Robotically Aided Regionalism
Reawakening stone stereotomy through robotic fabrication

Matthew Tanti
P5 Presentation
AE - Intecture, TU Delft
Contents:

Research Setting

Fascination
Context
Opportunity
Technique

Design Case

Site
Program
Concept
Form finding
Elevations, Plans, Sections
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Details
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Visuals
Research Setting - Fascination

Combination of Traditional Building Techniques with Digital Fabrication
Research Setting - Context

The Maltese Islands

Basic Info:

- Total Area: 316 km²
- Population: 450,000
- Language: Maltese and English
- Independence: 21 September 1964
- Predominant Religion: Roman Catholic

- Climate: 270 days of Sunshine
- Lowest Temperature: 7 °C
- Highest Temperature: 35 °C

- Only Building Material: Limestone
Research Setting - Context
Maltese Stone Architecture
**Research Setting - Context**

“The most subtle and exquisite part of Architecture...
is the formation of every sort of Arches and vaults, cutting their stones, and adjusting them with surface artifice,
that the same gravity and weight which should have precipitated them to the earth,
maintain them constant in the air, supporting one another in virtue of the mutual complication which links them”

Vincente on Stereotomy - 1707
Research Setting - Context

Problem: Loss of Architectural Heritage
An issue of Communication

Reasons:
Stone Stereotomy requires a high level of integration between design and craftsmanship.

Proposal:
Attempt to prolong this building tradition in the future: The re-introduction of the pre-modern idea of 'Master Builder' through digital fabrication.
Research Setting - Opportunity

Digital Fabrication

Offers a direct link between designing and making.
Not affected by economy of scale, therefore all parts can be different.
Not affected by complexity

Left) RDM Rotterdam Robotics Lab Right) Gramazio and Kohler at ETH, Zurich
**Research Setting - Opportunity**

**Integrated design process**

- **Environmental Considerations:**
  - Solar radiation Levels
  - Thermal Mass
  - Wind Speed and Directions
  - Stack Effect
  - Glare

- **Architectural Intent:**
  - Concept
  - Program
  - Relation to surroundings
  - Views/privacy from interior
  - Indoor Lighting Levels
  - Aesthetics

- **Fabrication Consideration:**
  - Cutting Reach of Robot
  - Geometry - Ruled Surfaces
  - Time of cutting
  - Margin of Error
  - Assembly Logistics
  - Cost

- **Integrated Design Process:**

- **Material Properties:**
  - Largest raw dimension
  - Compression Strength
  - Porosity
  - Thermal coefficient
  - Workability of cutting
  - Waste
  - Cost

- **Structural Requirements:**
  - Equilibrium
  - Live/Dead loads
  - Wind loads
  - Force flows
  - Stacking Principles
## Research Setting - Technique

### Research

<table>
<thead>
<tr>
<th>Stone Properties</th>
<th>Craftmanship</th>
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<tbody>
<tr>
<td>Compression Only</td>
<td>Robotic Fabrication</td>
</tr>
<tr>
<td>Thermal Mass</td>
<td>Assembly</td>
</tr>
</tbody>
</table>

![Stone Properties](image1.png)

![Craftmanship](image2.png)
Research Setting - Technique

Stone Properties

Craftsmanship

Research Setting - Technique

Stone Properties

Craftsmanship

Research
**Research Setting - Technique**

**The System**

1. Compression Only Geometry
2. Shell Thickening
3. Tectonic of parts
4. Fabricate
Design Case - Site

Grand Harbour Region, Cospicua/Bormla
Design Case - Site

Grand Harbour Region, Cospicua
Design Case - Site
Design Case - Program

A Statement for a post colonial Identity.

A House for Maltese Literature.

A place were people gather to celebrate Maltese literature. Preserving its past and embracing its future.
Design Case - Concept
Typology Study

**SPACE**
- Altar
- Sala
- Zuntier

**STATUS**
- Private
- Communal
- Public

**ACTION**
- Reflect
- Gather
- Linger
Design Case - Concept

Elevate
From The Ground (Landscaping)
To The Sky (Tower)

From Words
To Literature
Design Case - Concept

Program on site
**Design Case - Form Finding**

**Topological Search**

**Digital Chain Simulation:**

Not imposing a form on a material, but have a dialogue between form and structure.

<table>
<thead>
<tr>
<th>#</th>
<th>Chain Simulation Input</th>
<th>Chain Simulation Output</th>
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<tbody>
<tr>
<td>1</td>
<td><img src="image1.png" alt="Image 1" /></td>
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<td>5</td>
<td><img src="image9.png" alt="Image 9" /></td>
<td><img src="image10.png" alt="Image 10" /></td>
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</tbody>
</table>
Design Case - Form Finding

Shell Division Logic

1) Define Axis
2) Define Columns
3) Divide Shell
2) Check if forces flow is perpendicular
Design Case - Form Finding

LIMESTONE FROM SIEGIEWI QUARRY:

-------------
MEAN COMPRESSIVE STRENGTH: 23.5N/MM2
@ DRY OVEN STATE.
SAFE ASSUMPTION: 21N/MM2
==
-2.1KN/cm2

MEAN DENSITY:
1724KG/M3

Analysis Info:
Shell thickness 18cm
Imposed Loads: 5KN/M^2
Design Case - Elevations

West Elevation 1:200
Design Case - Elevations
Design Case - Plans

Ground Floor Plan

- Performance Area
- W.Cs
- Info Point
- Tea House
- Main Reading Area
- Multimedia Help Desk
- Office/Meeting Room
- Archives Area
- Archives Help Desk

Architectural Plans
Maltese Literature Centre
Matthew Tanti
1:200     A1

Drawing:
Project Name:
Scale:
Drawn By:
Design Case - Plans

First Floor Plan

0 10m
Design Case - Plans

Second Floor Plan
Design Case - Plans

20m+ Level Plan

N

0 10m
Design Case - Sections

Grand Harbour and Valletta Panorama

Lateral Section A-A

Longitudinal Section B-B

Project Name: Maltese Literature Centre

Drawing:

Scale: 1:200

F.F.L + 0.00m

F.F.L + 6.30m

F.F.L + 10.40m

F.F.L + 17.50m

F.F.L + 24.35m

F.F.L + 31.20m

F.F.L + 38.10m

F.F.L + 45.00m

F.F.L + 6.30m

Summer Sun

Winter Sun

Drawn By: Matthew Tanti
Design Case - Schemes

Climate Scheme: Summer Situation

- Grand Harbour and Valletta Panorama
- F.F.L + 3.50m
- F.F.L + 17.50m
- F.F.L + 45.00m
- F.F.L + 38.10m
- F.F.L + 0.00m
- F.F.L + 6.30m
- F.F.L + 31.20m
- F.F.L + 24.35m
- F.F.L + 10.40m
- F.F.L + 0.1m

Landscaping

Drawn By: Matthew Tanti

Scale: 1:200     A1

Project Name: Maltese Literature Centre

Openings to the east

Fresh air Intake

Controlled air vents

Mechanically cooled air

Air Uptake Post

Fresh air Intake Mechanically cooled air

 Controlled air vents

Openings to the east

F.F.L + 6.30m

Landscaping

Longitudinal Section B-B

Lateral Section A-A
**Design Case - Schemes**

*Climate Scheme: Winter Situation*

- Grand Harbour and Valletta Panorama
- F.F.L + 0.00m
- F.F.L + 6.30m
- F.F.L + 10.40m
- F.F.L + 17.50m
- F.F.L + 24.35m
- F.F.L + 31.20m
- F.F.L + 38.10m
- F.F.L + 45.00m
- F.F.L + 6.30m

**Drawn By:** Matthew Tanti

**Scale:** 1:200

**Project Name:** Maltese Literature Centre

**Drawing:** A1
Design Case - Schemes

Stone - Steel Connection

- Roller Connection Allowing Sliding
- Stress Distribution Steel H-Section
- High Strength Neoprene Gasket
Design Case - Schemes

Stone Geometry on Shell - Following Thrust network

Network Lines

Split Surface

Component Geometry

Design Case - Details
**Design Case - Details**

- **Detail A - 1:10**
  - F.F.L +0.1m
  - Stone Skirting Piece
  - Expansion Joint
  - Mechanical Ventilation Outlet
  - Excavated Bed Rock
  - Lower Coralline Limestone
  - Foundation Stone

- **Detail B - 1:10**
  - Stone Skirting Piece
  - Expansion Joint
  - Mechanical Ventilation Outlet
  - Excavated Bed Rock
  - Lower Coralline Limestone
  - Foundation Stone

- **Detail C - 1:10**
  - Drainage Taking Advantage of Shell Inclination
  - 80mm Screed With Embedded Floor Heating, Plumbing & Electricity
  - 100mm EPS Floor Insulation
  - High Grade Concrete Infill Cast in Situ
  - 100mm EPS Insulation
  - High Grade Concrete Levelling Cast in Situ
  - High Strength Neoprene Gasket Between Components.
  - 100mm Globigerinal Limestone
  - 3mm Damp Proofing Bitumen
  - 3mm Roller Applied Bitumen Layer
  - 250-550mm (Varies) Globigerina Limestone Structural Shell
  - 50mm Air Gap
  - Rain Gutter
  - Spray Applied NanoShell Transparent stone impregnation Layer
  - 150mm Vertical Stone Support Element
  - Lower Coralline Limestone
  - Foundation Stone

- **Detail D - 1:10**
  - Double 6mm Glazing
  - Traditional Peeled Reed Matt (Hasira)
  - Galvanized Steel Flashing
  - Connector Piece
  - Rain Water Drainage Channel
Design Case - Fabrication
Design Case - Visuals
Design Case - Visuals
Design Case - Visuals
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Design Case - Visuals
Design Case - Visuals
Design Case - Visuals
Design Case - Visuals
Thanks for your attention