Introducing the team

Design goals

1. Software
2. Site context
3. Project Highlights:
   5.1 Architecture
   5.2 Engineering
   5.3 Envelope
   5.4 Efficiency
   5.5 Grid-Interactivity
   5.6 Life-Cycle
   5.7 Health
   5.8 Market
   5.9 Community

Why our project matters?
Introducing the team
Design goals
Software
Site context
Project Highlights:
  Architecture
  Engineering
 Envelope
  Efficiency
  Grid-Interactivity
  Life-Cycle
  Health
  Market
  Community

Software

- REVIT
- RHINOCEROS
- GRASSHOPER
- SKETCHUP
- AUTOCAD
- LUMION
- 3D MAX
- ILLUSTRATOR
- PHOTOSHOP
- EXCEL
- SAP2000
- KARAMBA
- TRNSYS
- DESIGN BUILDER
- ORACLE CRYSTAL BALL
- ODEON
- ONE CLICK LCA
- CLIMATE STUDIO
- LADYBUG
- MATLAB
Introducing the team

Design goals

Software

Site context

Project Highlights:

5.1 Architecture

5.2 Engineering

5.3 Envelope

5.4 Efficiency

5.5 Grid–Interactivity

5.6 Life–Cycle

5.7 Health

5.8 Market

5.9 Community

Why did we choose this site?

Analysis of poor areas in Tehran

Spatial analysis of poor areas ranking in Tehran Metropolis


Vol. 4, No. 13/5, Winter 2014, Pages: 19-36
Introducing the team

Design goals

Software

Site context

Project Highlights:

Architecture

Engineering

Envelope

Efficiency

Grid-Interactivity

Life-Cycle

Health

Market

Community
Introducing the team

Design goals

Software

Site context

Project Highlights:

Architecture

Engineering

Envelope

Efficiency

Grid-Interactivity

Life-Cycle

Health

Market

Community

Site’s Climate Zone: 2B

Hours of Comfort

Total Radiation

Annual wind rose

Psychrometric chart

Composite Climate graph
Introducing the team

Design goals

Software

Site context

Project Highlights:

Architecture

Engineering

Envelope

Efficiency

Grid-Interactivity

Life-Cycle

Health

Market

Community

Inhabitants:

Shop Owner:

Installing fences around the park restricted public access to the shops in the design area, leading to economic stagnation for those businesses. The park's secluded nature at night has attracted criminals, increasing crime rates and compromised security. Neglecting the maintenance of the shops’ original texture has led to their deterioration. The lack of employment opportunities for the youth in this area has led to a rise in delinquency and crime. Additionally, the presence of a poorly designed and uncontrolled large park filled with drug addicts has made the area unsafe at night, contributing to the increase in criminal activity. Unfortunately, this park has become a hotspot for young people and neighborhood residents to engage in criminal behavior.

Shop Worker:

The environment and atmosphere of this area is only for men and it has a masculine environment where only men can travel and there is no suitable atmosphere and space for women's activities and their movement. Even the restaurants and cafes in this area are male-dominated and families are reluctant to visit there.

Shop Owner:

The families and people of this neighborhood are among the lowest-income strata of Tehran, which has forced their children to work from an early age to help the family and earn. Mainly because this neighborhood is full of crime, they are attracted to illegal activities and delinquency. Young people should learn arts or crafts so that they don't have to commit crimes.
Why did we choose these arts for the school?

Revival of ancient culture and art in the young generation

- Pottery
- Carpet Weaving
- Fabric Design & Sewing
Our design stage divides into two parts:

1. New Buildings Design
2. Retrofit Buildings
New Building Design Process:
Be inspired by the model of traditional Iranian four-porch schools
New building concept design:

- Chahar Taqi having four arches

The project consists of modules
Introducing the team
Design goals
Software
Site context
Project Highlights:

5.1 Architecture
5.2 Engineering
5.3 Envelope
5.4 Efficiency
5.5 Grid–Interactivity
5.6 Life–Cycle
5.7 Health
5.8 Market
5.9 Community

Retrofit Process:

Existing:

Retrofitting:
**Introducing the team**

**Design goals**

**Software**

**Site context**

**Project Highlights:**

- **Architecture**
- **Engineering**
- **Envelope**
- **Efficiency**
- **Grid-Interactivity**
- **Life-Cycle**
- **Health**
- **Market**
- **Community**

### Space Types:

**Physical Program:**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Space</th>
<th>no.</th>
<th>Floor</th>
<th>Area m²</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Educational</strong></td>
<td>Classrooms</td>
<td>6</td>
<td></td>
<td>282 m²</td>
</tr>
<tr>
<td></td>
<td>Flexible Classrooms</td>
<td>2</td>
<td></td>
<td>94 m²</td>
</tr>
<tr>
<td></td>
<td>Workshops</td>
<td>3</td>
<td></td>
<td>214 m²</td>
</tr>
<tr>
<td><strong>Administrative</strong></td>
<td>Offices</td>
<td>9</td>
<td></td>
<td>159 m²</td>
</tr>
<tr>
<td><strong>Cultural</strong></td>
<td>Multifunctional Spaces</td>
<td>1</td>
<td></td>
<td>160 m²</td>
</tr>
<tr>
<td></td>
<td>Book Room</td>
<td>1</td>
<td></td>
<td>46 m²</td>
</tr>
<tr>
<td></td>
<td>Library</td>
<td>1</td>
<td></td>
<td>110 m²</td>
</tr>
<tr>
<td><strong>Commercial</strong></td>
<td>Bakery</td>
<td>1</td>
<td></td>
<td>33 m²</td>
</tr>
<tr>
<td></td>
<td>Pottery Shop</td>
<td>1</td>
<td></td>
<td>29 m²</td>
</tr>
<tr>
<td></td>
<td>Stationary Shop</td>
<td>1</td>
<td></td>
<td>29 m²</td>
</tr>
<tr>
<td></td>
<td>Fabric Shop</td>
<td>1</td>
<td></td>
<td>31 m²</td>
</tr>
<tr>
<td></td>
<td>Supermarket</td>
<td>1</td>
<td></td>
<td>20 m²</td>
</tr>
<tr>
<td></td>
<td>Persian Restaurant</td>
<td>1</td>
<td></td>
<td>52 m²</td>
</tr>
<tr>
<td></td>
<td>Students Products Shops</td>
<td>2</td>
<td></td>
<td>52 m²</td>
</tr>
<tr>
<td></td>
<td>Book Cafe</td>
<td>1</td>
<td></td>
<td>144 m²</td>
</tr>
<tr>
<td><strong>Services</strong></td>
<td>Facilities</td>
<td>1</td>
<td></td>
<td>111 m²</td>
</tr>
<tr>
<td></td>
<td>Janitor</td>
<td>1</td>
<td></td>
<td>24 m²</td>
</tr>
<tr>
<td></td>
<td>Buffet</td>
<td>1</td>
<td></td>
<td>63 m²</td>
</tr>
<tr>
<td></td>
<td>Prayer Room</td>
<td>1</td>
<td></td>
<td>48 m²</td>
</tr>
<tr>
<td></td>
<td>Storage</td>
<td>1</td>
<td></td>
<td>15 m²</td>
</tr>
<tr>
<td></td>
<td>Waste Disposal</td>
<td>1</td>
<td></td>
<td>14 m²</td>
</tr>
<tr>
<td></td>
<td>Air Conditioning Room</td>
<td>1</td>
<td></td>
<td>15 m²</td>
</tr>
</tbody>
</table>
Introducing the team

Design goals

Software

Site context

Project Highlights:

Architecture

1. New design plan (Ground Floor):

   - SANSEVIERIA
   - WEEPING FIG
   - POTHOS
   - LAVENDER
   - GERANIUM
   - DAVANA
   - MYCELIUM

   - CLASSROOM
   - FLEXIBLE CLASSROOM
   - MULTIPURPOSE HALL
   - MECHANICAL
   - WORKSHOP
   - BAKERY
   - POTTERY SHOP
   - STATIONARY SHOP
   - HEBERDASHERY
   - JANITOR ROOM
   - SUPER MARKET
   - PERSIAN RESTAURANT
   - BUFFET
   - STUDENTS PRODUCT SHOP
   - OFFICE
   - PRAYER ROOM
   - BOOK CAFE
   - STORAGE
   - WASTE MANAGEMENT ROOM
   - LIBRARY
New design plan (First Floor):

1. Classroom
2. Flexible Classroom
3. Multipurpose Hall
4. Mechanical
5. Workshop
6. Bakery
7. Pottery Shop
8. Stationary Shop
9. Hederesa
10. Janitor Room
11. Super Market
12. Persian Restaurant
13. Buffet
14. Students Product Shop
15. Office
16. Prayer Room
17. Book Cafe
18. Storage
19. Waste Management Room
20. Library

Introducing the team
Design goals
Software
Site context
Project Highlights:

- Architecture
- Engineering
- Envelope
- Efficiency
- Grid-Interactivity
- Life-Cycle
- Health
- Market
- Community
Introducing the team

Design goals

Software

Site context

Project Highlights:

Architecture

Engineering

Envelope

Efficiency

Grid-
Interactivity

Life-Cycle

Health

Market

New design plan (Second Floor):
Introducing the team

Design goals

Software

Site context

Project Highlights:

5.1 Architecture

5.2 Engineering

5.3 Envelope

5.4 Efficiency

5.5 Grid–Interactivity

5.6 Life–Cycle

5.7 Health

5.8 Market

5.9 Community

Newly Designed Buildings:

Classrooms:

Library:
Retrofitted Buildings:

1. Introducing the team
2. Design goals
3. Software
4. Site context
5. Project Highlights:
   5.1 Architecture
   5.2 Engineering
   5.3 Envelope
   5.4 Efficiency
   5.5 Grid-Interactivity
   5.6 Life-Cycle
   5.7 Health
   5.8 Market
   5.9 Community

Retrofitting the old Men’s Coffee House to a Persian restaurant:
A place for the Whole family (Men and Women)

Retrofitting the old stores into a Book Cafe:
A place for increasing public awareness
Introducing the team
Design goals
Software
Site context
Project Highlights:

5.1 Architecture
5.2 Engineering
5.3 Envelope
5.4 Efficiency
5.5 Grid-Interactivity
5.6 Life-Cycle
5.7 Health
5.8 Market
5.9 Community

Conversion of southern buildings into workshops with structural reinforcement:

Conversion of storage area near school entrance into a Bakery and a café:
Architectural Section:

Introducing the team
Design goals
Software
Site context
Project Highlights:

5.1 Architecture
5.2 Engineering
5.3 Envelope
5.4 Efficiency
5.5 Grid–Interactivity
5.6 Life–Cycle
5.7 Health
5.8 Market
5.9 Community
How did we make the structure modular?
Introducing the team

Design goals

Software

Site context

Project Highlights:

Architecture

Engineering

Envelope

Efficiency

Grid–Interactivity

Life–Cycle

Health

Market

Community

Why did we use second-hand scaffold pipes as the structural systems?

- Buy members from iron market
- Disassemble members from previous construction
- Simple and fast construction
- check the member’s strength in the lab
- Adding fireproof paint to structural parts
- Assembling the structure by non-expert
Why does our structure module have simple construction?
How did we check the structure’s durability against earthquakes?

Stability and degree of static indeterminacy

The DSI formula for pin jointed space frame: \( DSI = m + r - 3j \)

\( m \): members \hspace{1cm} \( r \): support reactions \hspace{1cm} \( j \): joints

- \( DSI < 0 \) UNSTABLE
- \( DSI = 0 \) DETERMINATE
- \( DSI > 0 \) INDETERMINATE

DSI for the structural module:

\[
776 + 48 - 3(225) = 149
\]

INDETERMINATE

The smallest repeating components (Square pyramid and Triangle) that make up the structural module have geometric stability.
How to integrate active renewable systems with HVAC systems?

Dynamic simulation flow chart

The TRNSYS model of the proposed trigeneration system

Total Solar Radiation on the Building
How did we supply *heating, cooling, and DHW loads*?
How do air ducts pass through the second-hand scaffold pipes structure?

HVAC Zones

Zone-01 AHU Supply and Return Ducts

Zone-02 AHU Supply and Return Ducts

HVAC Zones-01

HVAC Zones-02
Introducing the team

1. Design goals
2. Software
3. Site context
4. Project Highlights:
   5. Architecture
   5.1 Engineering
   5.2 Envelope
   5.3 Efficiency
   5.4 Grid-Interactivity
   5.5 Life-Cycle
   5.6 Health
   5.7 Market
   5.8 Community

How to generate on-site renewable energy?

Air-Based Ground Heat Exchanger:

Water-Based Ground Heat Exchanger:

BIPVT hot water system:

How to generate on-site renewable energy?

- Water-Based Ground Heat Exchanger:
- BIPVT hot water system:
What did we do about fire protection and water recovery systems?
Introducing the team

Design goals

Software

Site context

Project Highlights:

Architecture

Engineering

Envelope

Efficiency

Grid-Interactivity

Life-Cycle

Health

Market

Community

Technical section:
Introducing the team

Design goals

Software

Site context

Project Highlights:

5.1 Architecture

5.2 Engineering

5.3 Envelope

5.4 Efficiency

5.5 Grid-Interactivity

5.6 Life-Cycle

5.7 Health

5.8 Market

5.9 Community

**1**

**2**

**3**

**4**

**5**

**5.1**

**5.2**

**5.3**

**5.4**

**5.5**

**5.6**

**5.7**

**5.8**

**5.9**

---

### What Innovative Materials did we use?

**Second-Hand Scaffold Pipes**

**Mycelium Wheat Thermal Insulation**

**Algae Tile**

- **Innovative Materials**
  - Innovative Materials
    - Second-Hand Scaffold Pipes
    - Mycelium Wheat Thermal Insulation
    - Algae Tile

- **Raw Materials**
  - Hydration
  - Homogenisation
  - Sterilisation
  - Fungal Colonisation
  - Dehydration

- **Raw Material**
  - Washing
  - Cleaning
  - Sterilisation
  - Processing
  - Compressing
  - Floor and Wall Finishing

- **Composite Panels**
  - Insulating Panels

- **Manufacturing process of mycelium composites.**

- **Manufacturing process of algae tiles.**
How did we design the new building envelope?

External Wall Layers

Internal Floor Layers

Flat Roof Layers

1. Introducing the team
2. Design goals
3. Software
4. Site context
5. Project Highlights:
   5.1 Architecture
   5.2 Engineering
   5.3 Envelope
5.4 Efficiency
5.5 Grid-Interactivity
5.6 Life-Cycle
5.7 Health
5.8 Market
5.9 Community

How did we design the new building envelope?
How did we design the **new building envelope**?

South Face of Vaulted roof detail

North Face of Vaulted roof detail
How did we retrofit the existing building envelope?

Retrofit Envelope

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Envelope (m³)</td>
<td>1178.30</td>
</tr>
<tr>
<td>Total Demolition (m³)</td>
<td>371.75</td>
</tr>
<tr>
<td>Total Preserved (m³)</td>
<td>806.55</td>
</tr>
<tr>
<td>Total Demolition (%)</td>
<td>32%</td>
</tr>
<tr>
<td>Total Preserved (%)</td>
<td>68%</td>
</tr>
</tbody>
</table>

321 m² of brick was preserved after demolition and reused in the facade.
How did we reinforce the retrofitted building's structure?
Introducing the team

Design goals

Software

Site context

Project Highlights:

Architecture

Engineering

Envelope

Efficiency

Grid-Interactivity

Life-Cycle

Health

Market

Community

How did we solve the thermal bridges?

Wall Section

Thermal Bridge Analysis

Color Legend

64 | 105.6 | 202.8 | 300.0 | 402.5 | 505.1 | 607.6 | 710.1 | 812.6 | 915.1

Wall Section

ROCKWOOL

ALGAE PANEL

MYCELIUM WHEAT BOARD

SOIL

FOUNDATION
New building envelope thermal characteristics:

<table>
<thead>
<tr>
<th>Component</th>
<th>Thickness (m)</th>
<th>U-Value (W/m².K)</th>
<th>R-Value (m².K/W)</th>
<th>Required R-Value* (m².K/W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Building Internal Floor</td>
<td>0.692</td>
<td>0.209</td>
<td>4.790</td>
<td>1.800</td>
</tr>
<tr>
<td>New Building External Wall</td>
<td>0.485</td>
<td>0.209</td>
<td>4.790</td>
<td>1.800</td>
</tr>
<tr>
<td>New Building External Flat Roof</td>
<td>0.592</td>
<td>0.209</td>
<td>4.210</td>
<td>1.400</td>
</tr>
<tr>
<td>New Building External Vault Roof</td>
<td>0.753</td>
<td>0.219</td>
<td>4.550</td>
<td>3.600</td>
</tr>
<tr>
<td>New Building Ground Floor</td>
<td>0.160</td>
<td>0.269</td>
<td>3.710</td>
<td>1.400</td>
</tr>
<tr>
<td>New Building Semi-Exposed Floor</td>
<td>0.592</td>
<td>0.237</td>
<td>4.210</td>
<td>1.400</td>
</tr>
<tr>
<td>New Building Semi-Exposed Internal Wall</td>
<td>0.654</td>
<td>0.355</td>
<td>2.850</td>
<td>1.600</td>
</tr>
</tbody>
</table>

* According to Iranian Building Code No. 19
### Retrofit building envelope thermal characteristics:

<table>
<thead>
<tr>
<th>Retrofit Semi-Exposed Wall</th>
<th>Retrofit Semi-Exposed Floor</th>
<th>Retrofit External Roof</th>
<th>Retrofit Ground Floor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Thickness (m)</strong></td>
<td><strong>Thickness (m)</strong></td>
<td><strong>Thickness (m)</strong></td>
<td><strong>Thickness (m)</strong></td>
</tr>
<tr>
<td>0.680</td>
<td>0.690</td>
<td>0.743</td>
<td>0.190</td>
</tr>
<tr>
<td><strong>U-Value (W/m².K)</strong></td>
<td><strong>U-Value (W/m².K)</strong></td>
<td><strong>U-Value (W/m².K)</strong></td>
<td><strong>U-Value (W/m².K)</strong></td>
</tr>
<tr>
<td>0.240</td>
<td>0.308</td>
<td>0.222</td>
<td>0.334</td>
</tr>
<tr>
<td><strong>R-Value (m².K/W)</strong></td>
<td><strong>R-Value (m².K/W)</strong></td>
<td><strong>R-Value (m².K/W)</strong></td>
<td><strong>R-Value (m².K/W)</strong></td>
</tr>
<tr>
<td>4.150</td>
<td>4.46</td>
<td>4.500</td>
<td>3.000</td>
</tr>
<tr>
<td><em><em>Required R-Value</em> (m².K/W)</em>*</td>
<td><em><em>Required R-Value</em> (m².K/W)</em>*</td>
<td><em><em>Required R-Value</em> (m².K/W)</em>*</td>
<td><em><em>Required R-Value</em> (m².K/W)</em>*</td>
</tr>
<tr>
<td>1.600</td>
<td>1.400</td>
<td>3.600</td>
<td>1.400</td>
</tr>
</tbody>
</table>

* According to Iranian Building Code No. 19
How did we reach the zero energy target?

**Energy Target**

<table>
<thead>
<tr>
<th>IRAN Zero Energy EUI Target</th>
<th>25 kWh/m²/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing Building Site EUI</td>
<td>279 EUI</td>
</tr>
<tr>
<td>Existing Building Source EUI</td>
<td>610 EUI</td>
</tr>
<tr>
<td>Site Energy</td>
<td>81.85 EUI</td>
</tr>
<tr>
<td>Source Energy</td>
<td>167.23 EUI</td>
</tr>
<tr>
<td>Site Active Energy</td>
<td>80.77 EUI</td>
</tr>
<tr>
<td>Site EUI + Active System</td>
<td>38.43 EUI</td>
</tr>
<tr>
<td>Source EUI+ Active System</td>
<td>56.90 EUI</td>
</tr>
<tr>
<td>Total Site EUI</td>
<td>-29.77 EUI</td>
</tr>
<tr>
<td>Total Source EUI</td>
<td>-11.30 EUI</td>
</tr>
</tbody>
</table>

**Total EUI Values**

- **Existing Building**
  - Site EUI: 610 kWh/m²
  - Source EUI: 610 kWh/m²
- **Retrofit Building + New Building**
  - Site EUI: 167 kWh/m²
  - Source EUI: 57 kWh/m²

**Total EUI Calculation**

- **Total Site EUI**
  - Existing Building: 279 kWh/m²
  - Retrofit Building + New Building: 38.43 kWh/m²
  - Total Site EUI: 317.43 kWh/m²

- **Total Source EUI**
  - Existing Building: 610 kWh/m²
  - Retrofit Building + New Building: 57 kWh/m²
  - Total Source EUI: 667 kWh/m²

**Total Energy EUI**

- Total Energy EUI: -11 kWh/m²
How much energy did the active systems generate?

PV & BIPVT Electrical Energy Generation

BIPVT Thermal Energy Generation

Air-Based GHX Heat Energy Transfer

Water-Based GHX Energy Transfer

- Heat Extracted (kWh)  - Heat Injection
How much carbon did the energy systems emit?

New building

Existing building

Global warming kg CO2e - Classifications

- 1.1 Foundations (substructure)
- 1.4 Facades
- 2.2 In-built lighting system
- 2.4.1 Air handling units
- Electricity use - 45.7%
- 1.3.3 Stairs and ramps
- 1.4.2 Façade openings
- 2.3 Energy system - 8.0%
- Fuel use - 46.3%
- Other classifications

1.2.1 Frame (beams, columns and slabs)
1.2.3 External walls
1.3.1 Ground floor slab
2.2 In-built lighting system
2.3 Energy system - 17.7%
2.4.1 Air handling units
3. External works
Fuel use - 41.4%
Electricity use - 40.9%
Other classifications

47 81
How would we **collect the rain water?**

**Annual water consumption**

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Number of Occupants</th>
<th>Occupant Water Usage (liter/person.day)</th>
<th>Daily Water Usage (m³/day)</th>
<th>Active Days Per Year</th>
<th>Annual Water Usage (m³/year)</th>
<th>Daily Recovered Water (liter/day)</th>
<th>Annual Water Saving (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retrofit (Restaurant)</td>
<td>15</td>
<td>90</td>
<td>1.35</td>
<td>365</td>
<td>492.7</td>
<td>90</td>
<td>7</td>
</tr>
<tr>
<td>New Building</td>
<td>150</td>
<td>13</td>
<td>1.95</td>
<td>300</td>
<td>585.0</td>
<td>900</td>
<td>46</td>
</tr>
</tbody>
</table>

Average annual rainfall in Tehran

- Jan: 1.68%
- Feb: 1.51%
- Mar: 1.49%
- Apr: 1.33%
- May: 0.61%
- Jun: 0.05%
- Jul: 0.18%
- Aug: 0.16%
- Sep: 0.09%
- Oct: 1.09%
- Nov: 1.09%
- Dec: 0.94%

Average annual rainfall in Tehran:

1.68% January
1.51% February
1.49% March
1.33% April
0.61% May
0.05% June
0.18% July
0.16% August
0.09% September
1.09% October
1.09% November
0.94% December

**How would we collect the rain water?**

1. **Introducing the team**
2. **Design goals**
3. **Software**
4. **Site context**
5. **Project Highlights:**
   5.1 **Architecture**
   5.2 **Engineering**
   5.3 **Envelope**
   5.4 **Efficiency**
   5.5 **Grid–Interactivity**
   5.6 **Life–Cycle**
   5.7 **Health**
   5.8 **Market**
   5.9 **Community**
5.5

Grid-Interactivity
Introducing the team

Design goals
Software
Site context

Project Highlights:
Architecture
Engineering
Envelope
Efficiency

Grid-Interactivity

How would we interact to the grid?

- Generating extra electricity and selling it to grid.
- Collecting waste and sending it for recycling.
- Collecting rainwater and refining, using it for irrigating plants and supplying to the grid.
- Generating hot water from geothermal energy and solar panel’s excess heat emission.
- Collecting and refining graywater for reuse in services and plant irrigation.

Save the future
5.6

Life-Cycle
Introducing the team

Design goals

Software

Site context

Project Highlights:

5.1 Architecture

5.2 Engineering

5.3 Envelope

5.4 Efficiency

5.5 Grid-Interactivity

5.6 Life-Cycle

5.7 Health

5.8 Market

5.9 Community

How would students learn about carbon emissions?

Mycelium Wheat Garden

What do you think we can do with the remaining fabrics?

We can use them to make the movable shading for Eyvan and exhibition stands both

Don't do this. We can reuse them by combining textile waste and ecological glue, and produce a kind of brick to make flexible outdoor furniture

We have a lot of pieces of cloth that we throw away every day.

Outdoor Cubic Furniture

Textile Waste: 80%
Ecological glue: 20%
How would we reuse the bricks from Demolition?

Bricks from Demolition were preserved and reused.
How did we calculate the life-cycle emission?

![Graph showing life-cycle stages and emissions](image)

**Life-cycle stage:**

- New building:
  - A1-A3 Materials: 13.4%
  - A5 Construction: 1.0%
  - B4-B5 Replacement: 1.4%
  - C2 Waste transport: 0.9%
  - C4 Waste disposal: 0.2%
  - A4 Transport: 0.2%
  - B3 Repair: 13.4%
  - B6 Energy: 69.4%
  - C3 Waste processing: 0.0%

- Existing building:
  - A1-A3 Materials: 13.4%
  - A5 Construction: 1.0%
  - B4-B5 Replacement: 1.4%
  - C2 Waste transport: 0.9%
  - C4 Waste disposal: 0.2%
Introducing the team

Design goals

Software

Site context

Project Highlights:

Architecture

Engineering

Envelope

Efficiency

Grid-Interactivity

Life-Cycle

Health

Market

Community

How did we calculate the life-cycle emission?

New building

<table>
<thead>
<tr>
<th>Cradle to grave (A1-A4, B4-B5, C1-C4)</th>
<th>kg CO₂e/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>(&lt; 370)</td>
<td>A</td>
</tr>
<tr>
<td>(370-460)</td>
<td>B One Click</td>
</tr>
<tr>
<td>(460-550)</td>
<td>C LCA</td>
</tr>
<tr>
<td>(550-640)</td>
<td>D</td>
</tr>
<tr>
<td>(640-730)</td>
<td>E</td>
</tr>
<tr>
<td>(730-820)</td>
<td>F</td>
</tr>
<tr>
<td>(&gt; 820)</td>
<td>G</td>
</tr>
</tbody>
</table>

Existing building

<table>
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<th>kg CO₂e/m²</th>
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<tr>
<td>(460-550)</td>
<td>C LCA</td>
</tr>
<tr>
<td>(550-640)</td>
<td>D</td>
</tr>
<tr>
<td>(640-730)</td>
<td>E</td>
</tr>
<tr>
<td>(730-820)</td>
<td>F</td>
</tr>
<tr>
<td>(&gt; 820)</td>
<td>G</td>
</tr>
</tbody>
</table>

New Buildings Embodied Carbon Emission Benchmark

Retrofitted Buildings Embodied Carbon Emission Benchmark
How did we calculate the building's circularity?

Sankey diagram, Global warming

New building

Retrofitted building
How would we **improve** the inhabitant's health?

**Health and Emissions of Materials and Systems:**

- **Air Intake**
- **Air Conditioning System**
- **Building Materials**
  - **Algae Tiles**
  - **Wood**
- **FREE ODOUR**
- **SCHOOL DESK**
- **Planting Seeds**
- **FREE VOC**
- **Cleaner Shoes Better Health**
- **DUSTPROOF**

**AHU Supply and Return Ducts**
Why have we design flexible furniture?

Classroom desks are designed in a way to accommodate different arrangements for flexible usage.
How would we improve the inhabitant’s health with green walls?

Vegetation:
- Fragrant Flowers:
  - Butterfly Bush
  - Honeysuckle
  - Lavender
  - Stocks

Oxygen-producing Plant:
- Bird’s-eye fern

Classroom’s Green wall

Workshop’s Green wall
How did we control the noise?

Rw According to the Position of the Dividing Walls

<table>
<thead>
<tr>
<th>Types of dividing wall</th>
<th>Calculated $R_w$ (dB)</th>
<th>$R_w$ (dB) according to national building regulations of Iran(topic 18)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classroom</td>
<td>43</td>
<td>40</td>
</tr>
<tr>
<td>Workshop</td>
<td>44</td>
<td>45</td>
</tr>
<tr>
<td>Office</td>
<td>44</td>
<td>40</td>
</tr>
<tr>
<td>Library</td>
<td>42.9</td>
<td>40</td>
</tr>
<tr>
<td>Between offices</td>
<td>62</td>
<td>45</td>
</tr>
<tr>
<td>classrooms and workshops from adjacent spaces</td>
<td>62</td>
<td>50</td>
</tr>
<tr>
<td>classroom and corridor</td>
<td>36-55</td>
<td>35</td>
</tr>
<tr>
<td>facility spaces and other adjacent spaces</td>
<td>62</td>
<td>55</td>
</tr>
</tbody>
</table>

Lnw According to the Position of the ceiling

<table>
<thead>
<tr>
<th>Floor Position</th>
<th>Calculated $L_{nw}$ (dB)</th>
<th>$L_{nw}$ (dB) according to national building regulations of Iran(topic 18)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor between classrooms</td>
<td>58</td>
<td>60</td>
</tr>
<tr>
<td>Floor between corridors</td>
<td>58</td>
<td>62</td>
</tr>
<tr>
<td>Office ceiling</td>
<td>58</td>
<td>65</td>
</tr>
</tbody>
</table>
How did we control the reverberation time?

Reverberation Time and the area of required Mycelium-Based Sound Absorption Panels for acoustic treatment

<table>
<thead>
<tr>
<th>Space Type</th>
<th>Reverberation Time in Octave Band Center Frequencies</th>
<th>$RT_{60}$ (s) averaged reverberation time</th>
<th>$RT_{60}$ (s) according to national building regulations of Iran(topic 18)</th>
<th>area of Mycelium-Based Sound Absorption Panels (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classroom</td>
<td>0.98 0.90 0.89 0.91 0.82 0.78 0.87 1.0</td>
<td>Not Required</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workshop</td>
<td>0.97 1.04 1.42 1.87 1.62 1.30 1.63 1.0-1.2</td>
<td>23.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Office</td>
<td>0.63 0.66 0.94 1.20 1.07 0.86 1.07 1.2</td>
<td>Not Required</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multifunctional space</td>
<td>0.99 0.92 1.07 1.20 1.26 1.24 1.17 0.8-0.9</td>
<td>68</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Library</td>
<td>1.10 1.13 1.14 1.23 1.08 0.99 1.15 0.7</td>
<td>51</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prayer Room</td>
<td>1.11 1.07 1.17 0.69 0.56 0.54 0.80 0.8-0.9</td>
<td>Not Required</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Introducing the team

Design goals

Software

Site context

Project Highlights:

- Architecture
- Engineering
- Envelope
- Efficiency
- Grid-Interactivity
- Life-Cycle
- Health
- Market
- Community

### Daylight improvements:

<table>
<thead>
<tr>
<th>Space</th>
<th>sDA (%)</th>
<th>ASE (%)</th>
<th>DGP (%)</th>
<th>UDI (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular Classroom</td>
<td>57.02</td>
<td>4.96</td>
<td>5.99</td>
<td>49.17</td>
</tr>
<tr>
<td>Regular Classroom</td>
<td>76.03</td>
<td>5.79</td>
<td>5.68</td>
<td>55.48</td>
</tr>
<tr>
<td>Regular Classroom</td>
<td>62.07</td>
<td>5.17</td>
<td>6.25</td>
<td>48.08</td>
</tr>
<tr>
<td>Flexible Classroom</td>
<td>52.14</td>
<td>8.55</td>
<td>7.59</td>
<td>45.18</td>
</tr>
<tr>
<td>Student product shop</td>
<td>86.17</td>
<td>22.34</td>
<td>32.95</td>
<td>62.80</td>
</tr>
<tr>
<td>Office</td>
<td>62.86</td>
<td>17.14</td>
<td>12.14</td>
<td>58.37</td>
</tr>
<tr>
<td>Office</td>
<td>100</td>
<td>3.57</td>
<td>23.44</td>
<td>84.67</td>
</tr>
<tr>
<td>Office</td>
<td>100</td>
<td>17.5</td>
<td>37.69</td>
<td>79.64</td>
</tr>
<tr>
<td>Office</td>
<td>100</td>
<td>16.55</td>
<td>28.80</td>
<td>75.93</td>
</tr>
<tr>
<td>Office</td>
<td>38.70</td>
<td>0.00</td>
<td>1.51</td>
<td>32.50</td>
</tr>
<tr>
<td>Buffet</td>
<td>100</td>
<td>17.90</td>
<td>45.19</td>
<td>80.30</td>
</tr>
<tr>
<td>Buffet</td>
<td>88.36</td>
<td>1.29</td>
<td>7.11</td>
<td>68.32</td>
</tr>
<tr>
<td>Janitor</td>
<td>66.13</td>
<td>16.13</td>
<td>19.56</td>
<td>62.03</td>
</tr>
<tr>
<td>Bakery</td>
<td>92.31</td>
<td>10.90</td>
<td>22.94</td>
<td>69.40</td>
</tr>
<tr>
<td>Pottery shop</td>
<td>97.44</td>
<td>11.54</td>
<td>33.49</td>
<td>74.35</td>
</tr>
<tr>
<td>Stationary shop</td>
<td>89.74</td>
<td>11.54</td>
<td>34.62</td>
<td>70.33</td>
</tr>
<tr>
<td>Fabric shop</td>
<td>78.21</td>
<td>12.82</td>
<td>33.49</td>
<td>73.05</td>
</tr>
<tr>
<td>Super market</td>
<td>100</td>
<td>26.60</td>
<td>56.11</td>
<td>73.64</td>
</tr>
<tr>
<td>Persian restaurant</td>
<td>97.48</td>
<td>32.70</td>
<td>59.78</td>
<td>72.61</td>
</tr>
<tr>
<td>Waste management room</td>
<td>18.60</td>
<td>4.65</td>
<td>5.80</td>
<td>32.15</td>
</tr>
<tr>
<td>Overall Result</td>
<td>61.7 %</td>
<td>8.8 %</td>
<td>18 %</td>
<td>63.4 %</td>
</tr>
</tbody>
</table>

* sDA: Space Daylight Availability
* ASE: Architectural Space Efficiency
* DGP: Global Potential
* UDI: Usable Daylight Index
### Daylight improvements:

<table>
<thead>
<tr>
<th>Space Name</th>
<th>sDA (%)</th>
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</thead>
<tbody>
<tr>
<td>Regular Classroom</td>
<td>65.45</td>
<td>8.18</td>
<td>9.43</td>
<td>57.27</td>
</tr>
<tr>
<td>Regular Classroom</td>
<td>66.67</td>
<td>9.65</td>
<td>9.65</td>
<td>54.15</td>
</tr>
<tr>
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<td>15.93</td>
<td>21.90</td>
<td>70.46</td>
</tr>
<tr>
<td>Flexible Classroom</td>
<td>85.96</td>
<td>2.63</td>
<td>6.14</td>
<td>67.55</td>
</tr>
<tr>
<td>Book Café</td>
<td>92.98</td>
<td>13.78</td>
<td>30.98</td>
<td>69.44</td>
</tr>
<tr>
<td>Office</td>
<td>91.67</td>
<td>28.00</td>
<td>47.92</td>
<td>65.97</td>
</tr>
<tr>
<td>Office</td>
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<td>20.34</td>
<td>26.48</td>
<td>65.65</td>
</tr>
<tr>
<td>Prayer room</td>
<td>32.23</td>
<td>0.00</td>
<td>0.10</td>
<td>29.24</td>
</tr>
<tr>
<td>Library office</td>
<td>74.29</td>
<td>19.05</td>
<td>26.90</td>
<td>64.60</td>
</tr>
<tr>
<td>Overall Result</td>
<td>60.3%</td>
<td>9.1%</td>
<td>16.3%</td>
<td>60.48%</td>
</tr>
<tr>
<td>Library salon</td>
<td>73.89</td>
<td>7.01</td>
<td>12.42</td>
<td>67.60</td>
</tr>
<tr>
<td>Reading room</td>
<td>38.62</td>
<td>2.76</td>
<td>7.07</td>
<td>60.87</td>
</tr>
<tr>
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<td>46.6%</td>
<td>6.9%</td>
<td>10.2%</td>
<td>64.7%</td>
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* Indicates calculated individual overall scores.

**Credits:**
- **3 credits**
- **sDA:** 60.3%
- **ASE:** 9.1%
Daylight improvements:

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<td>47.92</td>
<td>65.97</td>
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<td>Office</td>
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<td>20.34</td>
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<td>Prayer room</td>
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<td>0.00</td>
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<td>74.29</td>
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<td>2.76</td>
<td>7.07</td>
<td>60.87</td>
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<tr>
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<td>46.6 %</td>
<td>6.9 %</td>
<td>10.2 %</td>
<td>64.7 %</td>
</tr>
</tbody>
</table>
Classroom’s Artificial light improvements:

Office’s Artificial light improvements:
How would we improve the neighborhood's economy?

Construction and School Equipment Cost

Return on Investment

School and Community Income

Project Highlights:
- Architecture
- Engineering
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- Efficiency
- Grid-Interactivity
- Life-Cycle
- Health
- Market
- Community

1. Introducing the team
2. Design goals
3. Software
4. Site context
5. Project Highlights:
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   5.6 Life-Cycle
   5.7 Health
   5.8 Market
   5.9 Community
What are our construction process?

- **Construction process for each module**
  1. Preparation and production of construction materials
  2. Site preparation and Excavation
  3. Foundations
  4. Space frame
  5. Mechanical systems
  6. Finishing

- **Construction process for retrofitted a building**
  1. demolish some areas
  2. improve structure
  3. Mechanical systems
  4. Finishing
Introducing the team

Design goals

Software

Site context

Project Highlights:

Architecture

Engineering

Envelope

Efficiency

Grid-Interactivity

Life-Cycle

Health

Market

Community

What was the cost calculation process?

Total Cost: $856,608.20

Total Cost: $510,057.34

Cost comparison chart

Conventional schools in Tehran

Retrofit

New building

Building Cost per square ($)

357.14

283.37

69.13

What was the cost calculation process?

Purchased Electricity

Purchased gas

Sold Electricity

Sold thermal Energy

Repair & maintenance

Rent of Commercial units

incomes and costs per year

Electricity

Gas

Sold Electricity

Sold thermal Energy

Repair & maintenance

Rent of Commercial units

Building Cost per square ($)

$0.00

$10,000.00

$20,000.00

$30,000.00

$40,000.00

$50,000.00

$60,000.00

$70,000.00

-10,000.00

-$20,000.00

incomes and costs per year

Purchased

Gas

sold

Electricity

Electricity

Sold Thermal Energy

$856,608.20

$510,057.34

-$20,000.00

-$10,000.00

$0.00

$10,000.00

$20,000.00

$30,000.00

$40,000.00

$50,000.00

$60,000.00

$70,000.00

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-$20,000.00

Electricity

Gas

Electricity

Sold Thermal Energy

Repair & maintenance

Rent of Commercial units

357.14

283.37

69.13

Conventional schools in Tehran

Retrofit

New building

$856,608.20

$510,057.34

-$20,000.00

-$10,000.00

$0.00

$10,000.00

$20,000.00

$30,000.00

$40,000.00

$50,000.00

$60,000.00

$70,000.00

-10,000.00

-$20,000.00

Electricity

Gas

Electricity

Sold Thermal Energy

Repair & maintenance

Rent of Commercial units
**Why did we calculate the building cost in risk condition?**

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>NPV ($)</th>
<th>IRR (%)</th>
<th>PBT (Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Certainty</td>
<td>$2,010,109.69</td>
<td>23%</td>
<td>13</td>
</tr>
<tr>
<td>2-Risk</td>
<td>There is a 100% probability that it will be positive in the calculation period of 25 years.</td>
<td>100% probability is greater than 25% in the calculation period of 25 years.</td>
<td>100% PBT is less than 12 years and 2% less than 10 years.</td>
</tr>
</tbody>
</table>

**Normal Distribution for Rent of Commercial Units**

**Net Percent Value Analysis**

**Internal Rate of Return Analysis**

**Pay Back Time Analysis**
5.9

Community
How does the school interact with the neighborhood?
Introducing the team

Design goals

Software

Site context

Project Highlights:

Architecture

Engineering

Envelope

Efficiency

Grid-Interactivity

Life-Cycle

Health

Market

Community

School as a neighborhood center
Introducing the team

Design goals

Software

Site context

Project Highlights:

Architecture

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Envelope

Efficiency

Grid-Interactivity

Life-Cycle

Health

Market

Community

At what times do the students and neighborhoods can use the school?
How does the school interact with the neighborhood?

Secure Connection with the park

Crime Reduction

reduce the dangerous atmosphere in the park
How does the school interact with the neighborhood?

- change the function of the big storage place into book cafe
- Improve public culture
- enhance society’s consciousness
- revive the urban walls (landscape)
- encourage nightlife

The library is used by the students and neighborhood inhabitants

- longer Working Hours after school time
- Encouragement to read book
- Boost public culture
How does the school **interact** with the **neighborhood**?

- change the interior design of the old canteen
- make the place suitable for women and families
- Improve nightlife in this area
- Teach skills to girl students
- become accustomed to Persian art and culture
- teach how to make money from skills and arts
How does the school expand?

- Availability of vertical expansion
- Availability of horizontal expansion
How does the school help people in critical situations?

- Earthquake
- Infectious disease

- The possibility of quick construction of modules for settling people in critical situations.
The Green Sprout School Highlights

- Water & energy management
- Multifunctional and flexible space
- Minimizing embodied carbon & energy
- Using innovative materials
- Revival of Ancient Architecture
- Community engagement
- Building resilience
- Income Opportunity
- Occupancy Health Improvement
Industry partnership:
THANK YOU

U.S. Department of Energy
Solar Decathlon Organizers
Solar Decathlon Jurors