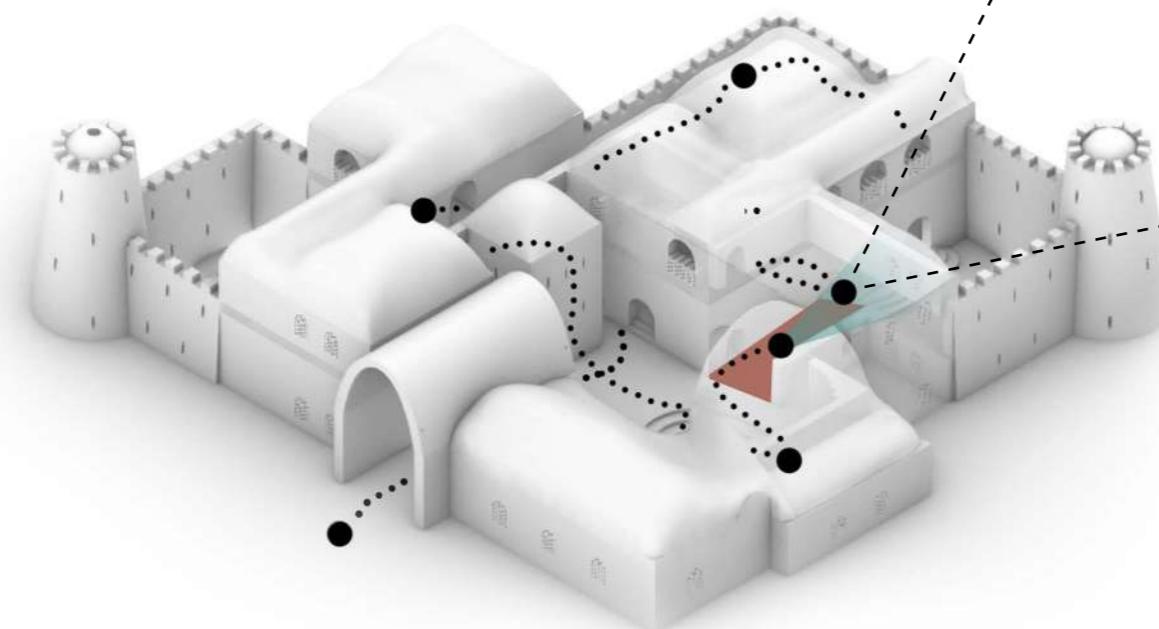
THE FLOW



THE FLOW



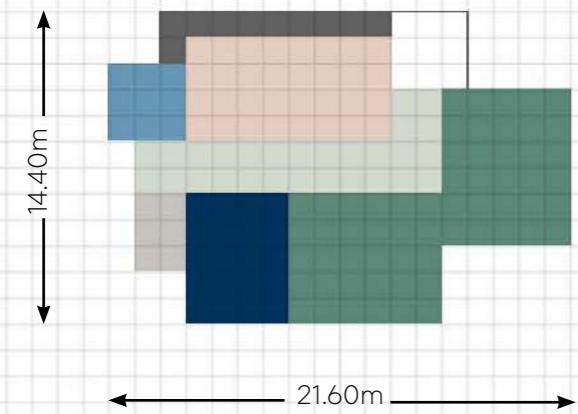
THE FLOW



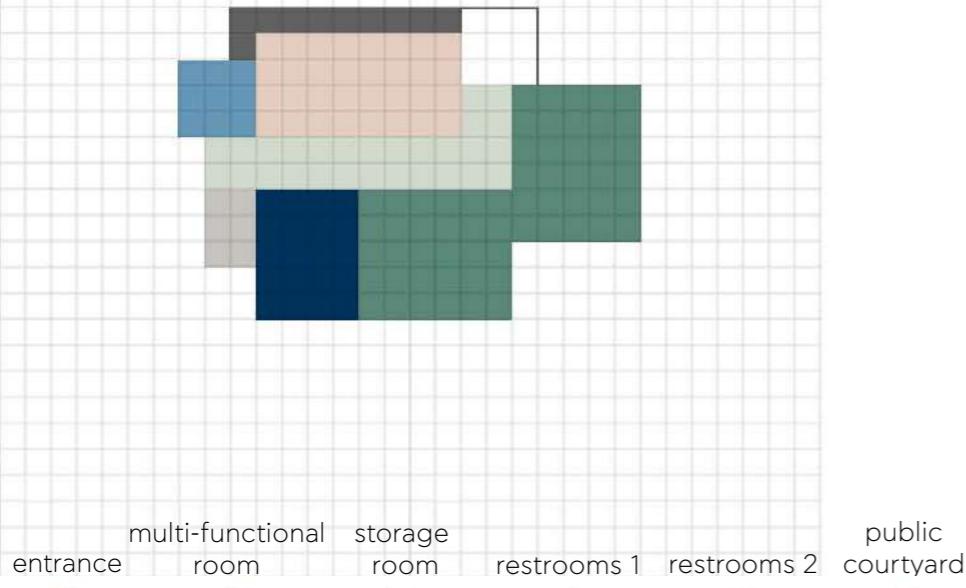


P R I O R I T Y 1

L E V E L 0

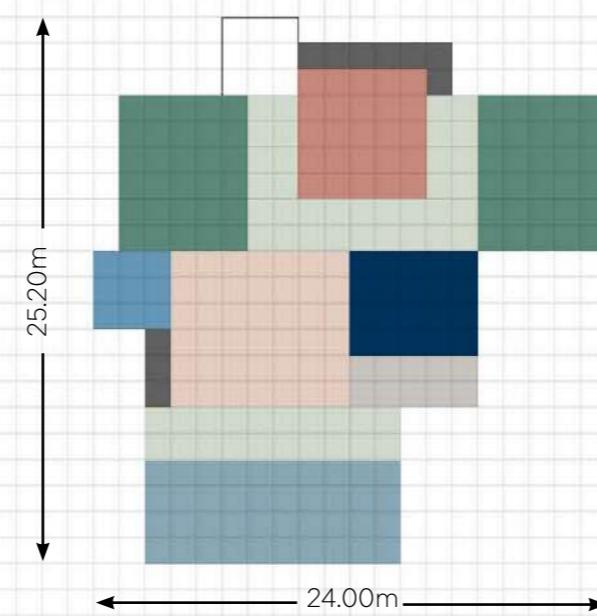


L E V E L 1



ANALYSIS

P R I O R I T Y 2

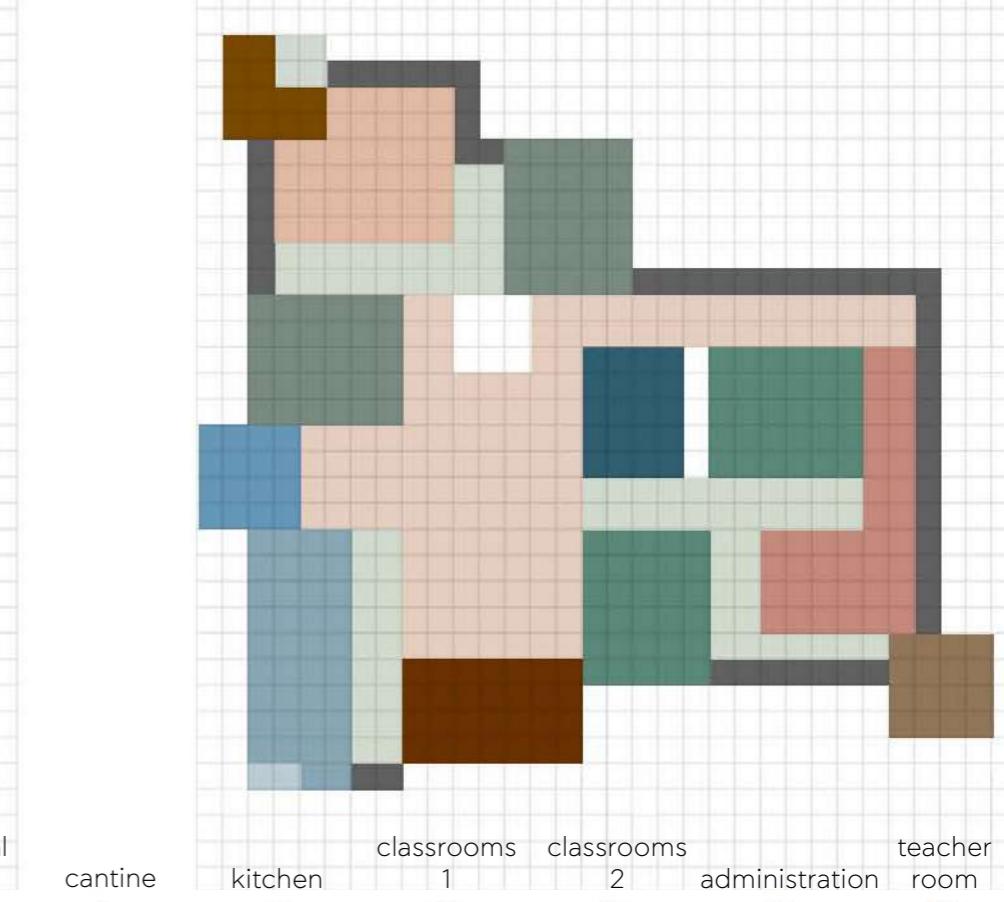
URBAN
LAYOUT

FORMING

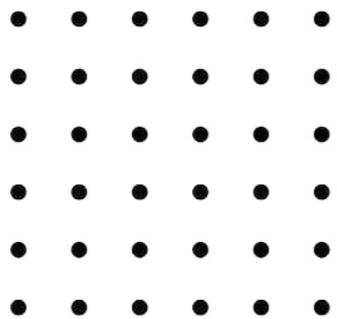
STRUCTURAL

CONSTRUCTION

P R I O R I T Y 3



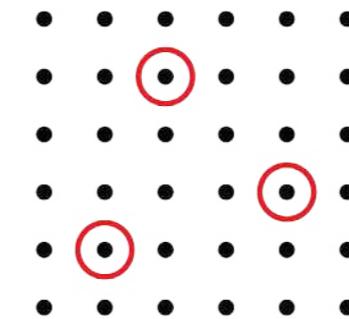
entrance	multi-functional room	storage room	restrooms 1	restrooms 2	public courtyard	courtyard 1	courtyard 2	iwan	winter living room	communal library	cantine	kitchen	classrooms 1	classrooms 2	administration	teacher room



Step 1: Create a grid of points,
0.6 meter from each other



Step 2: Create an Excel sheet
which assigns every room to
a point on the grid



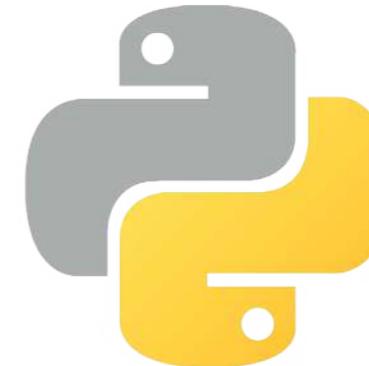
Step 3: Place the correct
points into an ordered
Grasshopper List



Step 4: Create an Excel sheet
with dimensions in X,Y and Z
of each room

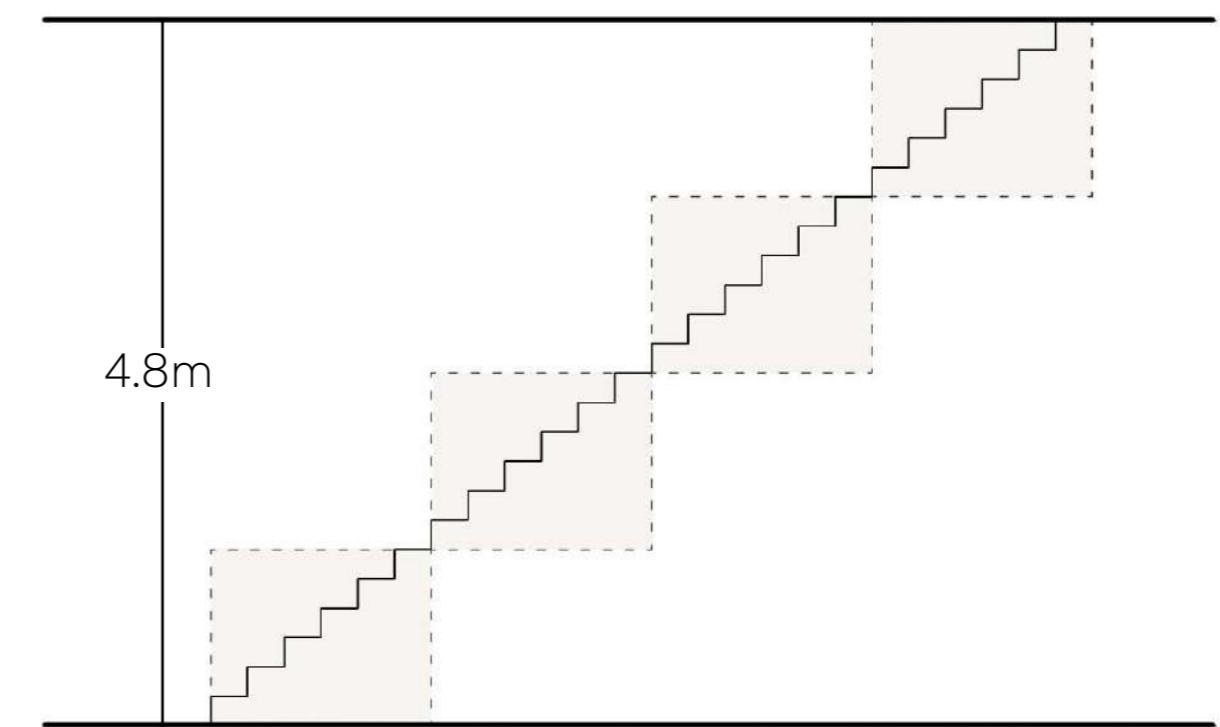
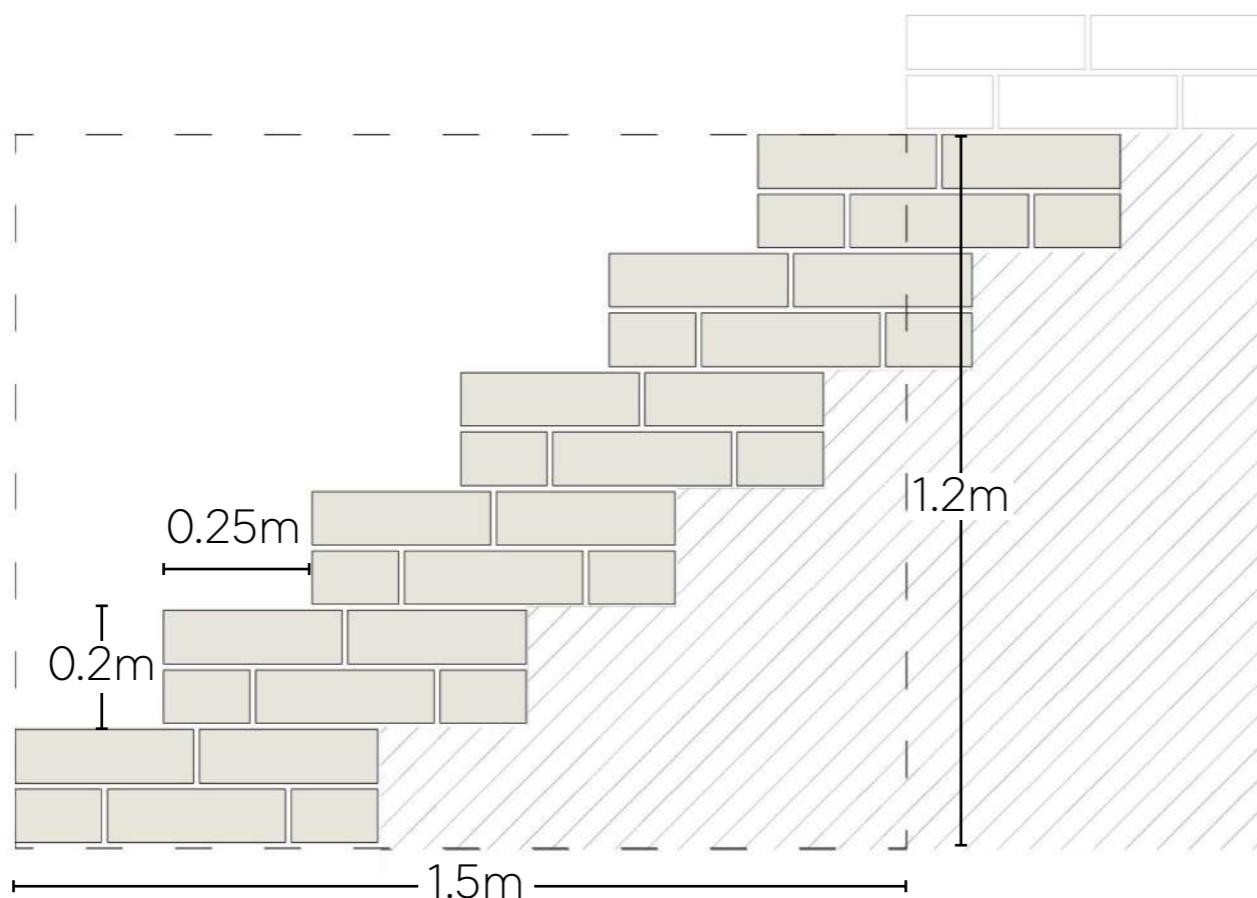
{1}		
0	7.2	
1	6	
2	2.4	
{2}		
0	13.2	
1	2.4	
2	2.4	
{3}		
0	6	
1	7.2	
2	2.4	

Step 5: Make a Grasshopper
List with the properties of
each room



Step 6: Insert the two made
lists into the Python script

STAIRS



DETAILS

TYPE
STAIRS

BRICK
TYPE A

