# BAZAARS FOR REFUGEE CAMPS

*A solution for more than only Zataari*

AR3B011 EARTHY (2019/20 Q1) Group 2
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Ir. P.R. Schnabel

# A city in Syria (Aleppo)

*Problem statement*

https://www.pinterest.com/pin/347058715019626040/

# War in Syria (Aleppo)

*Problem statement*

https://www.newsweek.com/syria-propaganda-aleppo-assad-536003

# Lost all qualities of life

*Problem statement*

https://hhi.harvard.edu/content/refugee-camp-panoramas-zaatari-refugee-camp-jordan

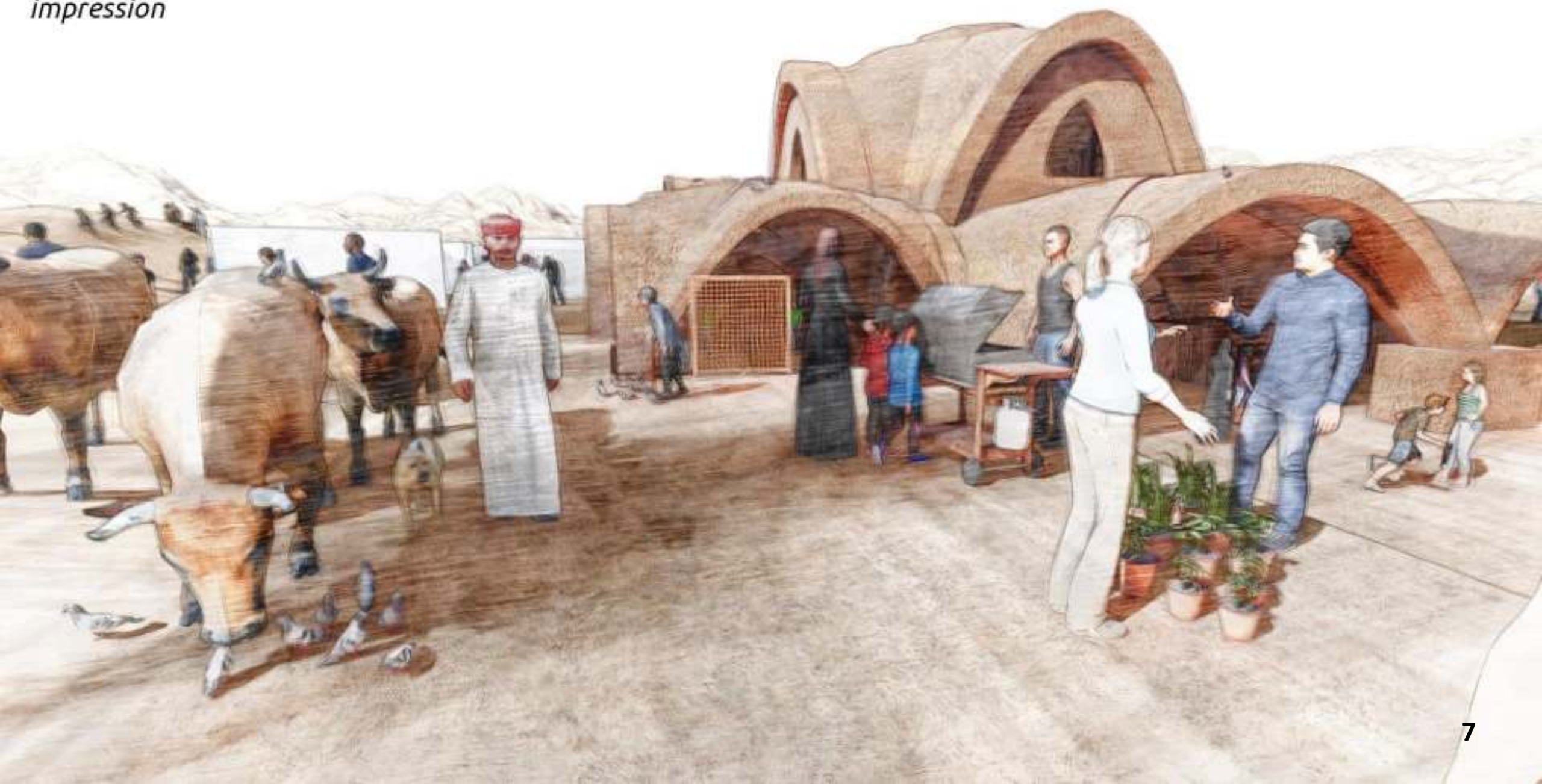
# PROBLEM STATEMENT

*Currently 25.9 million people live in refugee camps.*

## Question

*Can we design something that improves their lives?*

# Bazaar
*impression*



# BAZAARS FOR REFUGEE CAMPS

*why a bazaar?*

https://www.britannica.com/topic/bazaar

https://www.britannica.com/topic/spice-food

https://www.britannica.com/topic/spice-food

# Providing jobs (meaning of life)

https://www.britannica.com/topic/spice-food

Providing jobs (meaning of life)

Bringing back cultural value

https://www.britannica.com/topic/spice-food

Providing jobs (meaning of life)

Bringing back cultural value

A sense of identity

https://www.britannica.com/topic/spice-food

# PROBLEM

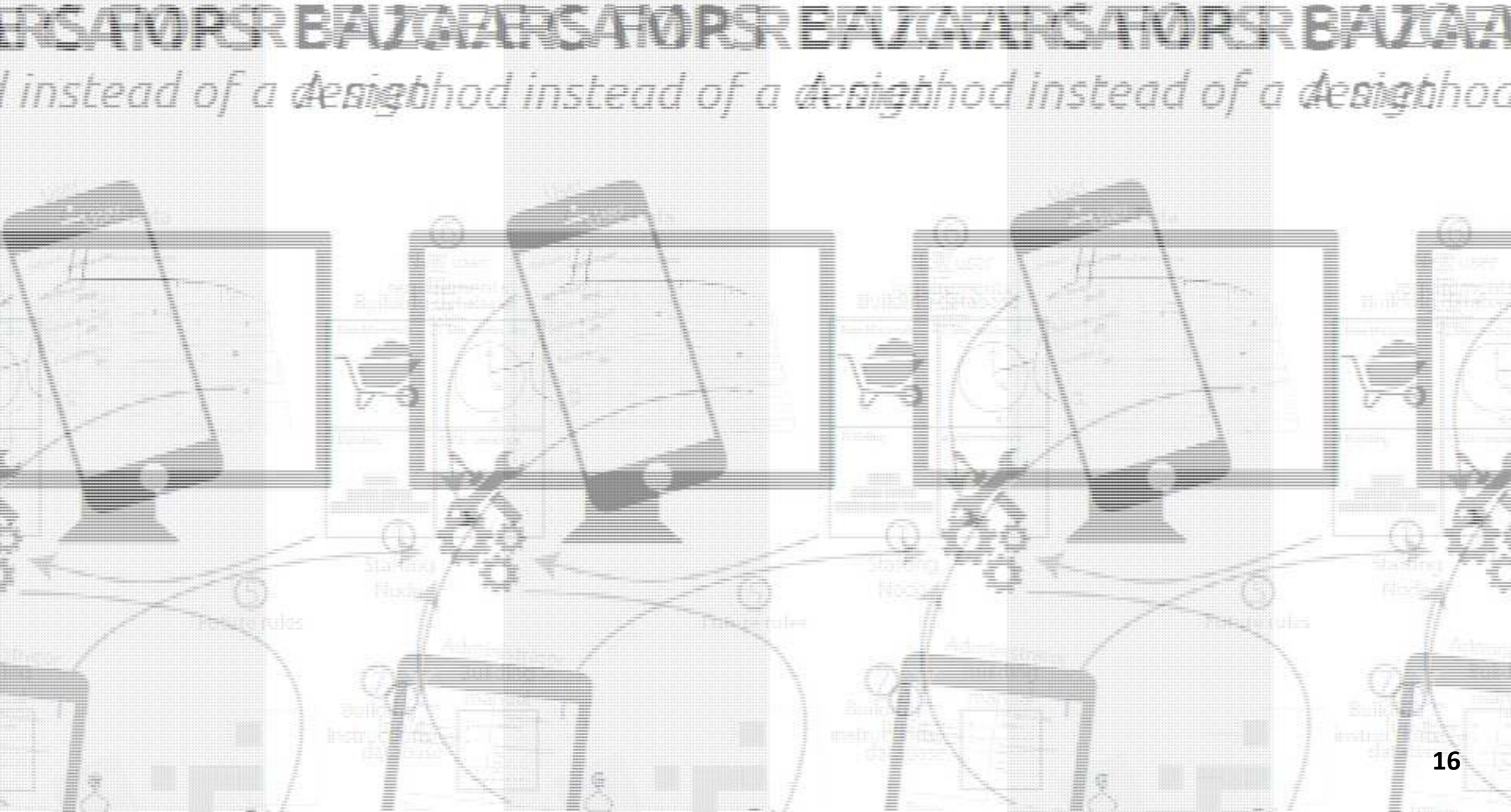
*If we make a solution for Zaatari we can't apply it somewhere else*

## Question

*Can we design something that is applicable in every Refugee camp?*

## how?

*By creating a Modular computational method*


instead of a designhod instead of a designhod instead of a designhod

**Designing vaults with adobe**

Learning from the past to design better

Designing a method, modular and applicable

## Designing vaults with adobe

- *Strength through geometry*
- *form finding: 2D topology to 3D form*
- *Optimisation spring stiffness and material thickness*
- *Results*

# STRENGTH THROUGH GEOMETRY

*Designing vaults with adobe*

Prof. Dr. Philippe Block from ETH Zurich

# STRENGTH THROUGH GEOMETRY

*Designing vaults with adobe*

Prof. Dr. Philippe Block from ETH Zurich
https://www.doityourself.com/stry/how-to-make-adobe-brick

# STRENGTH THROUGH GEOMETRY

*Designing vaults with adobe*

*Gaustavino vault load test 1901*

*Eth block research group load test 2013*

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# STRENGTH THROUGH GEOMETRY

*Designing vaults with adobe*

*Gaustavino vault load test 1901*

*Eth block research group load test 2013*

Prof. Dr. Philippe Block from ETH Zurich
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## Challenge with adobe?

## Challenge with adobe?

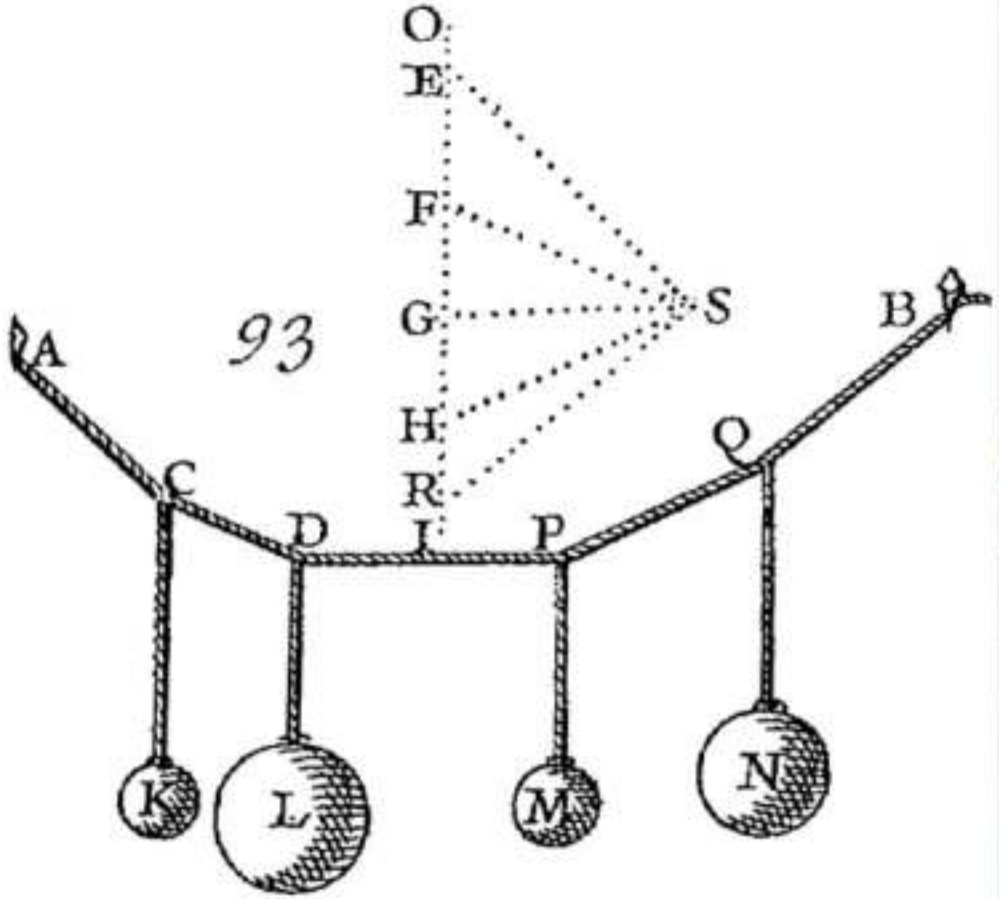
*preventing tension in both principle directions!*

# Form finding a tension-less shape

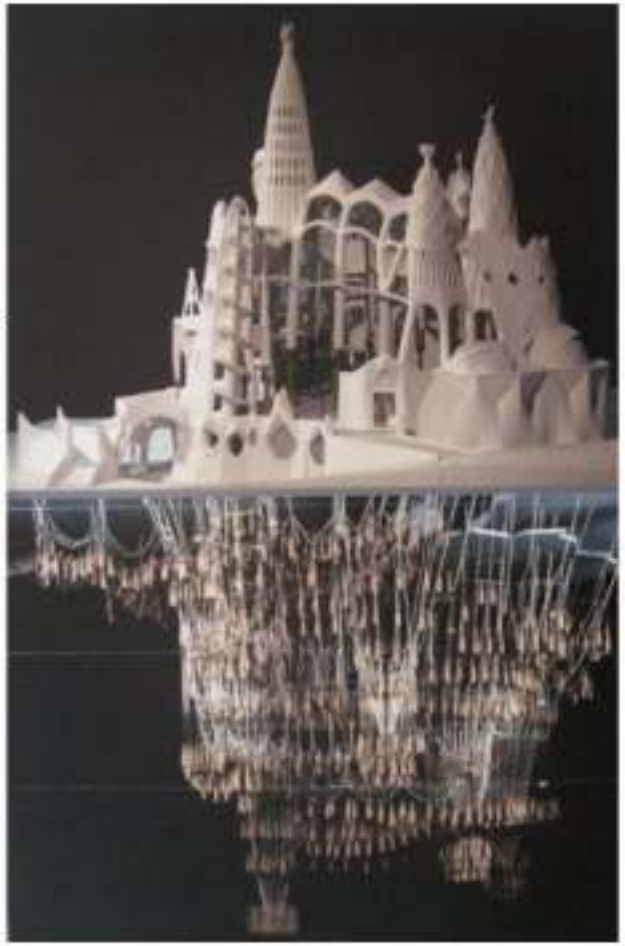
*Finding a form which prevent tension in both principle directions!*

# HOW DO WE FIND THESE FORMS?

*Designing vaults with adobe*




Prof. Dr. Philippe Block from ETH Zurich



Antoni Gaudi

# FORM FINDING

*Designing vaults with adobe*

## Methods

- Natural Shape finding
- Force Density Method
- Surface Stress Density Method
- Trust Network Analysis
- Dynamic Relaxation
- Particle-Spring system

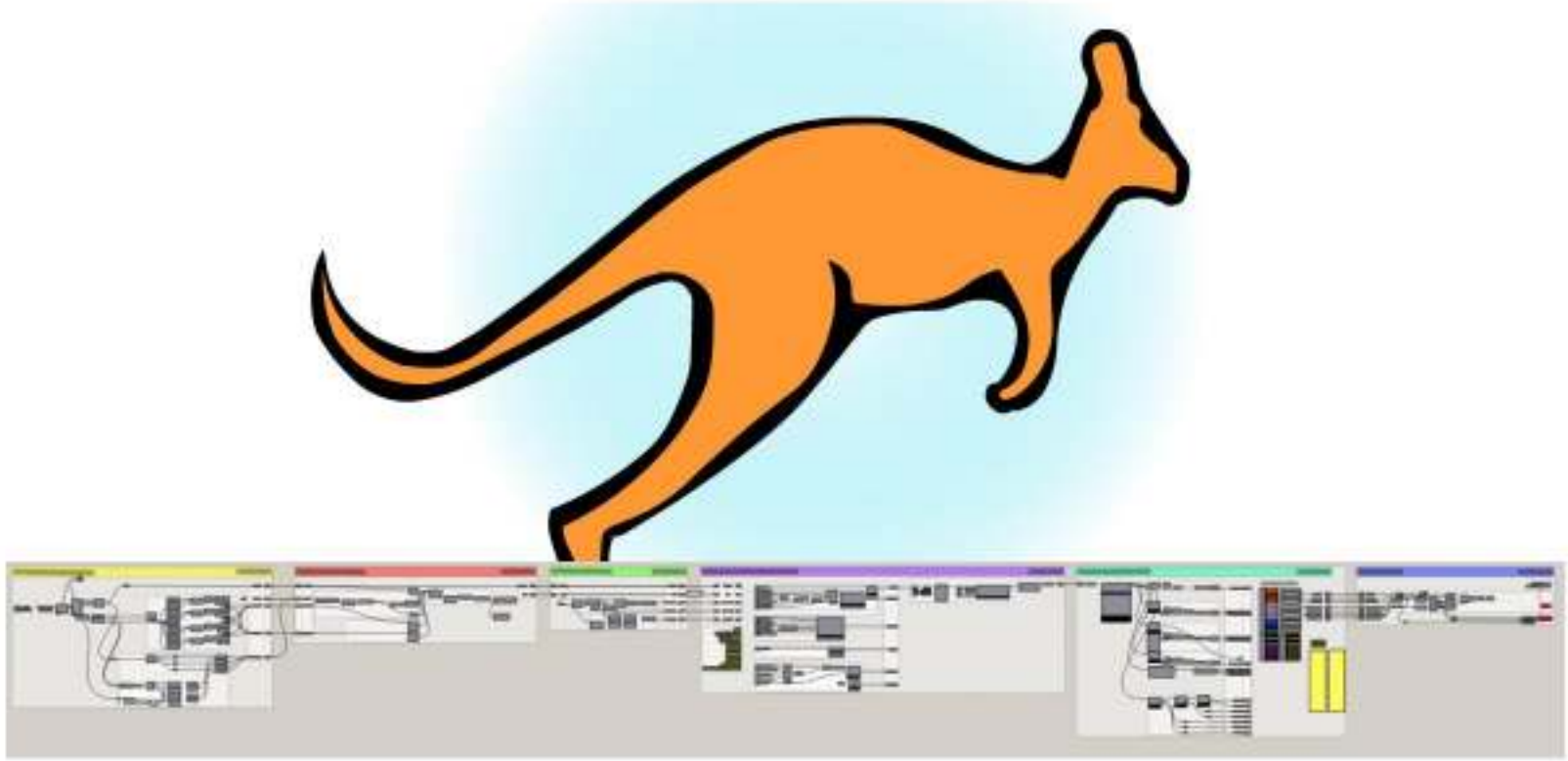
# FORM FINDING

*Designing vaults with adobe*

## Methods

| | |
|---|---|
| Stiffness matrix | Natural Shape finding |
| Geometric stiffness | Force Density Method<br>Surface Stress Density Method<br>Trust Network Analysis |
| Dynamic equilibrium | **Dynamic Relaxation**<br>Particle-Spring system |

## Used Dynamic Relaxation

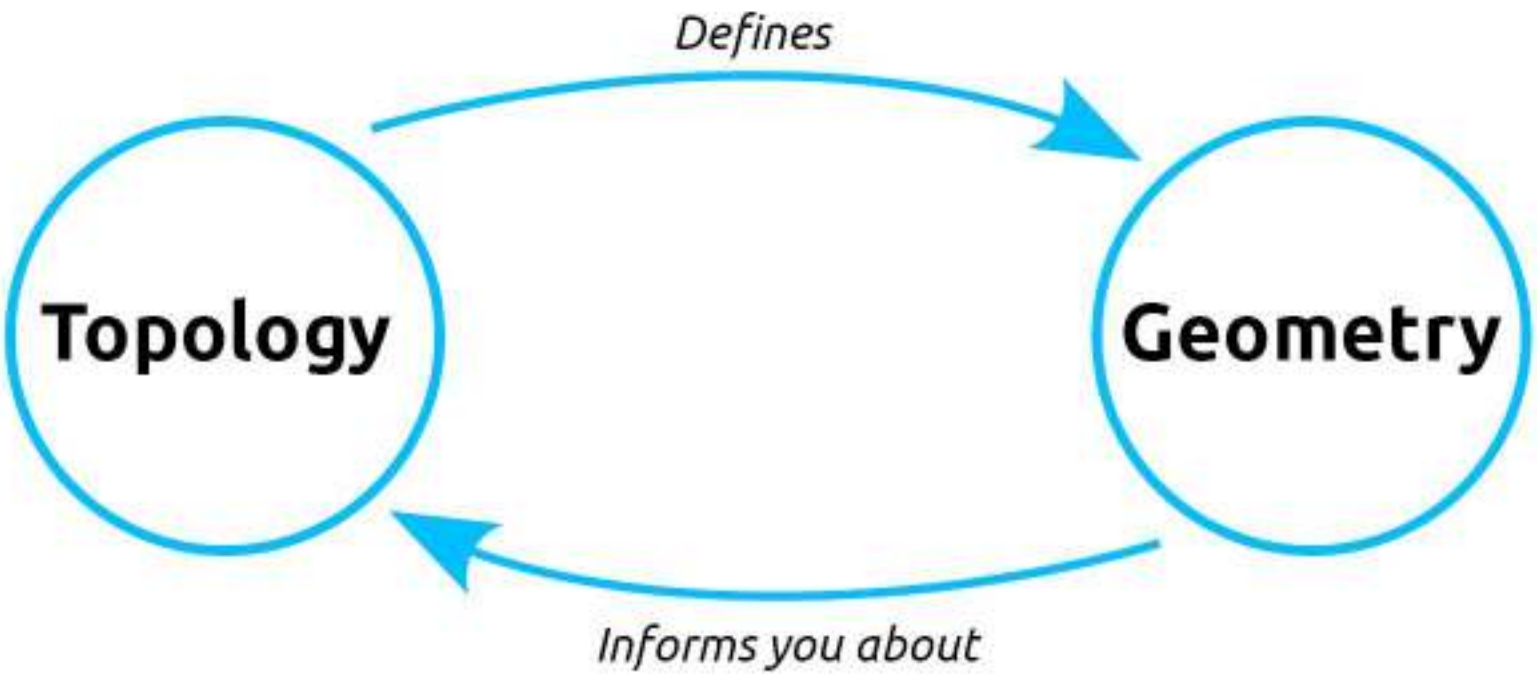


## Dynamic Relaxation: 2 things are important

Your 2D topology defines your 3D form

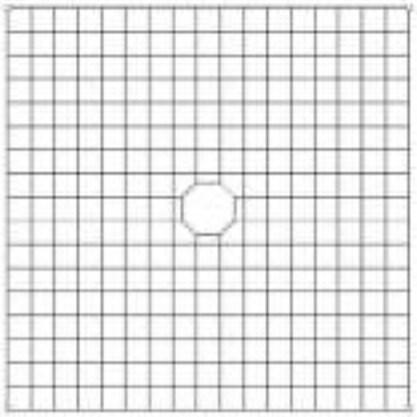
# FORM FINDING

*Designing vaults with adobe*



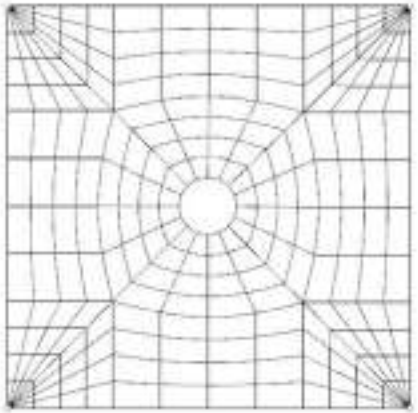
# FORM FINDING Topology and shape

*Designing vaults with adobe*



*Holedeck waffle slab*

https://www.youtube.com/watch?v=xH26K3zpnR0

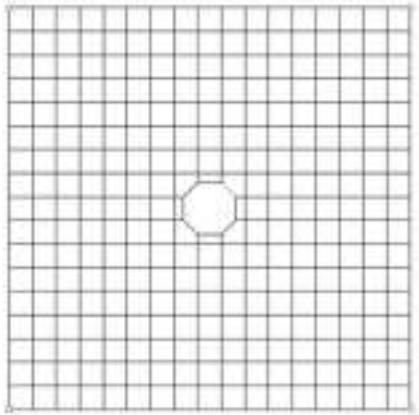


*Nervi's ribbed slab*

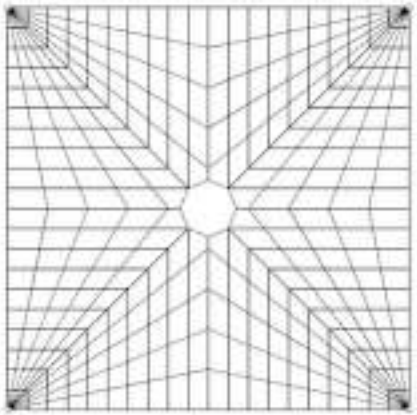
Prof. Dr. Philippe Block from ETH Zurich

# FORM FINDING Topology and shape

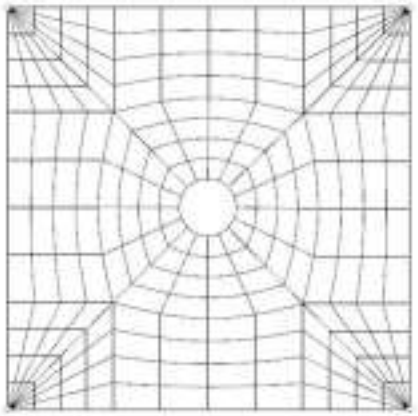
*Designing vaults with adobe*



*Rectengular tesselation*



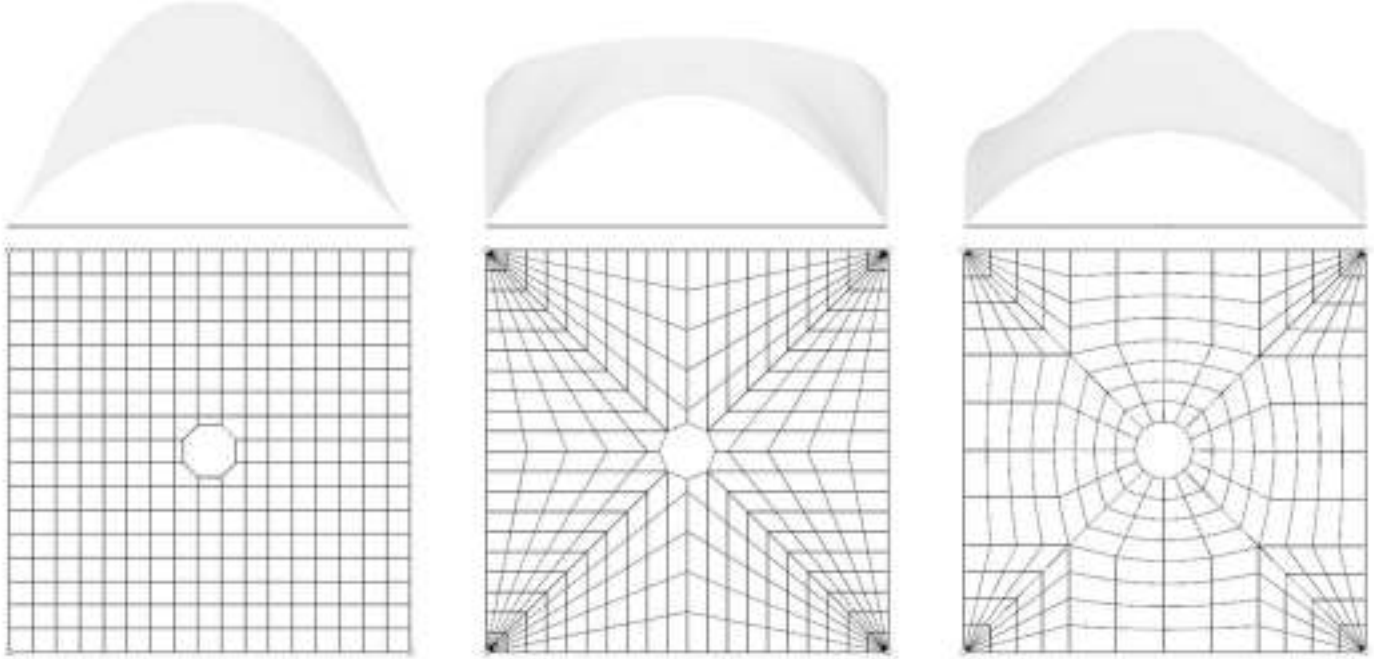
*Featurepoint tesselation*



*Medial axis tesselation*

# FORM FINDING Topology and shape

*Designing vaults with adobe*



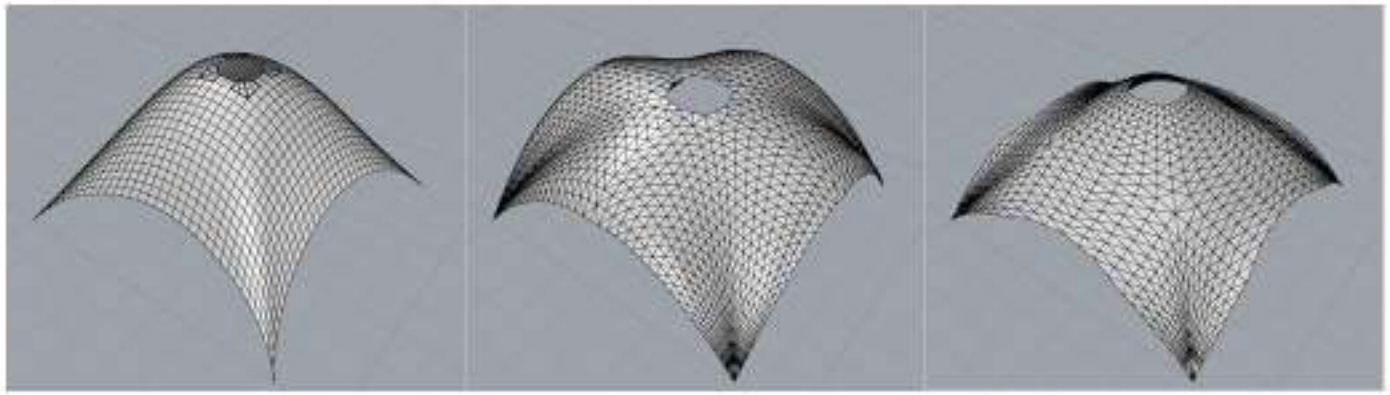
*Rectengular tesselation*

*Featurepoint tesselation*

*Medial axis tesselation*

# FORM FINDING Topology and shape

*Designing vaults with adobe*



| | | |
|---|---|---|
| Max compression stress P1 [N/mm2] | Max compression stress P1 [N/mm2] | Max compression stress P1 [N/mm2] |
| -2.18 | -1.57 | -1.79 |
| Max tensile stress P1 [N/mm2] | Max tensile stress P1 [N/mm2] | Max tensile stress P1 [N/mm2] |
| -0.00381 | 0.0264 | 0.076 |
| Max compression stress P2 [N/mm2] | Max compression stress P2 [N/mm2] | Max compression stress P2 [N/mm2] |
| -2.18 | -1.57 | -1.79 |
| Max tensile stress P2 [N/mm2] | Max tensile stress P2 [N/mm2] | Max tensile stress P2 [N/mm2] |
| -0.00381 | 0.0264 | 0.076 |
| X (horizontal) resultant force [kN] | X (horizontal) resultant force [kN] | X (horizontal) resultant force [kN] |
| 28.717674 | 25.179816 | 33.606158 |
| Y (horizontal) resultant force [kN] | Y (horizontal) resultant force [kN] | Y (horizontal) resultant force [kN] |
| 28.717673 | -25.179813 | -33.597341 |
| Z (vertical) resultant force [kN] | Z (vertical) resultant force [kN] | Z (vertical) resultant force [kN] |
| 38.37115 | 51.517691 | 46.78453 |

# FORM FINDING rib vault topology

*Designing vaults with adobe*

## Final tesselation pattern

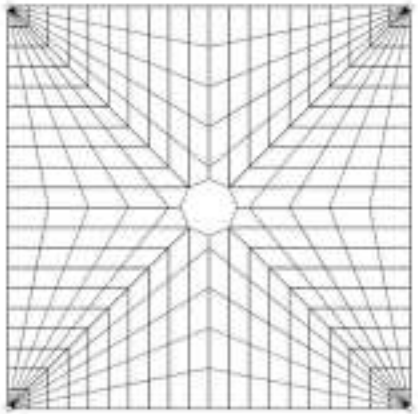
- Ribbed vault (constructability)
- Matching boundary (modularity)

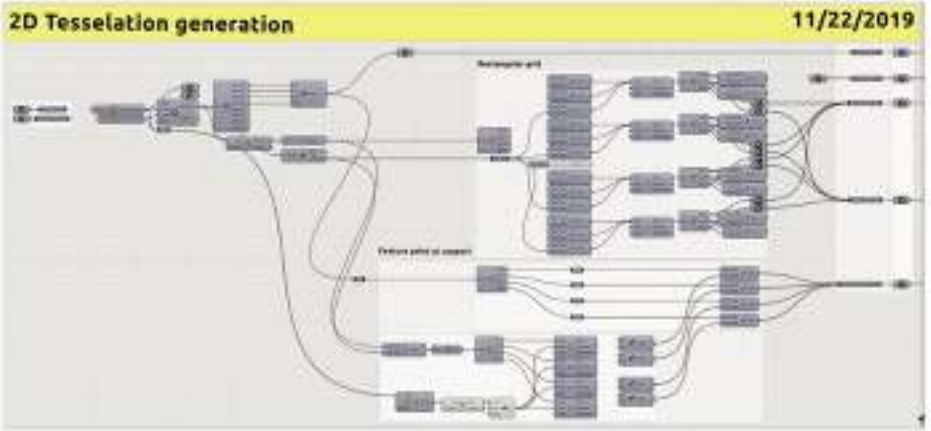
# FORM FINDING rib vault topology

*Designing vaults with adobe*

## Final tesselation pattern

- Ribbed vault (constructability)
- Matching boundary (modularity)





## Dynamic Relaxation: 2 things are important

Your 2D topology defines your 3D form

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Your 2D topology defines your 3D form

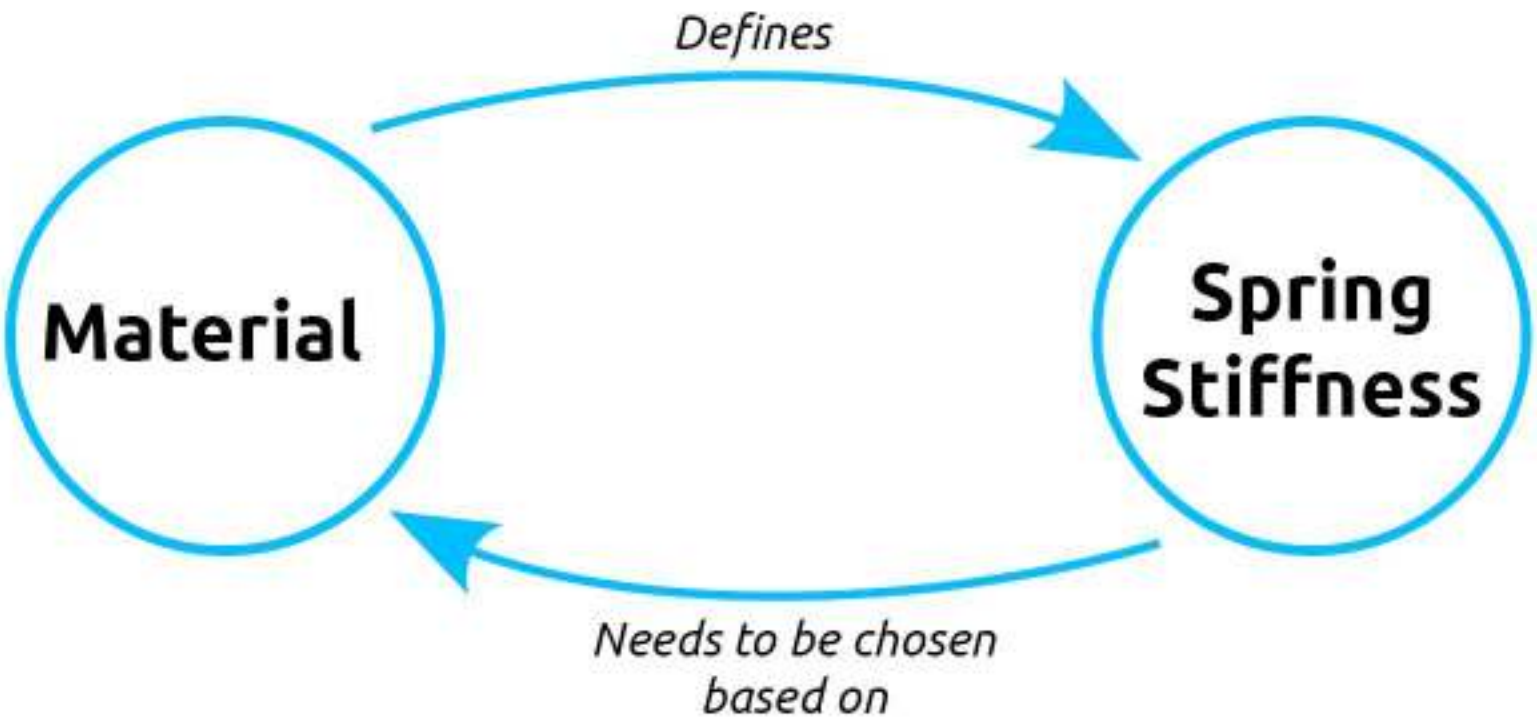
## Dynamic Relaxation: 2 things are important

Your 2D topology defines your 3D form

Material defines your spring-stiffness

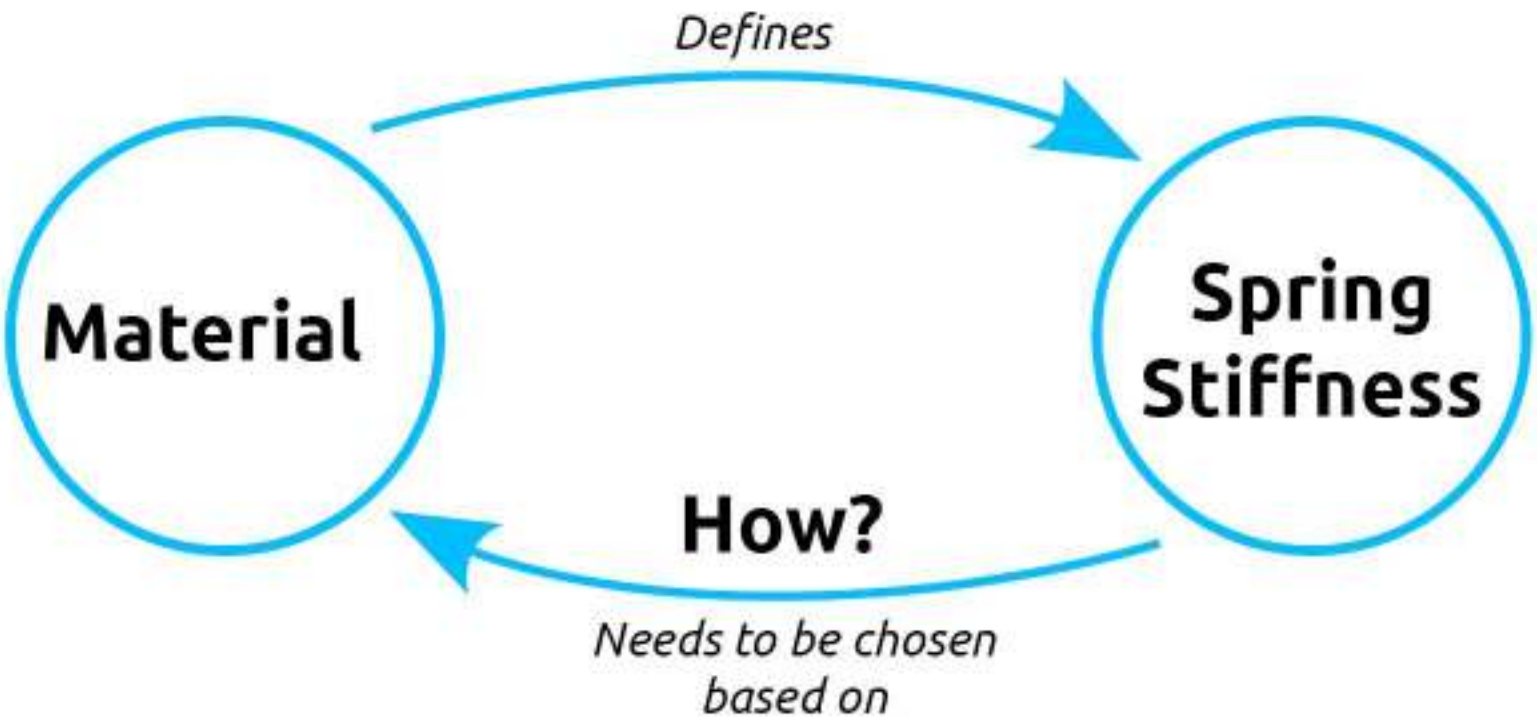
# Material Spring stiffness

*Designing vaults with adobe*



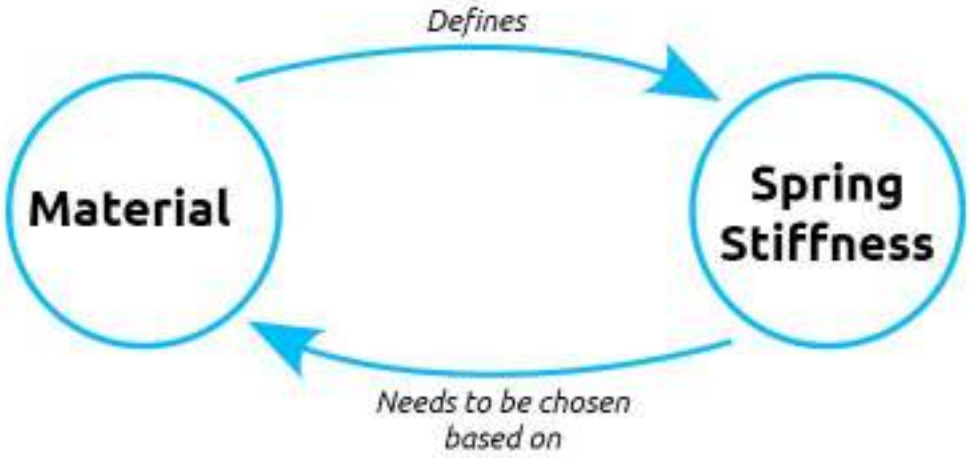
# Material Spring stiffness

*Designing vaults with adobe*



# Material Spring stiffness

*Designing vaults with adobe*



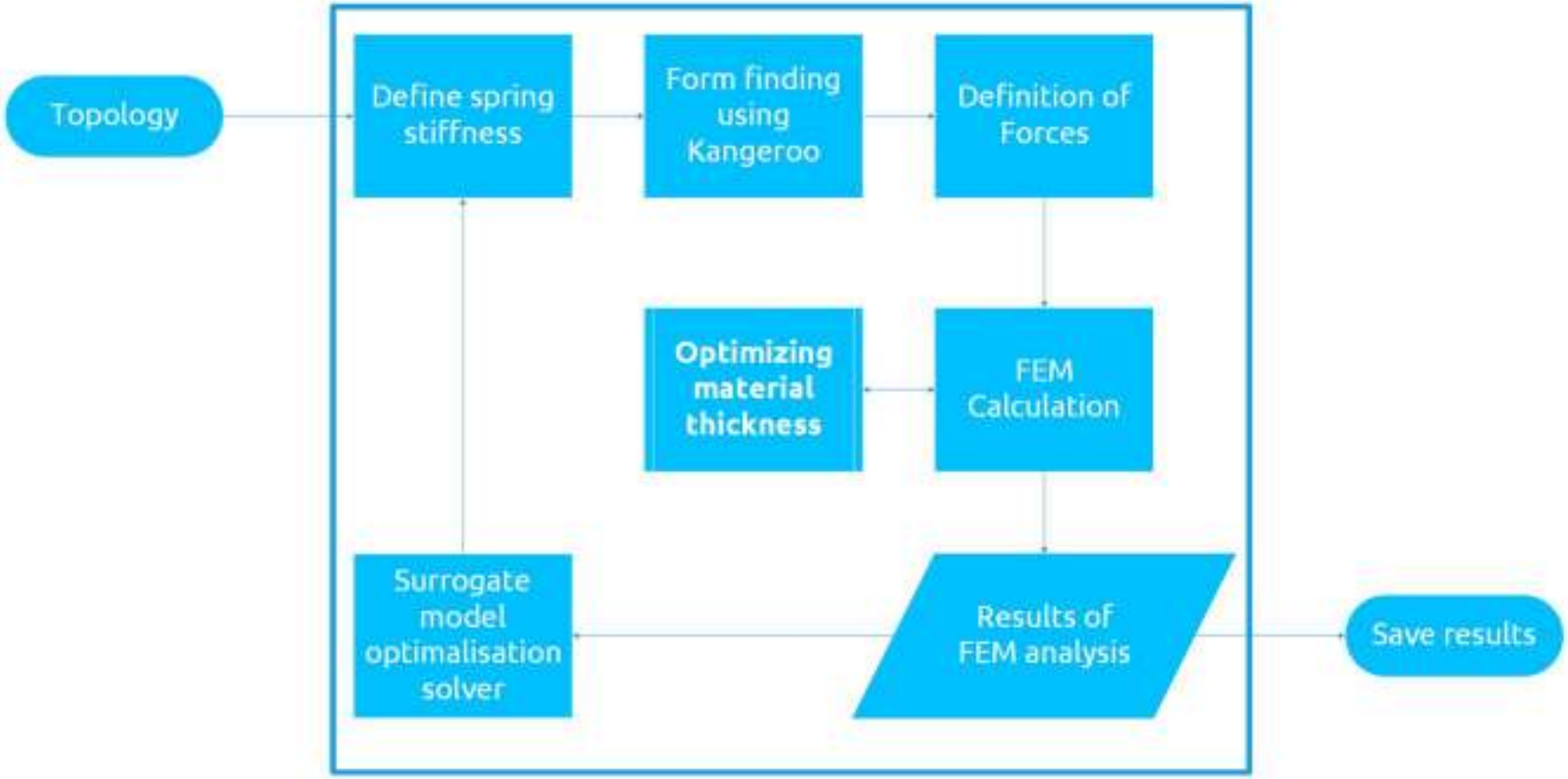

**Answer:**
**To complicated for 8 weeks**

**How?**
**Ask Fred!**

# FORM FINDING Optimalisation loop

*Designing vaults with adobe*

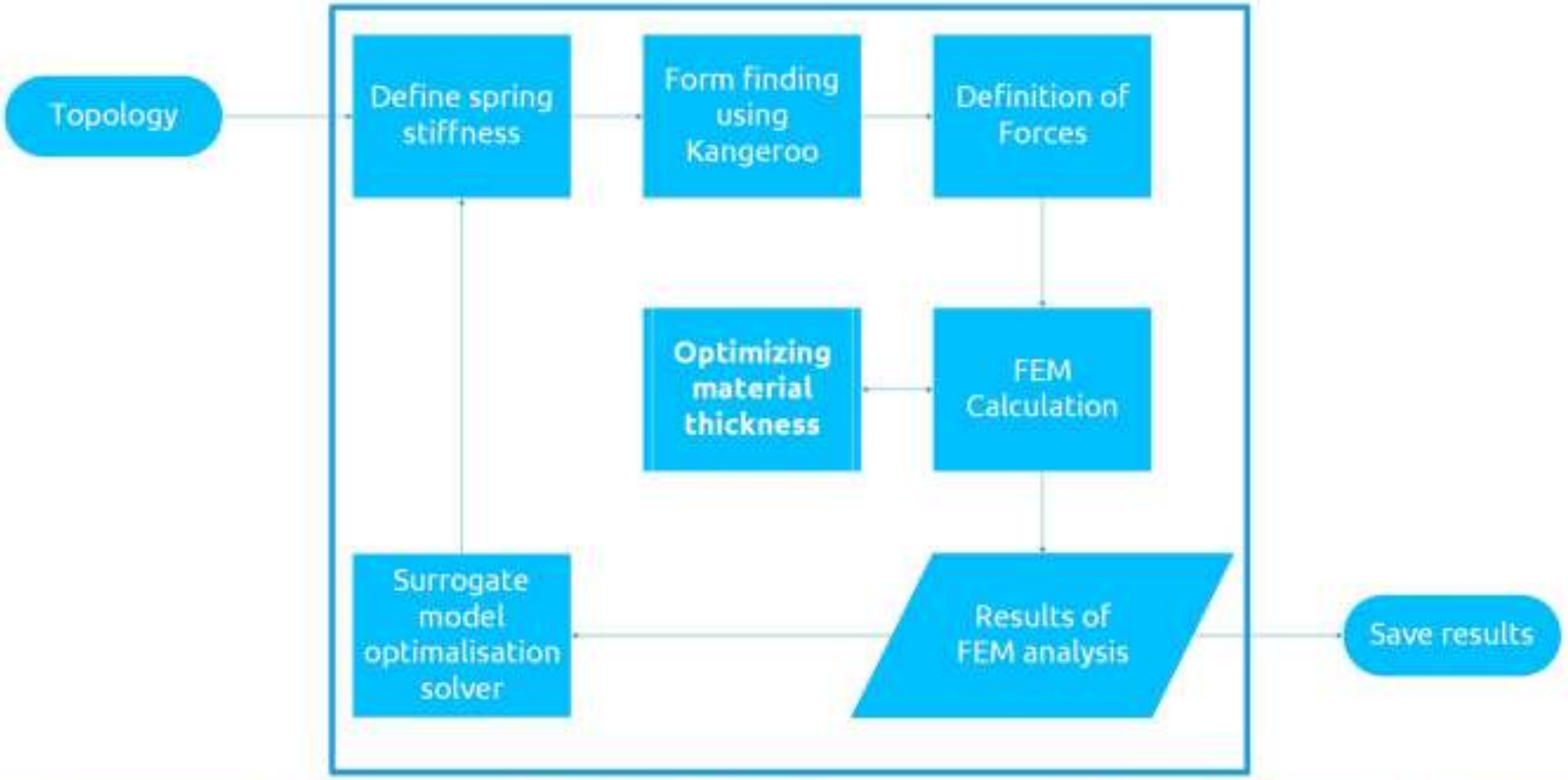
*Result based optimalisation*



# FORM FINDING Optimalisation loop

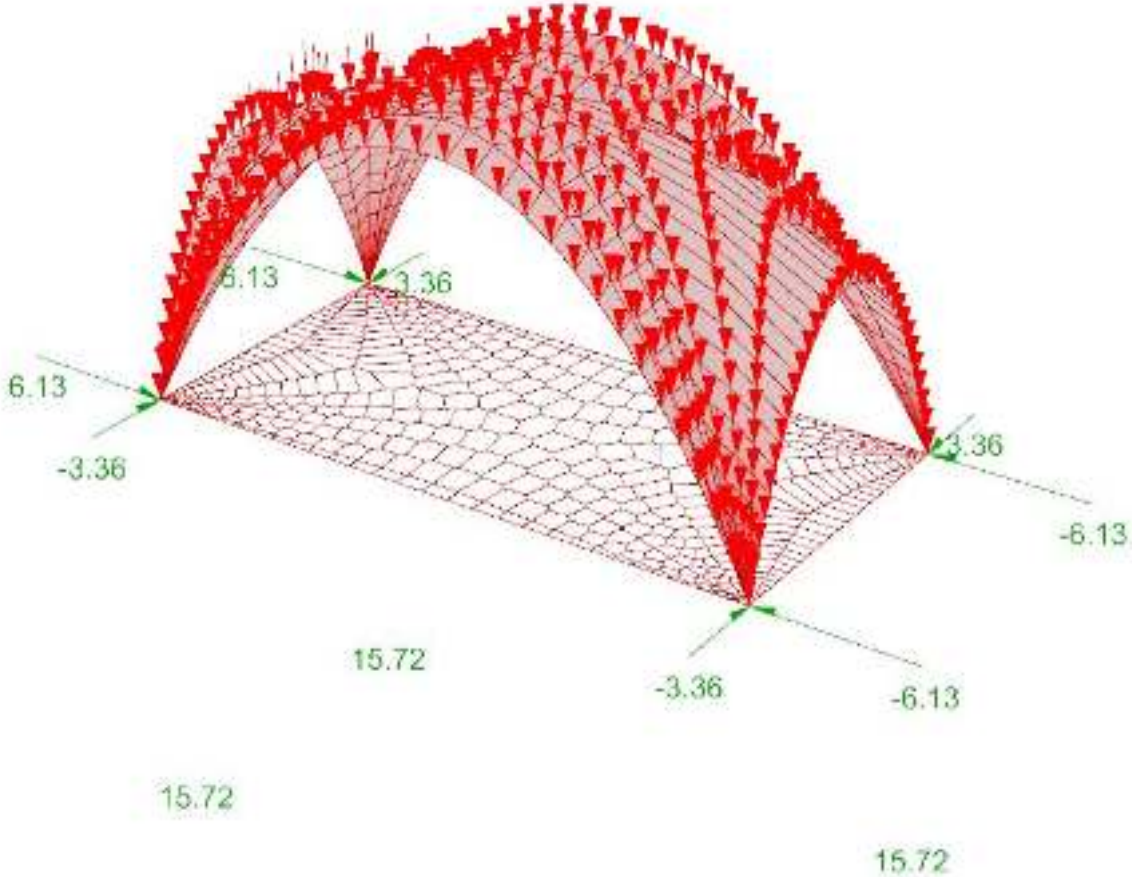
*Designing vaults with adobe*

*Result based optimalisation*



# FORM FINDING Optimalisation loop

*Designing vaults with adobe*



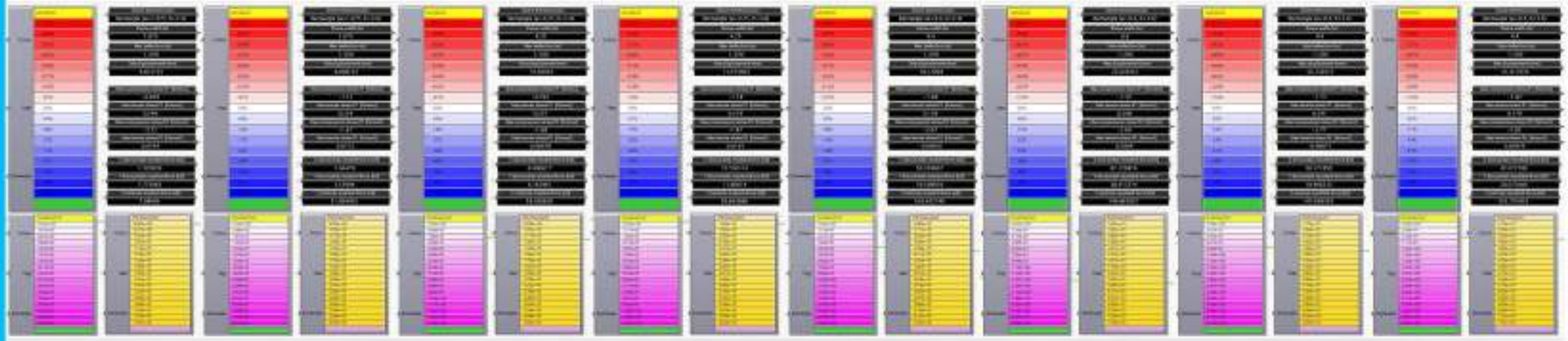

| | |
|---|---|
| Dome dimension [m] | Rectangle (w=1.675, h=3.6) |
| Dome width [m] | 1.675 |
| Max deflection [m] | 1/200 |
| Max displacement [mm] | 3.98325 |
| Max compression stress P1 [N/mm2] | -0.349 |
| Max tensile stress P1 [N/mm2] | 0.161 |
| Max compression stress P2 [N/mm2] | -1.03 |
| Max tensile stress P2 [N/mm2] | 0.00211 |
| X (horizontal) resultant force [kN] | 3.362526 |
| Y (horizontal) resultant force [kN] | 6.129149 |
| Z (vertical) resultant force [kN] | 15.720412 |

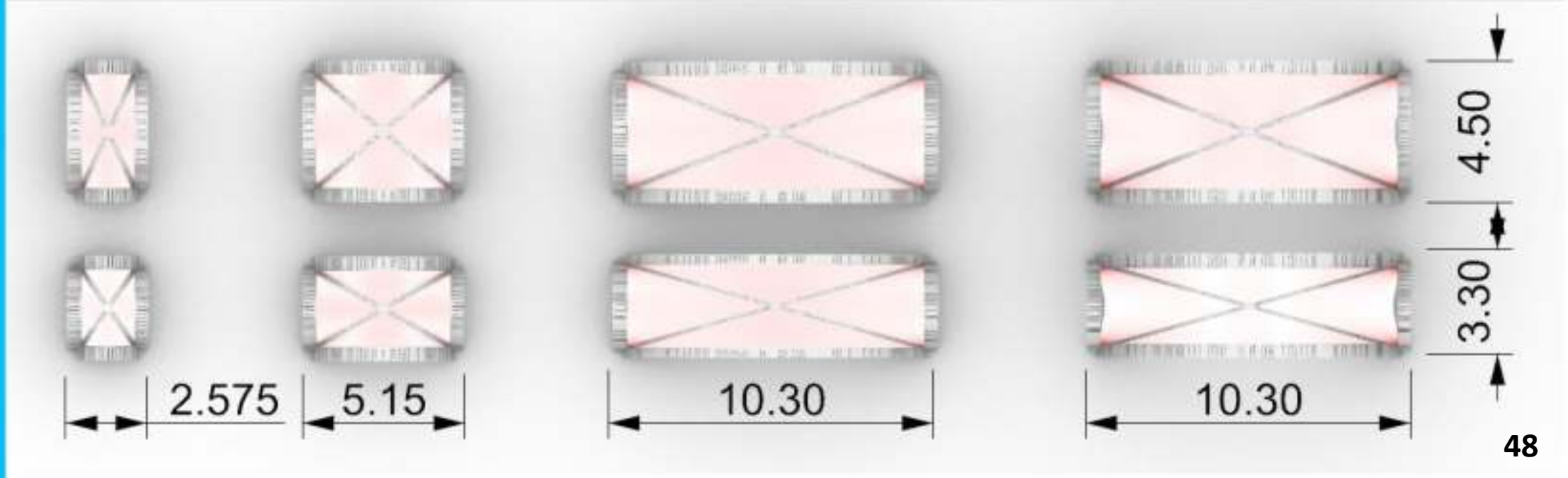
# Final Modular Design units

*Successfully found the form with no tension in both principle directions!*

# FORM FINDING Results

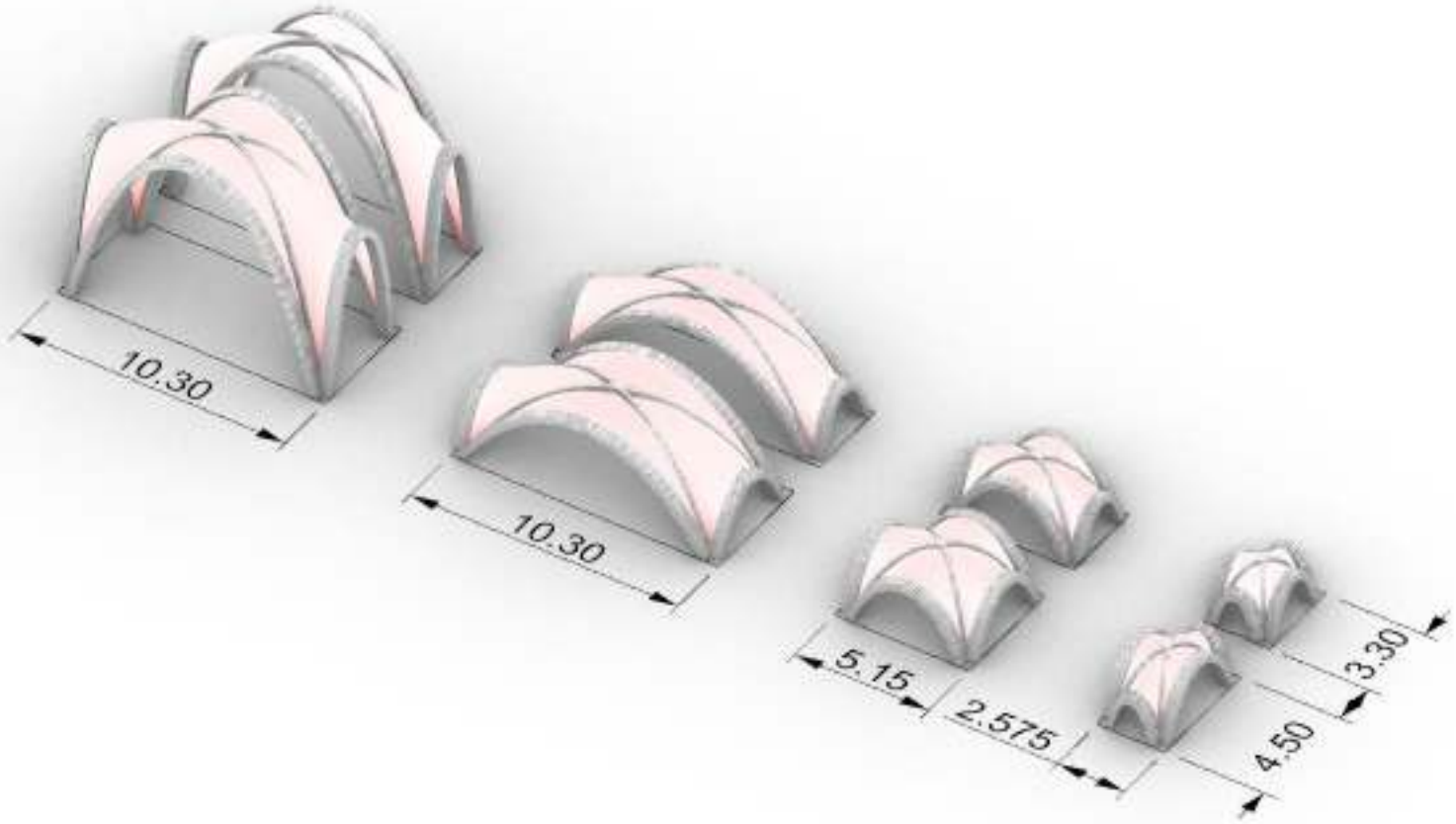
*Designing vaults with adobe*





# FORM FINDING Results

*Designing vaults with adobe*



# How do we build it?

*using the local resources and man/woman-power*

Designing vaults with adobe

**Learning from the past to design better**

Designing a method, modular and applicable

https://www.thoughtco.com/what-is-adobe-sustainable-energy-efficient-177943

# Making it constructable by local people

https://www.thoughtco.com/what-is-adobe-sustainable-energy-efficient-177943

# Making it constructable by local people

# Using local materials

https://www.thoughtco.com/what-is-adobe-sustainable-energy-efficient-177943

**Making it constructable by local people**

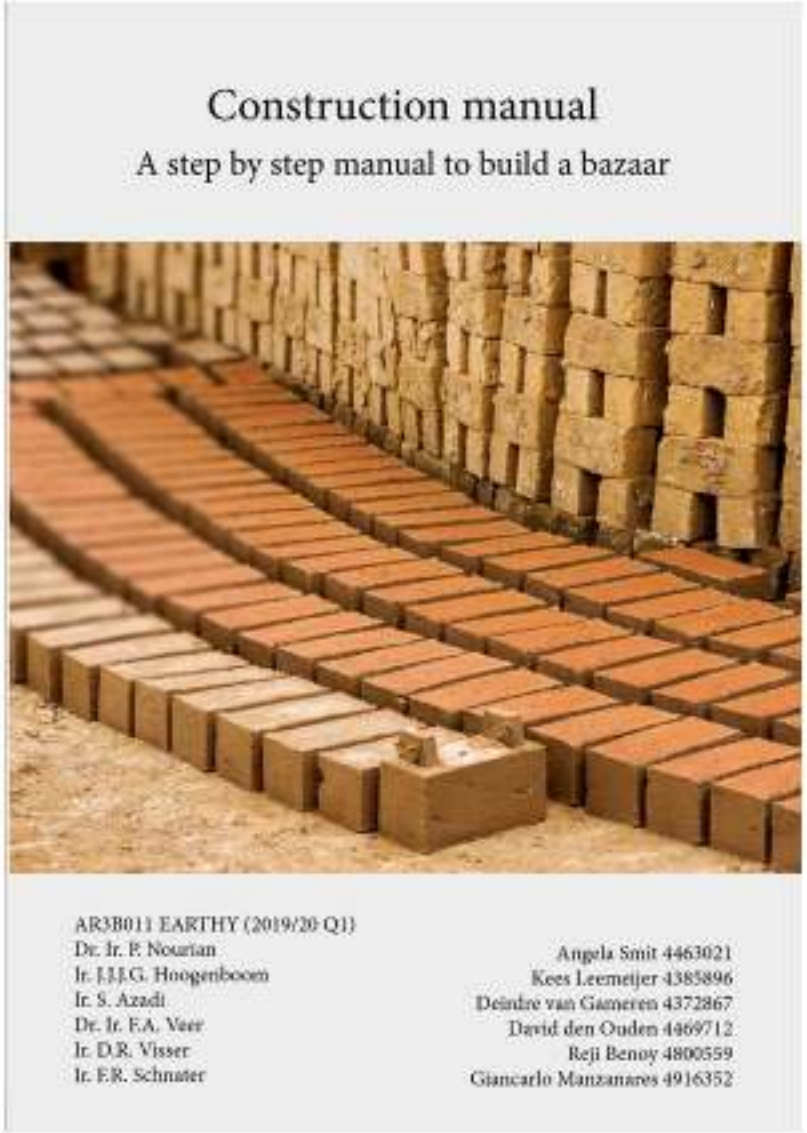
**Using local materials**

**Applying known methods**

https://www.thoughtco.com/what-is-adobe-sustainable-energy-efficient-177943

# Educating the local population

*Learning from the past to design better*



Construction manual

A step by step manual to build a bazaar

AR3B011 EARTHY (2019/20 Q1)
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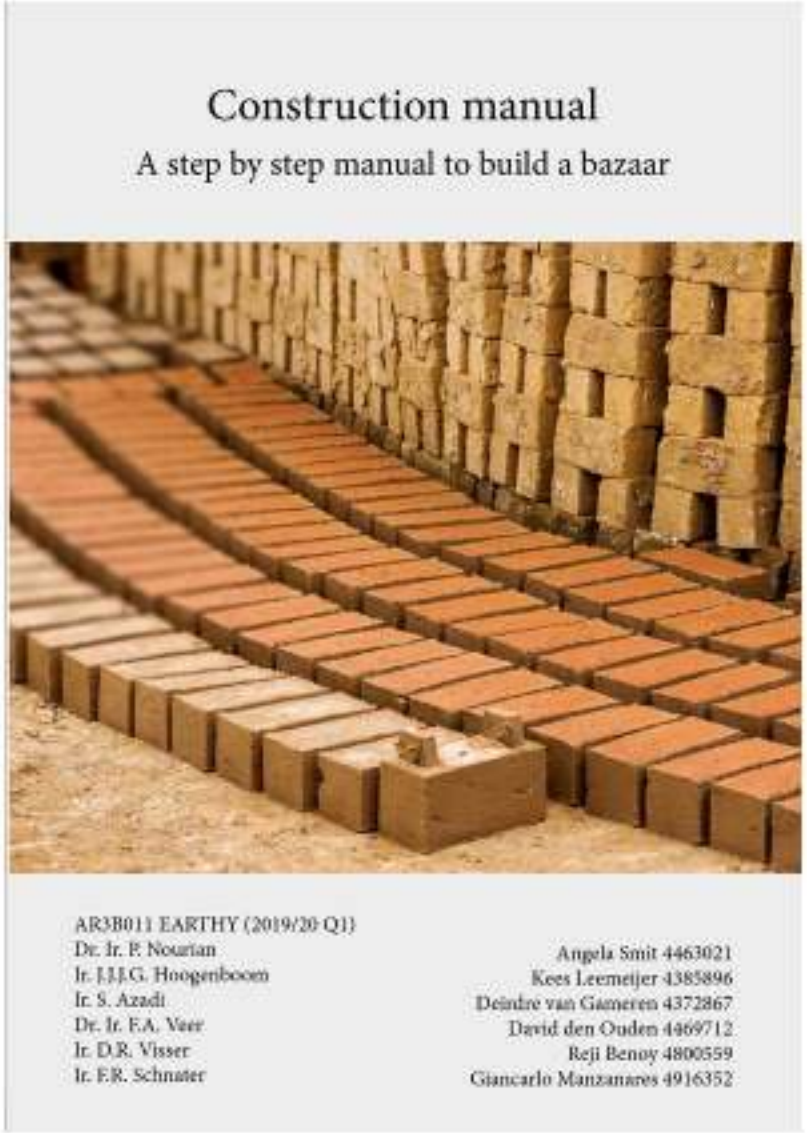
## Manual design

# Educating the local population

*Learning from the past to design better*



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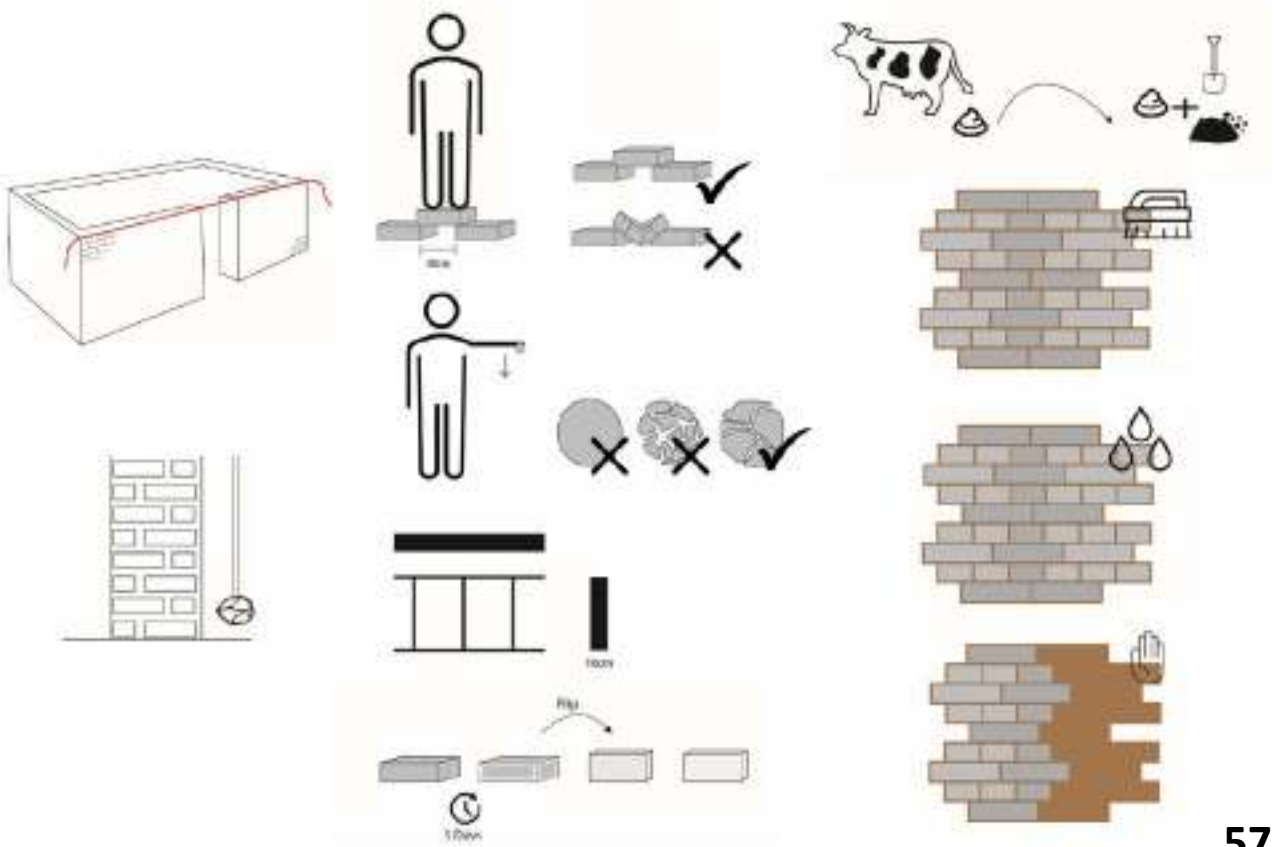
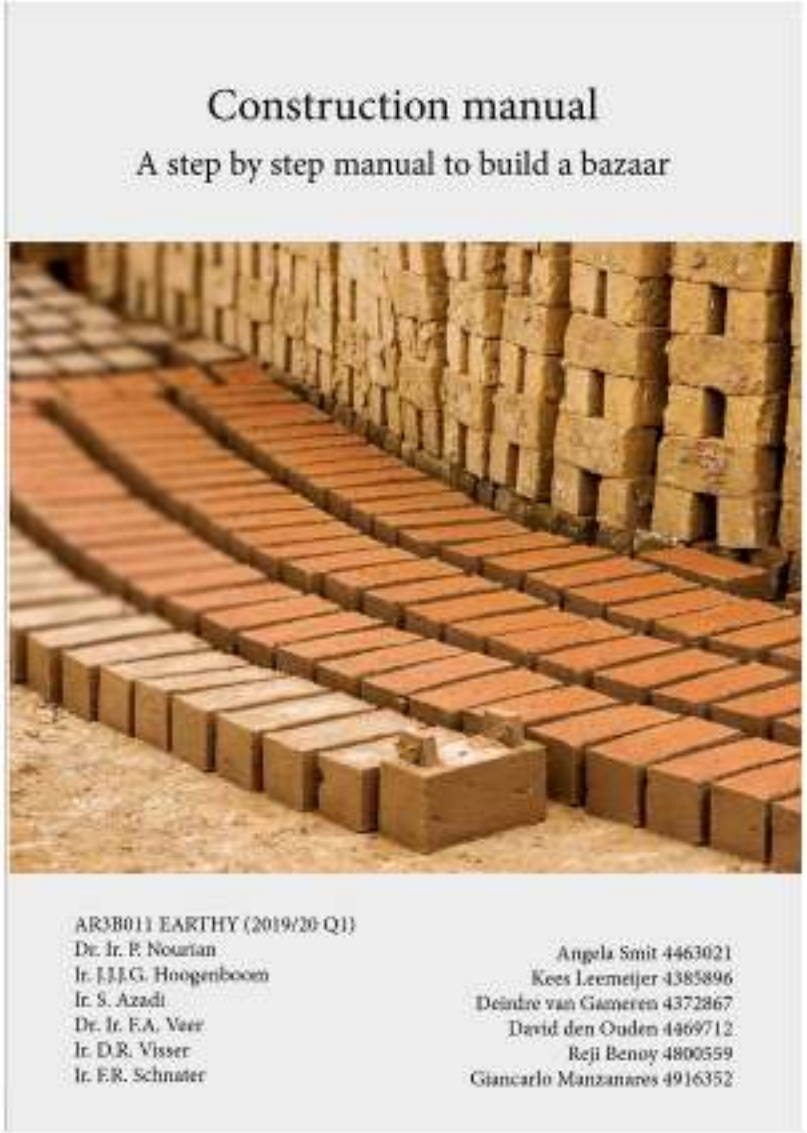
## Manual design

*helping the locals build the bazaar*



# Educating the local population

*Learning from the past to design better*



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## Manual design

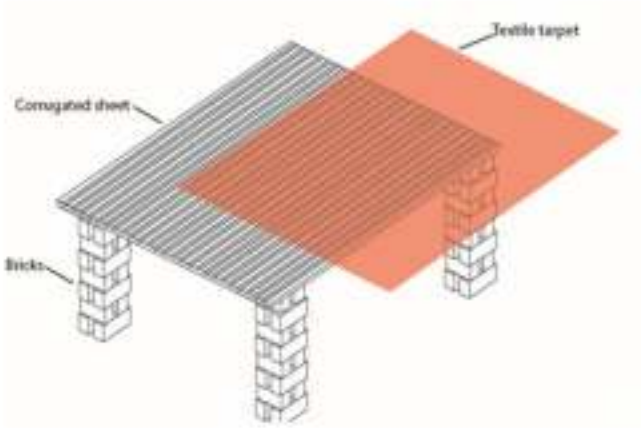
*Using local materials*

| | Sand/ clay | Rocks | Water | Corrugated sheet | Wood | Feathers | Cardboard | Straw | Textile | Inflatable mould |
|---|---|---|---|---|---|---|---|---|---|---|
| Source/ Owner | On/ around the site (Digging) | On/ around the site (Digging) | On the site (tap locations) | On the site (Roof of caravans) | On/ around the site (Very limited) | On/ around the site (e.g. chickens) | On the site (Waste) | On/ around the site | On the site (Waste) | On the site (Via Unicef) |
| Application purpose | Raw materials for bricks | Raw materials for bricks | Raw materials for bricks | Surface for scaffolding | Ladder for the brick moulds | Raw materials for bricks | Guideline for bricklaying windows/ doors | Raw materials for bricks | Protection inflatable mould | Support/ guideline for bricklaying domes/ vaults |

# Scaffolding

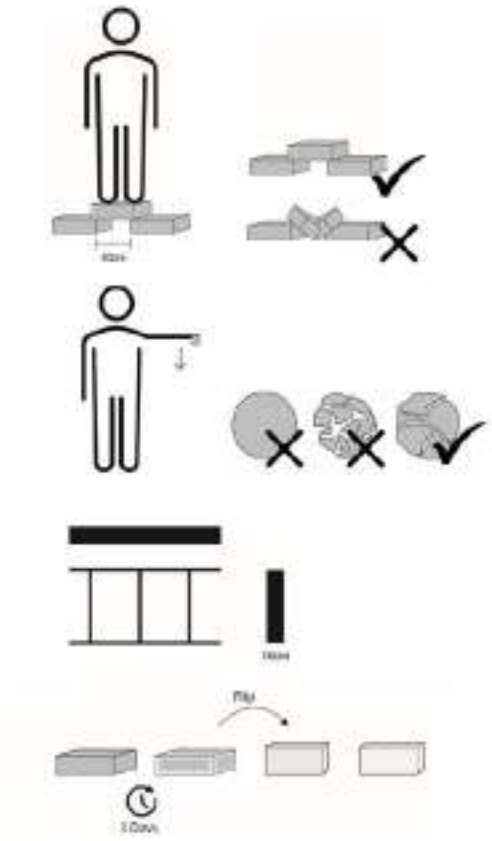
*Learning from the past to design better*

https://www.adobeinaction.org/event-calender/2019/7/8/adobe-wall-construction-online



# Making bricks

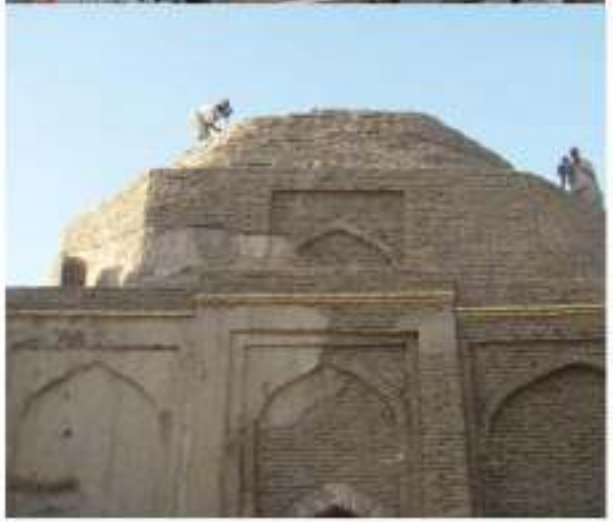
*Learning from the past to design better*

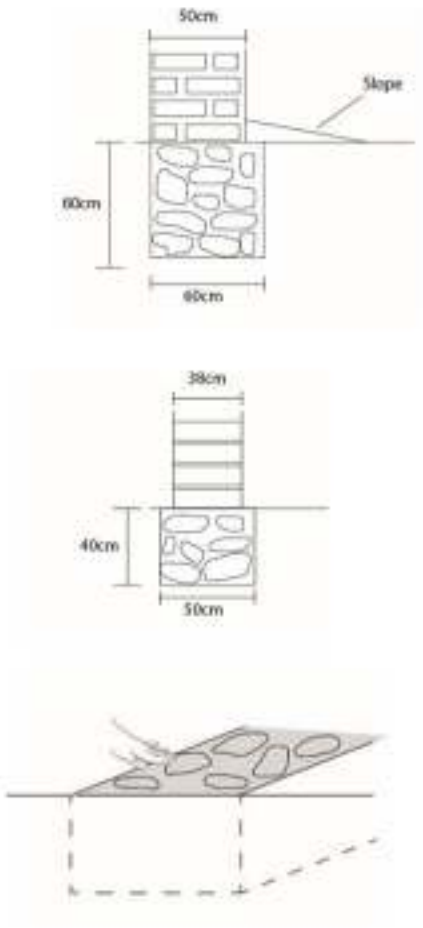


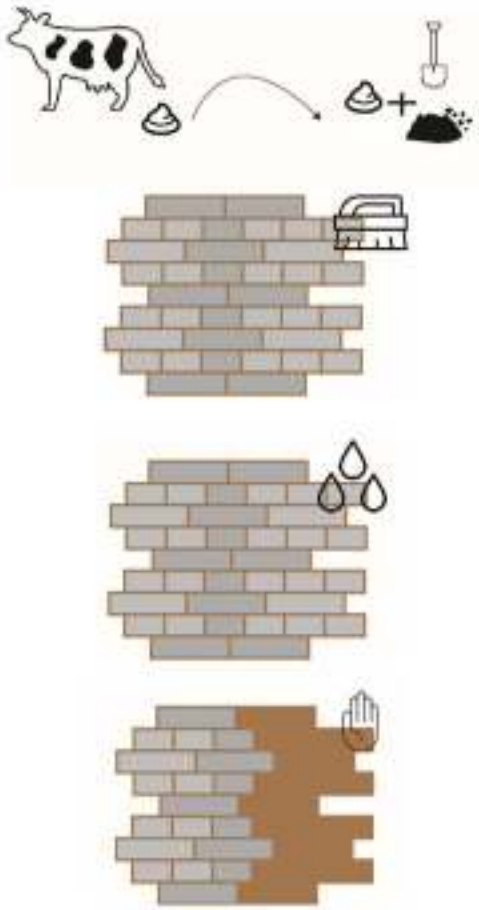
https://www.doityourself.com/stry/how-to-make-adobe-brick

# Waterproofing

*Learning from the past to design better*



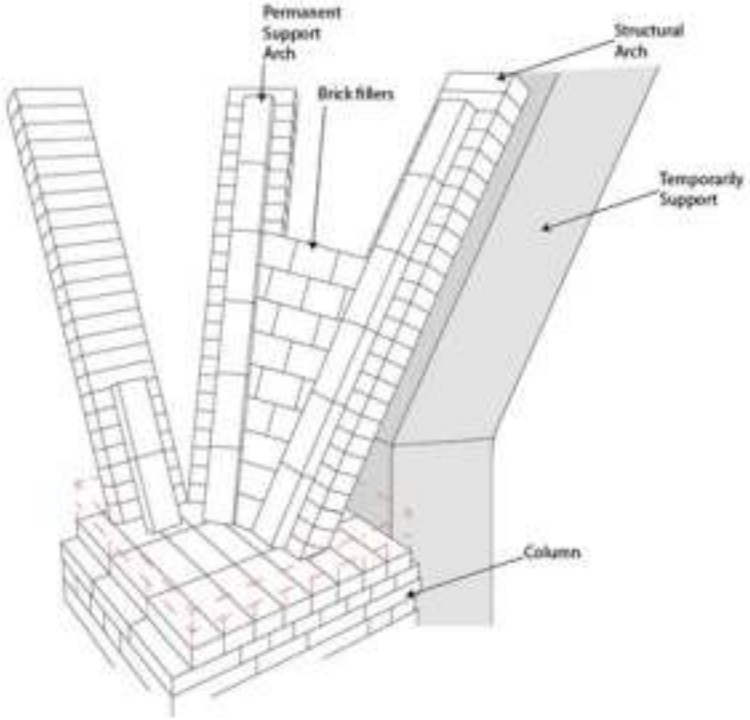


http://www.greenhomebuilding.com/articles/adobeiniran.htm
http://mit24h.com/156HRt8_8t986y5/

# Corner construction

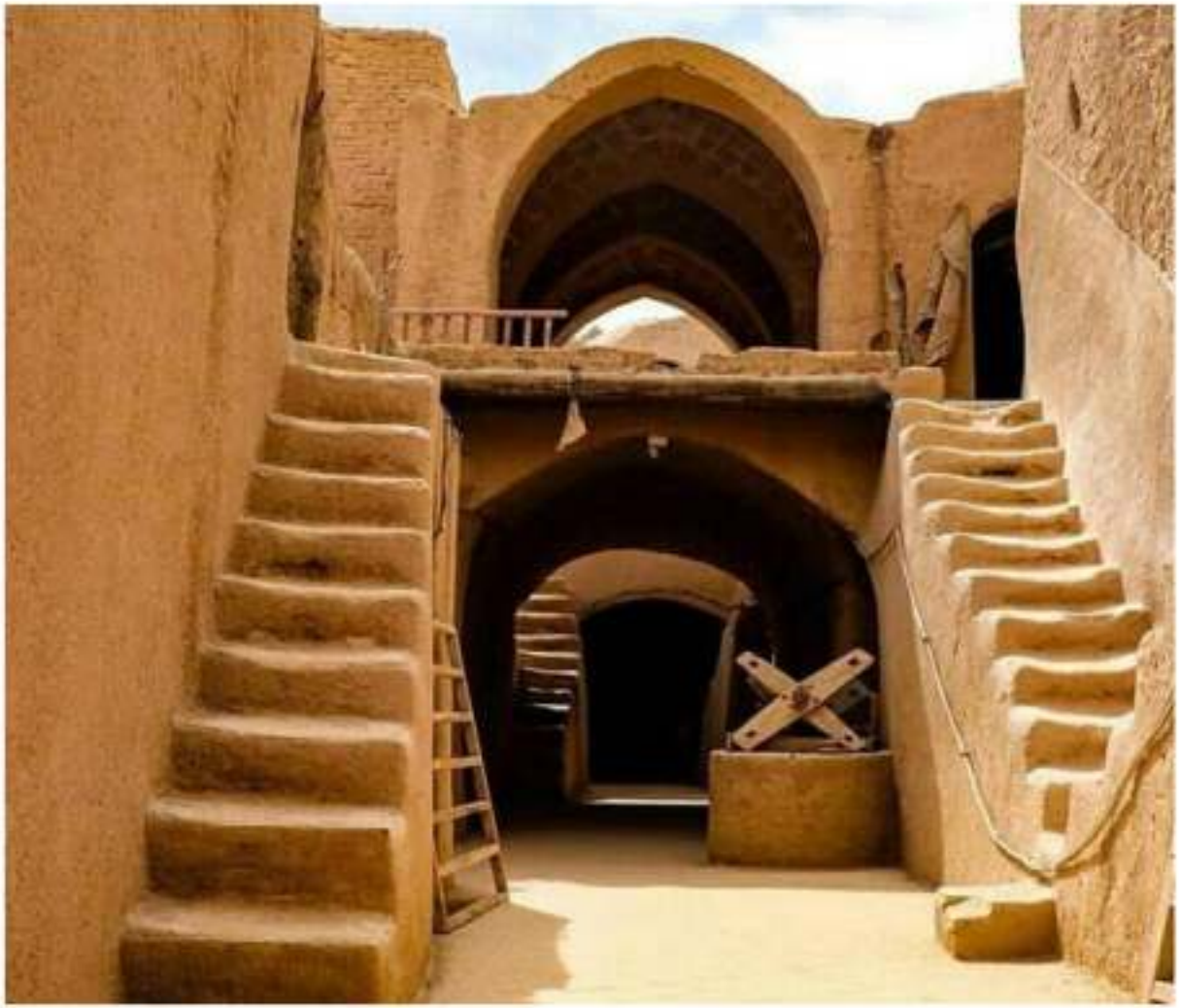
*Learning from the past to design better*

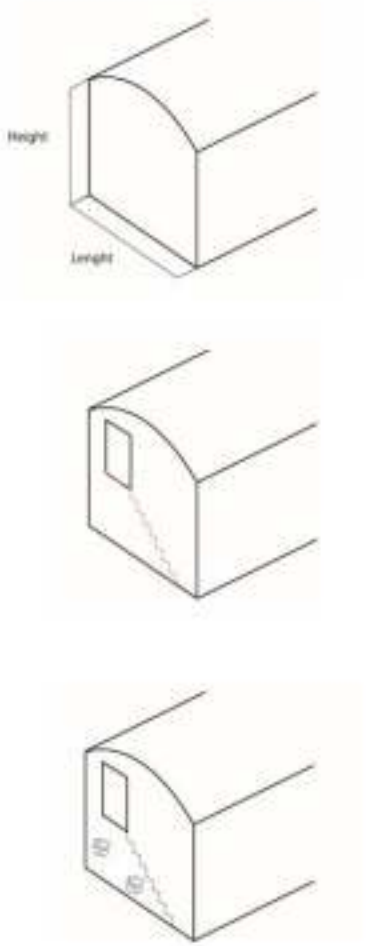



© James Bellamy

# Stair construction

*Learning from the past to design better*

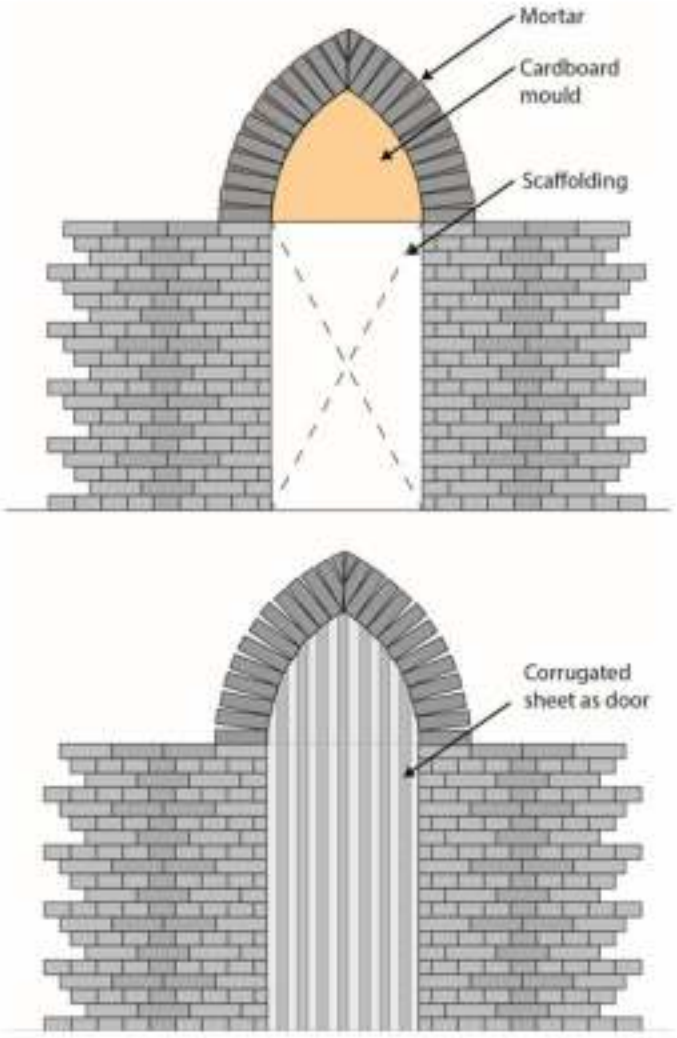





http://inboundpersia.com/dtext-48-yazd

# Sub-structure

*Learning from the past to design better*




Prof. Dr. Philippe Block from ETH Zurich

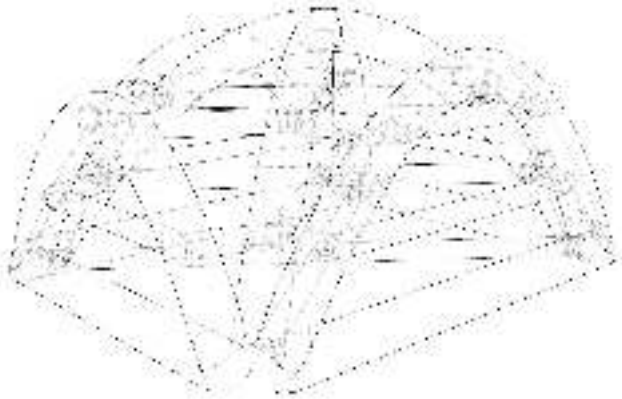
# Inflatable Sub-structure

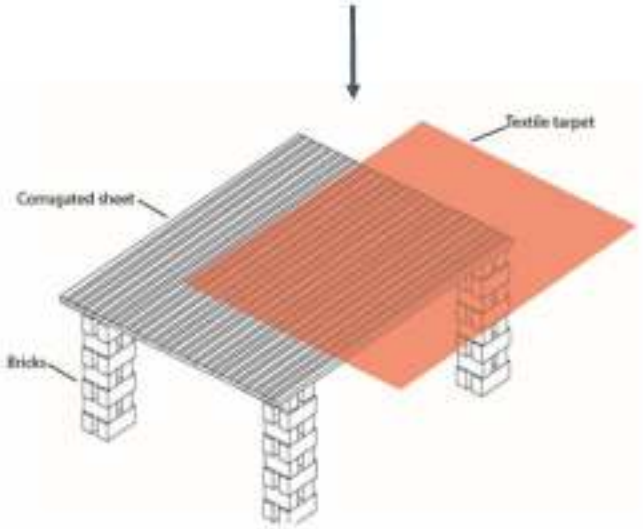
*Learning from the past to design better*

http://web.usm.my/jcdc/vol23_1_2018/jcdc2018.23.1.3.pdf

# Sub-structure

*Learning from the past to design better*

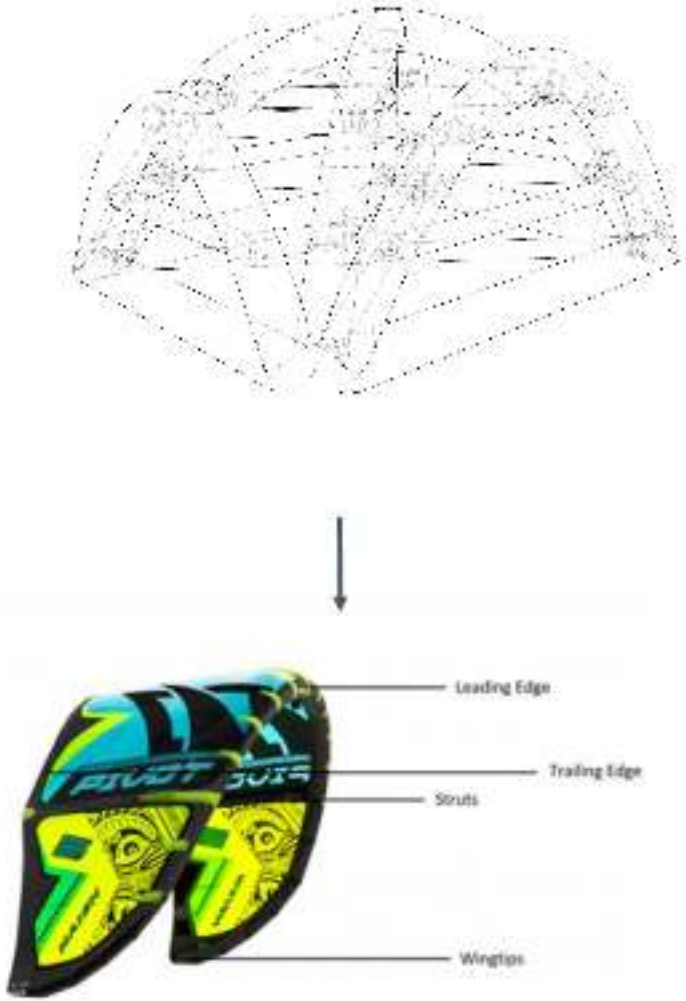





Prof. Dr. Philippe Block from ETH Zurich

# Sub-structure

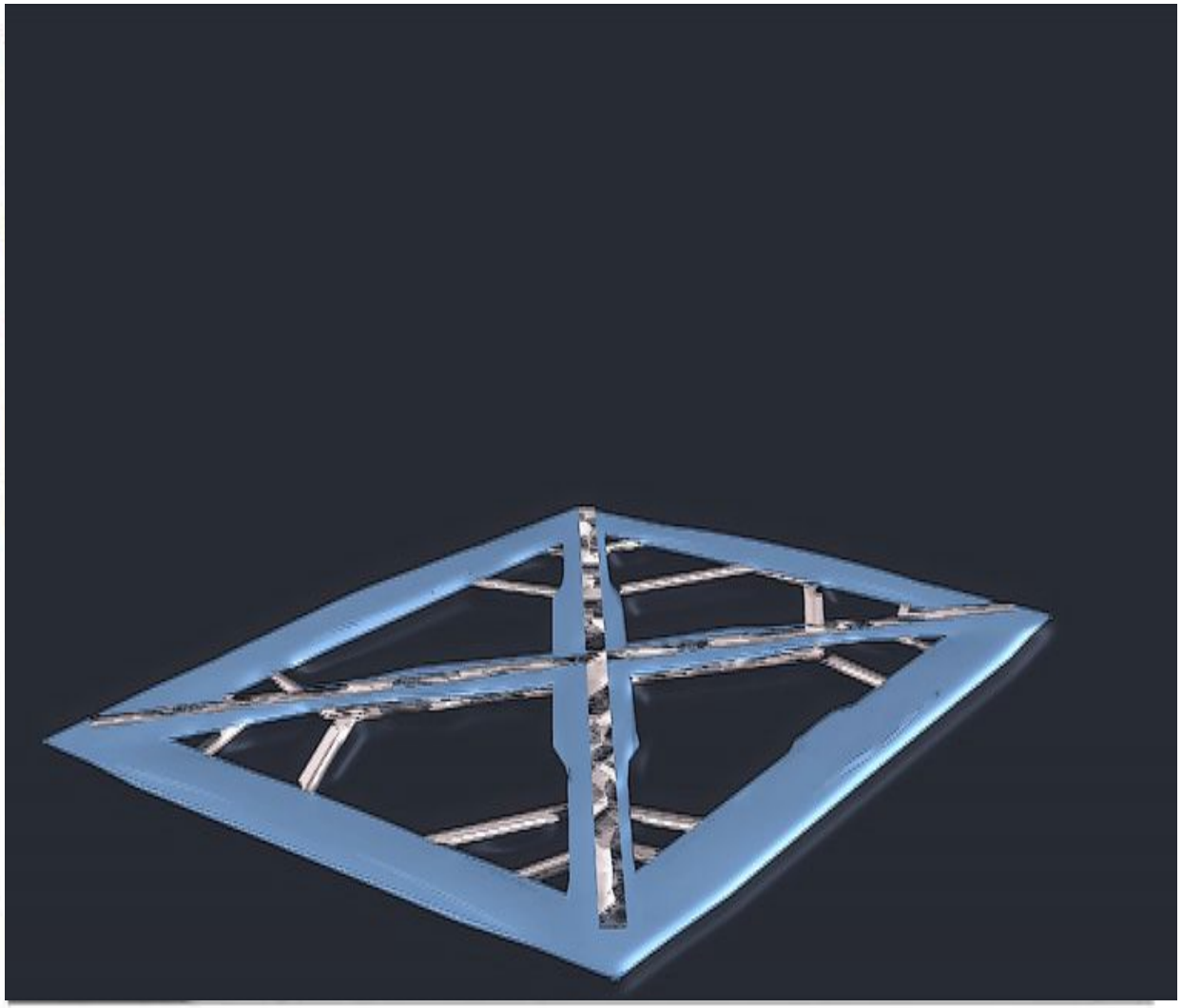
*Learning from the past to design better*

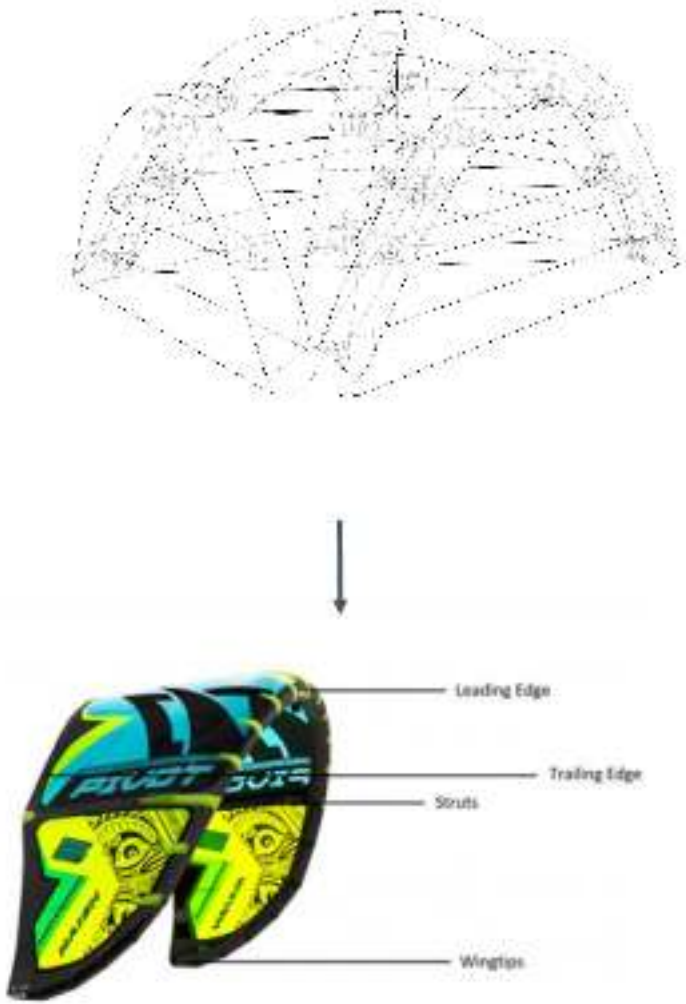



Prof. Dr. Philippe Block from ETH Zurich

# Sub-structure

*Learning from the past to design better*





Designing vaults with adobe

Learning from the past to design better

**Designing a method, modular and applicable**

# Urban Guidelines

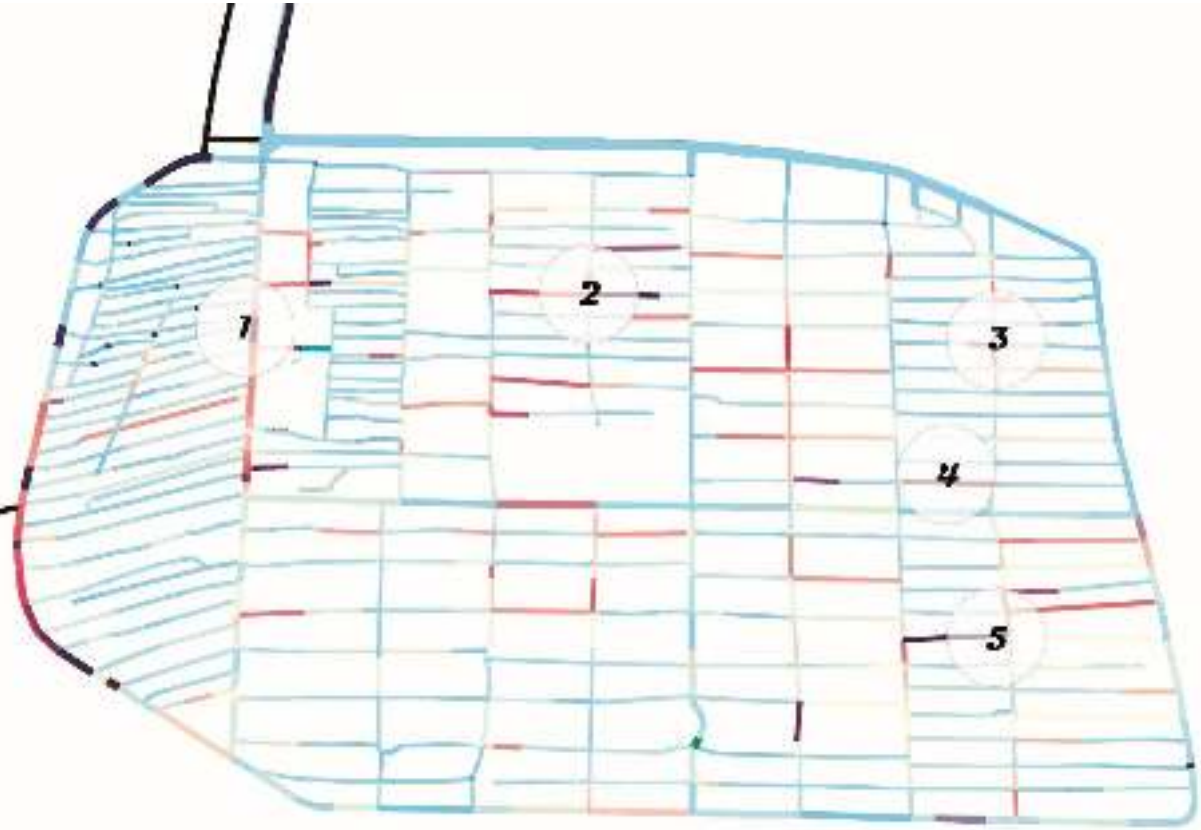
*Designing a method, modular and applicable*

# Betweenness centrality

*Designing a method, modular and applicable*

**Rules:**
-No cars aloud
-Access to water
-Near to a Mosque
-Near a logistical point
-The map

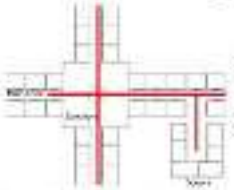
Decided between 2-3-5
**Chosen location: 2**
-> Near highest density camp



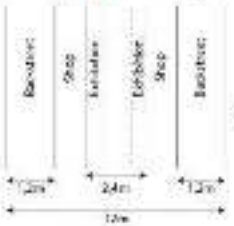
# Bazaar guidelines

*Designing a method, modular and applicable*

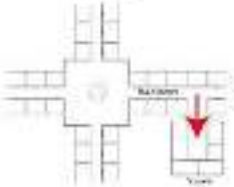
## Bazaar guidelines



Main street connects junction and square



Street lay-out



Square parallel to main street

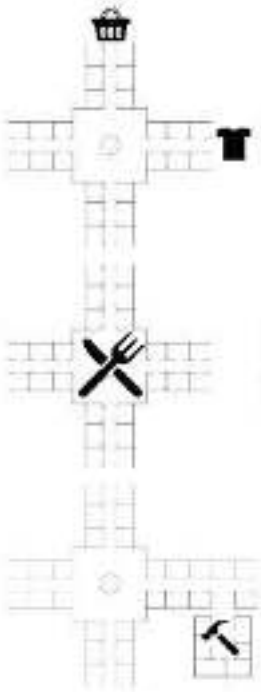
Cluster similar functions

Noise/ dust pollution shops not near community/ food

# Bazaar guidelines

*Designing a method, modular and applicable*

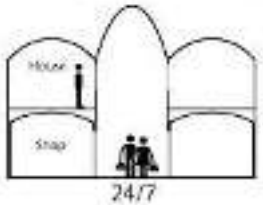
## Bazaar guidelines



Food & Merchandise in the street

Community around junction or square

Workshop in square

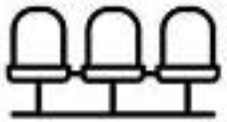



Social control

Space for housing above shops

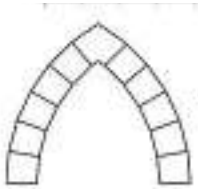
## Bazaar guidelines

Backdoor in every shop



Public seatings in junction/ square

Community seatings in Junction



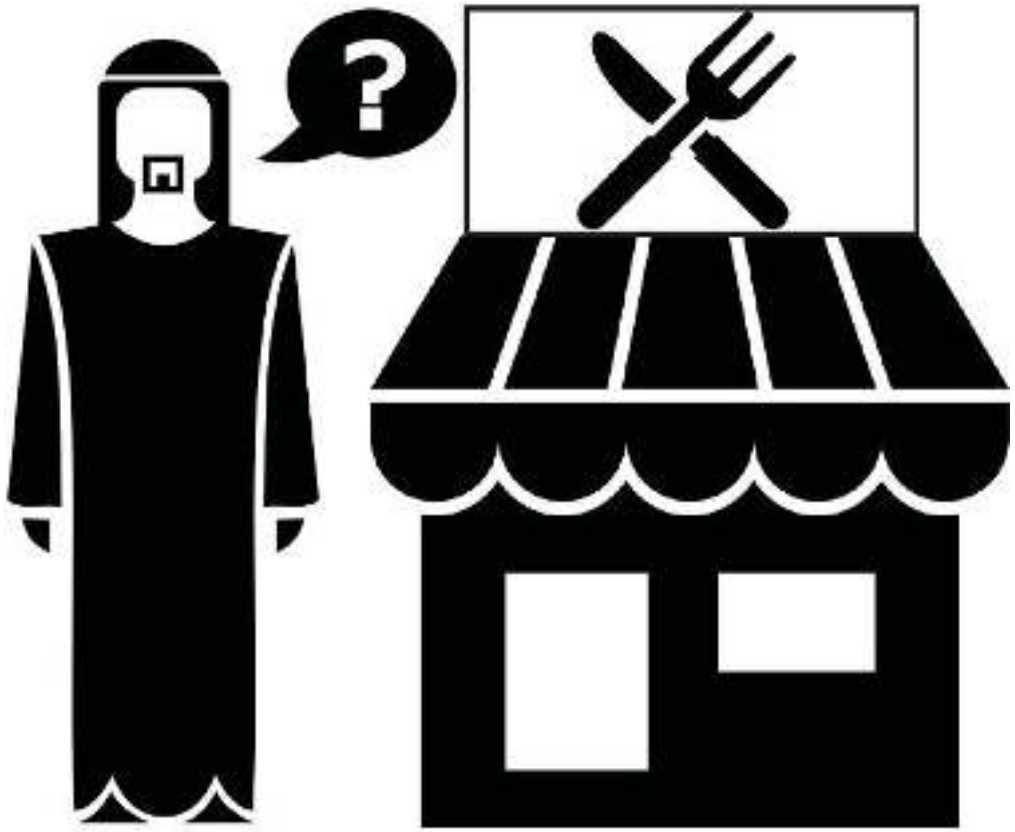
Rib arch structure

Inflated roof support structure

Cardboard window support structure

# User interface, an app

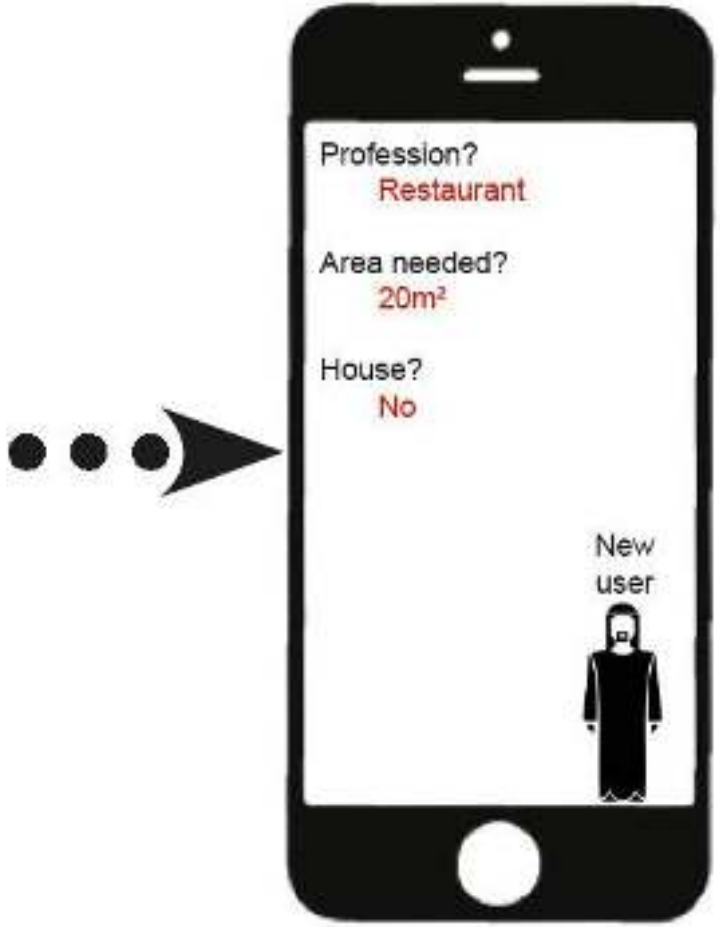
*Designing a method, modular and applicable*



1 Kazem wants a restaurant

# User interface, an app

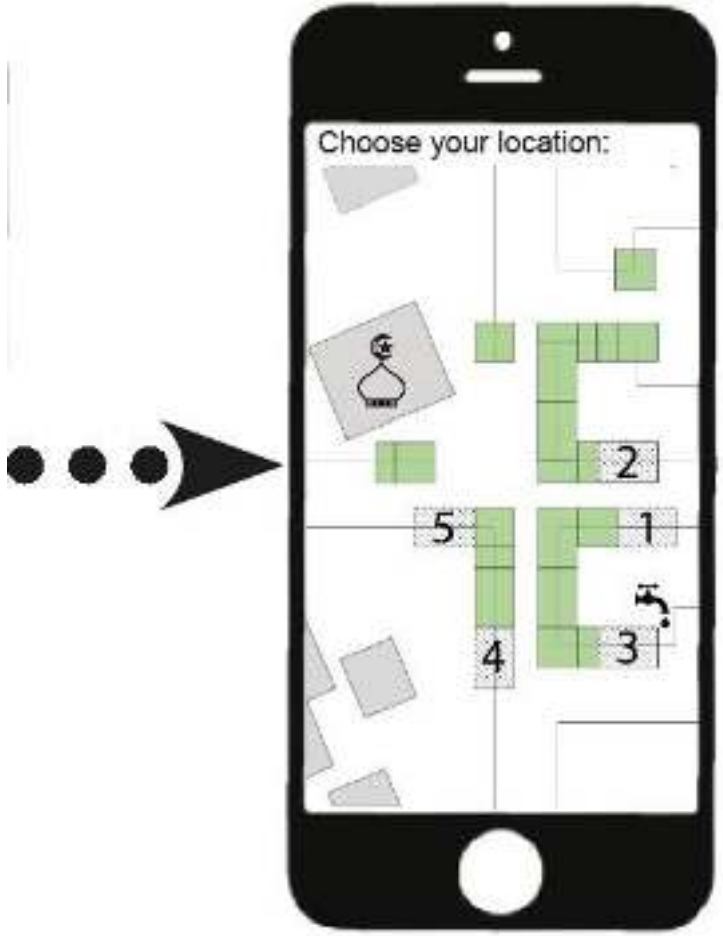
*Designing a method, modular and applicable*




2 Kazem enters requirements

# User interface, an app

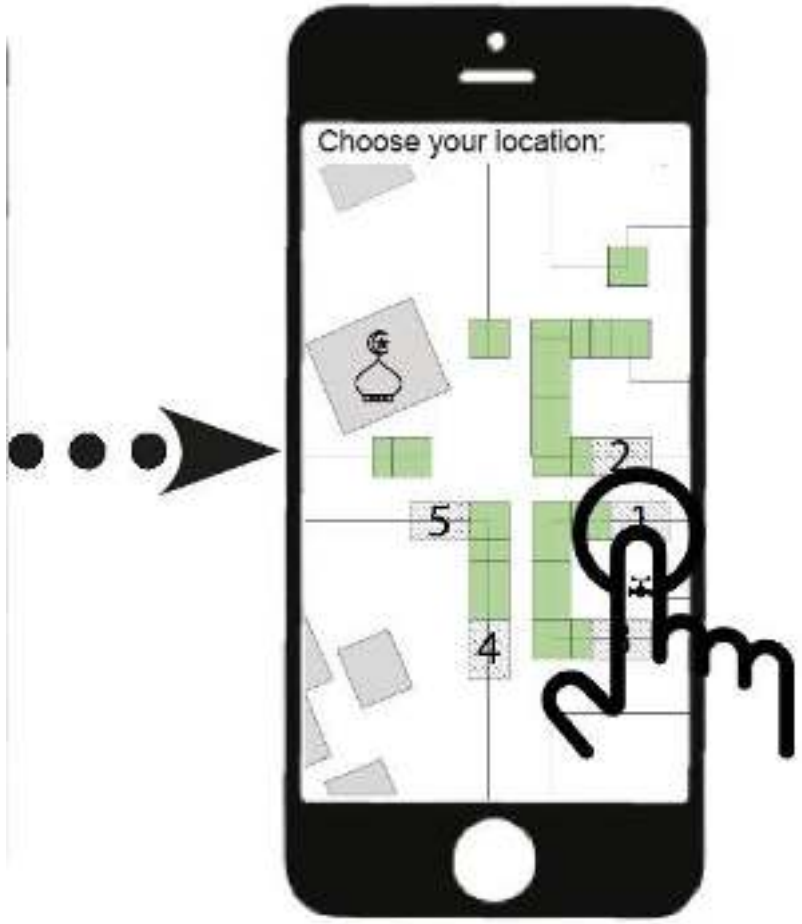
*Designing a method, modular and applicable*




3 App generates locations

# User interface, an app

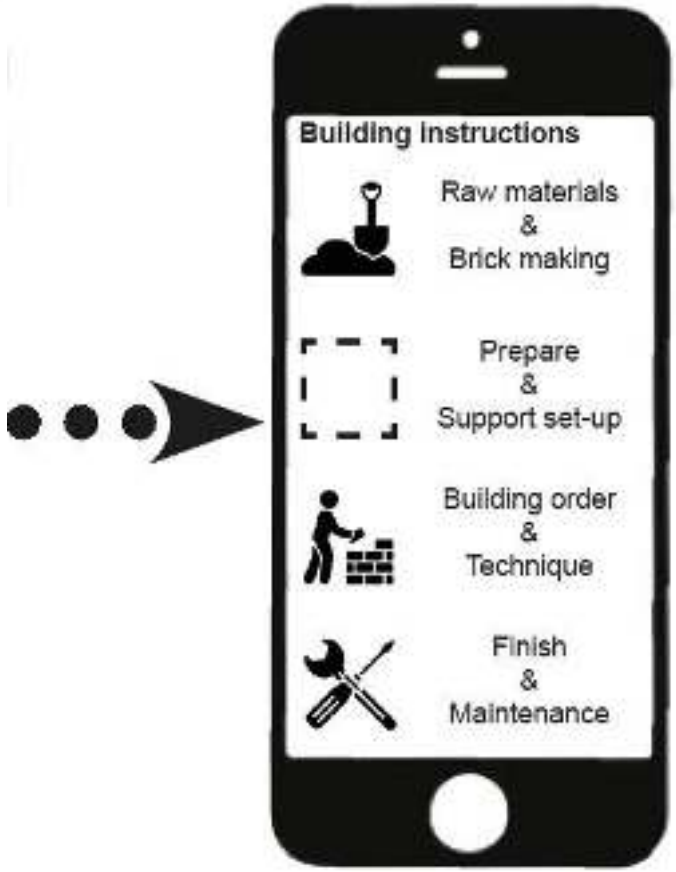
*Designing a method, modular and applicable*




4 Kazem chooses a location

# User interface, an app

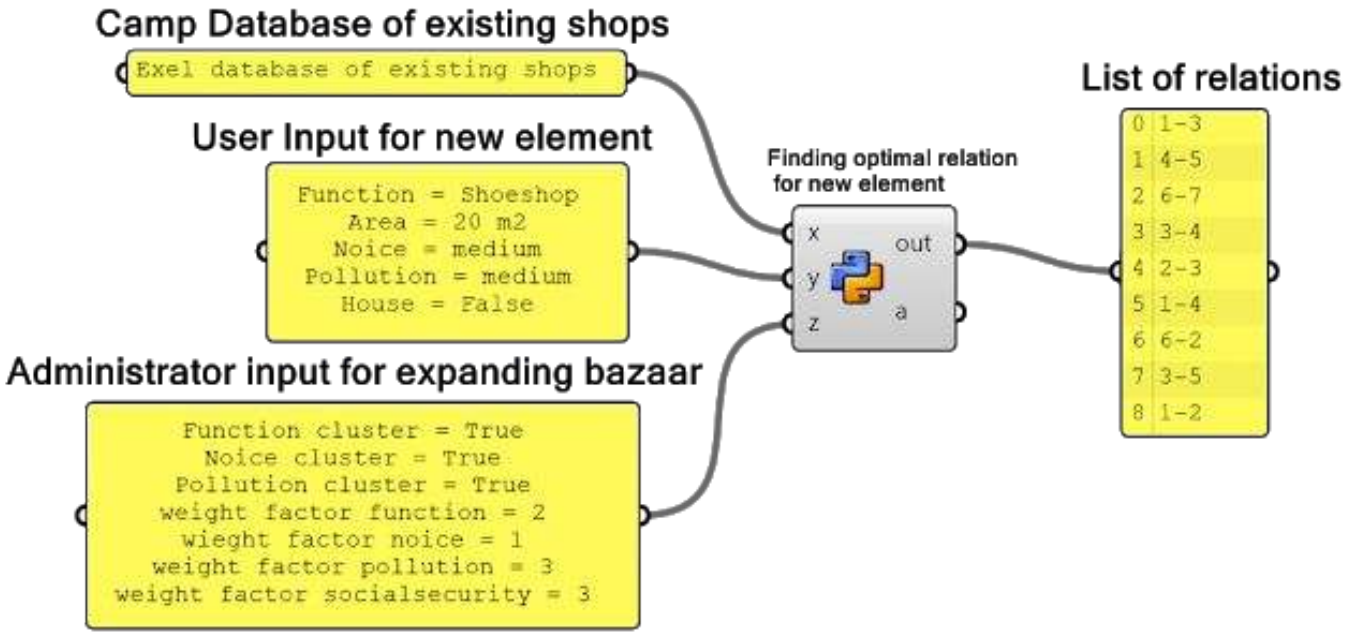
*Designing a method, modular and applicable*




5 Constructers receive assignment

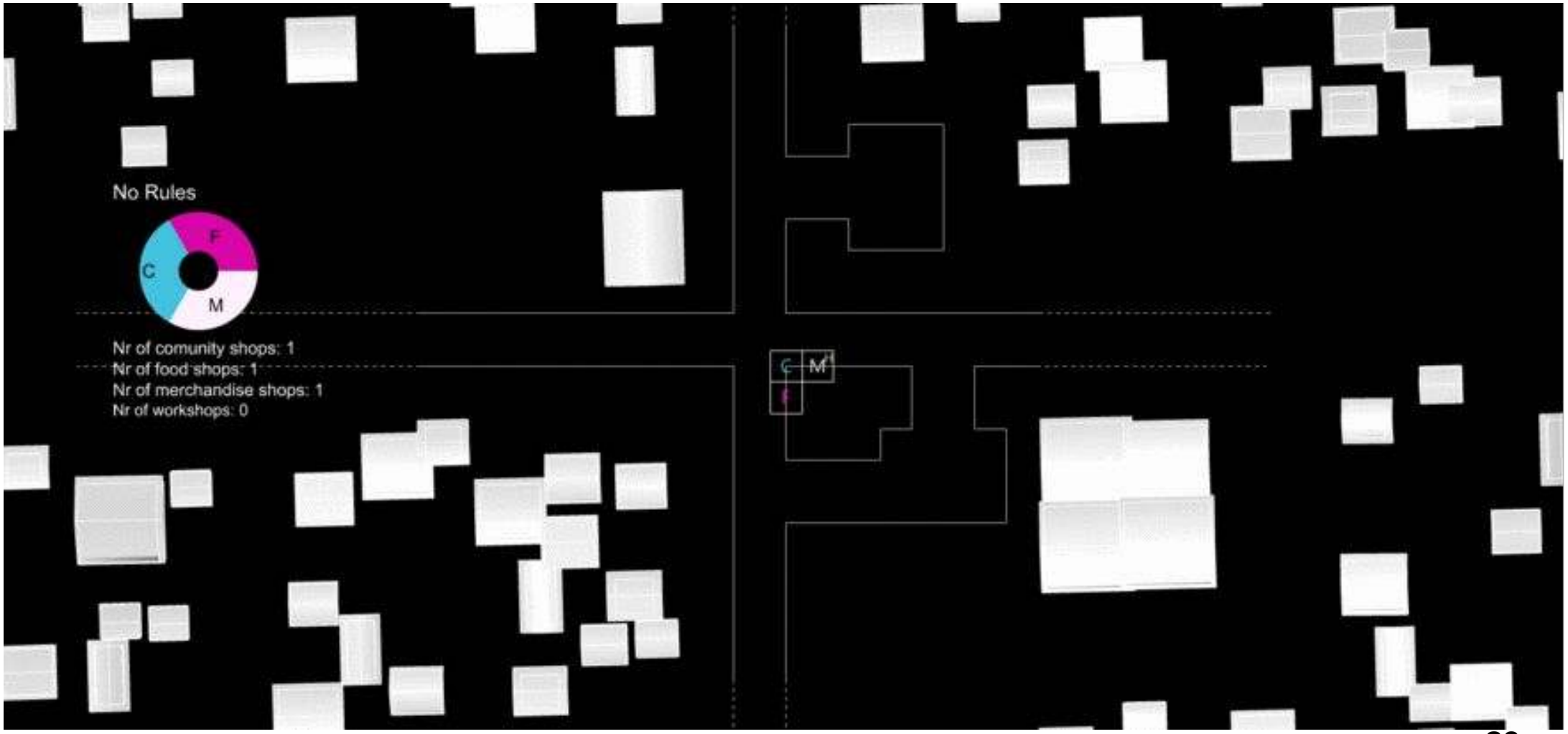
# Implementing the guidelines for growing the bazaar in a computational way

*Designing a method, modular and applicable*



# Using python and shop objects to visualize the growing bazaar

*Designing a method, modular and applicable*

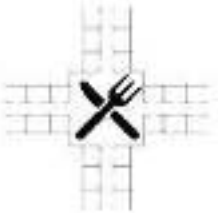


# How to implement the guidelines?

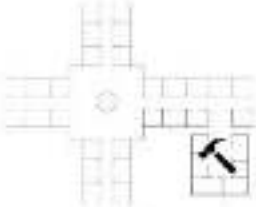
*Designing a method, modular and applicable*

Cluster similar functions

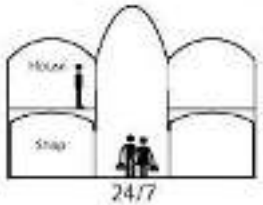
Noise/ dust pollution shops not near community/ food



Community around junction or square



Workshop in square



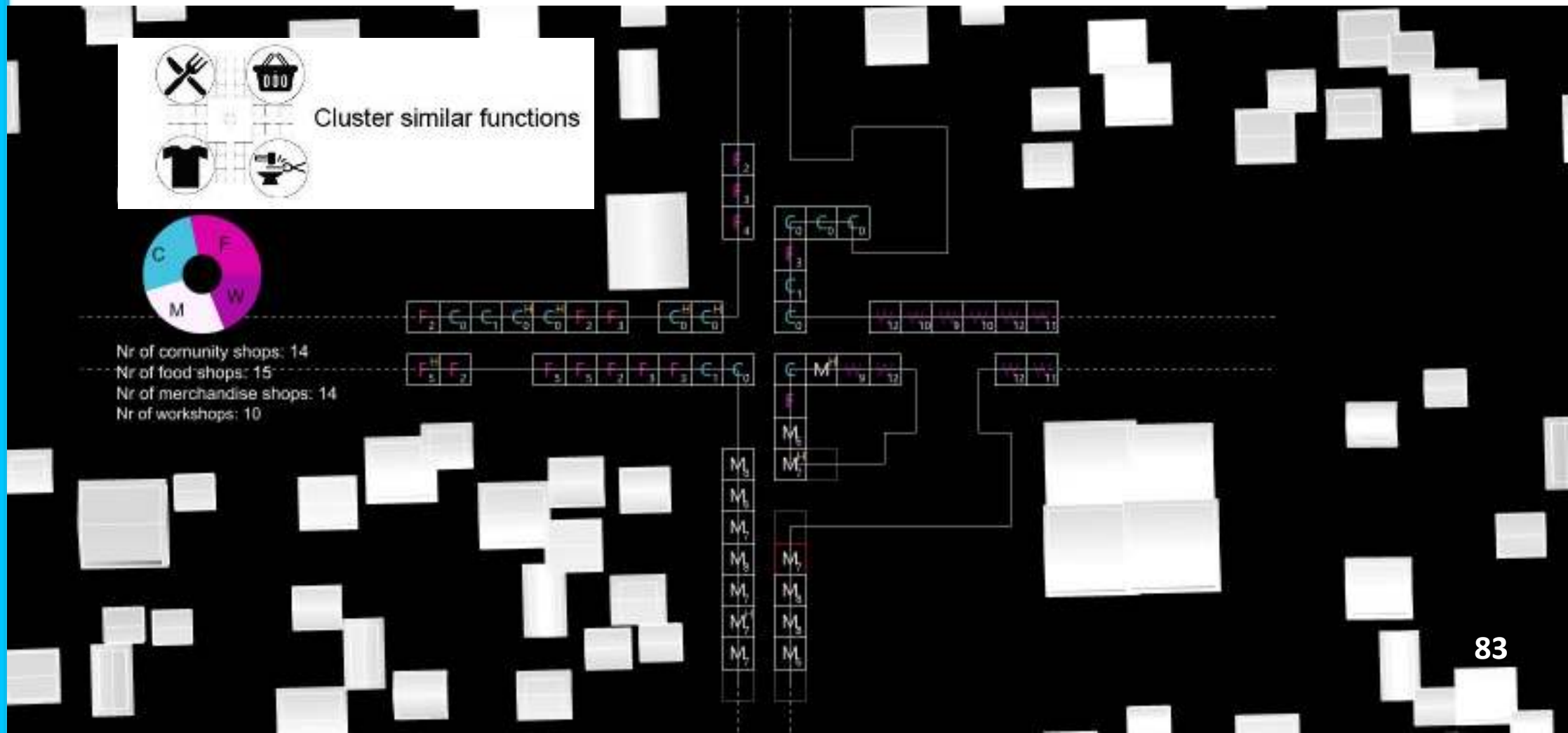

Social control

# Clustering similar functions

*Designing a method, modular and applicable*

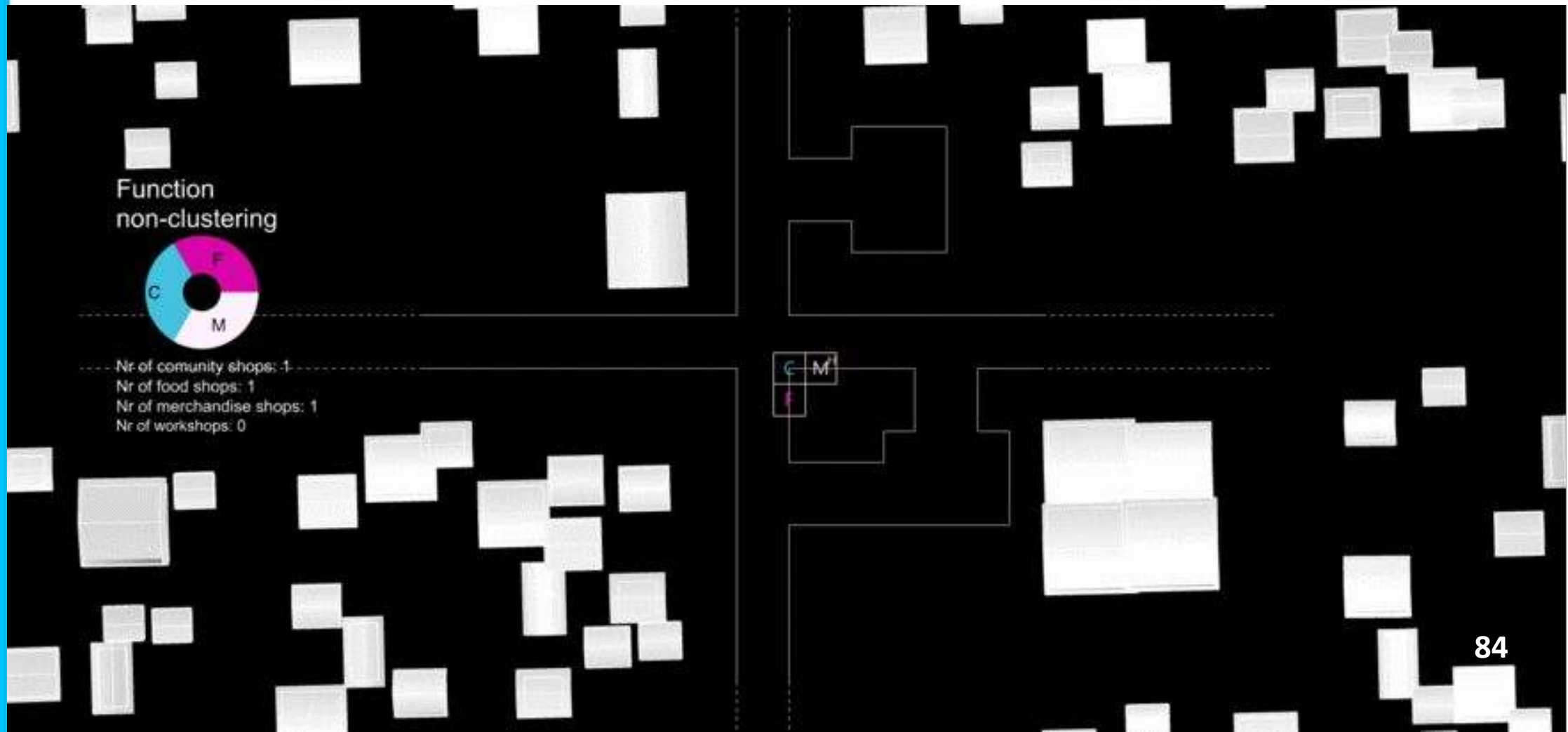
# Clustering similar functions

*Designing a method, modular and applicable*



# Or maybe they go mixed?

*Designing a method, modular and applicable*



# Or maybe they go mixed?

*Designing a method, modular and applicable*

# Clustering the houses

*Designing a method, modular and applicable*

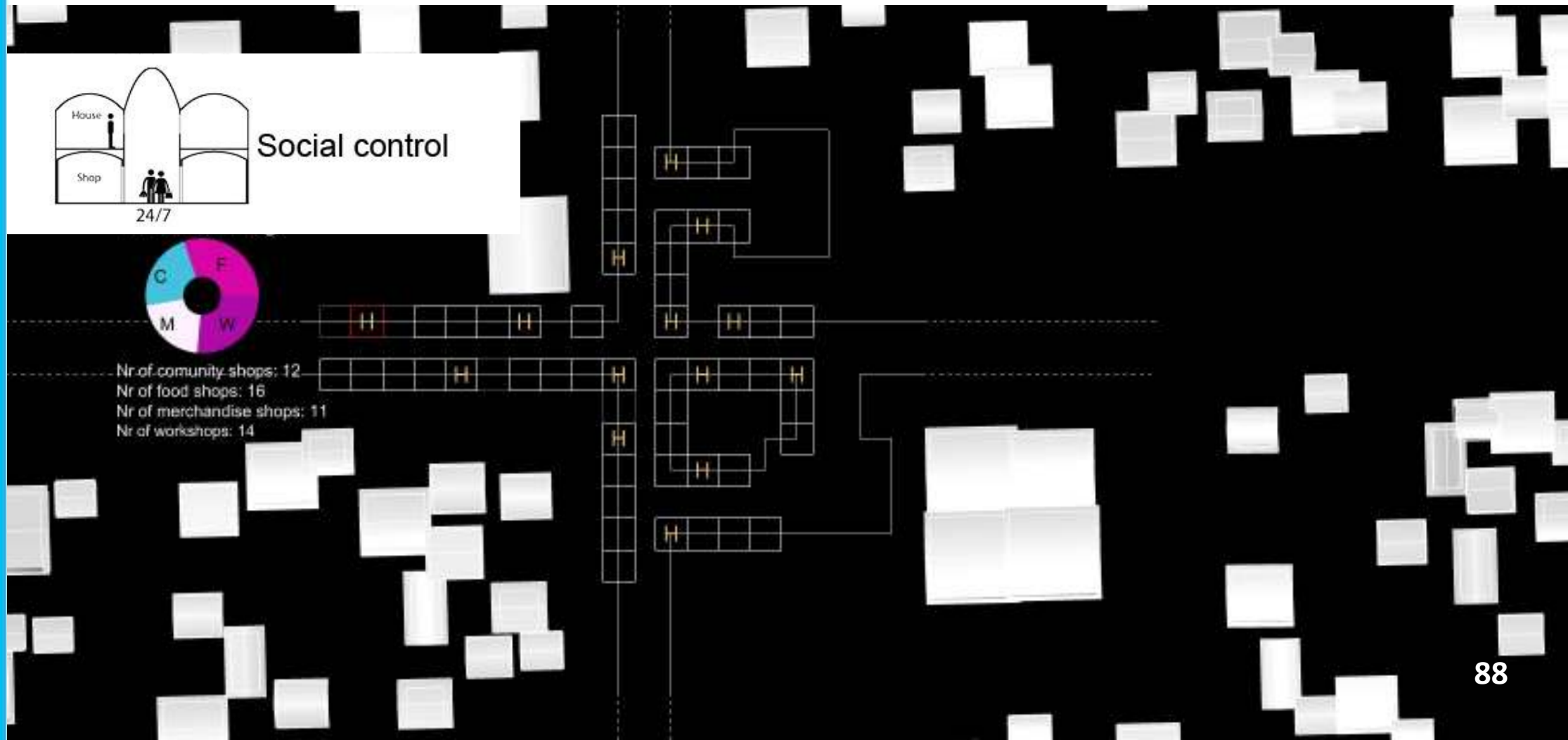
*However this is not wanted due to social security*

# Spreading houses for social control

*Designing a method, modular and applicable*

# Spreading houses for social control

*Designing a method, modular and applicable*

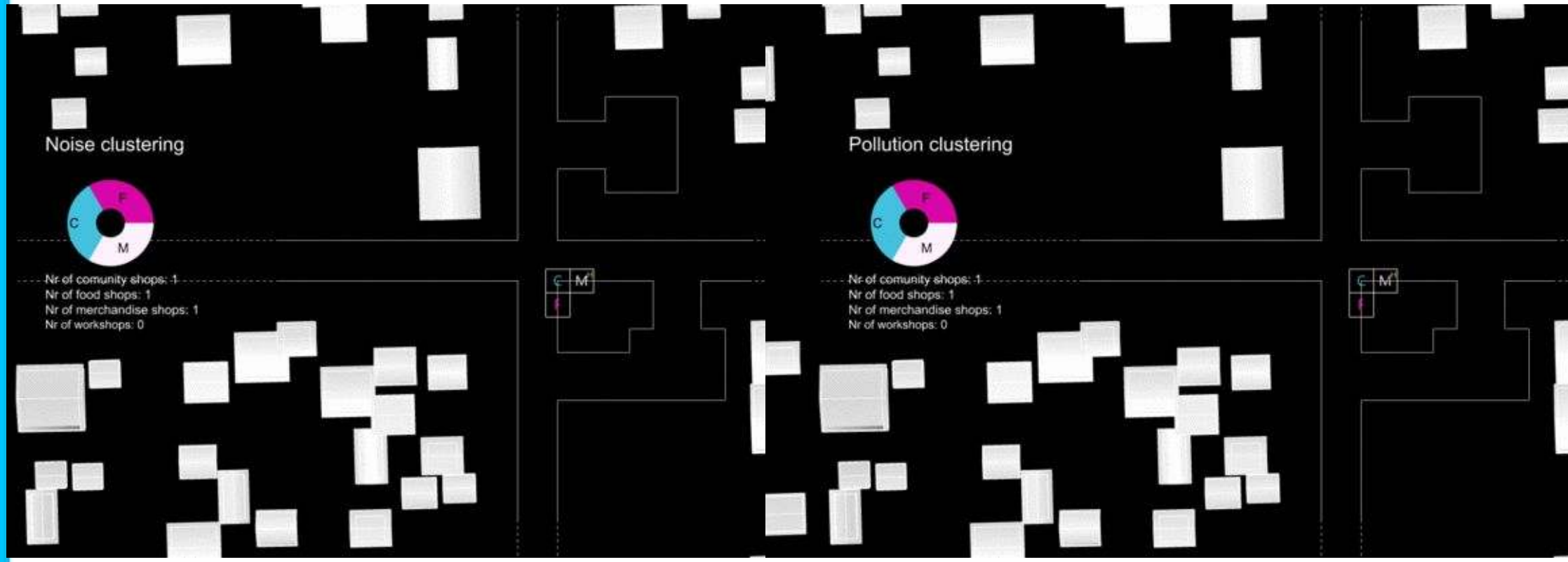


# Noise and pollution clustering

*Designing a method, modular and applicable*

*Noise clustering*

*Pollution clustering*



# Rules become guidelines

*Designing a method, modular and applicable*

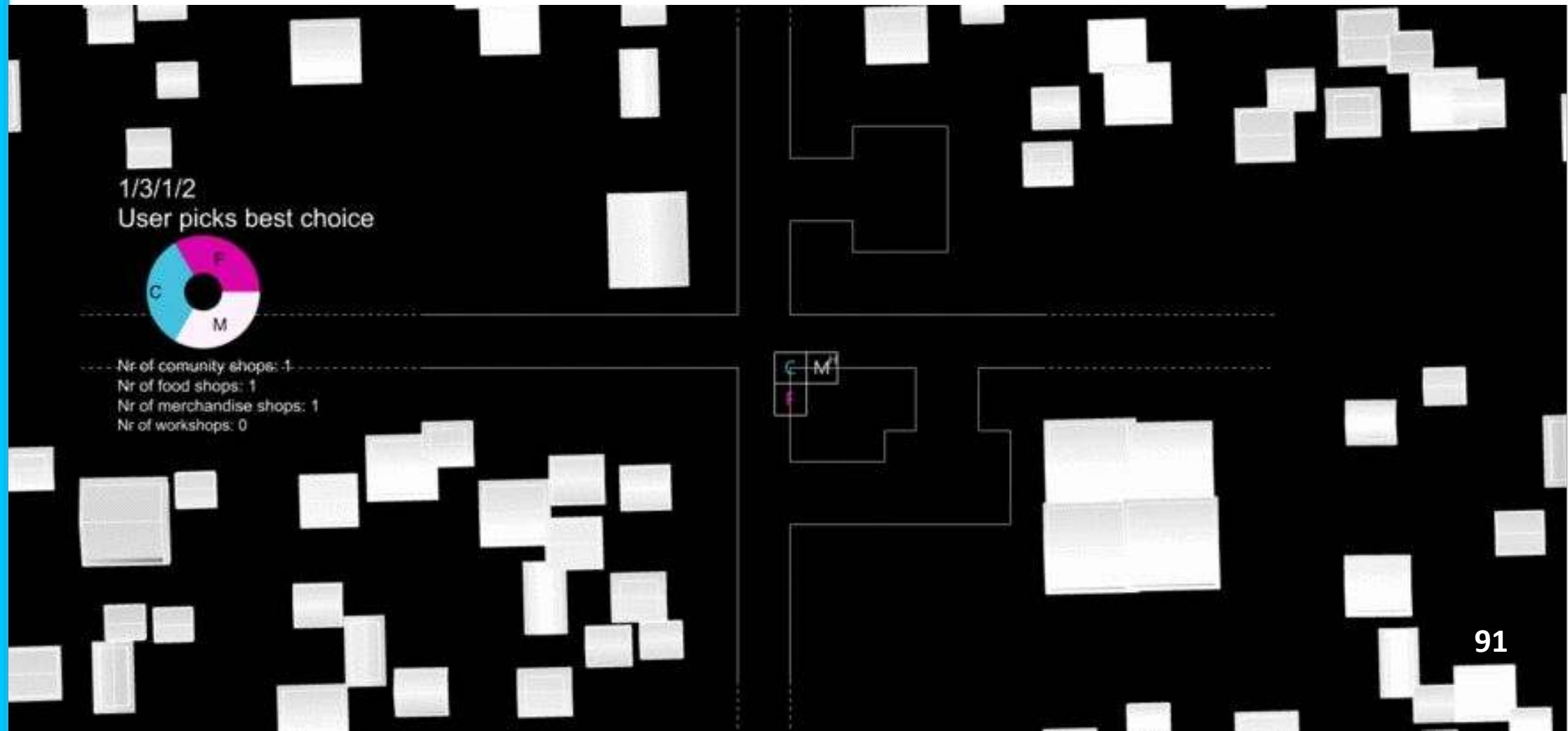
-User has the opportunity to choose a spot of his liking out of a list off top spots.

-These are a maximum of 5 spots highlighted in gray

-However, the more freedom a user is allowed the more the guidelines start to fade

# Scenario: user always picks best choice

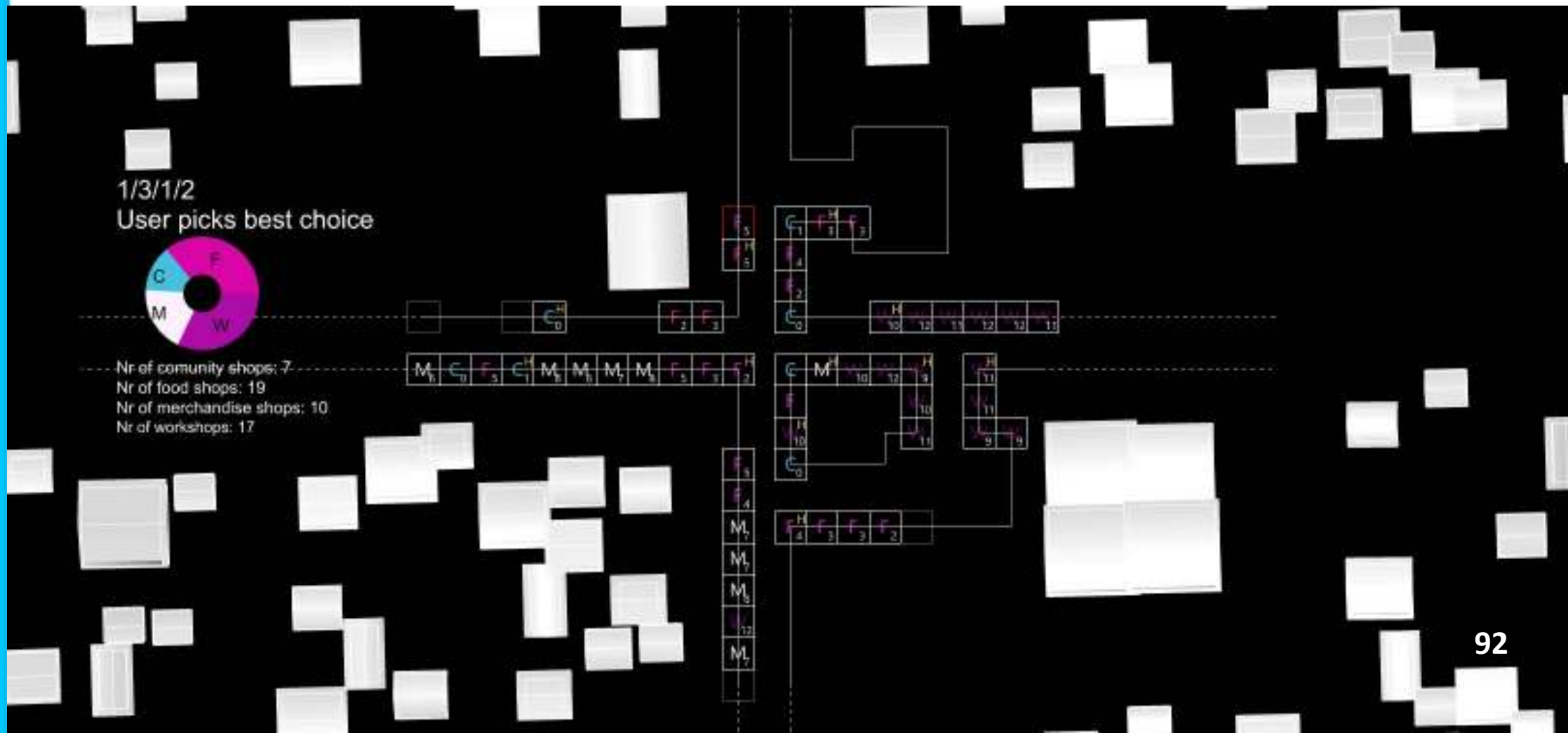
*Designing a method, modular and applicable*



# Scenario: user always picks best choice

*Designing a method, modular and applicable*

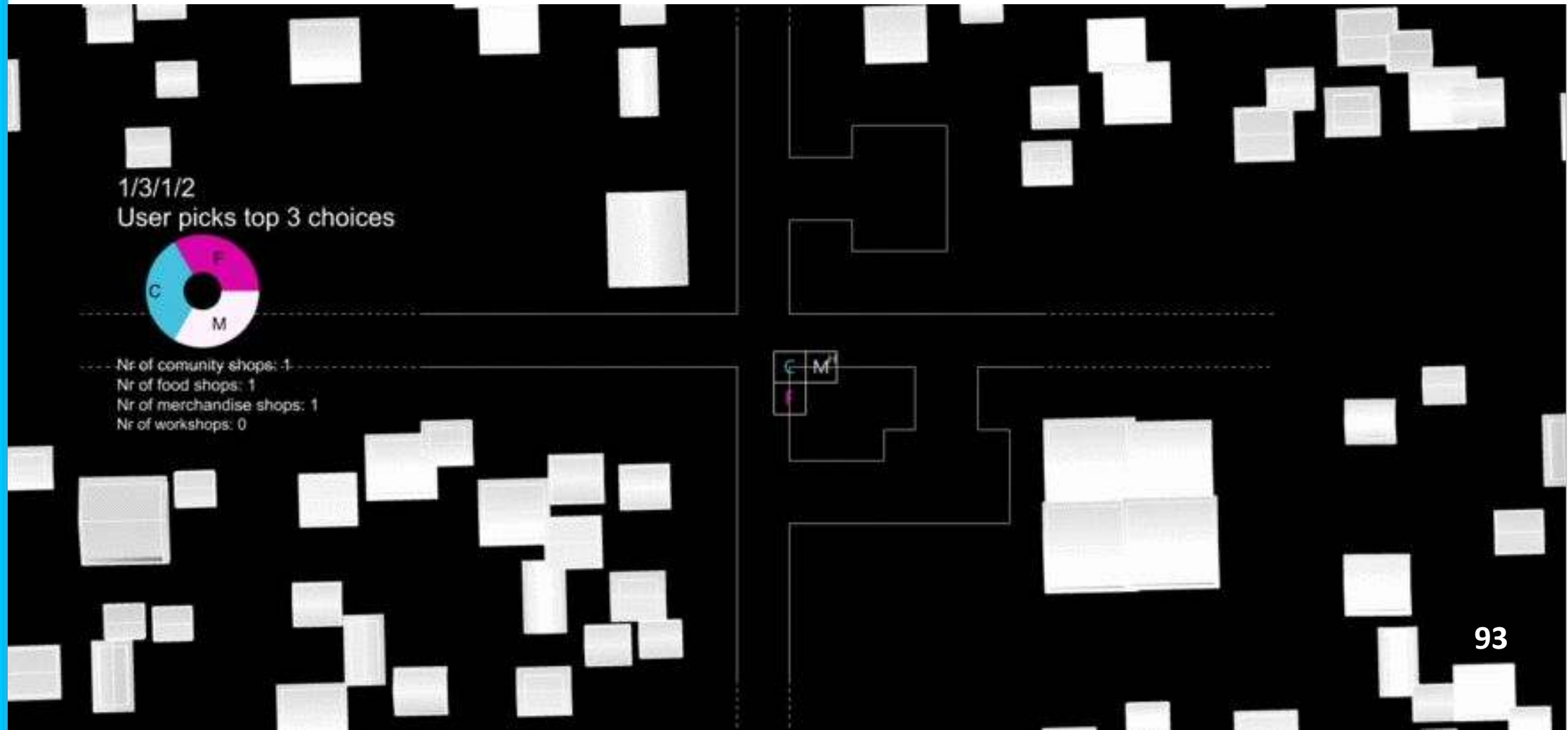
*You can see that the clustering works for the shops and the non clustering for the housing.*



# Scenario: user always picks from top 3 choices

*Designing a method, modular and applicable*

*Giving the people a choice, instead of obligate them to pick the best shop*



# Scenario: user always picks from top 3 choices

*Designing a method, modular and applicable*

*Shops are less clustered*

# Scenario: user always picks from top 3 choices

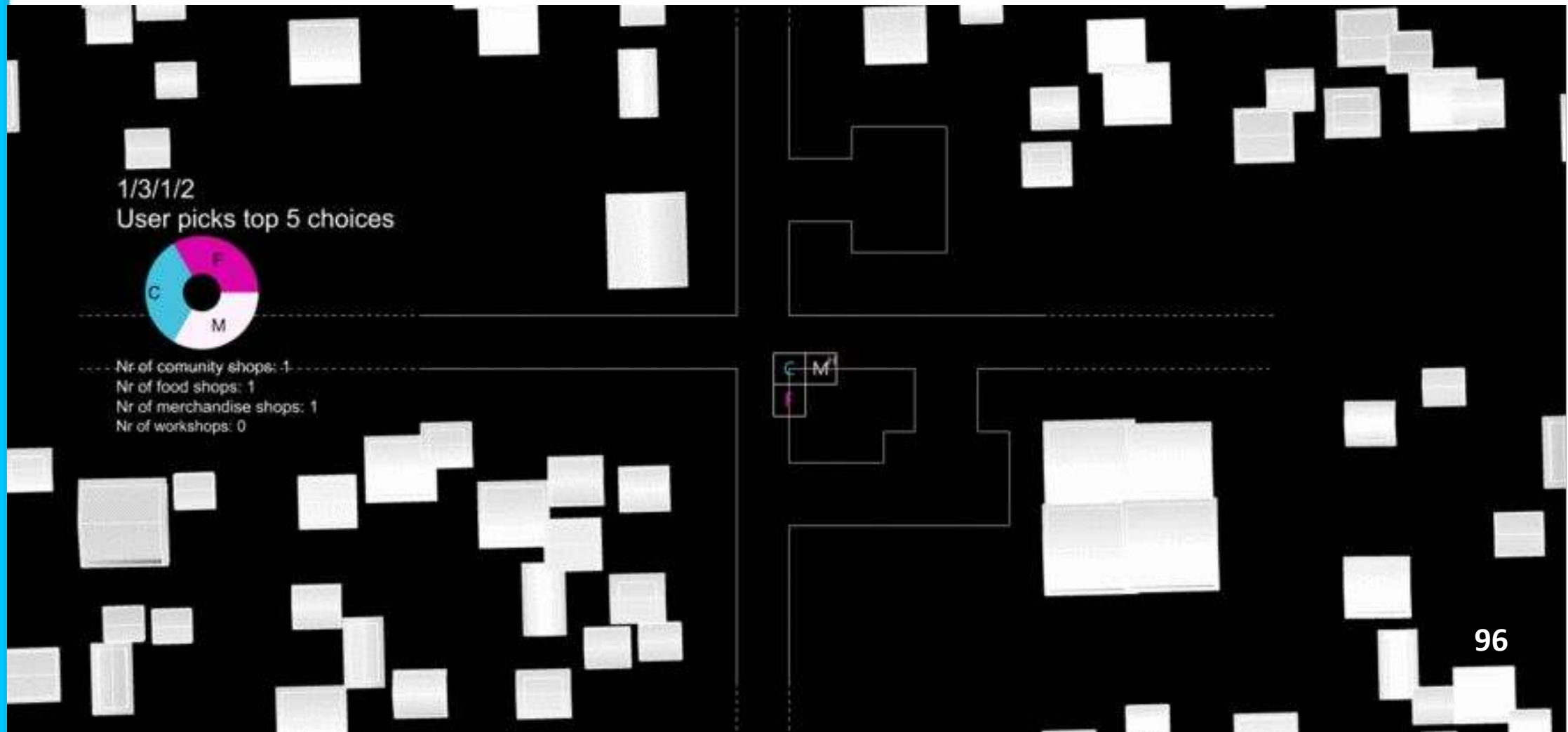
*Designing a method, modular and applicable*

*Due to clustering the new (red) M should be placed in the North. However the shop owner picked to place it at the South.*

# Scenario: user always picks any choice

*Designing a method, modular and applicable*

*When giving more choices...*



# Scenario: user always picks any choice

*Designing a method, modular and applicable*

*….less clustering can be seen*

Can the user also choose a size?

# Scenario: user can choose multiple sizes

*Designing a method, modular and applicable*

*Going from one size shop to 3 size shops, Small, Medium, Big.*

# Scenario: user can choose multiple sizes

*Designing a method, modular and applicable*

*Different scenario*

# Scenario: user can choose multiple sizes

*Designing a method, modular and applicable*

# What can the script do?

*Designing a method, modular and applicable*

- Calculate the most optimal spot for a shop depending on admin and user input.
- This is based on distance, noise, function, pollution and social security

-Three different sizes shops can be chosen

-The top 5 locations can be offered

-identify junctions and give community shops priority there

-identify squares and give community workshops priority there

-Visualize

# What can the script not do?

*Designing a method, modular and applicable*

- The script can not connect the junction and street perfectly, the junction should be bigger

- Walkways are not added

-Due to the way the shopsizes are arranged, they will not match perfectly

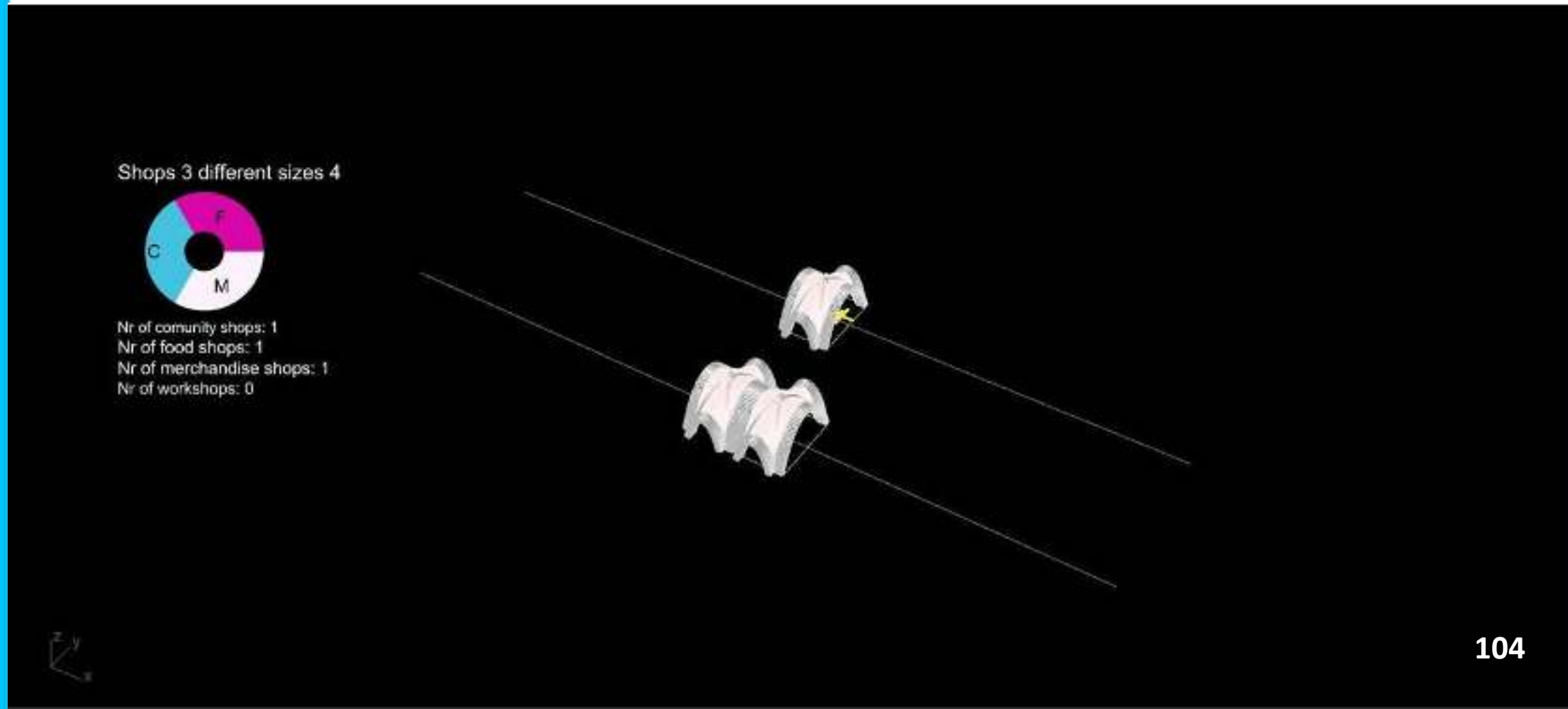
-Script does not prioritise finishing both sides of street

-Script could be written more efficient

# The script combined with the actual design

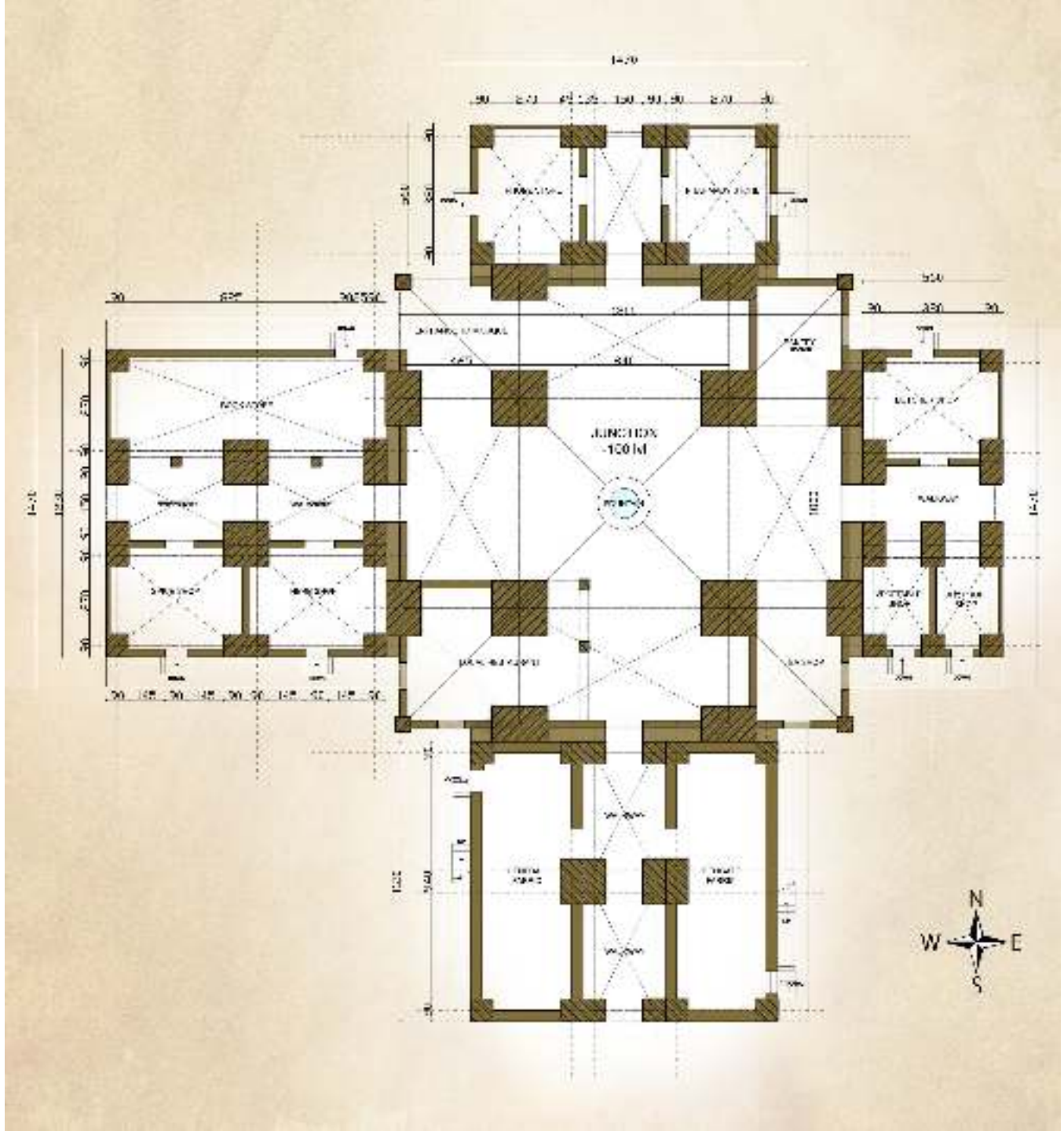
*Designing a method, modular and applicable*

*Combining the script with the modular units.*

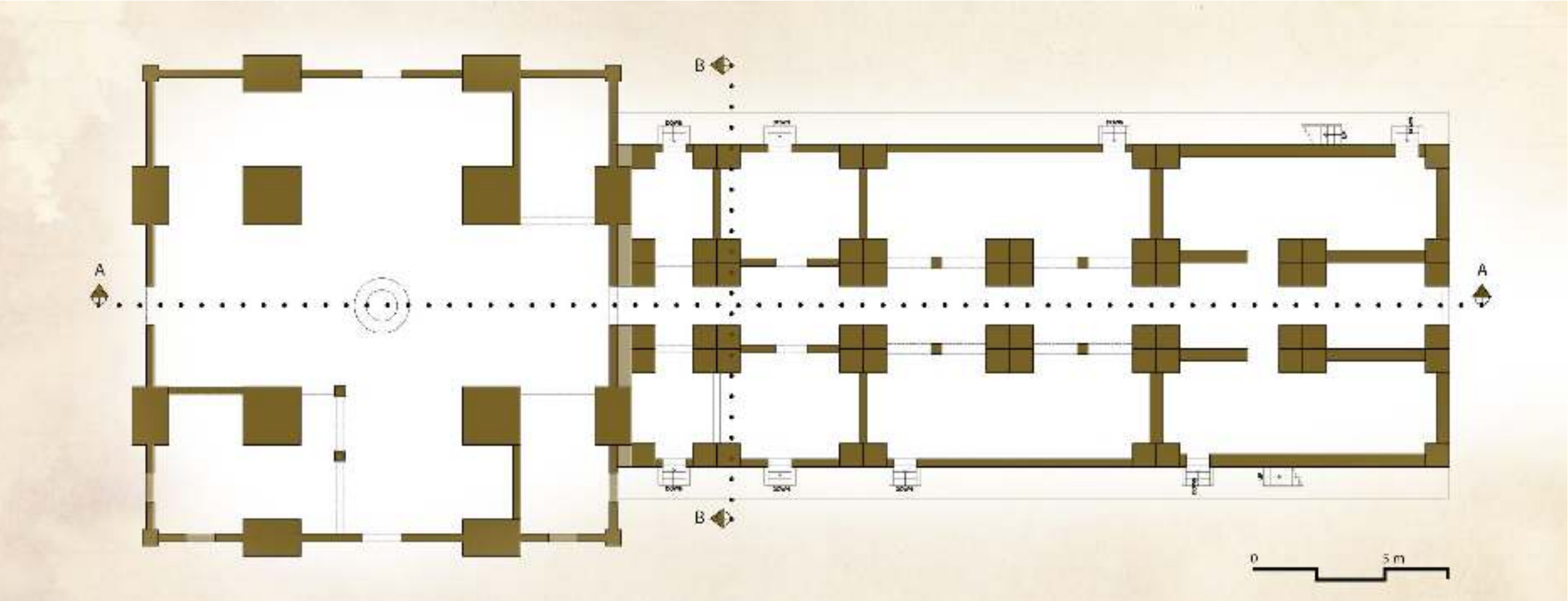


# A MODULAR DESIGN FOR ZAATARI

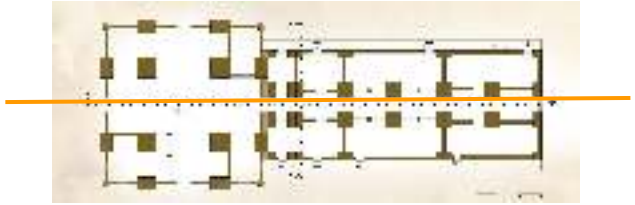
# Floor plan -Junction

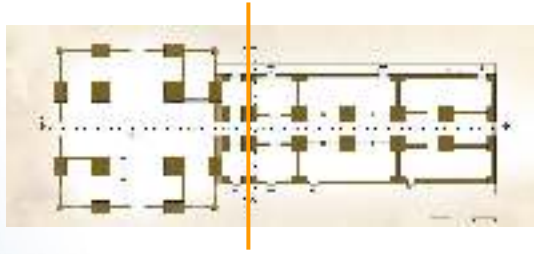


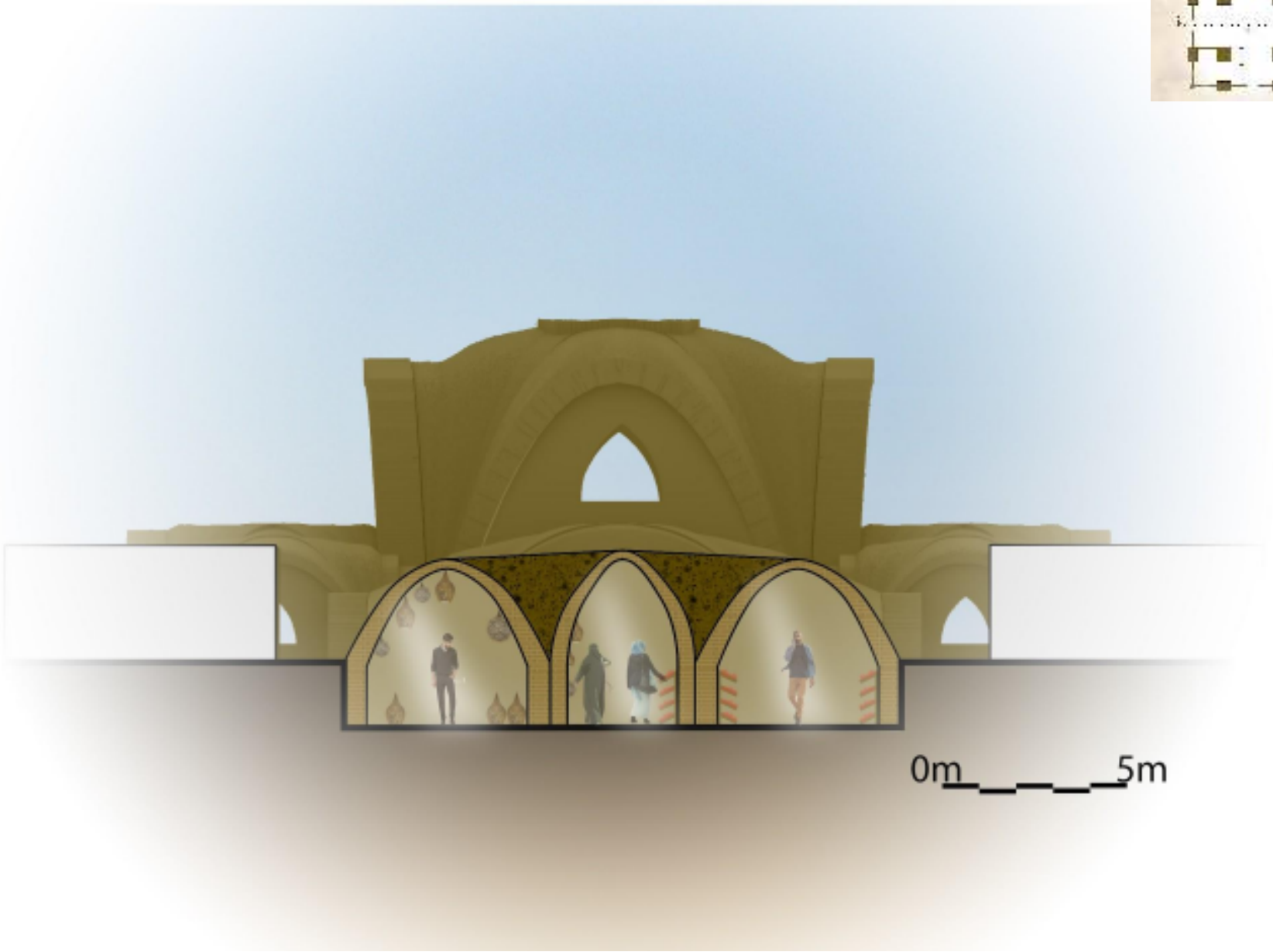
# Floor plan - Street



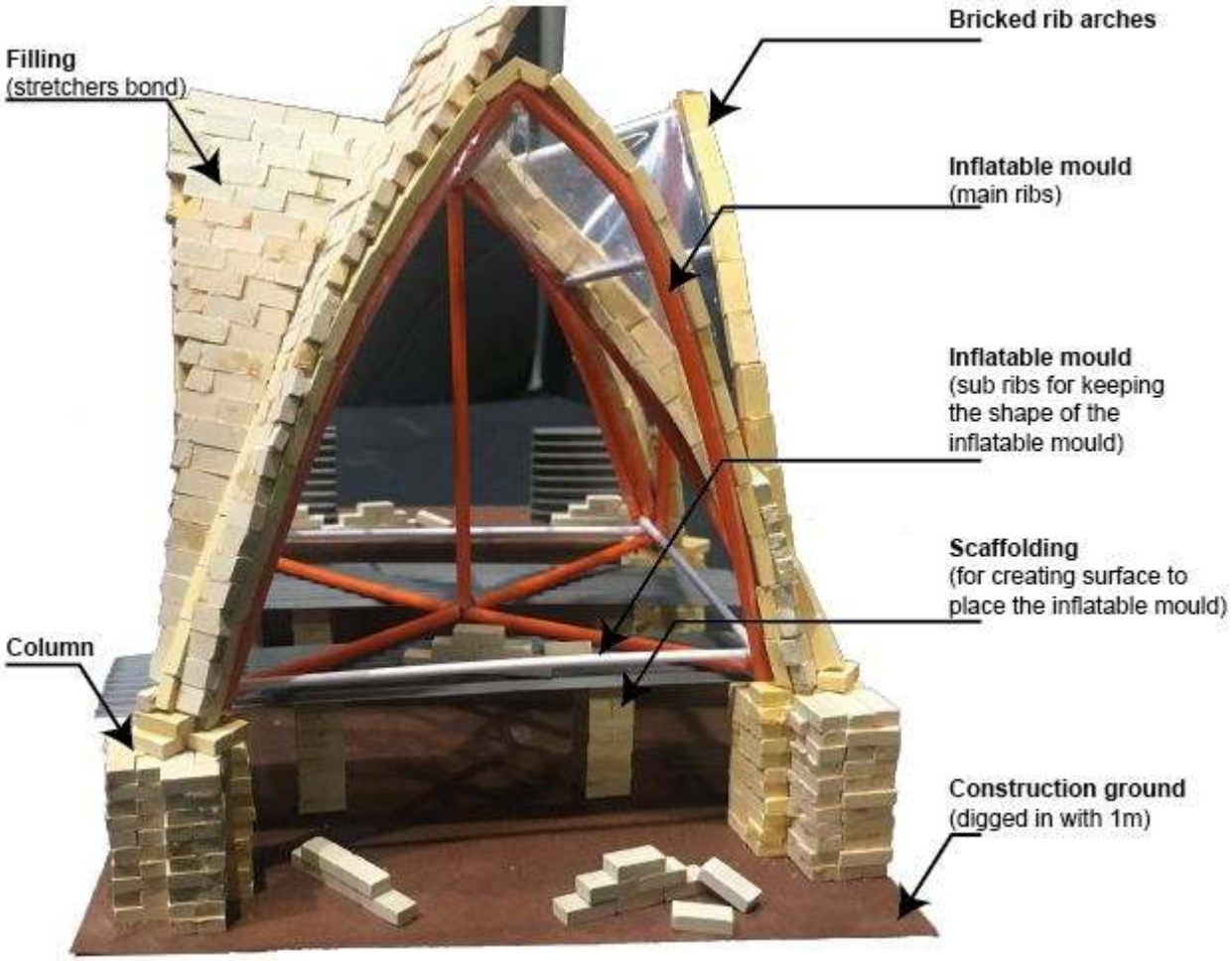
# Section - Junction and Street





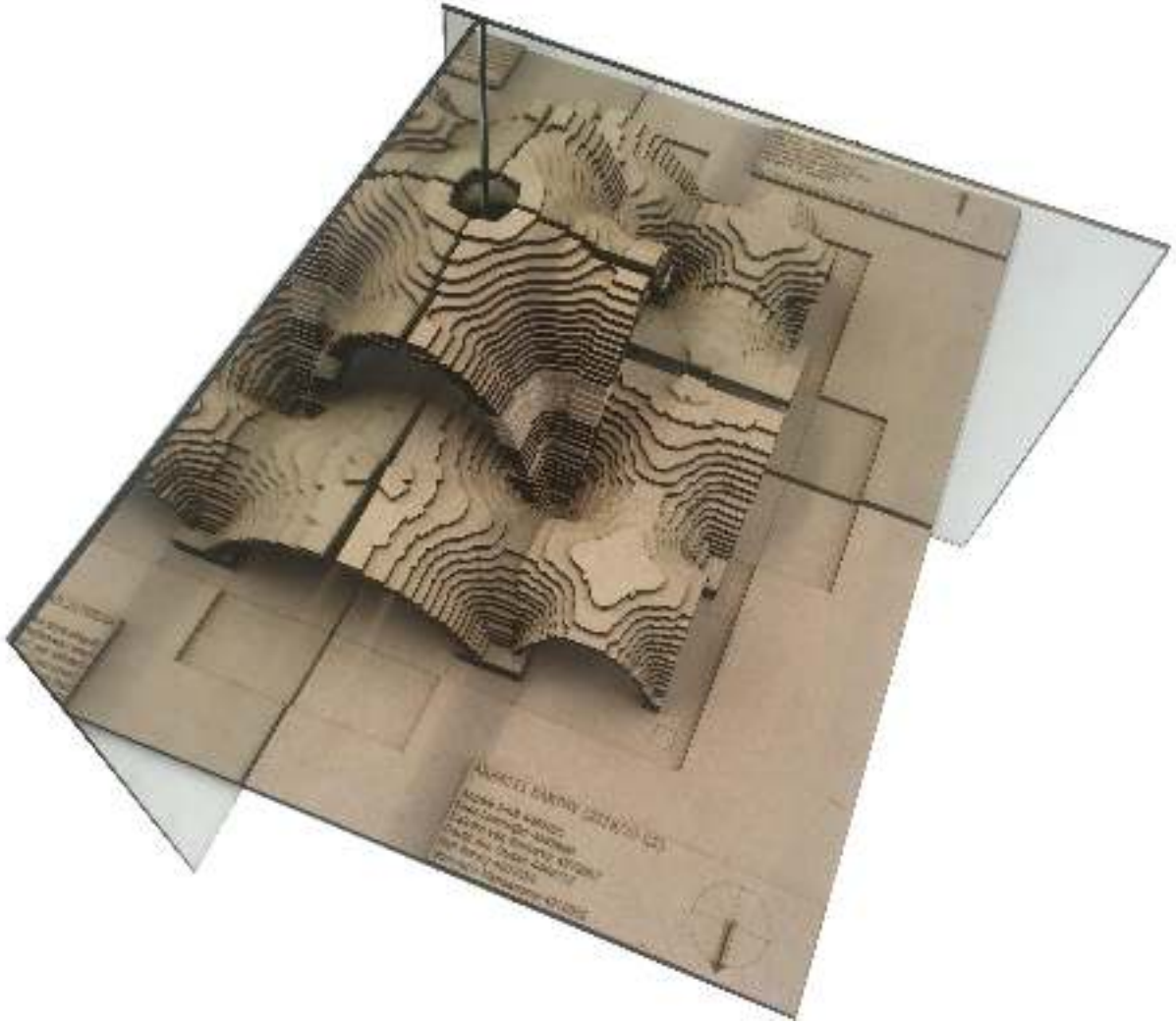

0m
5m

# Model inflatable mould

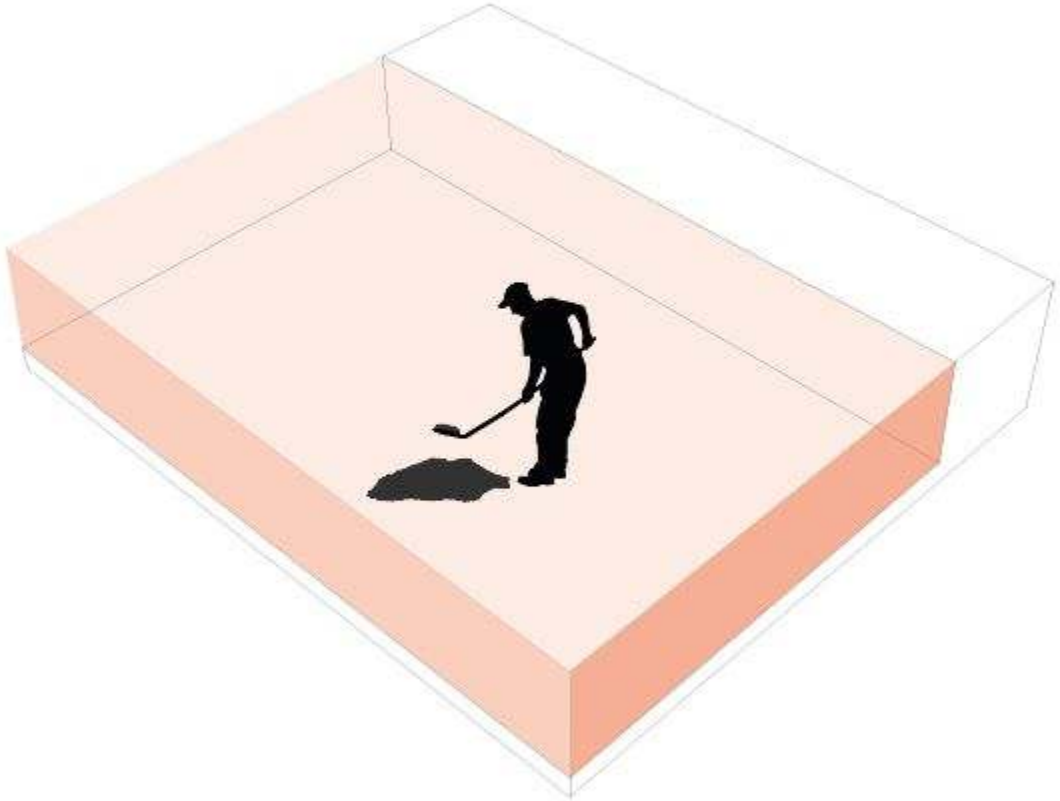


# Model Street

# Model Junction

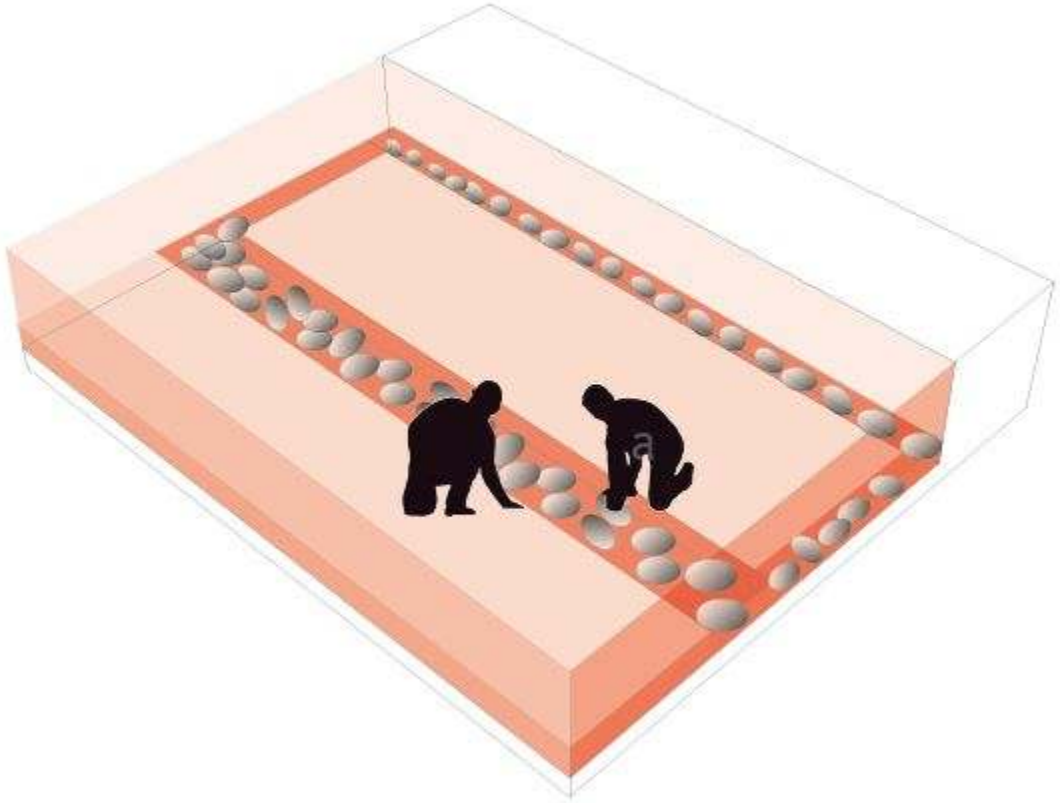


# Construction phases



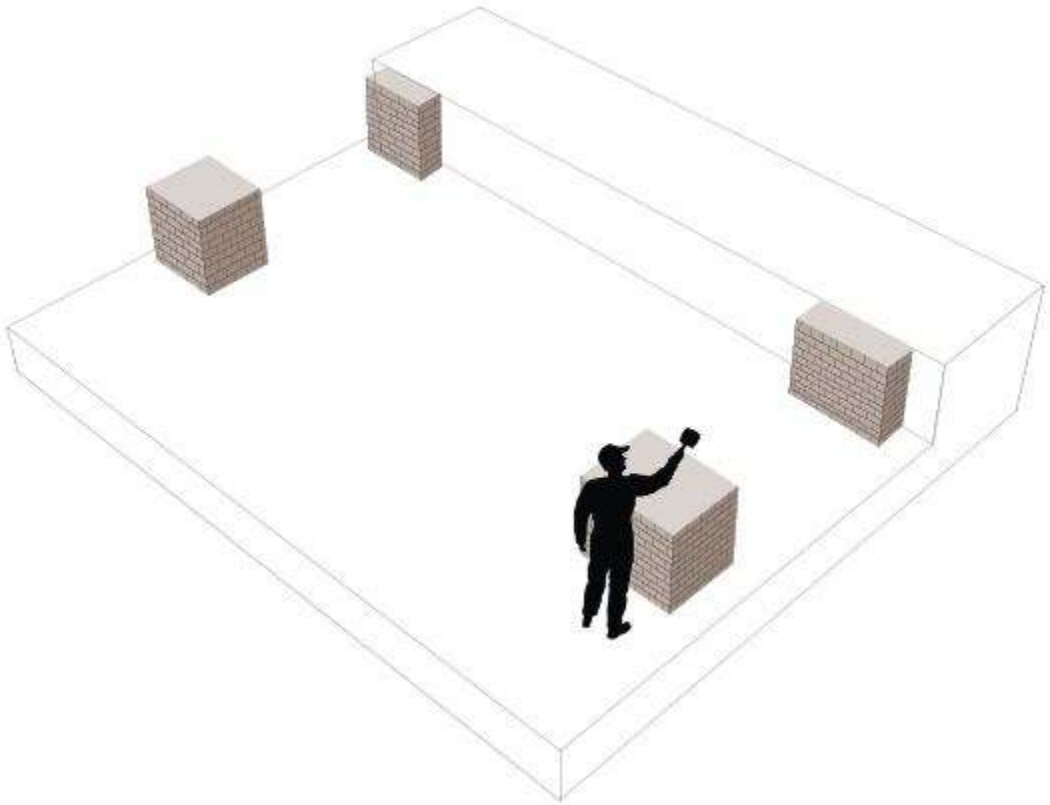
**Phase 1: Digging the ground**
The bazaar is being digged in for climate and structural reasons.

# Construction phases



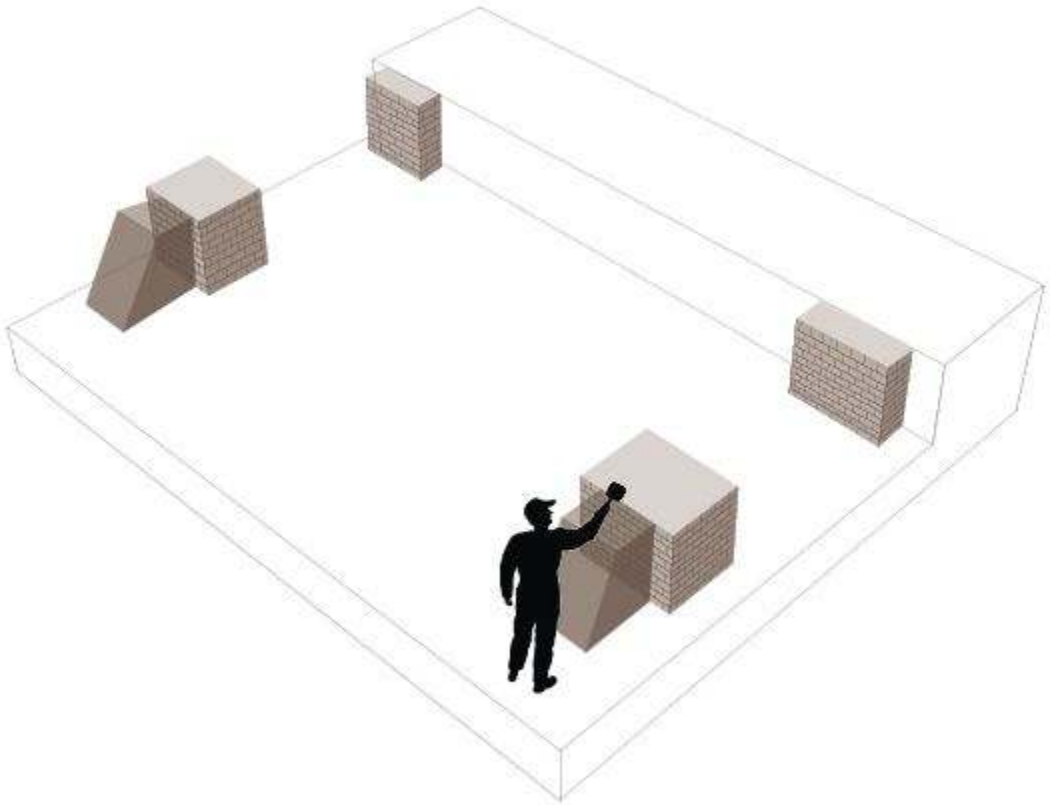
**Phase 2: Foundation**
The base of the columns and walls with stones

# Construction phases



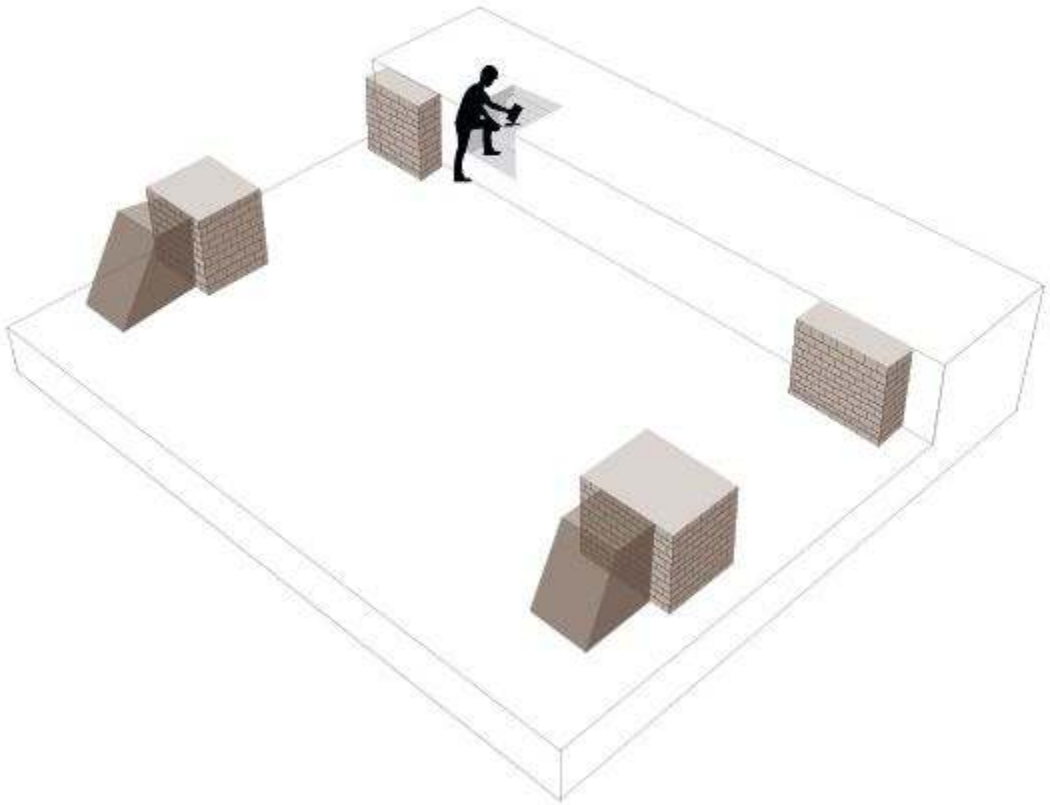
**Phase 3: Bricklaying the columns**
1m height to create usable walking space before the roof starts

# Construction phases



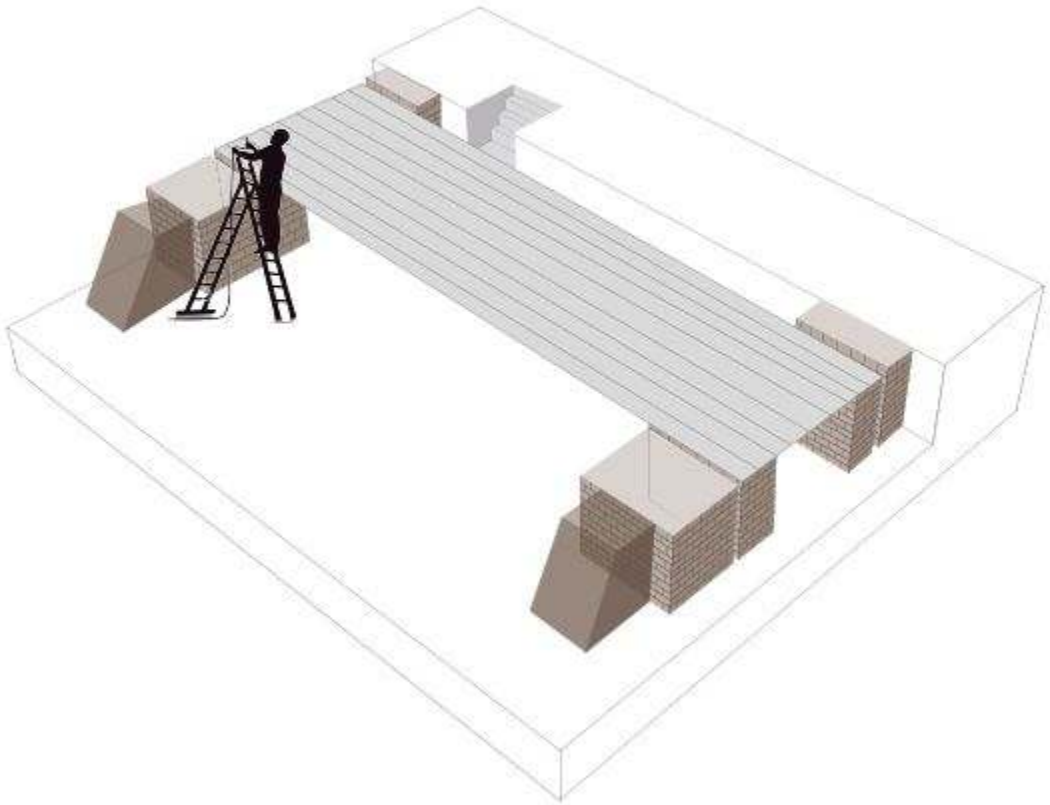
**Phase 3a: Bricklaying the buttresses**
Required for the trustline of the construction.
Buttresses can be used as columns when the rib arches are constructed of the walkway.

# Construction phases



**Phase 4: Stairs**
To create back enterances for the shops.

# Construction phases

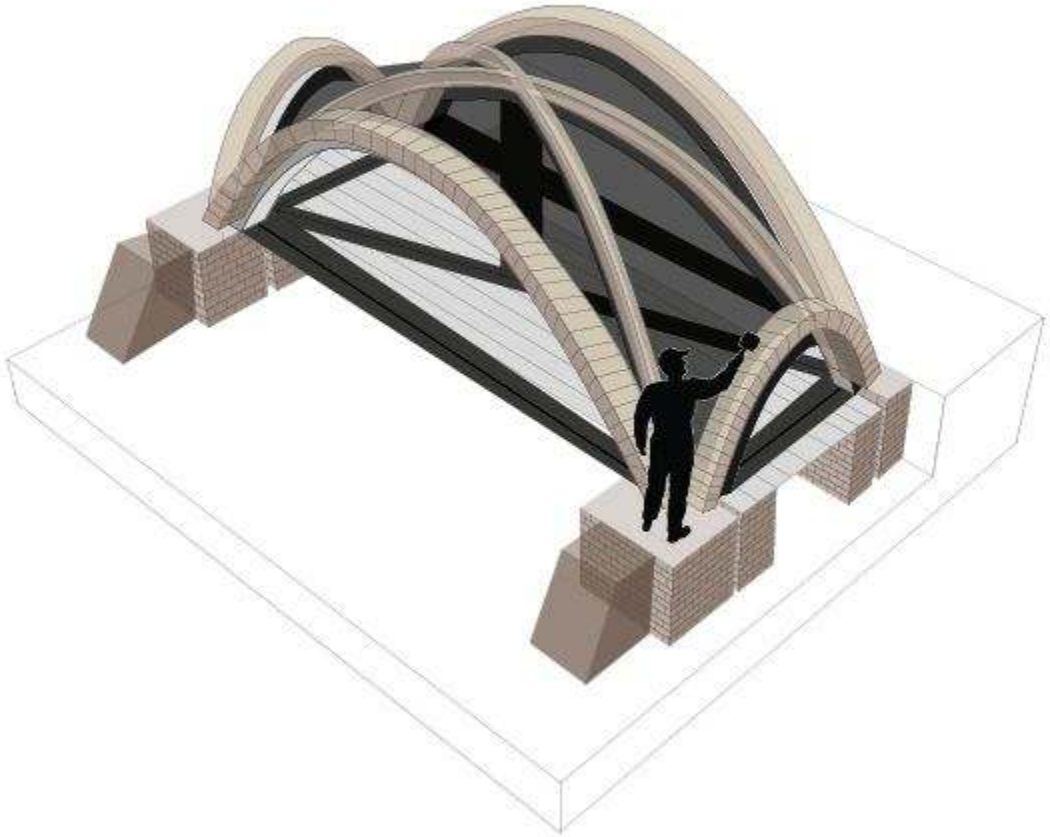


**Phase 5: Scaffolding**
To create surface for the inflatable mould

# Construction phases

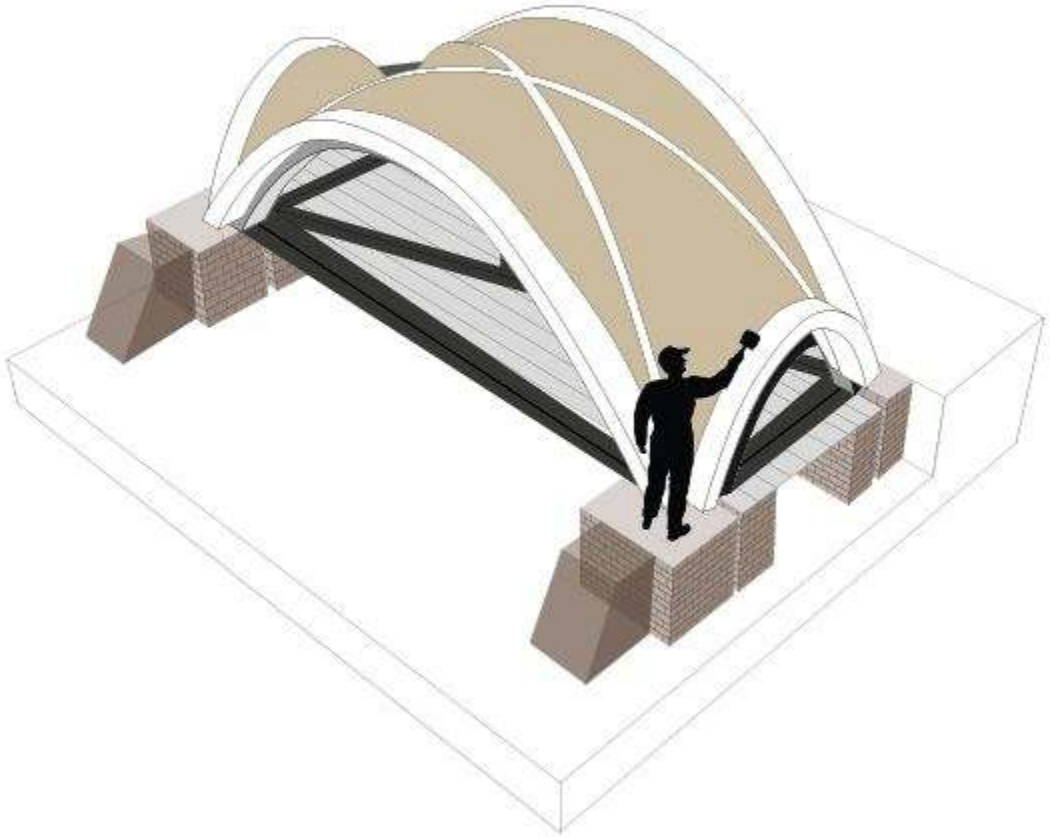
**Phase 5a: Placing the inflatable mould**
To create a support and guideline for bricklaying the rib arches

# Construction phases



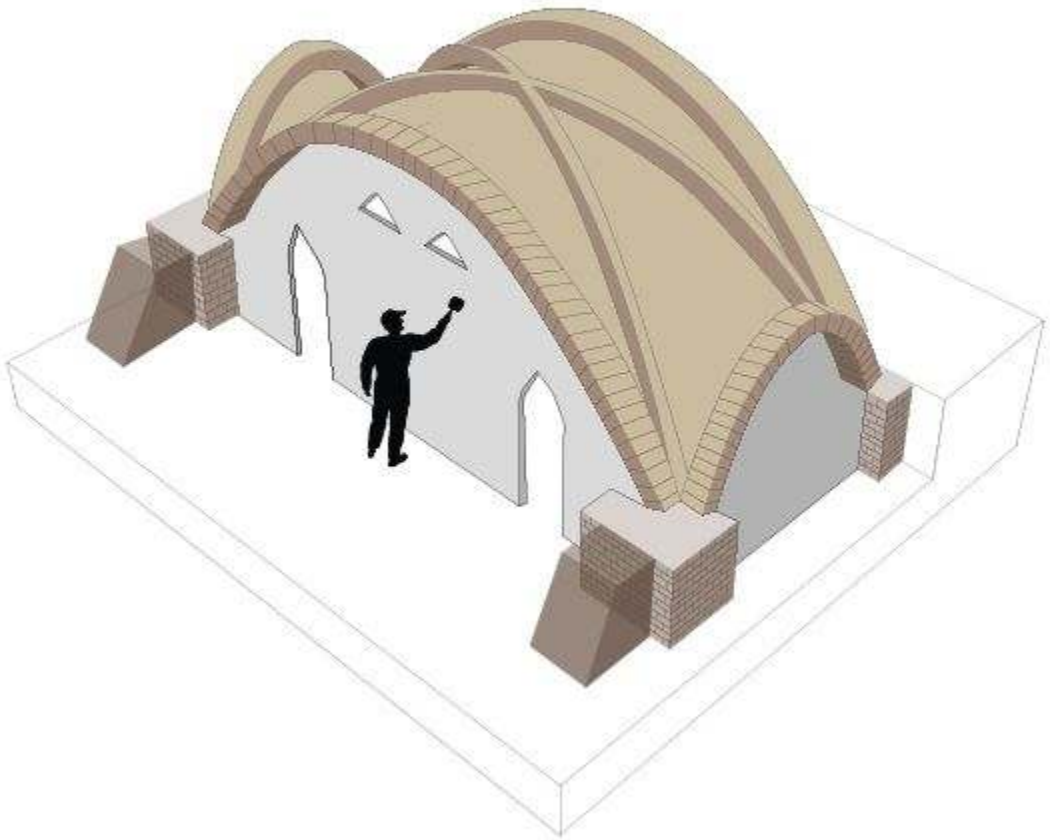
**Phase 6: Bricklaying the arches**
With a inflatable mould placed on scaffolding as support and guideline.

# Construction phases



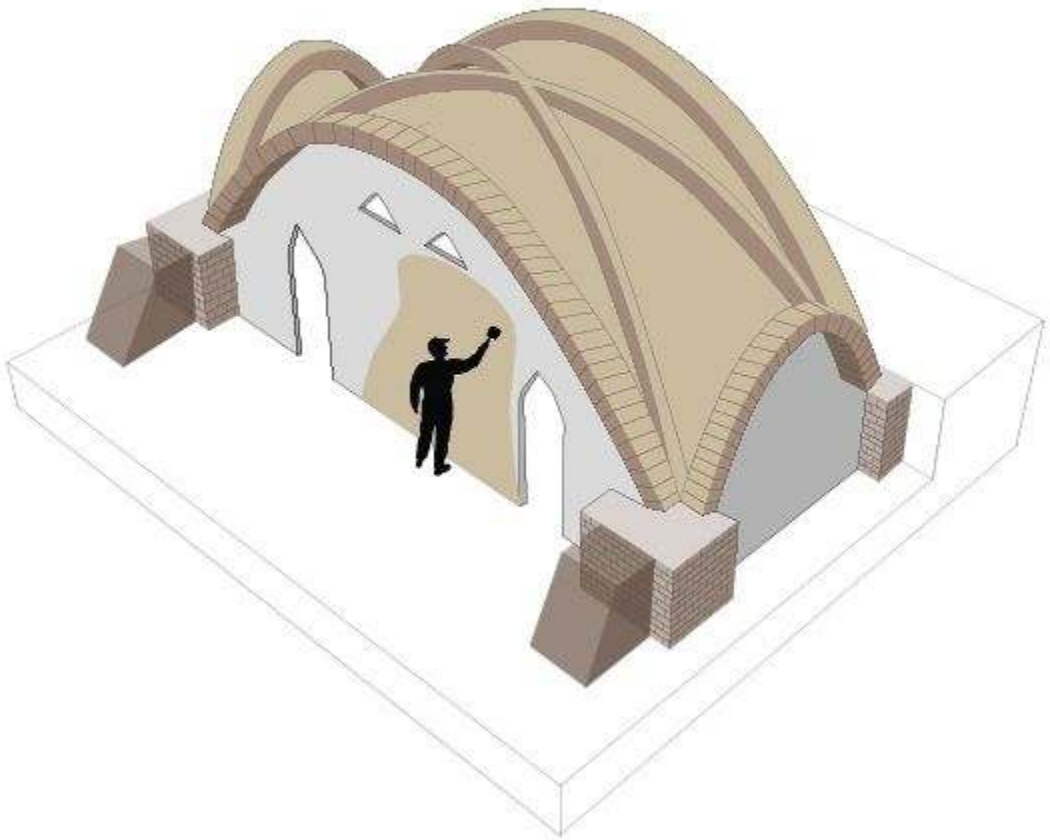
**Phase 7: Bricklaying the fills between arches**
With a inflatable mould as support and guideline.

# Construction phases



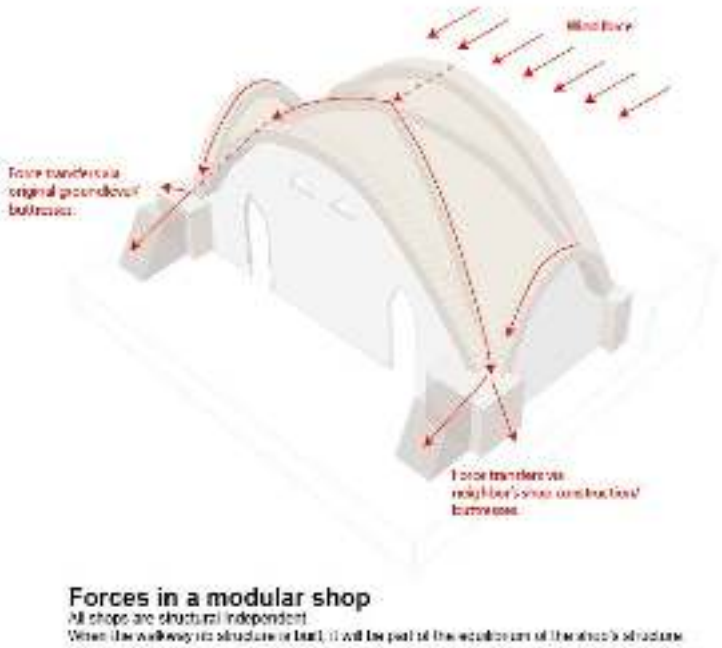
**Phase 8: Bricklaying the walls and windows**
Walls are not structural required for the the rib vaults.
Opening with cardboard support

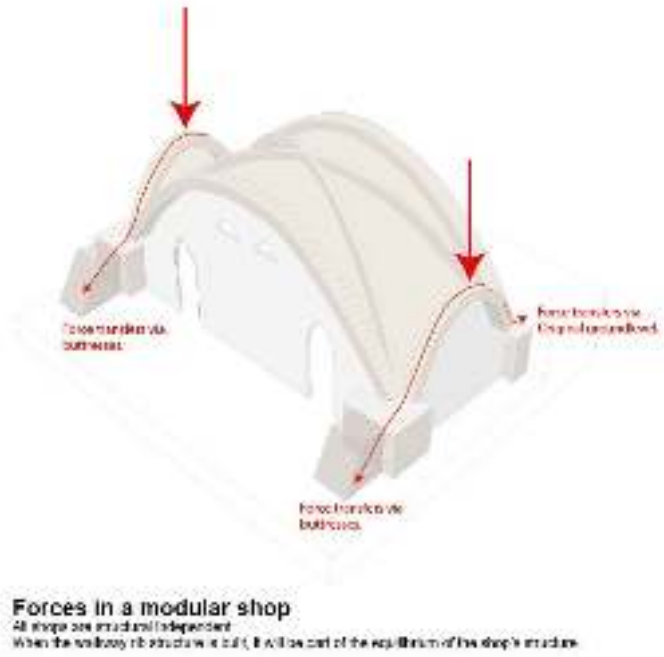
# Construction phases



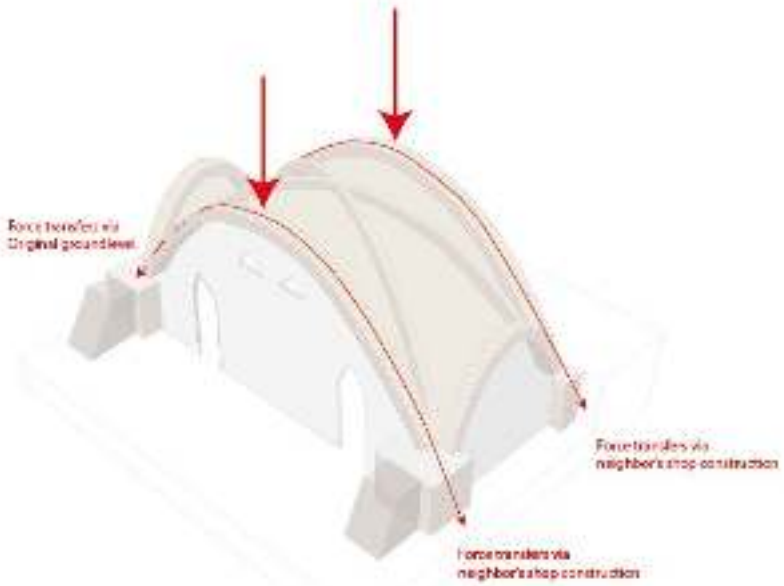
**Phase 9: Coating the outside of the walls and structure**
To waterproof the building

# Forces in modular shop

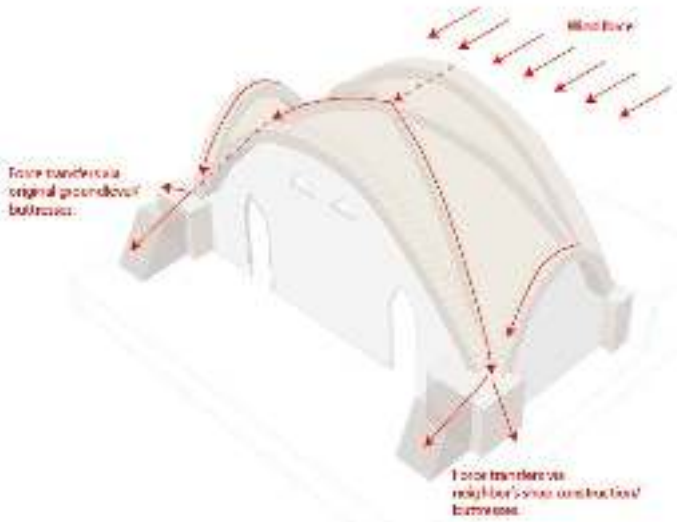


# Forces in modular shop

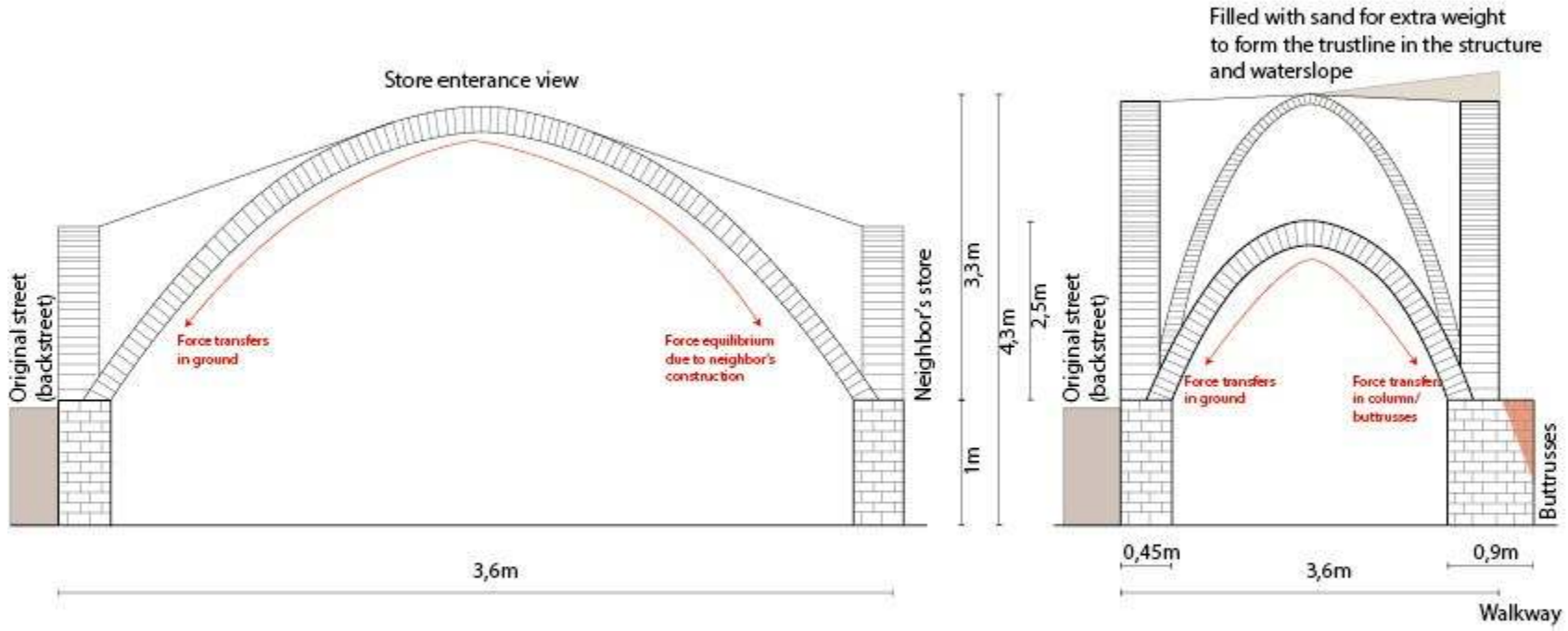



**Forces in a modular shop**
All shops are structural independent
When the walkway's structure is built, it will be part of the equilibrium of the shop's structure

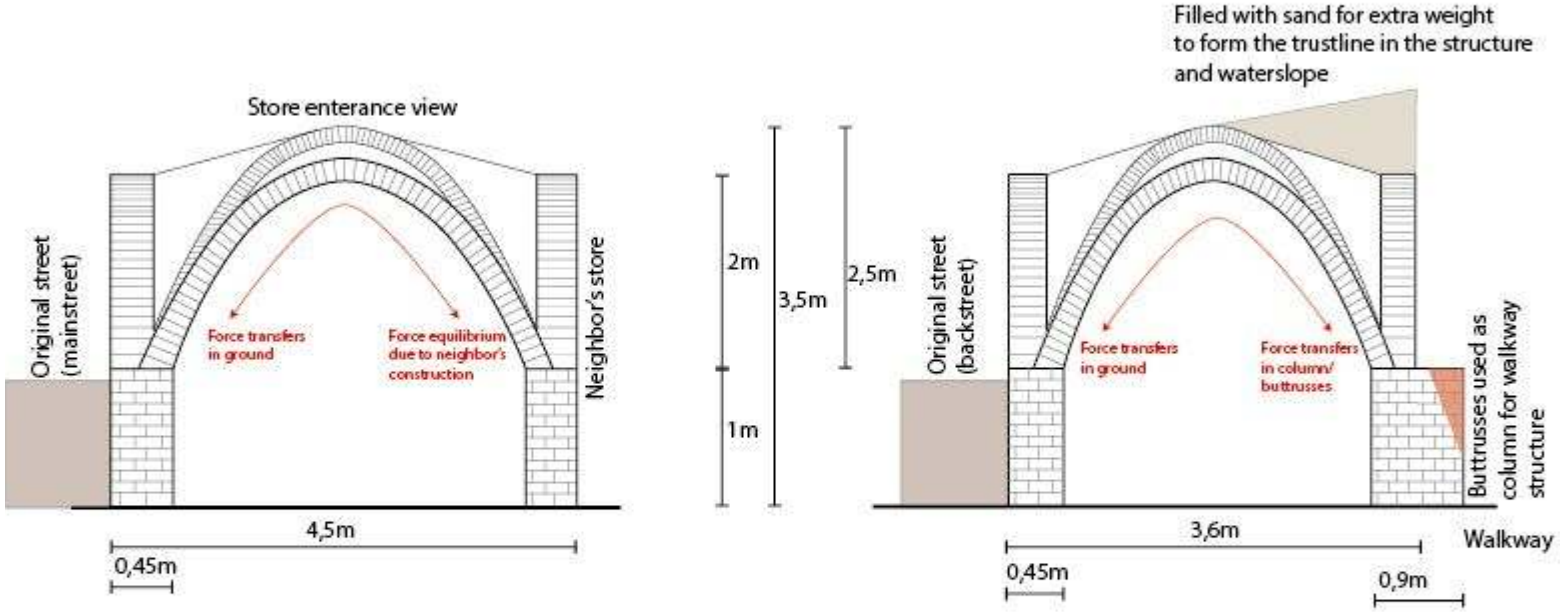



**Forces in a modular shop**
All shops are structural independent
When the walkway's structure is built, it will be part of the equilibrium of the shop's structure

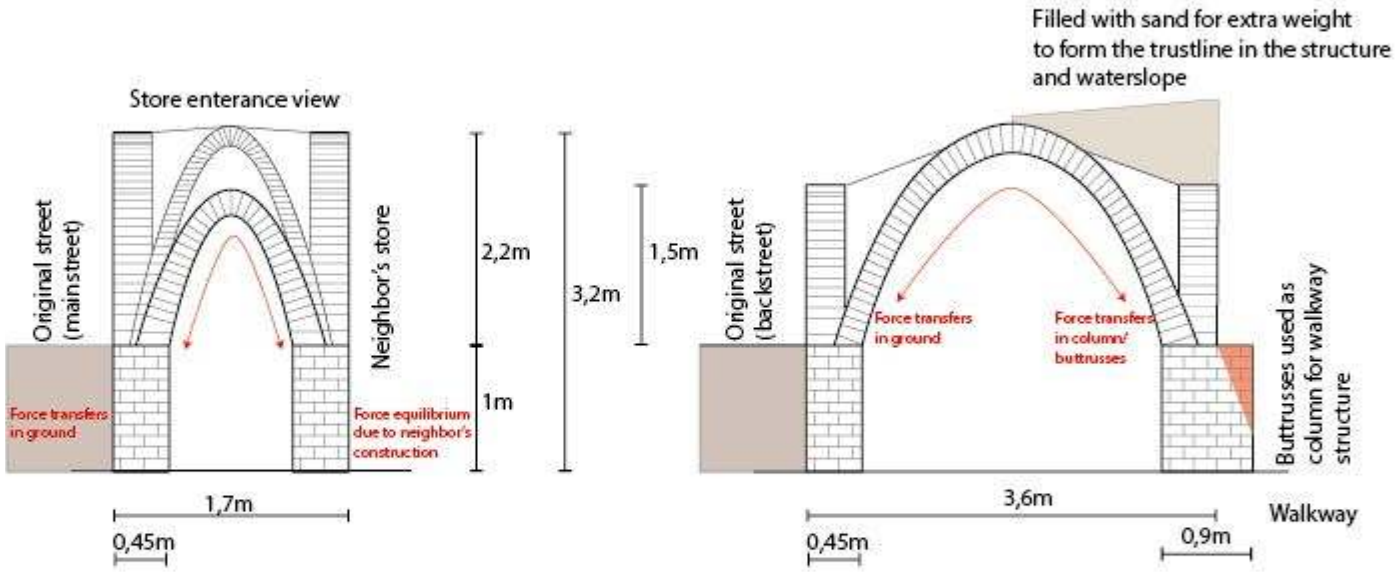
# Technical section - Big store



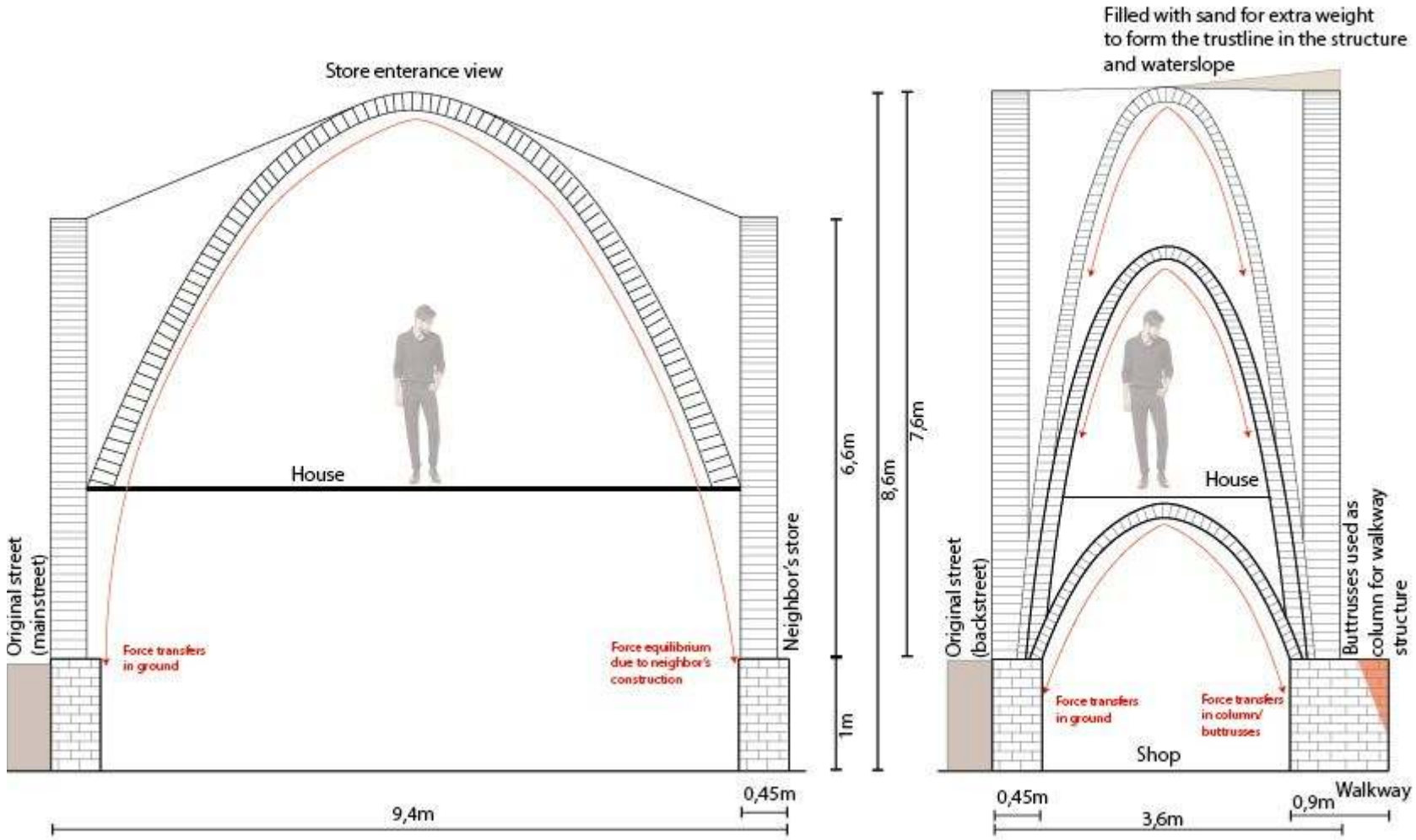
# Technical section - Medium store



# Technical section - Small store



# Technical section - House

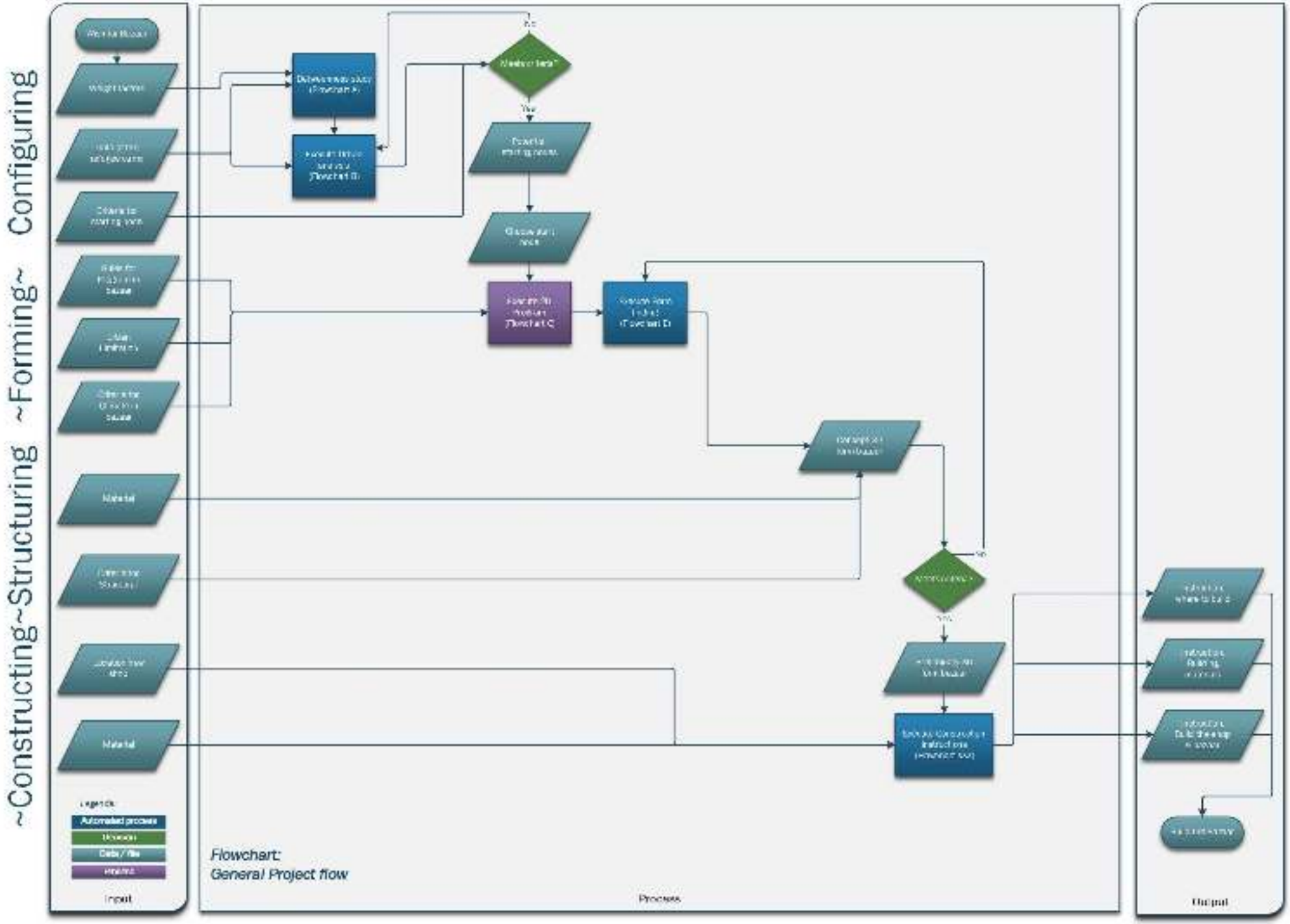


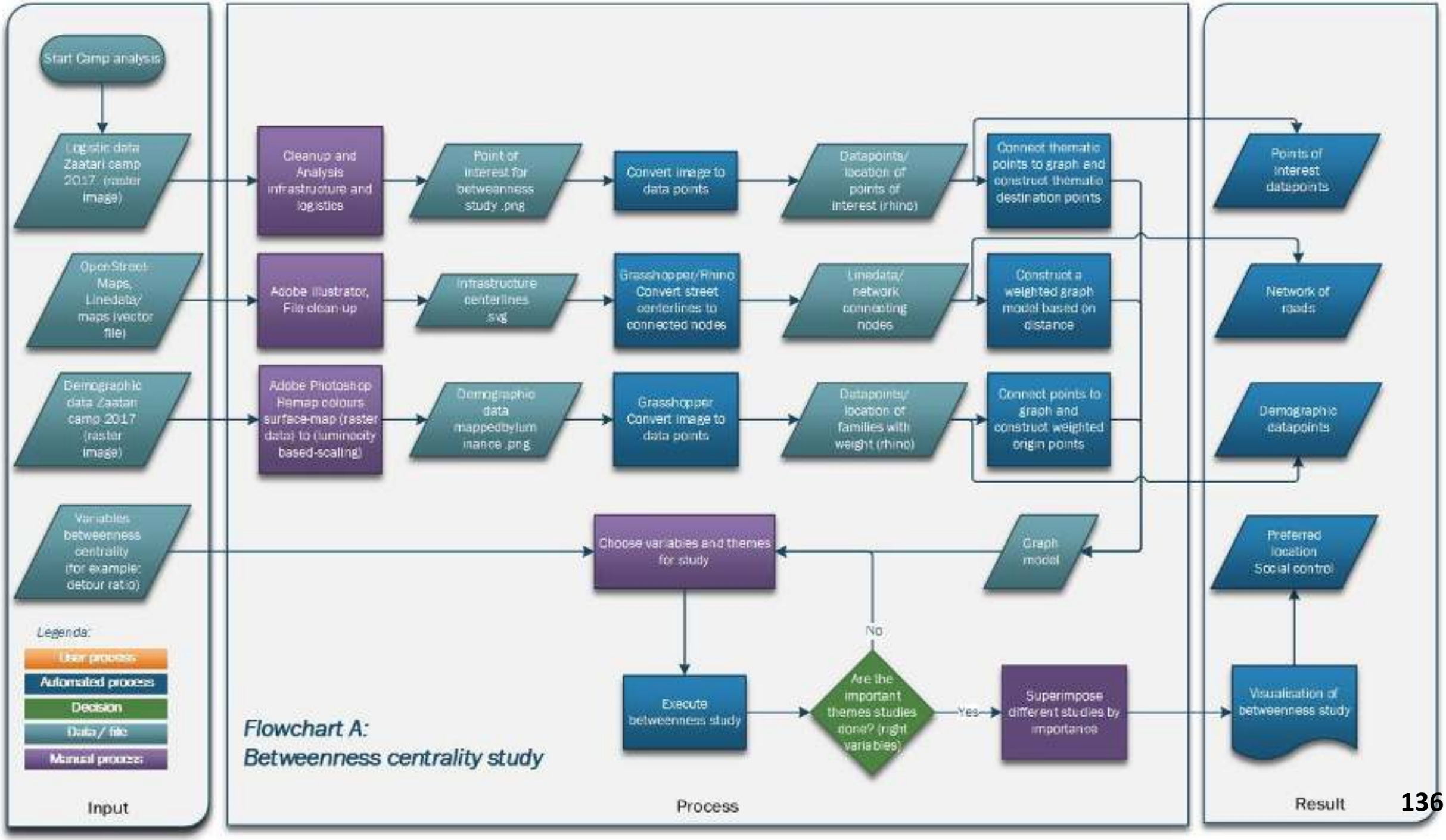
# Brick Making - Compressive Stress

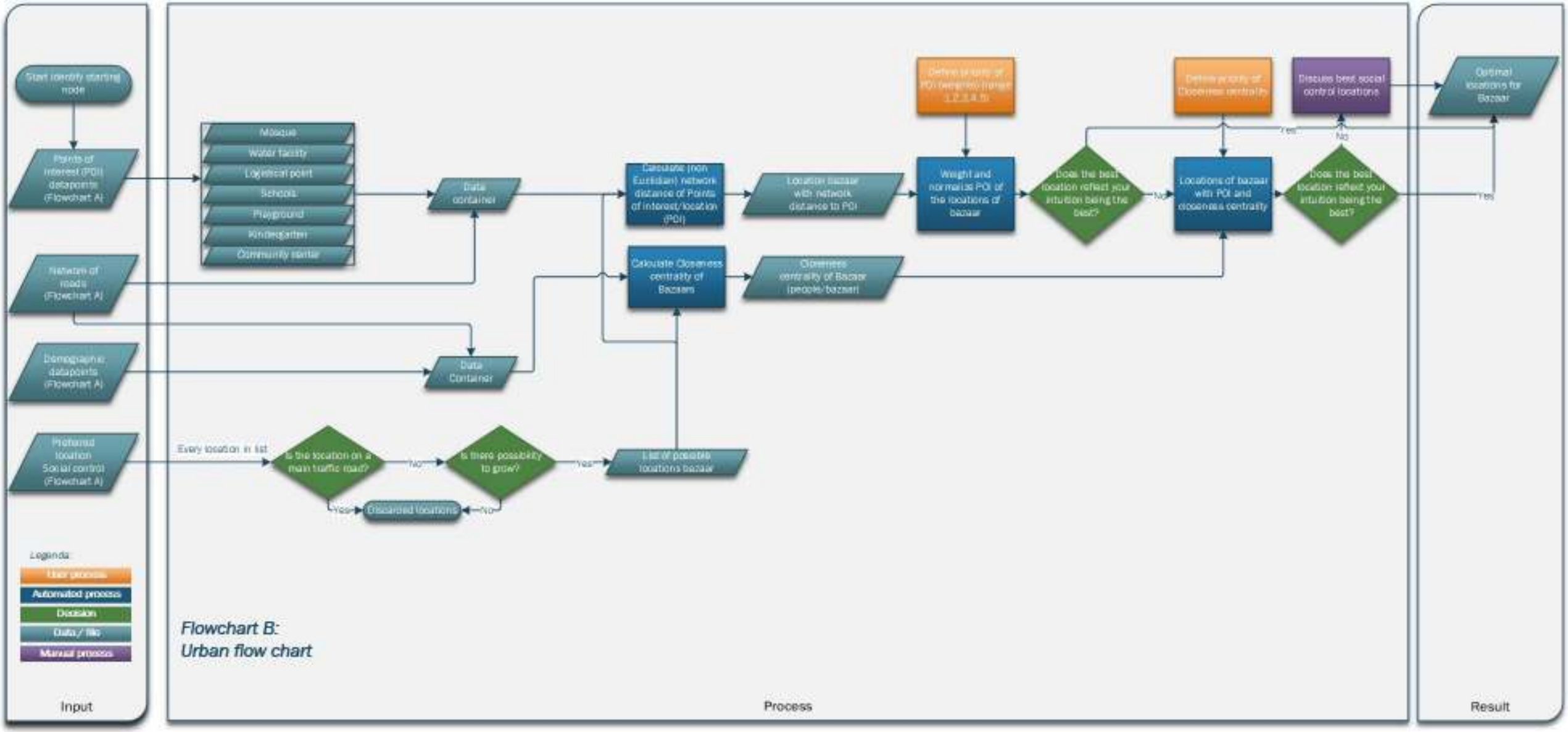
| Compressive stress [N/mm2] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Adobe only | | | | | | | Straw | Wood chip | Soghum | Feathers |
| | All | Limited range | Limited 0-5000mm² | Limited 5000-7500mm² | Limited 7.500-10.000mm² | Limited 10.000-15.000mm² | Limited 15.000+ mm² | All | All | All | All |
| Min | 0,06 | 1,07 | 1,49 | 1,39 | 3,70 | 0,84 | 0,06 | 2,28 | 1,22 | 0,97 | 0,93 |
| Max | 24,23 | 6,93 | 24,23 | 12,94 | 11,26 | 8,83 | 3,35 | 10,48 | 7,55 | 1,61 | 7,95 |
| Average | 4,19 | 2,75 | 10,51 | 4,00 | 7,31 | 2,87 | 1,03 | 5,00 | 3,50 | 1,13 | 3,75 |
| Median | 2,13 | 2,13 | 9,01 | 2,62 | 6,79 | 1,47 | 0,76 | 3,81 | 2,84 | 1,04 | 3,25 |
| st. dev | 4,46 | 1,50 | 8,33 | 3,46 | 3,39 | 3,02 | 0,86 | 2,32 | 1,83 | 0,24 | 2,49 |
| Correction factor | 1,96 | 1,96 | 2,78 | 2,13 | 2,23 | 2,16 | 2,16 | 1,96 | 2,12 | 2,57 | 2,37 |
| n | 60,00 | 32,00 | 5,00 | 16,00 | 11,00 | 14,00 | 14,00 | 22,00 | 17,00 | 6,00 | 8,00 |
| Correction | 1,13 | 0,52 | 10,35 | 1,84 | 2,28 | 1,74 | 0,50 | 0,97 | 0,94 | 0,25 | 2,09 |
| Min Stress | 3,07 | 2,23 | 0,16 | 2,16 | 5,04 | 1,13 | 0,53 | 4,03 | 2,56 | 0,87 | 1,66 |
| Max Stress | 5,32 | 3,27 | 20,86 | 5,84 | 9,59 | 4,61 | 1,53 | 5,97 | 4,44 | 1,38 | 5,84 |
| Safety factor | 2,00 | 2,00 | 2,00 | 2,00 | 2,00 | 2,00 | 2,00 | 2,00 | 2,00 | 2,00 | 2,00 |
| Min Stress incl. factor | 1,53 | 1,12 | 0,08 | 1,08 | 2,52 | 0,56 | 0,27 | 2,02 | 1,28 | 0,44 | 0,83 |
| Max Stress incl. factor | 2,66 | 1,63 | 10,43 | 2,92 | 4,80 | 2,30 | 0,77 | 2,99 | 2,22 | 0,69 | 2,92 |
| Physical test result | Complete destroyed | | | | | | | Shape mostly remained | Complete destroyed | Complete destroyed | Shape mostly remained |

# Brick Making - Young’s Modulus

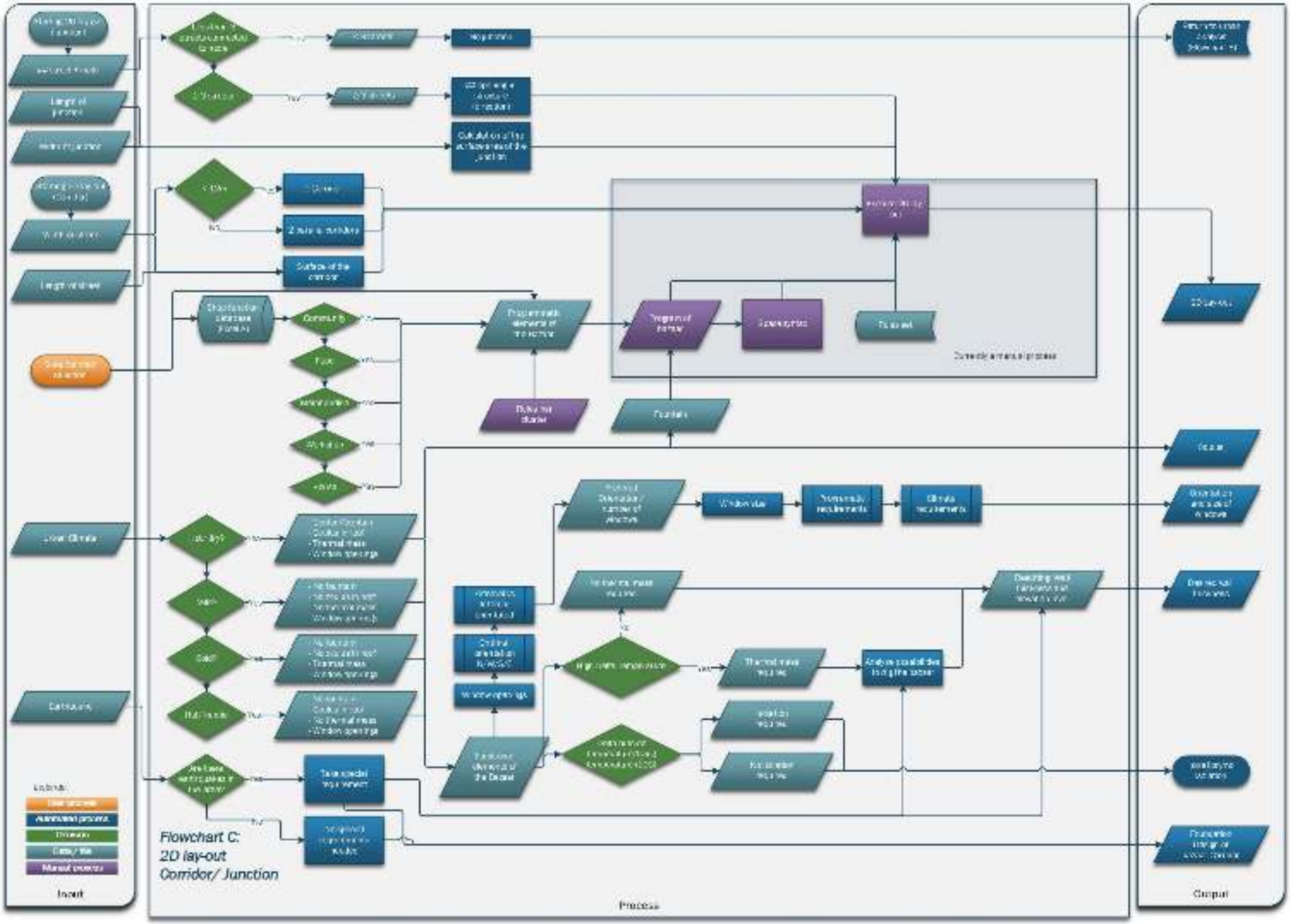
| Young's Modulus [N/mm2] | | | | | |
|---|---|---|---|---|---|
| | Adobe only | Straw | Wood chip | Soghum | Feathers |
| | All | All | All | All | All |
| Min | 6,62 | 15,44 | 13,72 | 9,23 | 11,54 |
| Max | 647,00 | 174,63 | 141,12 | 16,85 | 55,70 |
| Average | 68,13 | 63,64 | 54,05 | 14,36 | 30,40 |
| Median | 25,22 | 55,94 | 50,74 | 15,99 | 24,37 |
| st. dev | 115,08 | 41,27 | 36,74 | 3,14 | 15,69 |
| Correction factor | 1,96 | 1,96 | 2,20 | 2,78 | 2,37 |
| n | 42,00 | 22,00 | 12,00 | 5,00 | 8,00 |
| Correction | 34,80 | 17,24 | 23,33 | 3,90 | 13,15 |
| Min E-modulus | 33,33 | 46,40 | 30,72 | 10,46 | 17,25 |
| Max E-modulus | 102,94 | 80,89 | 77,38 | 18,26 | 43,55 |
| Physical test result | Complete destroyed | Shape mostly remained | Complete destroyed | Complete destroyed | Shape mostly remained |

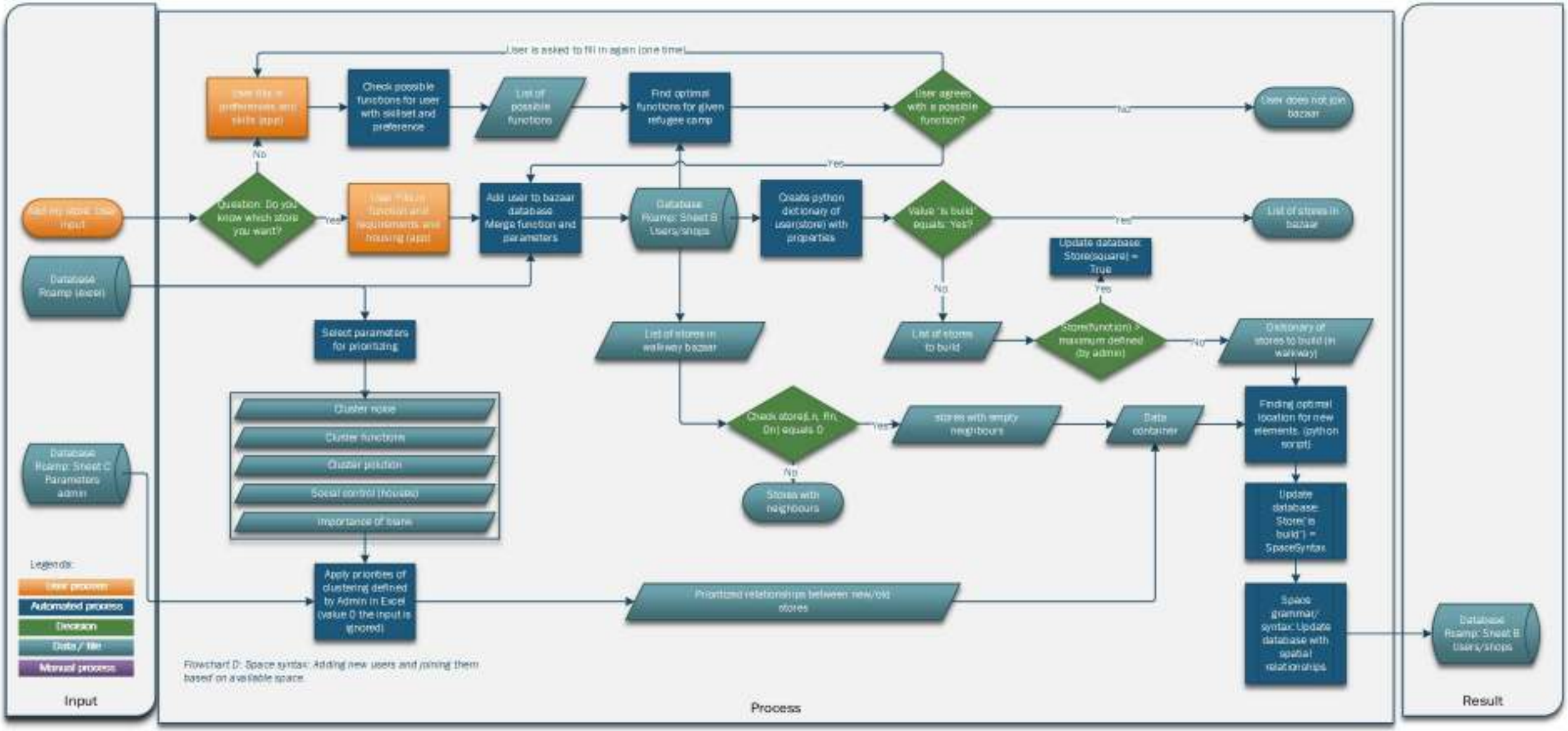

~Constructing~Structuring ~Forming~ Configuring
Material
Material
Flowchart:
General Project flow
Input
Process
Output


Start Camp analysis
Logistic data Zaatari camp 2017 (raster image)
OpenStreet Maps, Linedata/ maps (vector file)
Demographic data Zaatari camp 2017 (raster image)
Variables betweenness centrality (for example: detour ratio)
Legenda:
User process
Automated process
Decision
Data / file
Manual process
Input
Cleanup and Analysis infrastructure and logistics
Point of interest for betweenness study .png
Convert image to data points
Datapoints/ location of points of interest (rhino)
Connect thematic points to graph and construct thematic destination points
Adobe Illustrator, File clean-up
Infrastructure centerlines .svg
Grasshopper/Rhino Convert street centerlines to connected nodes
Linedata/ network connecting nodes
Construct a weighted graph model based on distance
Adobe Photoshop Remap colours surface-map (raster data) to (luminocity based-scaling)
Demographic data mappedbylum inance .png
Grasshopper Convert image to data points
Datapoints/ location of families with weight (rhino)
Connect points to graph and construct weighted origin points
Choose variables and themes for study
Graph model
Execute betweenness study
Are the important themes studies done? (right variables)
No
Yes
Superimpose different studies by importance
Flowchart A:
Betweenness centrality study
Process
Points of interest datapoints
Network of roads
Demographic datapoints
Preferred location Social control
Visualisation of betweenness study
Result

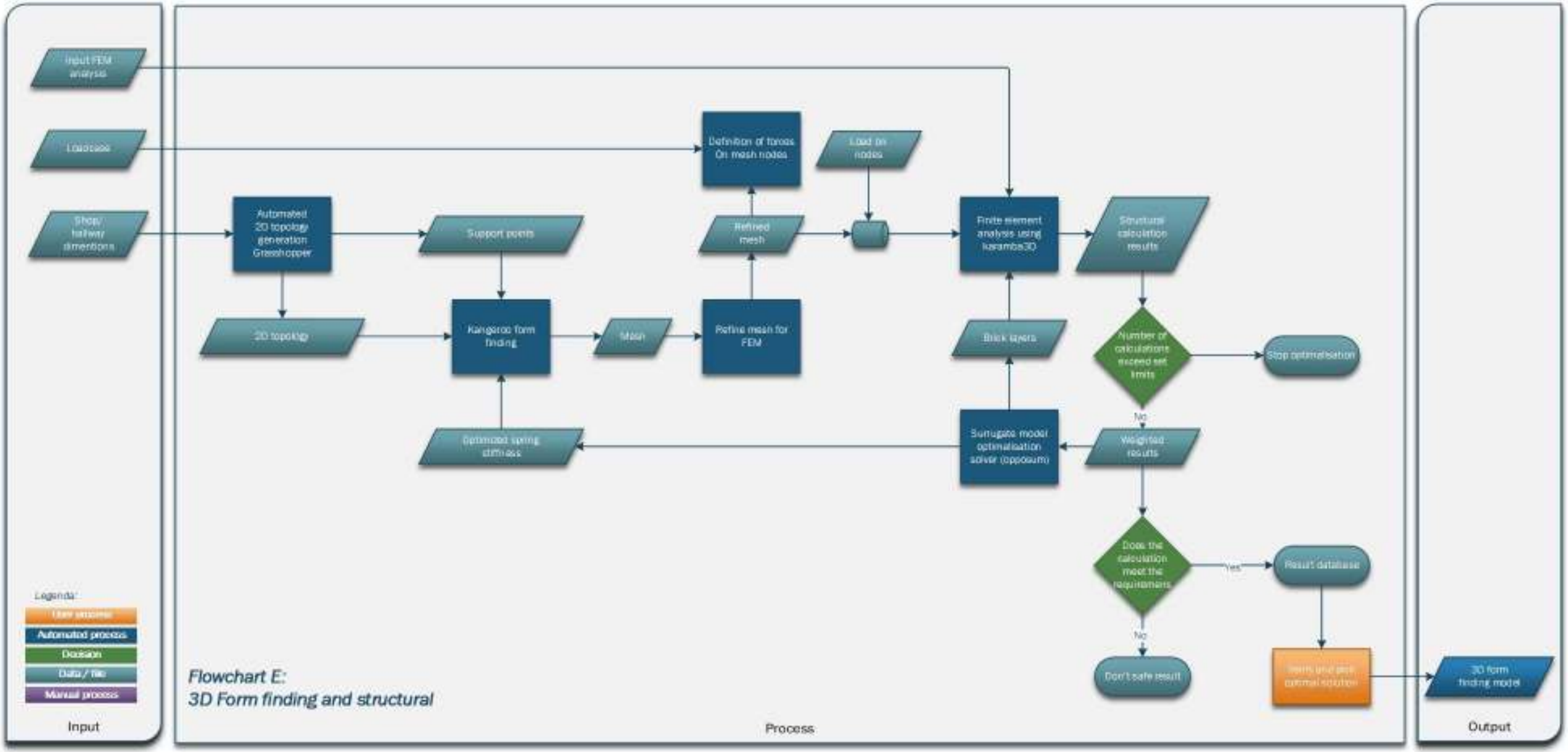


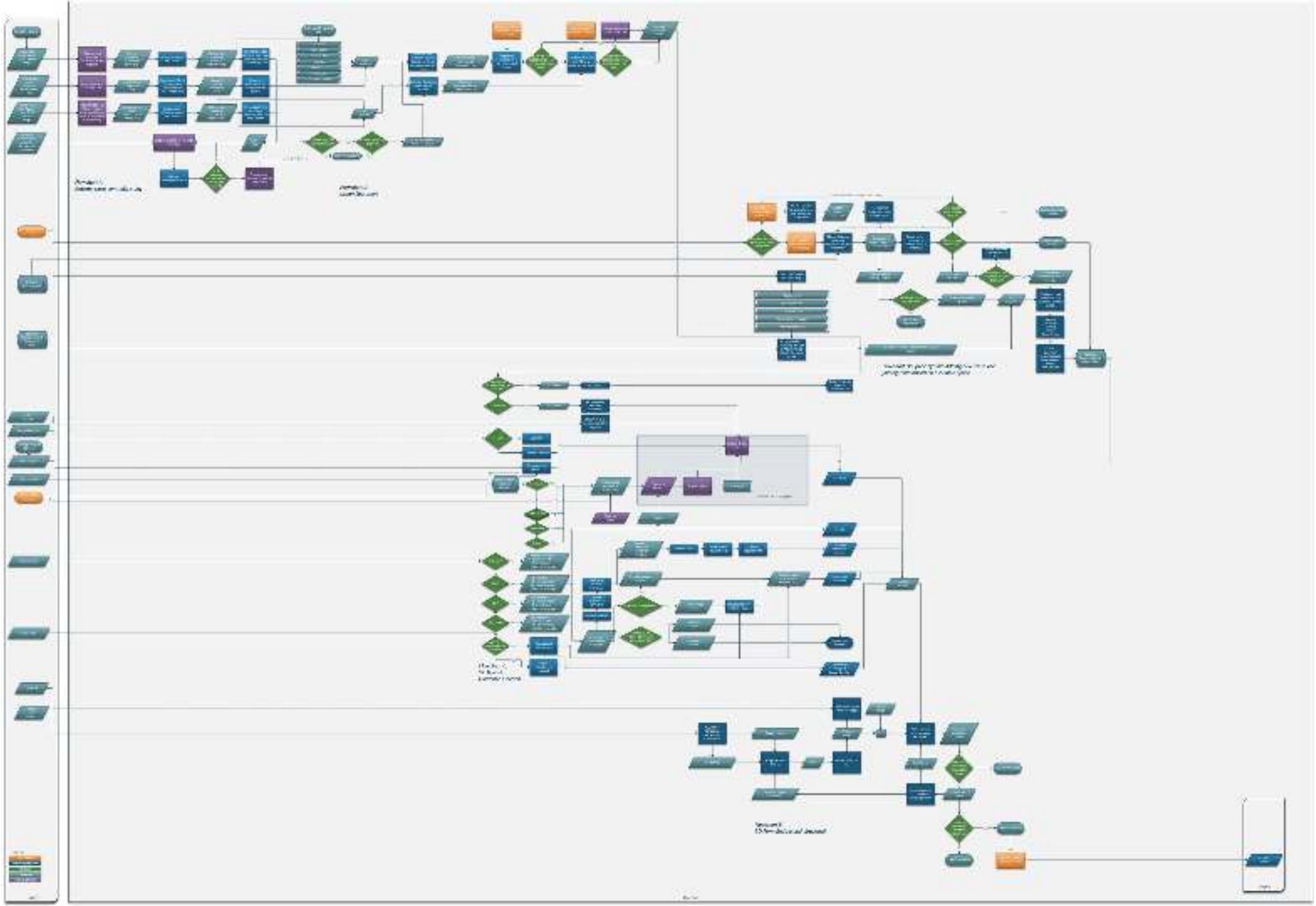

*Flowchart B:*
*Urban flow chart*


Flowchart C:
2D lay-out
Corridor/ Junction
Input
Process
Output




Flowchart D: Space syntax: Adding new users and joining them based on available space




*Flowchart E:*
*3D Form finding and structural*