

# MODUL\_ABILITY



## **AR3B011 Earthy**

### **Flexible Housing**

#### **Mentors**

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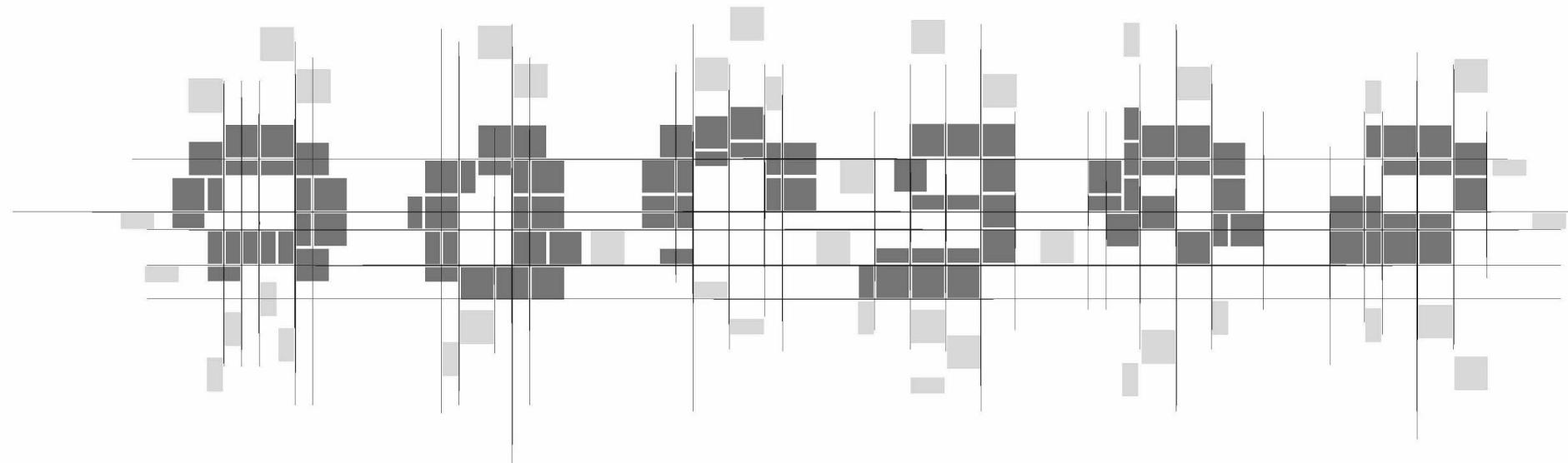
#### **Group 6**

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<i>Fredy Fortich</i>	4821858
<i>Kiana Mousavi</i>	4878736
<i>Stephanie Moumdjian</i>	4907663

# CONCEPT

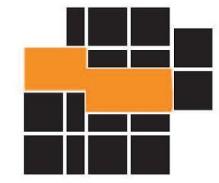
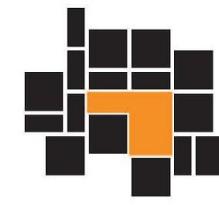
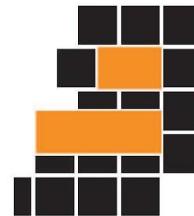
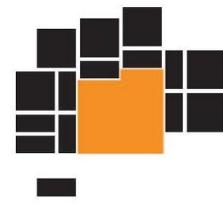
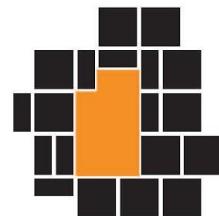
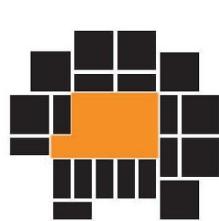
# ADAPTIVE / MODULAR

## Housing that can be extended or repurposed organically



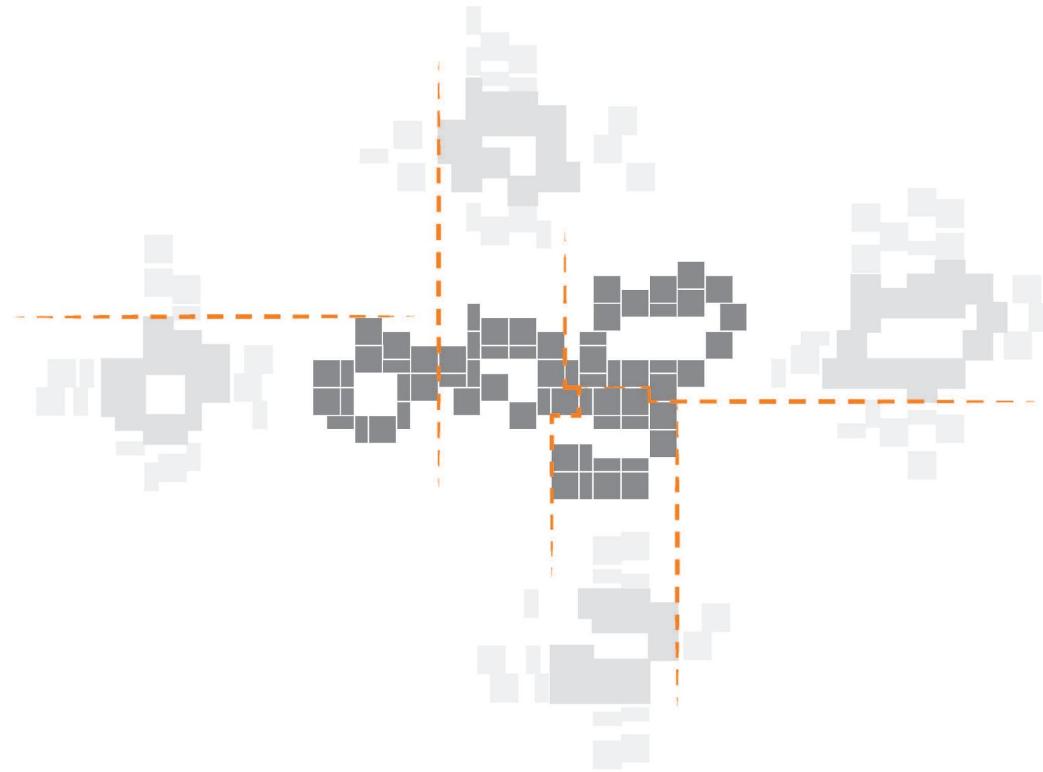
## OPEN SPACE / MULTIPLE FUNCTIONS

Housing with communal open spaces and configurations that could serve for different usages in the future.



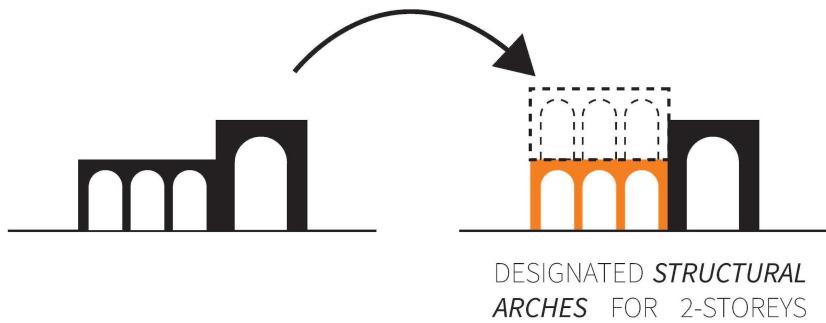
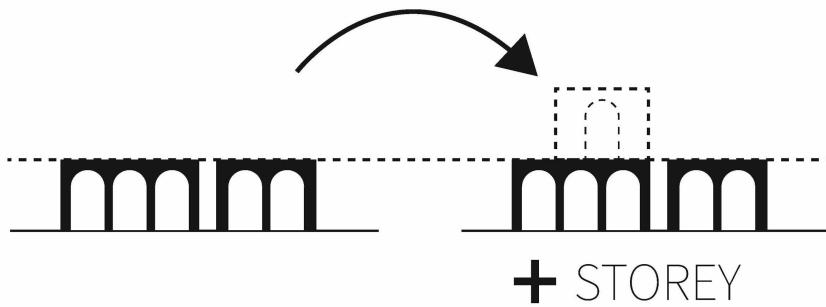
# COMMUNITY INTEGRATED DISTRICT

## Merging families for sharing facilities and creating clusters



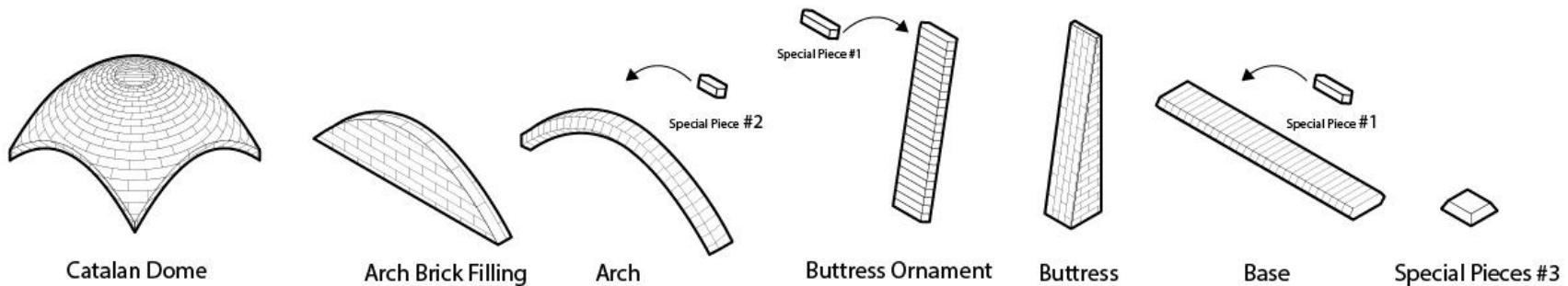
FLEXIBLE BUILT AREA

+ EXTENSION FOR FUTURE USE



# FEASIBILITY OF CONSTRUCTION

## A CONSTRUCTION CATALOG



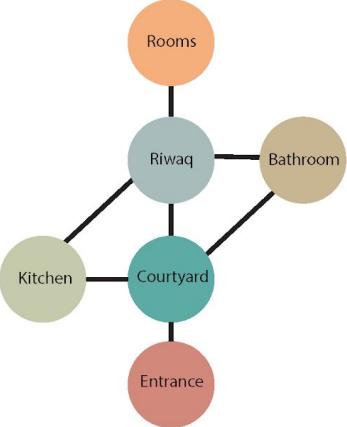
Components' List for all Modules



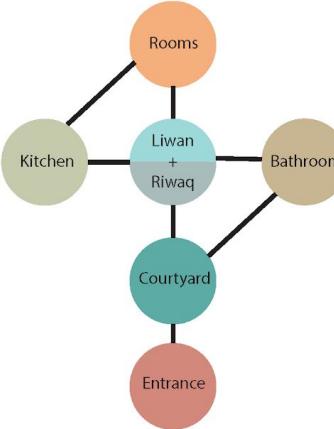
# CONFIGURING

# HOUSING TYPOLOGIES

Typology 3



Typology 4



Typology 3

Room	Entrance	Riwaq	Courtyard	Kitchen	Rooms	Bathroom
Entrance	1	0	0	0	0	0
Riwaq	0	1	0	0	0	0
Courtyard	1	1	1	0	0	0
Kitchen	0	1	1	1	0	0
Rooms	0	1	0	0	1	0
Bathroom	0	1	1	0	0	1

Typology 4

Room	Entrance	Riwaq/Liwan	Courtyard	Kitchen	Rooms	Bathroom
Entrance	1	0	0	0	0	0
Riwaq/Liwan	0	1	0	0	0	0
Courtyard	1	1	1	0	0	0
Kitchen	0	1	1	1	0	0
Rooms	0	1	0	0	1	0
Bathroom	0	1	1	0	0	1

Direct Connection	1
No Connection	0

# PROGRAM OF REQUIREMENTS

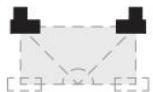
Name of Space	Abbreviation	Privacy	Roof	Desired Area (m2)	Max No. of Occupants	Free Height (m)	Daylight Requirement
Entrance	E	Med	No	8	1	-	Low
Courtyard	C	Med	No	-	8	-	High
Riwaq (Open Gallery)	R	Med	Yes	8	4	3	Med
Bathroom	WC	High	Yes	8	1	2.5	Low
Kitchen (non shared)	K	Med	Yes	16	4 - 8	3	Med
Bedroom (Family number of member required)	B	High	Yes	4 or 16	1-2	2.5	High

## INTERNAL SPACES OF A SINGLE UNIT

# UNITS AND MODULES

## Units

**Half-Vault Unit**  
*Riwaq Unit - 2 Units*  
 $1.25m * 2.5m$



**Single Module Riwaq**  
*Corner Unit*  
 $1.25m * 1.25m$

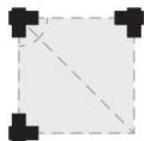


**Single Module Riwaq**  
*T Intersection Unit*  
 $1.25m * 1.25m$

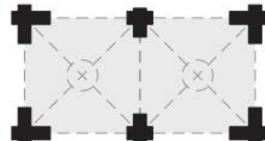


## Modules

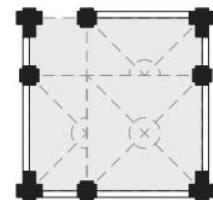
**Low-Vault**  
*Riwaq Corner Module*  
 $2.5m * 2.5m$



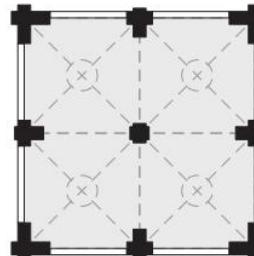
**Low-Vault**  
*Riwaq Module*  
 $5m * 2.5m$



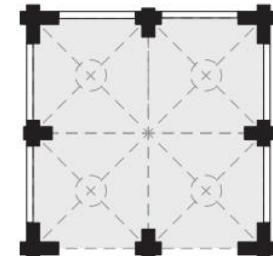
**Medium Room**  
*Small Dome + Double Vault*  
 $3.8m * 3.8m$



**Low-Dome**  
*(4 Domes)*  
 $5m * 5m$



**High-Dome**  
*(Single Dome)*  
 $5m * 5m$

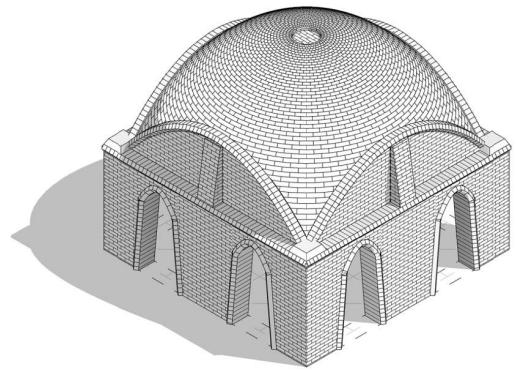


# LARGE DOME MODULE

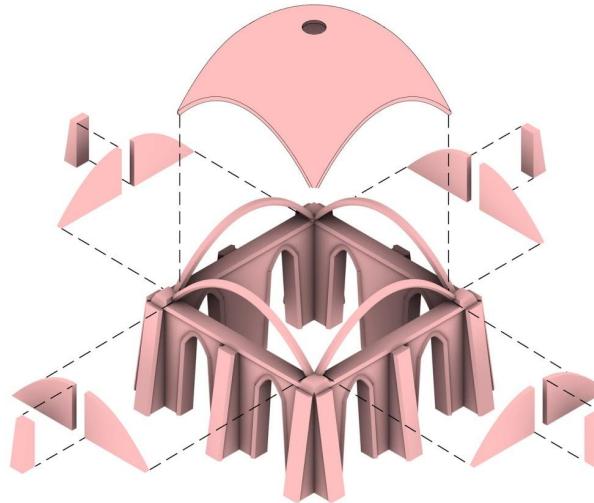
## Construction Manual



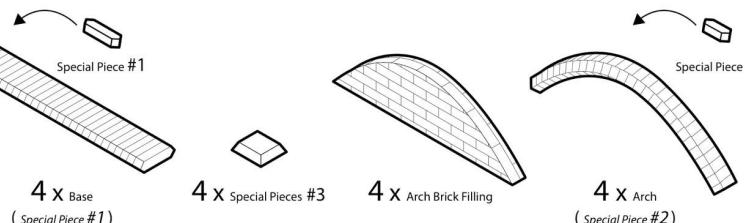
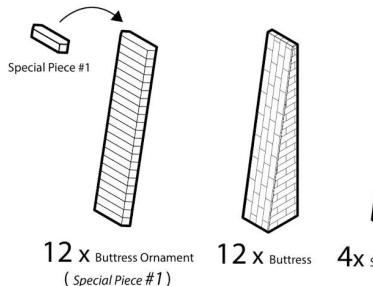
Large Dome  
*Module in Context*



Large Dome  
*Module Isolation*



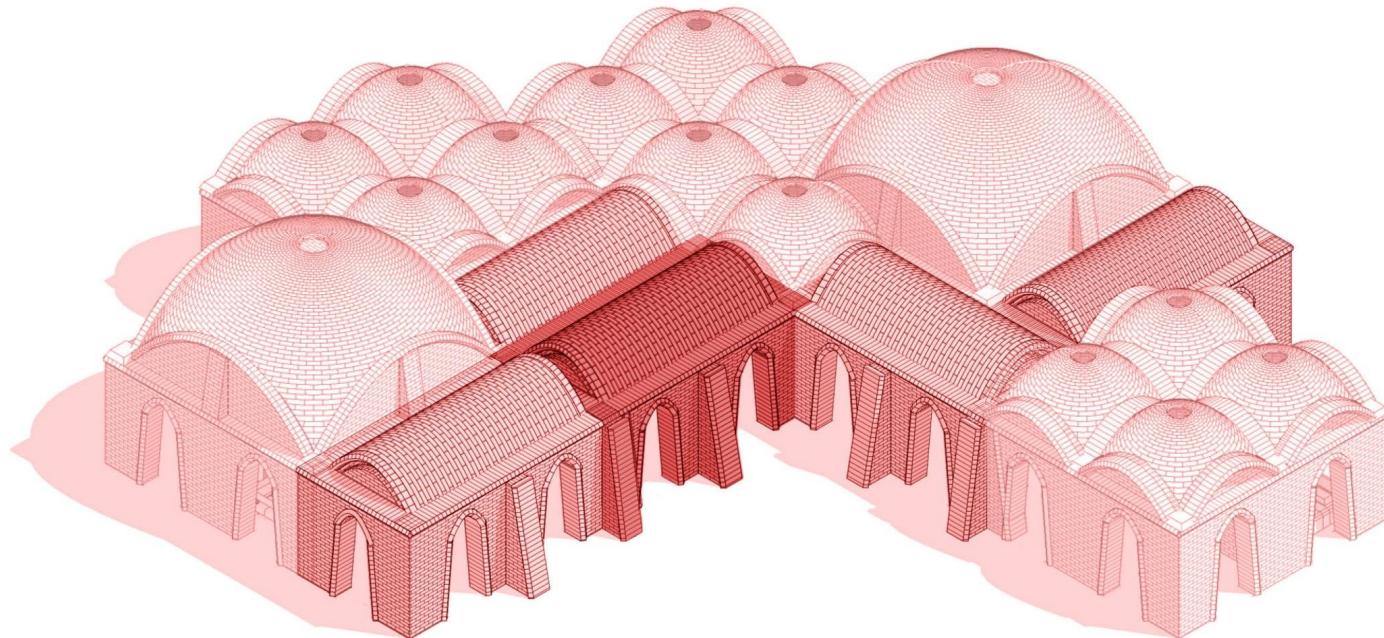
Large Dome  
*Exploded Axonometric*



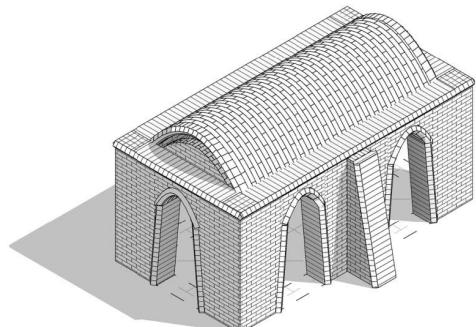
Components' List  
*for one Corner Riwaq Module*

# NORMAL VAULT MODULE

## Construction Manual



Normal Vault  
*Module in Context*



Normal Vault  
Module Isolation



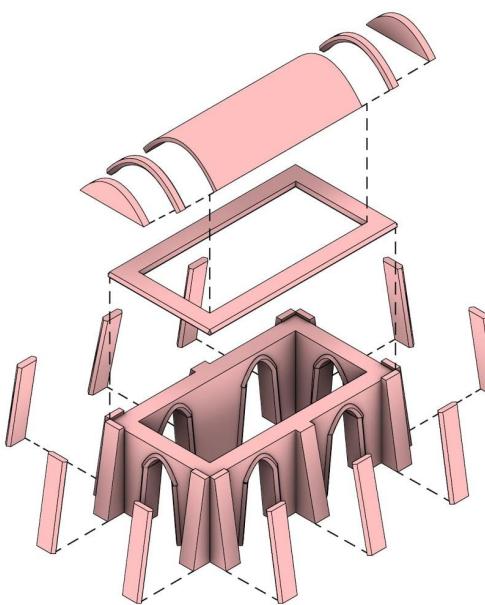
10 x Buttress Ornament  
( 22 x Special Piece #1 )



10 x Buttress



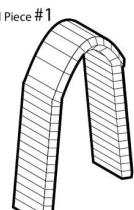
4 x Base  
( Special Piece #1 )



Normal Vault  
Exploded Axonometric



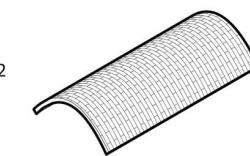
Special Piece #1



1 x Catalan Vault  
( Special Piece #1 )



2 x Arch  
( Special Piece #2 )

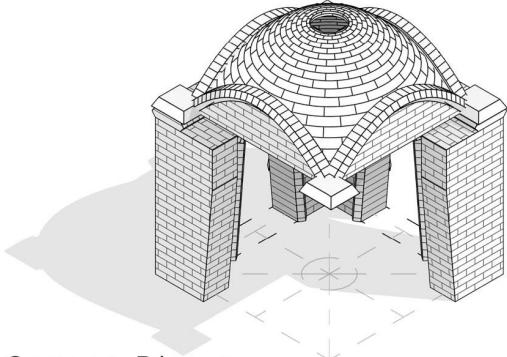


# CORNER RIWAQ MODULE

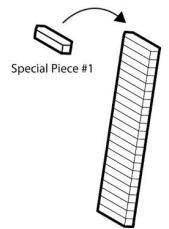
## Construction Manual



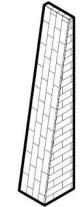
Corner Riwaq  
*Module in Context*



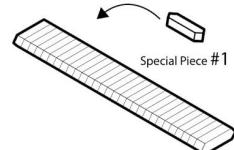
**Corner Riwaq  
Module Isolation**



**2 X Buttress Ornament  
( 22 x Special Piece #1 )**

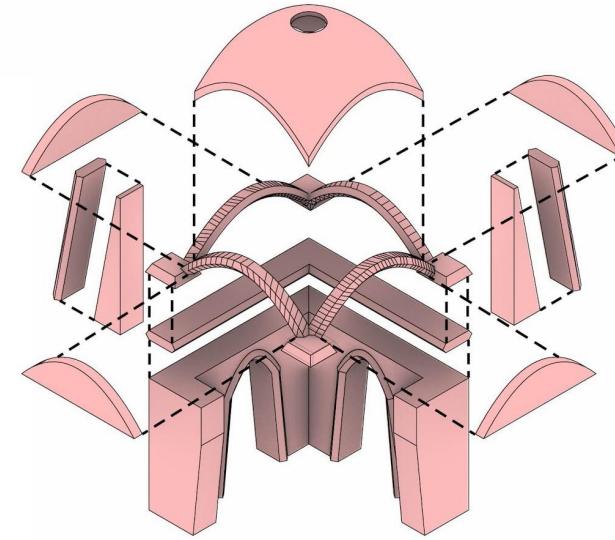


**2 X Buttress**

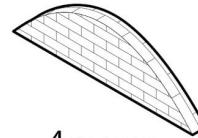


**2 X Base  
( 29 x Special Piece #1 )**

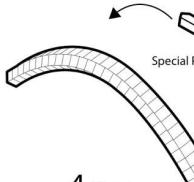
**Corner Riwaq  
Exploded Axonometric**



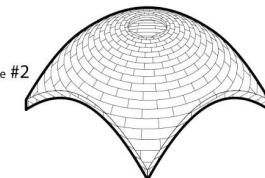
**4 X Special Pieces #3**



**4 X Arch Brick Filling**



**4 X Arch  
( 28 x Special Piece #2 )**

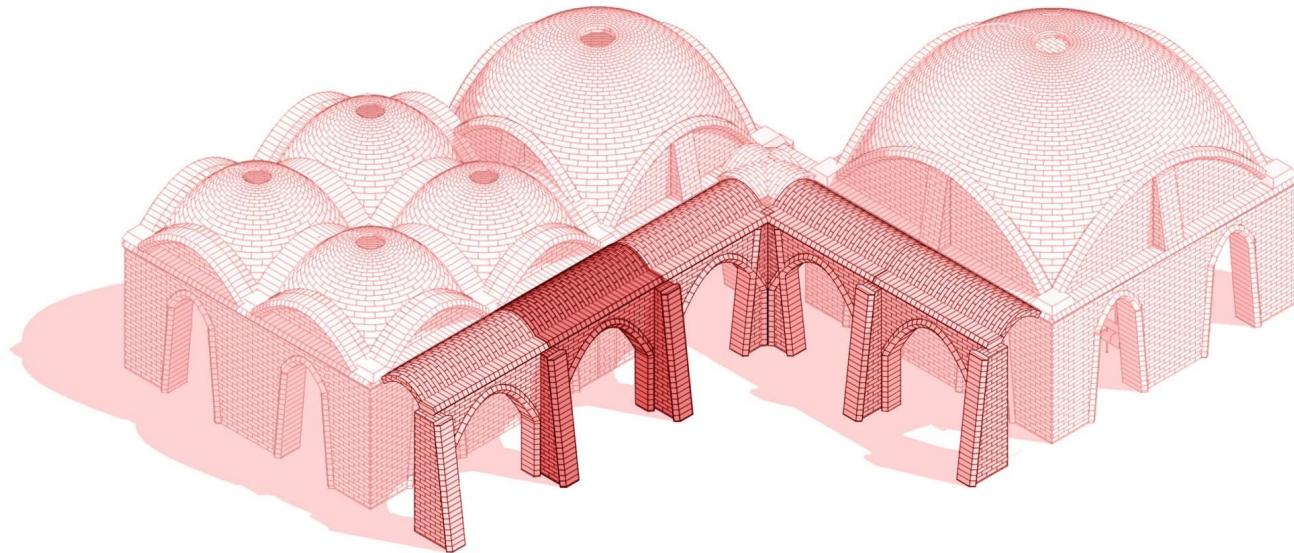


**1 X Catalan Dome**

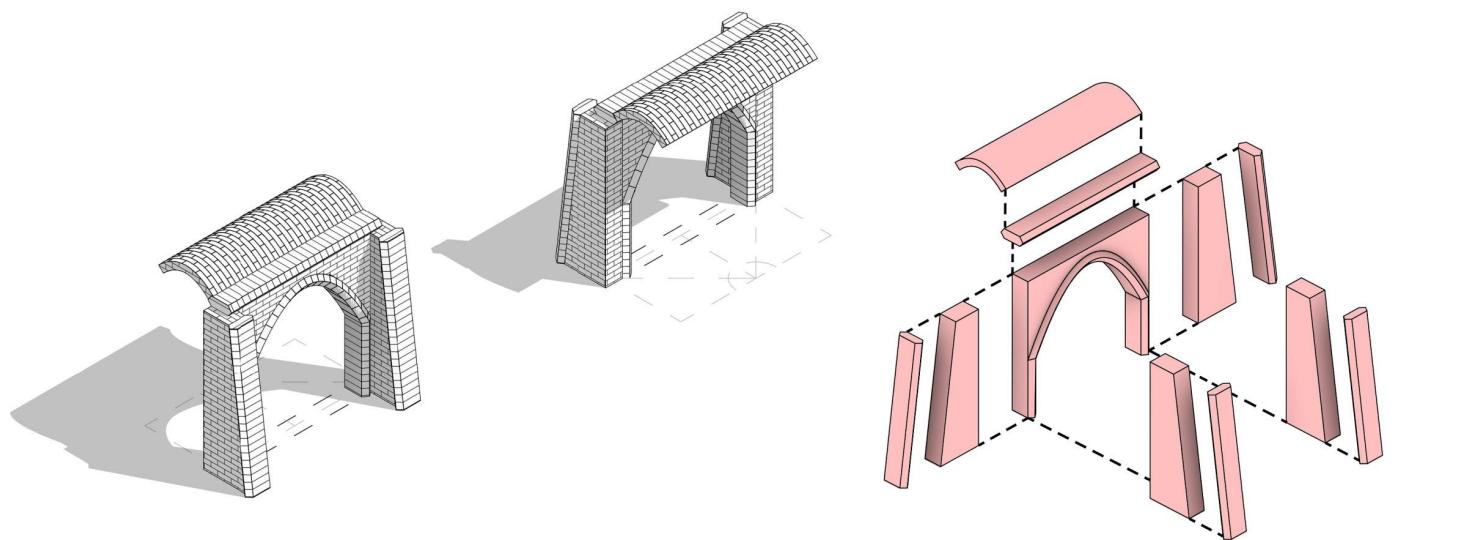
**Components' List  
for one Corner Riwaq Module**

# HALF-VAULT MODULE

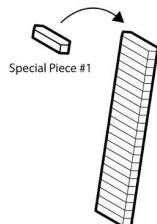
## Construction Manual



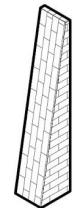
Half-Vault  
*Module in Context*



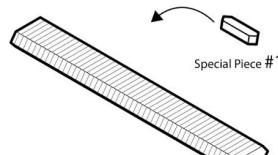
*Half-Vault  
Module Isolation*



**4 x** Buttress Ornament  
(22 x Special Piece #1)

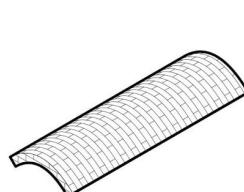


**4 x** Buttress

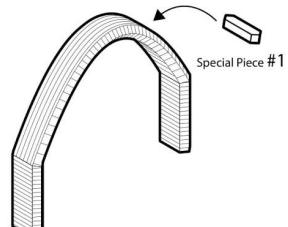


**2 x** Base  
(50 x Special Piece #1)

*Half-Vault  
Exploded Axonometric*



**2 x** Half Vault

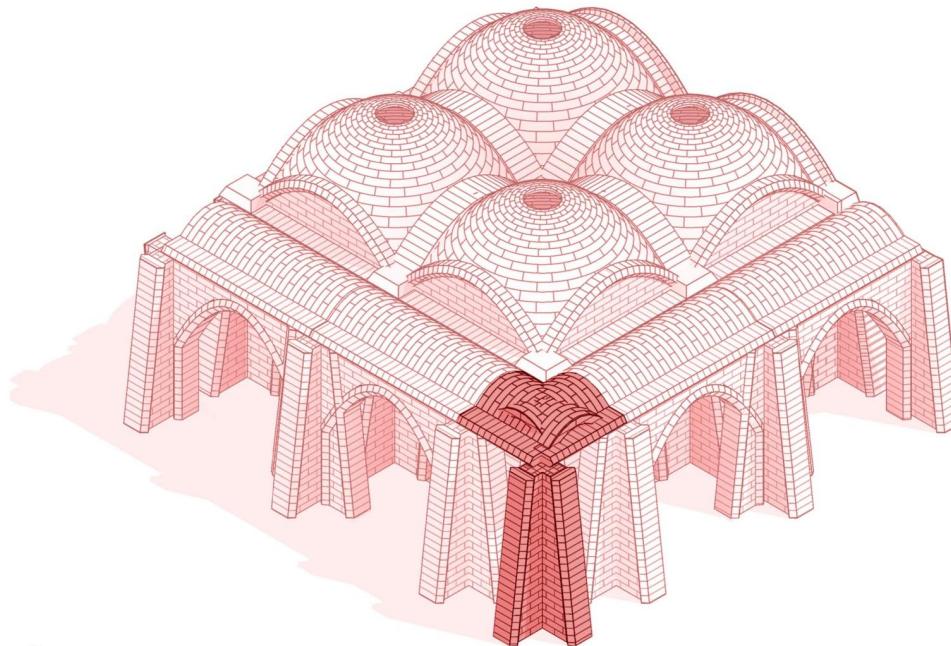


**1 x** Door Ornament Arch  
(Special Piece #1)

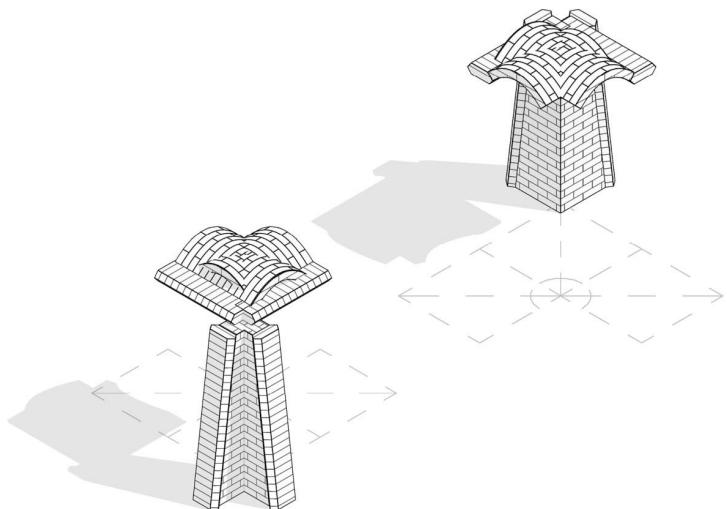
*Components' List  
for one Half-Vault Module*

# HALF-VAULT CORNER MODULE

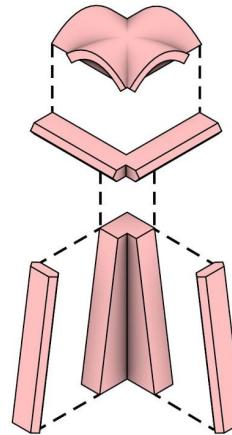
## Construction Manual



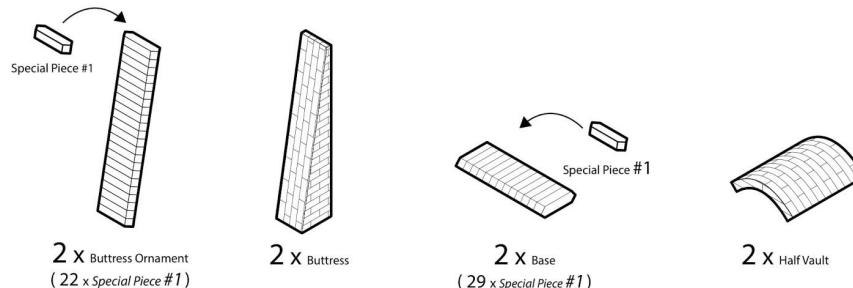
Half-Vault Corner  
*Module in Context*



**Half-Vault Corner  
Module Isolation**



**Half-Vault Corner  
Exploded Axonometric**



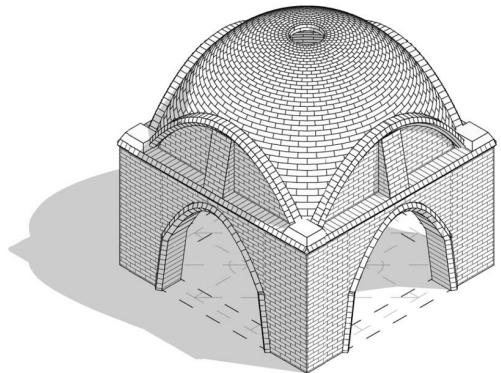
**Components' List  
for one Half-Vault Corner Module**

# MEDIUM ROOM MODULE

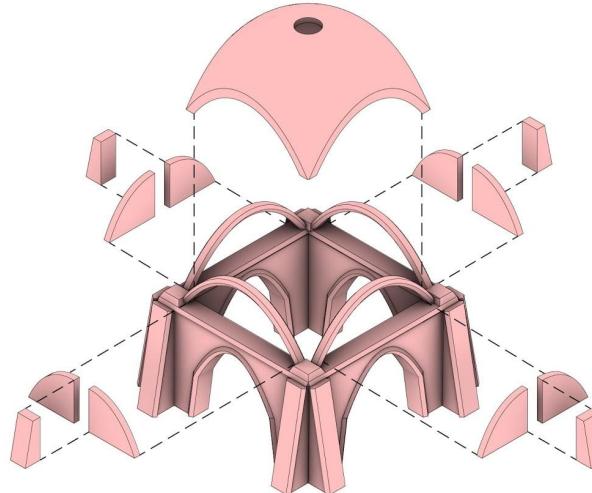
## Construction Manual



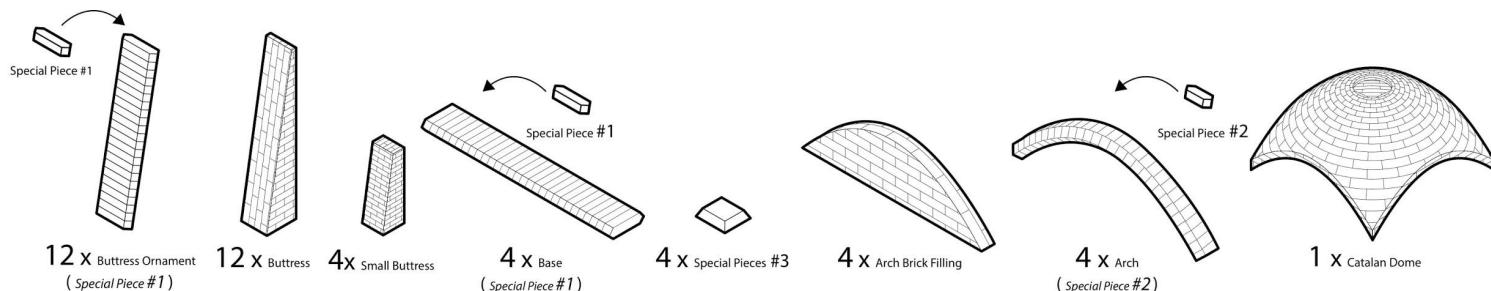
Medium Room  
*Module in Context*



Medium Room  
*Module Isolation*



Medium Room  
*Exploded Axonometric*



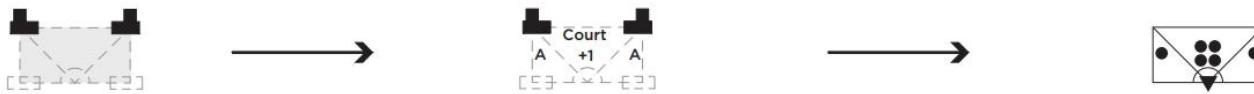
Components' List  
for one Medium Room

## DOMINO CODE: GAMES RULES

- A *Main Connection*
- B *Closed +/- Translate into A, if necessary*
- C *Closed. Can only connect to C*
- COURT *Can only connect to Open Space*
- EXT *Can only connect to external urban area*
- + PLUS *It is allowed to Build / Walk on top*
- ▼ UP *It is allowed to Walk on top*
- O *It is not allowed to Build / Walk on top*

# TRANSLATION OF MODULE TO DOMINOS

Half-Vault Unit



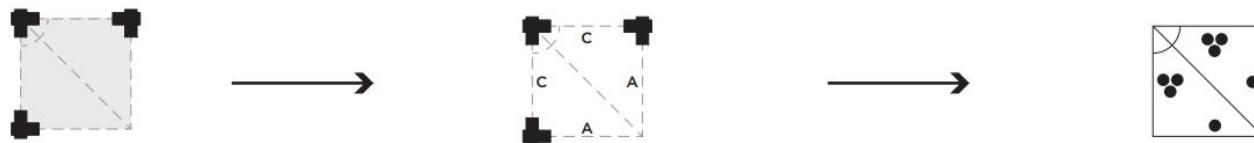
Corner Unit



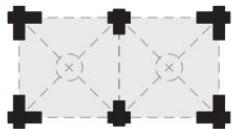
T Intersection Unit



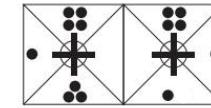
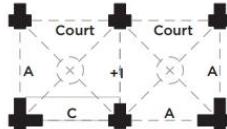
Riwaq Corner Module



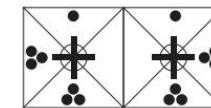
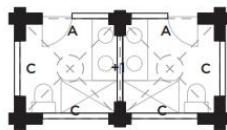
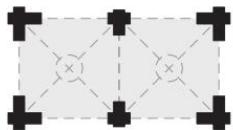
Low-Vault Module



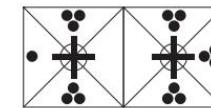
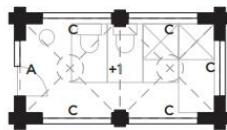
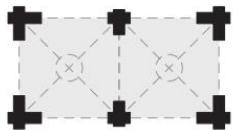
Riwaq Module



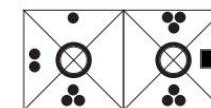
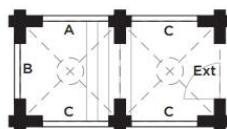
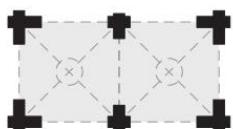
Bathroom Module  
*Type 1*



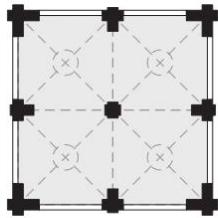
Bathroom Module  
*Type 2*



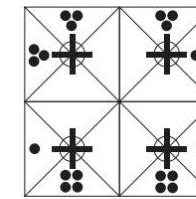
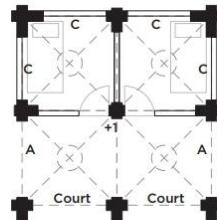
Entrance Module



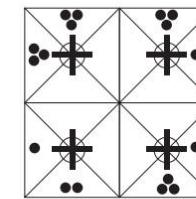
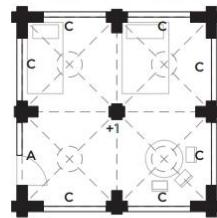
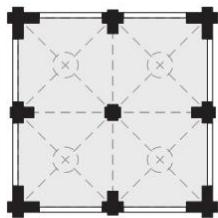
4 Low-Domes Module



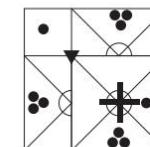
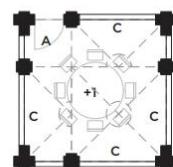
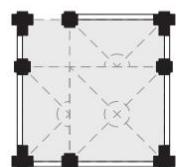
2 Small Rooms + Riwaq



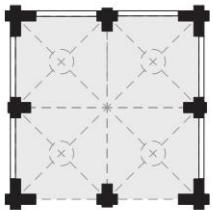
Large Room  
with Central Column



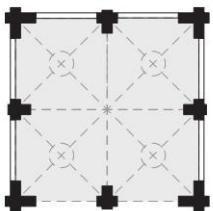
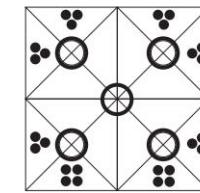
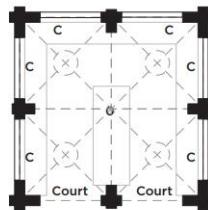
Medium Room



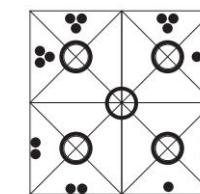
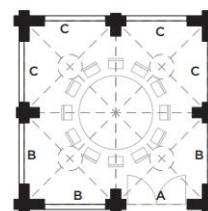
High - Dome



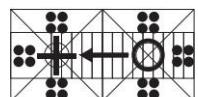
Shared Kitchen



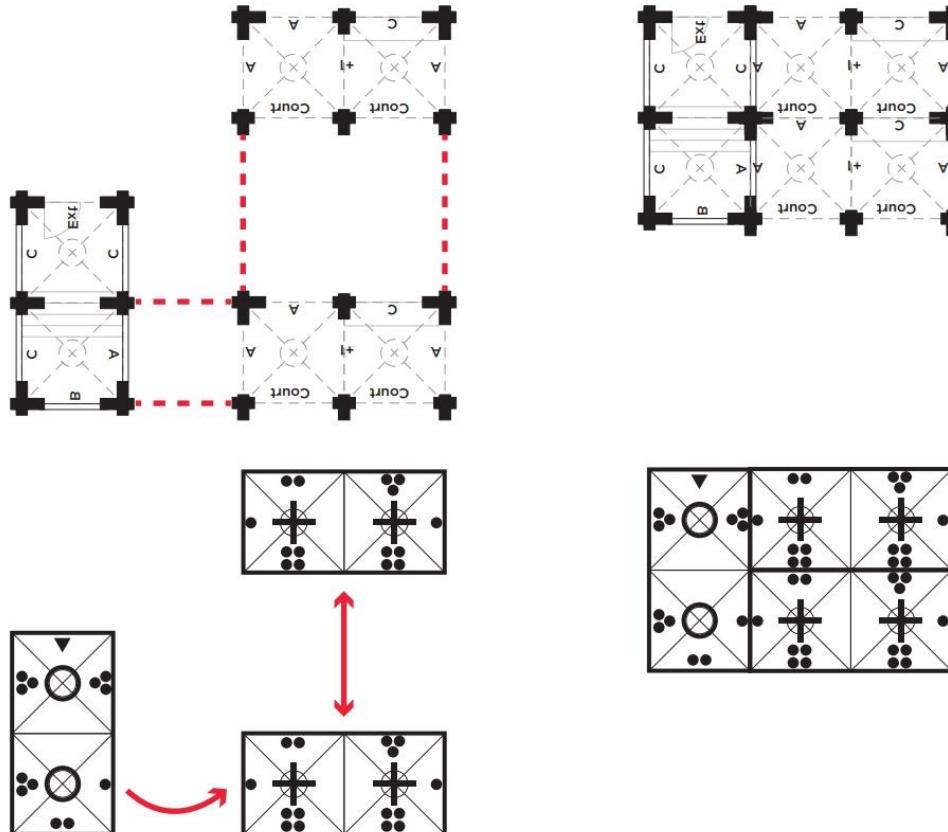
Large Room



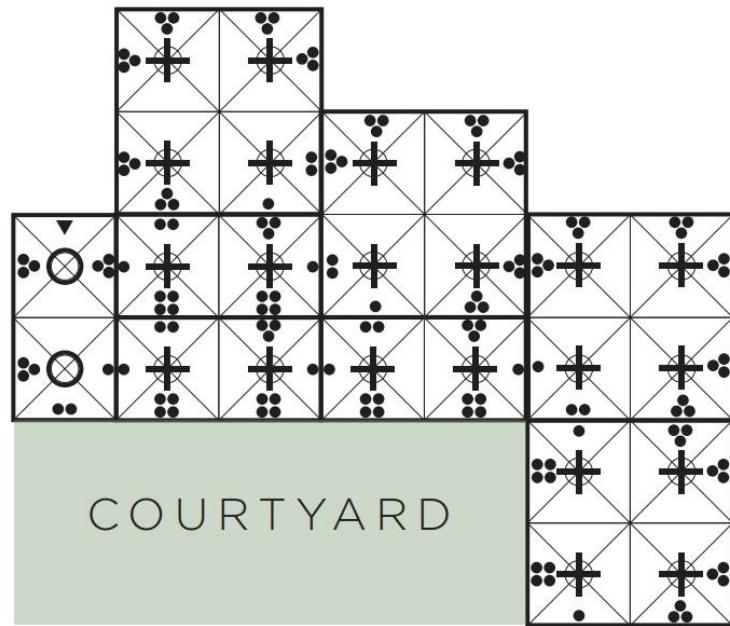
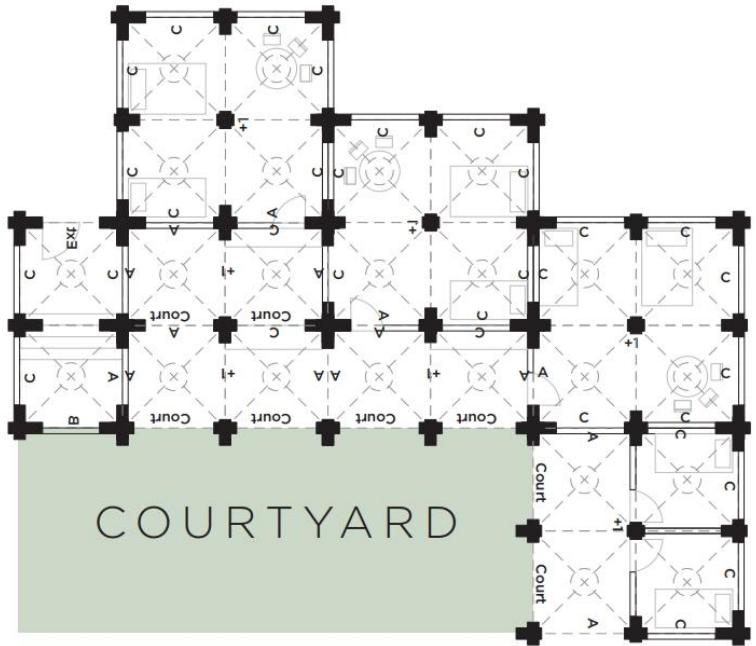
Stairs Module



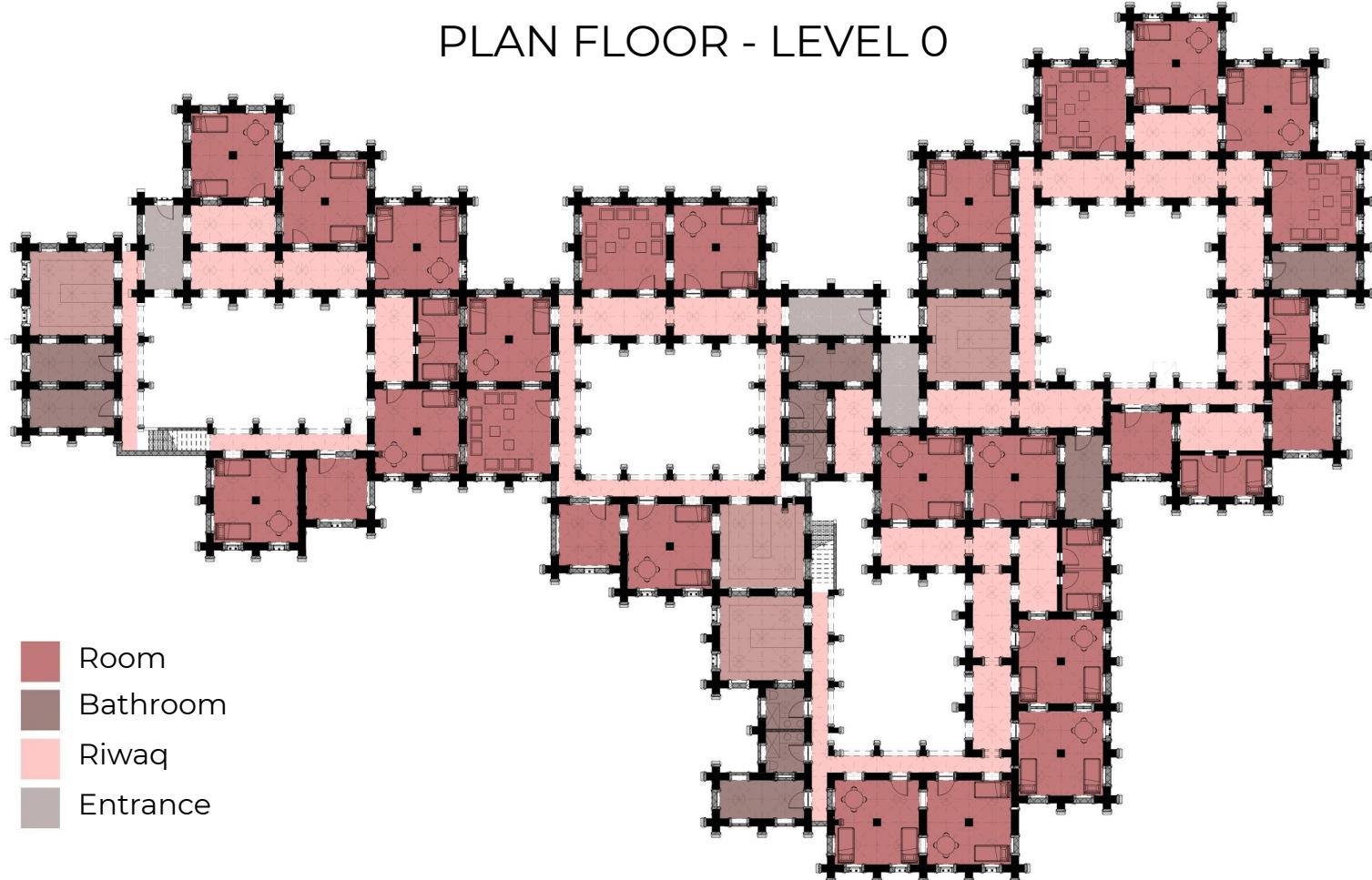
# CONNECTION OF DOMINO MODULES



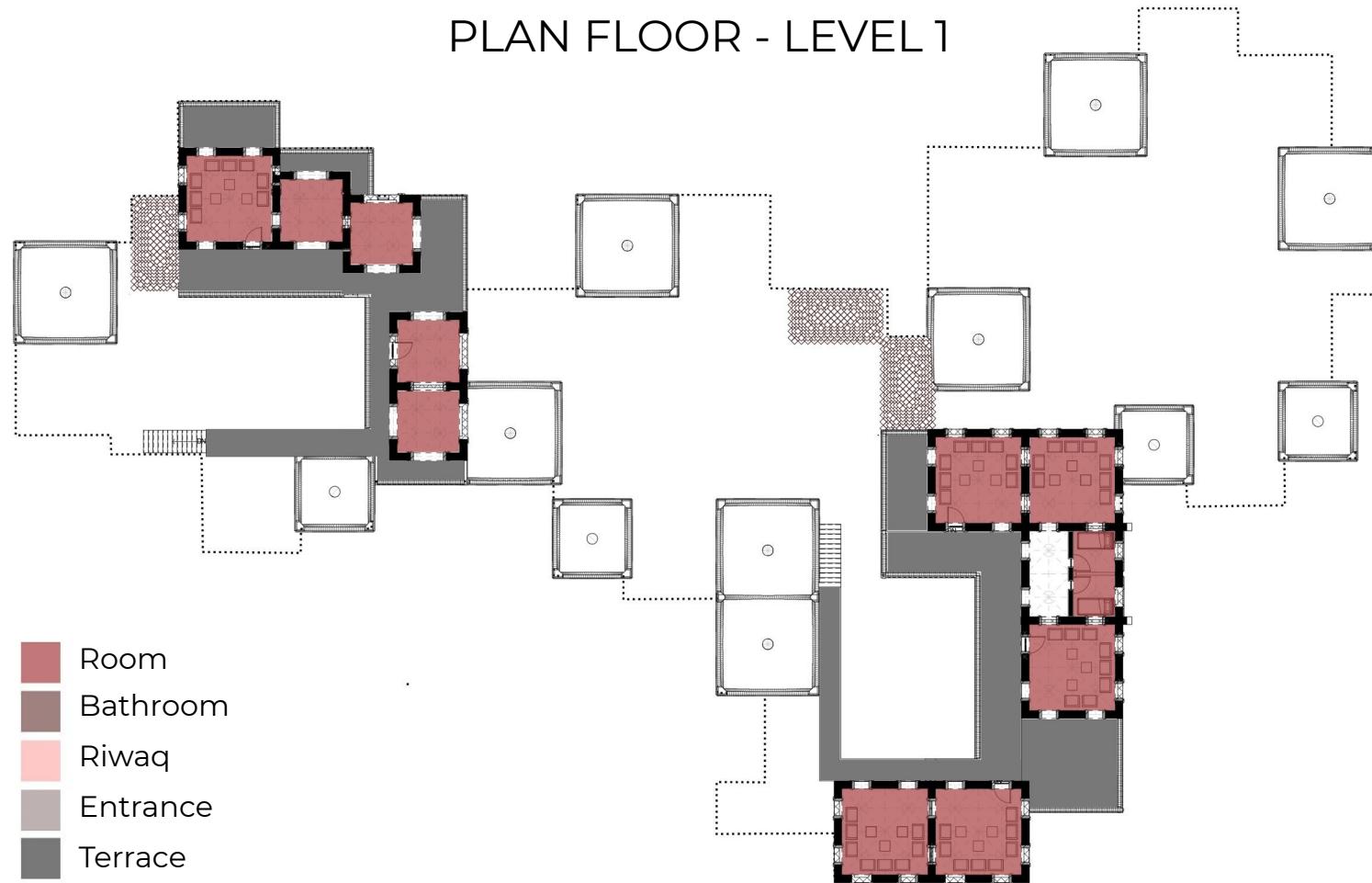
# CONNECTION OF DOMINO MODULES



# PLAN FLOOR - LEVEL 0



# PLAN FLOOR - LEVEL 1





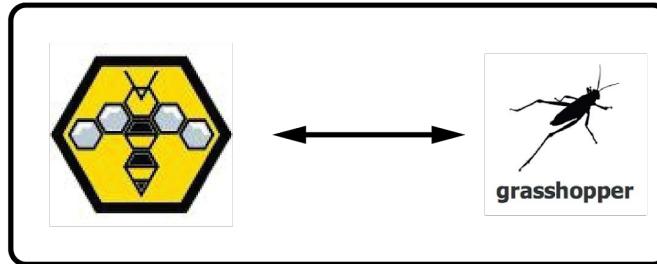
# Computational Language

*Translation*  
from Rule  
to Computational Logic



# WASP Plug-In Tool

Assigning Connection Points to a Module



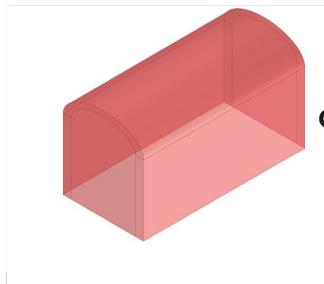
*Creation of Modules  
**Geometry***

*Generate **Connection Points**  
of Modules*  
+ Set of **RULES**

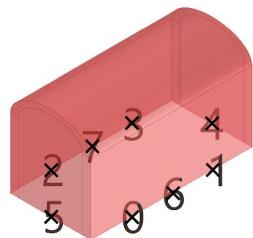
- Simplify the Geometry
- Numerical Data (Number as Connection)
- Assign / Decide which numbers is which connection (Human Decision)

# Creation of Modules

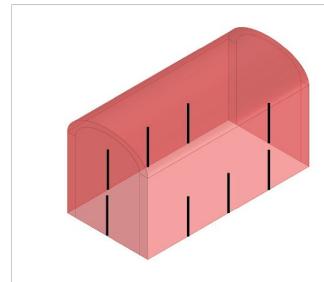
*Create Data for Modules Geometry & Connections*



**Geometry** of Module

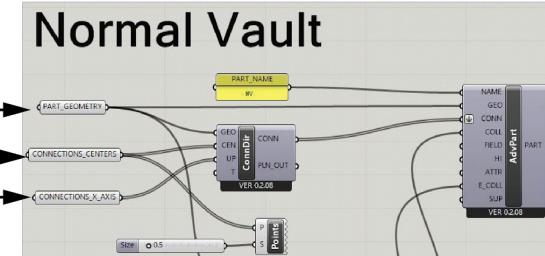


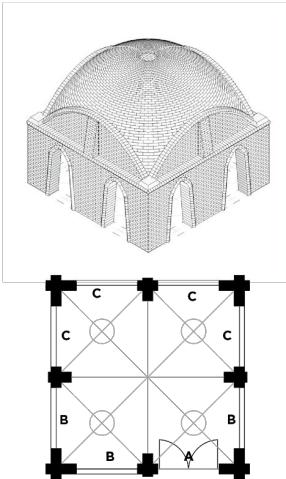
Points at  
**Desired Connection**



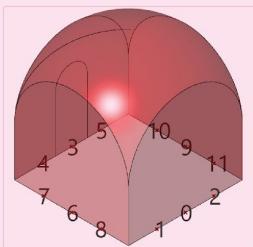
Direction of the  
**Axis of Connection**

**Normal Vault**



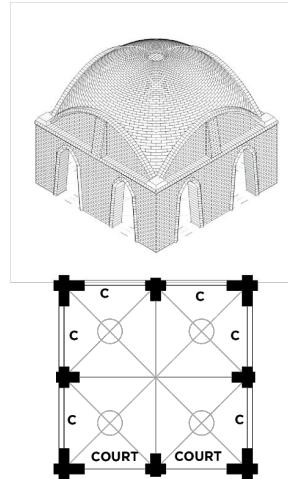


Large Dome  
\_module

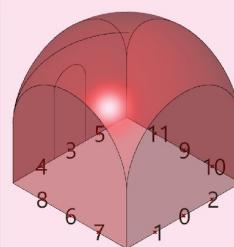


4	5
7	10
6	9
8	11
1	0
2	

2 --> Connection



Kitchen  
\_module



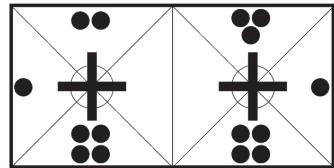
4	5
8	11
6	9
7	10
1	0
2	

1 / 2 --> Courtyard by Similar Edge  
0 --> Courtyard by Centrality

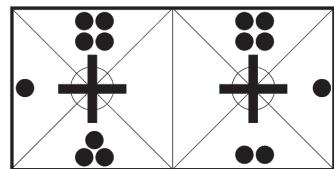
## Domino Rules

V/S

## Script Rules



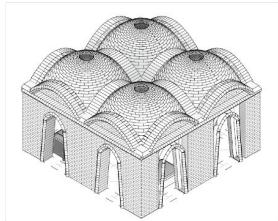
$$\begin{array}{c} \bullet\bullet = \bullet\bullet \\ AND \\ \bullet\bullet = \bullet\bullet \end{array}$$



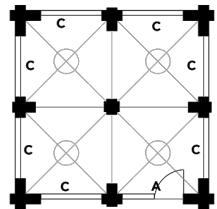
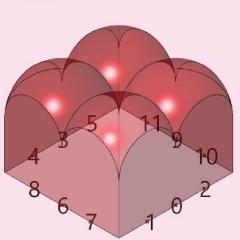
2		3
5	7	4
0	6	1

$$6 = 6$$

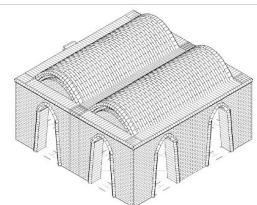
1		0
4	6	5
3	7	2



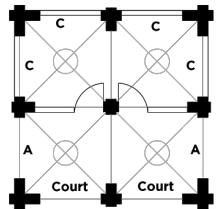
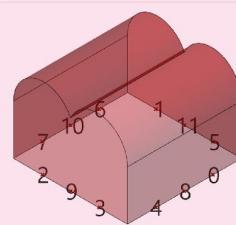
4 Dome  
*\_module*



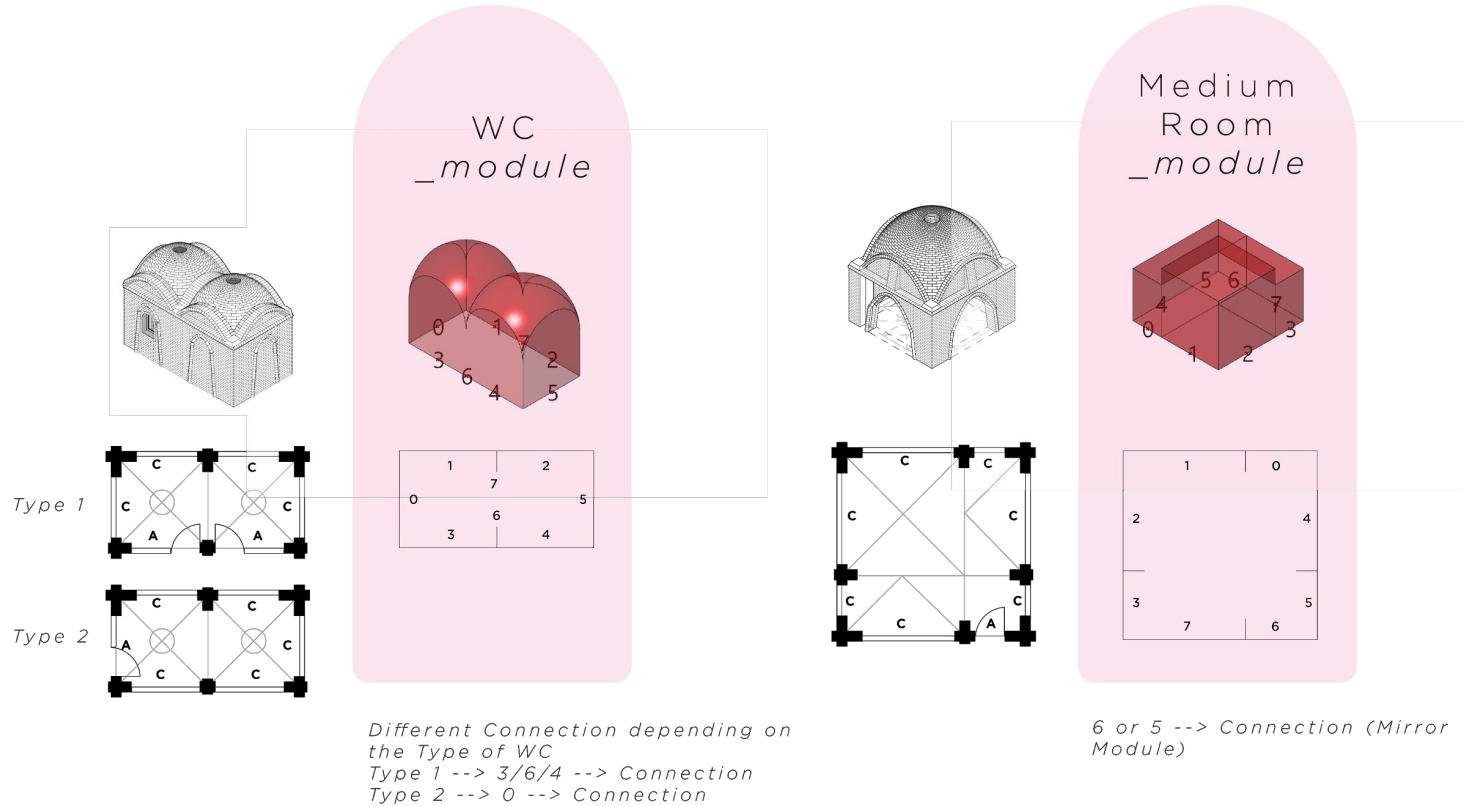
2 --> Connection

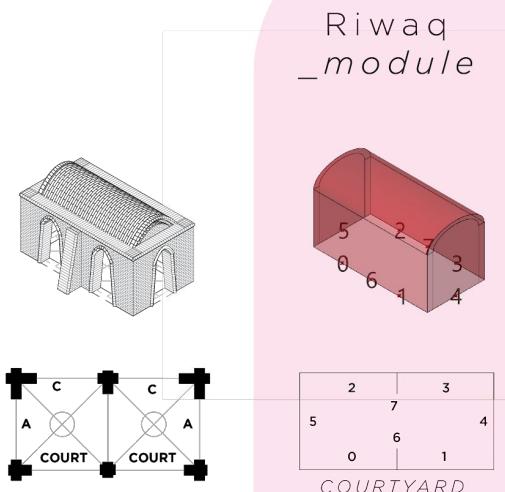


Room & Riwaq  
*\_module*

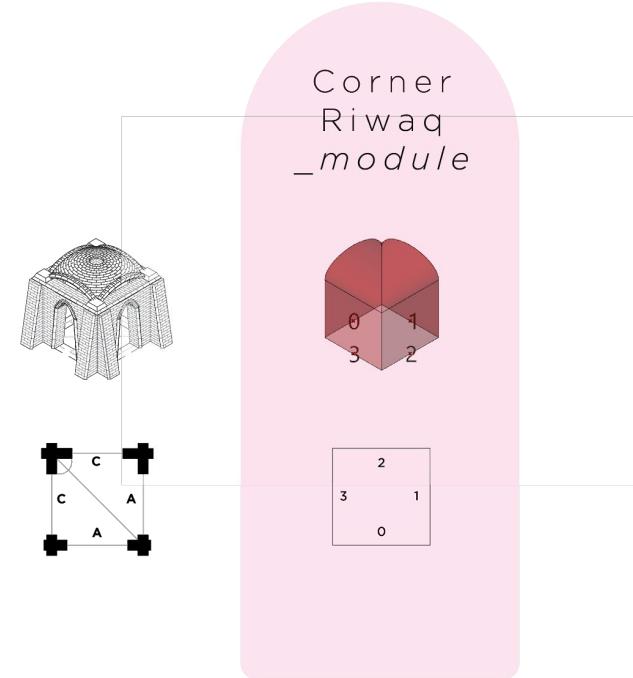


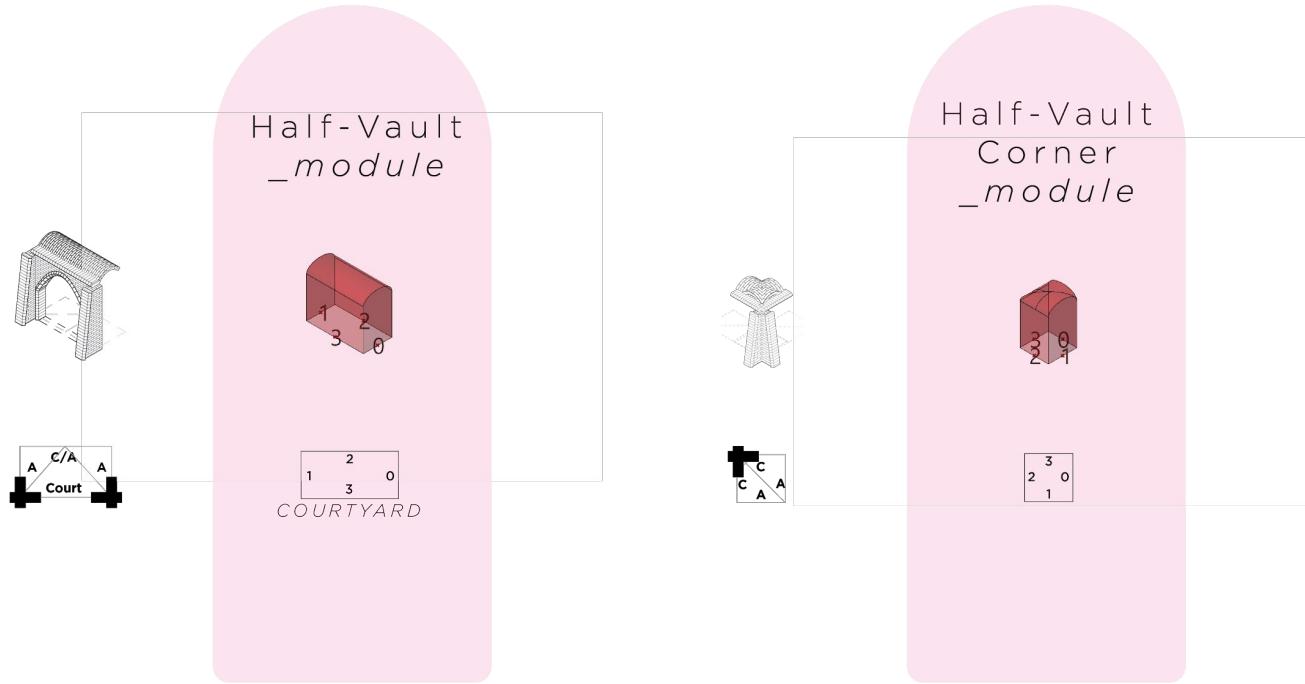
0 / 4 --> Courtyard at Edge  
8 --> Courtyard at Center  
3 / 5 --> Riwaq Connection





$0 / 1 / 6 \rightarrow$  Courtyard (No Connection) --> COLLIDER  
 $4 / 5 \rightarrow$  Connection to Corner or Riwraq  
 $2 / 7 / 3 \rightarrow$  Connection





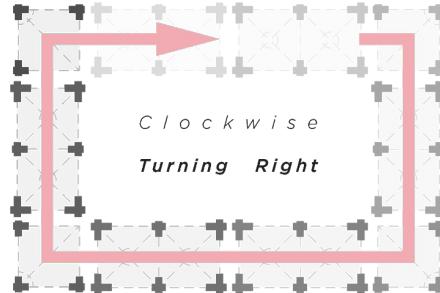
$0 / 1 \rightarrow$  Connection to Corner  
 or Riwaq  
 $3 \rightarrow$  Courtyard (No Connection) --> COLLIDER  
 $2 \rightarrow$  Connection

$0 / 1 \rightarrow$  Riwaq Connection  
 $2 / 3 \rightarrow$  Connection to Other Room

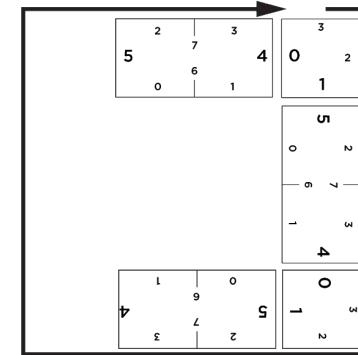
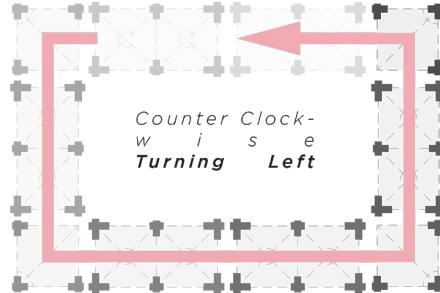
# Adaptation of Modules

Corners Connections generate 2 Types of Corner

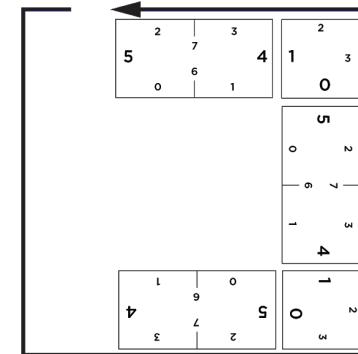
Type 1



Type 2



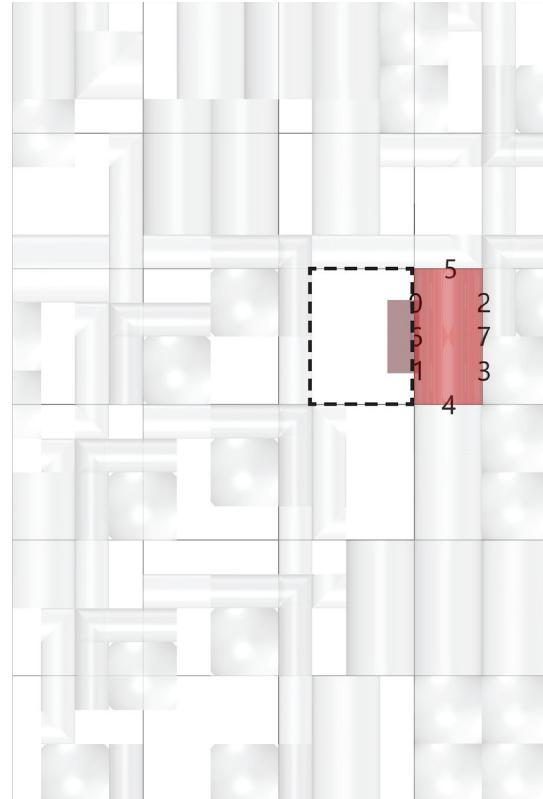
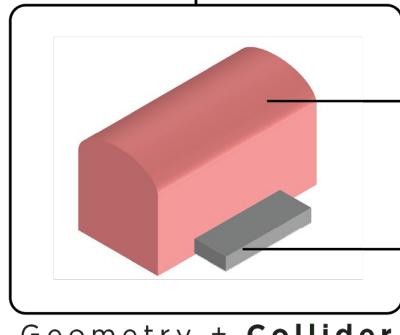
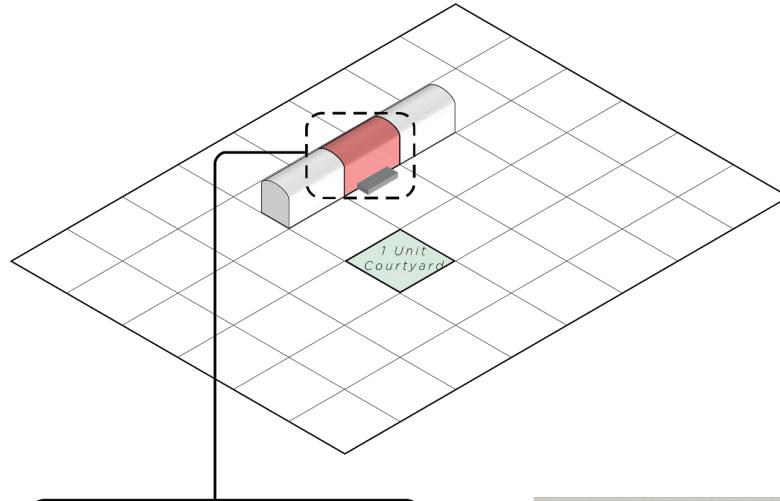
5 = 1  
4 = 0  
5 = 1  
4 = 0  
5 = 1  
4 = 0  
5 = 1  
4 = 0  
...



5 = 0  
4 = 1  
5 = 0  
4 = 1  
5 = 0  
4 = 1  
5 = 0  
4 = 1  
...

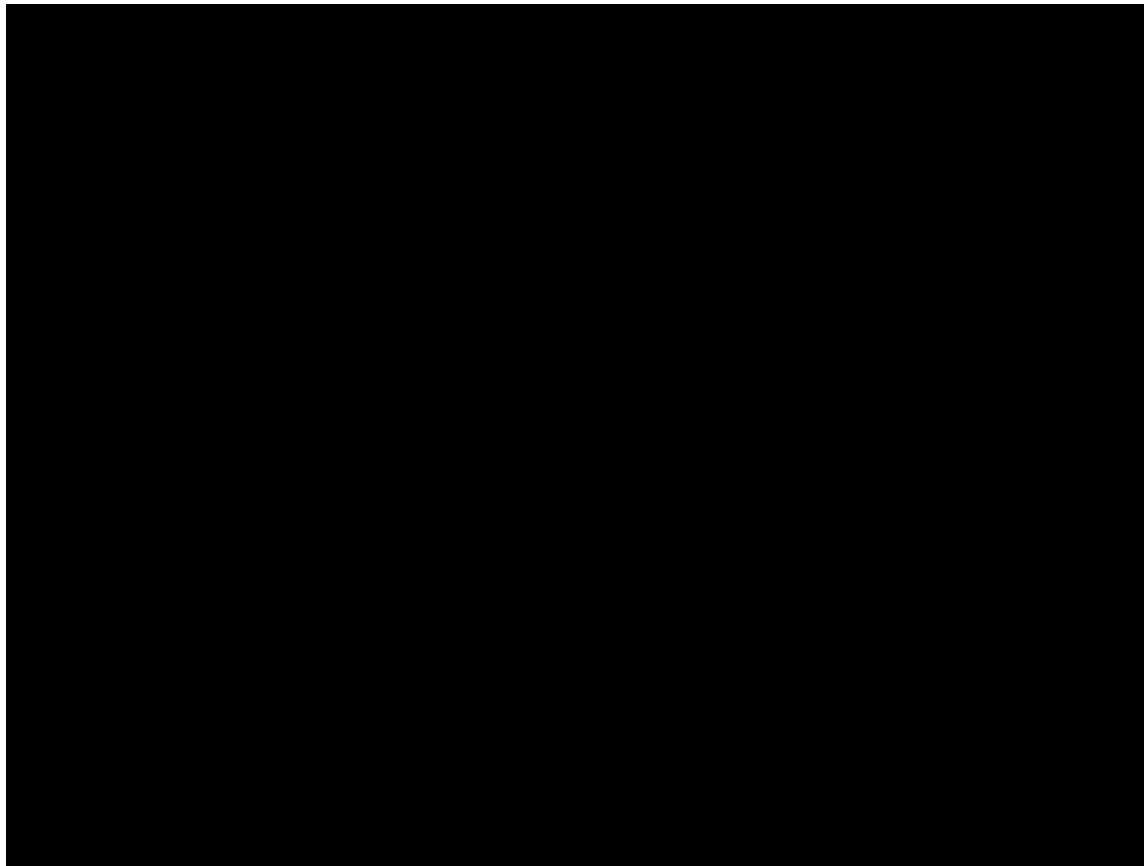
# Collider as “Non-Built”

*Create Collider to Generate the Courtyards / Open Spaces*



**COURT** Can only connect to Open Space

## Urban Level Growth Animation

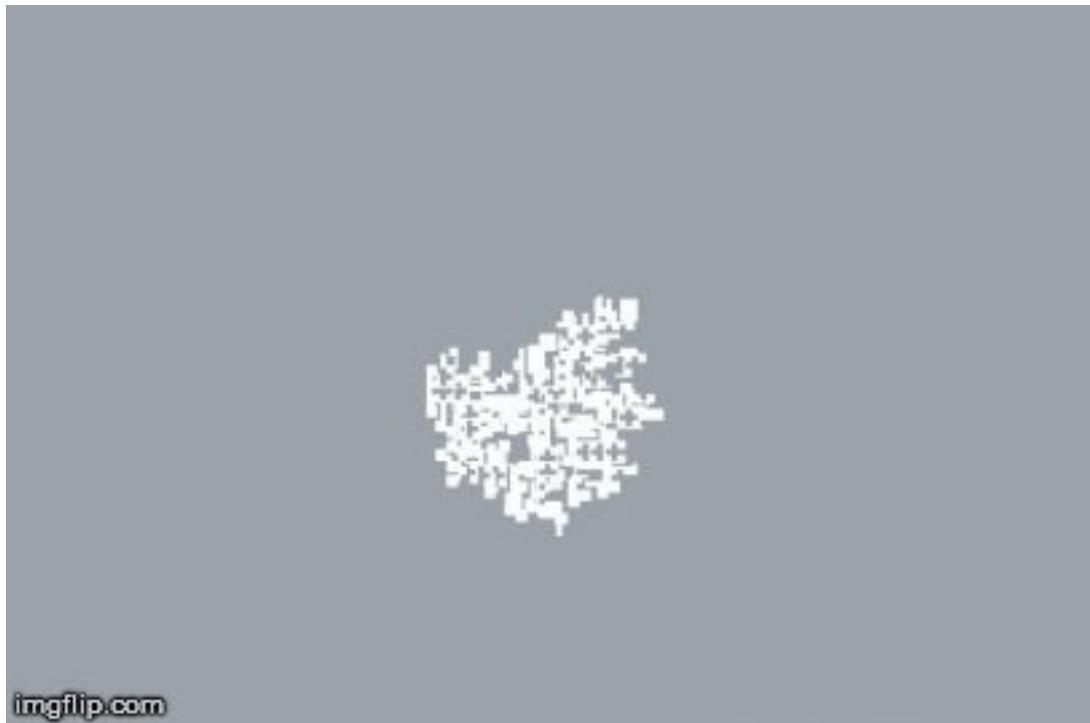




# Urban Level Growth Animation



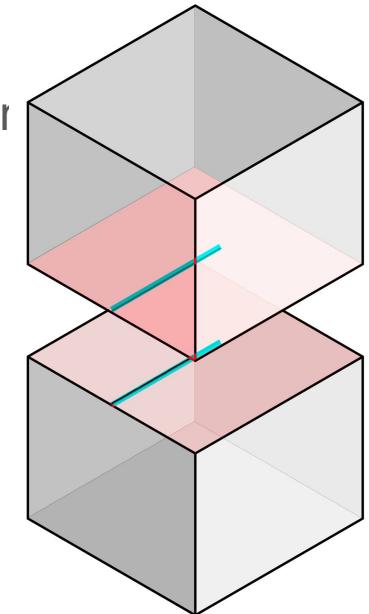
## Generation of Different Configuration

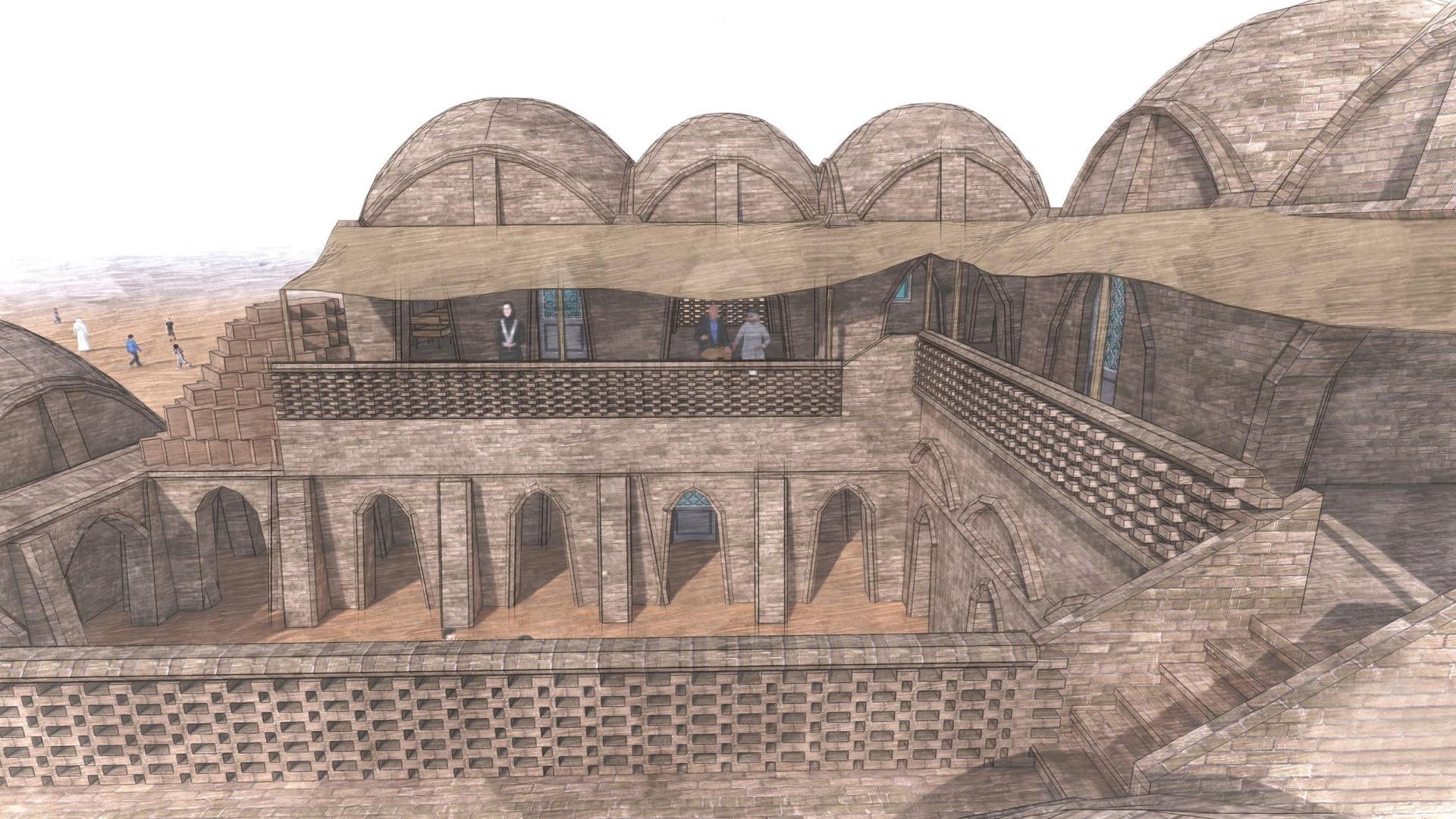


imgflip.com

## Limitation of the Script / Future Development

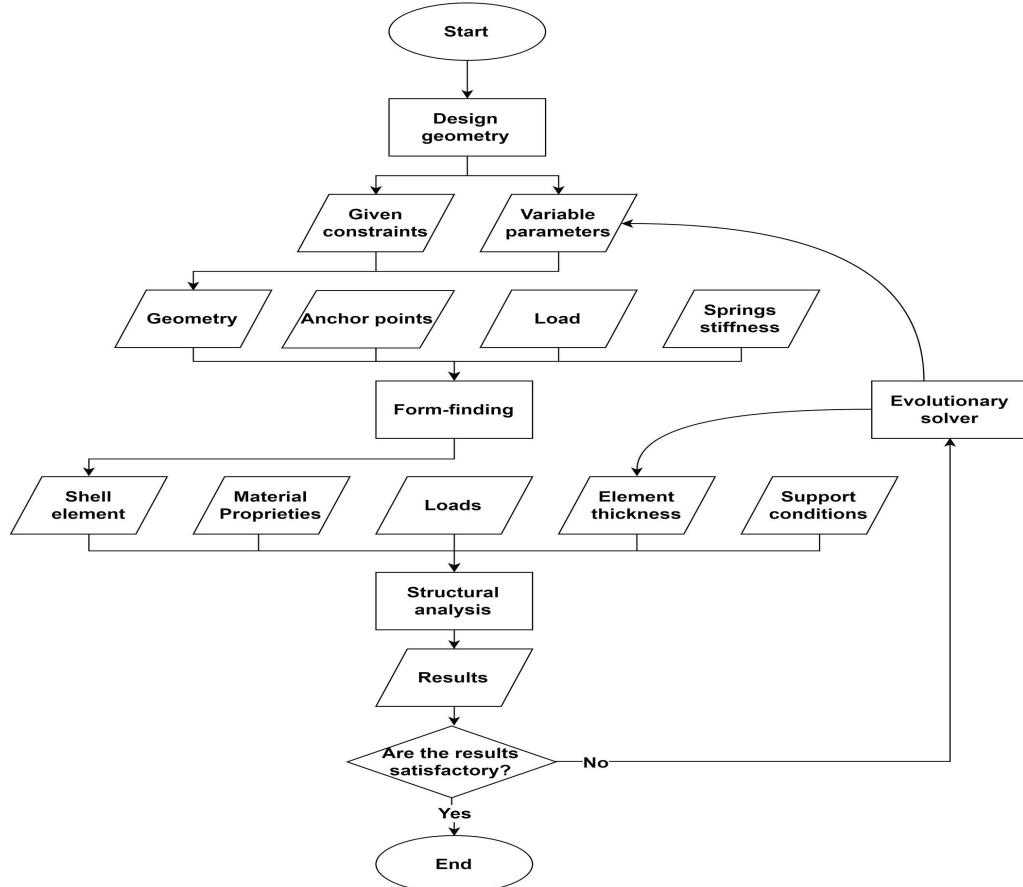
- The Script was built for Single Floor only. The development for a Second Storey is possible by adding “Direction Axis” or the upper face of the geometry connected to the downward face of the other one
- The amount of modules needed in script compared to real game, makes it more complex and requires more time
- Roads were not added for the script





# STRUCTURE

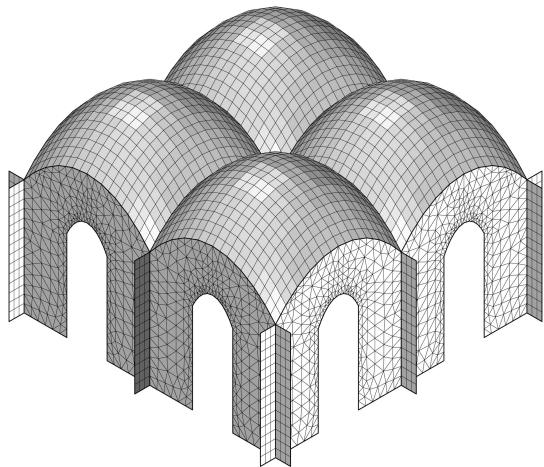
# STRUCTURAL OPTIMIZATION PROCESS



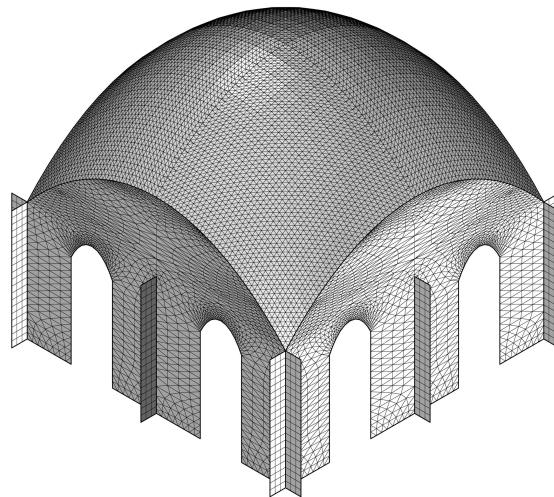
## Material properties and limitations

Young's Modulus	$60 \text{ MPa}$
Compressive Strength	$1.5 \text{ MPa}$
Tensile Strength	$0.15 \text{ Mpa}$
Max Strain Allowed	$15\% \text{ of thickness}$

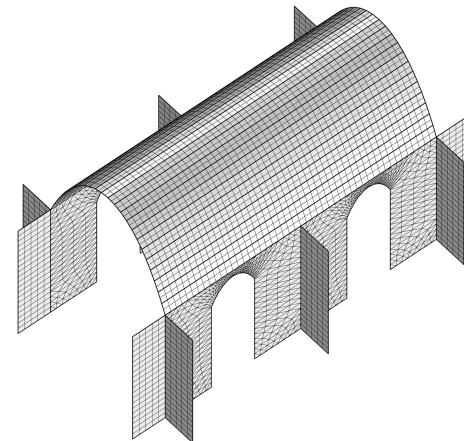
## MESH REFINEMENT



4 dome module

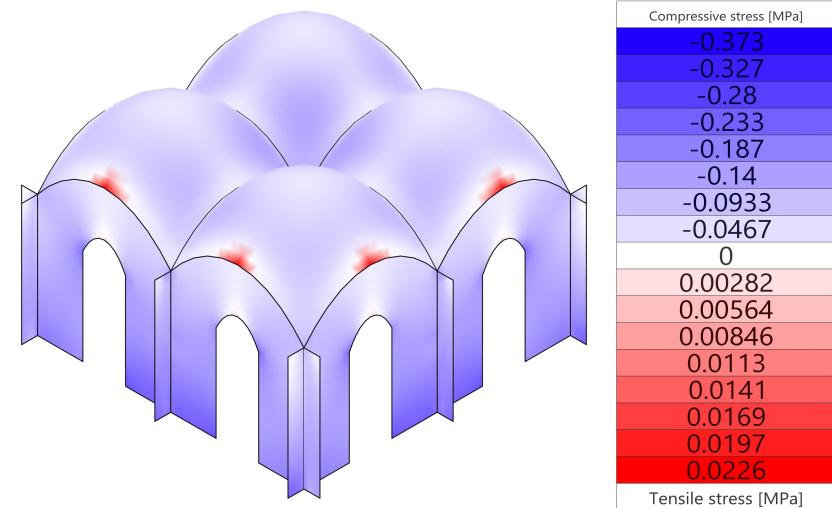
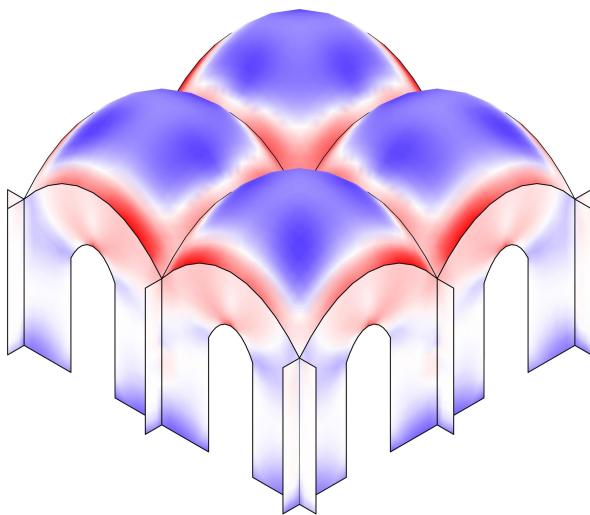


Large dome module



Riwaq module

## 4 DOME MODULE



Tensile stress

0.108 MPa

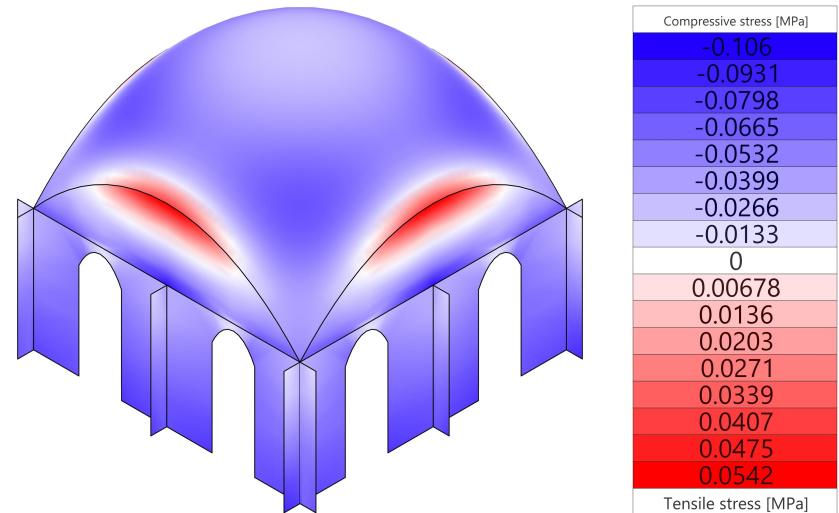
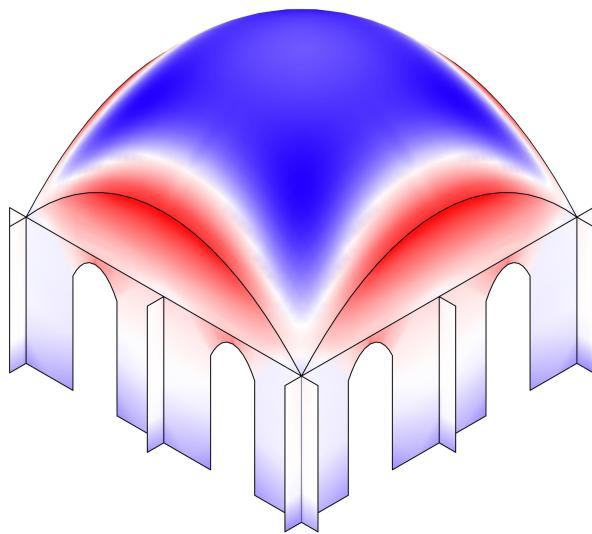
Compressive stress

0.373 MPa

Displacement

11.9 mm

# LARGE DOME MODULE



Tensile stress

0.068 MPa

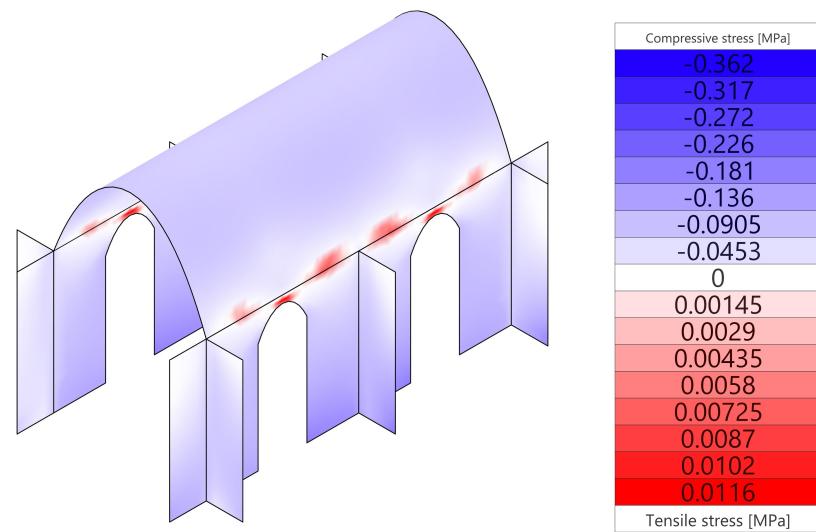
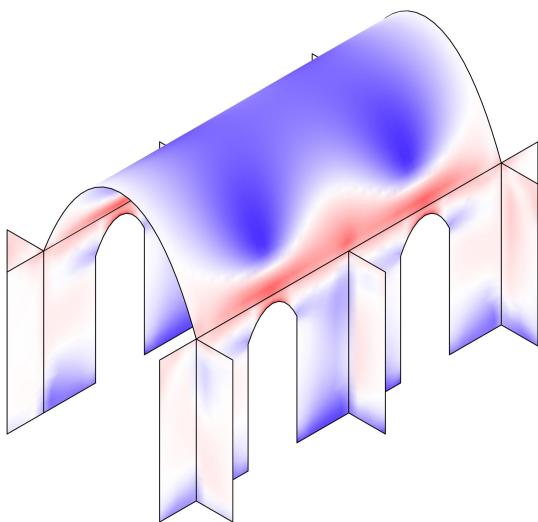
Compressive stress

0.106 MPa

Displacement

7.05 mm

# RIWAQ MODULE



Tensile stress

0.062 MPa

Compressive stress

0.362 MPa

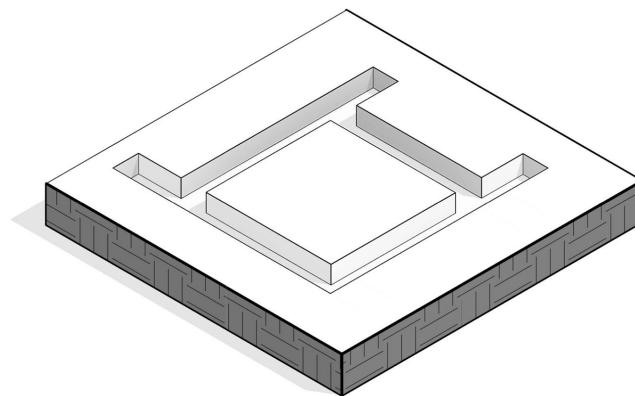
Displacement

7.5 mm

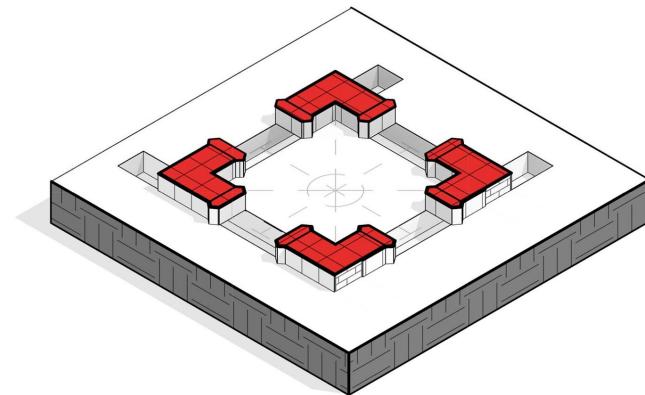


# FORMING

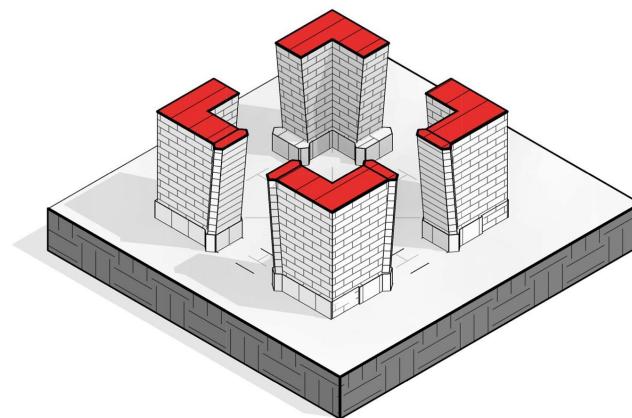
# CONSTRUCTION SEQUENCE



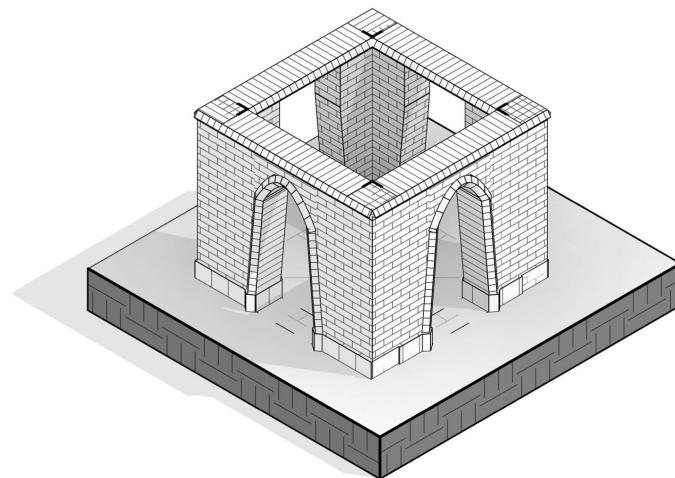
# CONSTRUCTION SEQUENCE



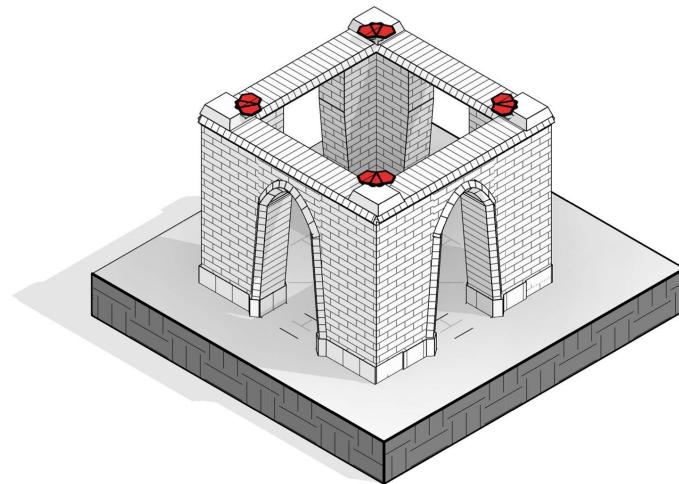
# CONSTRUCTION SEQUENCE



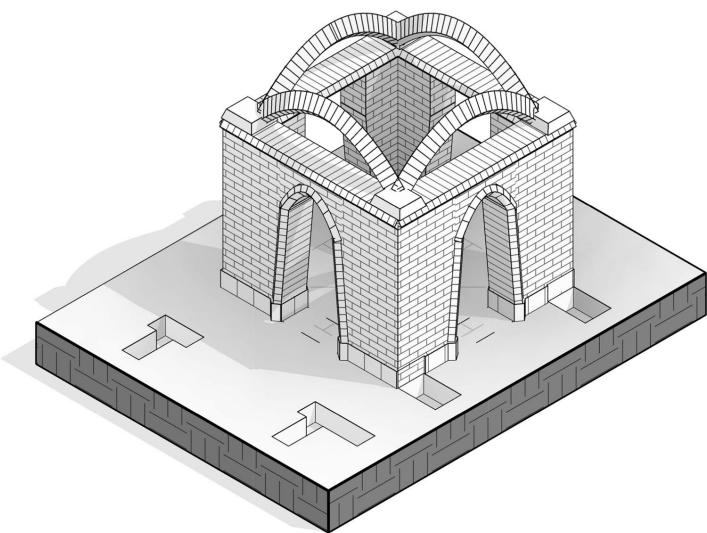
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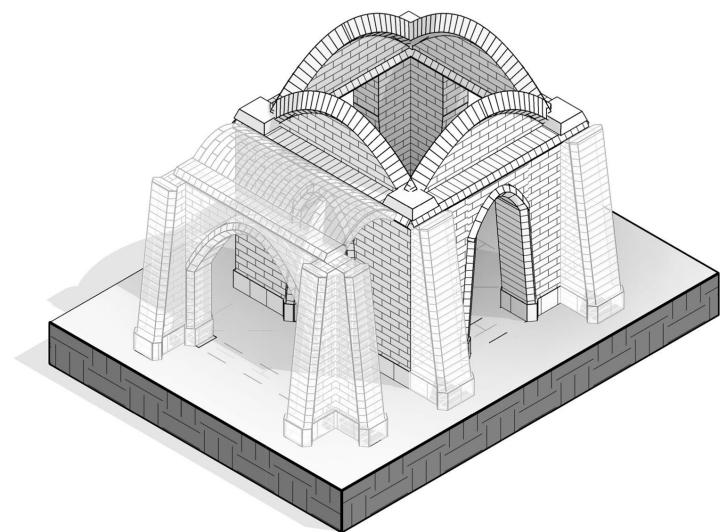
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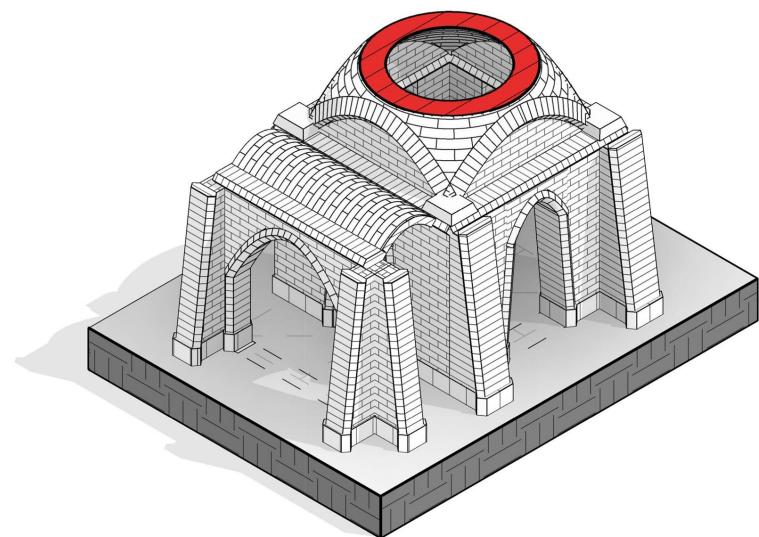
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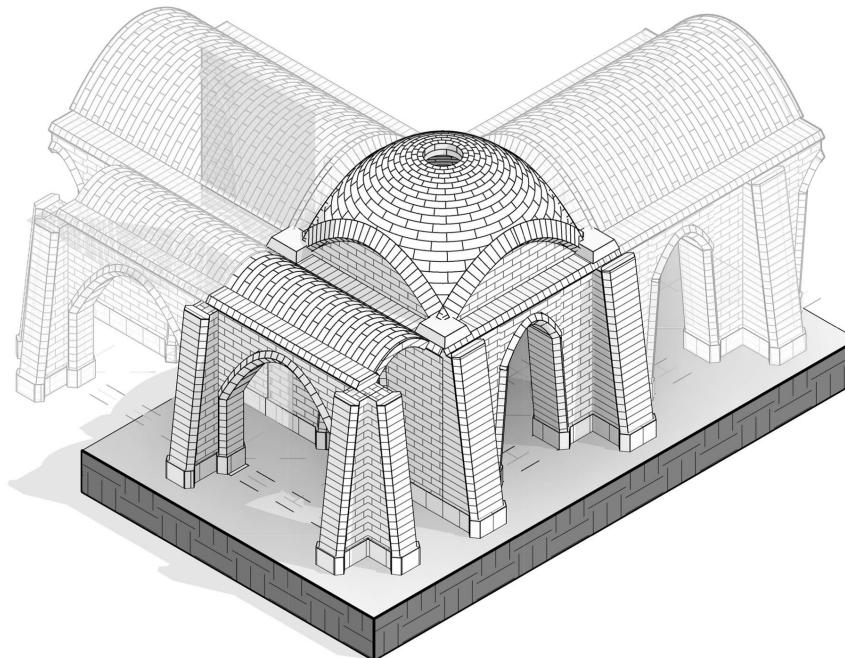
# CONSTRUCTION SEQUENCE



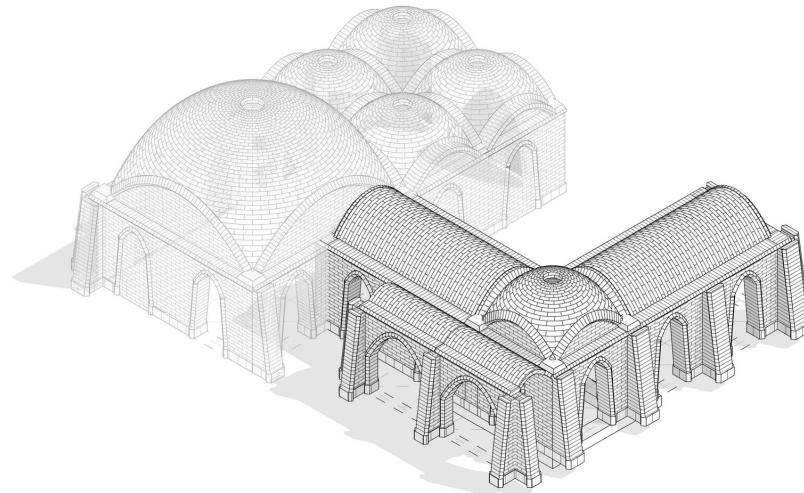
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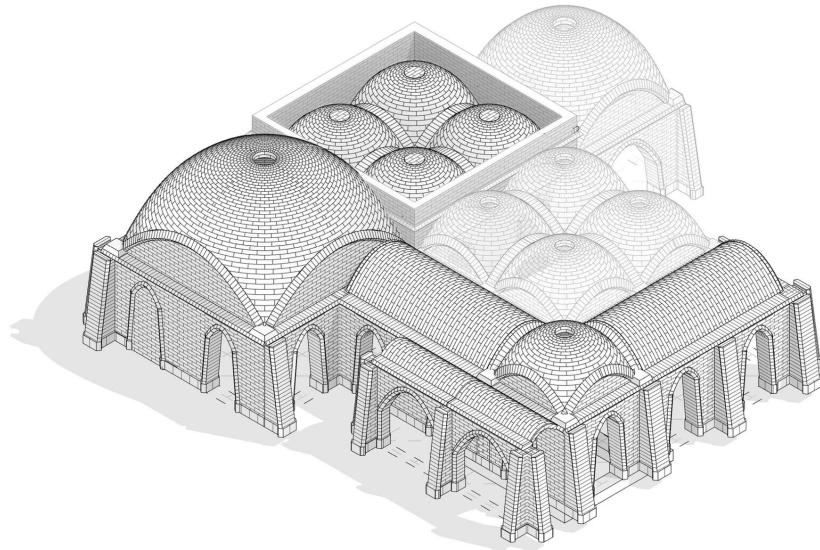
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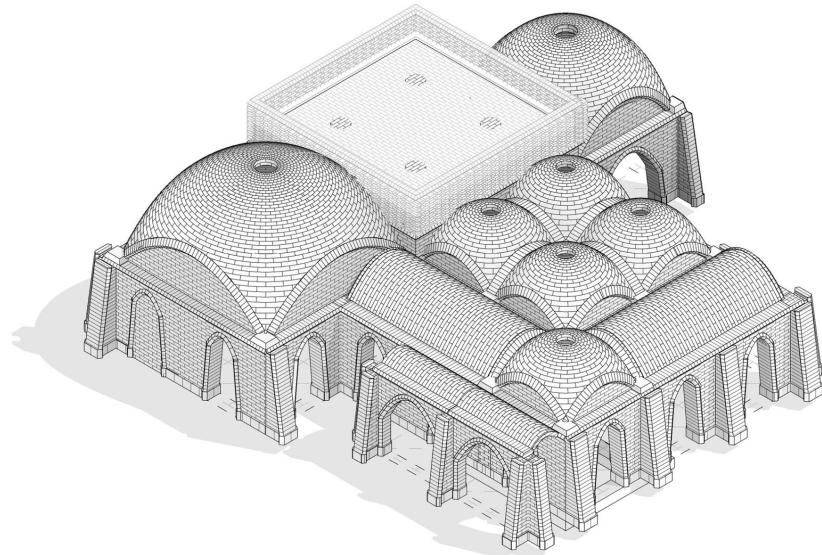
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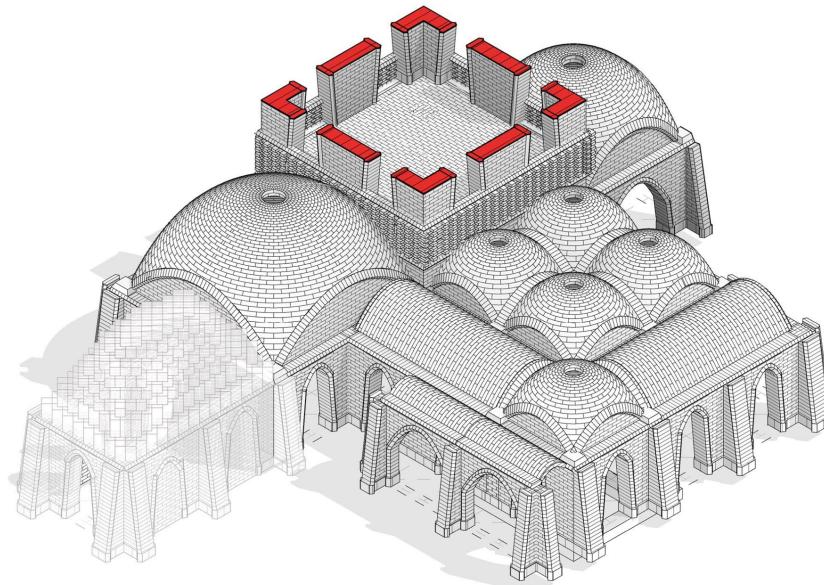
# CONSTRUCTION SEQUENCE

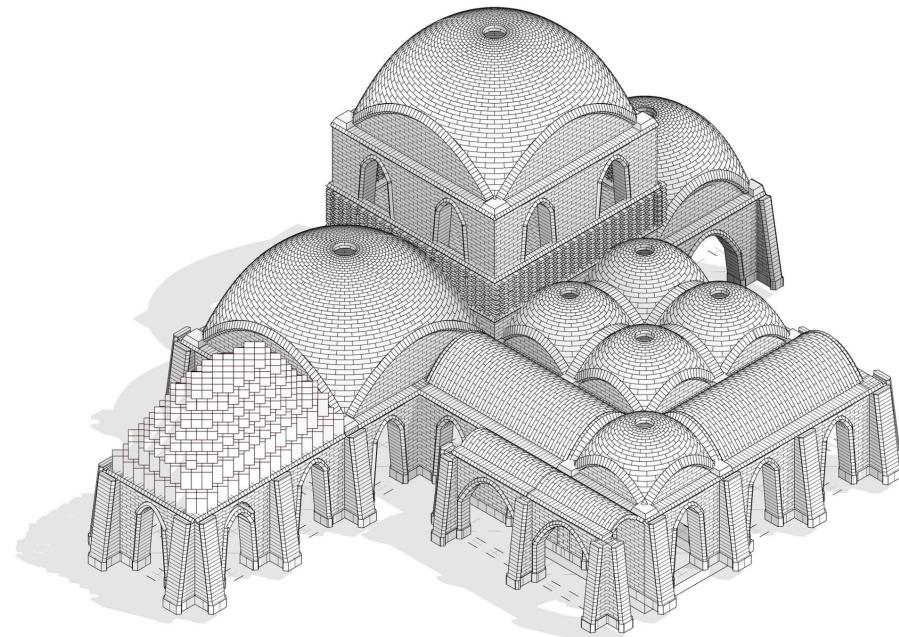


# CONSTRUCTION SEQUENCE



# CONSTRUCTION SEQUENCE

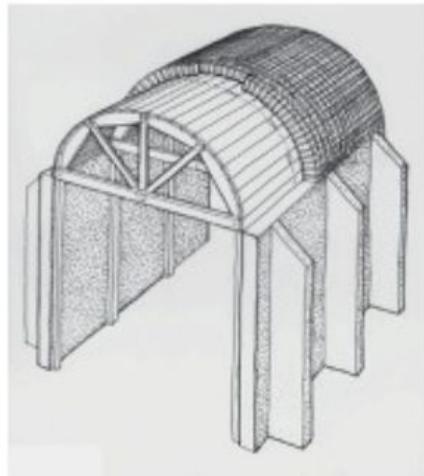




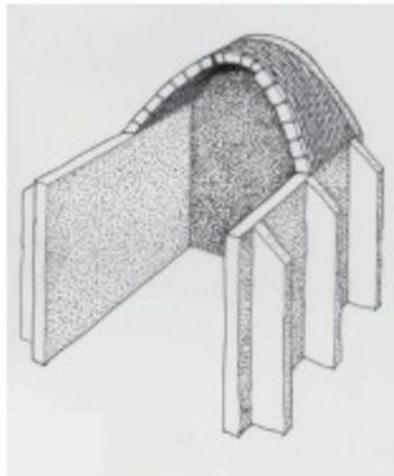
# CONSTRUCTION METHOD

Fig. 3. Three methods of brick vault construction [7]: a) Northern European vaults require extensive wooden centering; b) pitched brick vaults, built in North Africa and Mexico, eliminate the need for centering; and c) Mediterranean tile vaults may be constructed without centering.

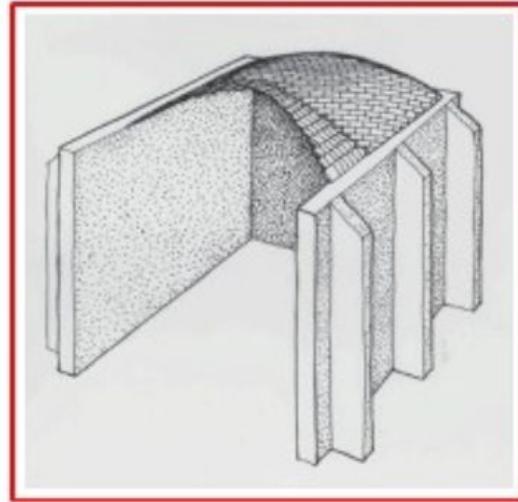
Roman /Northern European



Pitched / Nubian

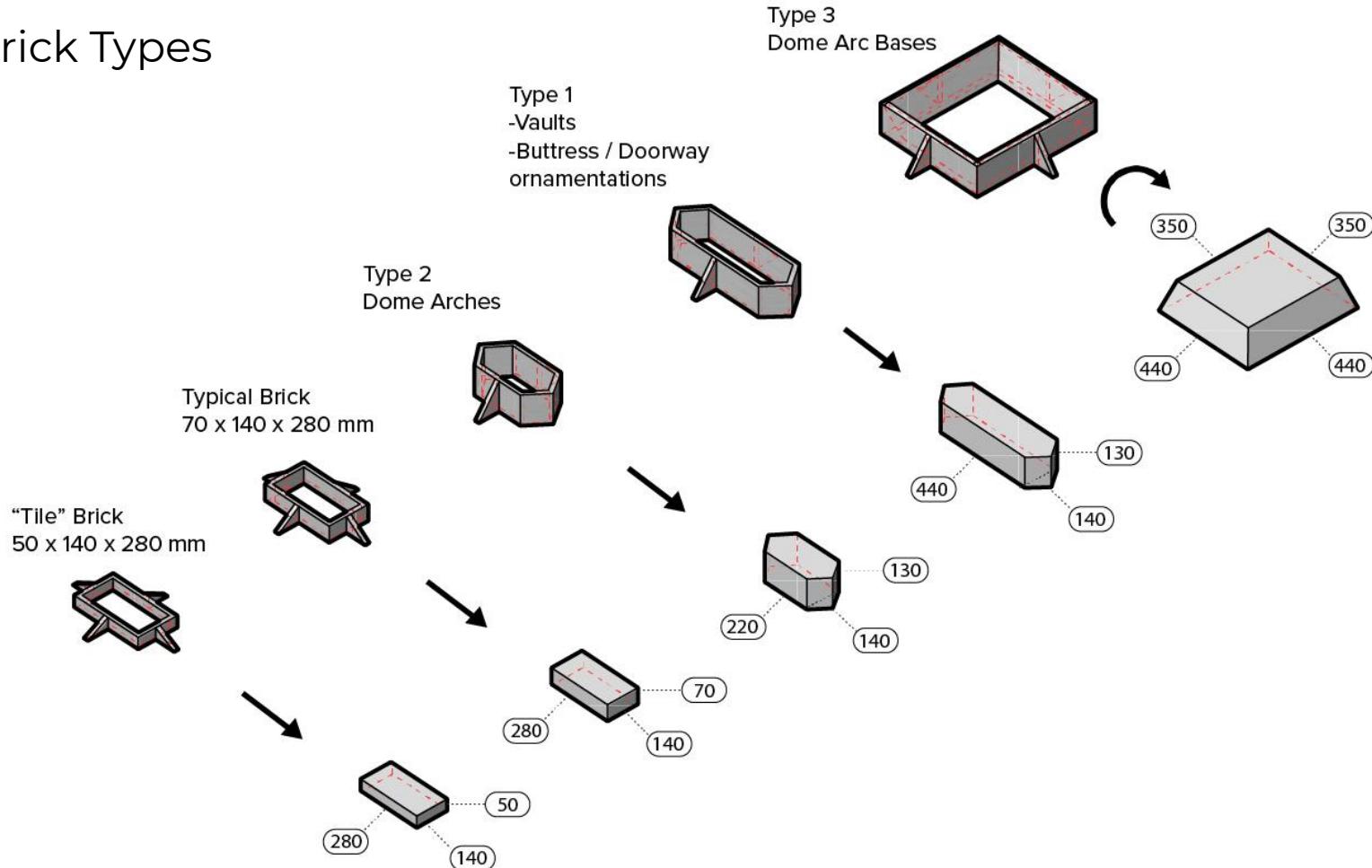


Catalan / Guastavino / Mediterranean

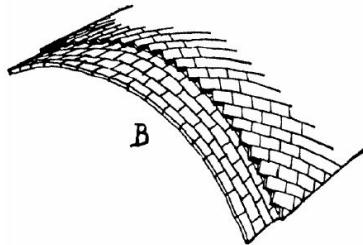


"Tile vaulted systems for low-cost construction in Africa", BlockDeJongDavisOchsendorf, 2010

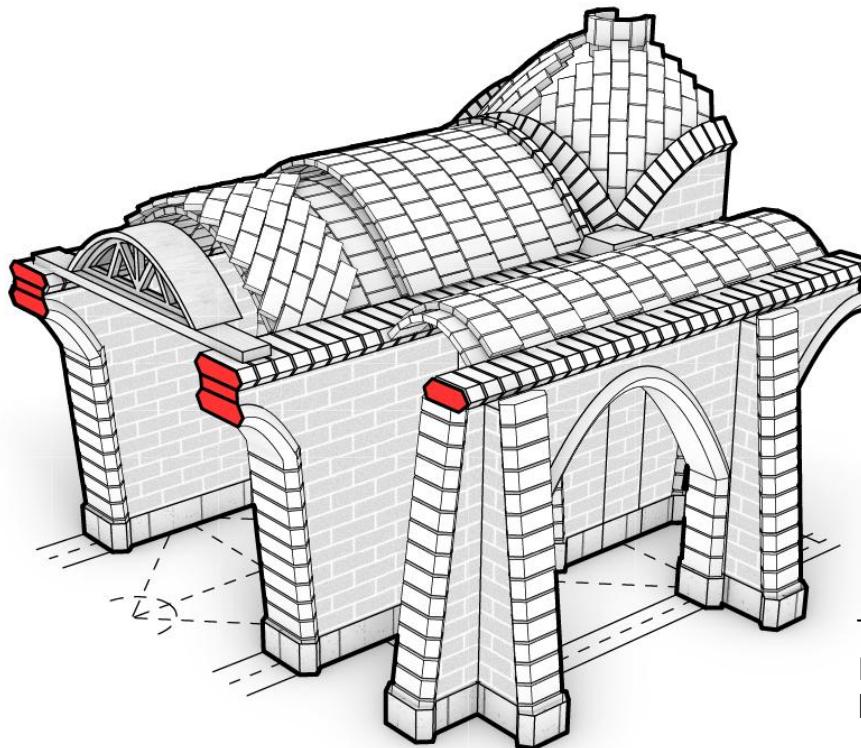
# Brick Types



## DETAILS

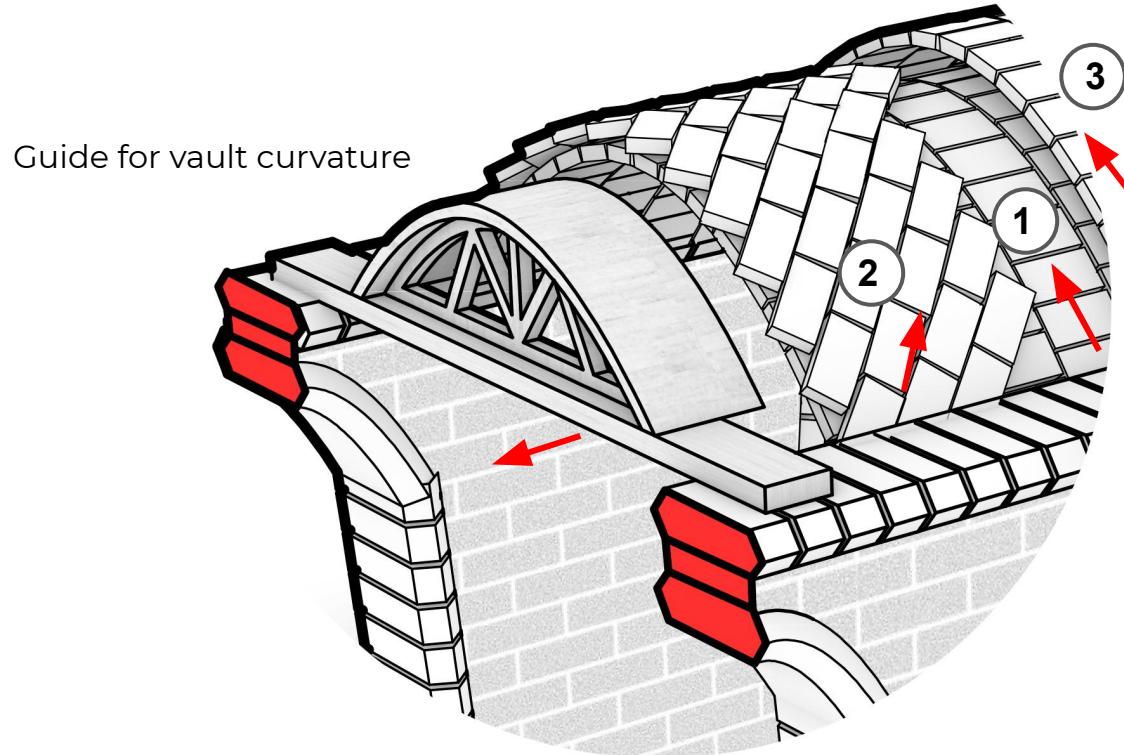


Altered tiling pattern to prevent continuous joints and establish strong structural bond

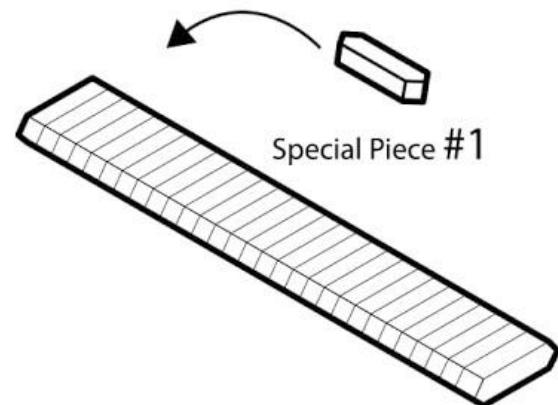


Temporary Perimeter  
Buttresses if not contained  
by neighboring modules

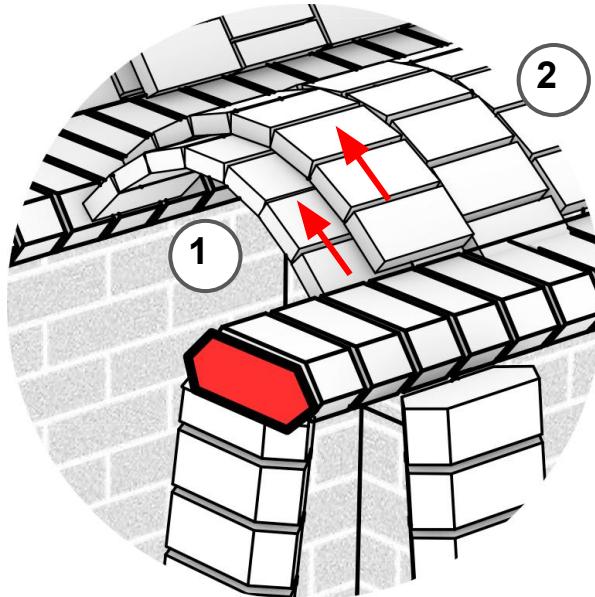
## DETAILS - VAULTS



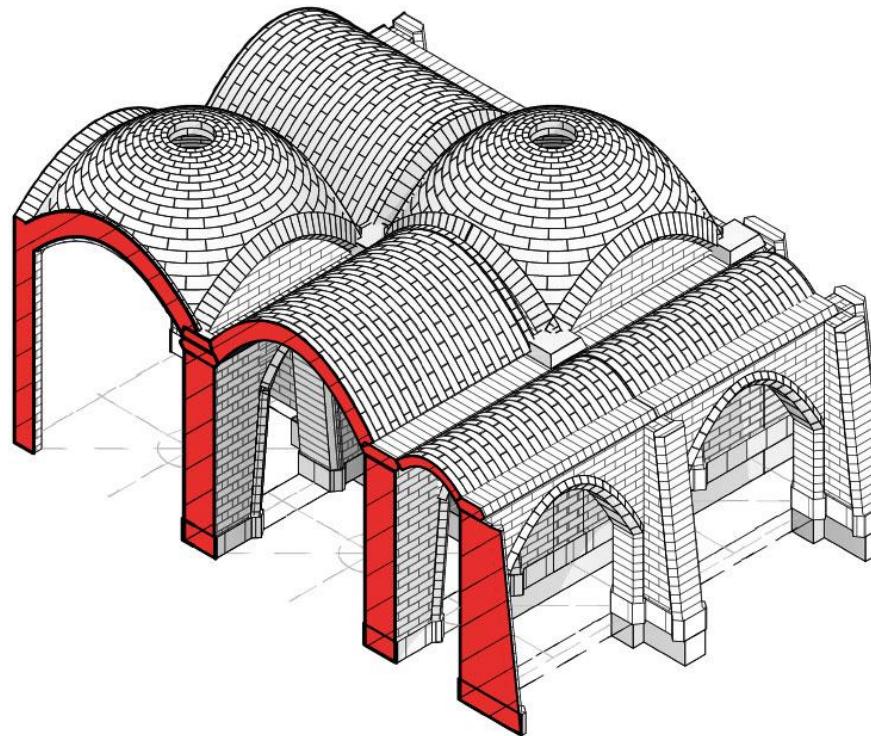
## DETAILS - VAULTS



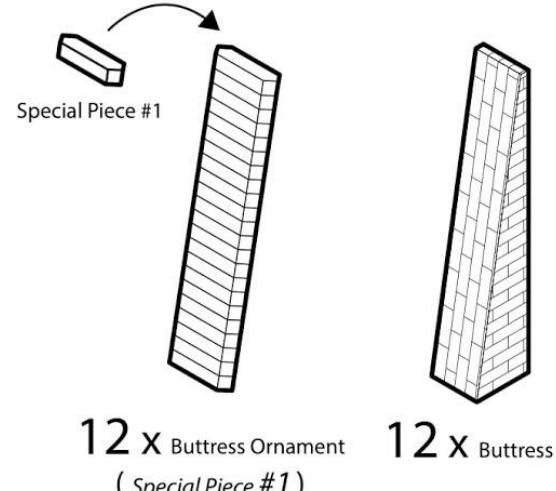
Special piece #1  
440 mm for  
future vaults



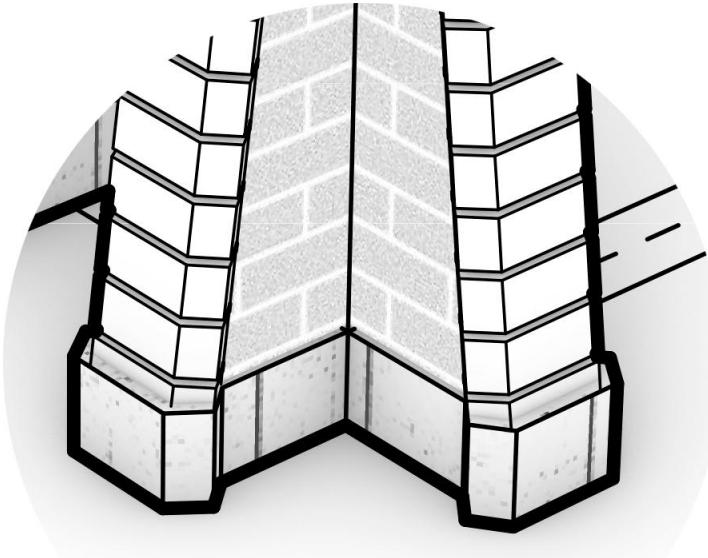
## AXONOMETRIC DETAILS



## DETAILS - FOUNDATION

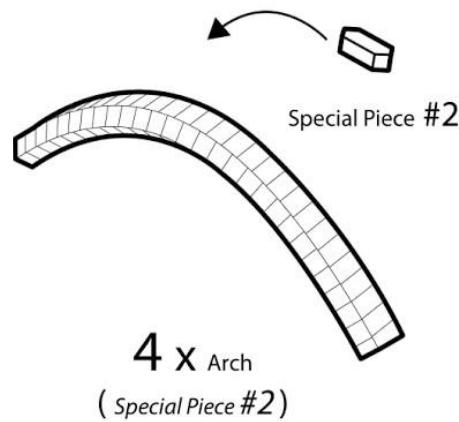


Special piece #1  
also finishing  
ornament

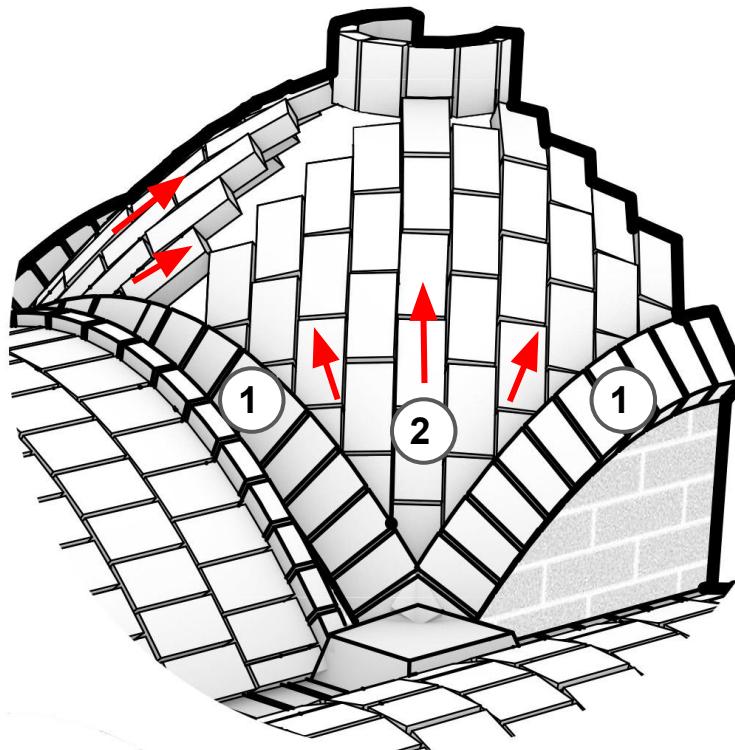


Basalt stone base to  
avoid moisture to  
adobe wall

## DETAILS - DOMES

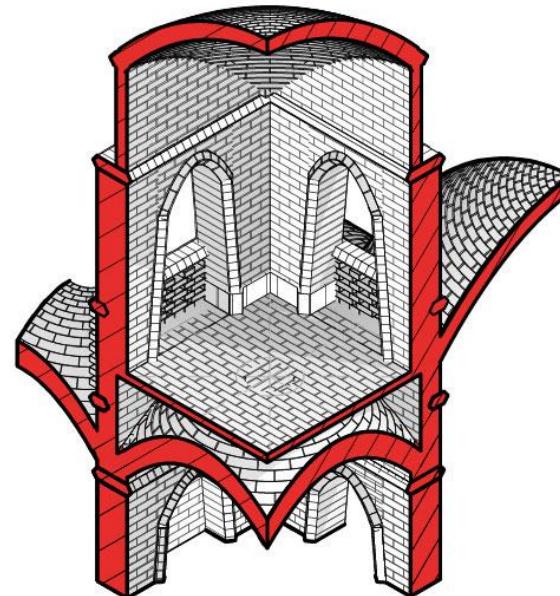
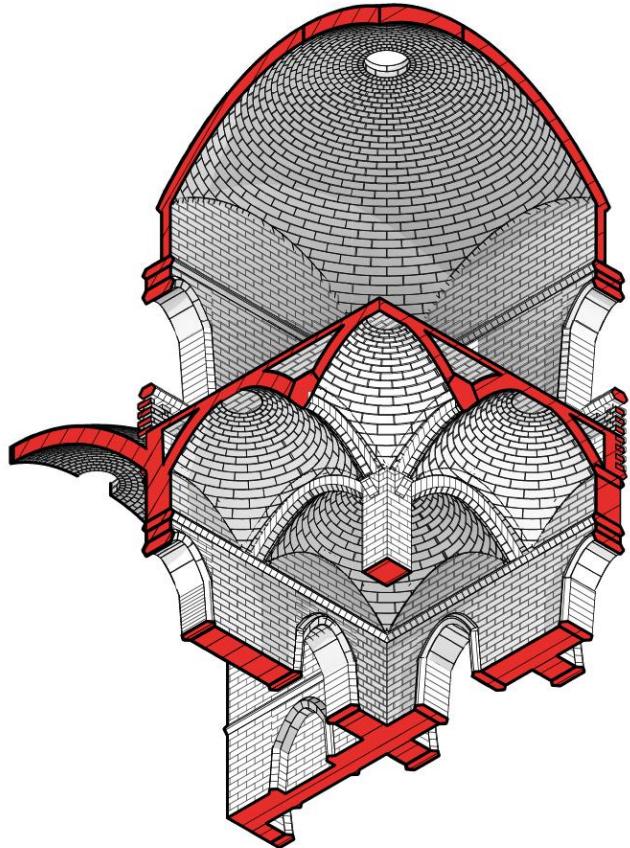


Special Piece #2  
220 mm  
for dome arches



Special Piece #3  
440 x 440 mm  
for future domes

## AXONOMETRIC DETAILS



## AXONOMETRIC DETAILS

