# AR3B011: EARTHY

## Generative Design for Earth & Masonry Architecture

## Course Introduction


**Pirouz Nourian**

*Computational Designer,*
*Architect,*
*Research Software Engineer,*
*Maker*


## Course Coordinator:

- Developing the syllabus
- Teaching maths
- Teaching programming
- Teaching computational design
- Teaching earth architecture
- Playing with mud
- Getting my hands dirty
- Shovelling dirt
- Etc.

https://genesis-lab.dev/courses/earthy/




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# LEARNING GOALS

# COLLECTIVE INTELLIGENCE



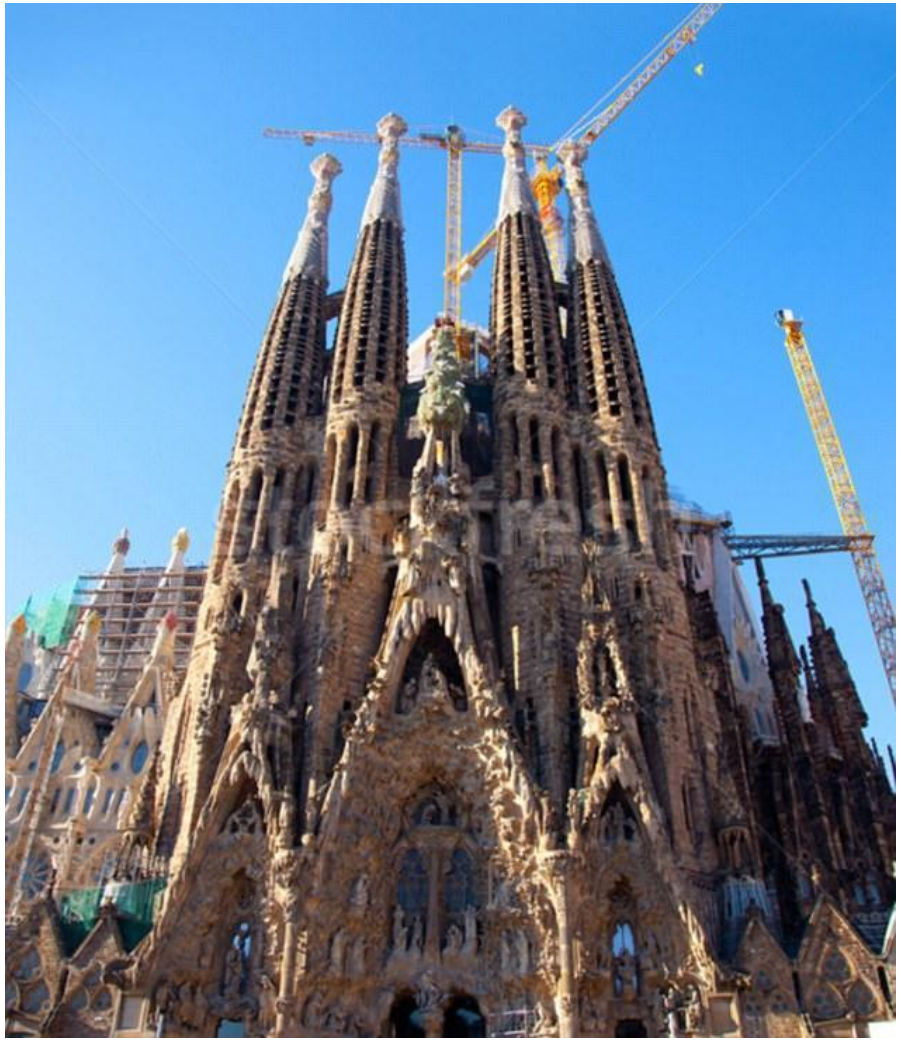


Image Credit: Professor Richard Dawkins https://www.dailymail.co.uk/sciencetech/article-5110527/Mysterious-creators-cathedral-like-structure-revealed.html


*Image Credit:* [Student Project Terra_Tetris](), [Student Project Adobe_CC](), [Student Project Bazaar](), [Student Project Makers' Bazaar]()

# LEARNING GOALS



Having successfully finished the course, the student is expected to be able to:

- 0) systematically develop open-science content (including but not limited to open-source software) towards producing open, explainable, and reproducible knowledge.
- 1) analytically develop an urban/architectural configuration though analysing the urban context of the given site in terms of access to opportunities, diversity of activities, and usage intensities (considering social, cultural, and ethical aspects); making a synthesis of these analyses; and accordingly proposing an idea for a building specified in a functional configuration with an added value for the context.
- 2) develop a computational workflow consisting of procedures/algorithms to generate a masonry architectural form, satisfying both the spatial/configurational and structural requirements; optimize it for a desired structural performance given material properties; and propose a construction approach for building the form.
- 3) construct a Finite Element Model of the building as a masonry structure for performing structural analysis and validation; proposing a building method for the designed vaults through a low-tech construction process (relying on low-cost, recycled, reused materials, and local labour); and checking the stability of the structure throughout the proposed construction process.

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# LEARNING GOALS



The objectives of the course are:

- 0) to learn to develop open-science content
- 1) to learn to analytically develop an urban/architectural configuration
- 2) to learn to utilize complex geometry and topology in designing form-effective and functional buildings and settlements by means of (visual) programming, Python (NumPy), C#, or MATLAB.
- 3) to learn and utilize the physical relation between structural functionality of forms and structural properties of materials

# What not

- it is about things that do not exist (methods and tools), so inherently a WIP (always)
- not about pushing buttons, but learning how to build your own tools
- not about making the simplest structure but the most elegant, human, and dignified
- we do not have all the answers and solutions; we will find/create them together

https://en.wikipedia.org/wiki/Earth_structure

https://www.designboom.com/architecture/earth-a-building-material-of-the-future/

# EARTHY TEACHERS

**Dr. Ir. Pirouz Nourian**

*Assistant Professor of Design Informatics*

**Dr. Ir. Fred Veer**

*Associate Professor of Structural Mechanics*

**Ir. Hans Hoogenboom**

*Lecturer of Design Informatics*

**Dr. Charalampos Andriotis**

*Assistant Professor of Structural Mechanics*

**Ir. Frank Schnater**

*Lecturer of Design of Construction*

# EARTHY GUEST LECTURERS



***Genesis Lab:***

- Ir. Shervin Azadi

***LEVS architecten***:

- Ir. Jurriaan van Stigt

***Matierra***

- Ir. Pietro Degli Esposti

***Arup Amsterdam***

- Dr. Michele Palmieri
- Ir. Shibo Ren
- Ir. Kotryna Valeckaite

***Forensic Architecture***

- Ir. Nour Abu Zaid

***Block Research Group***

- Prof. Philippe Block
- Dr. Tom van Mele
- Dr. Robin Oval

***Buro Happold***

- Ir. Dirk Visser

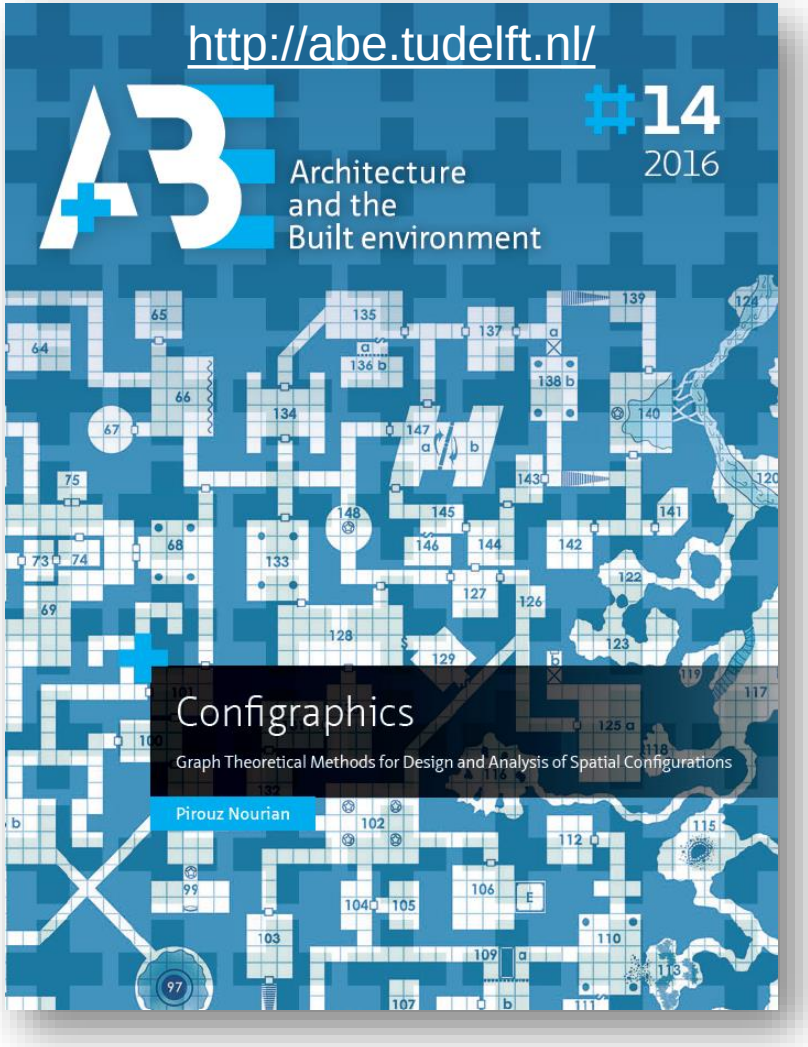
***Pieters Bouwtechniek***

Ir. Rick van Dijk

# ABOUT ME

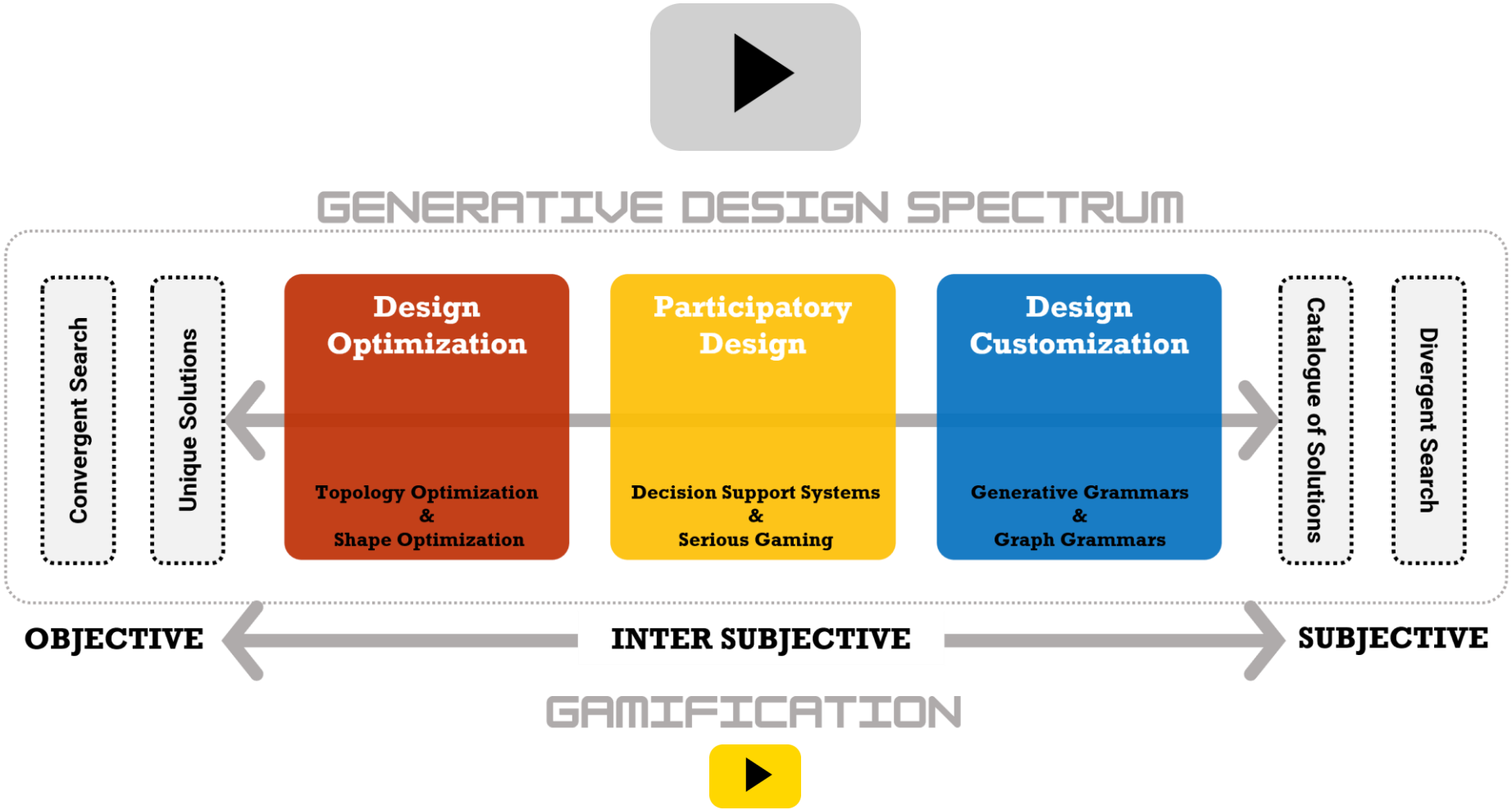
**Dr. Ir. Pirouz Nourian**

*PhD Design Informatics, MSc Architecture, BSc Control Engineering*
*Assistant Professor of Design Informatics*
*Department of Architectural Engineering & Technology*
*Faculty of Architecture and Built Environment*



# GENERATIVE DESIGN






https://genesis-lab.dev/about/

# COURSES ON GENERATIVE DESIGN

**Applications:** Computational Design (Spatial Analysis, Synthesis, Simulation, Evaluation, and Optimization
**Methods:** Linear Algebra, Computational Geometry, Topology, and Graph Theory), Programming (C#, Python)

- Learning Goals
- Teachers
- Generative Design
- Earth Architecture
- Motivation: EA
- Motivation: GD
- Vernacular & Modern
- Material-Form-Structure
- Learning Activities
- Typical Agenda
- Evaluation
- Exhibition

Mathematics

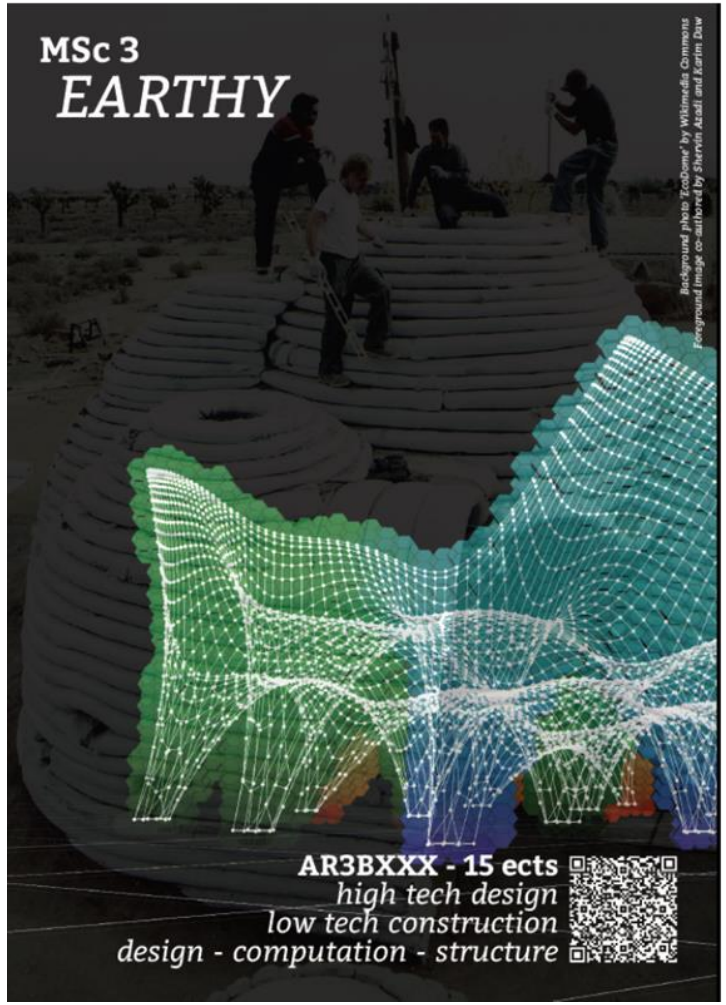
NumPy

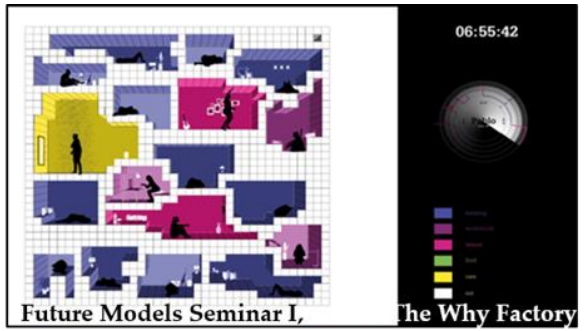
Microsoft .NET

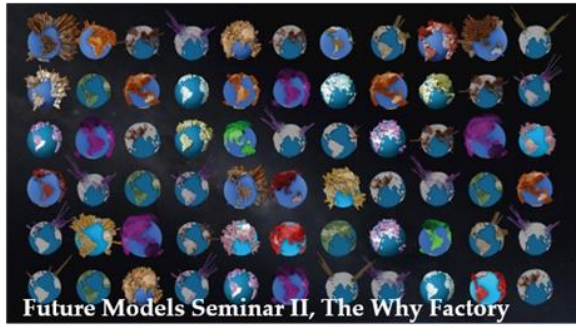
PYTHON

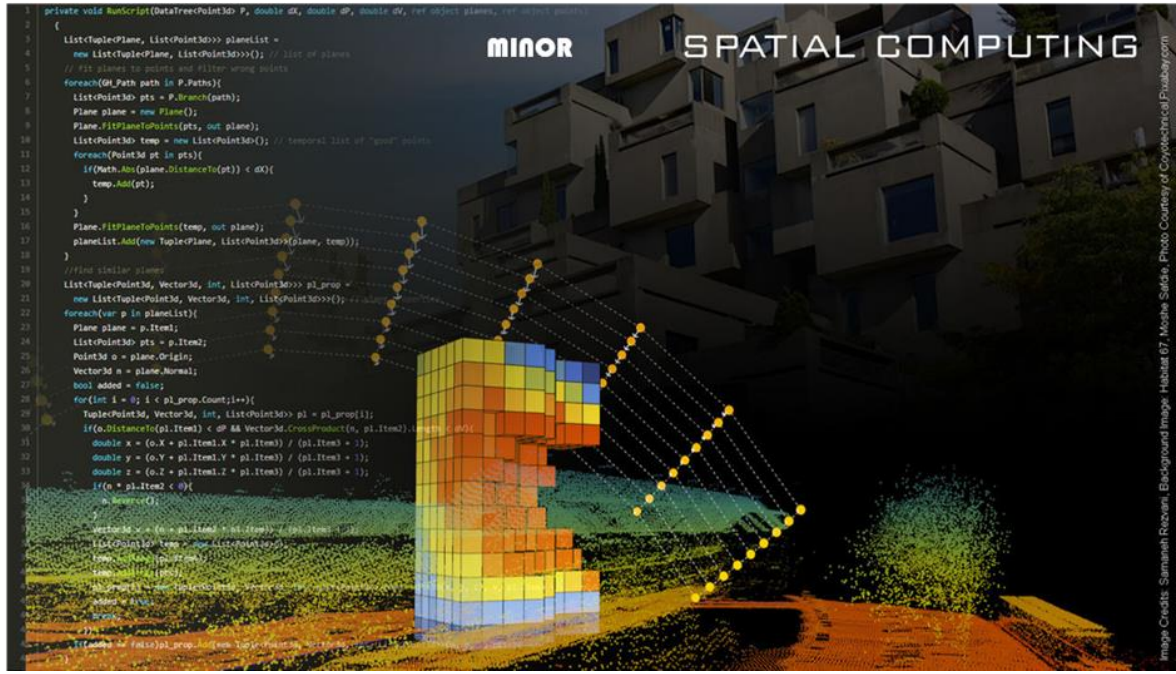
HOUDINI

Gitlab



# GENERATIVE DESIGN FOR EARTHY ARCHITECTURE

In collaboration with the Chair of Structural Design & Mechanics, AET, ABE

Student Work Samples from EARTHY 2019: **BUSTAN**
Akash Changiani, Shasan Chokshi, Kazi Fahriba Mustafa, Thai Wannasawang, Yarai Z. Montemayor, Elisa Vintimila Salas

Student Work Samples from EARTHY 2019: **MODULABITAT**
Allesandro Passoni, Alessio Vigorito, Kiana Mousavi, Fredy Fortich Mora, Stephanie Moumdjian

Mathematics

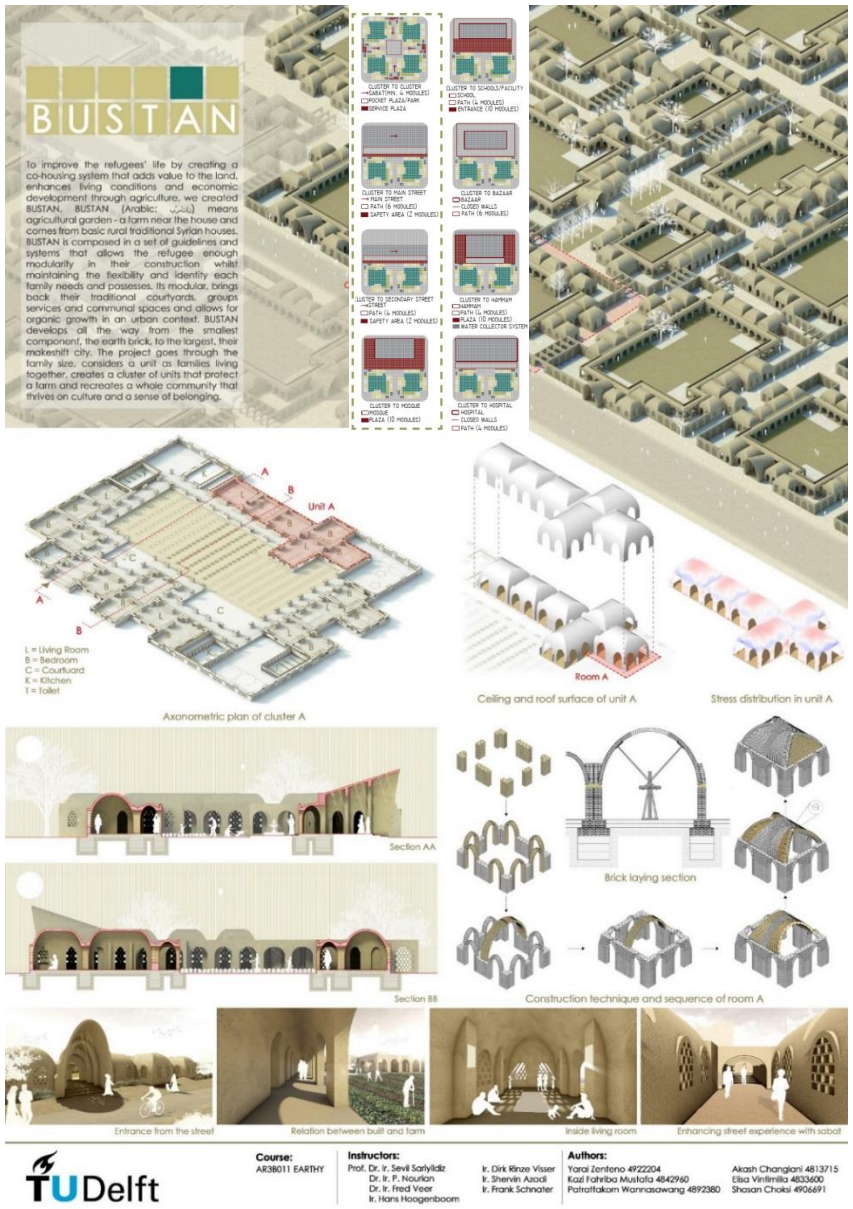
NumPy

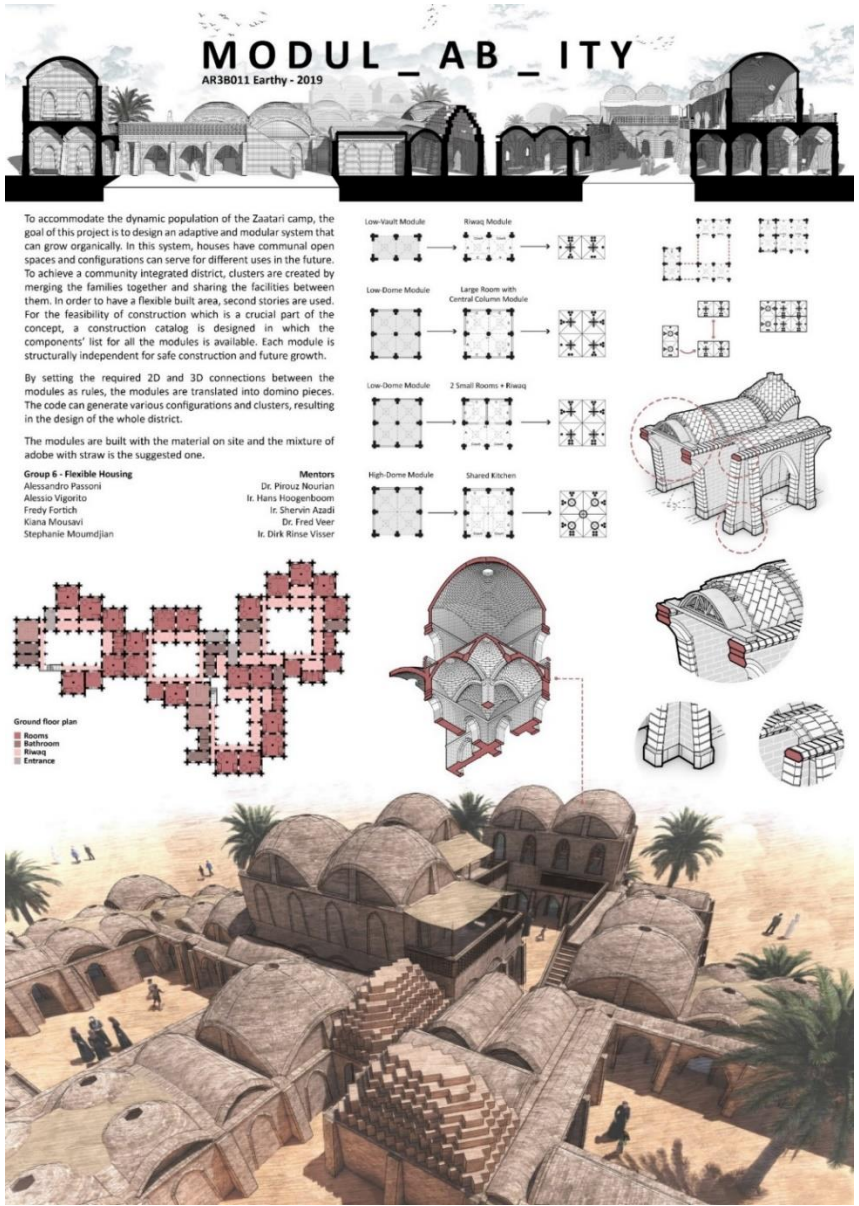
Microsoft .NET

PYTHON

HOUDINI

Gitlab



# SPATIAL COMPUTING DESIGN STUDIO

In collaboration with the Chair of Computer Graphics & Visualization, EEMC

Student Work Samples from EARTHY 2019: **COHO**
Fé van Lookeren Campagne, Max Ketelaar, Ruben Schonewille

Mathematics

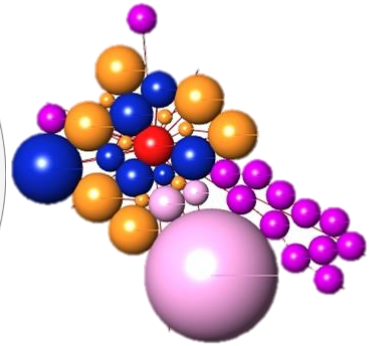
NumPy

Microsoft .NET

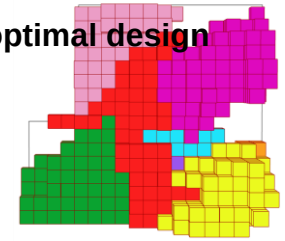
PYTHON

HOUDINI

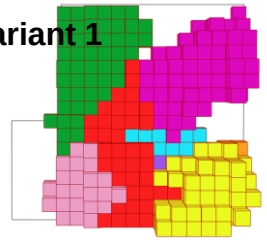
Gitlab

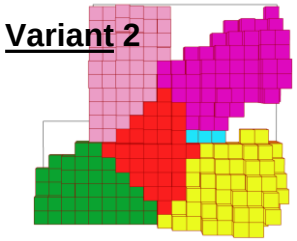
optimal design



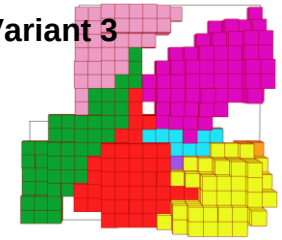
Variant 1

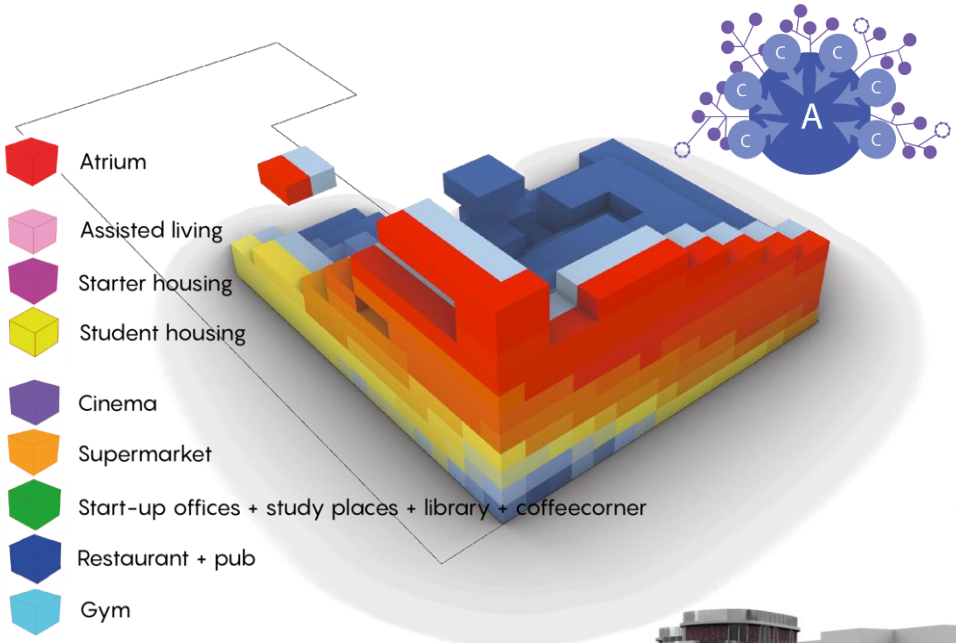


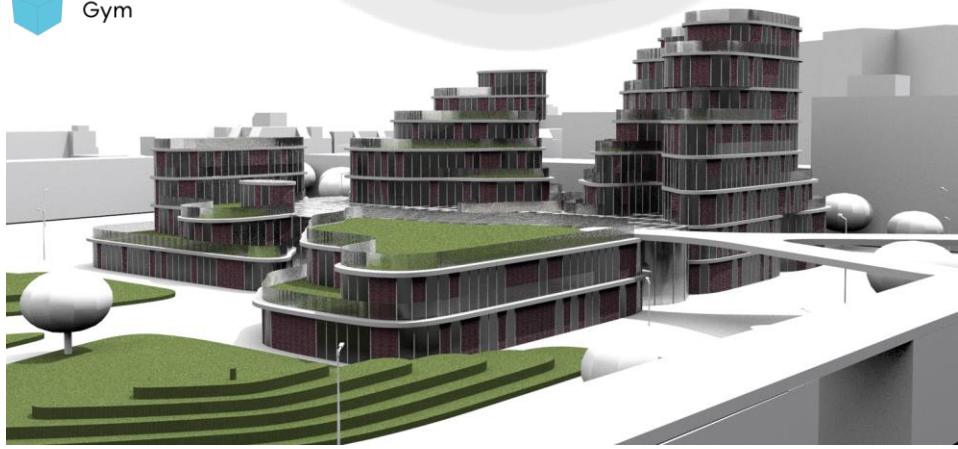
Variant 2



Variant 3





# DIGITALIZATION OF DESIGN

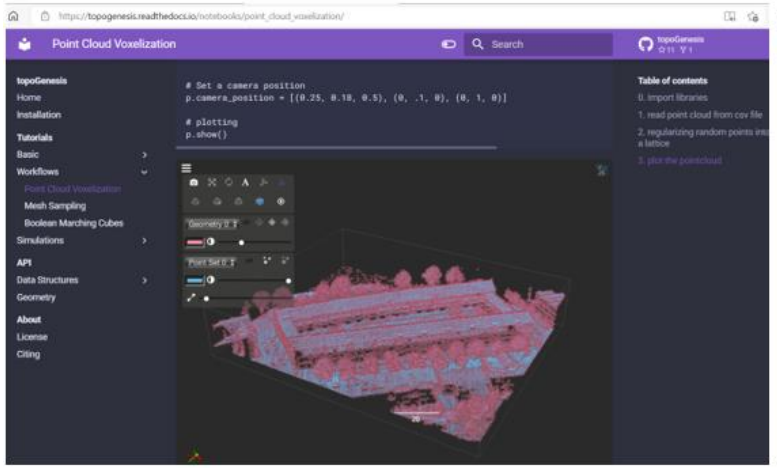


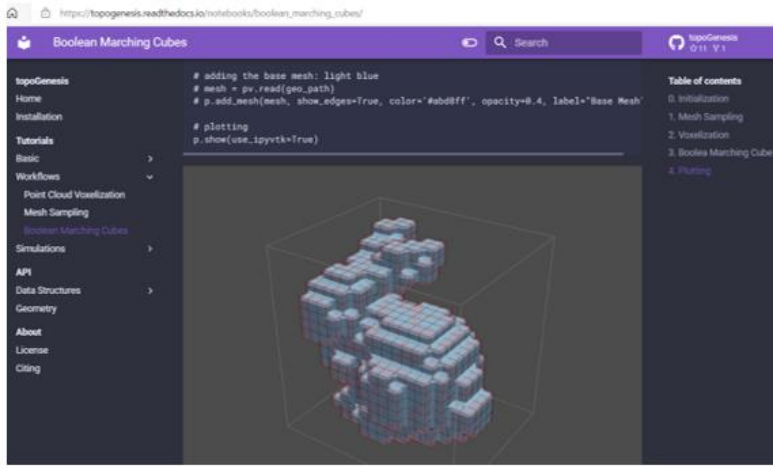
| Tools | Applications |
|---|---|
| topoGenesis | *A python library for topological voxelization & synthesis of configurations (2020 onward)* |
| vectoRelax | *Vecotorized Dynamic Relaxation for Masonnry Shape Optimization (2019 onward)* |
| Solaris | *Vecotorized Solar Evaluation Tools for Generative Design (WIP)* |
| RasterWorks | *Raster3D tools for voxel field modelling and Isosurface Design (2014 onward)* |
| Syntactic | *Space Syntax for Generative Design (2013 onward)* |
| Configurbanist | *Urban Configuration Analysis for Walking and Cycling Accessibility (2012 onward)* |

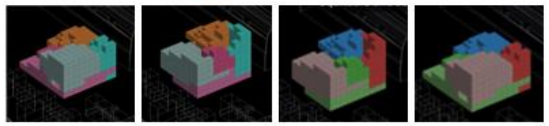
# TOPOGENESIS

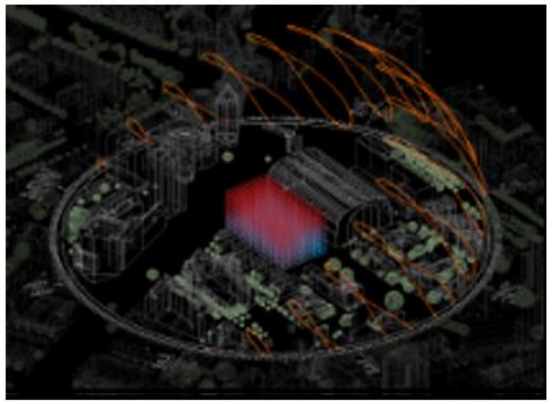
| | |
|---|---|
| Title: | topoGenesis: a python library for topological voxelization and voxel generative design |
| Type: | Research Software Development |
| Year: | April 2020-Present |
| Team: | Ir. Shervin Azadi & Dr. Pirouz Nourian |
| Page: | https://genesis-lab.dev/products/topogenesis/<br>GitHub Repository, Documentation |
| Nexus: | Spatial Computing, GoDesign, EquiCity, Earthy, RasterWorks |

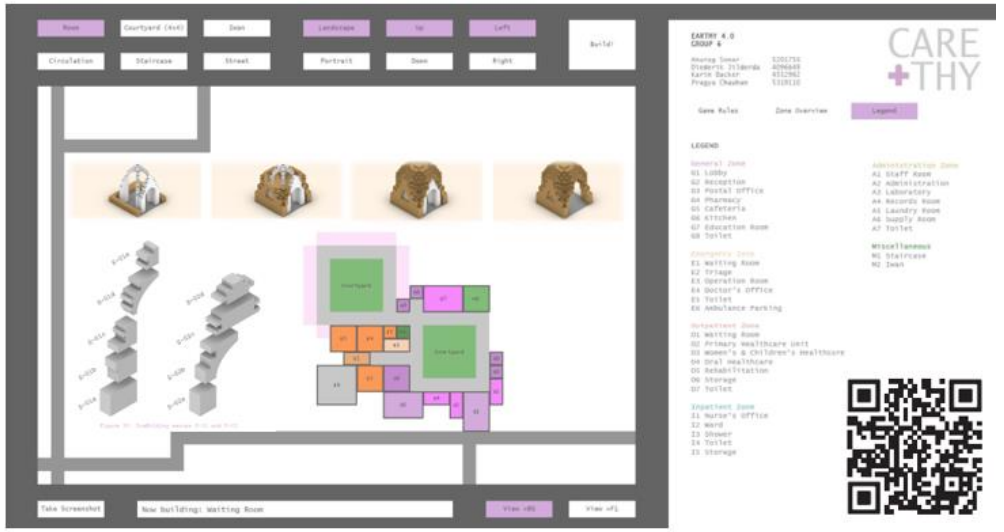








# EARTHY ARCHITECTURE

- domes & vaults
- wattle & daub
- rammed earth
- cave architecture (e.g. Cappadocia)
- adobe
- earth blocks, gypsum, lime
- brick and/or stones



https://en.wikipedia.org/wiki/Earth_structure
https://www.designboom.com/architecture/earth-a-building-material-of-the-future/

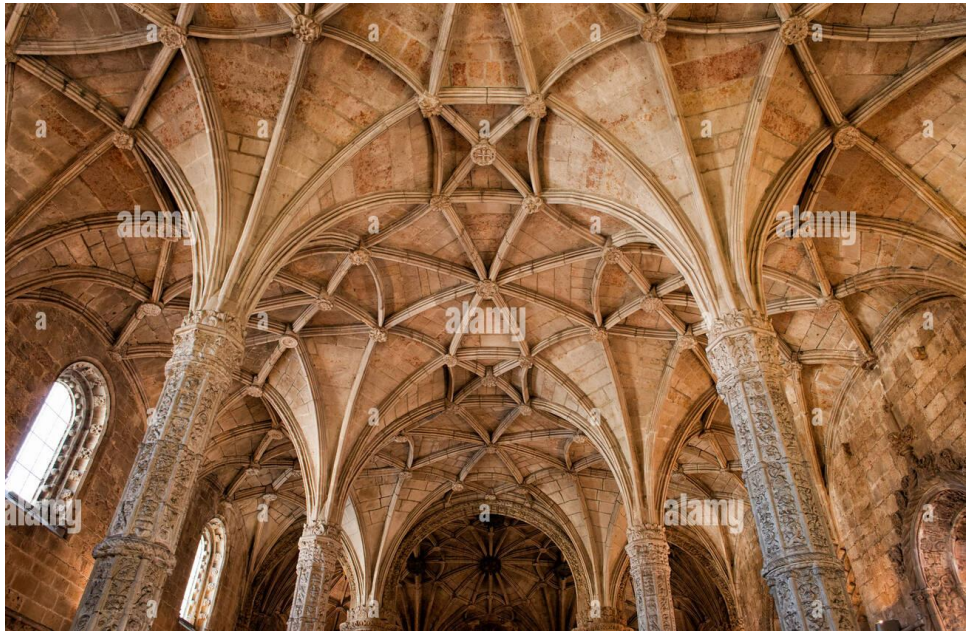
# EARTHY ARCHITECTURE
# NOT ABOUT WALLS; IT IS ABOUT CEILINGS!

## READ MORE

## MODEULAR EARTHY ARCHITECTURE

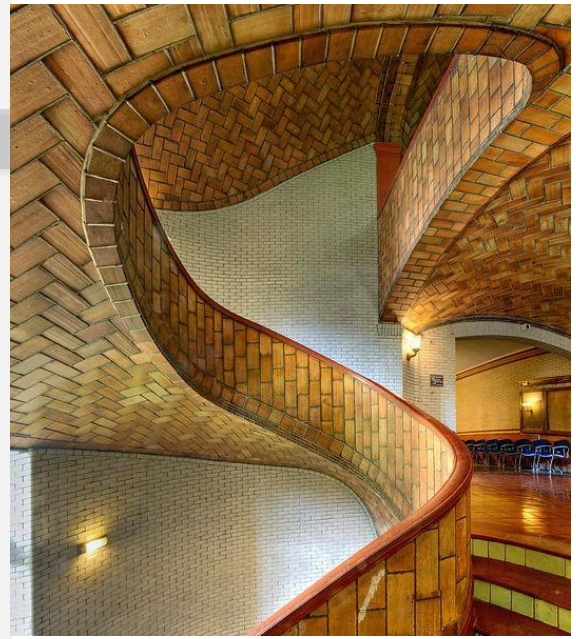


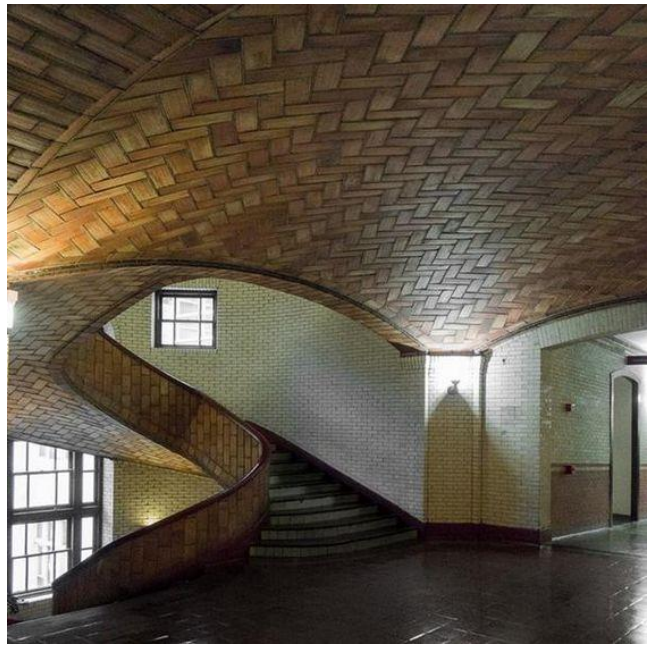
Chehel Sotoun Palace. Isfahan, Iran



Jeronimos Monastery Church of Santa Maria in Lisbon, Portugal

- Masonry-only structures: domes & vaults





Carnegie Mellon University Hall, Architect: Rafael Gustavino

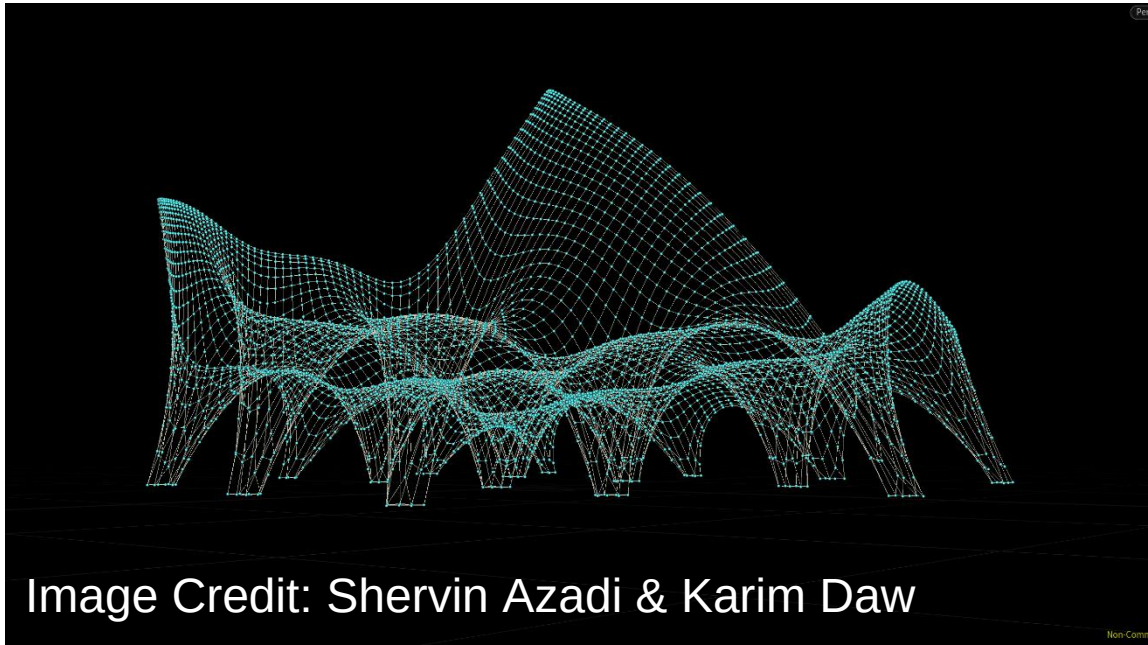
https://en.wikipedia.org/wiki/Earth_structure

https://www.designboom.com/architecture/earth-a-building-material-of-the-future/

# BACKGROUND



- External: designing decent dwellings for displaced communities
- Internal: learning math, programming, and structural design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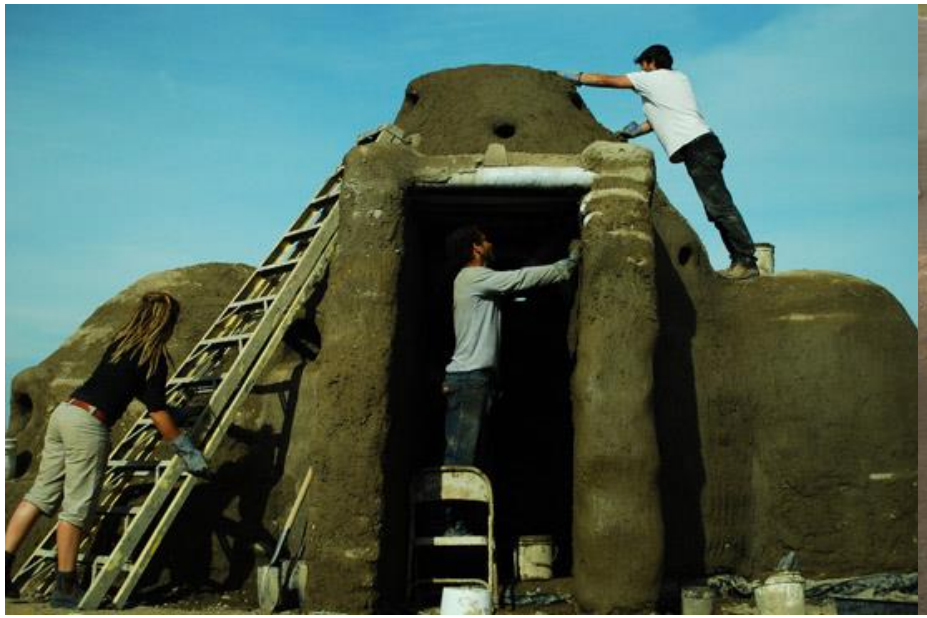
# Mid-term Alternative to Tents for Displaced Communities

- External: designing decent dwellings for displaced communities



**Haiti Prototype by Cal Earth Institute**
http://www.calearth.org/

https://www.designboom.com/architecture/haiti-prototype-by-cal-earth-institute/

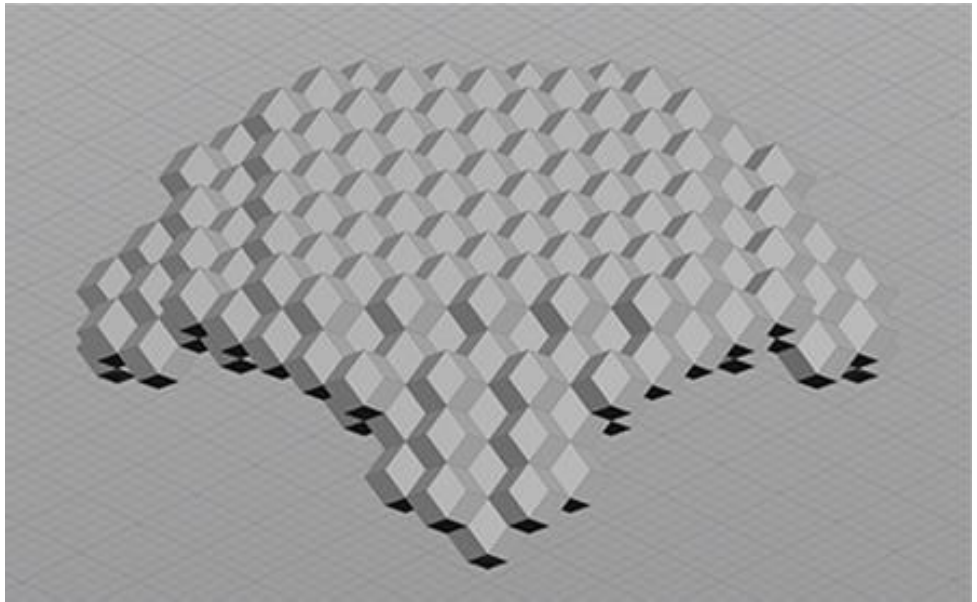
# WHY EARTHY ARCHITECTURE?

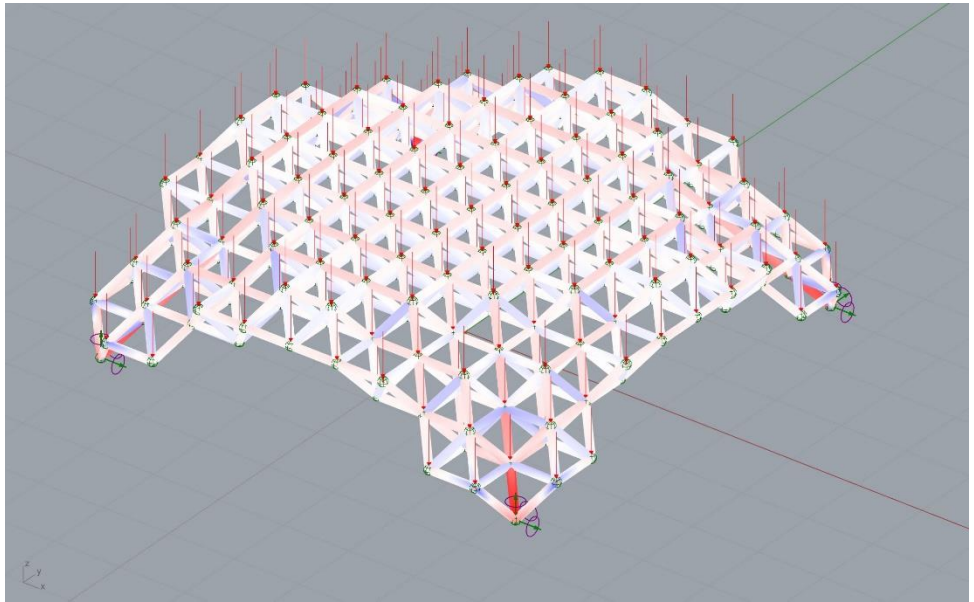


- Internal: learning math, programming, and structural design

- Computational Design (form-finding)
- Finite-Element-Method

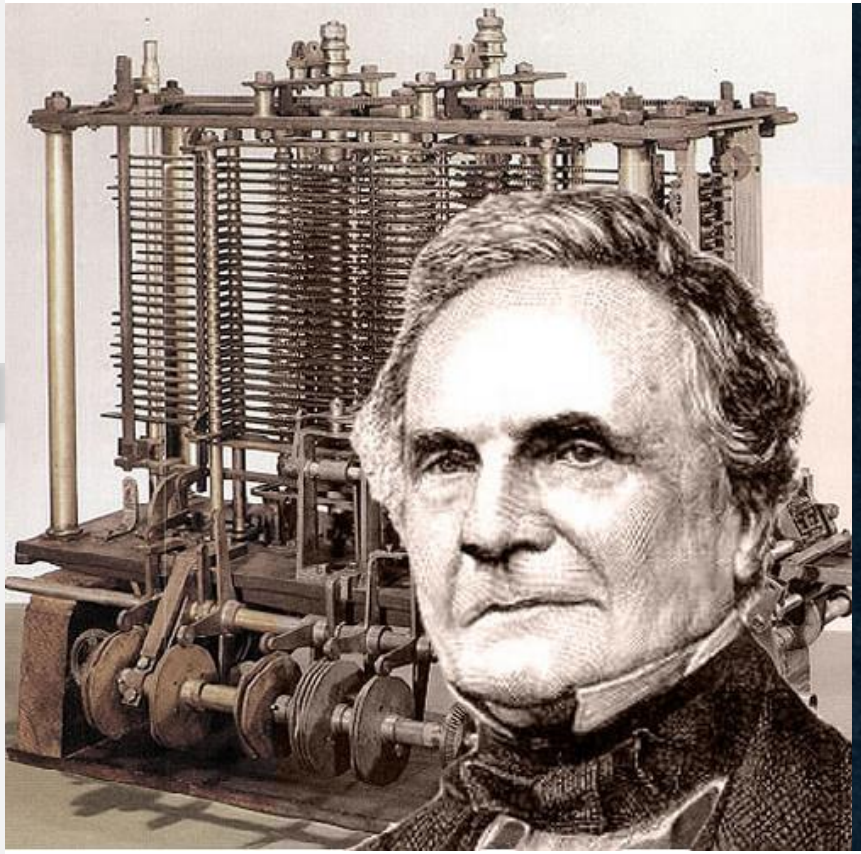
Image Credits: Karim Daw, Shervin Azadi, Pirouz Nourian, Hans Hoogenboom





# WHY GENERATIVE DESIGN? METHODS & TOOLS





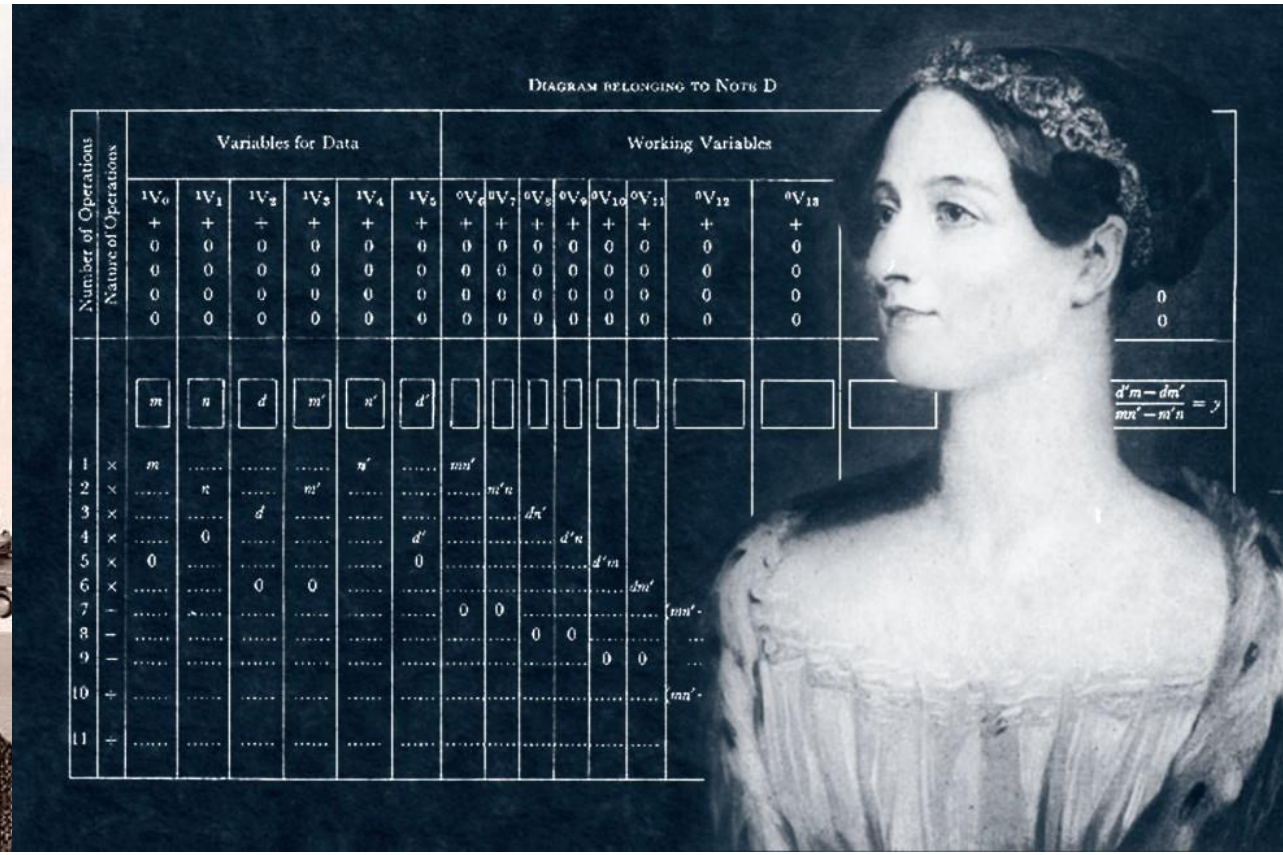



Image Credits: https://www.techtricksworld.com/charles-babbage/ & https://iq.intel.com.au/ada-lovelace-the-first-computer-programmer/

# WHY GENERATIVE DESIGN? METHODS & TOOLS



- Topology Optimization (a.k.a. Generative Design)
- Shape Optimization (a.k.a. Form-Finding)
- Discrete Construction Design (for ultimate constructability)
- Elegance, Repeatability, Process-Documentation

# THE VERNACULAR & THE MODERN

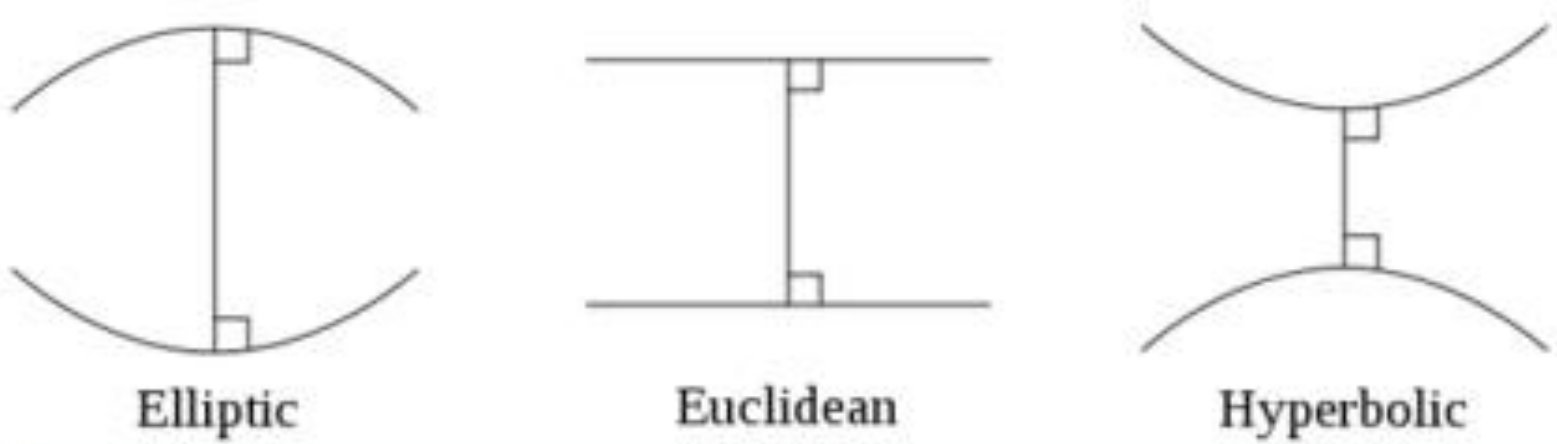


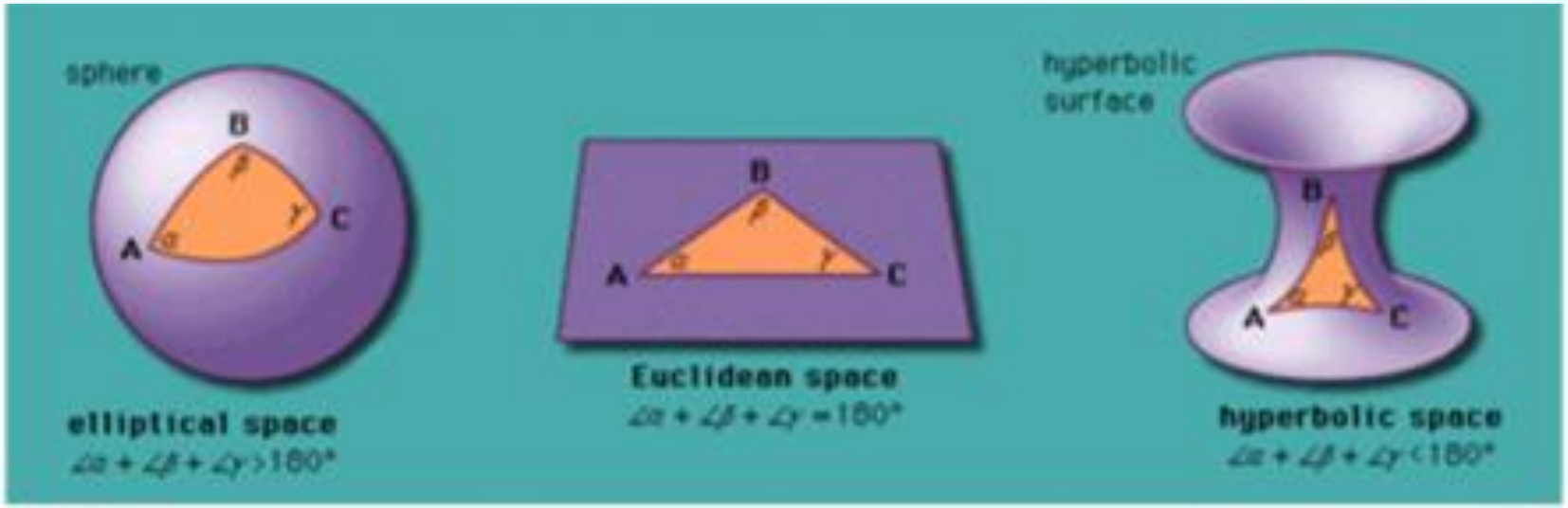

Left: Historic City of Yazd, a Unesco World Heritage Site, Image courtesy of Yazd.Today

Right: Armadillo Vault, Block Research Group, Image courtesy of BRG

# MATERIAL-FORM-STRUCTURE



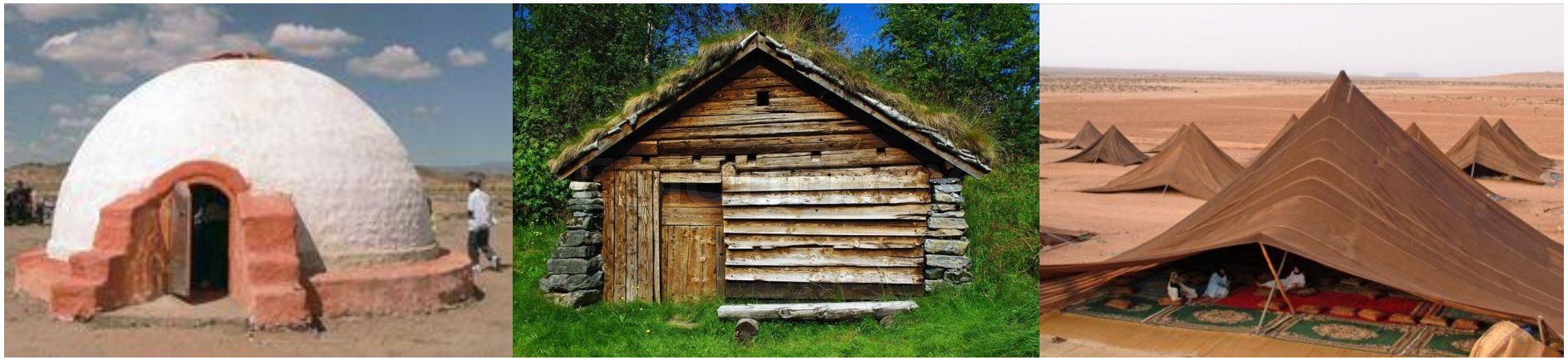


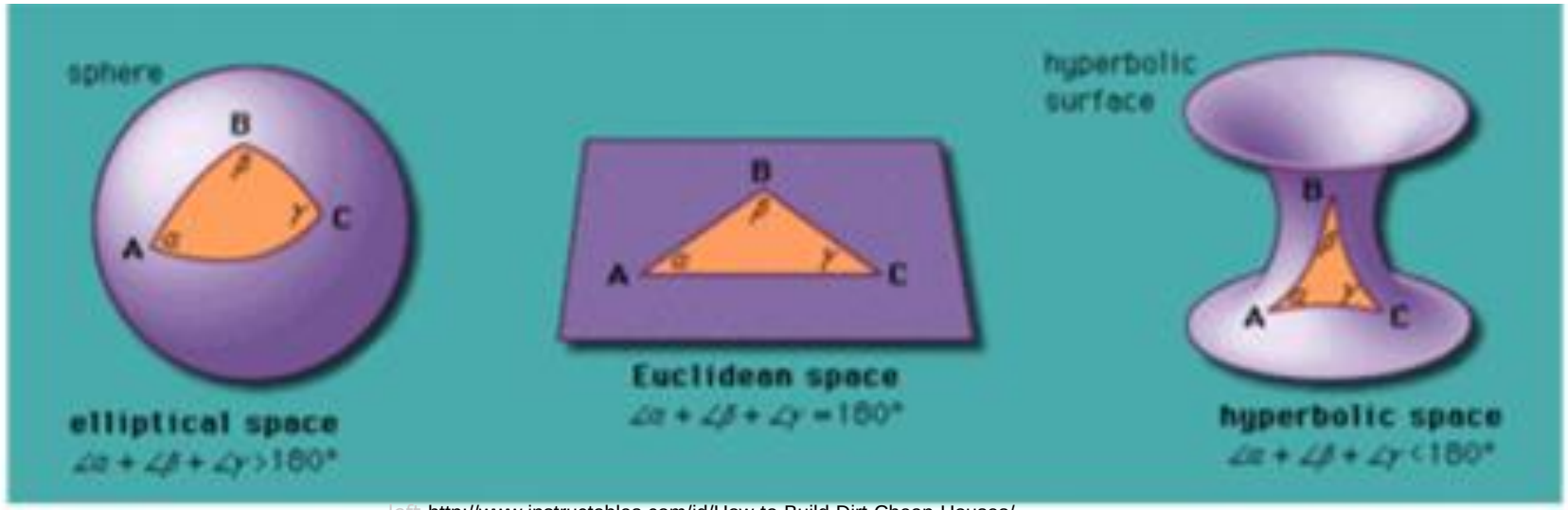




http://original.britannica.com/eb/art-322/Contrasting-triangles-in-Euclidean-elliptic-and-hyperbolic-spaces

# MATERIAL-FORM-STRUCTURE








left http://www.instructables.com/id/How-to-Build-Dirt-Cheap-Houses/

Middle: https://www.colourbox.com/image/ancient-fisherman-s-wooden-hut-in-ethnic-park-of-alesund-norway-image-1723627

Right: https://www.colourbox.com/image/ancient-fisherman-s-wooden-hut-in-ethnic-park-of-alesund-norway-image-1723627

bottom: http://original.britannica.com/eb/art-322/Contrasting-triangles-in-Euclidean-elliptic-and-hyperbolic-spaces

# WHAT WE DO IN THE COURSE EARTHY

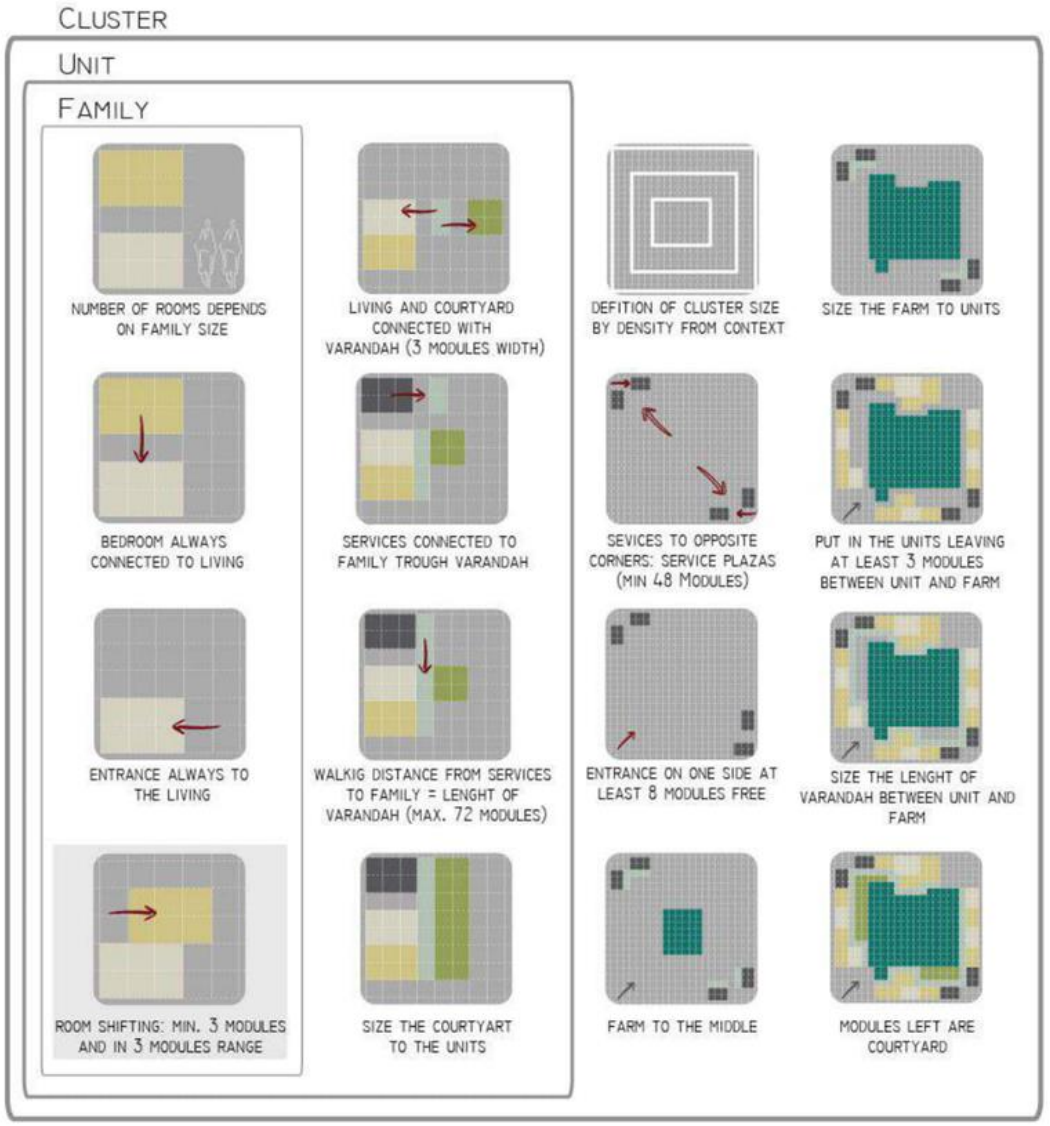


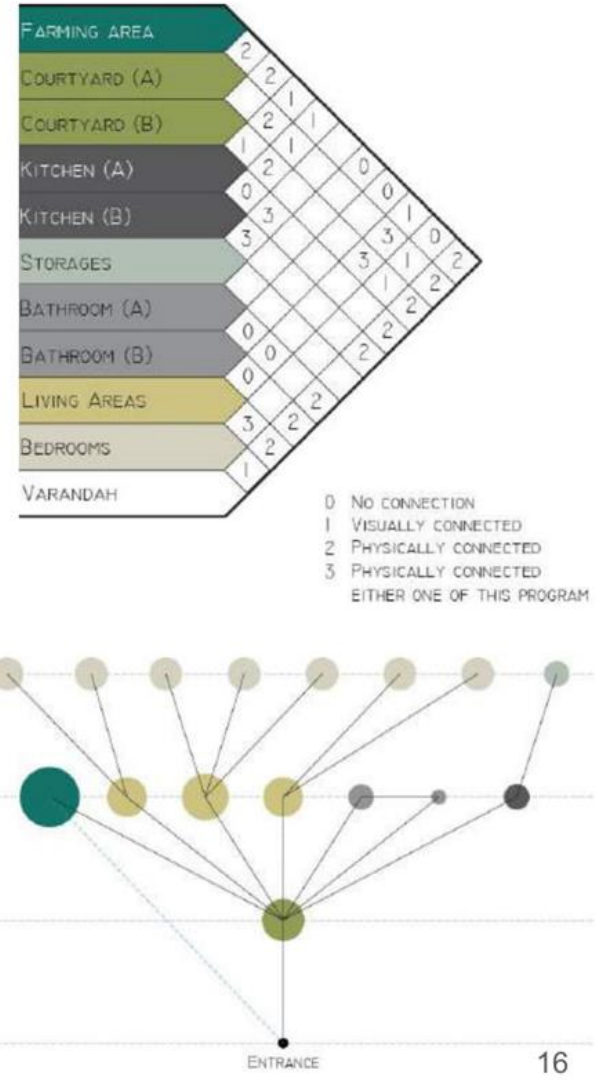
1. Configuring: arrangement of a settlement for a displaced community considering accessibility of amenities, and functional layout of communal/public buildings;
2. Forming: devising the 3D shape of the buildings based on their functional configuration, climatic functionality, and structural performance;
3. Structuring: construction design of an earth building for a zero-waste circular construction process.

# Configuring

Student Work Samples from EARTHY 2019: Project Bustan
Akash Changiani, Shasan Chokshi, Kazi Fahriba Mustafa, Thai Wannasawang, Yarai Z. Montemayor, Elisa Vintimila Salas



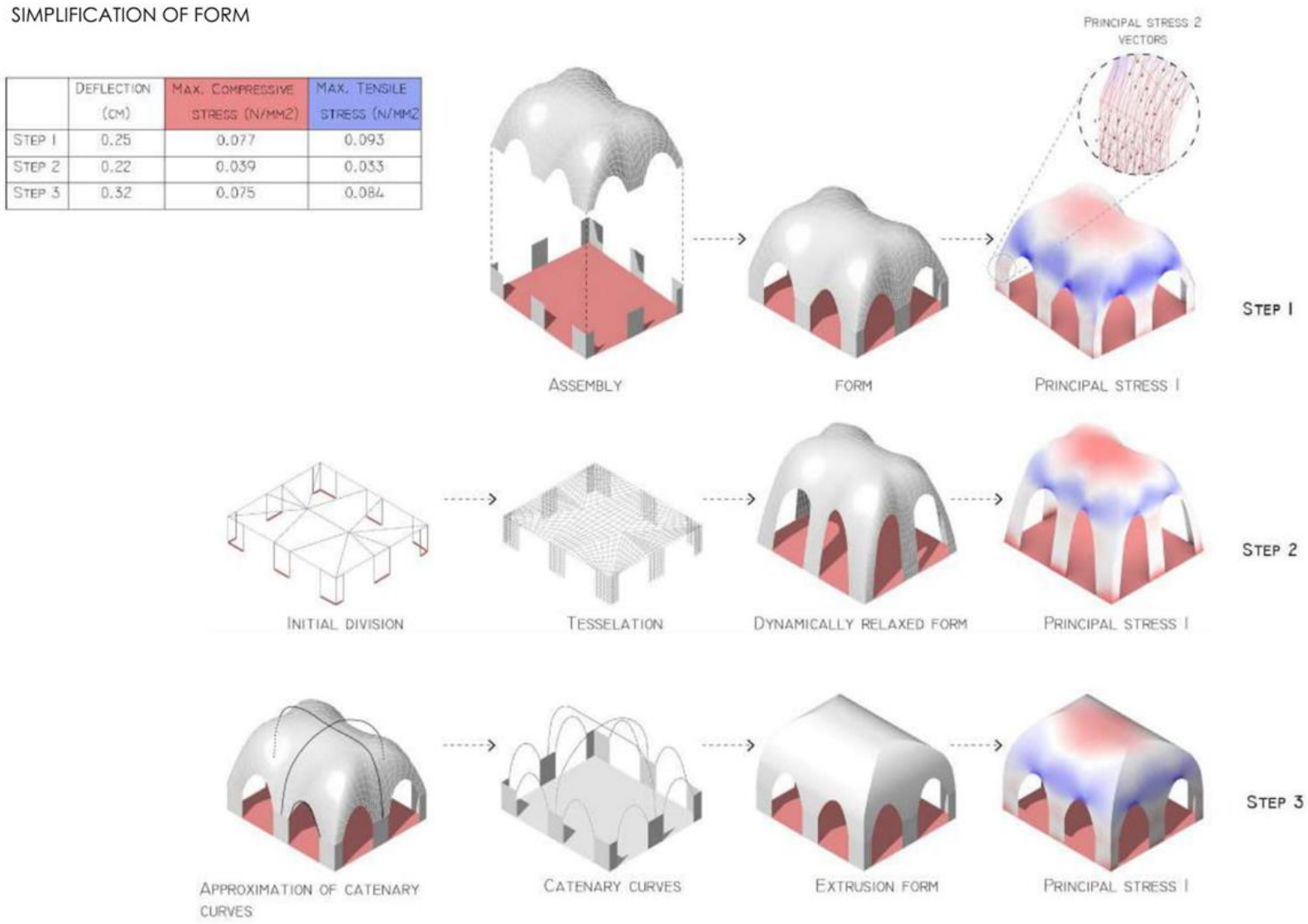



# Forming

Student Work Samples from EARTHY 2019: Project Bustan
Akash Changiani, Shasan Chokshi, Kazi Fahriba Mustafa, Thai Wannasawang, Yarai Z. Montemayor, Elisa Vintimila Salas



# Structuring

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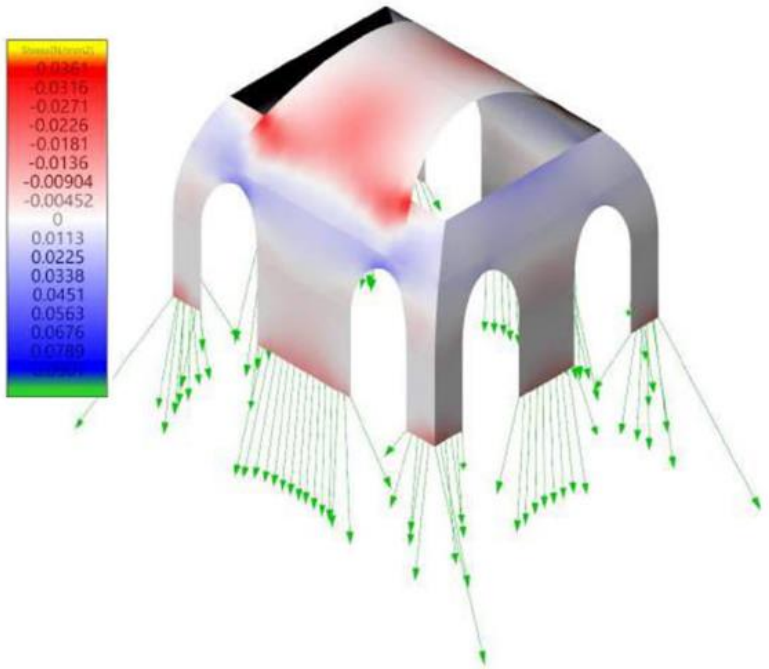
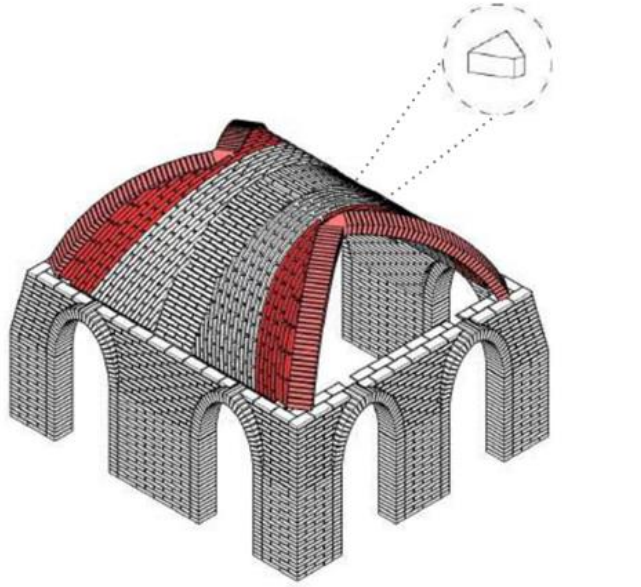


**STEP 6:** THE CORNER RIB ARCHES ARE MADE WITH COMPASS.

JUNCTION OF THE TWO RIBS ARCHES FROM OPPOSITE SIDES CLOSED WITH A TRIANGULAR BRICK

# WHAT WE DO IN THE COURSE EARTHY



- participatory planning and design;
- form-follows-function (structure, climate, ergonomics);
- shape-active structures;
- masonry/compression-only materials;
- not making the thinnest shell, but making the most liveable building;
- participatory construction;
- learning spatial mathematics & computation;
- mass-customization with 'DIY robotics';
- making prototypes with real materials;
- open-source development;
- tool-development;

https://www.designboom.com/architecture/earth-a-building-material-of-the-future/

# PRACTICAL MATTERS



- Groups of 3-5 students, with clear-cut responsibilities (not roles)
- Check the online **course description**.
- There will be some costs for making the prototypes; but we will do our best to keep the total cost low.
- You do not have to be an expert in programming or structural design; but you have to be interested to learn these skills.

| Week No. | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 |
|---|---|---|---|---|---|---|---|---|---|---|
| Quarter | Quarter 1 | | | | | | | | | |
| Teaching week | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Monday | 31-Aug | 07-Sep | 14-Sep | 21-Sep | 28-Sep | 05-Oct | 12-Oct | 19-Oct | 26-Oct | 02-Nov |
| Tuesday | 01-Sep | 08-Sep | 15-Sep | 22-Sep | 29-Sep | 06-Oct | 13-Oct | 20-Oct | 27-Oct | 03-Nov |
| Wednesday | 02-Sep | 09-Sep | 16-Sep | 23-Sep | 30-Sep | 07-Oct | 14-Oct | 21-Oct | 28-Oct | 04-Nov |
| Thursday | 03-Sep | 10-Sep | 17-Sep | 24-Sep | 01-Oct | 08-Oct | 15-Oct | 22-Oct | 29-Oct | 05-Nov |
| Friday | 04-Sep | 11-Sep | 18-Sep | 25-Sep | 02-Oct | 09-Oct | 16-Oct | 23-Oct | 30-Oct | 06-Nov |
| Saturday | 05-Sep | 12-Sep | 19-Sep | 26-Sep | 03-Oct | 10-Oct | 17-Oct | 24-Oct | 31-Oct | 07-Nov |
| Sunday | 06-Sep | 13-Sep | 20-Sep | 27-Sep | 04-Oct | 11-Oct | 18-Oct | 25-Oct | 01-Nov | 08-Nov |
| What you do in these weeks | Programming | Configuring | Shaping | | | Structuring | | Documenting | Making | Final Evaluation |
| | A0 | A1 | A2 | | | A3 | | Document | Present | Rest |
| | 0 Pts | 15 pts | 25 pts | | | 30 pts | | 10 pts | 20 pts | 100 pts |
| due dates | 04-Sep | 11-Sep | | | 02-Oct | | 16-Oct | 23-Oct | 30-Oct | |

JUST AN ILLUSTRATIVE SCHEDULE !!!,
The official schedule will be in the 50th edition of the course brief!

| Week | Day | Date | To Do | AM1 (9:00-9:45) | AM2 (10:00-10:45) | AM3 (11:00-11:45) | AM4 (12:00-12:45) | Break | PM1 (14:00-14:45) | PM2 (15:00-15:45) | PM3 (16:00-16:45) | PM4 (17:00-17:45) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Tuesday | 01-Sep | A0: warmup | Course Intro. and grouping, PZN | | Configuring Earth & Masonry Architecture, Nour Abuzaid | | | Rudiments of Linear Algebra and Computer Graphics, PZN | | Earth Arch., Ir. Juriaan van Stigt, LEVS Architecten | |
| 1 | Thursday | 03-Sep | | Computer Geometry & Topology, PZN | | Programming I: Introduction to Python, SAZ, HHG, PZN | | | Design Studio: Ideation (Configuring) | | | |
| | Tuesday | 08-Sep | A1: Configuring | Earthship Architecture, SSZ | | Programming II: Python and Voxels, SAZ, HHG, PZN | | | Design Studio: Consultation (Configuring) | | | |
| 2 | Thursday | 10-Sep | | Graphs & Fields, PZN | | Programming III: Digital Brick-Laying, PZN,SAZ, HHG | | | Programming IV: Functions & Calculus, HHG, SAZ, PZN | | | |
| | Tuesday | 15-Sep | A2: Shaping | Material Science of Earth, FVR | | Bricking Lecture and Workshop, Ir. Koen Mulder | | | Karamba Workshop, Ir.Shibo Ren, ARUP | | | |
| 3 | Thursday | 17-Sep | | FEM for Earthy Buildings, FVR | | Structural Design with Earth, DRZ | | | Design Studio: Consultation (Forming) | | | |
| | Tuesday | 22-Sep | | Dynamic Relaxation, PZN | | Programming V, NumPy and Dynamic Relaxation, SAZ & Kotryna Valeckaite | | | Design Studio: Consultation (Forming) | | | |
| 4 | Thursday | 24-Sep | | FEM and Research, FVR | | Graphical Equillibirium Analysis, Prof. Philippe Block, BRG | | | Programming VI: COMPAS, Dr. Tom van Mele, BRG | | | |
| | Tuesday | 29-Sep | | Research, Design and Development | | | | | Design Studio: Consultation (Forming & Structuring) | | | |
| 5 | Thursday | 01-Oct | | | | | | | Midterm Review (Pinup Presentation) | | | |
| | Tuesday | 06-Oct | A3: Structuring | | | | | | Design Studio: Consultation (Structuring and Forming) | | | |
| 6 | Thursday | 08-Oct | | | | | | | Design Studio: Consultation (Structuring) | | | |
| | Tuesday | 13-Oct | | | | | | | Design Studio: Consultation (Construction Design) | | | |
| 7 | Thursday | 15-Oct | | | | | | | Design Studio: Consultation (Structuring) | | | |
| | Tuesday | 20-Oct | Documenting | | | | | | Design Studio: Consultation (Code Documentation) | | | |
| 8 | Thursday | 22-Oct | | | | | | | Design Studio: Consultation (Shareable Technical Reports) | | | |
| | Tuesday | 27-Oct | Making & Presenting | | | | | | | | | |
| 9 | Thursday | 29-Oct | | | | | | | Final Presentatios and Feedback | | | |
| | Tuesday | 03-Nov | Evaluation | final submission deadline | | | | | | | | |
| 10 | Thursday | 05-Nov | | grading by instructors | | | | | | | | |

JUST AN EXEMPLARYSCHEDULE !!!,
The official schedule is in the course brief!

# RUBRIC

## Grade Constituents

0(A0)+15(A1)+25(A2)+30(A3)+10(D) +20(P)= 100 pts

## Grading Rubric

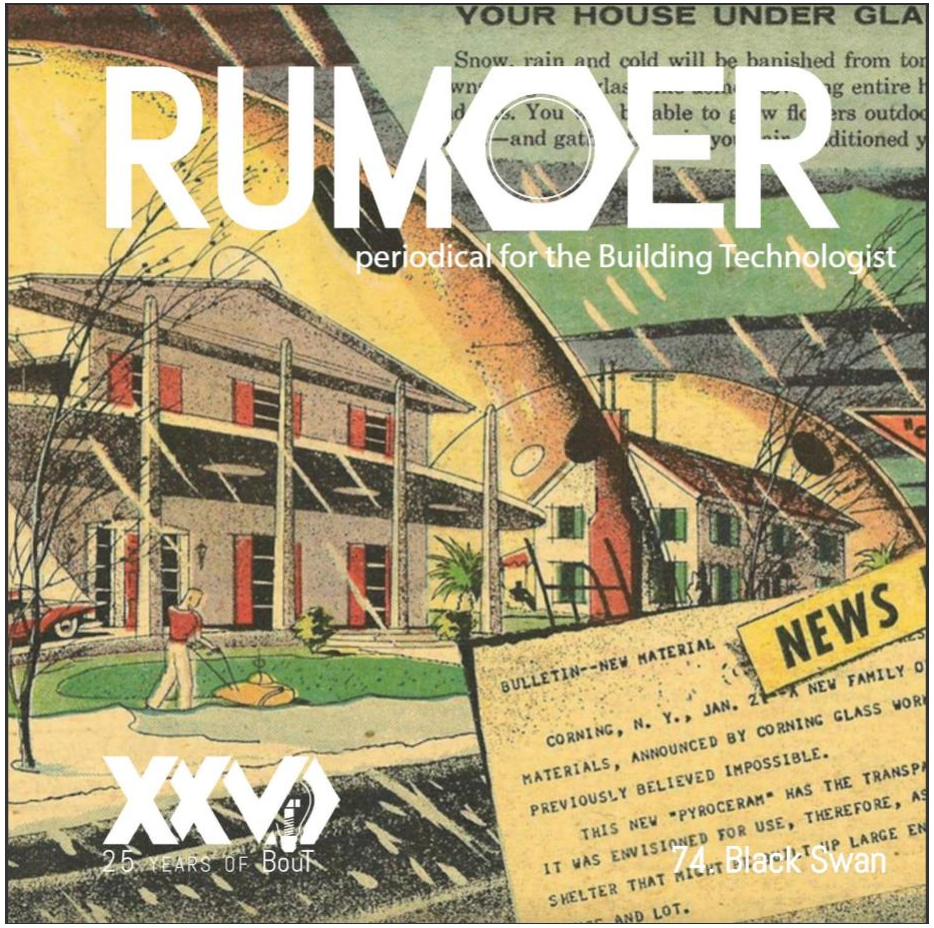
| ***Label*** | ***Mark*** | ***Explanation*** |
|---|---|---|
| Wretched | 1-2 | There is not enough evidence for assessing any meaningful contribution attributed to the individual in question. |
| Poor | 3-4.5 | Has done things sporadically but has not had a sufficiently meaningful contribution to the project. |
| Deficient | 5-5.5 | Has contributed to all deliverables but not done enough to reach a sound design, has not fully taken the complexity of the assignment into account, and thus the final results, as well as processes lack sophistication. |
| Sufficient | 6-6.5 | Has done everything necessary at a basic level to get to a sound design but the result as well as the process do not present any innovation. The complexity of the problem has been not been taken into account and the results are primitive or incomplete. |
| Fair | 7-7.5 | Has adequately utilized existing techniques to produce sound designs, however, the approach is still simplistic and does not fully take into account the complexity of the problem. There are a few useful methods developed in GH or in Python. |
| Good | 8-8.5 | Has gone at least a few small steps beyond existing techniques and attempted to achieve not only sound but also elegant designs. A few useful and noteworthy methods are developed and well documented in GH or in Python. |
| Excellent | 9-10 | Has gone quite a few steps beyond existing techniques, extended the presented knowledge, and achieved not only sound but also elegant designs. There are noteworthy technical contributions in GH or in Python. |

Important change compared to the previous rubric:

Learning programming and delivering assignments in Python/MATLAB is optional
(highly appreciated but not mandatory or necessary even for getting the highest grade)

# Peer Evaluation


Group Work



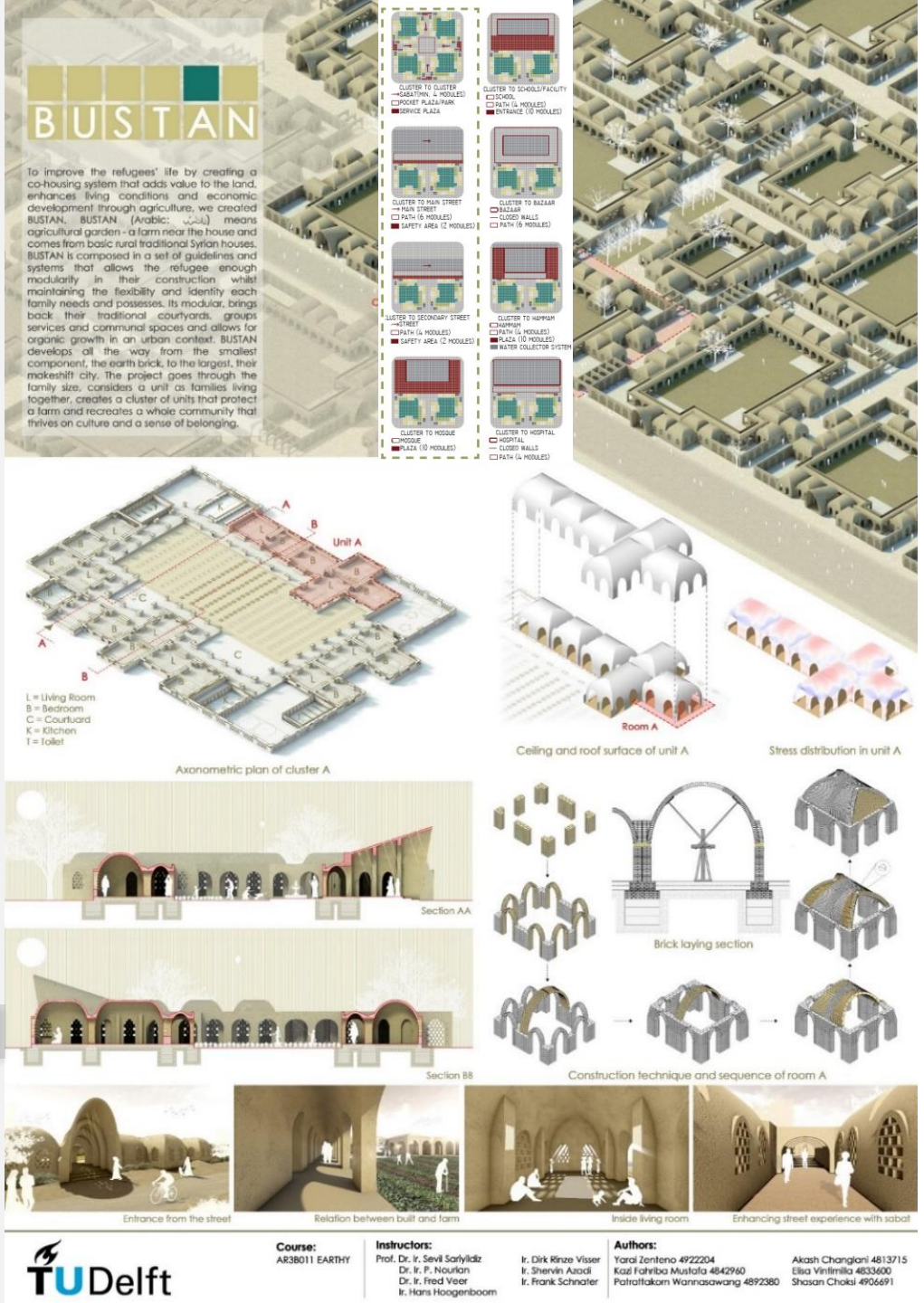


On Earthy

On Generative Design

Gamification of Design

- Learning Goals
- Teachers
- Generative Design
- Earth Architecture
- Motivation: EA
- Motivation: GD
- Vernacular & Modern
- Material-Form-Structure
- Learning Activities
- Typical Agenda
- Evaluation
- Exhibition

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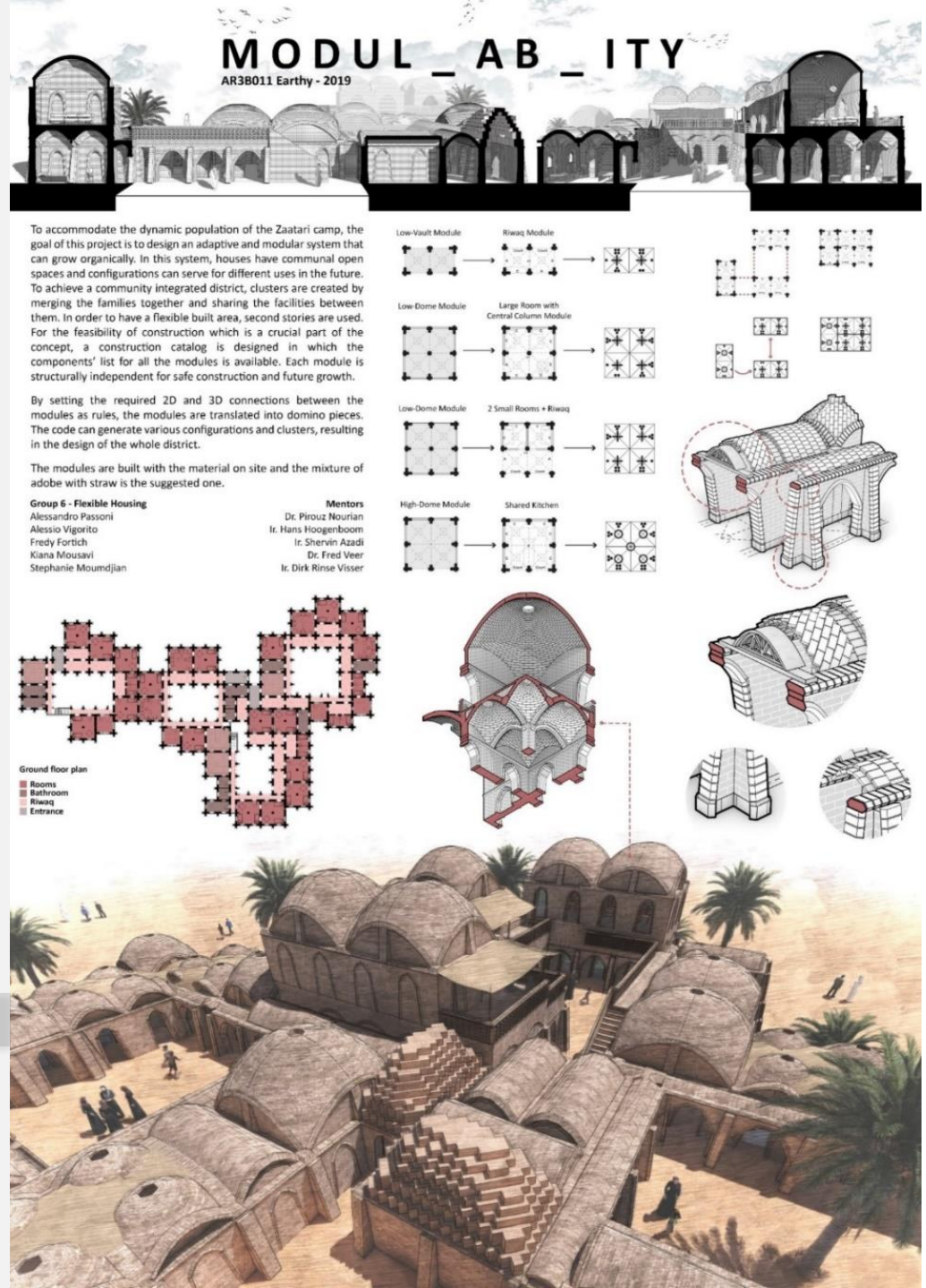


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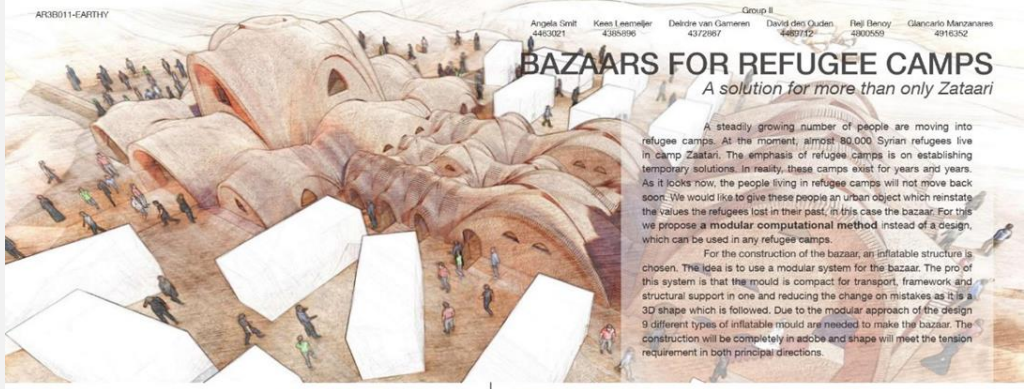
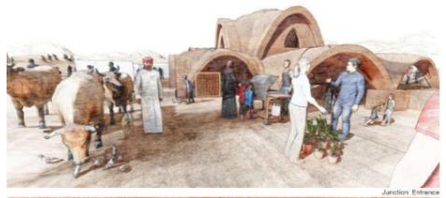
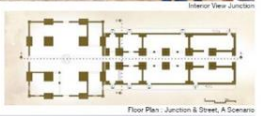
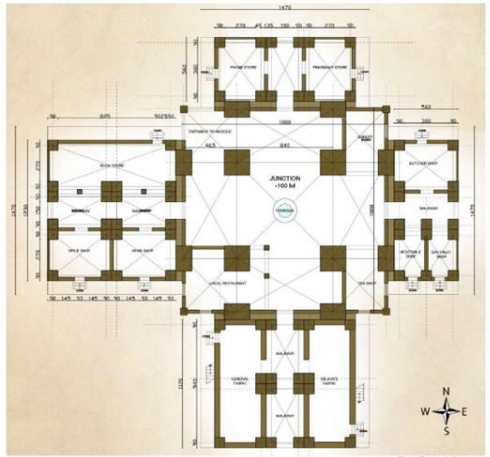






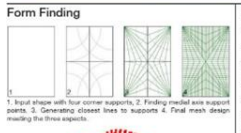


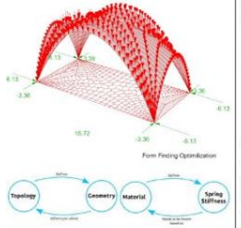
Floor Plan : A Scenario

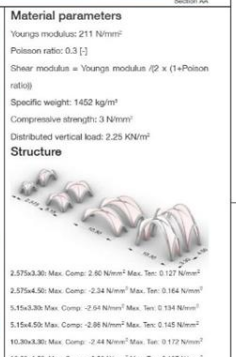

**A Modular Computational Method**

In order to make a computational method for developing a bazaar, a script was written using python and grasshopper. This script takes an existing bazaar and user input for a new shop. Using these, together with implemented guidelines, the script gives 5 good locations for a new shop from which the user gets to choose. This is how the bazaar expands. The output rectangles are the input for the structural form finding and are modular. The script simulates how the program will work, in real life the users would be able to use an app.

Bazaar Generation Using PYTHON





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TU Delft

# JANNAT AL-TOHR

## A RETREAT FROM EVERYDAY LIFE


Nikoleta Sidiropoulou 4822555, Hans Garrerschlag 4783100, Noah van den Berg 4282620
Hamidreza Shahriari 4931963, Rick van Dijk 4373618, Maximilian Mandat 4931068

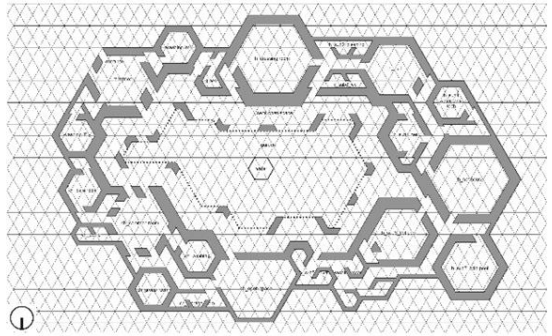

جنة الطهر

Birdeye view

courtyard gardenw view

longitudinal section

cross section



floor plan

site plan

Located in the north of Jordan the Zaatari camp houses over 80.000 Syrian refugees for and undetermined period of time.
The main idea behind this project was to give the inhabitants of Zaatari a temporary retrieve from their daily lives in the camp. Hammams are a big part of islamic culture, they serve as a place of relaxation and purification. By introducing hammams into the camp we want to give the inhabitants back something they lost during the war.

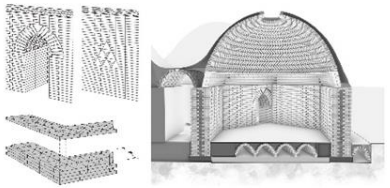
During the cesign process of the project the emphasis was placed on the use of the computational approach, as we set out to designing a methodology of designing a hammam that could be used in other locations not just for this camp. This made it so that the construction will not the easiest thing to realize, with the large spans and the irregular shapes we are trying to push the limits of what one can build with adobe.

| Chosen Mixture | |
|---|---|
| clay | 30% |
| fine sand | 30% |
| coarse sand | 40% |
| water | 10% |

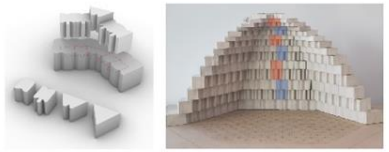
| Material properties used in structural calculations [Mpa] | |
|---|---|
| Youngs modulus | 7,6 |
| maximum compressive strenght | 1,88 |
| maximum compressive strengh after safety factor | 1,27 |
| maximum tensile strenght | 0,254 |

material properties


karamba analysis of ceilings

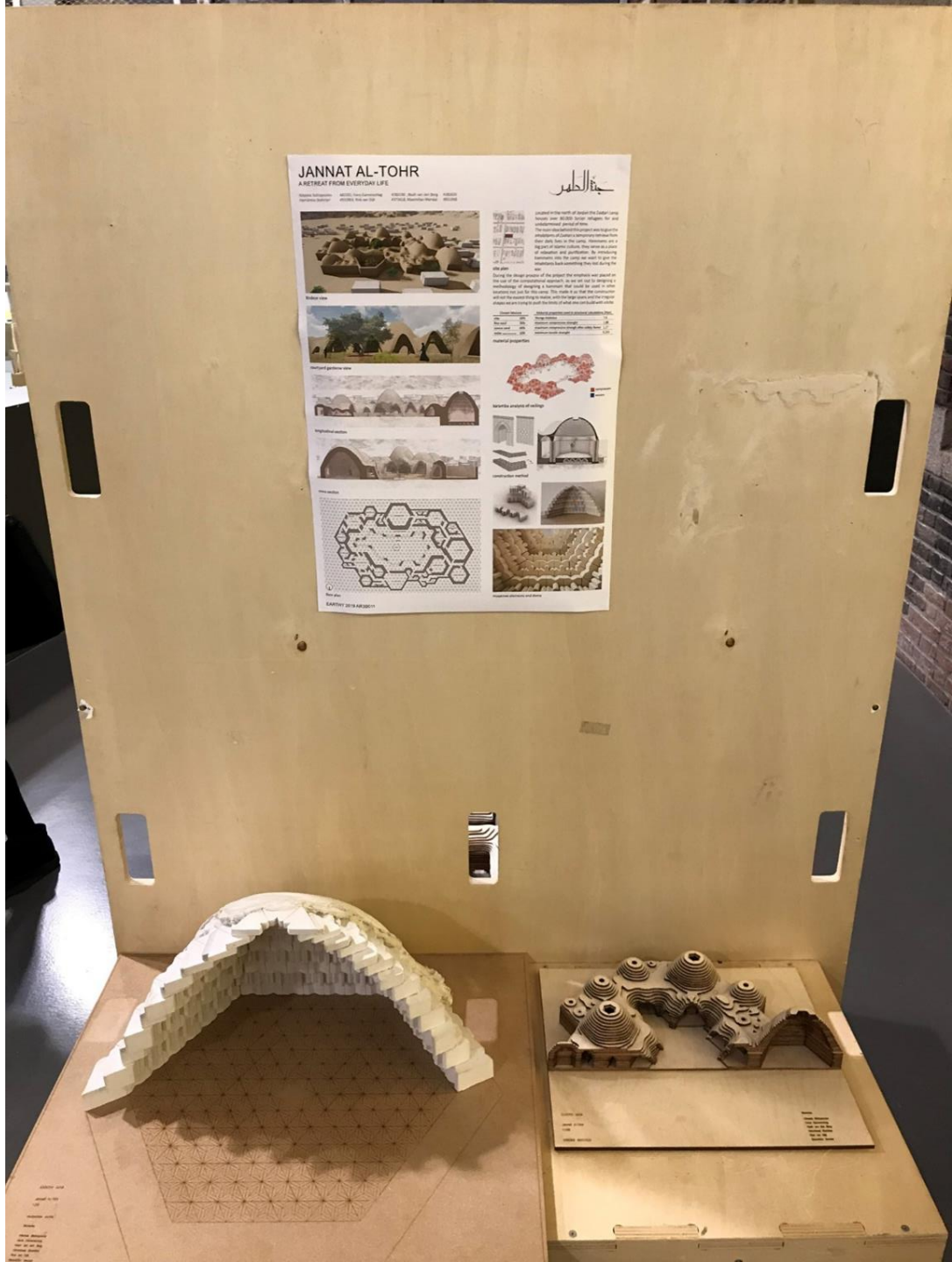


construction method



muqarnas elements and dome

EARTHY 2019 AR3B011



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TU Delft

# Sandcastle - Elementary School

**Abstract**

Proposed are urban and architectural solutions for the Syrian refugees in Zaatari Camp, Jordan. An urban master plan of school placements and upgrades was determined based on number of unenrolled children within 400m and proximity to other facilities.

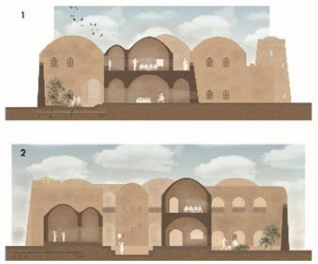
Earthy architecture can provide a high quality solution, and yet a temporary structure since it's "demountable"/destructible and circular. However earth can only be used used in compression-only structures.

One school project has been elaborated into a detailed design embracing a castle style typology. The castle design would create a sense of belonging and a safe school environment that kids would be motivated to go to.

The graph theoretical method for the layout of spatial configurations of floor plans was used first. This included RFI charts and bubble diagrams. Later meshing, welding, and grasshopper tessellation. Ansys and Karamba 3D structurally verified the dynamically relaxed ceilings by Kangaroo. Python was used for brick-laying patterns.

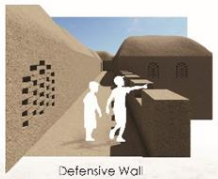


Final - Ground Floor



Final - Sections

Liwan, Central Courtyard



Defensive Wall

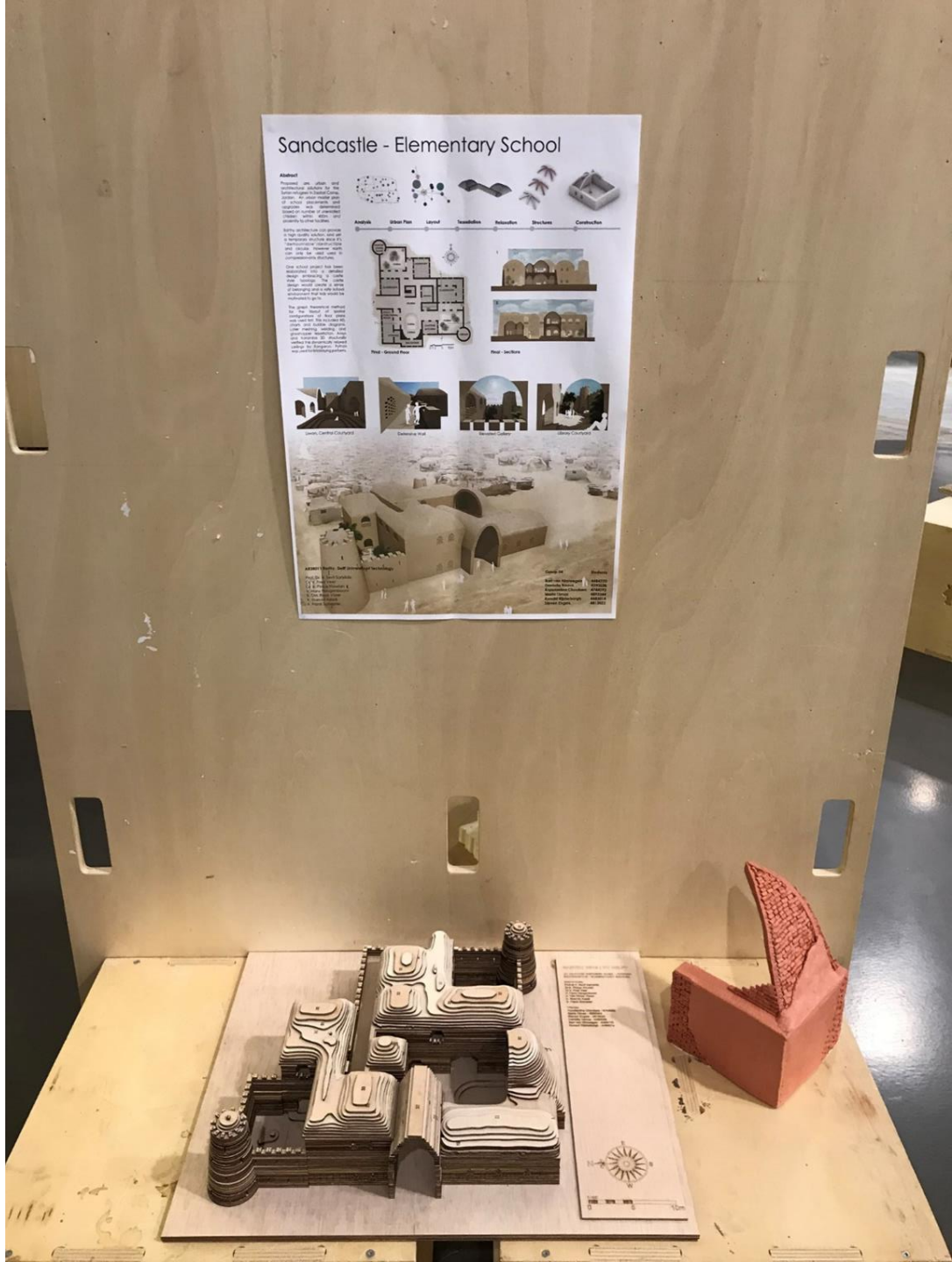
Elevated Gallery

Library Courtyard

**AR3B011 Earthy, Delft University of Technology**

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

| Group 04 | Students |
|---|---|
| Bart van Nimwegen | 4484770 |
| Daniella Naous | 4290038 |
| Konstantina Choulara | 4744292 |
| Maria Dimas | 4893344 |
| Ronald Rijsterborgh | 4483014 |
| Steven Engels | 4813022 |



# EARTHY 2.0

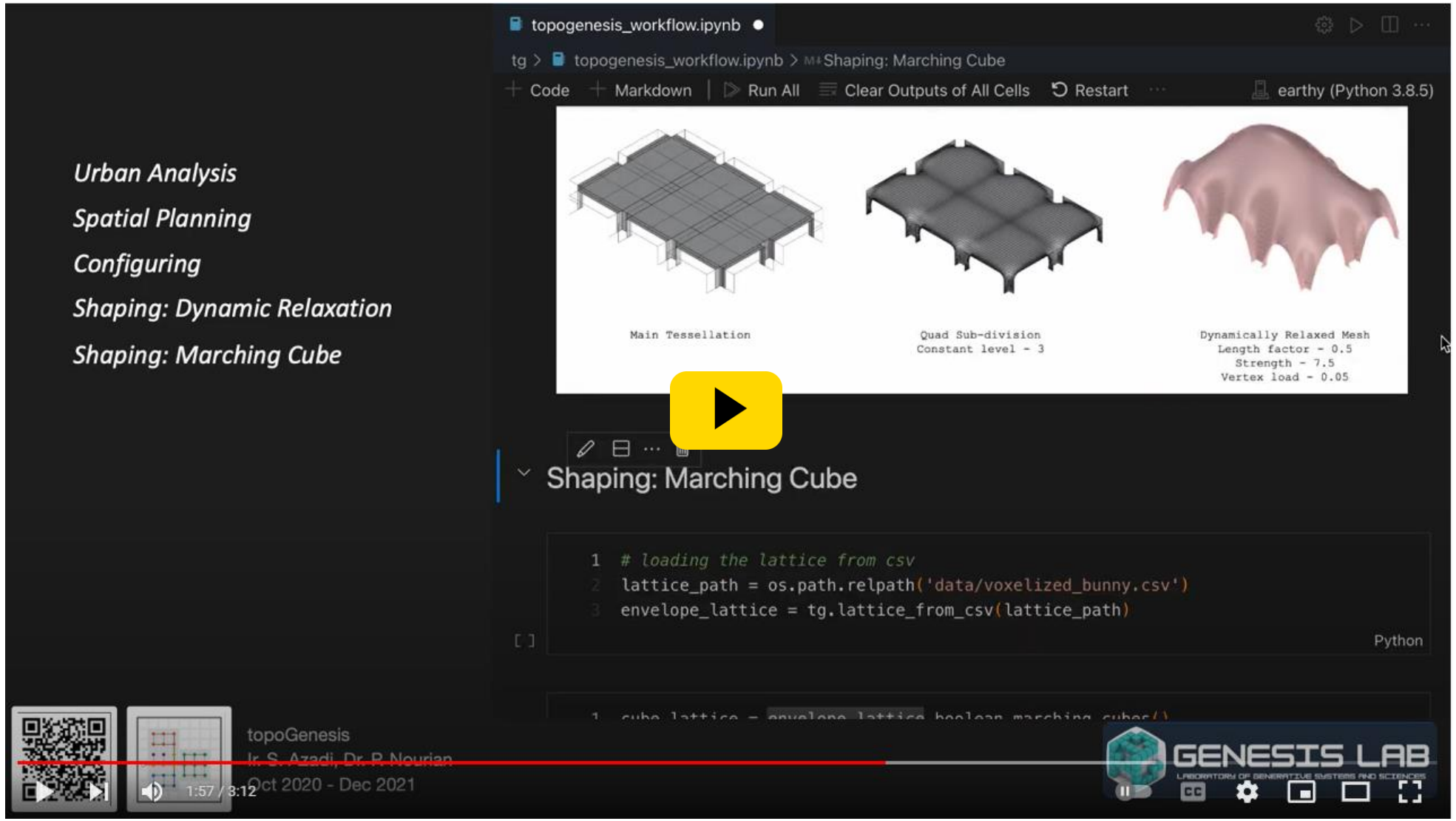


# EARTHY 3.0



# EARTHY 4.0





# EARTHY 5.0?

EARTHY 4.0: Project's eBook — DOI Coming Soon!

EARTHY 3.0: Project's eBook — DOI 10.5281/zenodo.4297471

EARTHY 2.0: Project's eBook — DOI 10.5281/zenodo.4297469

EARTHY 1.0: Project's eBook — DOI 10.5281/zenodo.4297480

## *Acknowledgements*

We, the instructors of EARTHY, would like to thank the great students of the classes 2018, 2019, 2020, and 2021, as well as the guest lecturers and colleagues who have supported our initiative so far by adding valuable pieces, sharing their knowledge, or giving helpful suggestions:

From TU/e: Ir. Shervin Azadi, from ***LEVS architecten***: Ir. Jurriaan van Stigt, from ***Arup Amsterdam***: Dr. Michele Palmieri & Ir. Shibo Ren, Ir. Kotryna Valeckaite, From ***Forensic Architecture***, Ir. Nour Abu Zaid.

Special thanks to the ***Block Research Group*** **(**Prof. Philippe Block, Dr. Tom van Mele, Dr. Robin Oval, Dr. Mariana Popescu, and Ir. Selina Bitting**)** in ETH Zurich for delivering excellent guest lectures.

Additionally, we will be indebted to the veterans of Earthy 2.0 and 3.0 for giving amazing motivational lectures: Ir. Prateek Wahi, Ir. Aditya Pravin Soman, Ir. Bezawit Zerayacob Bekele, and Ir. Anastasia Florou

GENESIS LAB
LABORATORY OF GENERATIVE SYSTEMS AND SCIENCES

# Questions & Answers

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TU Delft