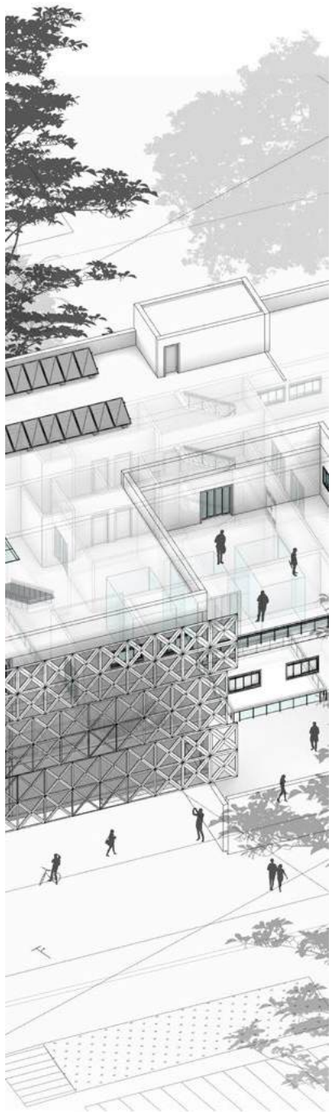

# AbbasPour **Student Center**

*High Performance Building Design*

***Instructor:*** Dr.Zomorodian

***Student:*** Nima Forouzandeh

***Winter 2020***

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# 01 **Preliminary Evaluation** and **design,Early Investigations**

## Definition

- Cost-Effectiveness
- Safety and security
- Sustainability
- Accessibility
- Functionality
- Productivity
- Historic Preservation
- Aesthetics

## Benefits

Green Building › Green University

GSA data-driven study examined 200 a three-year period:

| | |
|---|---|
| **%**23 | **Energy** Use |
| **%**28 | **Water** Use |
| **%**23 | Operation **Expenses** |
| **%**9 | **Historic** Preservation |
| **%**2 | Tenant **Satisfaction** |

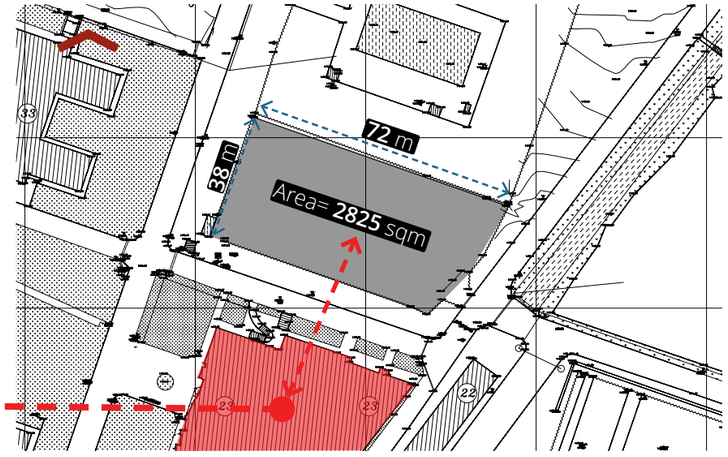
## Case Studies

| | Name/Location | Climate (Koppen) | Highlights | Pictures |
|---|---|---|---|---|
| 1 | Green Center for Student Success at Southern New Hampshire University/ **New Hampshire** | Humid Continental Climate(**Dbf**) | • LEED Silver certification.<br>• replacing the entire envelope with high-performance metal panels, curtain wall and storefronts systems, skylights and insulated and reflective roof, improved thermal performance and minimized energy costs.<br>• New HVAC units improved performance drastically while minimizing energy costs and eliminating harmful refrigerants.<br>• Low flow fixtures and water efficient landscaping.<br>• sustainable finishes and wood products<br>• Low VOC adhesives and paints<br>• specified materials that minimized waste of natural resources and maximized comfort. |  |
| 2 | Emory University Student Center/ **Atlanta** | Humid Subtropical Climate(**Cfa**) | • LEED Platinum Certification.<br>• Geothermal system<br>• Solar-powered water systems<br>• Exterior shading through a sunshade canopy that unifies the Student Center complex<br>• Energy-efficient mechanical heating/cooling systems<br>• Window shade sensors<br>• Occupancy sensors<br>• Chilled beams in the majority of student life areas<br>• Ceiling fans set to automatically increase thermal comfort during hot months<br>• Daylight harvesting, with electric lighting automatically adapting to interior light levels<br>• Improved wall insulation to minimize heat gain/loss |  |
| 3 | New Mexico HightLands University/ **Las Vegas** | Subtropical Hot Desert (**BWh**) | • LEED Gold Certified<br>• A large three-storey atrium<br>• The -100seat student and governance chamber council that floats above this central space; to enhance its presence, natural light washes the curved surface of the chamber drum.<br>• Motorized sun tracking louver systems<br>• The ground floor has interior blinds rather than the louver system<br>• Green roofs<br>• Geothermal well field |  |

## Public Transportation




## Site Dimentions and Adjacent buildings




Conference hall and public dining spaces, suitable for extention purposes.

## Location




Main Streets  Seconcary Access Roads  **Key**

## Views From the Site

**Eastern** Side



**Southern** Side



**Western** Side



**Northern** Side



**Eastern** Side

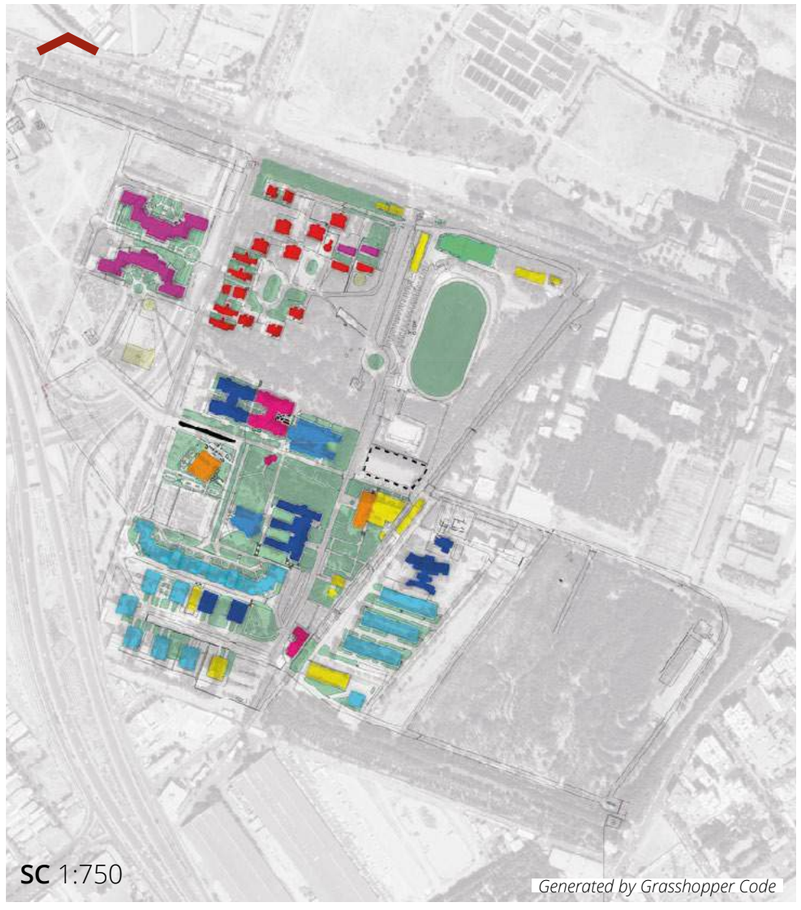


**Southern** Side



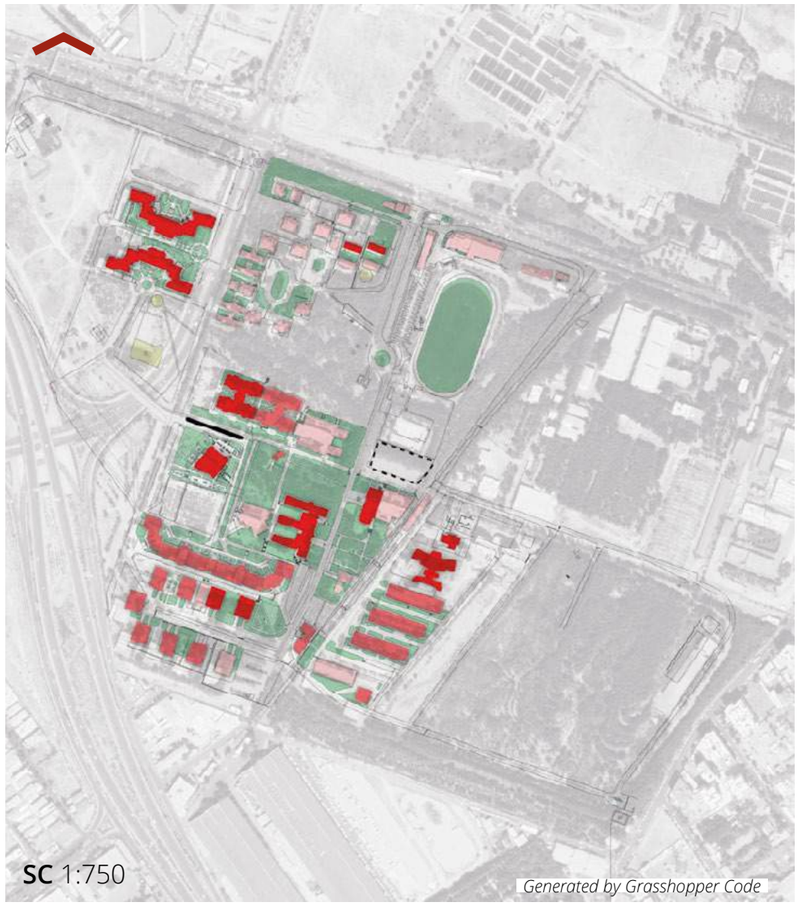
# Location and Accessibility

## Buildings Use



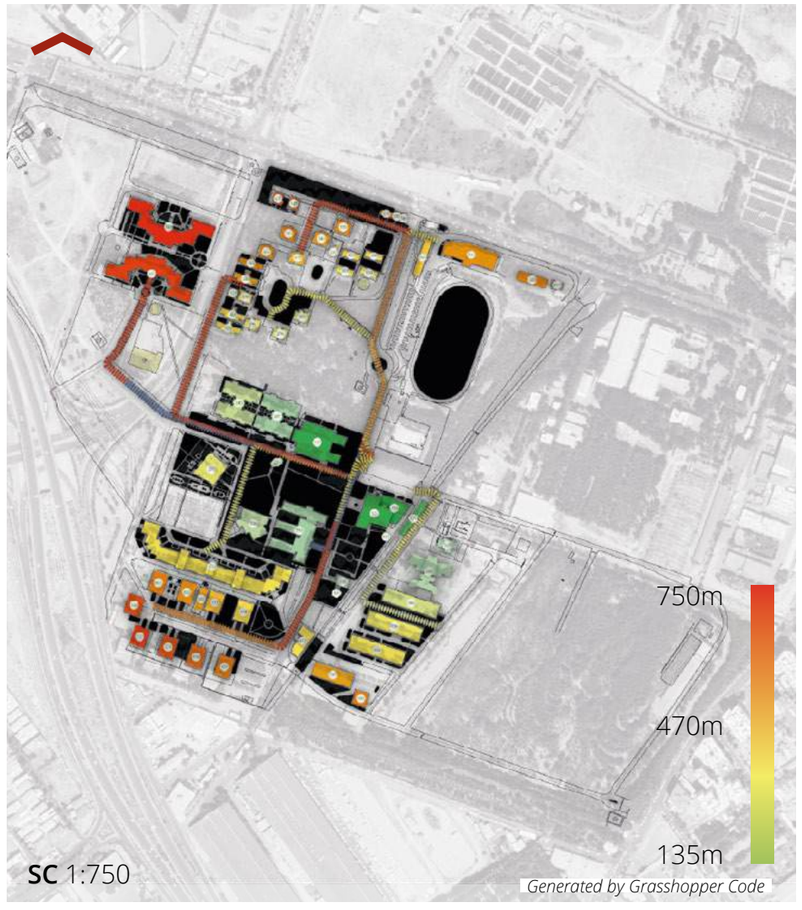

- Lecture Classrooms
- Workshops
- Classrooms-Staff
- Administration
- Sport Hall
- Equipements and Services
- Cultural
- Dormitory
- Temporary Residence
- Green Space

## Frequency of Use




- High
- Medium
- Low

## University Buildings Accessibility to the Site




| | | |
|---|---|---|
| **Average** Distance | 470**m** | **5.5** minutes |
| **Minimum** Distance | 135**m** | **1.5** Minutes |
| **Maximum** Distance | 750**m** | **9** Minutes |

## Temperature and Comfort

### Tehran in Köppen Climate Classification

Cold and Semi-arid **Bsk**

HDD Cooling Degree-days and Heating
CDD Degree-days in Occupancy days

HDD 1779 CDD 459

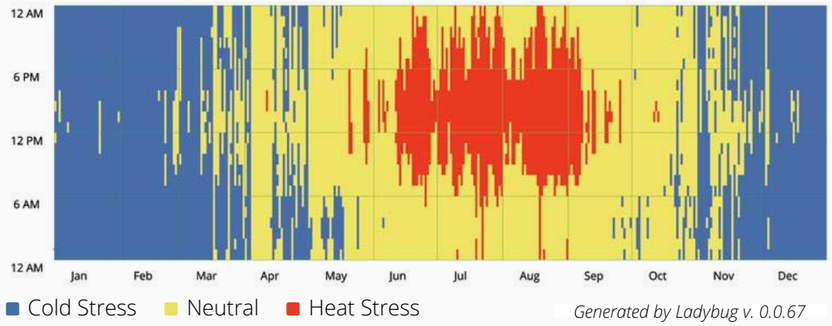
### Thermal Stress (hrs)

| **Heat** Stress | **Neutral** Stress | **Cold** Stress |
|---|---|---|
| 1021 | 2683 | 1171 |

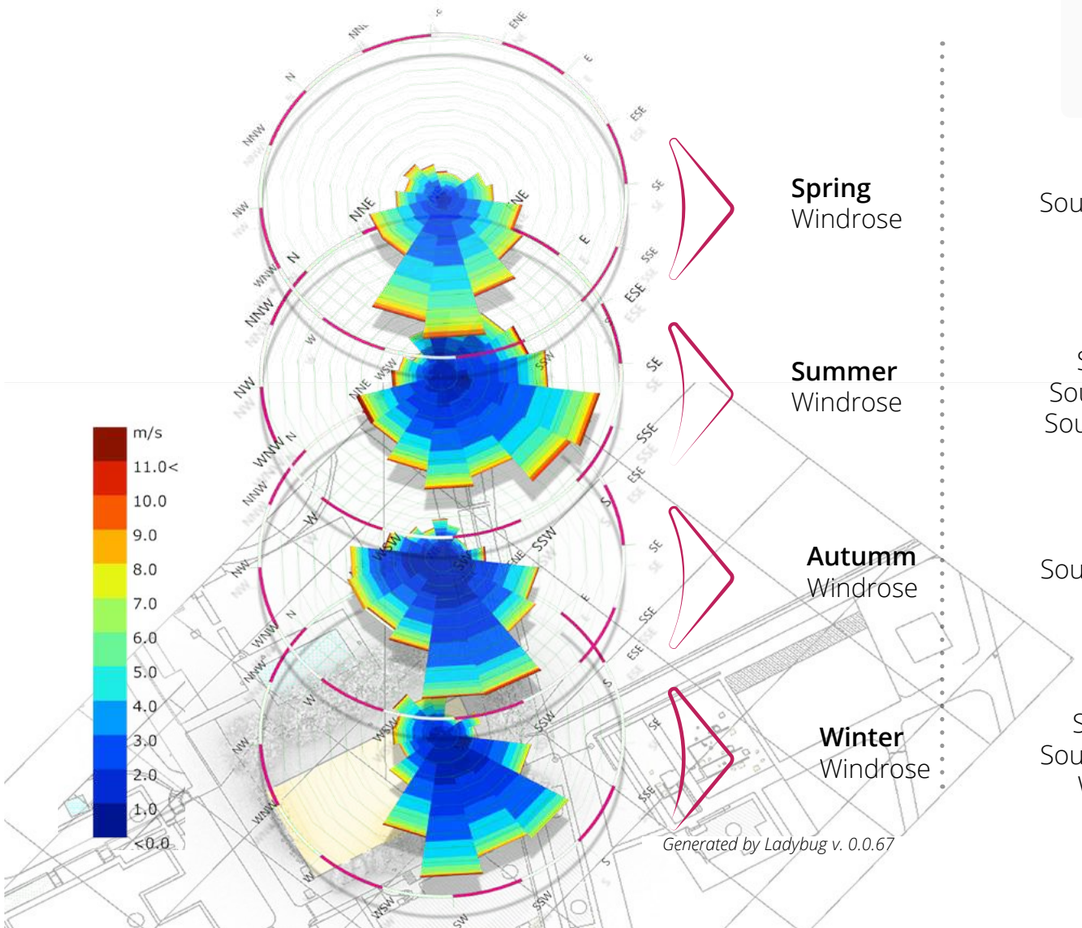
### Common Strategies and TC

| | **Measures list** | **% of Time Comfortable** |
|---|---|---|
| | No Measures | **12**.1 |
| Active | Evaporative Cooling | **35**.23 |
| Active | Occupant Use of fans | **23**.37 |
| Passive | Thermal Mass + Night Ventilation | **18**.14 |
| Passive | Capture Internal Heat Gain | **37**.2 |
| Passive | Passive Solar Heating | **39**.2 |

### Annual Thermal Stress



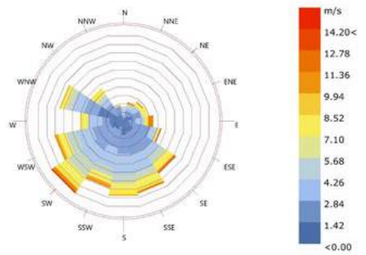

## Wind Analysis



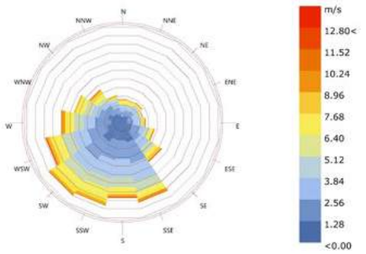

| | Prevailing **Direction** | Average **Velocity** (m/s) | **Frequency** |
|---|---|---|---|
| **Spring** Windrose | South West | 3.5 | 12 |
| **Summer** Windrose | South South East South West | 2.88 | 10 |
| **Autumm** Windrose | South West | 2.11 | 12 |
| **Winter** Windrose | South South West West | 2.03 | 12 |

Windroses in **Occupancy months**

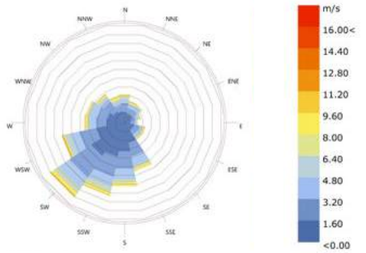
Windrose in **Hot** Hours ( DBT <28 °C )




Windrose in **Cold** Hours ( DBT >20 °C )




Windrose in **Desirable** Temperatures ( 20< DBT <28 °C )

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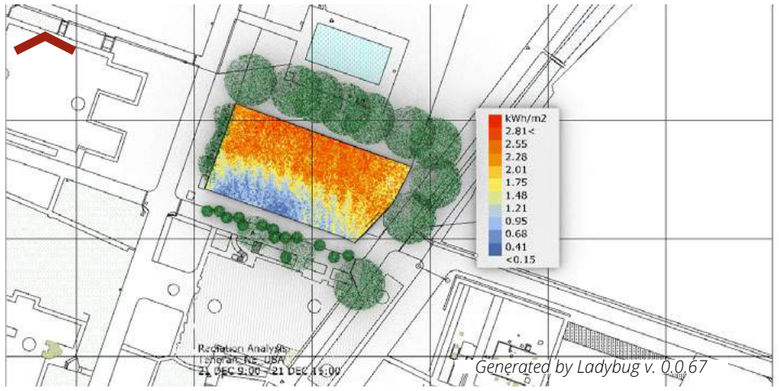
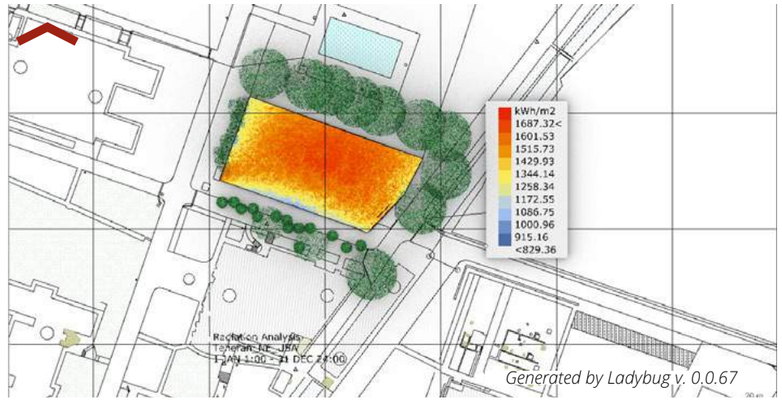
## Radiation Analysis




Radiation Analysis, 21 DEC. , 9:00-15:00




Radiation Analysis, Annual

## Photovoltaic Production Potential

| Area (s.q.m.) | Annual Energy(kWh) | % of Baseline | Co2 Emmission Reduction | Annual Cost Saving (IRR) |
|---|---|---|---|---|
| 50 | 2908.5 | % 0.5 | | 9,412,000 |
| 100 | 5817 | % 1 | | 18,824,000 |
| 150 | 8725.5 | % 1.5 | | 28,236,000 |
| 200 | 11634 | % 2 | | 37,648,000 |
| 250 | 14542.5 | % 2.5 | | 47,060,000 |
| 300 | 17451 | % 3 | | 56,472,000 |
| 350 | 20359.5 | % 3.5 | | 65,884,000 |
| 400 | 23268 | % 4 | | 75,296,000 |

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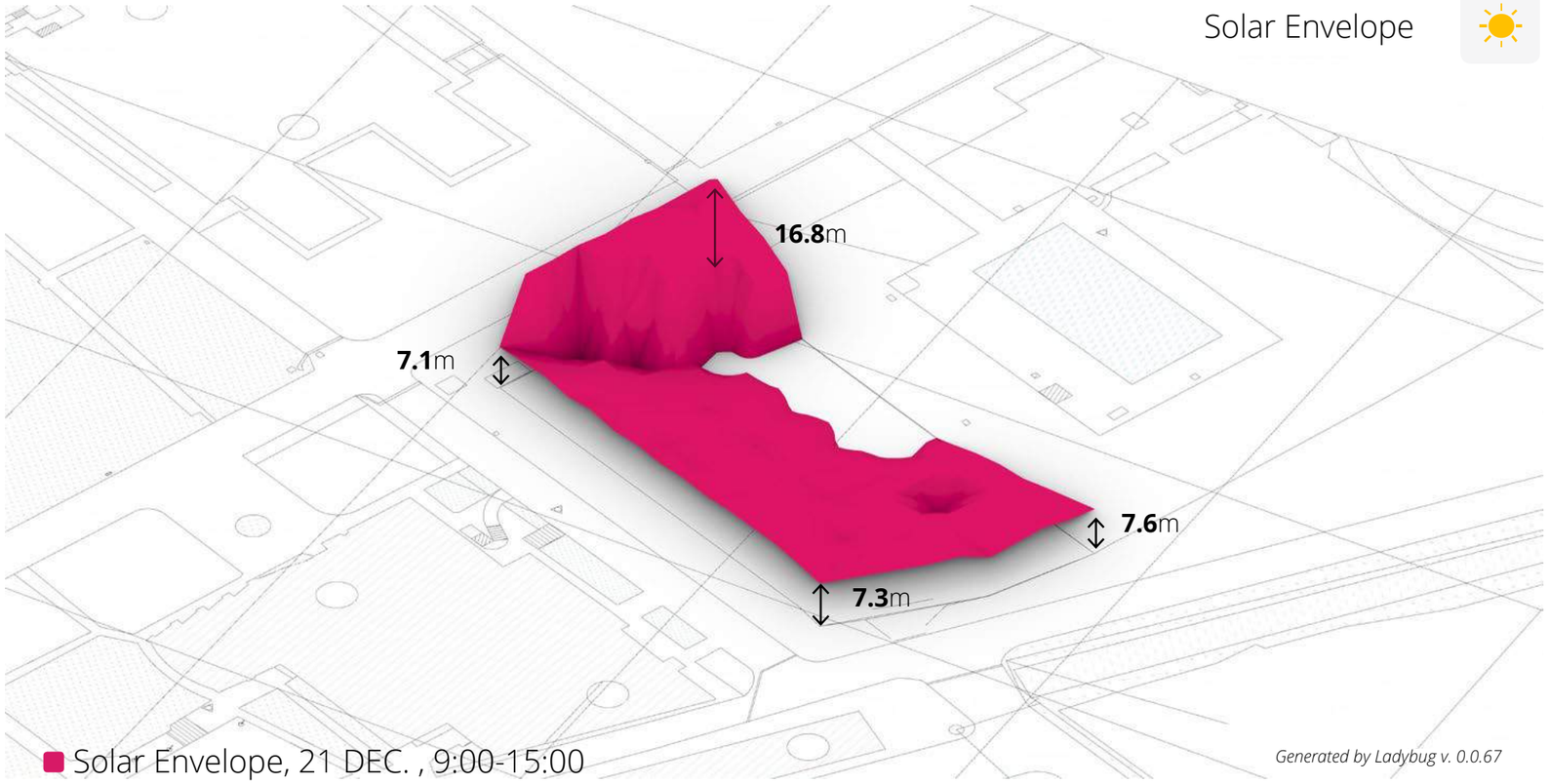
## Solar Envelope




Solar Envelope, 21 DEC. , 9:00-15:00

*Generated by Ladybug v. 0.0.67*

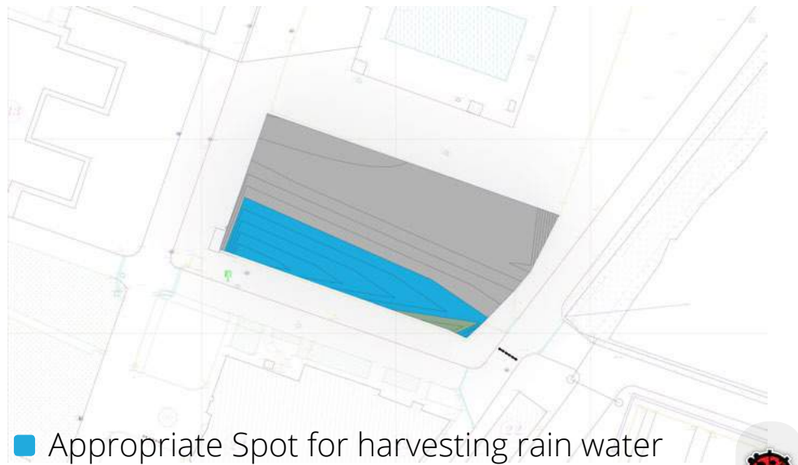
## **Rainwater Harvesting** Potential

Site Annual Average Precipitation

**220**mm

Site Potential for Water Harvesting

**627.88** cu m = **627,880** lit



Appropriate Spot for harvesting rain water

## Benchmarking

### Energy

| | |
|---|---|
| Gas Consumption | **39.56** kWh/sqm |
| Electricity Consumption | **161** kWh/sqm |
| Total Site Energy Consumption | **200** kWh/sqm |
| Primary Energy Consumption | **622** kWh/sqm |

### Carbon

| | |
|---|---|
| Operational Carbon Emmition | **270,400** kg |
| = | **58.7** X |

### Water

| | |
|---|---|
| Gas Consumption | **753,275.75** (liters/year) |

## Goals and Targets

### Main **Goals**

**Energy** & atmosphere

- %50-32 Energy Use Reduction from Baselie (Baseline: 130kWh/sqm)
- %3-1Renewable energy production

Indoor Environmental Quality**(IEQ)**

- Ventilation Requierements
- Tobacco Smoke Control
- Enhanced IAQ Strategies
- Low-emitting materials
- Thermal comfort
- Interior lighting
- Daylighting

**Water** Efficiency

- Reduce Water Consumption
- Harvest Rain Water
- Water recycling

**Acoustics**

- Sound Mapping
- Maximum Noise Levels
- Sound Barriers
- Sound Absorption
- Sound Masking
- β - Impact Noise Management

USGBC LEED — WELL

### Secondary **Goals**

Mind · Thermal Comfort · Water · Light · Movement

Materials · Air · Resiliency · Community · Innovation

WELL and RELi

## Site Orientation Study

Site

| | Daylight Availability | Solar Heat Gain – Cooling Seasons | Solar Heat Gain – Heating Seasons | Silence | Exposure to Users & Attraction | Site Orientation Study |
|---|---|---|---|---|---|---|
|  **South**ern Side | 1 | 2 | 1 | 3 | 2 | 1 |
|  **West**ern Side | 3 | 3 | 2 | 5 | 1 | 1 |
|  **North**ern Side | 5 | 5 | 5 | 1 | 3 | 3 |
|  **East**ern Side | 3 | 3 | 2 | 3 | 4 | 4 |
|  **Roof** Side | 1 | 1 | 4 | 1 | 5 | 5 |

Functional Zones

| | | | | | |
|---|---|---|---|---|---|
| **Cultural** Spaces | H | M | H | - | L |
| **Service** and **Equipement** Spaces | L | L | L | - | H |
| **Educational** Spaces | H | M | H | - | L |
| **Administration** Spaces | M | M | L | - | L |

## Massing and Orientation

### Alternative 1

**1161.75** s.q.m. — +2
Study Hall, Conference Room, Student Organizations, TV Room, Game Room, Administration, Lounge, Class Rooms,

**1336.75** s.q.m. — +1
Service and Prayers Room, Foodcourt, Lounge,

**1322.5** s.q.m. — 0
Multi-functional space, conference hall, Gallery, Lounge, Shop, Central Plant, Electrical and Automation Room, Fire Control, Administration, Entrance

### Alternative 2

**1453.75** s.q.m. — +2
Study Hall, Conference Room, Student Organizations, Game Room, Service and Prayers Room, Class Rooms, Administration,

**1218.75** s.q.m. — +1
Multi-functional space, Lounge, Gallery, TV Room,

**1087.5** s.q.m. — 0
Shop, Foodcourt, Administration, Entrance, conference hall, Central Plant,

**597.5** s.q.m. — -1
Electrical and Automation Room, Fire Control,

### Alternative 3

**1063.75** s.q.m. — +2
Conference Room, Student Organizations, Administration, Game Room, Service and Prayers Room, Class Rooms, Lounge, Study Hall, TV Room, Gallery,

**1418.75** s.q.m. — +1
Multi-functional space, Foodcourt, Shop, Administration, Entrance, conference hall, Central Plant,

**1153.75** s.q.m. — 0
Electrical and Automation Room, Fire Control, Foodcourt Storage,

**722.25** s.q.m. — -1

## Massing Alternatives

**A. 1** ✗
- \+ System Acoustical Isolation
- − More Storeys

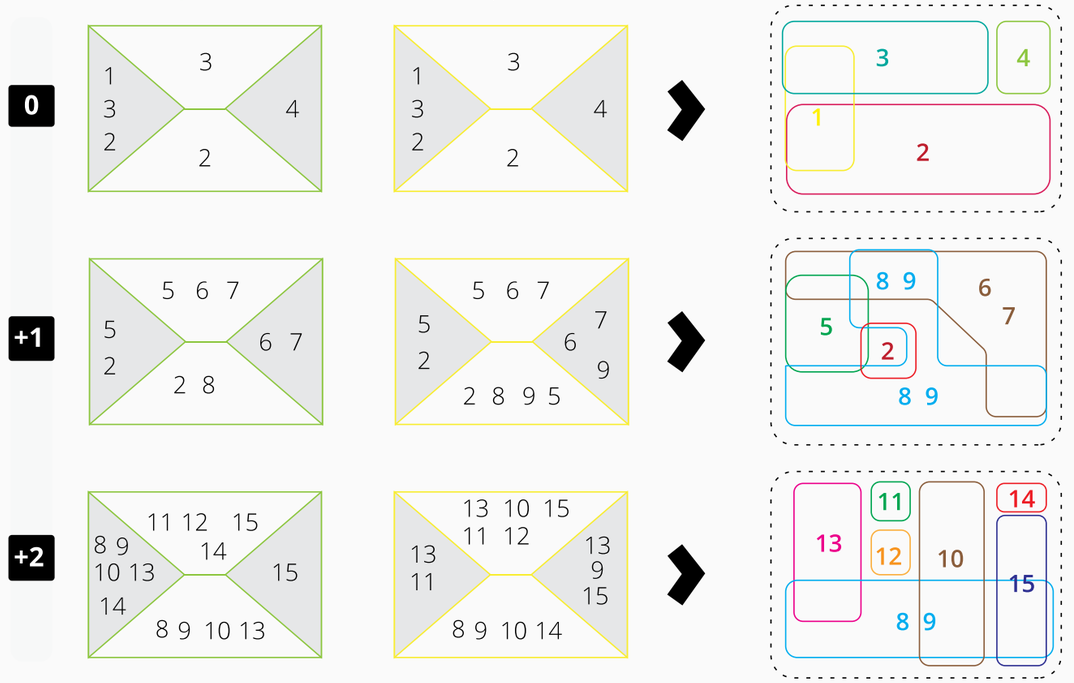
**A. 2** ✗
- \+ Less Storeys
- − System Noise

**A. 3** ✓
- \+ System Acoustical Isolation
- \+ Spaces Functional Distribution
- − More Storeys

## Orientation

**Key**

1 Entrance and Administration
2 Foodcourt
3 Conference Hall
4 Shop
5 Multi-Functional Space
6 TV Room
7 Gallery
8 Study Hall
9 Lounge
10 Class Rooms
11 Student Organization
12 Administration
13 Game Room
14 Conference Room
15 Service & Prayers Room

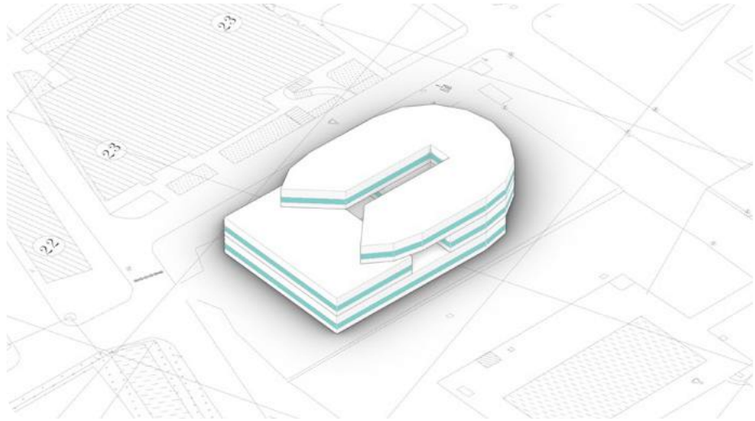


# **Concept** Design

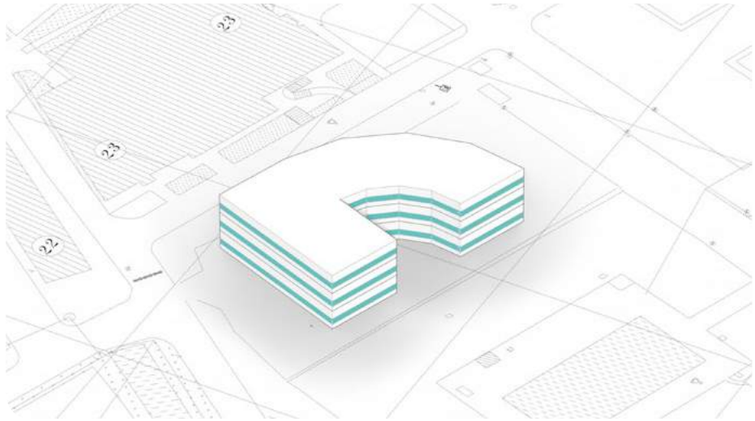
02

## Form Alternatives

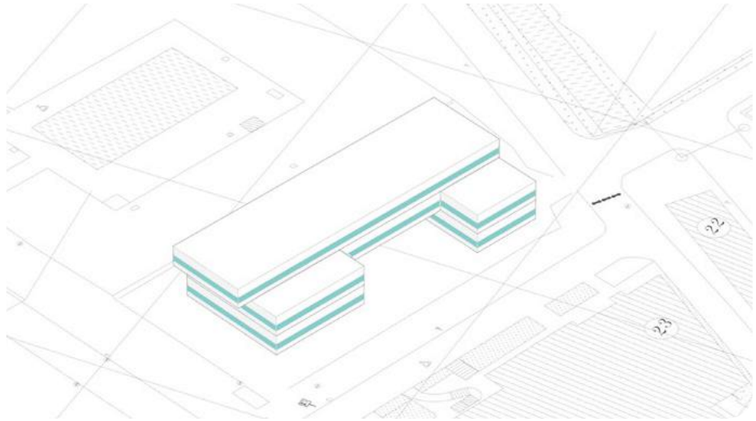
Code A.1 SVF 0.44 Floor Area 2988sqm



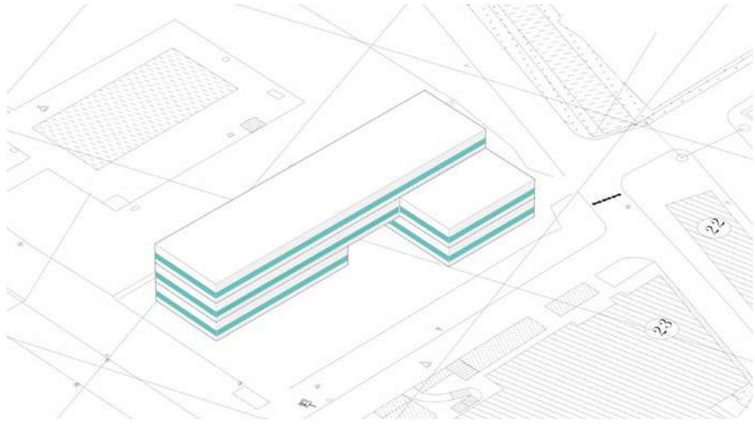
Code A.2 SVF 0.33 Floor Area 3137sqm



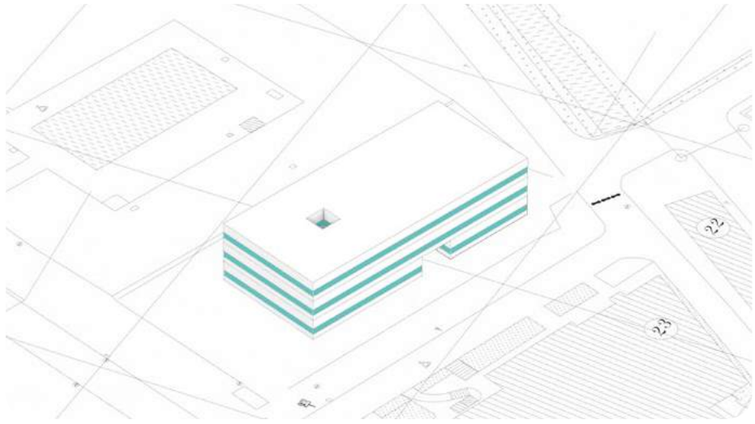
Code A.3 SVF 0.37 Floor Area 2704sqm



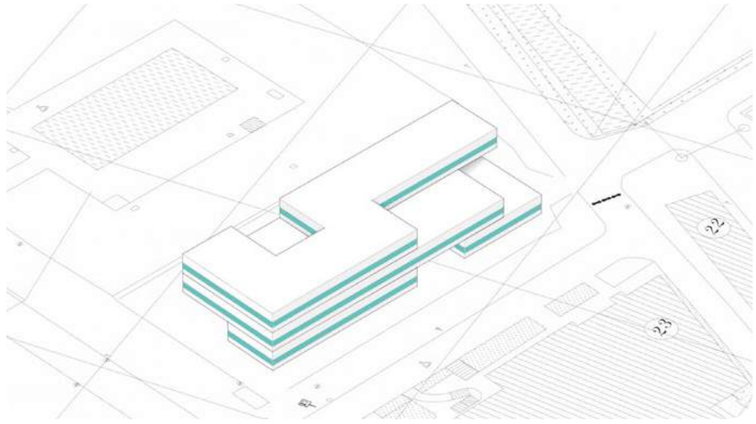
Code A.4 SVF 0.35 Floor Area 3090sqm



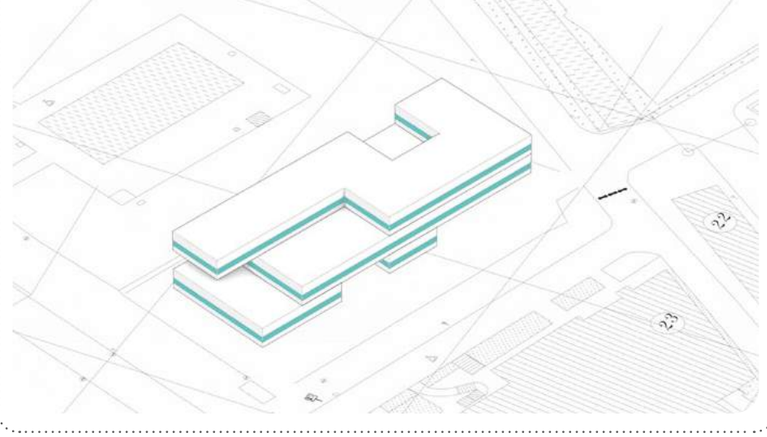
Code A.5 SVF 0.33 Floor Area 3094sqm



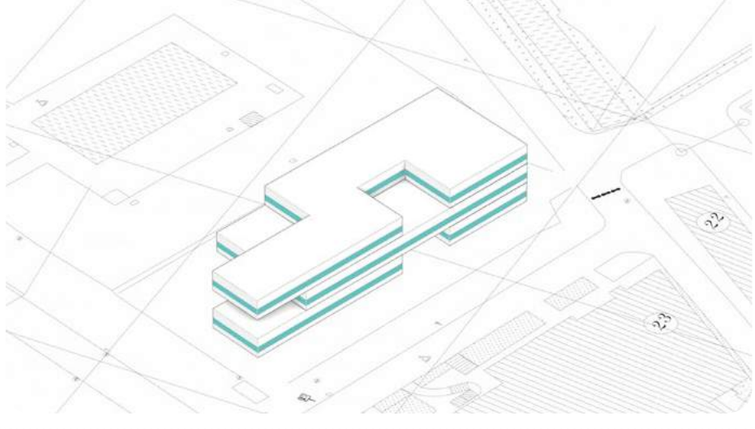
Code A.6 SVF 0.40 Floor Area 3090sqm



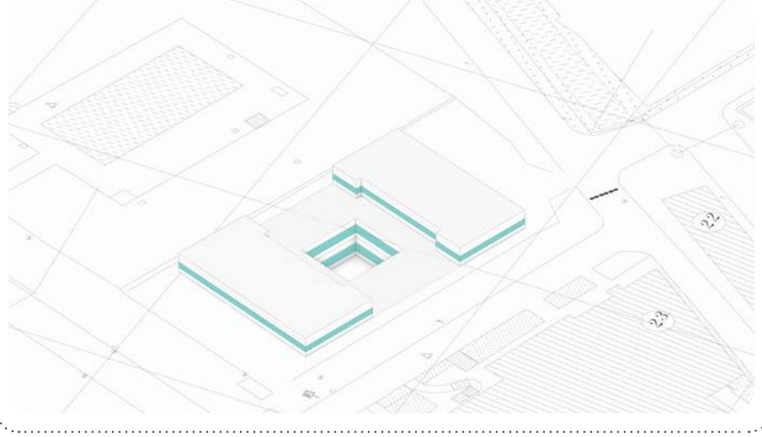
Code A.7 SVF 0.40 Floor Area 3090sqm



Code A.8 SVF 0.38 Floor Area 3124sqm



Code A.9 SVF 0.38 Floor Area 3164sqm

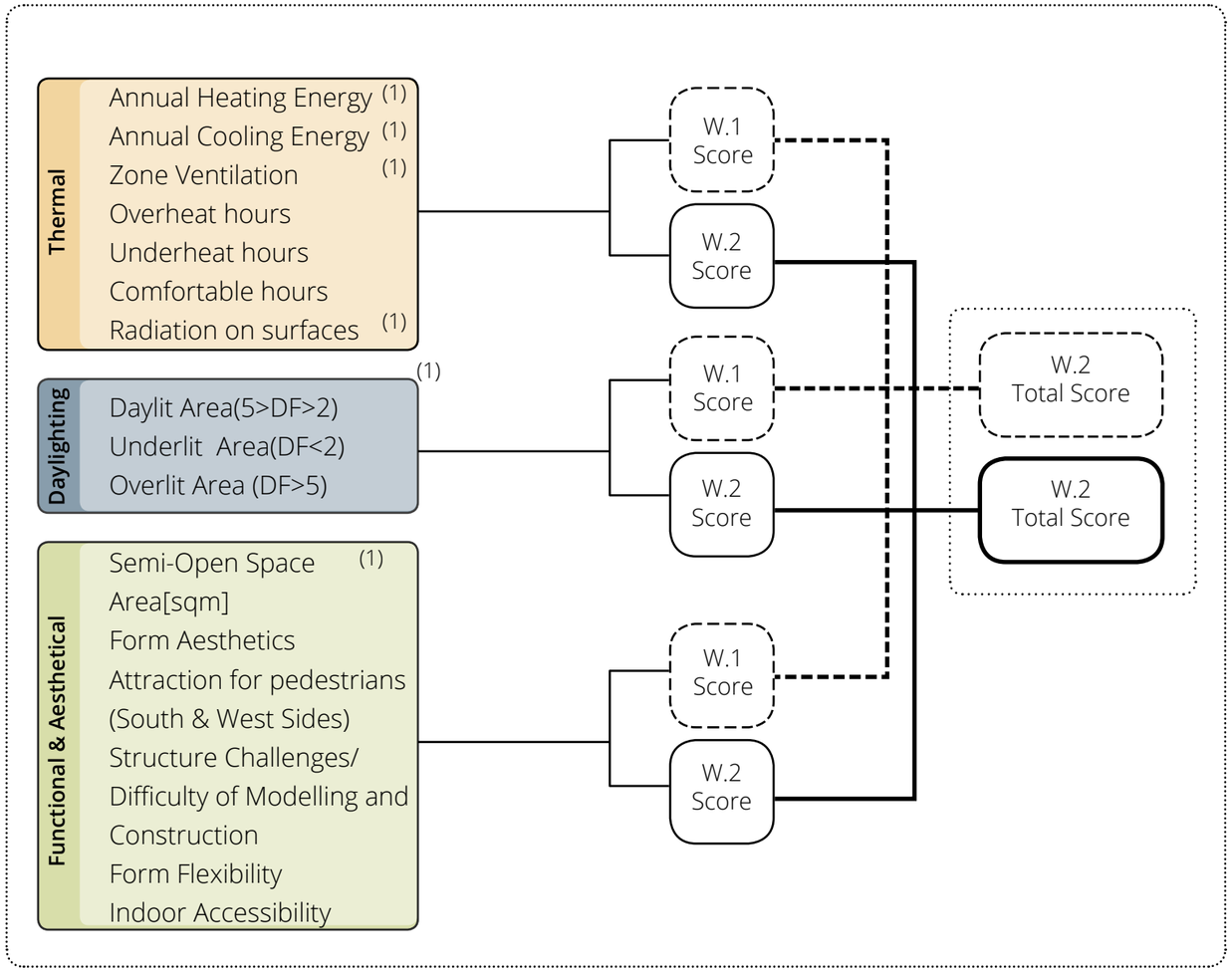


## Modelling Key Assumptions

| | | |
|---|---|---|
| **Ventilation** | • Scheduled Ventilation | Off |
| | • Natural Ventilation | On |
| | • Setpoint | 18 |
| | • Min Outdoor Temperature | 0 |
| | • Max Outdoor Temperature | 30 |
| | • Max Rel. Humidity | 90 |
| | • Infiltration | On |
| | • Infiltration ACH | 0.1 |
| | • Constant Term Coefficient | 1 |
| | • Temperature Term Coefficient | 0 |
| | • Velocity Term Coefficient | 0 |
| | • Velocity Squared Term Coefficient | 0 |
| **Constructions** | • Window Conductivity [W/m.K] | 0.9 |
| | • Window Visible Transmittance | 0.913 |
| | • Window SHGF | 0.905 |
| | • Wall U-value [W/m-2k] | 9.2(Default) |
| | • Floor U-value [W/m-2k] | 9.2(Default) |
| | • Ceiling U-value [W/m-2k] | 9.2(Default) |
| | • Roof U-value[W/m-2k] | 9.2(Default) |
| | • WWR[%] | 30 |
| **Loads** | • People | On |
| | • Schedule | 8 to 6 |
| | • density [p/m2] | 0.2 |
| **Conditioning** | • Heating | On |
| | • Constant Setpoint | 20 |
| | • Availablity Schedule | AllOn |
| | • Heating Limit[W/m2] | 100 |
| | • Flow Limit[W/m2] | 100 |
| | • Cooling On | |
| | • Constant Setpoint | 26 |
| | • Availablity Schedule | AllOn |
| | • Cooling Limit[W/m2] | 100 |
| | • Flow Limit[W/m2] | 100 |
| | • Humidity Control | Off |
| | • Mechanical Ventilation | Off |
| **Analysis Grid** | • Spacing[m] | 1.5 |
| | • Height[m] | 0.76 |
| | • Offset from walls[m] | 0.6 |
| **Surfaces** | • Ceiling reflectance[%] | 70 |
| | • Wall reflectance[%] | 70 |
| | • Window Transmittance[%] | 80 |
| | • Floor reflectance[%] | 30 |
| | • Ground reflectance[%] | 20 |

## Form Selection Process

A. 1
A. 2
A. 3
A. 4
A. 5
A. 6
A. 7
A. 8
A. 9




(1) Score Calculation Equations

$$Score_{Heating/Cooling\ Energy} = \frac{E - E_{min}}{E_{max} - E_{min}} \times 100$$

$$Score_{Natural\ Ventilation} = \frac{V - V_{min}}{V_{max} - V_{min}} \times 100$$

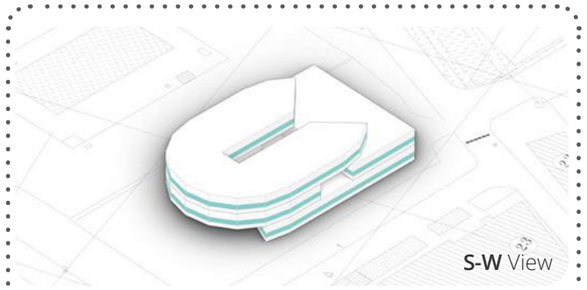
$$Score_{Daylight} = \frac{1}{5} \times (Overlit\ \%\ of\ times) + \frac{4}{5} \times (Daylit\ \%\ of\ times)$$

$$Score_{Radiation} = \frac{R - R_{min}}{R_{max} - R_{min}} \times 100$$

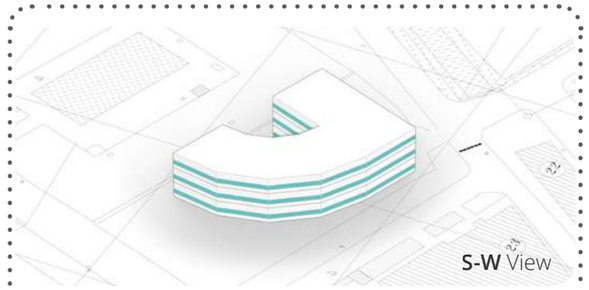
$$Score_{Open\ and\ Semi-open\ Areas} = \frac{A - A_{min}}{A_{max} - A_{min}} \times 100$$

# Form Alternatives Analysis

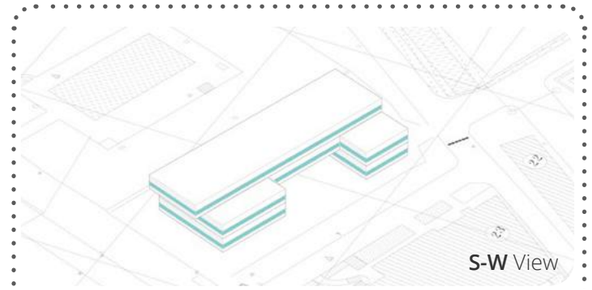
| | Weighting I | Weighting II |
|---|---|---|
| **Thermal** | X **1** | X **3** |
| **Daylighting** | X **1** | X **2** |
| **Functional** | X **1** | X **4** |




Code A.1 SVF 0.44 Floor Area 2988sqm




Code A.2 SVF 0.33 Floor Area 3137sqm

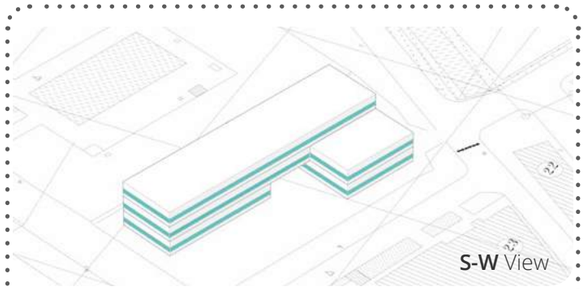



Code A.3 SVF 0.37 Floor Area 2704sqm

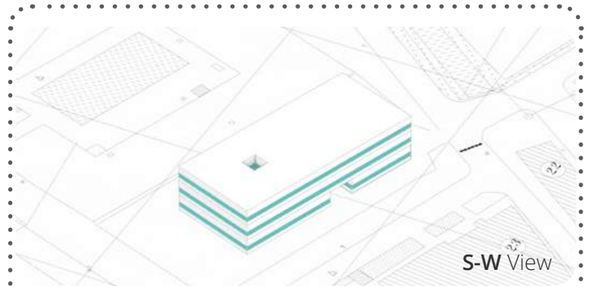
| | Key Parameters | Detailed Weightings | Values/ Raw Scores | Scores | Overall Scores | Values/ Raw Scores | Scores | Overall Scores | Values/ Raw Scores | Scores | Overall Scores |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Thermal** | Annual Heating Energy [Jouls/sqm] | 20/100 | 4.87E+ 9 | 0 | I 28.85 II 28.85 | 3.53E +9 | 28 | I 35.10 II 35.10 | 4.83E+09 | 1 | I 25.52 II 25.52 |
| | Annual Cooling Energy [Jouls/sqm] | 20/100 | 4.57E+ 7 | 0 | | 3.71E+07 | 19 | | 4.32E+07 | 6 | |
| | Zone Ventilation [ACH] | 15/100 | 7.54 | 100 | | 6.69 | 61 | | 7.22 | 85 | |
| | Overheat hours [% of times] | | 2.12 | | | 1.82 | | | 1.56 | | |
| | Underheat hours | | 73.02 | | | 68.98 | | | 73.90 | | |
| | Comfortable hours [% of times] | 40/100 | 24.86 | 24.9 | | 29.19 | 29.2 | | 24.53 | 24.5 | |
| | Radiation on surfaces [W/sqm](BIPV Potential) | 5/100 | 334512.09 | 78 | | 382492.72 | 100 | | 238364.67 | 33 | |
| **Daylighting** | Daylit Area(5>DF>2) | 80/100 | 19.51 | 22 | I 21.55 II 14.44 | 17.22 | 19 | I 19.49 II 13.06 | 20.16 | 21 | I 21.04 II 14.10 |
| | Underlit Area(DF<2) | | 51.19 | | | 54.47 | | | 32.27 | | |
| | Overlit Area (DF>5) | 20/100 | 27.64 | | | 26.31 | | | 23.66 | | |
| **Functional & Aesthetical** | Semi-Open Space Area[sqm] | 20/100 | 645 | 56 | I 37.71 II 32.25 | 60 | 0 | I 25.00 II 66.04 | 616 | 53 | I 49.65 II 63.4 |
| | Form Aesthetics | 10/100 | 40 | 40 | | 40 | 40 | | 60 | 60 | |
| | Attraction for pedestrians (South & West Sides) | 20/100 | 25 | 25 | | 25 | 25 | | 50 | 50 | |
| | Structure Challenges/ Difficulty of Modelling and Construction | 10/100 | 25 | 25 | | 60 | 60 | | 30 | 30 | |
| | | | 25 | 25 | | 25 | 25 | | | | |
| | Form Flexibility | 20/100 | | | | | | | 50 | 50 | |
| | Indoor Accessibility | 20/100 | 50 | 50 | | 75 | 75 | | 50 | 50 | |
| | **Total Scores:** | | | I 88.1 | II 76.5 | **Total Scores:** | | I 79.6 | II 114.2 | **Total Scores:** | I 96.2 | II 102.7 |

# Form Alternatives Analysis

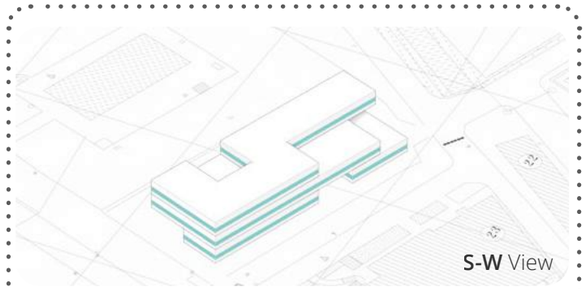
| | Weighting I | Weighting II |
|---|---|---|
| **Thermal** | X **1** | X **3** |
| **Daylighting** | X **1** | X **2** |
| **Functional** | X **1** | X **4** |




Code A.4 SVF 0.35 Floor Area 3090sqm




Code A.5 SVF 0.33 Floor Area 3094sqm

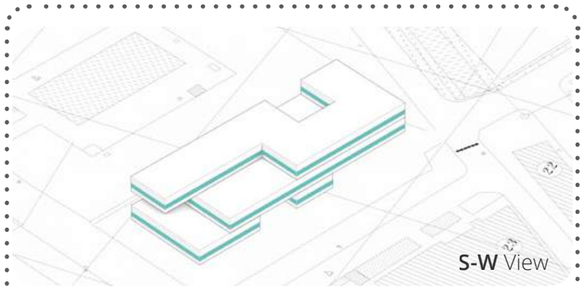



Code A.6 SVF 0.41 Floor Area 3090sqm

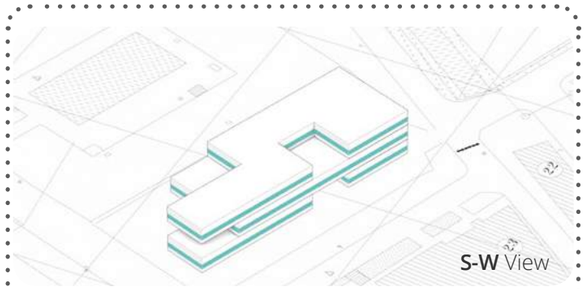
| | Key Parameters | Detailed Weightings | Values/ Raw Scores | Scores | Overall Scores | Values/ Raw Scores | Scores | Overall Scores | Values/ Raw Scores | Scores | Overall Scores |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Thermal** | Annual Heating Energy [Jouls/sqm] | 20/100 | 4.18E+09 | 14 | I 27.53 II 27.53 | 4.24E+09 | 13 | I 29.45 II 29.45 | 4.56E+09 | 6 | I 27.78 II 27.78 |
| | Annual Cooling Energy [Jouls/sqm] | 20/100 | 4.08E+07 | 11 | | 3.97E+07 | 13 | | 4.32E+07 | 5 | |
| | Zone Ventilation [ACH] | 15/100 | 6.934869 | 72 | | 7.21 | 85 | | 6.96 | 73 | |
| | Overheat hours [% of times] | | 2.14 | | | 2.05 | | | 2.02 | | |
| | Underheat hours [% of times] | | 71.55 | | | 71.88 | | | 73.14 | | |
| | Comfortable hours [% of times] | 40/100 | 26.30 | 26.3 | | 26.07 | 26.1 | | 24.83 | 24.8 | |
| | Radiation on surfaces [W/sqm](BIPV Potential) | 5/100 | 220460.08 | 24 | | 211583.3 | 20 | | 358619.62 | 89 | |
| **Daylighting** | Daylit Area(5>DF>2) | 80/100 | 23.57 | 24 | I 24.39 II 16.34 | 5.12 | 4 | I 3.85 II 2.58 | 27.55 | 29 | I 29.46 II 19.74 |
| | Underlit Area(DF<2) | | 48.23 | | | 93.93 | | | 16.97 | | |
| | Overlit Area (DF>5) | 20/100 | 26.82 | | | 0 | | | 35.20 | | |
| **Functional & Aesthetical** | Semi-Open Space Area[sqm] | 20/100 | 420 | 34 | I 47.40 II 55.34 | 144 | 8 | I 41.61 II 90.61 | 302 | 81 | I 68.13 II 102.41 |
| | Form Aesthetics | 10/100 | 60 | 60 | | 50 | 50 | | 80 | 80 | |
| | Attraction for pedestrians (South & West Sides) | 20/100 | 50 | 50 | | 25 | 25 | | 75 | 75 | |
| | Structure Challenges/ Difficulty of Modelling and Construction | 10/100 | 45 | 45 | | 100 | 100 | | 80 | 80 | |
| | Form Flexibility | 20/100 | 50 | 50 | | 25 | 25 | | 80 | 80 | |
| | Indoor Accessibility | 20/100 | 50 | 50 | | 75 | 75 | | 25 | 25 | |
| | **Total Scores:** | | | I 99.3 | II 99.2 | **Total Scores:** | | I 74.9 | II 122.6 | **Total Scores:** | I 125.4 II 149.9 |

## Form Alternatives Analysis

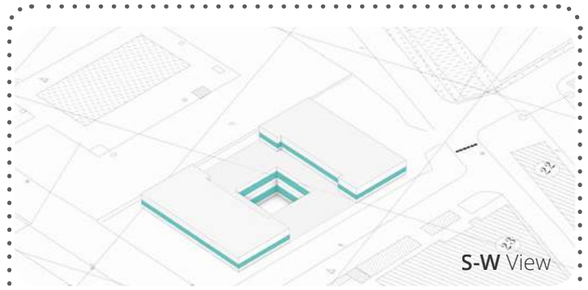
| | Weighting I | Weighting II |
|---|---|---|
| **Thermal** | X **1** | X **3** |
| **Daylighting** | X **1** | X **2** |
| **Functional** | X **1** | X **4** |




Code A.7 SVF 0.41 Floor Area 3090sqm



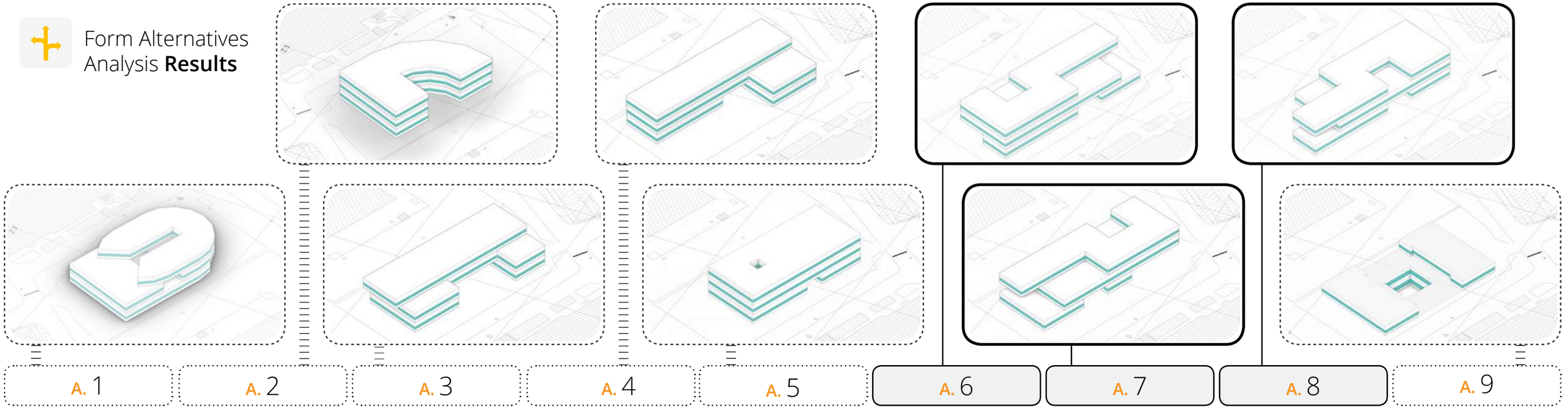

Code A.8 SVF 0.38 Floor Area 3124sqm

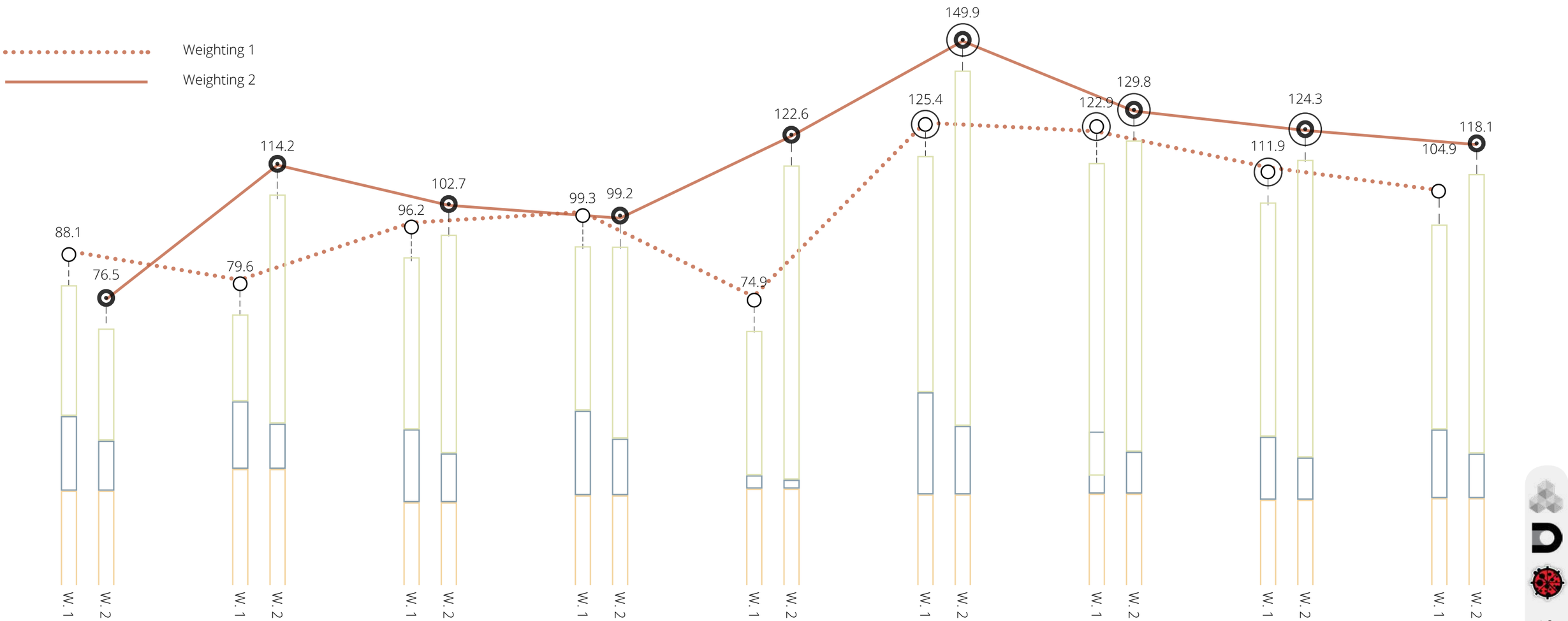



Code A.9 SVF 0.36 Floor Area 3164sqm

| | Key Parameters | Detailed Weightings | Values/ Raw Scores | Scores | Overall Scores | Values/ Raw Scores | Scores | Overall Scores | Values/ Raw Scores | Scores | Overall Scores |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Thermal | Annual Heating Energy [Jouls/sqm] | 20/100 | 4.57E+09 | 6 | I 28.01 II 28.01 | 4.50E+09 | 8 | I 26.24 II 26.24 | 4.87E+09 | 64 | I 26.70 II 26.70 |
| | Annual Cooling Energy [Jouls/sqm] | 20/100 | 4.20E+07 | 8 | | 4.30E+07 | 6 | | 4.57E+07 | 17 | |
| | Zone Ventilation [ACH] | 15/100 | 6.95 | 73 | | 6.77 | 65 | | 7.54 | 0 | |
| | Overheat hours [% of times] | | 1.94 | | | 2.00 | | | 2.12 | | |
| | Underheat hours | | 73.41 | | | 73.19 | | | 73.02 | | |
| | Comfortable hours [% of times] | 40/100 | 24.65 | 24.6 | | 24.81 | 24.8 | | 24.86 | 25.8 | |
| | Radiation on surfaces [W/sqm](BIPV Potential) | 5/100 | 354517.25 | 87 | | 334122.21 | 77 | | 334512.09 | 0 | |
| Daylighting | Daylit Area(5>DF>2) | 80/100 | 17.75 | 18 | I 17.91 II 12.00 | 18.18 | 18 | I 18.18 II 12.18 | 19.51 | 8 | I 19.18 II 12.85 |
| | Underlit Area(DF<2) | | 63.46 | | | 63.4 | | | 51.19 | | |
| | Overlit Area (DF>5) | 20/100 | 18.36 | | | 18.18 | | | 27.64 | | |
| Functional & Aesthetical | Semi-Open Space Area[sqm] | 20/100 | 1104 | 100 | I 77.00 II 89.77 | 608 | 52 | I 67.50 II 85.84 | 558 | 48 | I 59.4 II 78.52 |
| | Form Aesthetics | 10/100 | 80 | 80 | | 80 | 80 | | 40 | 40 | |
| | Attraction for pedestrians (South & West Sides) | 20/100 | 100 | 100 | | 100 | 100 | | 25 | 25 | |
| | Structure Challenges/ Difficulty of Modelling and Construction | 10/100 | 80 | 80 | | 80 | 80 | | 45 | 45 | |
| | Form Flexibility | 20/100 | 80 | 80 | | 80 | 80 | | 80 | 80 | |
| | Indoor Accessibility | 20/100 | 25 | 25 | | 25 | 25 | | 100 | 100 | |
| | **Total Scores:** | | | I 122.9 | II 129.8 | **Total Scores:** | | I 111.9 | II 124.3 | **Total Scores:** | I 104.9 | II 118.1 |

## Form Alternatives Analysis **Results**



## Selected Forms From Step 1

### Highlights and Features

High Comfortable hours
High Solar Radiation on Envelope
High Daylit Floor Area
Open and Semi-open Areas
Form Aesthetics
Form Flexibility

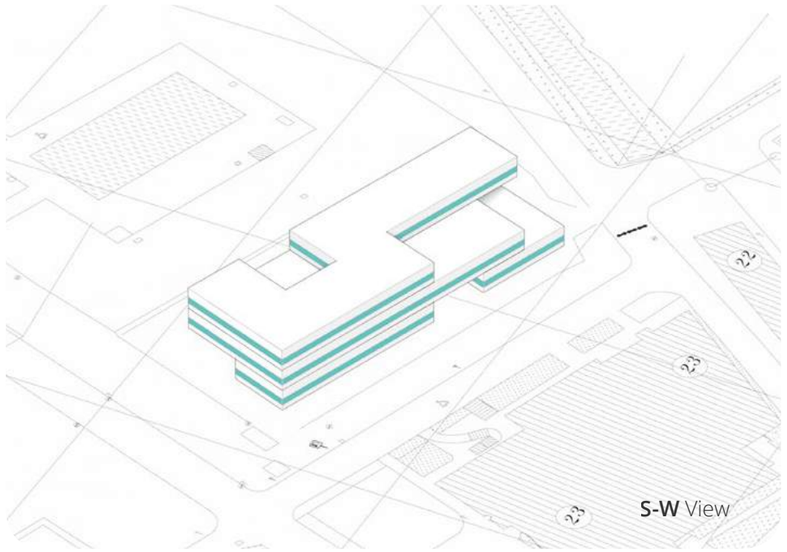
• Total Scores
**Weighting I** 125.4
**Weighting II** 149.9
• Final Ranking
**Weighting I** 1st
**Weighting II** 1st

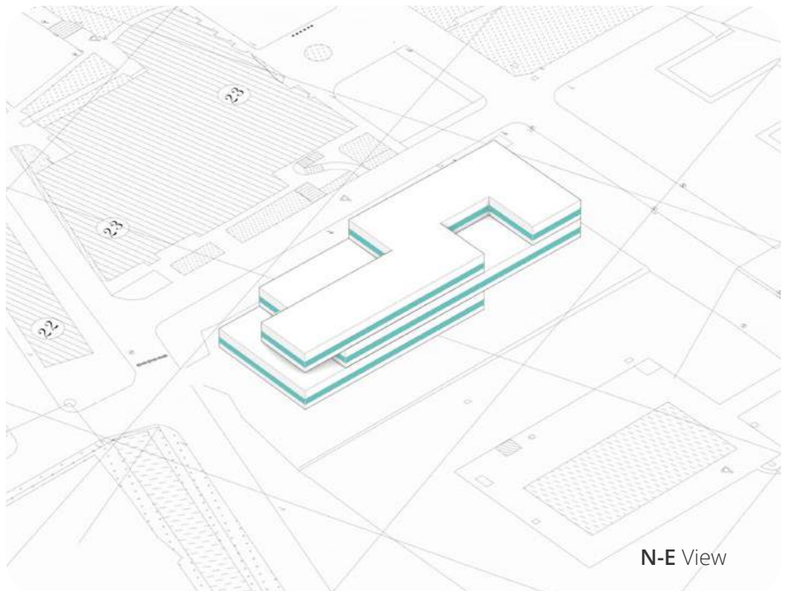
High Comfortable hours
High Solar Radiation on Envelope
Attraction for pedestrians
Open and Semi-open Areas
Form Aesthetics
Form Flexibility
Low Structure Challenges/ Difficulty of Modelling and Construction

• Total Scores
**Weighting I** 122.8
**Weighting II** 129.8
• Final Ranking
**Weighting I** 2nd
**Weighting II** 2nd

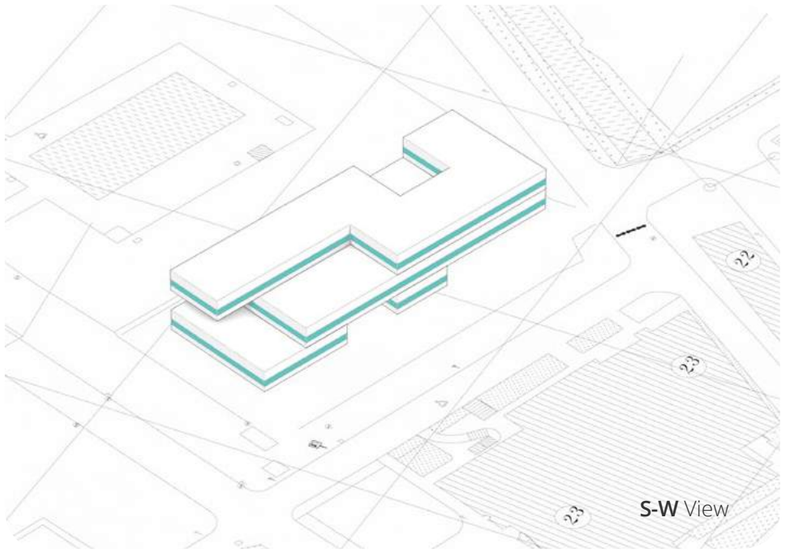
High Comfortable hours
High Solar Radiation on Envelope
Attraction for pedestrians
Open and Semi-open Areas
Form Aesthetics
Form Flexibility
Low Structure Challenges/ Difficulty of Modelling and Construction

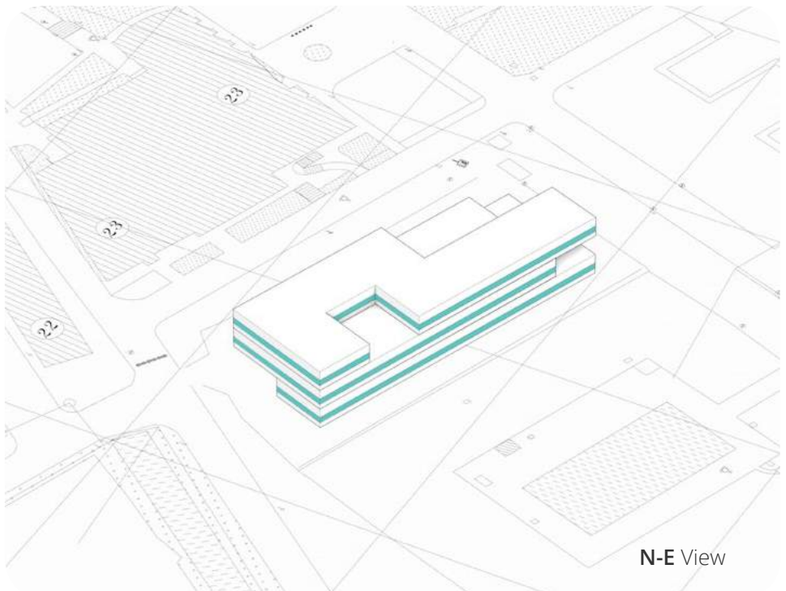
• Total Scores
**Weighting I** 111.9
**Weighting II** 124.3
• Final Ranking
**Weighting I** 3rd
**Weighting II** 3rd



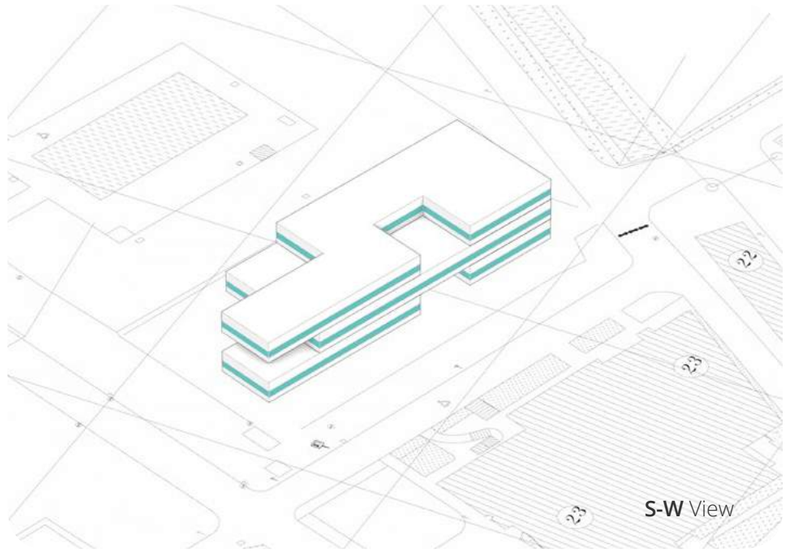



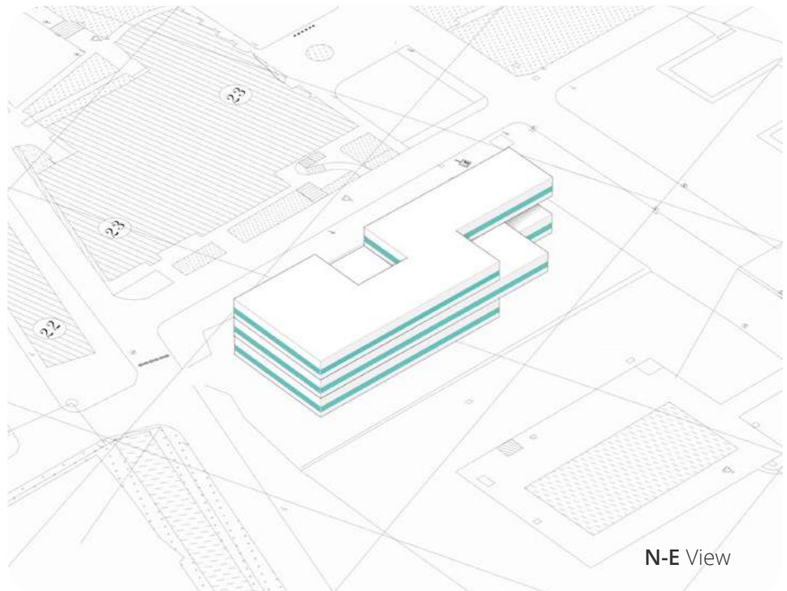

Code A.6 SVF 0.40 Floor Area 3090sqm




Code A.7 SVF 0.41 Floor Area 3090sqm



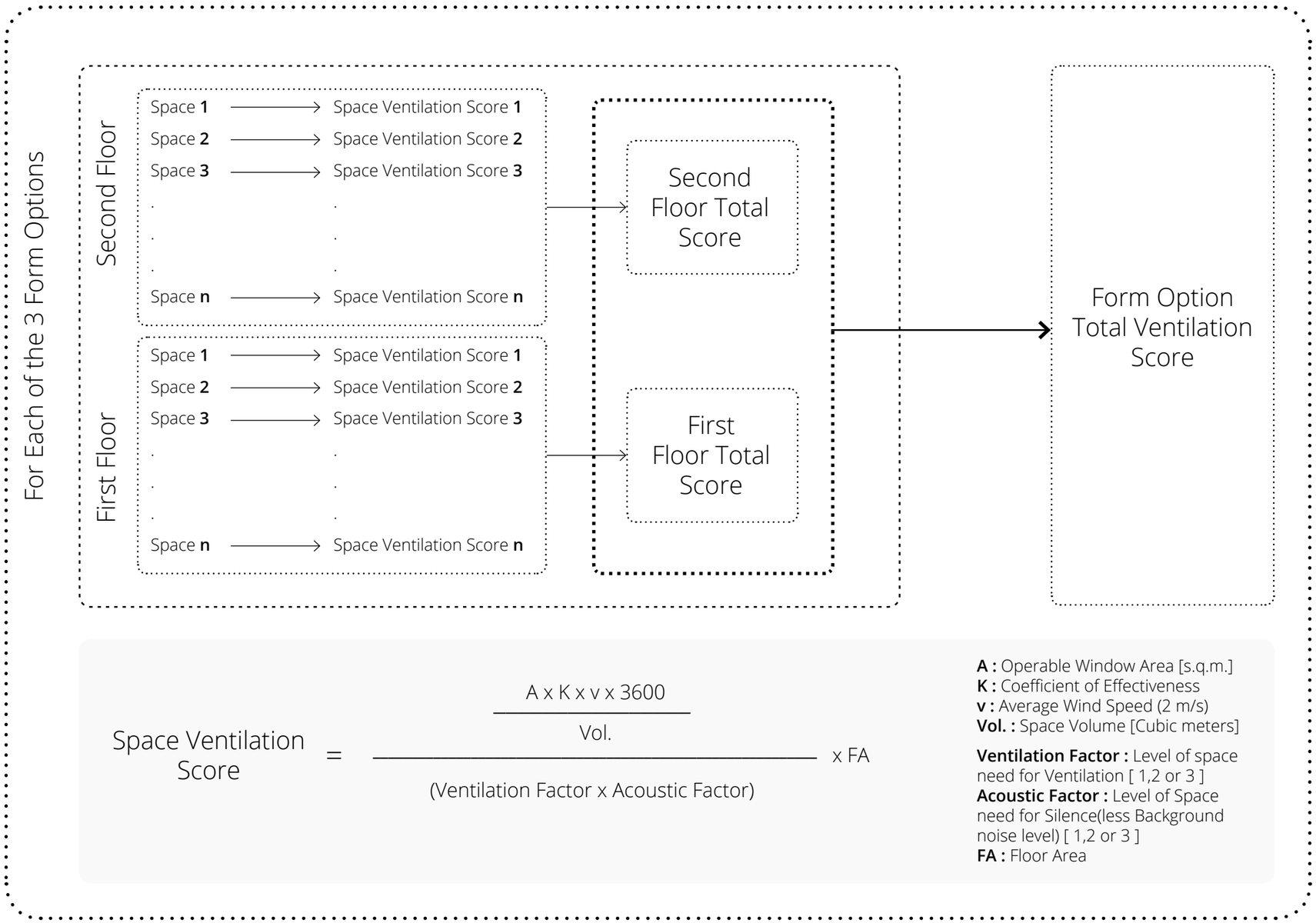

Code A.8 SVF 0.38 Floor Area 3124sqm

## Modelling Key Assumptions

| | | |
|---|---|---|
| **Ventilation** | • Scheduled Ventilation | Off |
| | • Natural Ventilation | On |
| | • Setpoint | 18 |
| | • Min Outdoor Temperature | 0 |
| | • Max Outdoor Temperature | 30 |
| | • Max Rel. Humidity | 90 |
| | • Infiltration | On |
| | • Infiltration ACH | 1.1 |
| | • Constant Term Coefficient | 1 |
| | • Temperature Term Coefficient | 0 |
| | • Velocity Term Coefficient | 0 |
| | • Velocity Squared Term Coefficient | 0 |
| **Constructions** | • Window U-Value [W/m²K] | 2.72 |
| | • Window Visible Transmittance | 0.813 |
| | • Window SHGF | 0.76 |
| | • Wall U-value [W/m²K] | 0.7(Default) |
| | • Floor U-value [W/m²K] | 0.7(Default) |
| | • Ceiling U-value [W/m²K] | 0.7(Default) |
| | • Roof U-value[W/m-2k] | 0.7(Default) |
| | • WWR[%] | 30 |
| **Loads** | • People | On |
| | • Schedule | 8 to 6 |
| | • density [p/m2] | 0.2 |
| | • Equipement | On |
| | • density [W/m2] | 6 |
| | • Lighting | On |
| | • density [W/m2] | 5 |
| **Conditioning** | • Heating | Off |
| | • Cooling | Off |
| | • Humidity Control | Off |
| | • Mechanical Ventilation | Off |
| **Analysis Grid** | • Spacing[m] | 1.0 |
| | • Height[m] | 0.76 |
| | • Offset from walls[m] | 0.6 |
| **Surfaces** | • Ceiling reflectance[%] | 70 |
| | • Wall reflectance[%] | 70 |
| | • Window Transmittance[%] | 80 |
| | • Floor reflectance[%] | 30 |
| | • Ground reflectance[%] | 20 |
| | • Tree Transmittance[%] | 19 |

# Form Analysis(Step 2)

## **Ventilation Analysis** Process



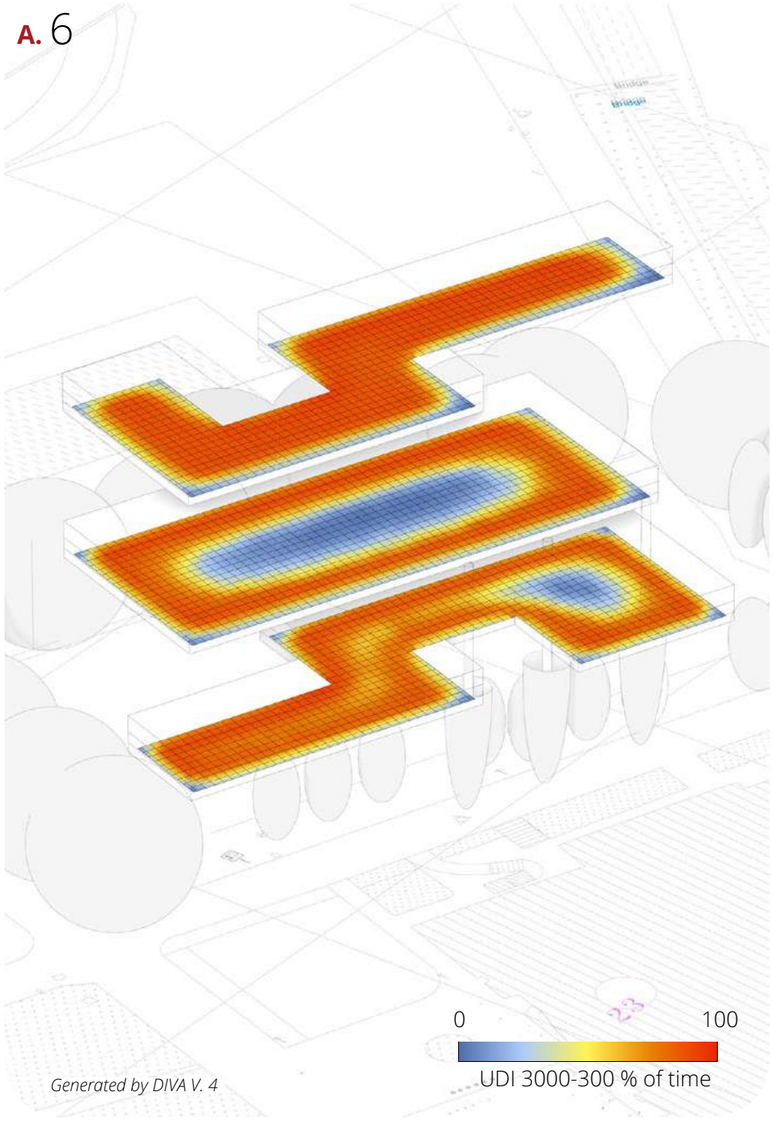

$$\text{Space Ventilation Score} = \frac{\frac{A \times K \times v \times 3600}{Vol.}}{(\text{Ventilation Factor} \times \text{Acoustic Factor})} \times FA$$

**A :** Operable Window Area [s.q.m.]
**K :** Coefficient of Effectiveness
**v :** Average Wind Speed (2 m/s)
**Vol. :** Space Volume [Cubic meters]

**Ventilation Factor :** Level of space need for Ventilation [ 1,2 or 3 ]
**Acoustic Factor :** Level of Space need for Silence(less Background noise level) [ 1,2 or 3 ]
**FA :** Floor Area

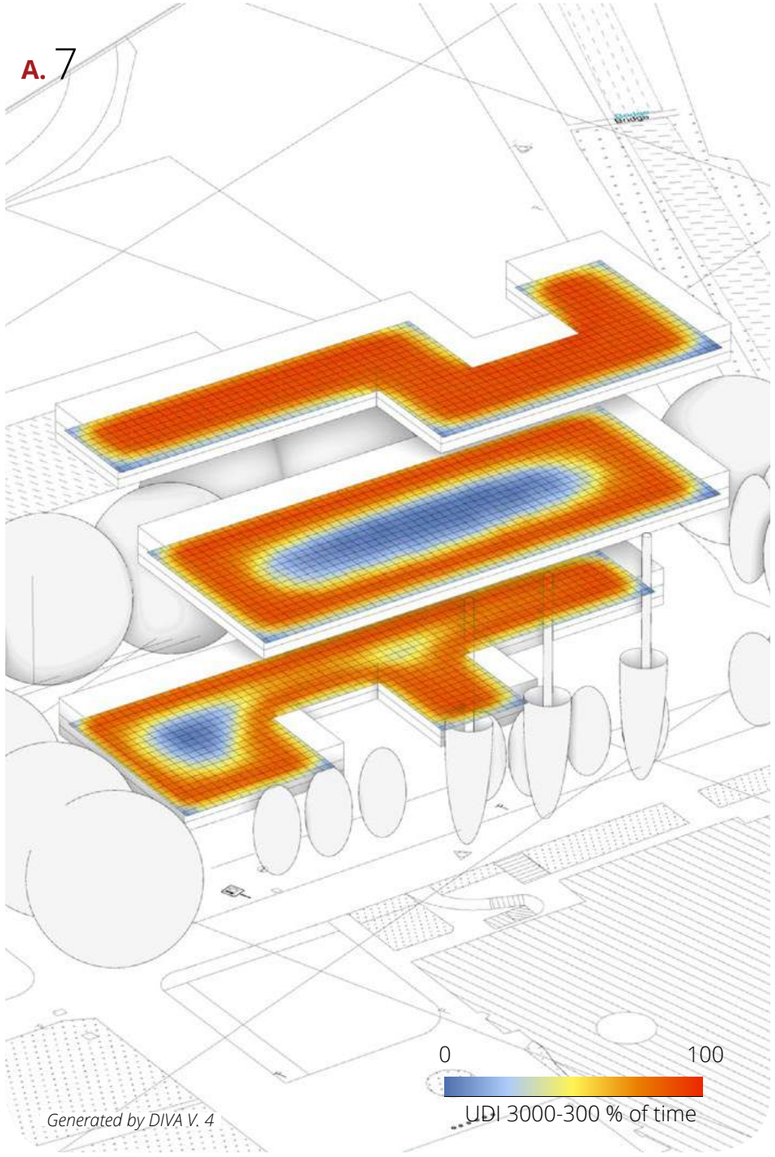
## Form Analysis(Step 2)

**A.** 6



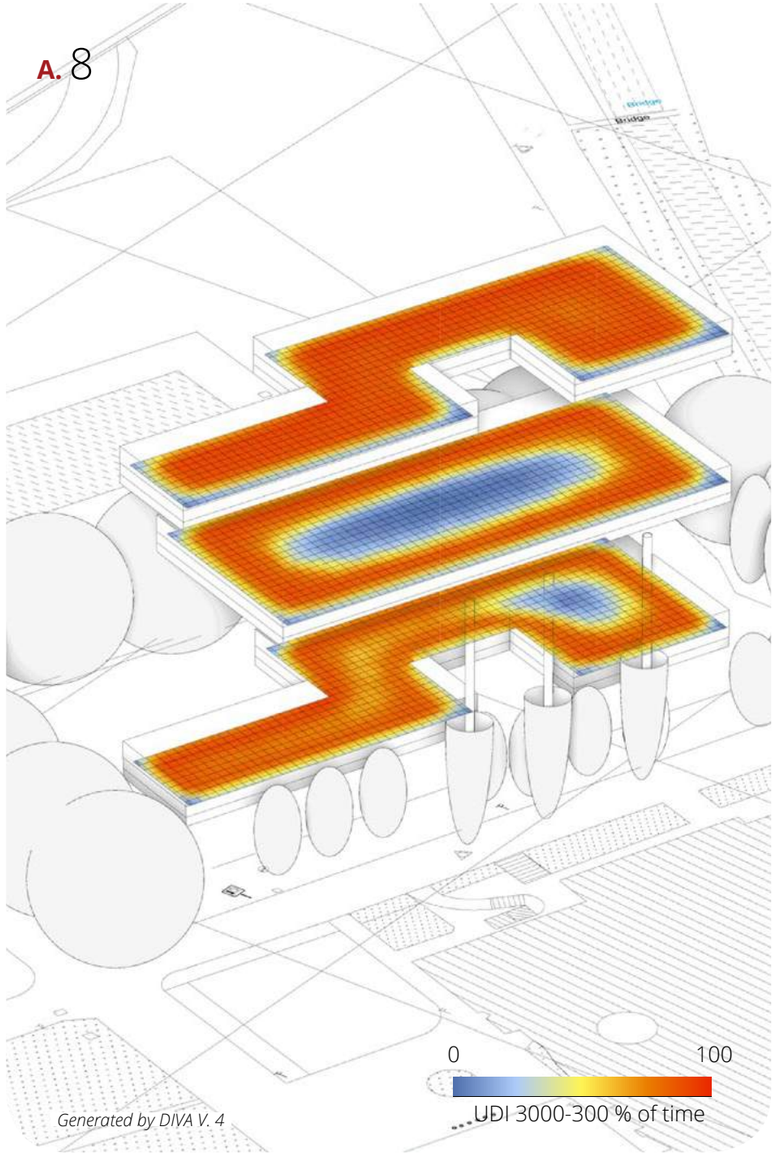

| UDI % of Area more than %50 of times Between 3000-300 | |
|---|---|
| Second Floor | **76.9** |
| First Floor | **60.03** |
| Ground Floor | **78.52** |

**A.** 7



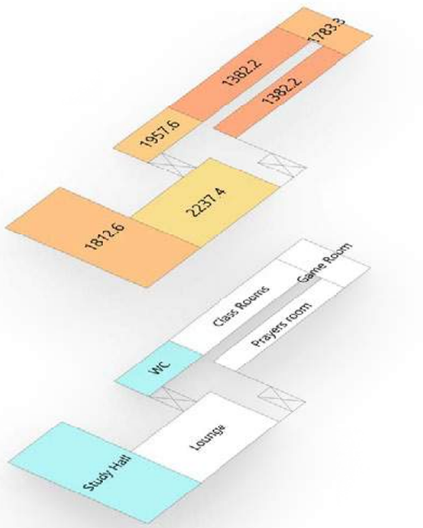

| UDI % of Area more than %50 of times Between 3000-300 | |
|---|---|
| Second Floor | **74.3** |
| First Floor | **59.8** |
| Ground Floor | **77.58** |

**A.** 8




| UDI % of Area more than %50 of times Between 3000-300 | |
|---|---|
| Second Floor | **75.8** |
| First Floor | **61.02** |
| Ground Floor | **74.7** |

## Ventilation Analysis




*Generated by Grasshopper Code*

Alter 6

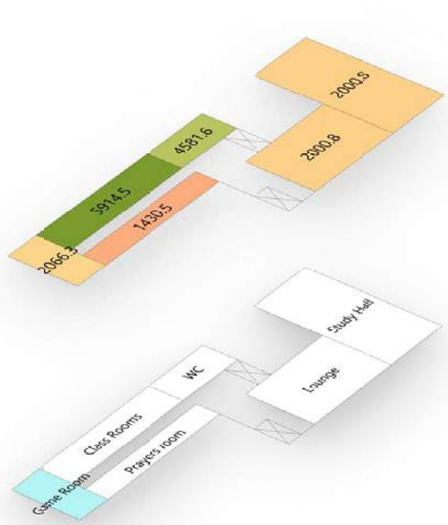
Total Score

**33745.9**

2nd Floor

Score

**21665.6**




*Generated by Grasshopper Code*

Alter 7

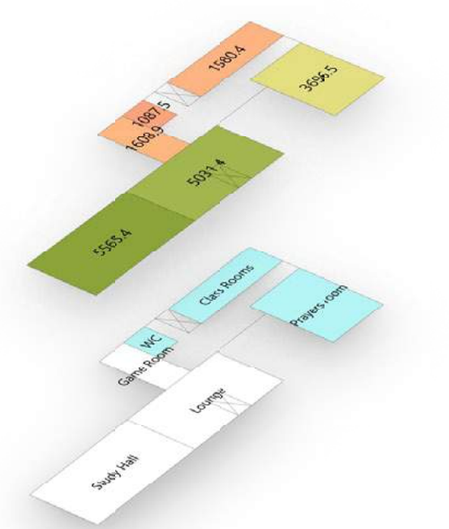
Total Score

**34791.7**

2nd Floor

Score

**23448.5**




*Generated by Grasshopper Code*

Alter 8

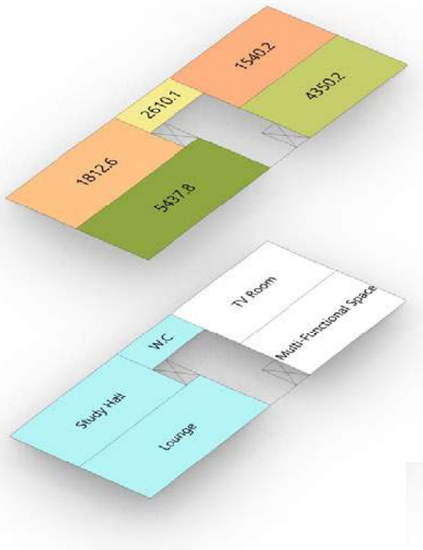
Total Score

**27313.2**

2nd Floor

Score

**18570.4**

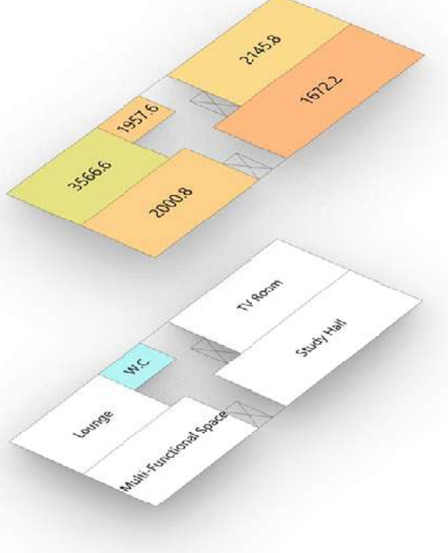



*Generated by Grasshopper Code*

1st Floor

Score

**12080.2**

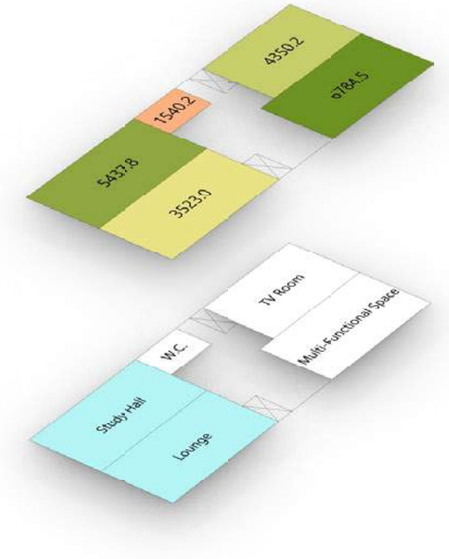



*Generated by Grasshopper Code*

1st Floor

Score

**11343.1**




*Generated by Grasshopper Code*

1st Floor

Score

**8742.8**

1060 6800 Final Score

3 2 Ventilation Need level

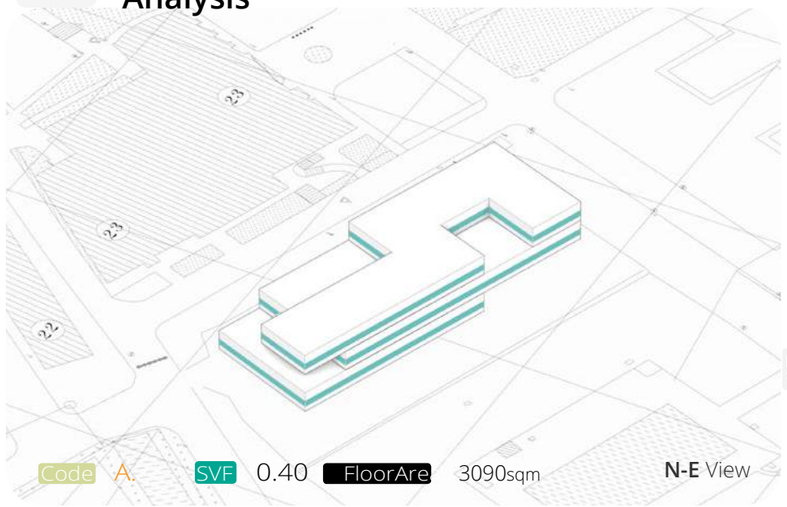
1060 6800 Final Score

3 2 Ventilation Need level

1060 6800 Final Score

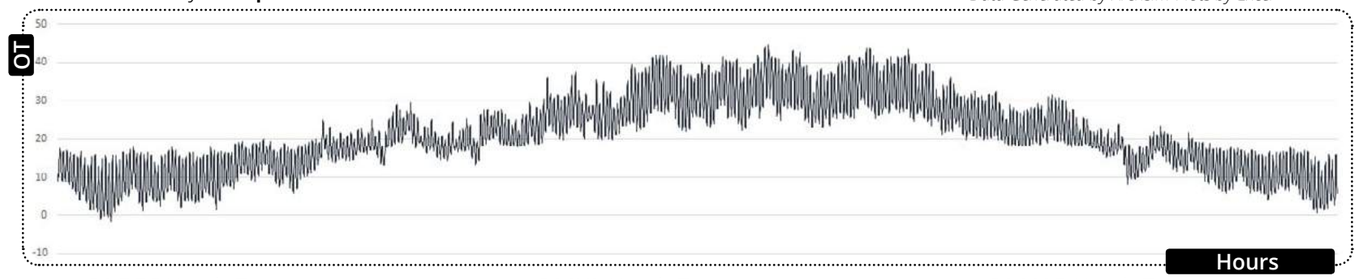
3 2 Ventilation Need level

# Thermal Comfort Analysis

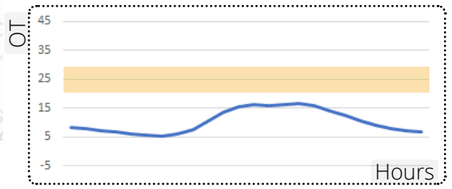



Annual Hourly **Temperatures**

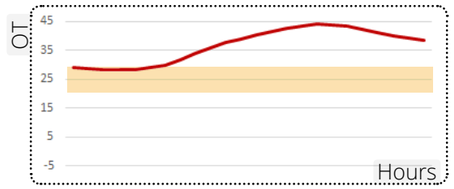
*Data Generated by Archsim-Plots by Excel*



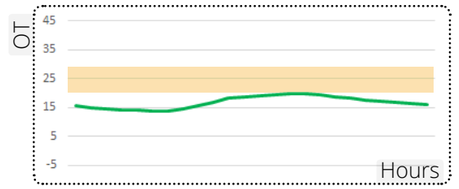

**21 DEC** Hourly Temperatures




**21 JUL** Hourly Temperatures




**21 MAR** Hourly Temperatures

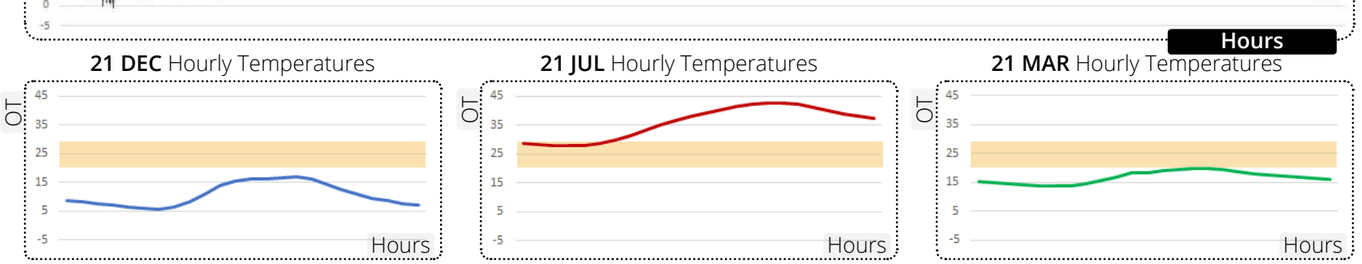



Maximum **OT**
44.7
Minimum **OT**
-1.6
Average **OT**
20.8
Total **Air change rate**[ACH]
7.23
**Overheat** % of times
23.42
**Underheat** % of times
54.38
**Comfortable** % of times
22.21




Annual Hourly **Temperatures**

*Data Generated by Archsim-Plots by Excel*




**21 DEC** Hourly Temperatures




**21 JUL** Hourly Temperatures




**21 MAR** Hourly Temperatures

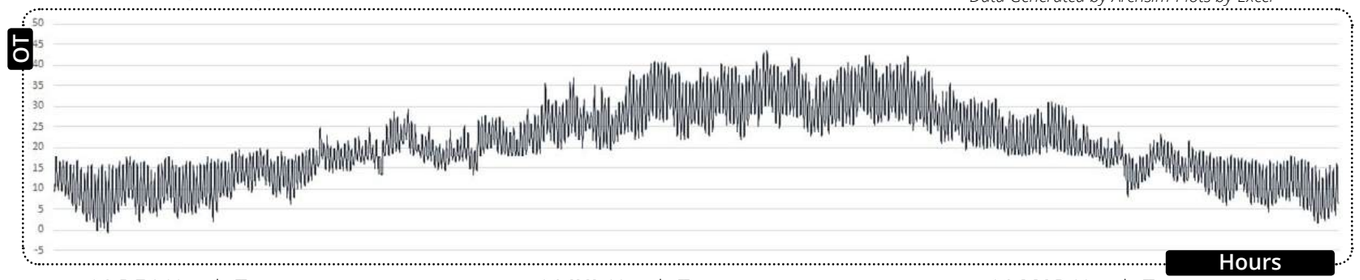



Maximum **OT**
43.3
Minimum **OT**
-0.7
Average **OT**
20.7
Total **Air change rate**[ACH]
6.69
**Overheat** % of times
22.50
**Underheat**% of times
54.86
**Comfortable** % of times
22.56

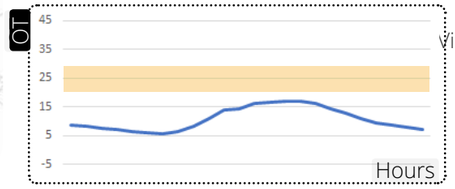



Annual Hourly **Temperatures**

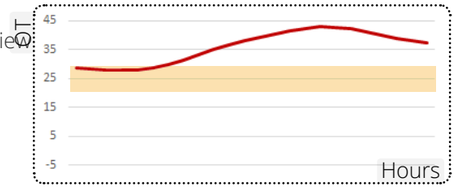
*Data Generated by Archsim-Plots by Excel*



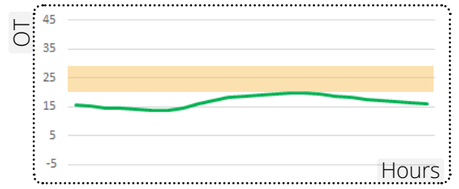

**21 DEC** Hourly Temperatures




**21 JUL** Hourly Temperatures

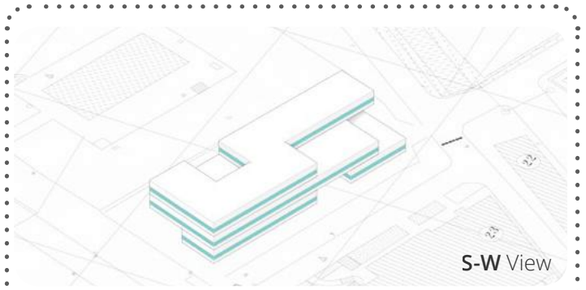


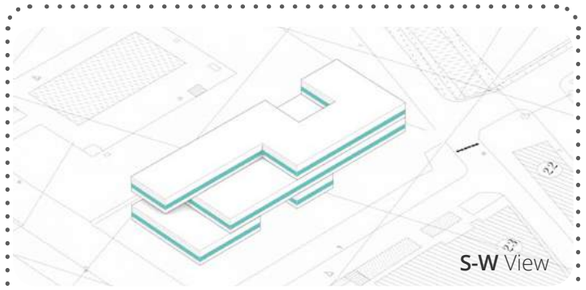

**21 MAR** Hourly Temperatures

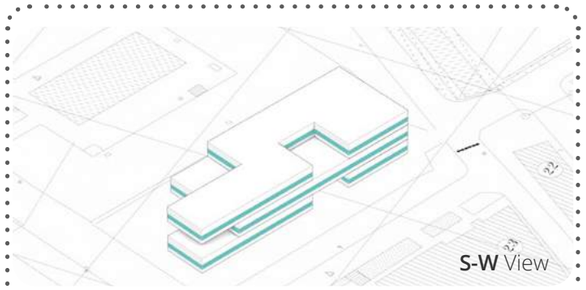



Maximum **OT**
43.3
Minimum **OT**
-0.7
Average **OT**
20.7
Total **Air change rate**[ACH]
6.67
**Overheat** % of times
22.62
**Underheat**% of times
54.73
**Comfortable**% of times
22.66

## Final Results




| | Key Parameters | Detailed Weightings | Values/ Raw Scores | Scores (Unweighted) | Overall Weighted Scores | Values/ Raw Scores | Scores (Unweighted) | Overall Weighted Scores | Values/ Raw Scores | Scores (Unweighted) | Overall Weighted Scores |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ventilation Potential | Ventilation Score(Rules of Thumb) | 80/100 | 33746 | 88.8 | x 3/13 | 34791 | 80.4 | x 3/13 | 27313 | 0.0 | x 3/13 |
| | Average Annual ACR(Simulated[ACH]) | 20/100 | 7.23 | | | 6.69 | | | 6.68 | | |
| Loads/Energy | Zone Ideal Loads Total Heating Energy | 80/100 | 2.85E+13 | 0.0 | x 2/13 | 2.85E+13 | 51.5 | x 2/13 | 2.83E+13 | 89.4 | x 2/13 |
| | Zone Ideal Loads Total Cooling Energy | 20/100 | 8.05E+11 | | | 7.35E+11 | | | 7.50E+11 | | |
| Thermal Autonomy | Overheat hours [% of times] | 10/100 | 23.4 | 10 | x 2/13 | 22.5 | 89.0 | x 2/13 | 22.6 | 83.2 | x 2/13 |
| | Underheat hours [% of times] | 30/100 | 54.3 | | | 54.8 | | | 54.7 | | |
| | Comfortable hours [% of times] | 60/100 | 22.2 | | | 22.6 | | | 22.7 | | |
| Daylighting | Daylit Area(5>DF>2) | 80/100 | 71.5 | 78.3 | x 3/13 | 68.3 | 20.0 | x 3/13 | 72.5 | 80.0 | x 3/13 |
| | Underlit Area(DF<2) | | 11.6 | | | 16.1 | | | 12.0 | | |
| | Overlit Area (DF>5) | 20/100 | 36.7 | | | 36.9 | | | 34.5 | | |
| Functional & Aesthetical | Semi-Open Space Area[sqm] | 20/100 | 608 | 63.9 | x 3/13 | 608 | 77.0 | x 3/13 | 558 | 57.0 | x 3/13 |
| | Form Aesthetics | 10/100 | 80 | | | 80 | | | 40 | | |
| | Attraction for pedestrians (South & West Sides) | 20/100 | 100 | | | 100 | | | 25 | | |
| | Structure Challenges/ Difficulty of Modelling and Construction | 10/100 | 80 | | | 80 | | | 45 | | |
| | Form Flexibility | 20/100 | 80 | | | 80 | | | 80 | | |
| | Indoor Accessibility | 20/100 | 25 | | | 25 | | | 100 | | |



## Plans

## **Basement Floor** Plan










KEY

| | |
|---|---|
| 1 | Entrance |
| 2 | Information |
| 3 | Conference Hall |
| 4 | W.C. |
| 5 | Kitchen |
| 6 | Food Stall |
| 7 | Shop |
| 8 | FoudCourt Sitting Area |
| 9 | Fire Control Room |
| 10 | Electrical/ Systems Control |
| 11 | Facility Room |
| 12 | Facility Access/Parking |
| 13 | Gallery |
| 14 | Gallery-Storage |
| 15 | Multi-Functional Space |
| 16 | TV Room |
| 17 | Lounge |
| 18 | Study Hall (Individual) |
| 19 | Study Hall (Group) |
| 20 | Game Room |
| 21 | Class Room |
| 22 | Prayers Room |
| 23 | Management |
| 24 | Administration |
| 25 | Conference Room |
| 26 | Student Association |
| 27 | Book Cafe |

## **Ground Floor** Plan




KEY

| | |
|---|---|
| 1 | Entrance |
| 2 | Information |
| 3 | Conference Hall |
| 4 | W.C. |
| 5 | Kitchen |
| 6 | Food Stall |
| 7 | Shop |
| 8 | FoudCourt Sitting Area |
| 9 | Fire Control Room |
| 10 | Electrical/ Systems Control |
| 11 | Facility Room |
| 12 | Facility Access/Parking |
| 13 | Gallery |
| 14 | Gallery-Storage |
| 15 | Multi-Functional Space |
| 16 | TV Room |
| 17 | Lounge |
| 18 | Study Hall (Individual) |
| 19 | Study Hall (Group) |
| 20 | Game Room |
| 21 | Class Room |
| 22 | Prayers Room |
| 23 | Management |
| 24 | Administration |
| 25 | Conference Room |
| 26 | Student Association |
| 27 | Book Cafe |

## **First Floor** Plan




KEY

1 Entrance
2 Information
3 Conference Hall
4 W.C.
5 Kitchen
6 Food Stall
7 Shop
8 FoudCourt Sitting Area
9 Fire Control Room
10 Electrical/ Systems Control
11 Facility Room
12 Facility Access/Parking
13 Gallery
14 Gallery-Storage
15 Multi-Functional Space
16 TV Room
17 Lounge
18 Study Hall (Individual)
19 Study Hall (Group)
20 Game Room
21 Class Room
22 Prayers Room
23 Management
24 Administration
25 Conference Room
26 Student Association
27 Book Cafe

## **Second Floor** Plan



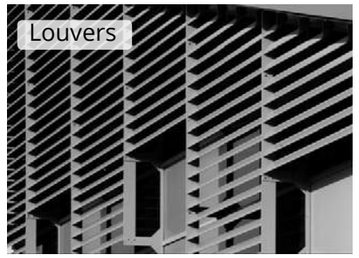

KEY

1 Entrance
2 Information
3 Conference Hall
4 W.C.
5 Kitchen
6 Food Stall
7 Shop
8 FoudCourt Sitting Area
9 Fire Control Room
10 Electrical/ Systems Control
11 Facility Room
12 Facility Access/Parking
13 Gallery
14 Gallery-Storage
15 Multi-Functional Space
16 TV Room
17 Lounge
18 Study Hall (Individual)
19 Study Hall (Group)
20 Game Room
21 Class Room
22 Prayers Room
23 Management
24 Administration
25 Conference Room
26 Student Association
27 Book Cafe

## Facade Design

### Suitable Options



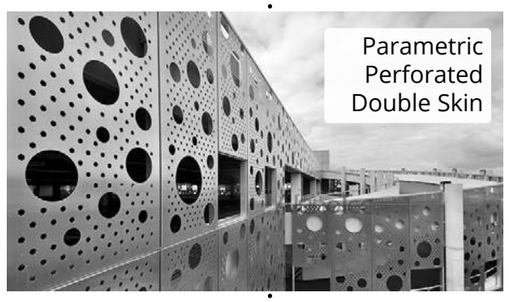








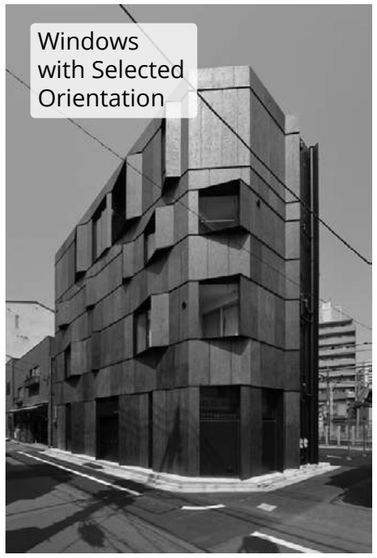


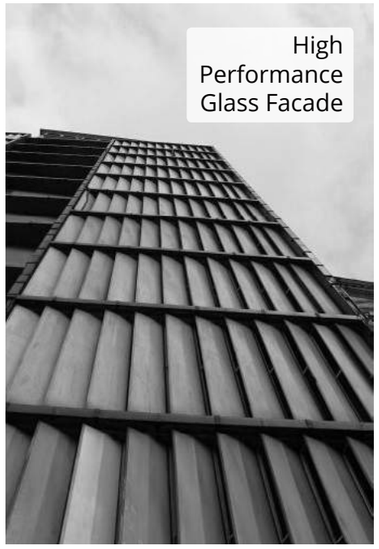








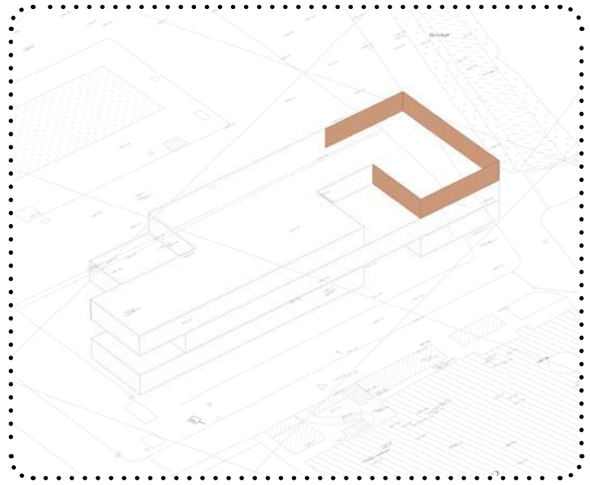



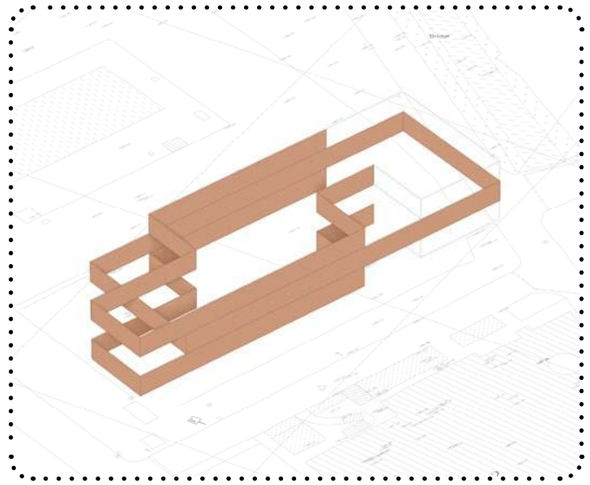



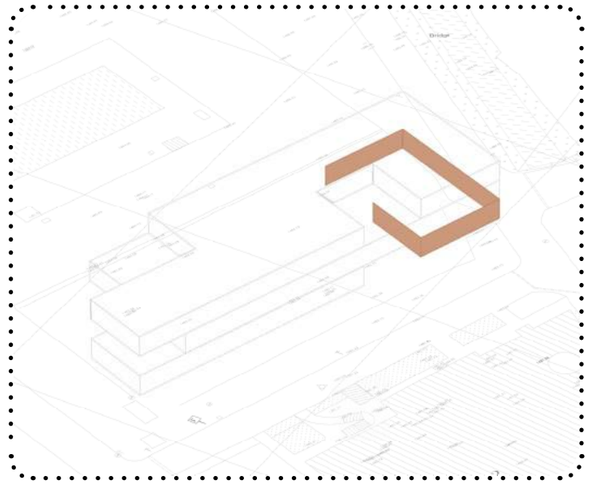

### Spaces

- Administration
  Management
  Classrooms
- Lounges
  FoodCourt
  Prayers Rooms
  Conference Room
  Study Spaces
  Game Room
  Multi-Functional
  Space
- Conference Hall

### Spottings







- **Type 1** Educational and Administration
- **Type 2** Public Spaces
- **Type 3** Solid

## Modelling Key Assumptions- **Step1**

| | | |
|---|---|---|
| **Ventilation** | • Scheduled Ventilation | Off |
| | • Natural Ventilation | On |
| | • Setpoint | 18 |
| | • Min Outdoor Temperature | 0 |
| | • Max Outdoor Temperature | 30 |
| | • Max Rel. Humidity | 90 |
| | • Infiltration | On |
| | • Infiltration ACH | 1.1 |
| | • Constant Term Coefficient | 1 |
| | • Temperature Term Coefficient | 0 |
| | • Velocity Term Coefficient | 0 |
| | • Velocity Squared Term Coefficient | 0 |
| **Constructions** | • Window U-Value [W/m²K] | 2.72 |
| | • Window Visible Transmittance | 0.813 |
| | • Window SHGF | 0.76 |
| | • Wall U-value [W/m²K] | 0.7(Default) |
| | • Floor U-value [W/m²K] | 0.7(Default) |
| | • Ceiling U-value [W/m²K] | 0.7(Default) |
| | • Roof U-value[W/m-2k] | 0.7(Default) |
| | • WWR[%] | 30 |
| **Loads** | • People | On |
| | • Schedule | 8 to 6 |
| | • density [p/m2] | 0.2 |
| | • Equipement | On |
| | • density [W/m2] | 6 |
| | • Lighting | On |
| | • density [W/m2] | 5 |
| **Conditioning** | • Heating | Off |
| | • Cooling | Off |
| | • Humidity Control | Off |
| | • Mechanical Ventilation | Off |
| **Analysis Grid** | • Spacing[m] | 1.0 |
| | • Height[m] | 0.76 |
| | • Offset from walls[m] | 0.6 |
| **Surfaces** | • Ceiling reflectance[%] | 70 |
| | • Wall reflectance[%] | 70 |
| | • Window Transmittance[%] | 80 |
| | • Floor reflectance[%] | 30 |
| | • Ground reflectance[%] | 20 |
| **Glare Analysis** | • Sky | Clear Sky with sun |
| | • Time | July 21st, 12:01 P.M. |
| | • Quality | Lowest |
| | • Tree Transmittance[%] | 19 |

## Modelling Key Assumptions- **Step2**

| | |
|---|---|
| **Thermal** | Infiltration Constant Rate(Scheduled method): 1 ACH<br>Infiltration Crack Template: Medium |
| HVAC | Heating: Off<br>Cooling: Off<br>Mechanical Ventilation: Off<br>Natural Ventilation: On<br>Natural Ventilation Method: Calculated<br>Occupancy densityp[people/s.q.m.]: 0.5 |
| **Constructions** | WWR-South: %60 ,%30<br>WWR-North: %50 ,%30<br>WWR-East/West: %25<br>Wndows U-value[W/m-2K]: 1.96<br>WndowsSHGC[%]: 0.691<br>WndowsDirect Solar Transmission[%]: 0.624<br>Wndows Light Transmission[%]: 65<br>External Walls U-Value[W/m-2K]: 0.95<br>Roofs U-Value[W/m-2K]: 0.5 |
| **Analysis Grid** | • Spacing[m] 1.0<br>• Height[m] 0.76<br>• Offset from walls[m] 0.6 |
| **Surfaces** | • Ceiling reflectance[%] 70<br>• Wall reflectance[%] 70<br>• Window Transmittance[%] 80<br>• Floor reflectance[%] 30<br>• Ground reflectance[%] 20 |

## Facade Design

Step 1

Step 2

F.01 F.02 F.03 F.04 F.05

### Decision-making Process

| | | | | |
|---|---|---|---|---|
| Comfort Hours in hot and cold weeks | Underlit, Overlit and daylit percentage of floor area | DGP Index in two critical angles- third floor - one day in july, 1 p.m. | Cost, Aesthetics, Improvement Potential | Average Window height |
| **Thermal Comfort** | **Daylight Analysis** | **Glare Analysis** | **Functional & Aesthetical** | **Ventilation Potential** |

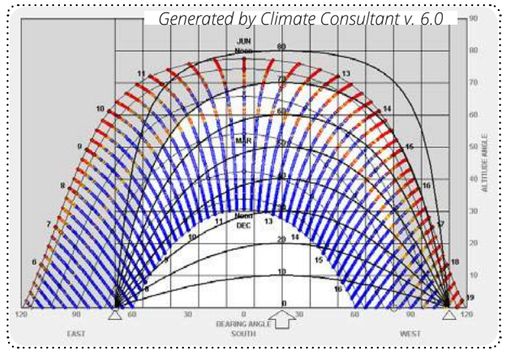
Package 1 Package 2 Package 3

| | | | | |
|---|---|---|---|---|
| Annual Comfortable hours in occupancy times | Underlit, Overlit and daylit percentage of floor area | 2nd Floor Percentage of Area Over %15 of times in direct Sunlight | Cost, Aesthetics | → **Final Package** |
| **Thermal Comfort** | **Daylight Analysis** | **Glare Analysis** | **Functional & Aesthetical** | |

## Simple Shading calculations

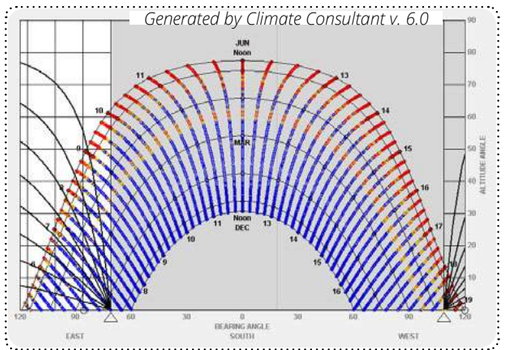
### Southern Facade

VSA 70 °
HSA(L) 0 °
HSA(R) 30 °



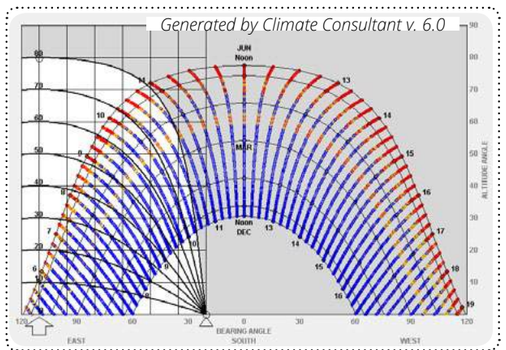

### Norththern Facade

VSA 90 °
HSA(L) 10 °
HSA(R) 0 °



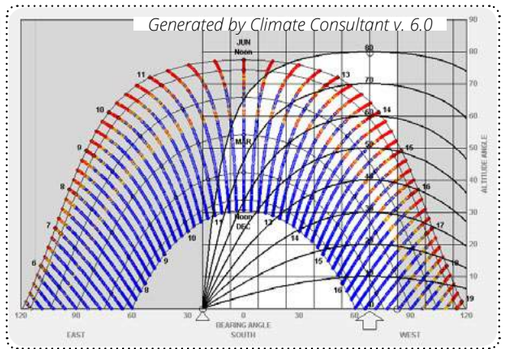

### Eastern Facade

VSA 80 °
HSA(L) 0 °
HSA(R) 0 °




### Western Facade

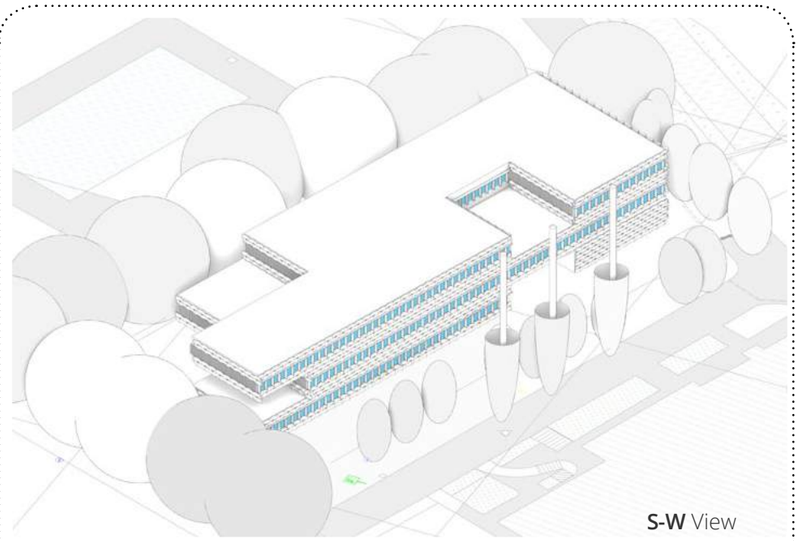
VSA 80 °
HSA(L) 0 °
HSA(R) 75 °



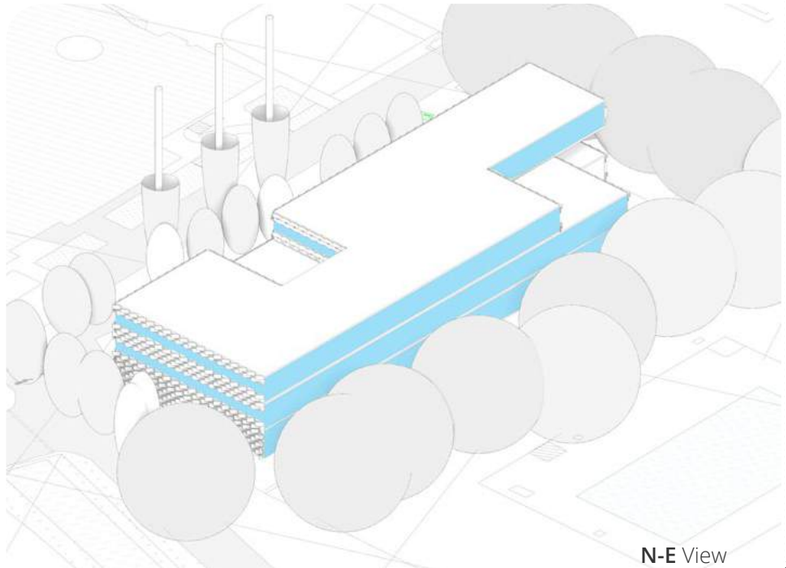
## Facade Alternatives

- Horizontal and Vertical Shadings
- Double pane Windows with %65 Transmittance
- shadings for solid Surfaces
- Window to Wall Ratio of %40

Code **F.1**



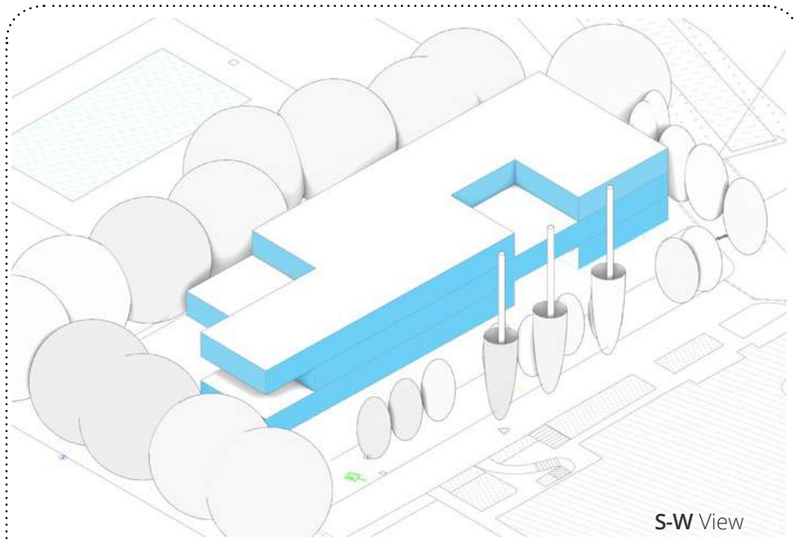
**S-W** View



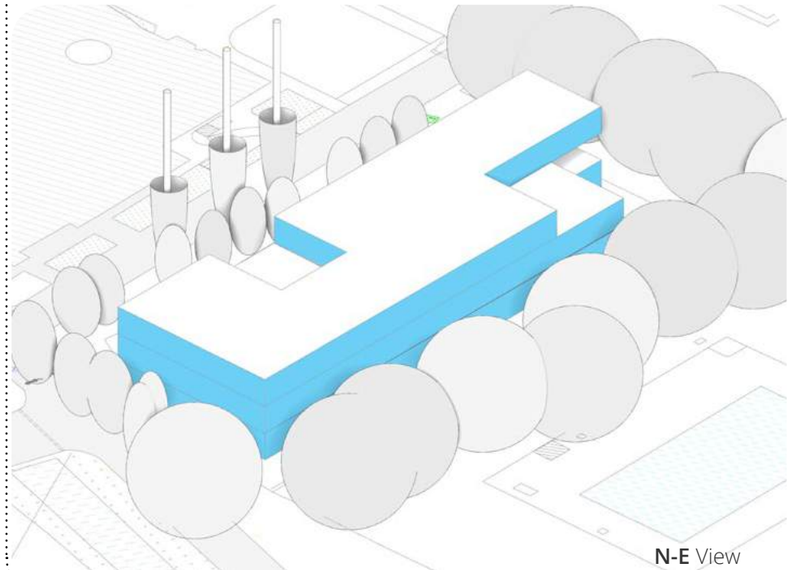
**N-E** View

- No Shadings
- High performance Windows in South, East and West Facades With %47 Transmittance
- Double pane Windows in northern side With %65 transmittance
- Window to Wall Ratio of %90

Code **F.2**



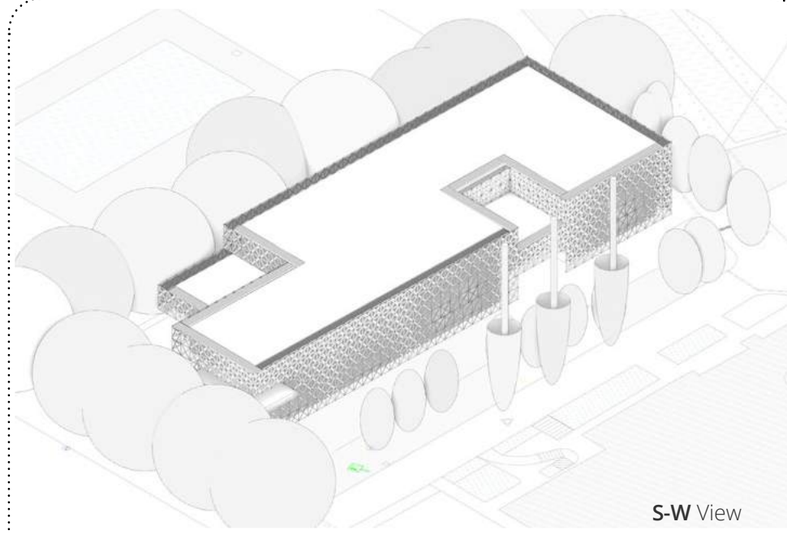
**S-W** View



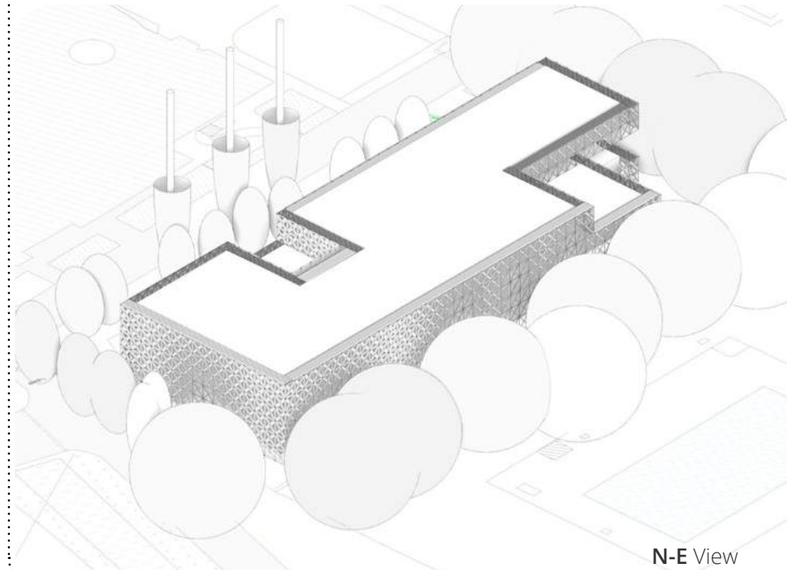
**N-E** View

- Parametric Shading (South, East, West, North)
- Double pane Windows With %65 transmittance
- Window to Wall Ratio of %90

Code **F.3**



**S-W** View

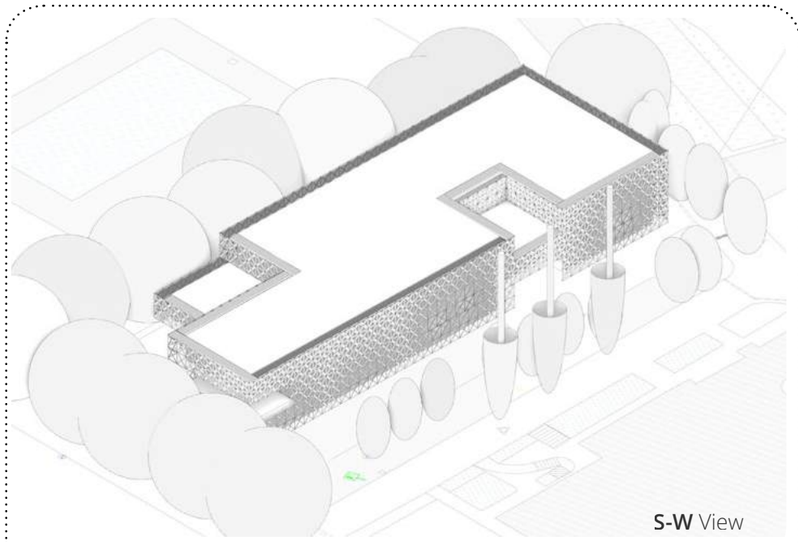


**N-E** View

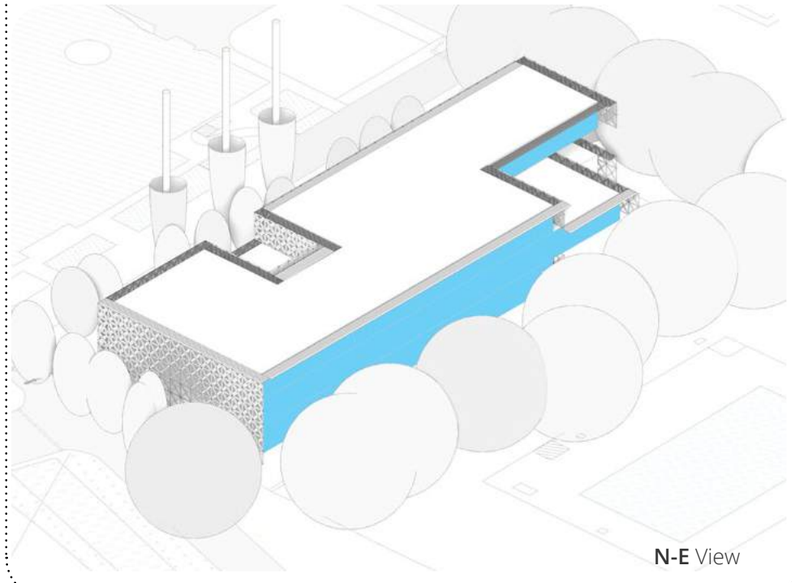
## Facade Alternatives

- Parametric Shading (South, East, West)
- No Shading (North)
- Double pane Windows With %65 transmittance
- Window to Wall Ratio of %90

Code **F.5**



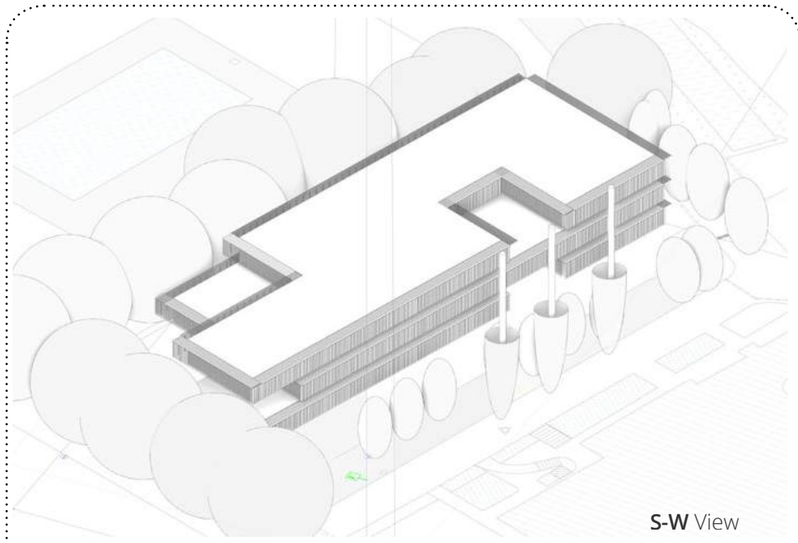
**S-W** View



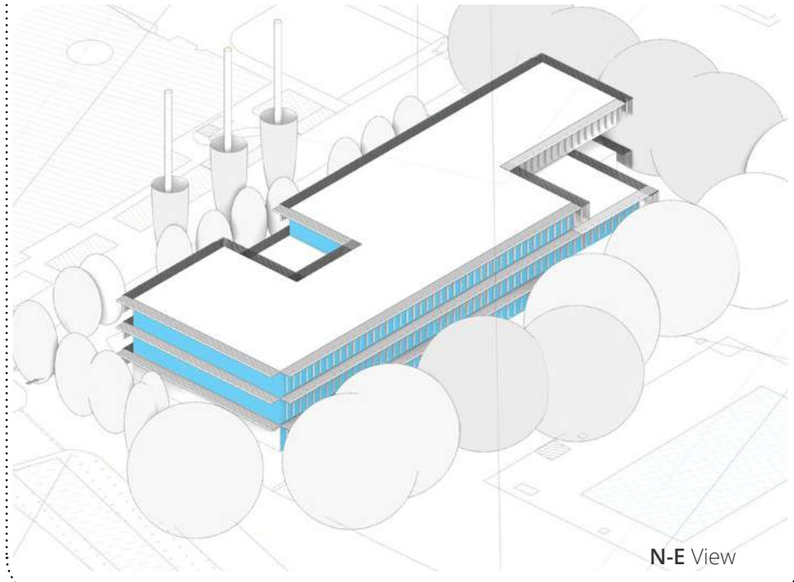
**N-E** View

- Horizontal and Vertical Louvers (South, East, West)
- No Shading (North)
- Double pane Windows With %65 transmittance
- Window to Wall Ratio of %90

Code **F.6**



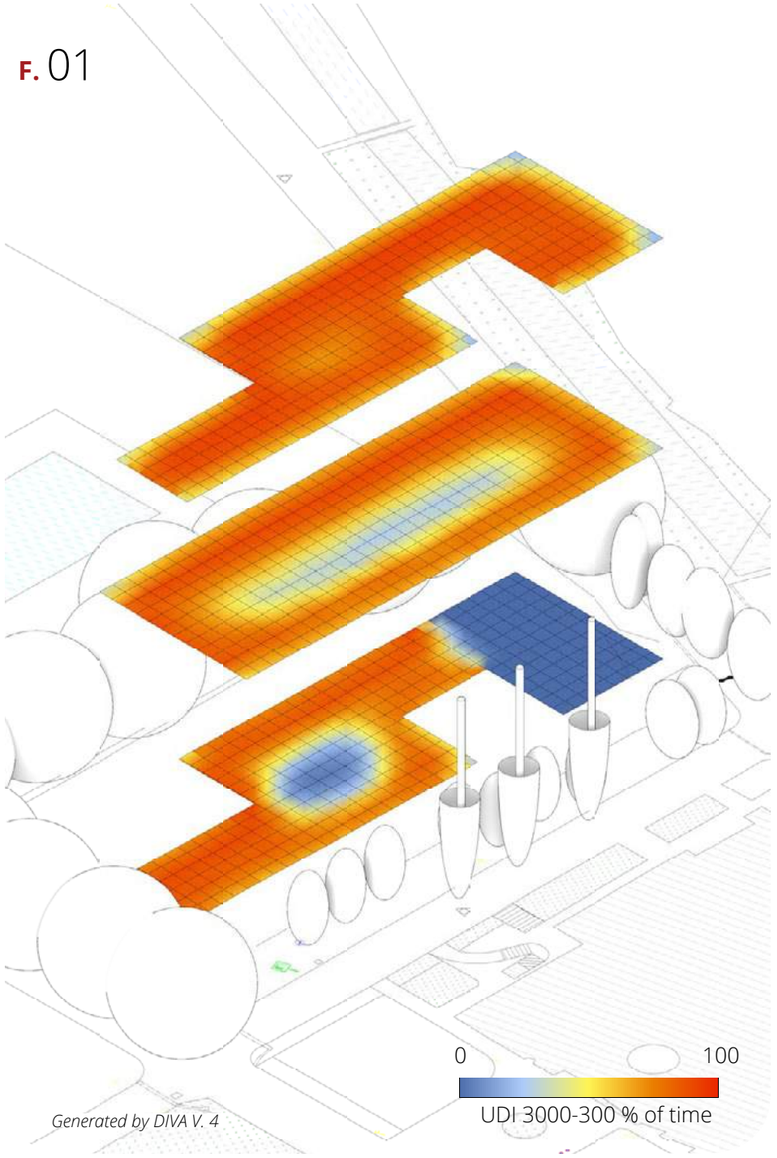
**S-W** View



**N-E** View

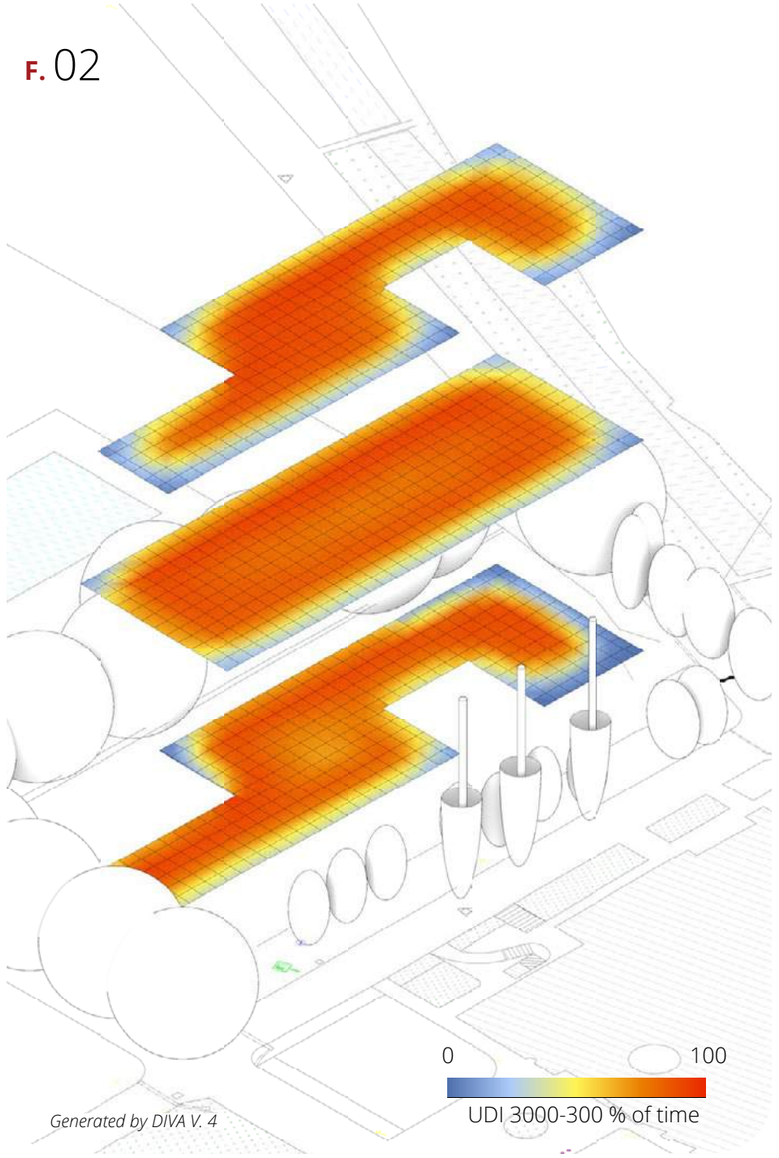
## Daylight Analysis

**F.** 01



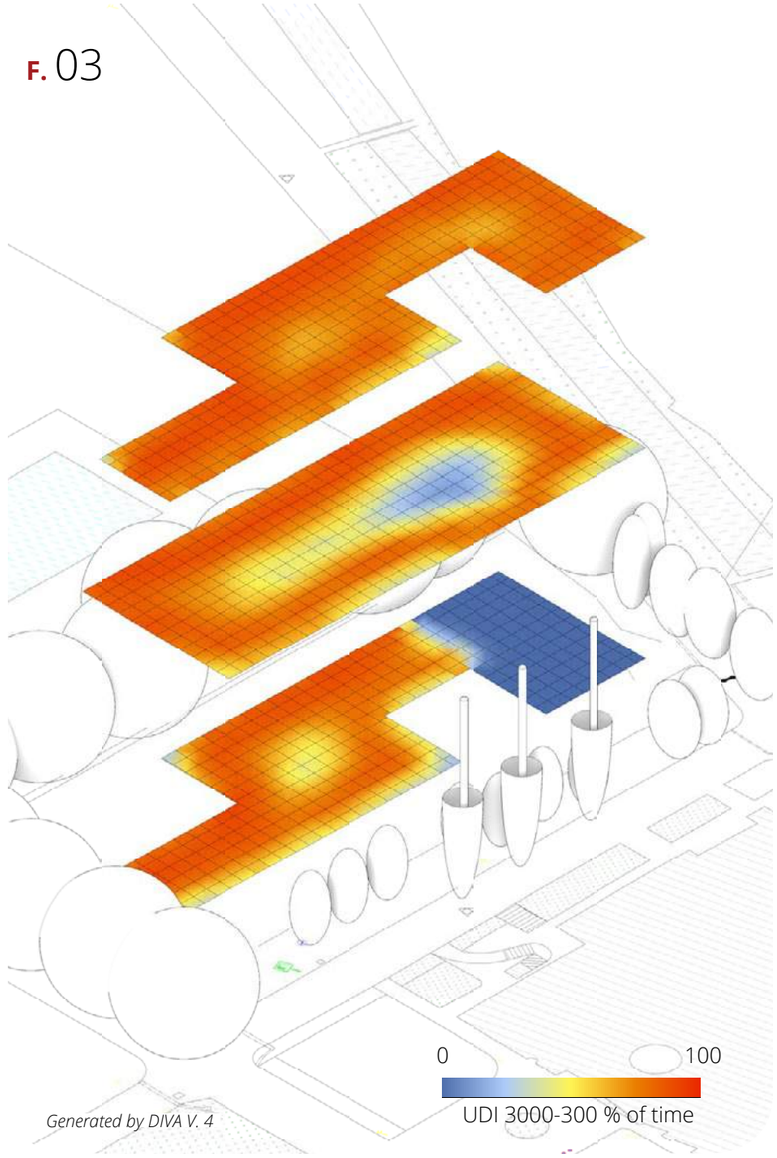

| UDI % of Area more than %50 of times Between 3000-300 | |
|---|---|
| Second Floor | **76.57** |
| First Floor | **83.24** |
| Ground Floor | **87** |

**F.** 02




| UDI % of Area more than %50 of times Between 3000-300 | |
|---|---|
| Second Floor | **81** |
| First Floor | **86** |
| Ground Floor | **79** |

**F.** 03




| UDI % of Area more than %50 of times Between 3000-300 | |
|---|---|
| Second Floor | **78** |
| First Floor | **82** |
| Ground Floor | **89** |

## Daylight Analysis

**F.** 01

UDI % of Area more than %50 of times Between 3000-300

| | |
|---|---|
| Second Floor | **76.57** |
| First Floor | **83.24** |
| Ground Floor | **87** |

**F.** 02

UDI % of Area more than %50 of times Between 3000-300

| | |
|---|---|
| Second Floor | **81** |
| First Floor | **86** |
| Ground Floor | **79** |

**F.** 03

UDI % of Area more than %50 of times Between 3000-300

| | |
|---|---|
| Second Floor | **78** |
| First Floor | **82** |
| Ground Floor | **89** |

**F.** 04

UDI % of Area more than %50 of times Between 3000-300

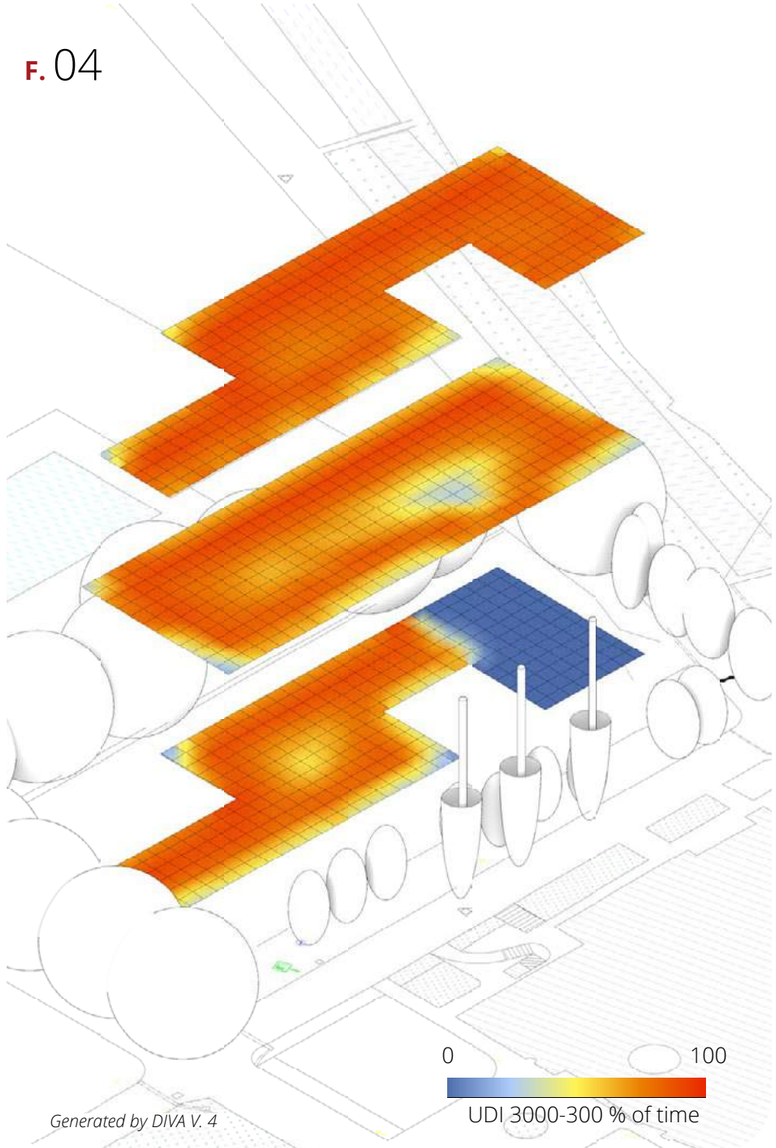
| | |
|---|---|
| Second Floor | **78** |
| First Floor | **86** |
| Ground Floor | **89** |

**F.** 05

UDI % of Area more than %50 of times Between 3000-300

| | |
|---|---|
| Second Floor | **78** |
| First Floor | **87** |
| Ground Floor | **87** |

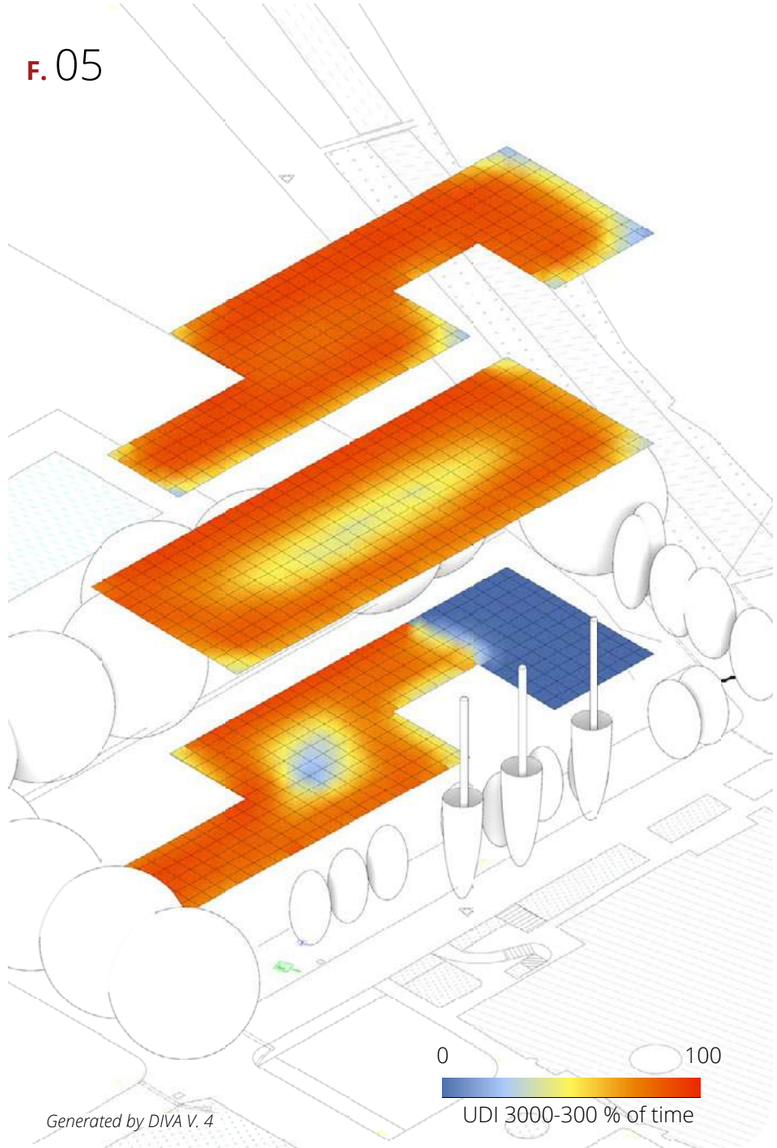
**F.** 04




UDI % of Area more than %50 of times Between 3000-300

| | |
|---|---|
| Second Floor | **78** |
| First Floor | **86** |
| Ground Floor | **89** |

**F.** 05



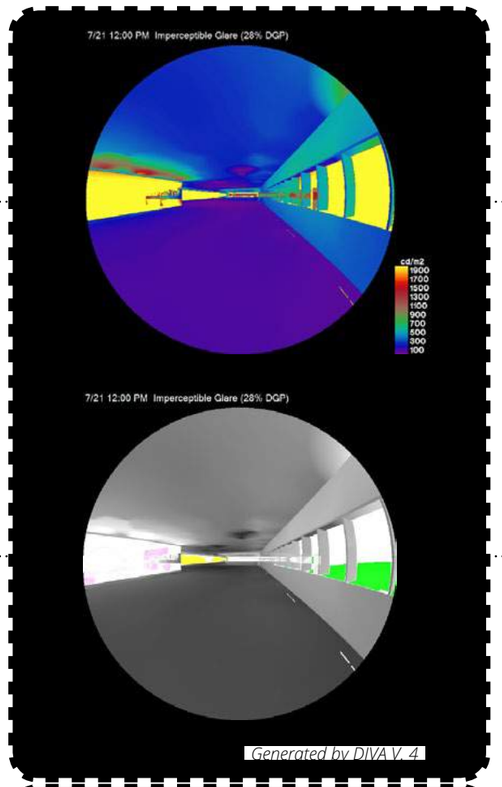

UDI % of Area more than %50 of times Between 3000-300

| | |
|---|---|
| Second Floor | **78** |
| First Floor | **87** |
| Ground Floor | **87** |

F.01

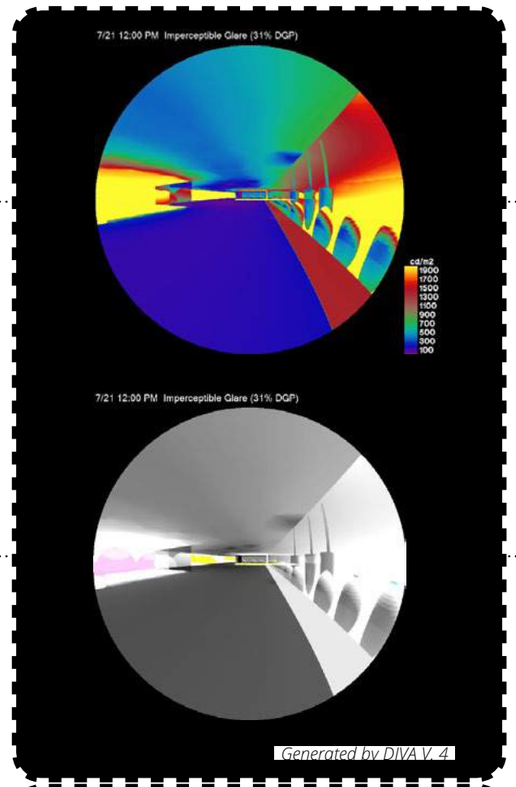
F.02

F.03



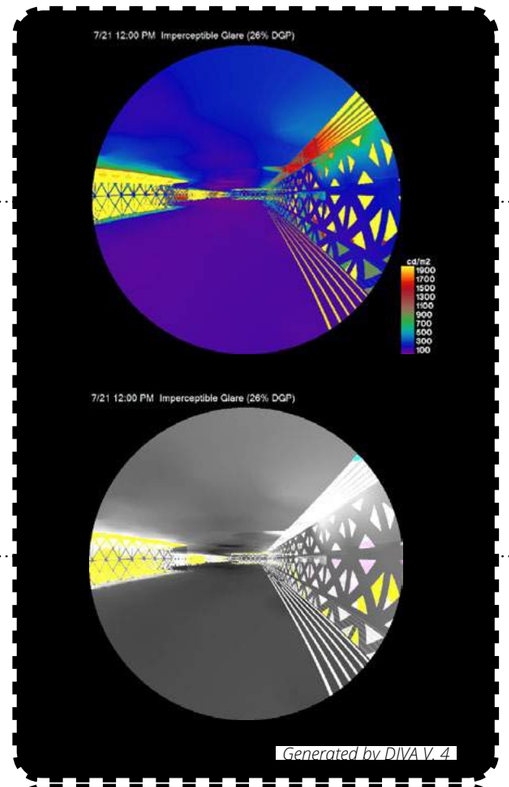

**DGP**

27.5 %




**DGP**

31.1 %




**DGP**

25.9 %

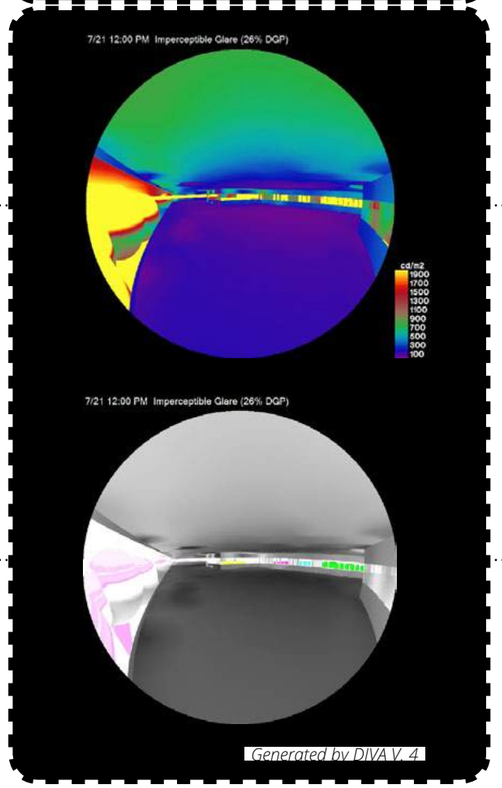
View 1

View 1

View 1

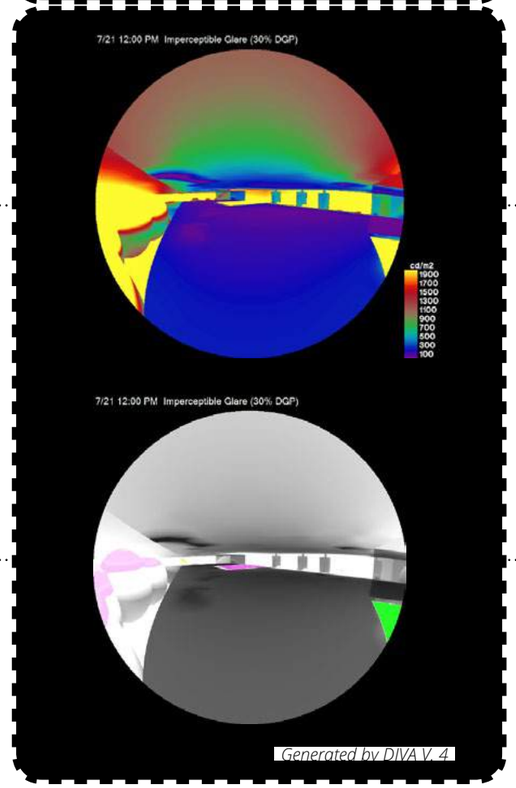
False Color

Glare Spotes



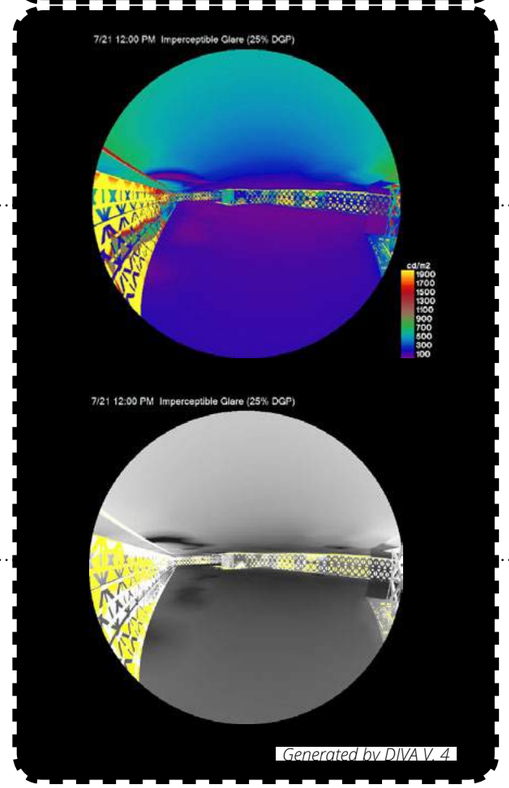

**DGP**

25.8 %




**DGP**

29.7 %




**DGP**

25.1 %

View 2

View 2

View 2

False Color

Glare Spotes

View 1

## Glare Analysis

F.04 F.05

**F. 01**

View 1
DGP Index[%] **27.5**
DGR Index Imperceptible

View 2
DGP Index[%] **25.8**
DGR Index Imperceptible

**F. 02**

View 1
DGP Index[%] **31.1**
DGR Index Imperceptible

View 2
DGP Index[%] **29.7**
DGR Index Imperceptible

**F. 03**

View 1
DGP Index[%] **25.9**
DGR Index Imperceptible

View 2
DGP Index[%] **25.1**
DGR Index Imperceptible

**F. 04**

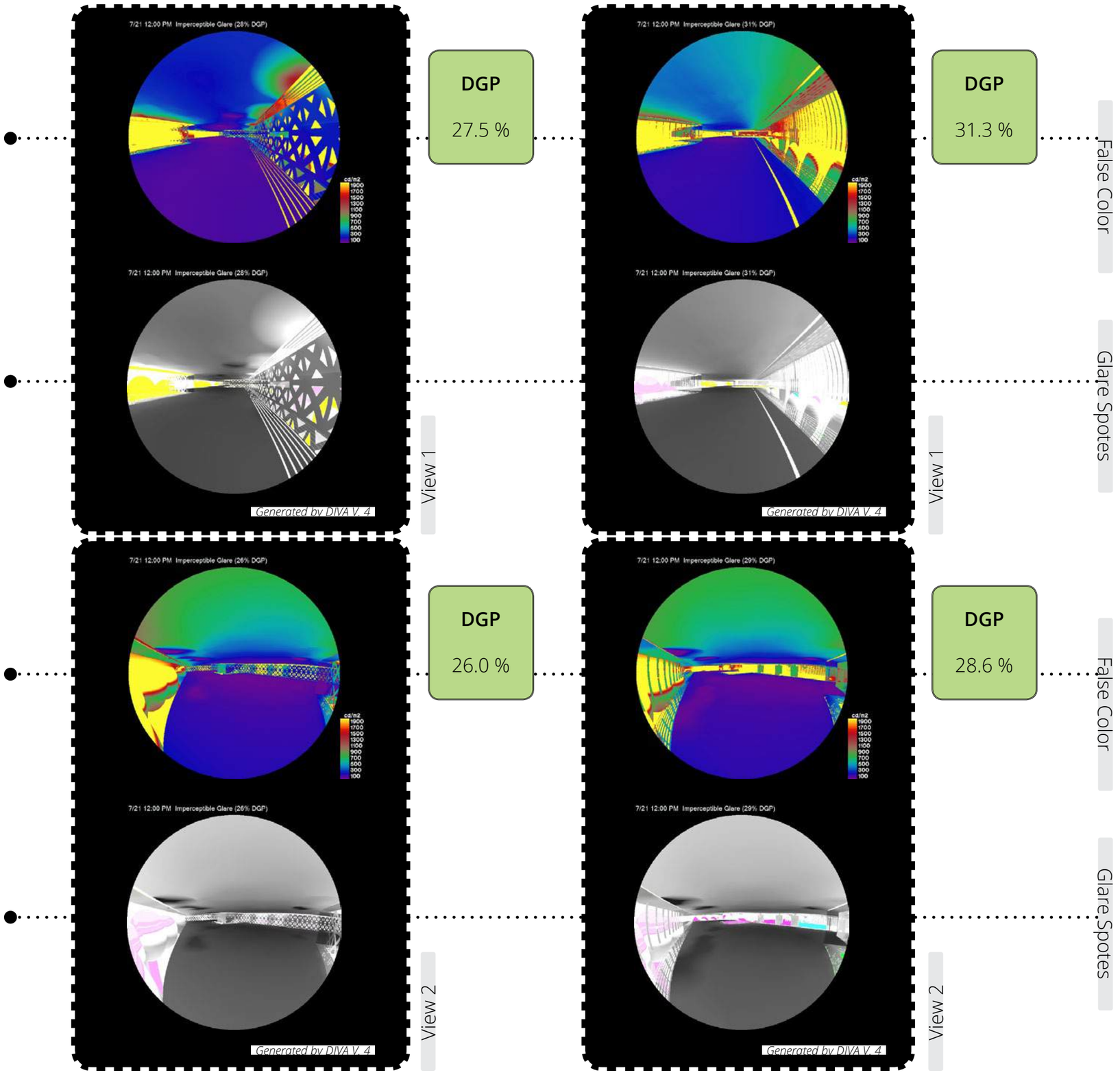
View 1
DGP Index[%] **27.5**
DGR Index Imperceptible

View 2
DGP Index[%] **26**
DGR Index Imperceptible

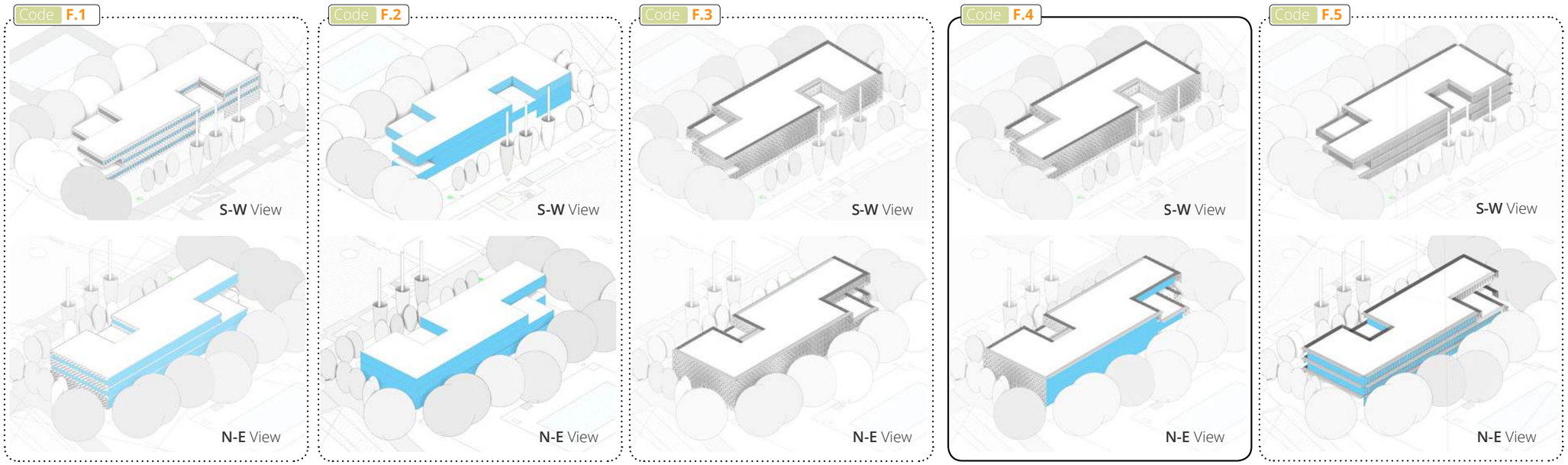
**F. 05**

View 1
DGP Index[%] **31.3**
DGR Index Imperceptible

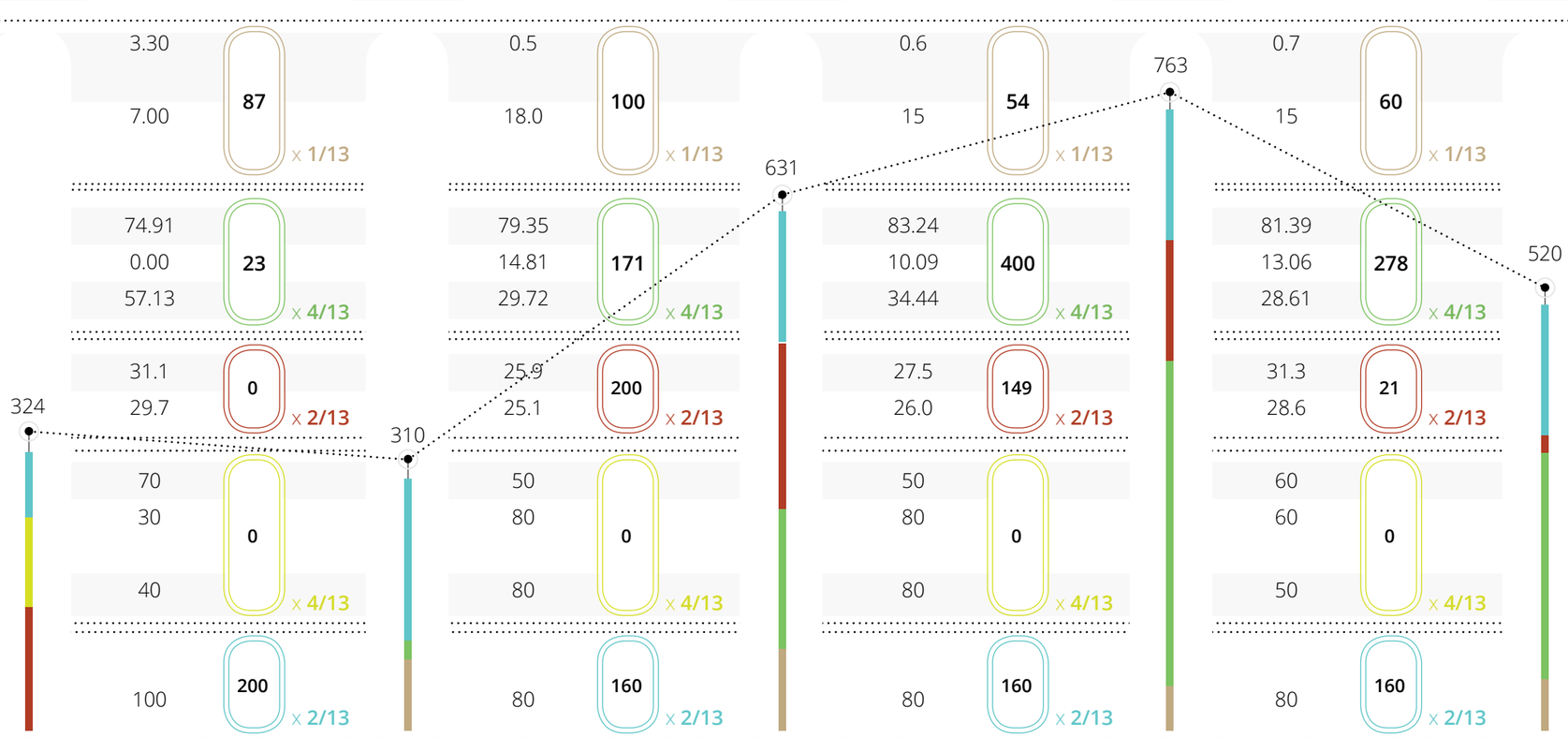
View 2
DGP Index[%] **28.6**
DGR Index Imperceptible



# Facade Alternatives Analysis **Results(Step1)**

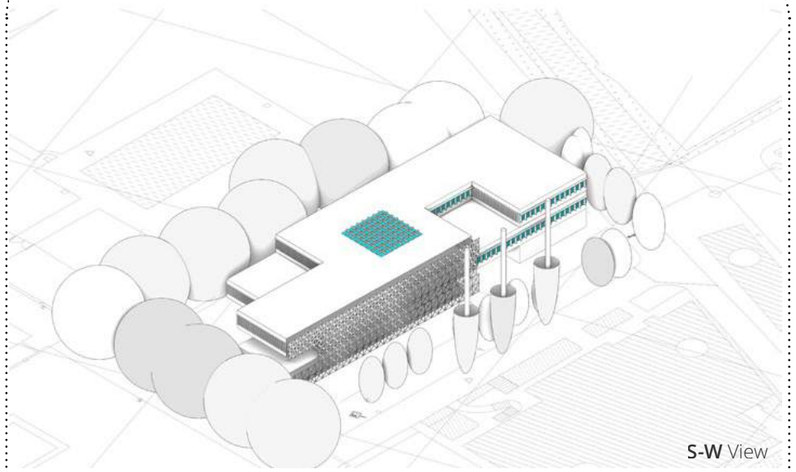



| | Key Parameters | Detailed Weightings | Values | Scores (Unweighted) | Overall Scores | Values | Scores (Unweighted) | Overall Scores | Values | Scores (Unweighted) | Overall Scores | Values | Scores (Unweighted) | Overall Scores | Values | Scores (Unweighted) | Overall Scores |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Thermal Comfort | Comfortable [% of time](Hot Week) | 50/100 | 0.3 | 0.0 | | 3.30 | 87 | | 0.5 | 100 | | 0.6 | 54 | | 0.7 | 60 | |
| | Comfortable [% of time](Cold Week) | 50/100 | 13.0 | | x 1/13 | 7.00 | | x 1/13 | 18.0 | | x 1/13 | 15 | | x 1/13 | 15 | | x 1/13 |
| Daylighting | Daylit | 80/100 | 76.5 | 0.0 | | 74.91 | 23 | | 79.35 | 171 | | 83.24 | 400 | | 81.39 | 278 | |
| | Underlit | | 18.5 | | | 0.00 | | | 14.81 | | | 10.09 | | | 13.06 | | |
| | Overlit | 20/100 | 24.2 | | x 4/13 | 57.13 | | x 4/13 | 29.72 | | x 4/13 | 34.44 | | x 4/13 | 28.61 | | x 4/13 |
| Glare | DGP View 1 [%] | 50/100 | 27.6 | 153 | | 31.1 | 0 | | 25.9 | 200 | | 27.5 | 149 | | 31.3 | 21 | |
| | DGP View 2 [%] | 50/100 | 25.8 | | x 2/13 | 29.7 | | x 2/13 | 25.1 | | x 2/13 | 26.0 | | x 2/13 | 28.6 | | x 2/13 |
| Functional & Aesthetical | Cost | 25/100 | 80 | 109 | | 70 | 0 | | 50 | 0 | | 50 | 0 | | 60 | 0 | |
| | Improvement Potential | 25/100 | 50 | | | 30 | | | 80 | | | 80 | | | 60 | | |
| | Aesthetics | 50/100 | 40 | | x 4/13 | 40 | | x 4/13 | 80 | | x 4/13 | 80 | | x 4/13 | 50 | | x 4/13 |
| Ventilation Potential | Average Window Height | | 40 | 80 | x 2/13 | 100 | 200 | x 2/13 | 80 | 160 | x 2/13 | 80 | 160 | x 2/13 | 80 | 160 | x 2/13 |

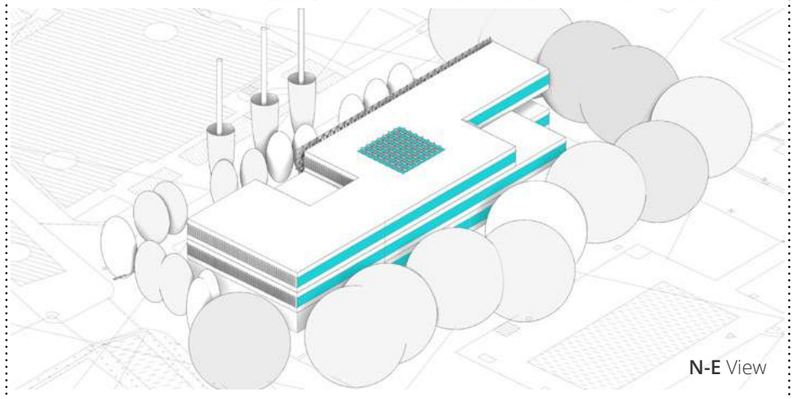


# Facade Design Alternatives (Step2)

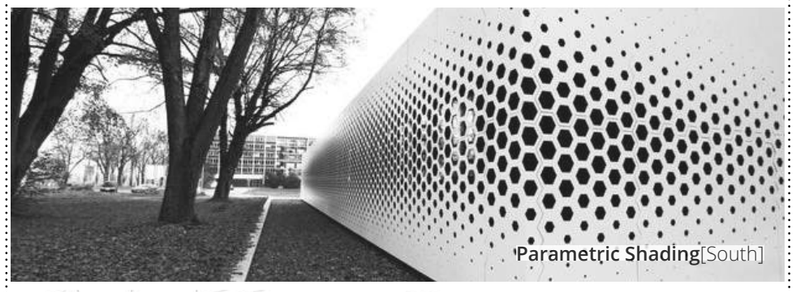
Code **P.1**



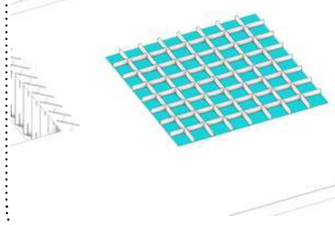
**S-W** View



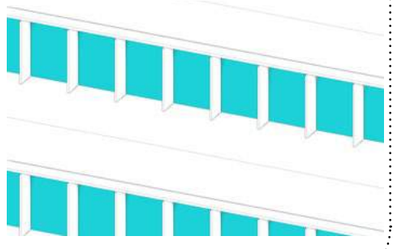
**N-E** View



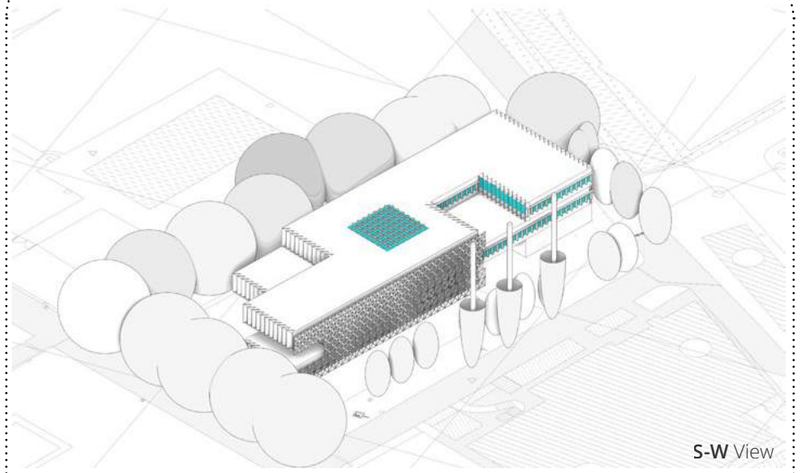

**Skylight**



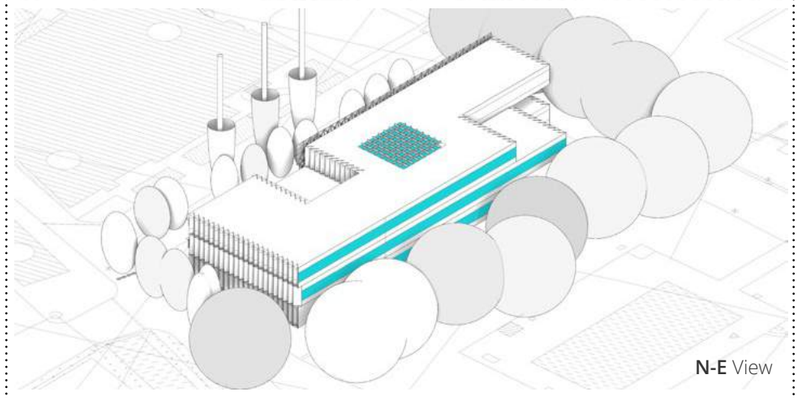
**Vertical+Horizontal Shadings**[South]



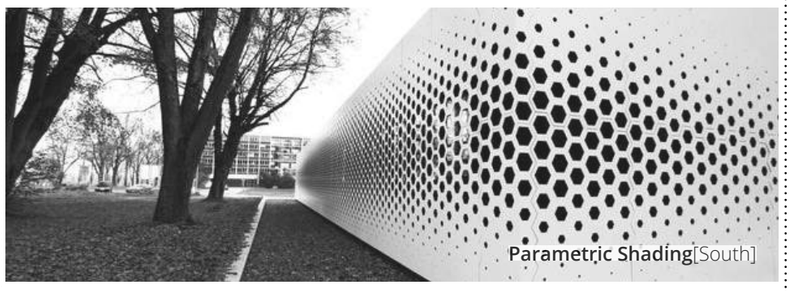
Code **P.2**



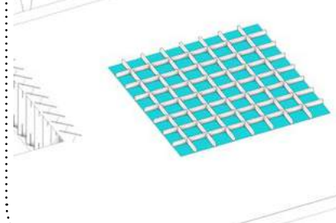
**S-W** View



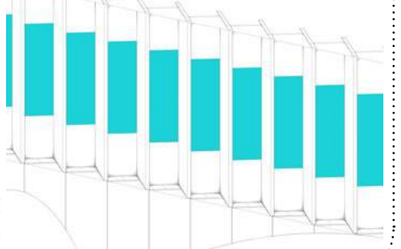
**N-E** View



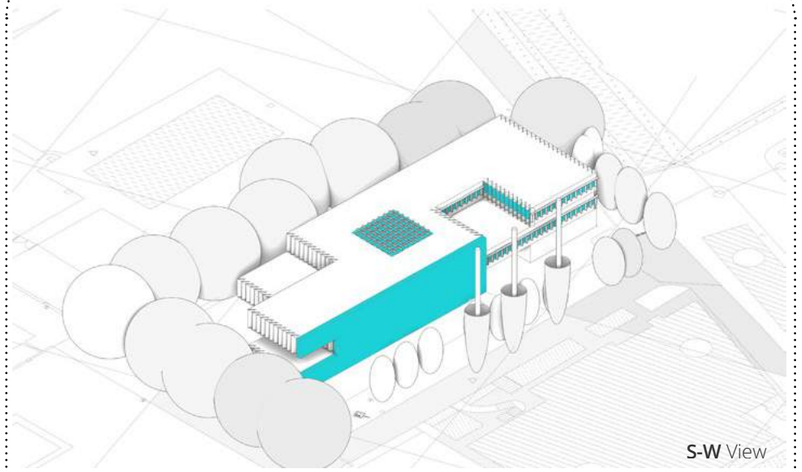

**Skylight**



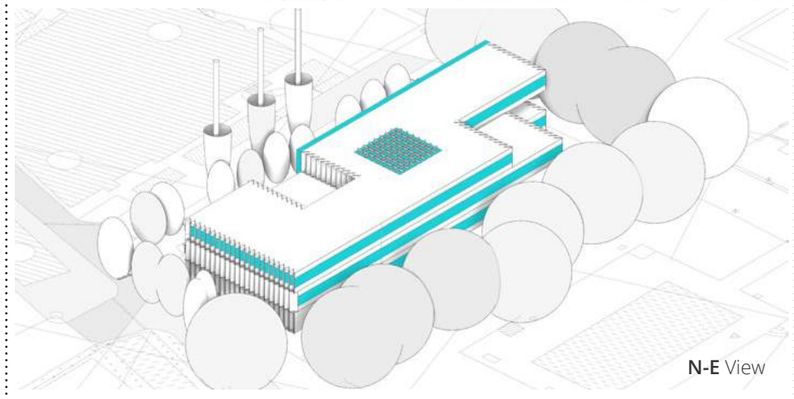
**East/West** side



Code **P.3**



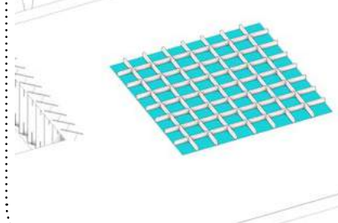
**S-W** View



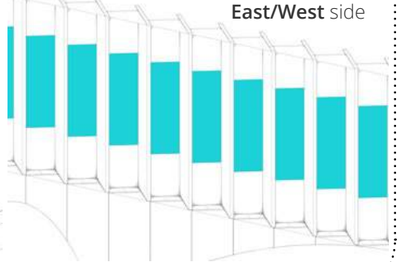
**N-E** View




**Skylight**

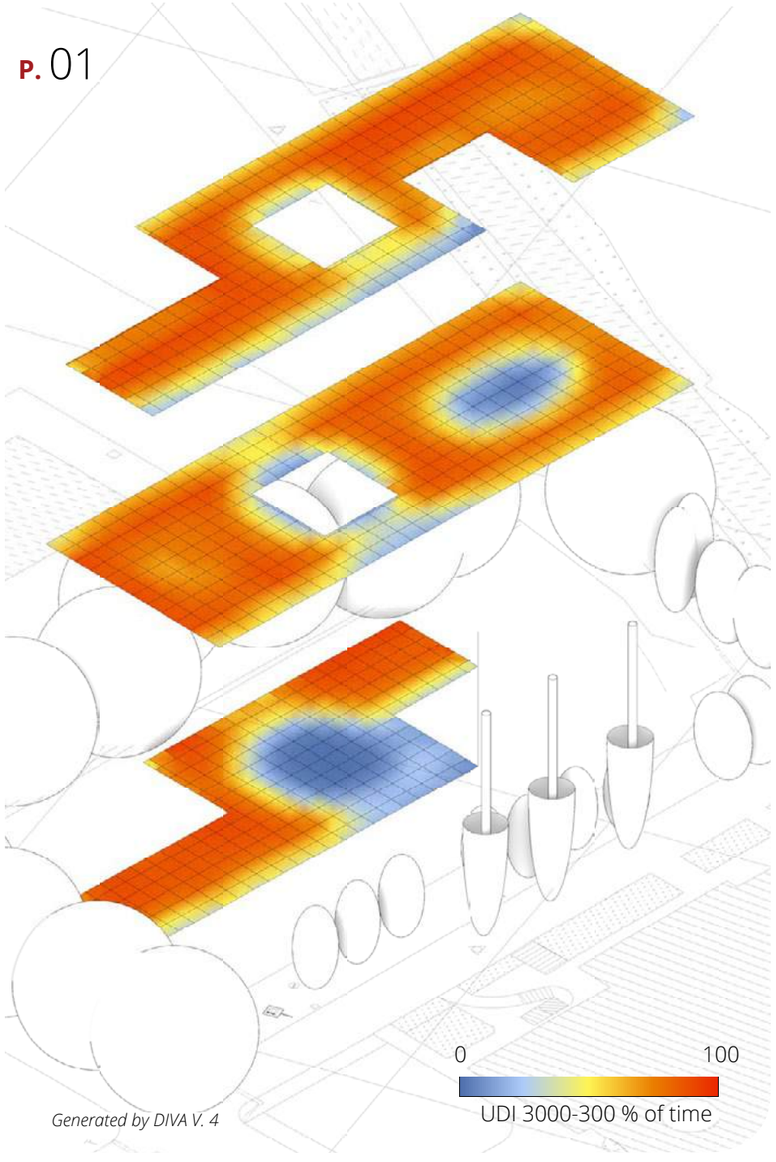


**East/West** side



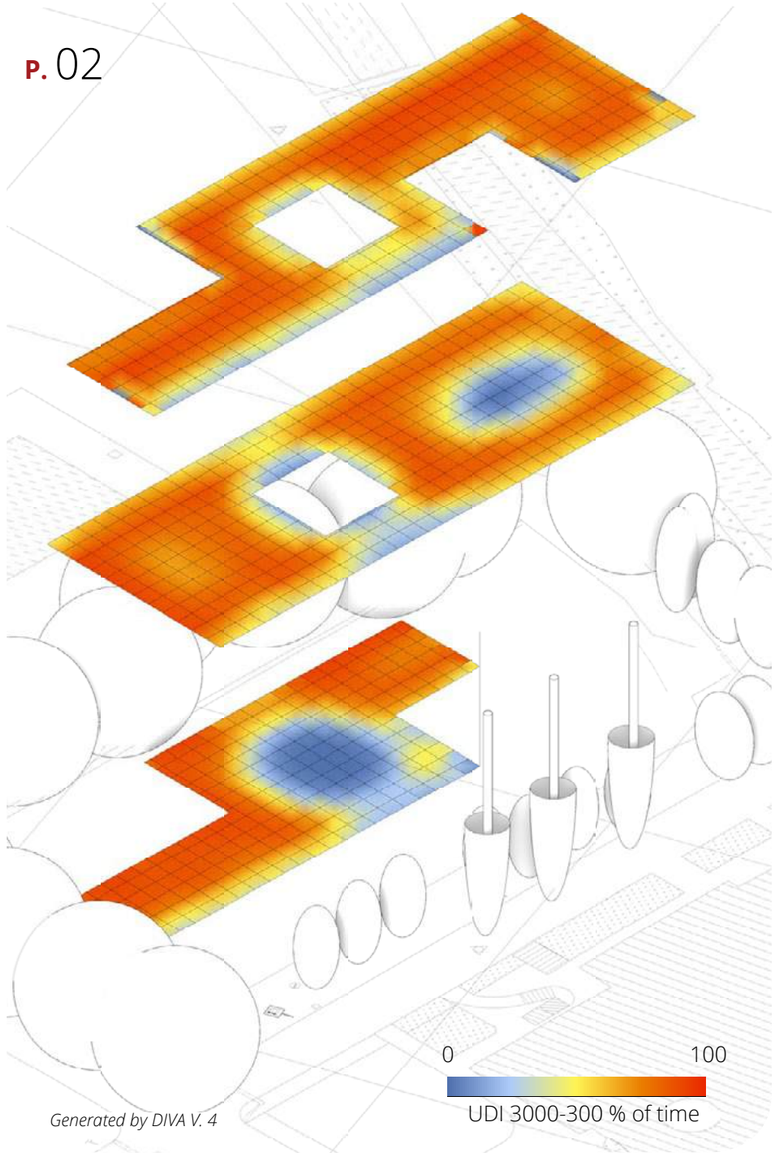
## Daylight Analysis

**P.** 01



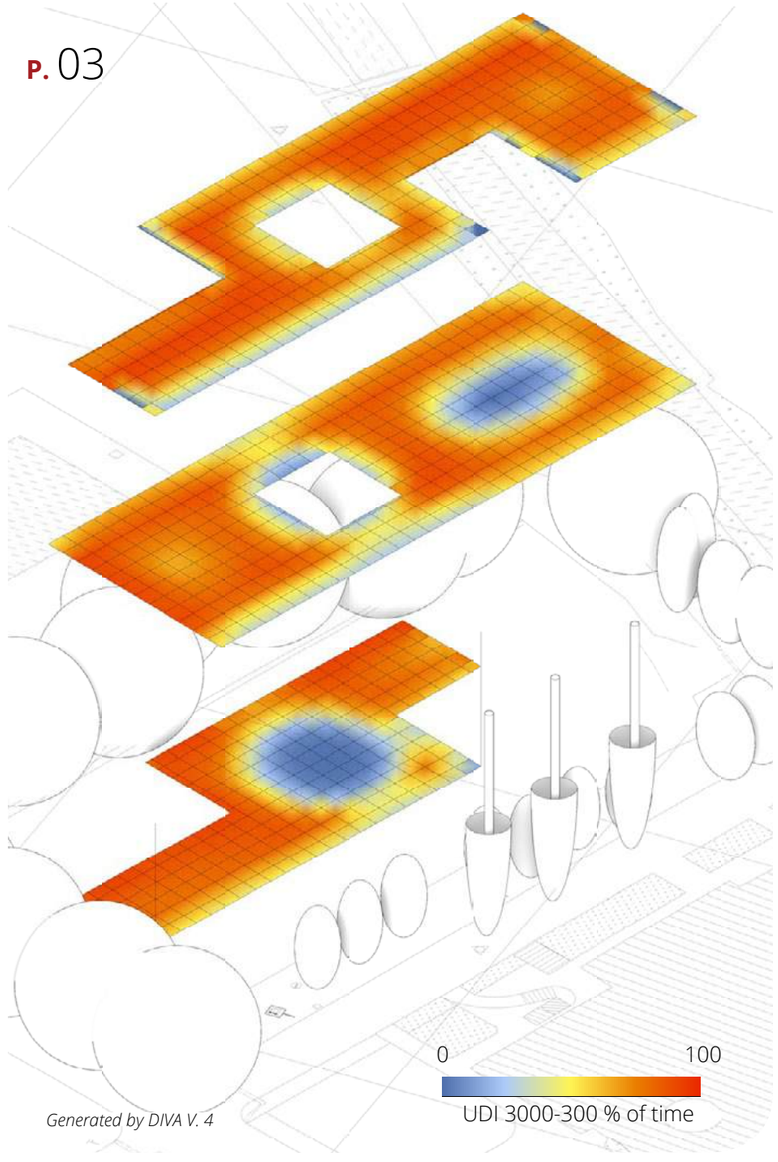

| UDI % of Area more than %50 of times Between 3000-300 | |
|---|---|
| Second Floor | **59.58** |
| First Floor | **72.83** |
| Ground Floor | **81.87** |

**P.** 02




| UDI % of Area more than %50 of times Between 3000-300 | |
|---|---|
| Second Floor | **62.50** |
| First Floor | **72.01** |
| Ground Floor | **79.60** |

**P.** 03




| UDI % of Area more than %50 of times Between 3000-300 | |
|---|---|
| Second Floor | **68.75** |
| First Floor | **73.10** |
| Ground Floor | **80.17** |

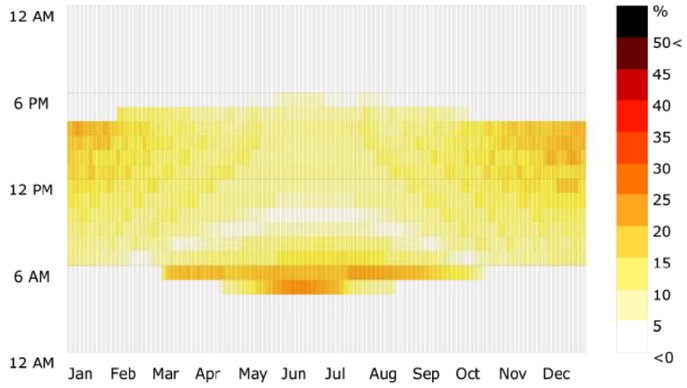
# **Glare Potential** (Eye Level)

Code **P.1**

2nd Floor Percentage of Area Over %15 of times in direct Sunlight

10.41

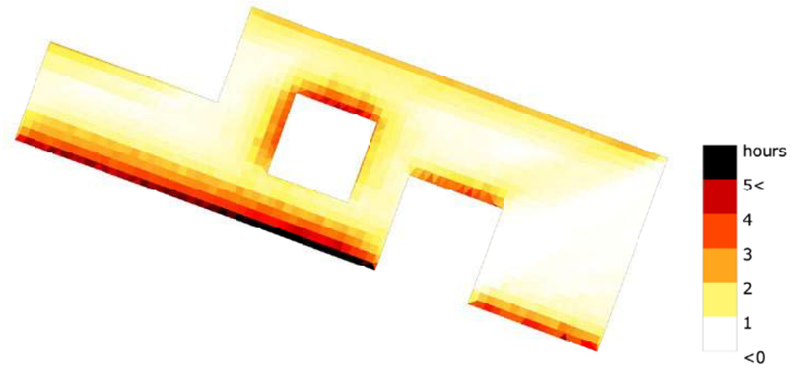
2nd Floor **Glare Potential** Temporal Map




Percent of Floor in Direct Sun (%) - someTimeStep
Test Surface
1 JAN 1:00 - 31 DEC 24:00

*Generated by Ladybug v. 0.0.67*

2nd Floor **Glare Potential** False-Color Map




Hours of a Typical Day in Direct Sun

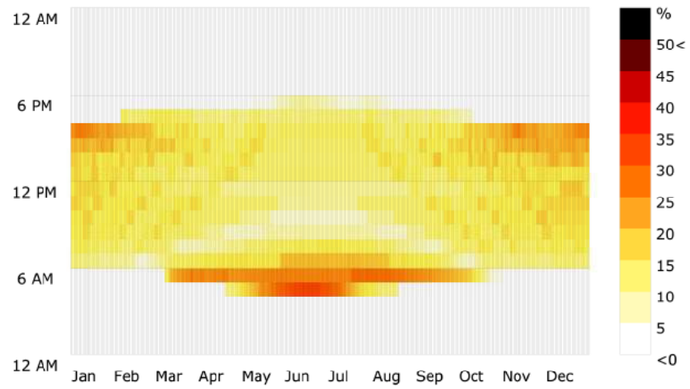
*Generated by Ladybug v. 0.0.67*

Code **P.1**

Code **P.2**

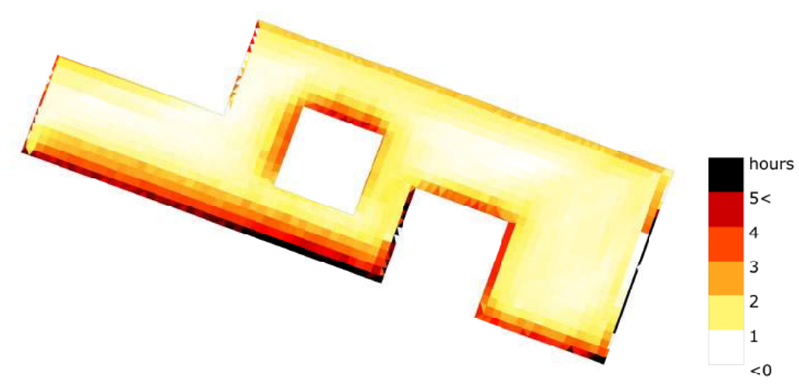
2nd Floor Percentage of Area Over %15 of times in direct Sunlight

12.96




Percent of Floor in Direct Sun (%) - someTimeStep
Test Surface
1 JAN 1:00 - 31 DEC 24:00

*Generated by Ladybug v. 0.0.67*




Hours of a Typical Day in Direct Sun

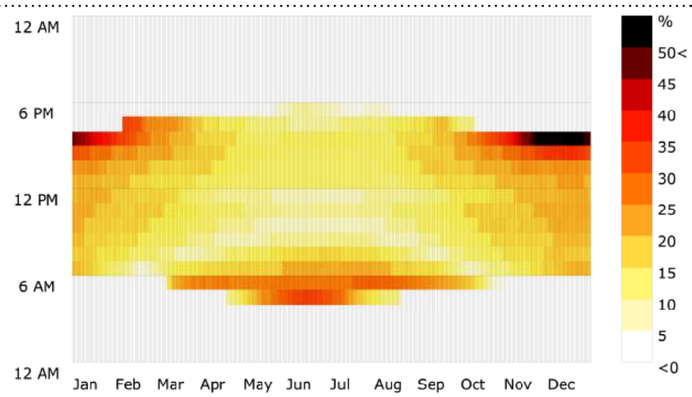
*Generated by Ladybug v. 0.0.67*

Code **P.2**

Code **P.3**

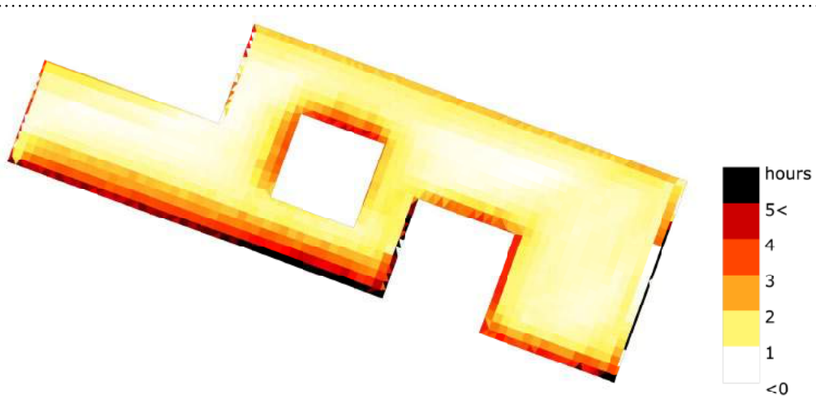
2nd Floor Percentage of Area Over %15 of times in direct Sunlight

27.81




Percent of Floor in Direct Sun (%) - someTimeStep
Test Surface
1 JAN 1:00 - 31 DEC 24:00

*Generated by Ladybug v. 0.0.67*



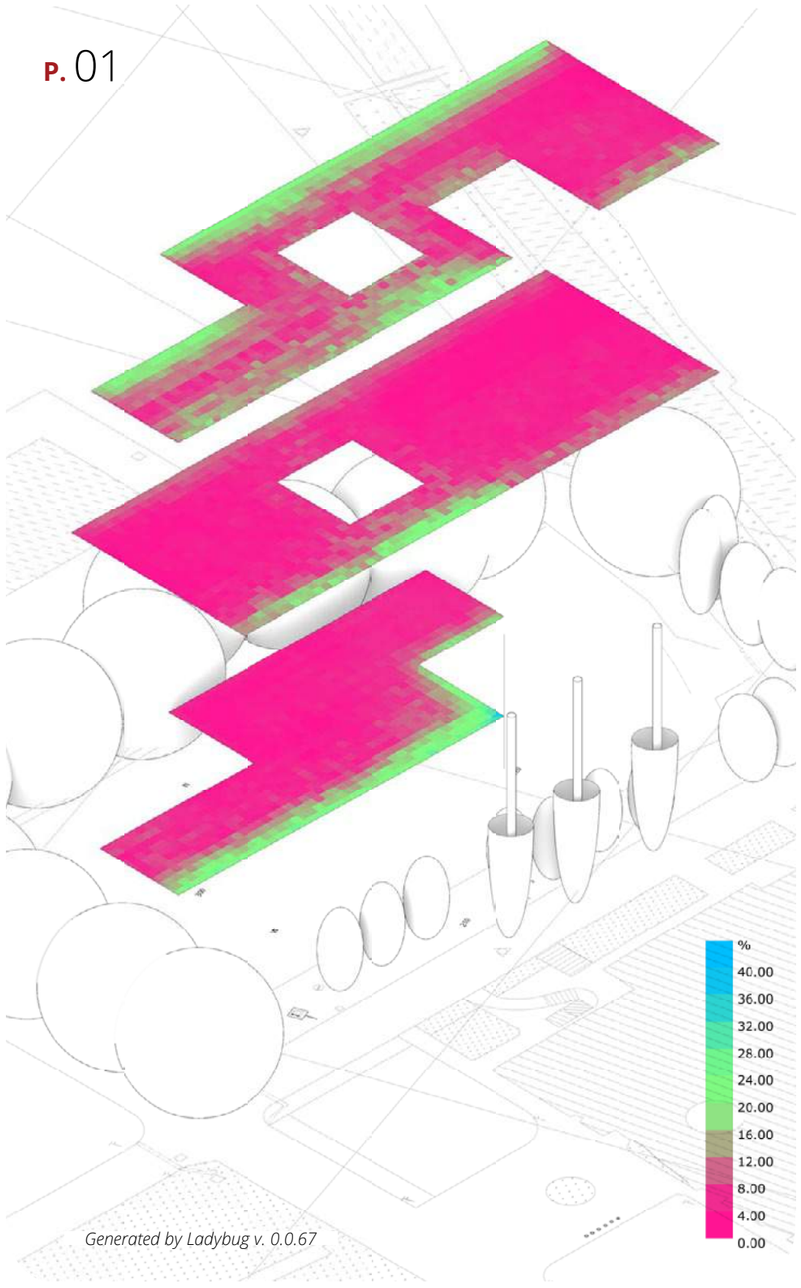

Hours of a Typical Day in Direct Sun

*Generated by Ladybug v. 0.0.67*

Code **P.3**

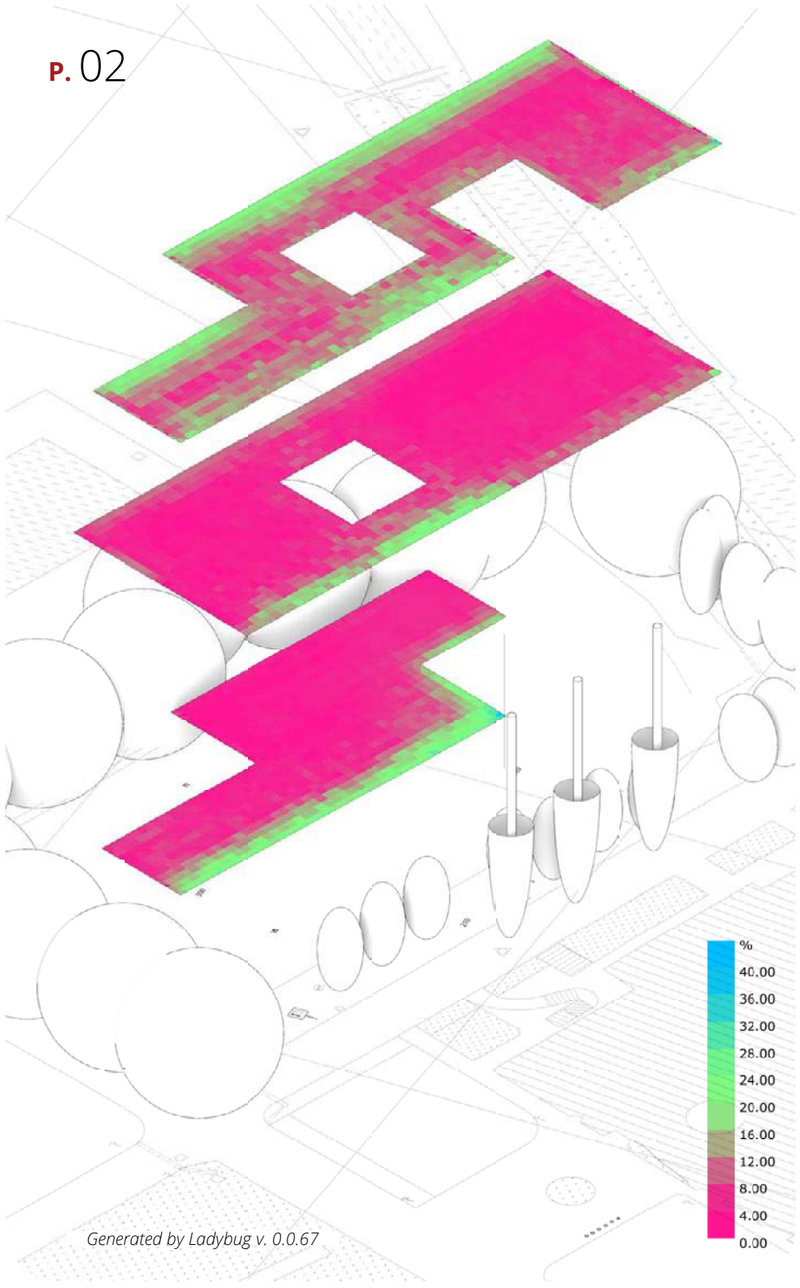
## **Horizontal 60° Cone of Vision Analysis** (Eye Level)

**P.** 01



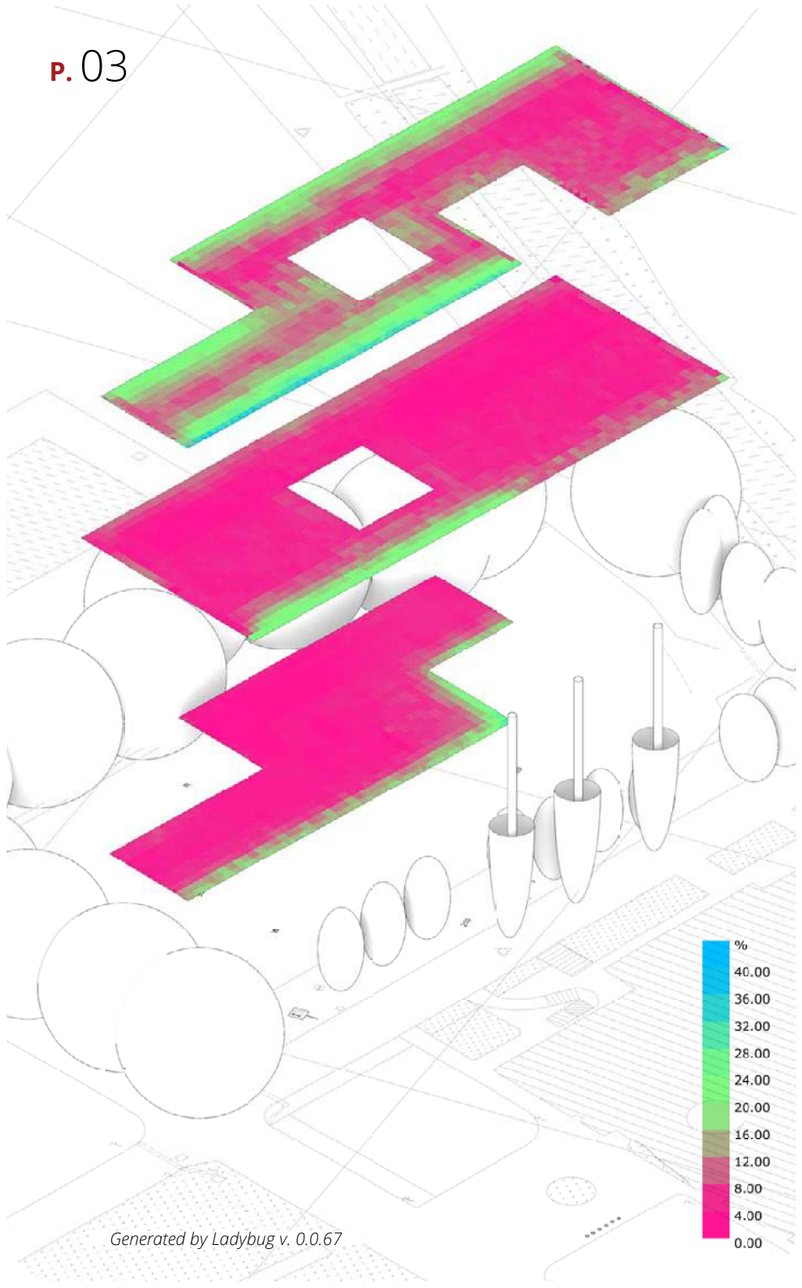

%of Area more than %15 of outdoor space is visible ..... 8.15

**P.** 02



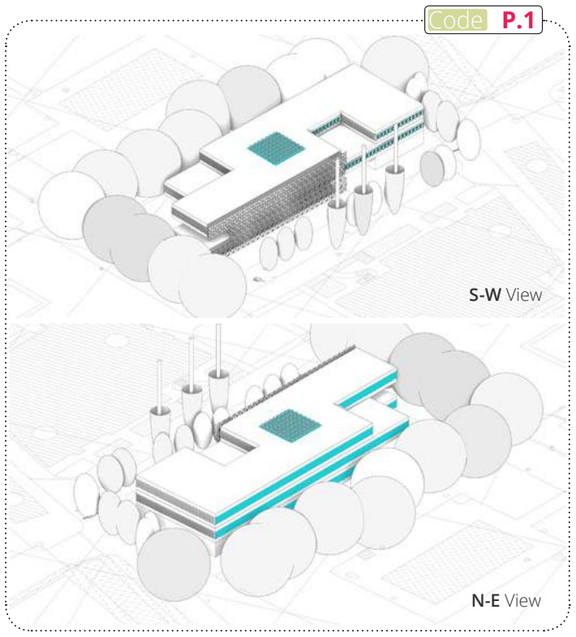

%of Area more than %15 of outdoor space is visible ..... 9.22

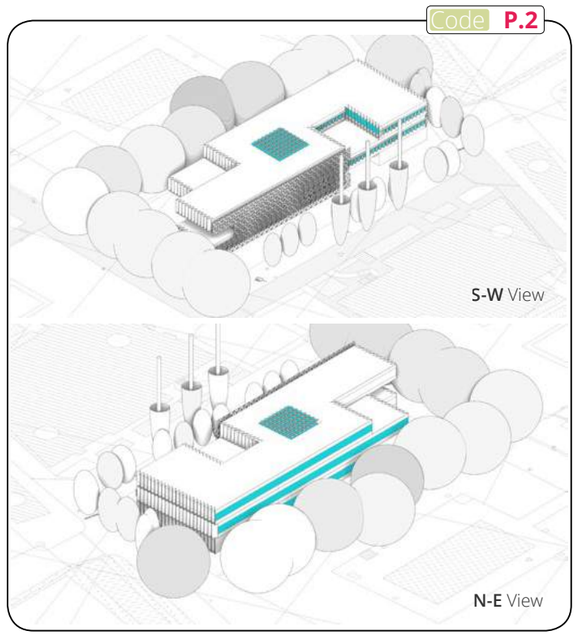
**P.** 03

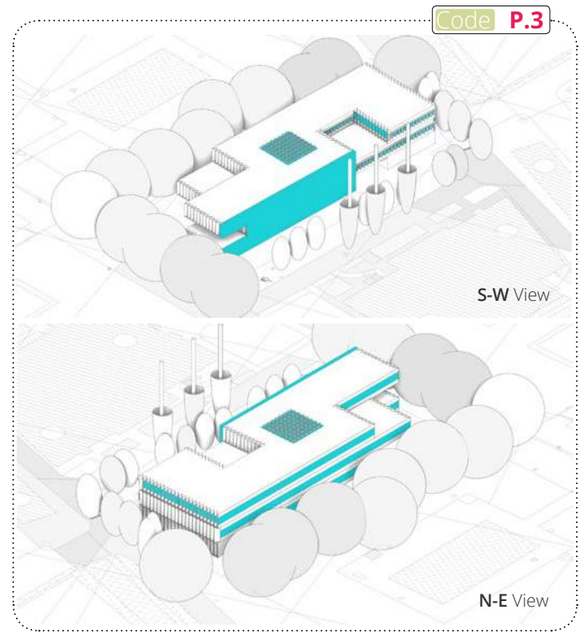



%of Area more than %15 of outdoor space is visible ..... 12.18

## Facade Alternatives Analysis Results(Step2)




| | Key Parameters | | Detailed Weightings | Values/ Raw Scores | Scores (Unweighted) | Overall Weighted Scores | Values/ Raw Scores | Scores (Unweighted) | Overall Weighted Scores | Values/ Raw Scores | Scores (Unweighted) | Overall Weighted Scores |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Thermal Autonomy | Overheat hours() [% of Occ times>28] | | | 49.9 | | | 47.4 | | | 49.6 | | |
| | Underheat hours [% of Occ times<21] | | | 5.7 | 44 | | 2.4 | 50 | | 1.8 | 48 | |
| | Comfortable hours [% of Occ times] | | 100/100 | 44.3 | | x4/12 | 50 | | x4/12 | 48.4 | | x4/12 |
| Daylighting | UDI Daylit [300-3000] | | 100/100 | 75.3 | | | 74.4 | | | 77.3 | | |
| | UDI Underlit [300>] | | | 2.8 | 75 | | 2.9 | 74 | | 3.8 | 77 | |
| | UDI Overlit [3000<] | | | 54.6 | | x2/12 | 57 | | x2/12 | 51.8 | | x2/12 |
| Glare Potenrial | 2nd Floor Percentage of Area Over %15 of times in direct Sunlight | | 100/100 | 10.41 | 89 | x1/12 | 12.96 | 87 | x1/12 | 27.81 | 72 | x1/12 |
| Cone of Vision Analysis | %of Area more than %15 of outdoor space is visible | | 100/100 | 8.15 | 65 | x2/12 | 9.22 | 73 | x2/12 | 12.18 | 97 | x2/12 |
| Functional & Aesthetical | Cost | | 50/100 | 80 | | | 50 | | | 0 | | |
| | Aesthetics | | 50/100 | 0 | 80 | x3/12 | 100 | 150 | x3/12 | 80 | 80 | x3/12 |
| | | | | | 787 | | | 1033 | | | 853 | |

Strategy **1**

**Windows**

Automated Windows
Operating Schedule
Free Aperture: %15





Strategy **2**

**Skylights and Void**

Dimentions: 8m*8m
Free Aperture: %25
plus Windows Free Aperture  of %5



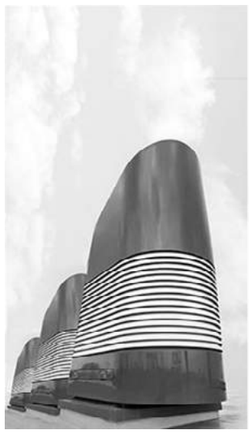


Strategy **3**

**Small-sized chimneys on the roof**

Dimentions: 1m*1m*1.5m
Number of Small-sized chimneys on the roof: 10
Plus Windows Free Aperture of %5

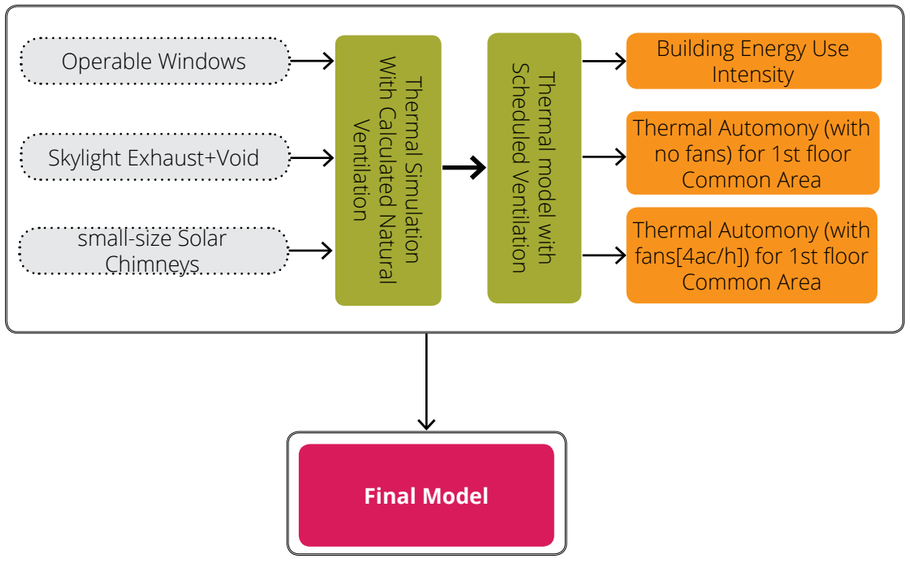


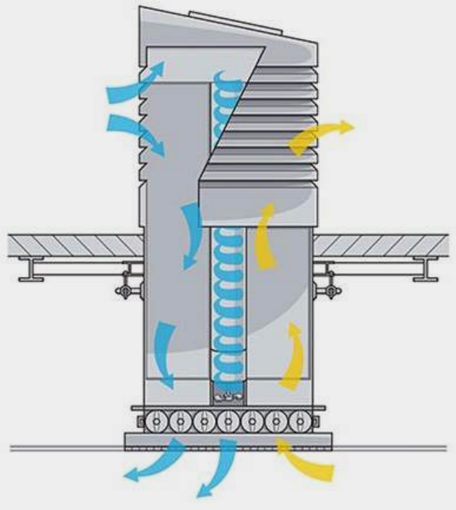


## Modelling Key Assumptions- **Step2**

| | |
|---|---|
| **Thermal** | Infiltration Constant Rate(Scheduled method): 1 ACH |
| | Infiltration Crack Template: Medium |
| HVAC | Heating: Off |
| | Cooling: Off |
| | Mechanical Ventilation: Off |
| | Natural Ventilation: On |
| | Natural Ventilation Method: Calculated |
| | Occupancy densityp[people/s.q.m.]: 0.5 |
| **Constructions** | WWR-South: %60 ,%30 |
| | WWR-North: %50 ,%30 |
| | WWR-East/West: %25 |
| | Wndows U-value[W/m-2K]: 1.96 |
| | WndowsSHGC[%]: 0.691 |
| | WndowsDirect Solar Transmission[%]: 0.624 |
| | Wndows Light Transmission[%]: 65 |
| | External Walls U-Value[W/m-2K]: 0.95 |
| | Roofs U-Value[W/m-2K]: 0.5 |

## **Natural Ventilation Strategy** Selection Process



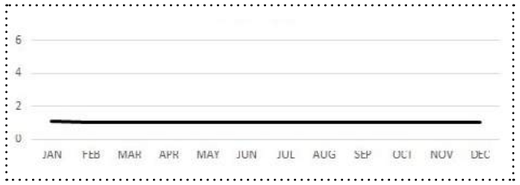



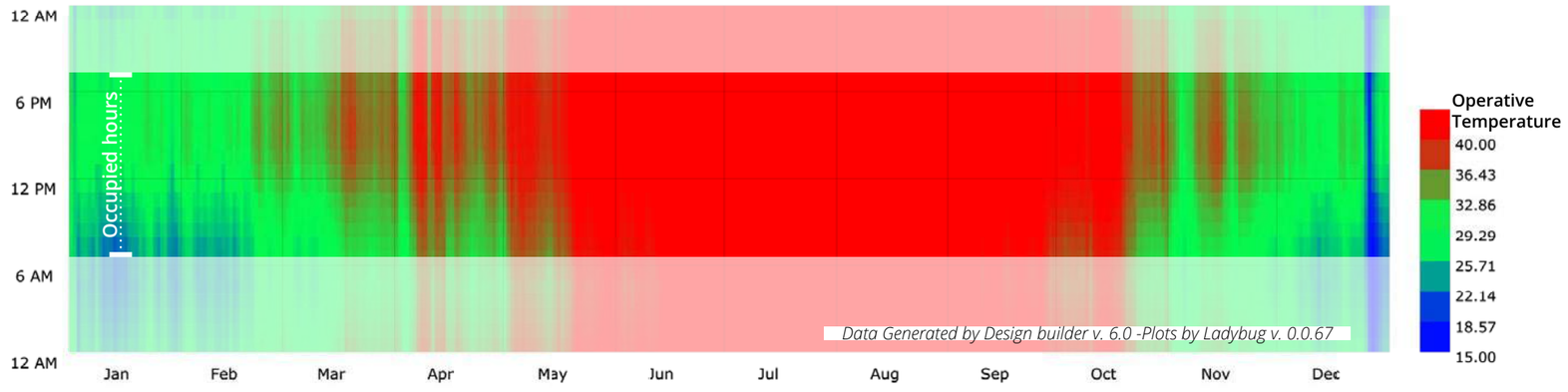
**Base Case**

No Natural Ventilation Strategies

| % of Occupied Hours | |
|---|---|
| Overheat[>28] | 69.7 |
| Underheat[<21] | 0.5 |
| Comfortable | 29.7 |
| Weighted Overheat Hours | 7056 |

EUI [kWh/m2]: 231.4



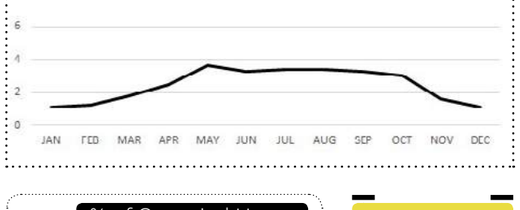



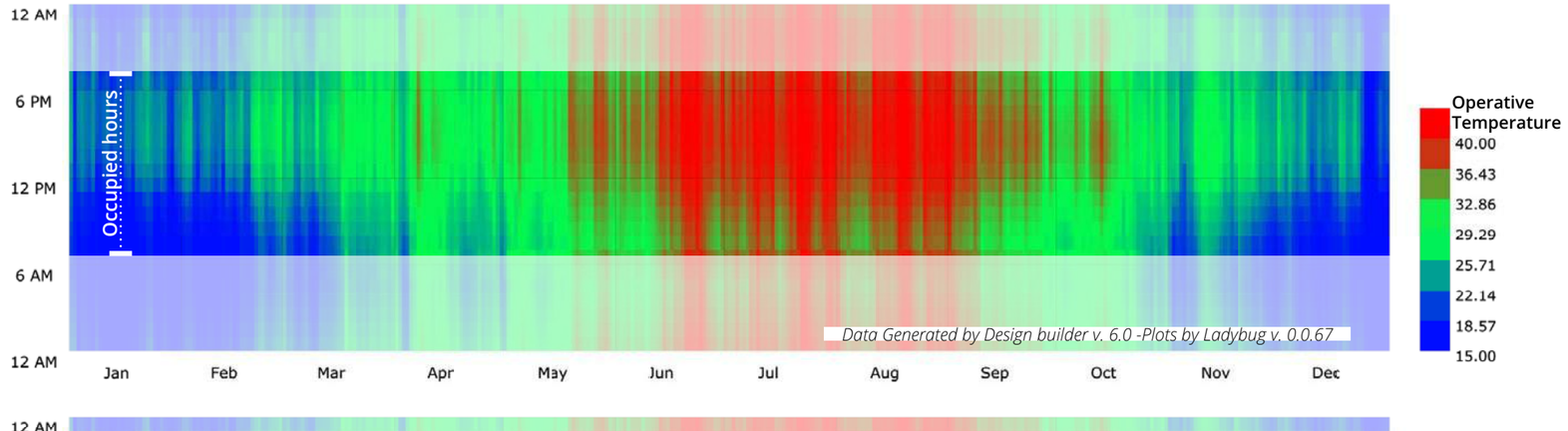

**Windows**

Automated Windows Operating Schedule
Free Aperture: %15

| % of Occupied Hours | |
|---|---|
| Overheat[>28] | 41.42 |
| Underheat[<21] | 18.33 |
| Comfortable | 40.25 |
| Weighted Overheat Hours | 8470 |

EUI [kWh/m2]: 181.0



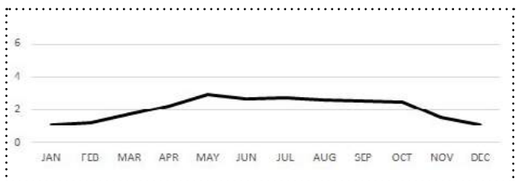



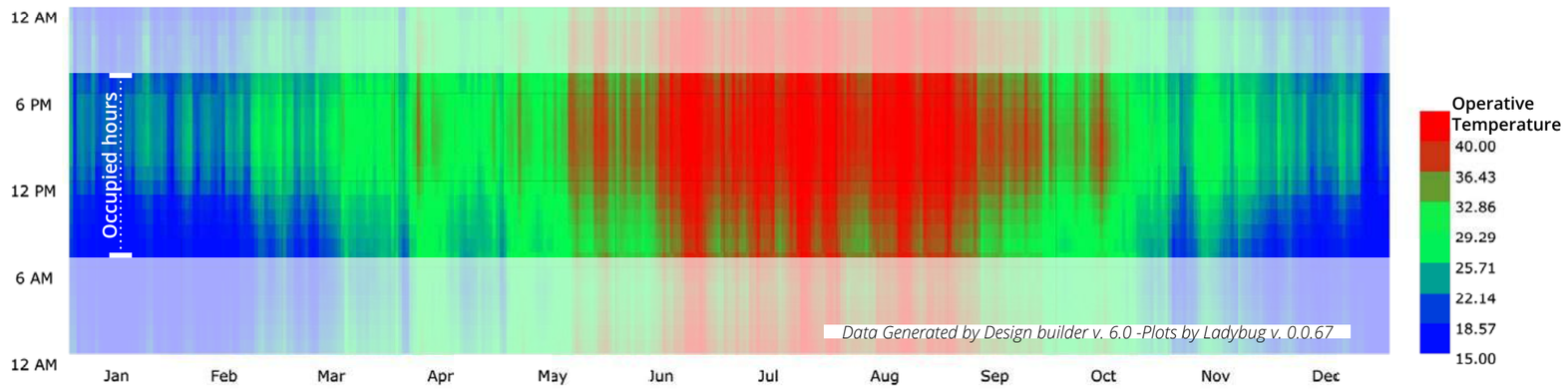

**Skylights and Void**

Dimentions: 8m*8m
Free Aperture: %25 plus Windows Free Aperture of %5

| % of Occupied Hours | |
|---|---|
| Overheat[>28] | 41.39 |
| Underheat[<21] | 18.92 |
| Comfortable | 39.70 |
| Weighted Overheat Hours | 9519 |

EUI [kWh/m2]: 182.8



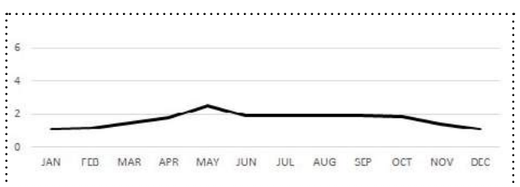



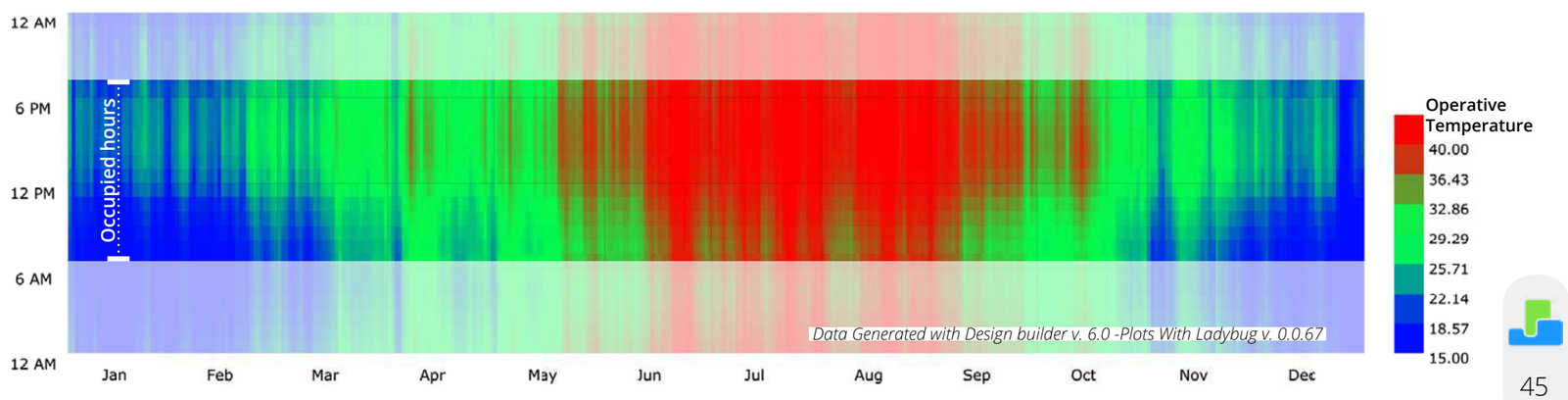

**Small-sized chimneys on the roof**

Dimentions: 1m*1m*1.5m
Number of Small-sized chimneys on the roof: 10
Plus Windows Free Aperture of %5

| % of Occupied Hours | |
|---|---|
| Overheat[>28] | 41.1 |
| Underheat[<21] | 19.99 |
| Comfortable | 38.90 |
| Weighted Overheat Hours | 9824 |

EUI [kWh/m2]: 185.5



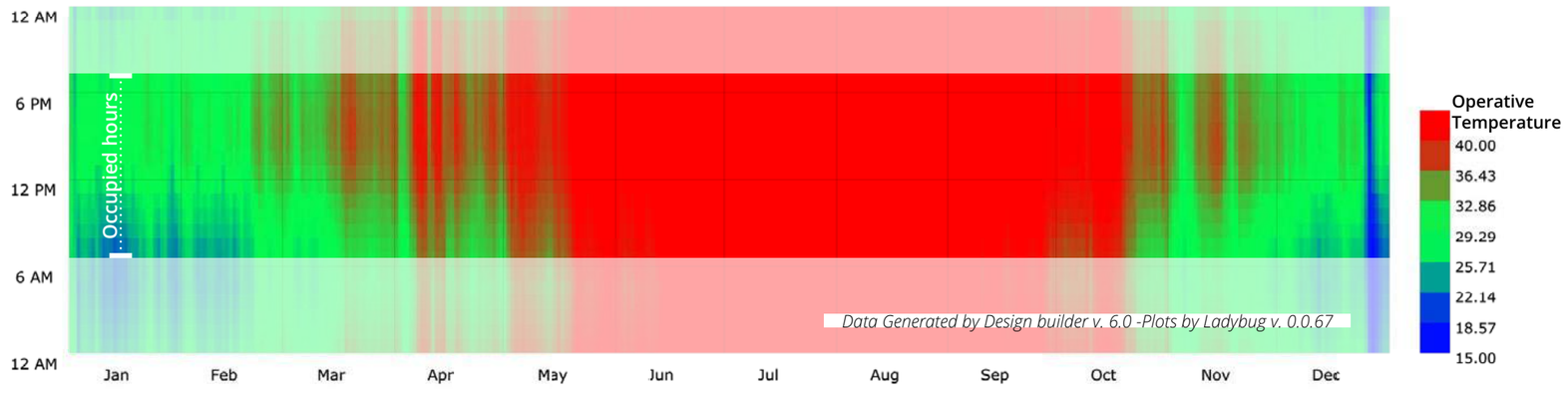
**Base Case**

No Natural Ventilation Strategies

| % of Occupied Hours | |
|---|---|
| Overheat[>28] | 69.7 |
| Underheat[<21] | 0.5 |
| Comfortable | 29.7 |
| Weighted Overheat Hours | 7056 |

EUI [kWh/m2]: 231.4



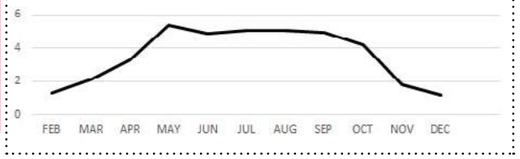

+ FAN (4 ac/h)

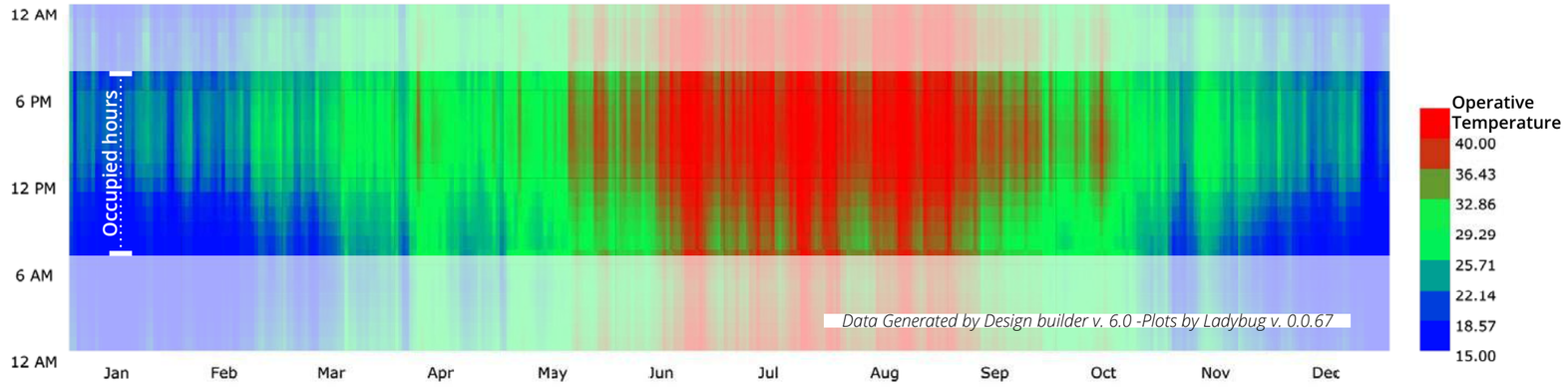
**Windows**

Automated Windows Operating Schedule
Free Aperture: %15

| % of Occupied Hours | |
|---|---|
| Overheat [>28] | 40.09 |
| Underheat[<21] | 18.24 |
| Comfortable | 41.67 |
| Weighted Overheat Hours | 9486 |

EUI [kWh/m2]: 178.4



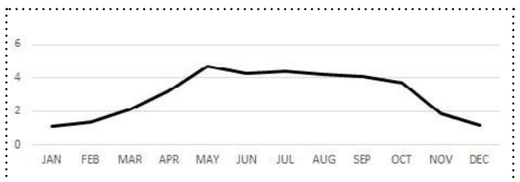

+ FAN (4 ac/h)

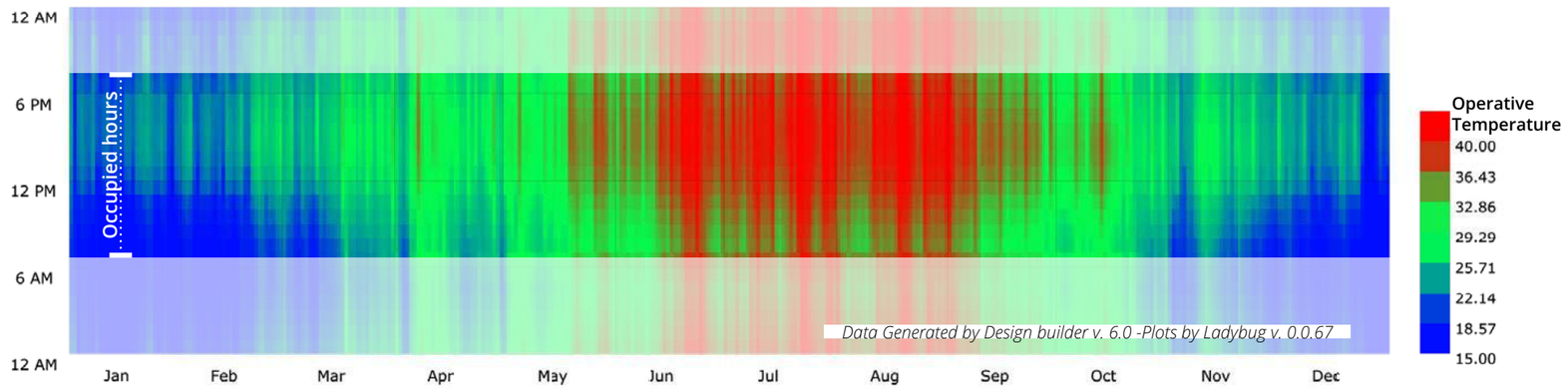
**Skylights and Void**

Dimentions: 8m*8m
Free Aperture: %25 plus Windows Free Aperture of %5

| % of Occupied Hours | |
|---|---|
| Overheat[>28] | 40.49 |
| Underheat[<21] | 18.50 |
| Comfortable | 41.01 |
| Weighted Overheat Hours | 9723 |

EUI [kWh/m2]: 179.3



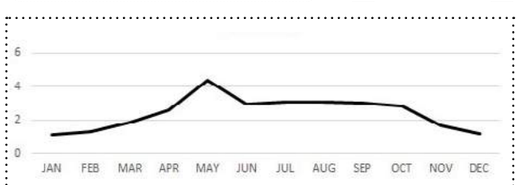

+ FAN (4 ac/h)

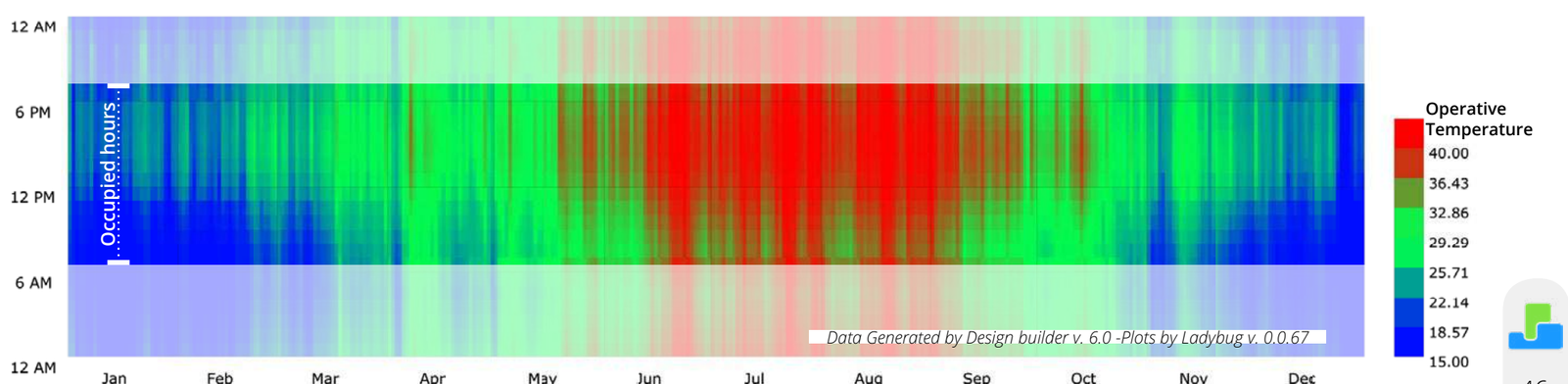
**Small-sized chimneys on the roof**

Dimentions: 1m*1m*1.5m
Number of Small-sized chimneys on the roof: 10
Plus Windows Free Aperture of %5

| % of Occupied Hours | |
|---|---|
| Overheat[>28] | 40.23 |
| Underheat[<21] | 19.25 |
| Comfortable | 40.52 |
| Weighted Overheat Hours | 9660 |

EUI [kWh/m2]: 181.2



## Concept Stage Final Results

### Modelling Key Assumptions

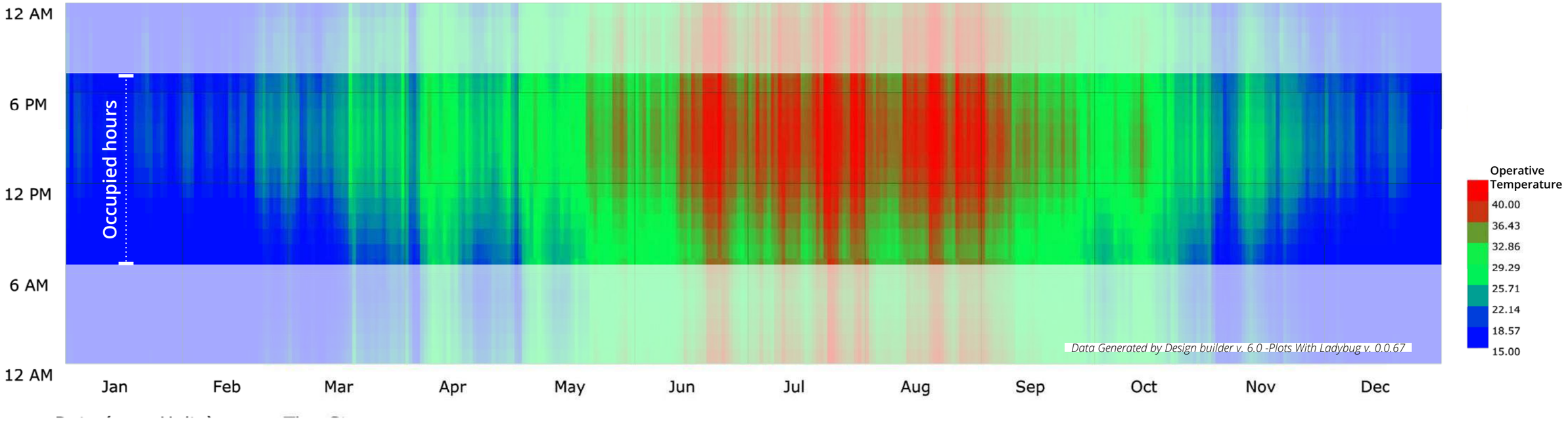
| | |
|---|---|
| **Thermal** | Infiltration Constant Rate(Scheduled method): 1 ACH |
| **HVAC** | Template: General Energy Code<br>Mechanical Ventilation: Off<br>Natural Ventilation: On<br>Natural Ventilation Method: Scheduled<br>Occupancy density[people/s.q.m.]: 0.5 |

| Surface | Construction | U-value |
|---|---|---|
| External walls | Brick air l/w concrete block & l/w plaster | 0.95 |
| Below grade walls | Brick air l/w concrete block & l/w plaster | 0.95 |
| Flat Roof | 19mm felt/bitumen on 25mm eps slab on 3mm steel | 1.245 |
| Pitched roof(occupied) | 19mm felt/bitumen on 25mm eps slab on 3mm steel | 1.24 |
| Pitched roof(unoccupied) | 19mm felt/bitumen on 25mm eps slab on 3mm steel | 1.245 |
| Partitions | Project partition | 1.6 |
| Semi-exposed walls | Brick air l/w concrete block & l/w plaster | 0.95 |
| Semi-exposed Ceilings | 19mm felt/bitumen on 25mm eps slab on 3mm steel | 1.245 |
| Semi-exposed floor | Floors, Steel-Joist, Spray-On Ins, R0.7) 4-) | 0.84 |
| Ground floor | Floors, Steel-Joist, Spray-On Ins, R0.7) 4-) | 0.84 |
| External floor | Floors, Steel-Joist, Spray-On Ins, R0.7) 4-) | 0.84 |
| Internal floor | Project internal floor | 2.9 |
| Glazing | Project external glazing | 1.96 |

| Space | Category | Name |
|---|---|---|
| Lounge/Foodcourt seating area/Study halls | ASHRAE | Educational Facilities - Multi-use assembly (%200 population of conference/meeting room) |
| Game Room | ASHRAE | Sports and Entertainment - Health club/aerobics room |
| Multi-functional | ASHRAE | Educational Facilities - Multi-use assembly (%200 population of conference/meeting room) |
| Conference hall | ASHRAE | Exh/w Assumed Occ/Rp/Ra - WC-public (continous operation>25 - (%50 L/(s*unit) |
| Gallery | ASHRAE | Public Assembly Spaces - Museum/gallery |
| Elevator shafts/ Staircase/ facilities/parkings,... | Libraries | Circulation area (corridors and stairways) - non public |
| Classrooms | ASHRAE | Educational Facilities - Classroom (+9) |
| Conference room | ASHRAE | General - Conference/Meeting |
| Prayers room | ASHRAE | General - Conference/Meeting |
| Administration+ student associations | ASHRAE | Office Buildings - Office--Enclosed |

## Energy and Comfort Results

| | | |
|---|---|---|
| Thermal Comfort | Overheat[% of Occ Times] | 38.39 |
| | Underheat[% of Occ Times] | 32.68 |
| | Comfortable[% of Occ Times] | 28.93 |
| | Weighted Overheat[% of Occ Times] | 11371 |
| Energy | Total Cooling Energy[kWh/m2] | 61 |
| | Total Heating Energy[kWh/m2] | 37 |
| | Energy Use Intensity[kWh/m2] | 197 |
| | Primary Energy[kWh/m2] | 618 |



# 03 Design **Developement**

# Constructions Alternatives

## Glazings

**Window-Base** — 380,000 T

| Name | SHGC[%] | VT[%] | VT/SHGC | Total U-value |
|---|---|---|---|---|
| Dbl Blue 6mm/13mm Air | 0.497 | 0.505 | 1.02 | **2.67** |

**Dbl Low-E** — 450,000 T

| Name | SHGC[%] | VT[%] | VT/SHGC | Total U-value |
|---|---|---|---|---|
| Dbl Blue 6mm/13mm Air | 0.598 | 0.789 | 1.29 | **1.786** |

**V-Cool Low-E** — 550,000 T

| Name | SHGC[%] | VT[%] | VT/SHGC | Total U-value |
|---|---|---|---|---|
| Dbl Blue 6mm/13mm Air | 0.31 | 0.55 | 1.77 | **1.1** |

## Ground Floors

**Ground Floor-Base** — 200,000 T

| Layer | Thichness | Conductivity | R-Value | Total U-value |
|---|---|---|---|---|
| Mosaic | 0.22 | 1.65 | 0.13 | **1.58** |
| Concrete | 0.1 | 0.25 | 0.40 | |
| Hardcore | 0.35 | 3.5 | 0.10 | |

**G.F Insulation L.1** — 230,000 T

| Layer | Thichness | Conductivity | R-Value | Total U-value |
|---|---|---|---|---|
| Mosaic | 0.22 | 1.65 | 0.13 | **0.72** |
| XPS | 0.030 | 0.04 | 0.75 | |
| Concrete | 0.1 | 0.25 | 0.40 | |
| Hardcore | 0.35 | 3.5 | 0.10 | |

**G.F Insulation L.2** — 260,000 T

| Layer | Thichness | Conductivity | R-Value | Total U-value |
|---|---|---|---|---|
| Mosaic | 0.22 | 1.65 | 0.13 | **0.47** |
| XPS | 0.060 | 0.04 | 1.50 | |
| Concrete | 0.1 | 0.25 | 0.40 | |
| Hardcore | 0.35 | 3.5 | 0.10 | |

**PCM-Coated Partition Walls** — 300,000 T

| | |
|---|---|
| Conductivity[W/m-k] | 0.20 |
| Thickness [mm] | 74 |
| Specific Heat [J/kg-K] | 1970 |
| Density[700] | 235 |

**PCM-Coated Partition Walls** — 360,000 T

| | |
|---|---|
| Conductivity[W/m-k] | 0.81 |
| Thickness [mm] | 50 |
| Specific Heat [J/kg-K] | 3140 |
| Density[700] | 929 |

**Green Roof**

| | |
|---|---|
| Moisture diffusion calculation method | Advanded |
| Height of plants[m] | 0.1 |
| Leaf Area index [LAI] | 2.7 |
| Leaf reflectivity | 0.22 |
| Leaf emissivity | 0.95 |
| Minimum stomatal resistance[s/m] | 180 |
| Max volumetric moisture content | 0.5 |
| Min residual volumetric moisture content | 0.01 |
| initial volumetric moisture content | 0.15 |

Other Modelling Assumptions = Concept Stage Final Model Assumptions

## Walls

**Brick Wall** — 100,000 T

| Layer | Thichness | Conductivity | R-Value | Total U-value |
|---|---|---|---|---|
| Inside Air | | | 0.11 | 1.59 |
| Gypsum plaster | 0.005 | 0.31 | 0.02 | |
| Gypsum-sand plaster | 0.02 | 0.59 | 0.03 | |
| Heavy Weight Brick | 0.22 | 0.69 | 0.32 | |
| Cement-Sand Plaster | 0.025 | 0.44 | 0.06 | |
| Light Weight Brick | 0.03 | 0.8 | 0.04 | |
| Outside Air | | | 0.06 | |

**AAC Block Wall** — 130,000 T

| Layer | Thichness | Conductivity | R-Value | Total U-value |
|---|---|---|---|---|
| Inside Air | | | 0.11 | **0.49** |
| Gypsum plaster | 0.005 | 0.31 | 0.02 | |
| Gypsum-sand plaster | 0.02 | 0.59 | 0.03 | |
| AAC Block | 0.22 | 0.158 | 1.39 | |
| Cement-Sand Plaster | 0.025 | 0.44 | 0.06 | |
| Light Weight Brick | 0.03 | 0.08 | 0.38 | |
| Outside Air | | | 0.06 | |

**AAC Block Insulation L.1** — 160,000 T

| Layer | Thichness | Conductivity | R-Value | Total U-value |
|---|---|---|---|---|
| Inside Air | | | 0.11 | **0.10** |
| Gypsum plaster | 0.005 | 0.31 | 0.02 | |
| Gypsum-sand plaster | 0.02 | 0.59 | 0.03 | |
| AAC Block | 0.22 | 0.158 | 1.39 | |
| XPS | 0.030 | 0.004 | 7.50 | |
| Cement-Sand Plaster | 0.025 | 0.44 | 0.06 | |
| Light Weight Brick | 0.03 | 0.08 | 0.38 | |
| Outside Air | | | 0.06 | |

## Roofs

**Roof-Base** — 450,000 T

| Layer | Thichness | Conductivity | R-Value | Total U-value |
|---|---|---|---|---|
| Outside Air | | | 0.05 | **1.000** |
| Polyurethane | 0.010 | 0.25 | 0.04 | |
| XPS | 0.030 | 0.04 | 0.73 | |
| Concrete | 0.220 | 2.5 | 0.09 | |
| Inside Air | | | 0.09 | |

**Roof -Insulation L.1** — 480,000 T

| Layer | Thichness | Conductivity | R-Value | Total U-value |
|---|---|---|---|---|
| Outside Air | | | 0.05 | **0.578** |
| Polyurethane | 0.010 | 0.25 | 0.04 | |
| XPS | 0.060 | 0.04 | 1.46 | |
| Concrete | 0.220 | 2.5 | 0.09 | |
| Inside Air | | | 0.09 | |

**Roof -Insulation L. 2** — 510,000 T

| Layer | Thichness | Conductivity | R-Value | Total U-value |
|---|---|---|---|---|
| Outside Air | | | 0.05 | **0.406** |
| Polyurethane | 0.010 | 0.25 | 0.04 | |
| XPS | 0.090 | 0.04 | 2.20 | |
| Concrete | 0.220 | 2.5 | 0.09 | |
| Inside Air | | | 0.09 | |

**Cool Roof+ Insulation L.1** — 490,000 T

| Layer | Thichness | Conductivity | R-Value | Total U-value |
|---|---|---|---|---|
| Outside Air | | | 0.05 | **0.577** |
| CoolCoating | 0.002 | 1 | 0.00 | |
| Polyurethane | 0.010 | 0.25 | 0.04 | |
| XPS | 0.060 | 0.04 | 1.46 | |
| Concrete | 0.220 | 2.5 | 0.09 | |
| Inside Air | | | 0.09 | |

**Cool Roof+ Insulation L.2** — 520,000 T

| Layer | Thichness | Conductivity | R-Value | Total U-value |
|---|---|---|---|---|
| Outside Air | | | 0.05 | **0.406** |
| CoolCoating | 0.002 | 1 | 0.00 | |
| Polyurethane | 0.010 | 0.25 | 0.04 | |
| XPS | 0.090 | 0.04 | 2.20 | |
| Concrete | 0.220 | 2.5 | 0.09 | |
| Inside Air | | | 0.09 | |

**Green Roof+Insulation L.1** — 930,000 T

| Layer | Thichness | Conductivity | R-Value | Total U-value |
|---|---|---|---|---|
| Green Roof | 0.1 | 1.35 | 0.22 | **0.487** |
| Polyurethane | 0.010 | 0.25 | 0.04 | |
| XPS | 0.060 | 0.04 | 1.46 | |
| Concrete | 0.220 | 2.5 | 0.09 | |
| Inside Air | | | 0.09 | |

**Green Roof+ Insulation Level2** — 960,000 T

| Layer | Thichness | Conductivity | R-Value | Total U-value |
|---|---|---|---|---|
| Green Roof | 0.1 | 1.35 | 0.22 | **0.373** |
| Polyurethane | 0.010 | 0.25 | 0.04 | |
| XPS | 0.090 | 0.04 | 2.20 | |
| Concrete | 0.220 | 2.5 | 0.09 | |
| Inside Air | | | 0.09 | |

## Constructions Selection (Step1)

| | Base Case | Insulation1 | Insulation2 | Cool Roof + Insulation1 | Window + Insulation 2 | Green Roof +Insulation1 | Green Roof +Insulation2 | PCM+Insulation1 | PCM+Insulation2 |
|---|---|---|---|---|---|---|---|---|---|
| **Roof** | Roof-Base | Roof -Insulation L.1 | Roof -Insulation L. 2 | Cool Roof+ Insulation L.1 | Cool Roof+ Insulation L.2 | Green Roof+Insulation L.1 | Green Roof+ Insulation Level2 | Roof -Insulation L.1 | Roof -Insulation L. 2 |
| **walls** | Brick Wall | AAC Block Wall | AAC Block Insulation L.1 | AAC Block Wall | AAC Block Insulation L.1 | AAC Block Wall | AAC Block Insulation L.1 | AAC Block Wall | AAC Block Insulation L.1 |
| **Ground Floors** | Ground Floor-Base | G.F Insulation L.1 | G.F Insulation L.2 | G.F Insulation L.1 | G.F Insulation L.2 | G.F Insulation L.1 | G.F Insulation L.2 | G.F Insulation L.1 | G.F Insulation L.2 |
| **Partition Walls** | - | - | - | - | - | - | - | PCM Coating | PCM Coating |
| **Glazings** | Window-Base | Dbl Low-E | V-Cool Low-E | Dbl Low-E | V-Cool Low-E | Dbl Low-E | V-Cool Low-E | Dbl Low-E | V-Cool Low-E |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Thermal Comfort | Overheat[% of Occ Times] | 38.39 | 39.66 | 40.30 | 39.66 | 39.26 | 39.69 | 40.28 | 40.00 | 40.51 |
| | Underheat[% of Occ Times] | 32.68 | 19.93 | 16.66 | 19.93 | 18.88 | 19.37 | 16.39 | 18.72 | 15.37 |
| | Comfortable[% of Occ Times] | 28.93 | 40.41 | 43.04 | 40.41 | 41.87 | 40.95 | 43.33 | 41.28 | 44.12 |
| | Weighted Overheat[% of Occ Times] | 11371.97 | 9639.56 | 9737.24 | 9639.56 | 9388.02 | 9642.13 | 9746.07 | 9804.00 | 9935.75 |
| Energy | Total Cooling Energy[kWh/m2] | 61.51 | 65.50 | 64.32 | 65.50 | 61.15 | 65.35 | 64.24 | 64.79 | 64.29 |
| | Total Heating Energy[kWh/m2] | 37.13 | 19.13 | 15.21 | 19.13 | 17.12 | 18.52 | 14.90 | 18.60 | 13.58 |
| | Energy Use Intensity[kWh/m2] | 194.6589648 | 194.6589648 | 175.0976451 | 181.8942886 | 173.8388976 | 181.1384741 | 174.7209388 | 180.078035 | 172.7625924 |
| | Primary Energy[kWh/m2] | 607.9408819 | 606.9913805 | 592.3348687 | 606.9913805 | 583.018026 | 605.7875893 | 591.733734 | 601.7929637 | 588.0070681 |
| Cost Analysis | Total Material Cost[T] | 1565476.333 | 2227491.333 | 2027704.733 | 1800877.333 | 2062764.733 | 2572197.333 | 2816554.733 | 2756997.333 | 3001354.733 |
| | Total Material Cost-BaseCase Cost[T] | 0 | 662015 | 462228.3999 | 235401 | 497288.3999 | 1006721 | 1251078.4 | 1191521 | 1435878.4 |
| | Annual Natural Gas Cost[T] | 4780459.615 | 2462961.058 | 1957711.442 | 2462961.058 | 2204138.654 | 2384834.135 | 1918831.442 | 2393951.25 | 1747690.096 |
| | Annual Electricity Costs[T] | 572568472 | 591251496 | 580946584 | 591251496 | 569618104 | 590719656 | 580679864 | 586888376 | 578226440 |
| | Total Energy Cost- Base Enegy Cost[T] | 0 | 16365525.44- | 5555363.827- | 16365525.44- | 5526688.962 | 15755558.52- | 5249763.827- | 11933395.63- | 2625198.481- |
| | Pay-back Period[years] | 0 | **-40** | **-83** | **-14** | **90** | **-63** | **-238** | **-100** | **-546** |

## Constructions Selection (Step2)

| | Base Case | Base+CoolRoof | Base+GreenRoof | Base+PCM | Window Dbl Low-E + CoolRoof | Window Dbl Low-E + GreenRoof | Window Dbl Low-E + PCM |
|---|---|---|---|---|---|---|---|
| **Roof** | Roof-Base | Roof -Insulation L.1 | Roof -Insulation L. 2 | Cool Roof+ Insulation L.1 | Cool Roof+ Insulation L.2 | Green Roof+Insulation L.1 | Green Roof+ Insulation Level2 |
| **External walls** | Brick Wall | AAC Block Wall | AAC Block Insulation L.1 | AAC Block Wall | AAC Block Insulation L.1 | AAC Block Wall | AAC Block Insulation L.1 |
| **Ground Floors** | Ground Floor-Base | G.F Insulation L.1 | G.F Insulation L.2 | G.F Insulation L.1 | G.F Insulation L.2 | G.F Insulation L.1 | G.F Insulation L.2 |
| **Partition Walls** | - | - | - | - | - | - | - |
| **Glazings** | Window-Base | Dbl Low-E | V-Cool Low-E | Dbl Low-E | V-Cool Low-E | Dbl Low-E | V-Cool Low-E |
| **Thermal Comfort** | | | | | | | |
| Overheat[% of Occ Times] | 38.39 | 35.81 | 36.98 | 35.81 | 36.68 | 37.94 | 37.89 |
| Underheat[% of Occ Times] | 32.68 | 33.01 | 30.55 | 32.32 | 30.13 | 26.41 | 35.21 |
| Comfortable[% of Occ Times] | 28.93 | 31.19 | 32.47 | 31.87 | 33.19 | 35.66 | 26.90 |
| Weighted Overheat[% of Occ Times] | 11371.97 | 8178.91593 | 8774.26067 | 8857.21531 | 8607.53653 | 9217.68164 | 11693.35722 |
| **Energy** | | | | | | | |
| Total Cooling Energy[kWh/m2] | 61.51 | 56.07 | 60.91 | 60.51 | 58.19 | 63.35 | 63.14 |
| Total Heating Energy[kWh/m2] | 37.13 | 40.11 | 35.69 | 31.58 | 34.82 | 30.60 | 28.06 |
| Energy Use Intensity[kWh/m2] | 194.6589648 | 192.4455434 | 192.7686444 | 187.7215909 | 189.29324 | 128.9144432 | 186.7969594 |
| Primary Energy[kWh/m2] | 607.9408819 | 592.5303733 | 604.7479848 | 596.8569922 | 594.4147161 | 607.9149442 | 602.3253166 |
| **Cost Analysis** | | | | | | | |
| Total Material Cost[T] | 1565476.333 | 1583006.333 | 2354326.333 | 1787236.333 | 1644807.933 | 2416127.933 | 1849037.933 |
| Total Material Cost-BaseCase Cost[T] | 0 | 17530 | 788850 | 221760 | 79331.6 | 850651.6 | 283561.6 |
| Annual Natural Gas Cost[T] | 4780459.615 | 5163703.846 | 4594442.308 | 4065144.231 | 561755776 | 3939536.538 | 3612132.692 |
| Annual Electricity Costs[T] | 572568472 | 554112440 | 571024520 | 567517056 | 566238050 | 579715160 | 576779272 |
| Total Energy Cost- Base Enegy Cost[T] | 0 | 18072787.77 | 1729969.308 | 5766731.385 | 550644894.4- | 6305764.923- | 3042473.077- |
| Pay-back Period[years] | 0 | **1** | **455** | **38** | **7** | **-134** | **-93** |

## HVAC Selection



**CAV**



**VAV**



**Fan Coil**

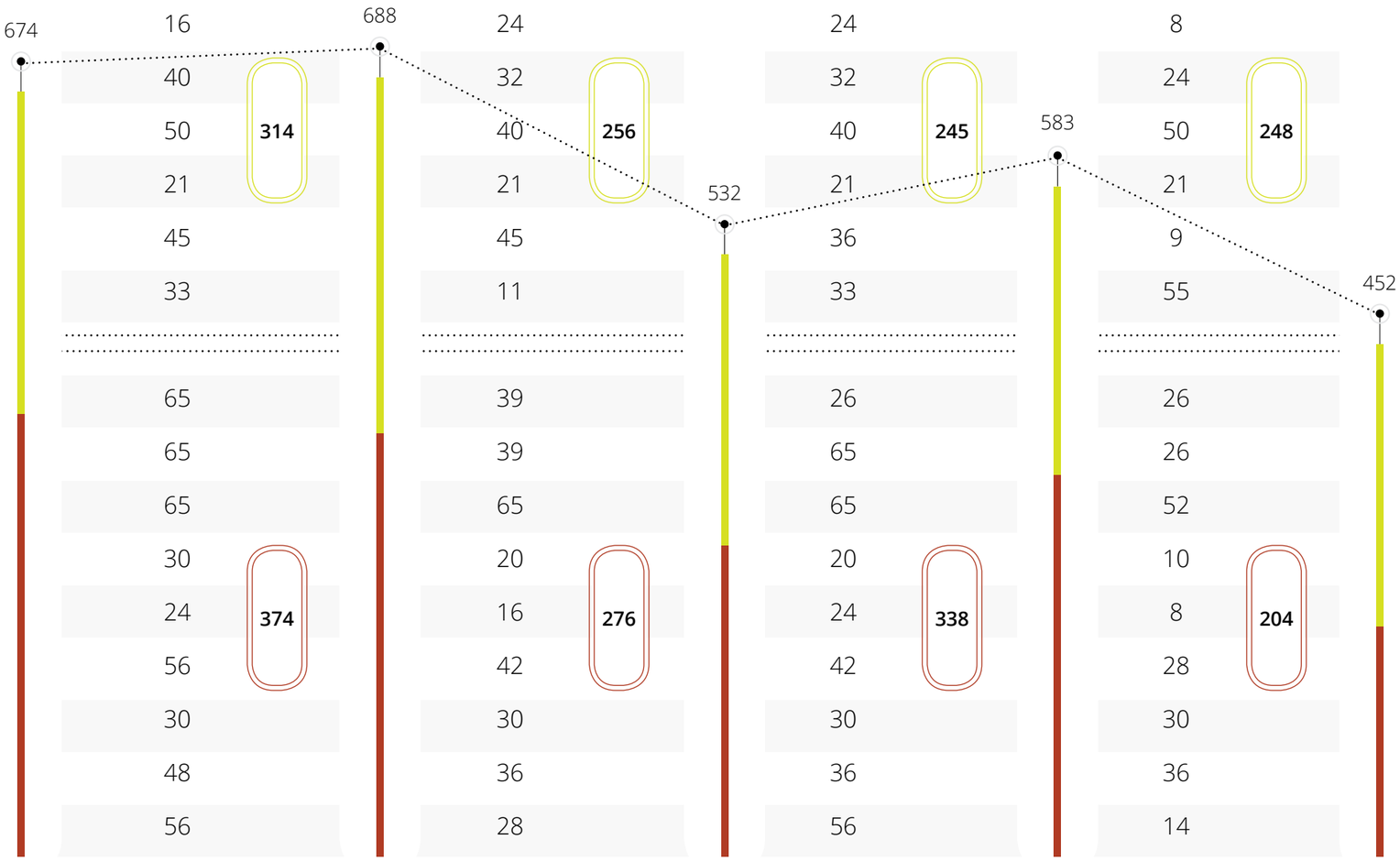


**Forced Air**



**Radient**

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **General Aspects** | Noise | 4 | 44 | | 44 | | 44 | | 33 | | 55 | |
| | Initial Cost | 4 | 16 | | 16 | | 24 | | 24 | | 8 | |
| | Opperating Cost | 2 | 32 | | 40 | | 32 | | 32 | | 24 | |
| | Occupancy | 4 | 50 | 284 | 50 | 314 | 40 | 256 | 40 | 245 | 50 | 248 |
| | Frequency of Use | 4 | 21 | | 21 | | 21 | | 21 | | 21 | |
| | User Control | 4 | 36 | | 45 | | 45 | | 36 | | 9 | |
| | Aesthetics | 2 | 33 | | 33 | | 11 | | 33 | | 55 | |
| **Energy Use and Technical aspects** | Enegry Consumption | 4 | 52 | | 65 | | 39 | | 26 | | 26 | |
| | Cooling Capacity | 5 | 65 | | 65 | | 39 | | 65 | | 26 | |
| | Heating Capacity | 5 | 65 | | 65 | | 65 | | 65 | | 52 | |
| | Humidity | 3 | 30 | 390 | 30 | 374 | 20 | 276 | 20 | 338 | 10 | 204 |
| | Pressure Control | 4 | 40 | | 24 | | 16 | | 24 | | 8 | |
| | Efficiency | 4 | 56 | | 56 | | 42 | | 42 | | 28 | |
| | Envriomental Impact | 2 | 30 | | 30 | | 30 | | 30 | | 30 | |
| | Life Span | 4 | 48 | | 48 | | 36 | | 36 | | 36 | |
| | Saftey and health | 5 | 56 | | 56 | | 28 | | 56 | | 14 | |



## HVAC Selection **Results**

| | Base Case | Package 1 | Package 2 | Package 3 | Package 4 | Package 5 | Package 6 | Package 7 |
|---|---|---|---|---|---|---|---|---|
| **Hot Water Supply** | Gas Boiler | Gas Boiler | Gas Boiler | Gas Boiler | Gas Boiler | Gas Boiler | Gas Boiler | Gas Boiler |
| **Chilled Water Supply** | Air Cooled Chiller | Air Cooled Chiller | Air Cooled Chiller | Air Cooled Chiller | Air Cooled Chiller | Air Cooled Chiller | Air Cooled Chiller | Air Cooled Chiller |
| **Terminals** | VAV + Reheat /All Spaces | VAV + Reheat / Communal Spaces Fan Coil Units/Small Spaces | VAV + Reheat /All Spaces | VAV + Reheat / Communal Spaces Fan Coil Units/Small Spaces | VAV + Reheat /All Spaces | VAV + Reheat / Communal Spaces Fan Coil Units/Small Spaces | VAV + Reheat /All Spaces | VAV + Reheat / Communal Spaces Fan Coil Units/Small Spaces |
| **Energy Conservation Systems** | - | - | Economiser | Economiser | Heat Recovery | Heat Recovery | Heat Recovery + Economiser | Heat Recovery + Economiser |

| Energy | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Gas[kWh/m2]** | 36.4 | 28.6 | 39.5 | 28.6 | 36.4 | 28.6 | 28.6 | 28.6 |
| **HVAC Electicity[kWh/m2]** | 59.9 | 54.3 | 57.5 | 46.8 | 53.8 | 46.6 | 46.7 | 46.7 |
| **HVAC total Energy[kWh/m2]** | 96.3 | 82.9 | 97.0 | 75.4 | 90.2 | 75.2 | 75.3 | 75.3 |
| **Total EUI[kWh/m2]** | 192.9 | 179.5 | 193.5 | 171.9 | 186.8 | 171.8 | 171.9 | 171.9 |
| **total primary[kWh/m2]** | **603.4** | **574.5** | **598.1** | **547.5** | **581.4** | **546.9** | **547.5** | **547.5** |

## Lighting System

| | ASHRAE Reference | Fluorescent | LED | LED+Linear control | LED+ Stepped control | LED+ Linear / off |
|---|---|---|---|---|---|---|
| **Normalised power density [W/m2]** | 5 | 3.3 | 2.5 | 2.5 | 2.5 | 2.5 |
| **Return Air Fraction** | 0 | 0 | 0 | 0 | 0 | 0 |
| **Radient Fraction** | 0.42 | 0.42 | 0.42 | 0.42 | 0.42 | 0.42 |
| **Visible Fraction** | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 |
| **Lighting Control** | Off | Off | Off | On | On | On |
| **Control type** | - | - | - | Linear | Stepped | Stepped |

| Energy | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Lighting Energy[kWh/m2]** | 90 | 60.0 | 45.4 | 26.2 | 25.6 | 24.2 |
| **Total EUI[kWh/m2]** | 205 | 140.2 | 125.4 | 105.5 | 104.9 | 102.6 |
| **Total Primary Energy[kWh/m2]** | **699** | **429.9** | **375.0** | **301.7** | **305.6** | **299.6** |

### System Sizing

1.25 Design Margin — **Heating Load** — 653.8 kWh

1.15 Design Margin — **Cooling Design Capacity** — 563.1 kWh

**Design Flow Rate** — 35.6 m3/s

# HVAC System **Diagram** And **Specifications**

## Modelling Key Assumptions

### Chiller

| | |
|---|---|
| Reference capacity | Autosize |
| Reference cop | 5.5 |
| Compressor motor efficiency | 1 |
| sizing Factor | 1 |
| Condenser fan power ratio | 0.035 |
| Reference leaving chilled water temperature | 6.67 |
| Reference entering condenser fluid temperature | 29.4 |
| Leaving chilled water temperature limit | 2 |
| Reference chilled water flow rate | autosize |
| Minimum part load ratio | 0.1 |
| Maximum part load ratio | 1 |
| Optimum part load ratio | 1 |
| Maximum unloading ratio | 0.25 |

### Chiller pump

| | |
|---|---|
| Design power consumption[W] | Autosize |
| Design Pump head[Pa] | 20000 |
| Design minimum flow rate[m3/s] | 0 |
| Motor efficiency | 0.9 |
| Fraction of Motor Inefficiencies to fluid stream | 0 |
| Comp control type | intermittent |

### Boiler

| | |
|---|---|
| Fuel type | Natural Gas |
| Nominal capacity[W] | Autosize |
| Parasitic electric load[W] | 25 |
| Sizing Factor | 1 |
| Nominal thermal efficiency | 0.89 |

### Boiler pump

| | |
|---|---|
| Design power consumption[W] | Autosize |
| Design Pump head[Pa] | 20000 |
| Design minimum flow rate[m3/s] | 0 |
| Motor efficiency | 0.9 |
| Fraction of Motor Inefficiencies to fluid stream | 0 |
| Comp control type intermittent | |

### AHU

| | |
|---|---|
| Availability | On 7/24 |

### Supply and extract fan

| | |
|---|---|
| Fan Total Efficiency | 0.7 |
| Pressure rise[Pa] | 600 |
| Motor efficiency | 0.9 |

## HVAC System Diagram

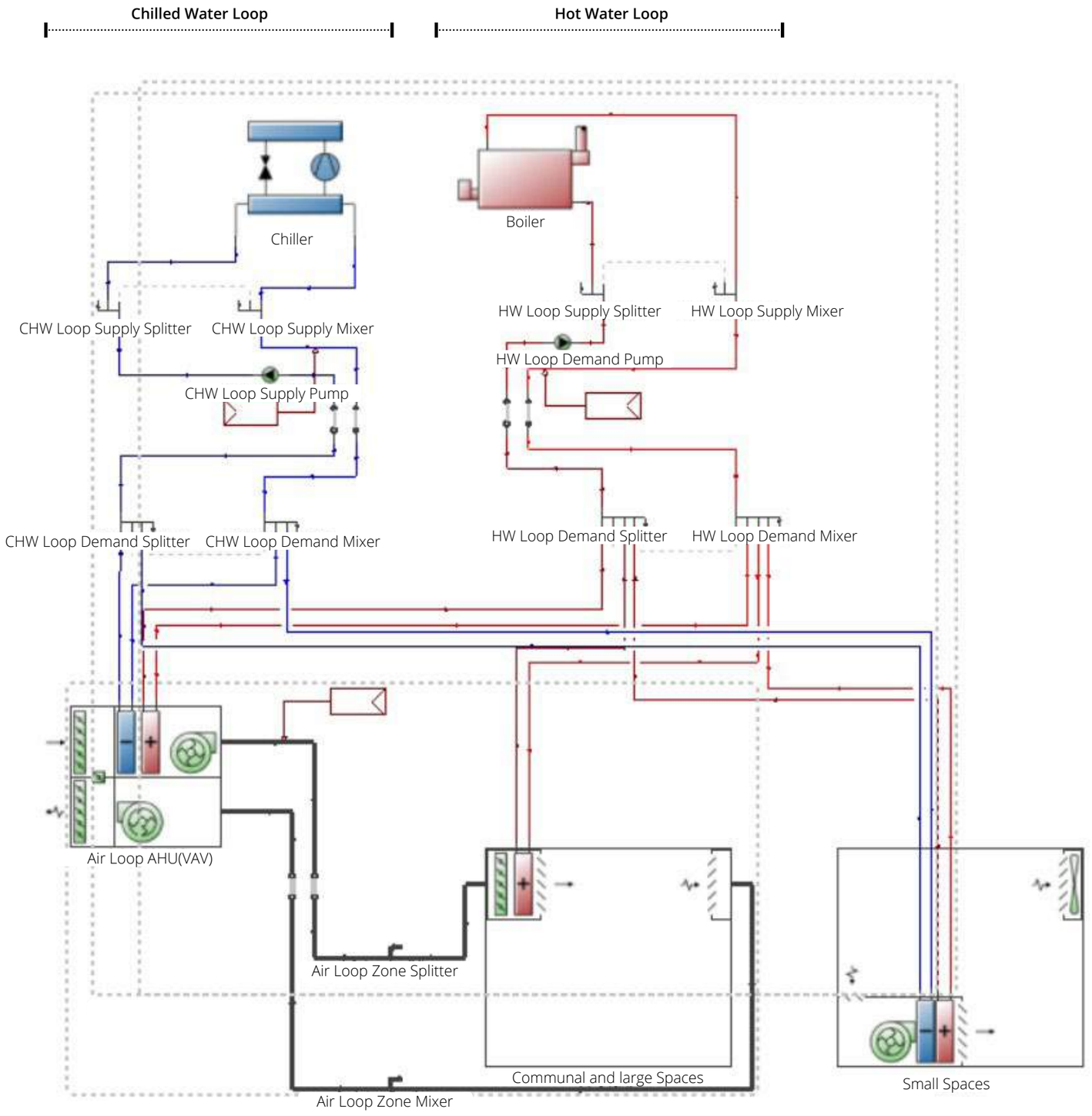
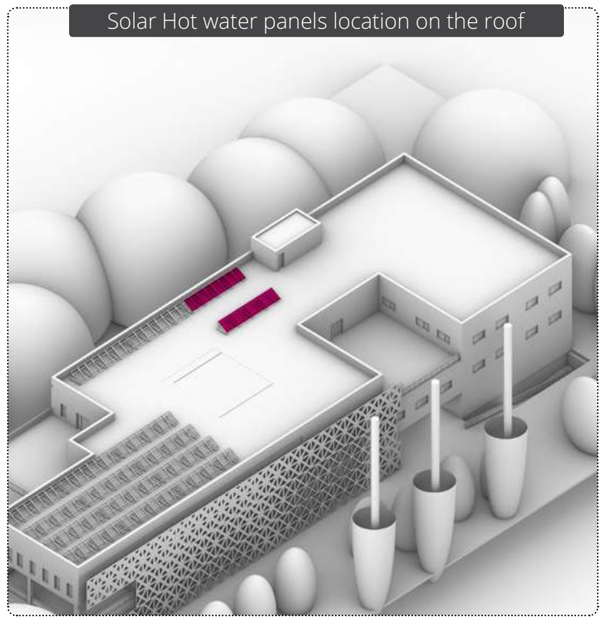



*Diagram Generated by Design builder v. 6.0*

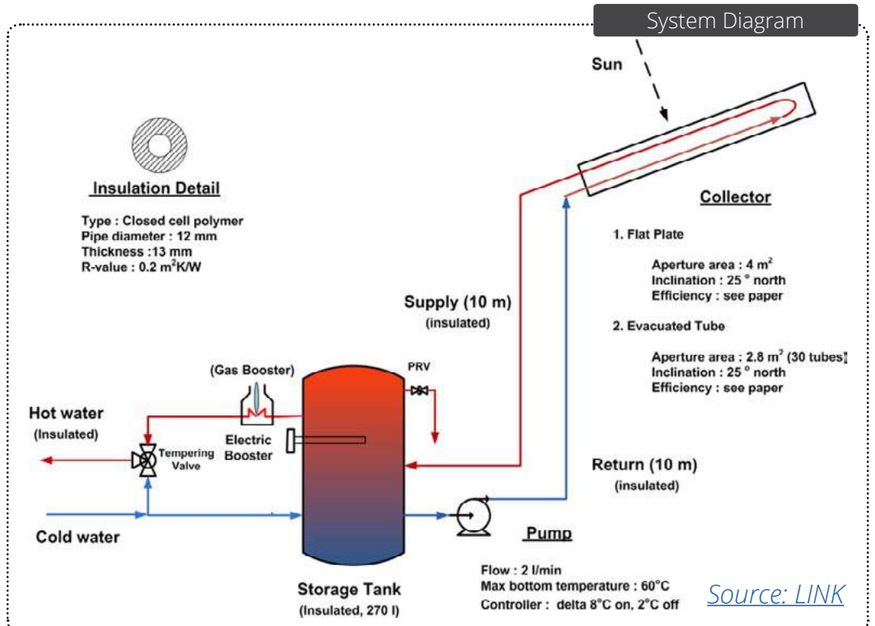
## **Solar DHW system** design

| | |
|---|---|
| Collector Optical Efficiency | 0.7 |
| Collector Thermal Loss[W/m2/C] | 4 |
| Collector Active Area Percent[%] | 90 |
| Working Fluid Heat Capacity[J/kg/C] | 3840 |
| Flow rate per m2[kg/s/m2] | 0.012 |
| IAM Coefficient | 0.1 |
| Sky exposure factor | 1 |
| Beam Index per hour | 1 |
| Max Working Temperature[C] | 95 |
| Discharge Temperature[C] | 3- |
| Delivary water temperature[C] | 60 |
| AVR January Cold Water Temperature[C] | 1 |
| Mechanical Room Temperature[C] | 20 |
| Pipe Length | 50 |
| tank size[lit] | 100 |
| tank loss[W/m2/C] | 0.3 |
| height diameter tank ratio | 2.6 |
| heat exchange effectiveness | 0.8 |

Solar Hot water panels location on the roof

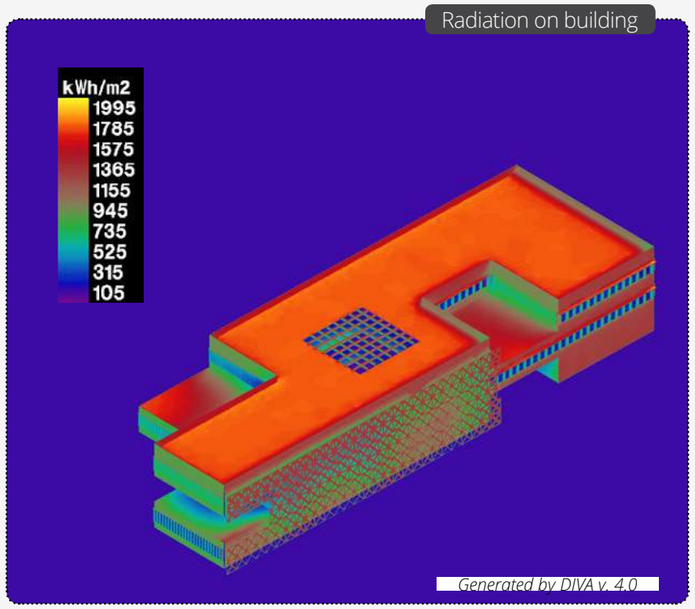


System Diagram

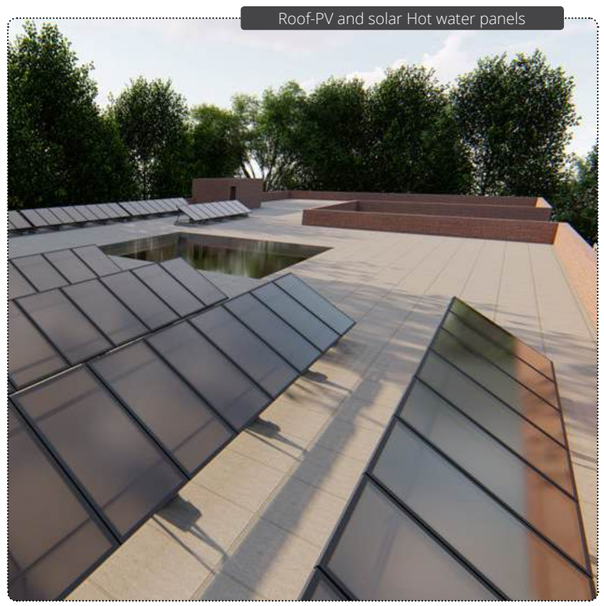



Source: LINK

Radiation on building




Roof-PV and solar Hot water panels



System Sizing

| Panels Total Area | DHW annual Load | Annual Solar DHW |
|---|---|---|
| 32 s.q.m. | 1989 kWh | 2460 kWh |

# Construction and Systems Final **Performance Results**

## Modelling Key Assumptions

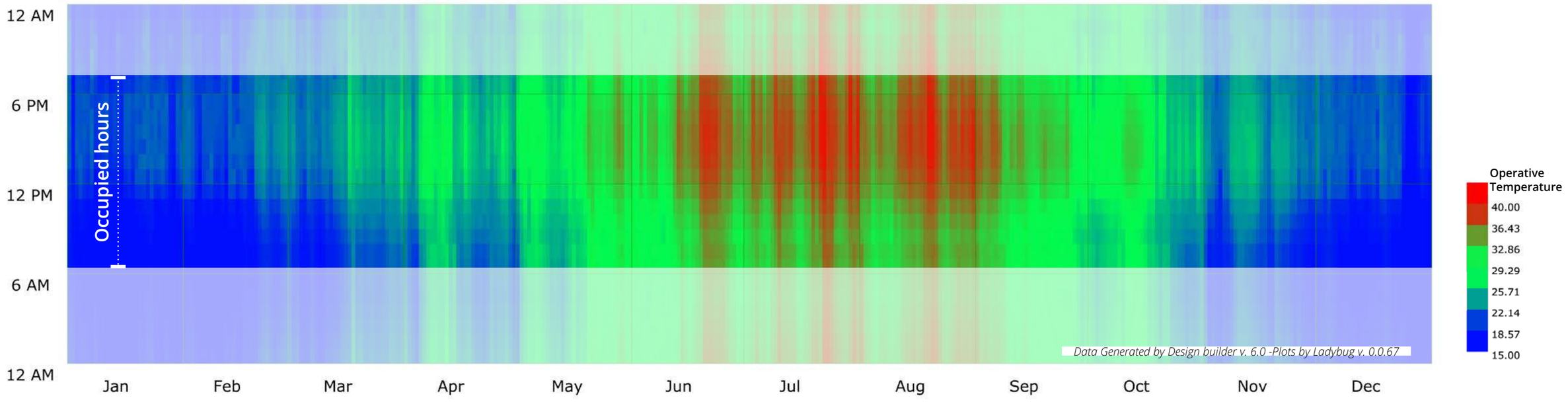
| | |
|---|---|
| **Thermal** | Building Airtightness: Medium |
| **HVAC** | VAV + Reheat /Communal Spaces |
| | Fan Coil Units/Small Spaces |
| | Natural Ventilation: On |
| | Natural Ventilation Method: Calculated |
| | Occupancy density[people/s.q.m.]: 0.5 |
| | Heating/ cooling Set points[C]: 20/27 |
| | Heating/ cooling Set backs[C]: 0/100 |
| **Lighting** | system: LED+Stepped Control |
| | Two lighting controls per zone |

| Surface | Construction | U-value |
|---|---|---|
| External walls | AAC Block Insulation L.1 | 0.1 |
| Below grade walls | Brick air l/w concrete block & l/w plaster | 0.95 |
| Flat Roof | Cool Roof+ Insulation L.2 | 1.245 |
| Partitions | Project partition | 1.6 |
| Semi-exposed walls | Brick air l/w concrete block & l/w plaster | 0.95 |
| Semi-exposed Ceilings | 19mm felt/bitumen on 25mm eps slab on 3mm steel | 1.245 |
| Semi-exposed floor | Floors, Steel-Joist, Spray-On Ins, R0.7) 4-) | 0.84 |
| Ground floor | G.F Insulation L.2 | 0.47 |
| External floor | Floors, Steel-Joist, Spray-On Ins, R0.7) 4-) | 0.84 |
| Internal floor | Project internal floor | 2.9 |
| Glazing | V-Cool Low-E | 1.5 |

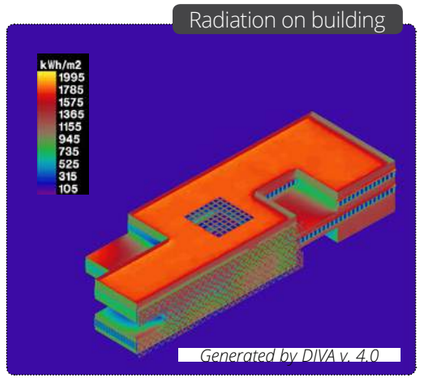
| Space | Category | Name |
|---|---|---|
| Lounge/Foodcourt seating area/Study halls | ASHRAE | Educational Facilities - Multi-use assembly (%200 population of conference/meeting room) |
| Game Room | ASHRAE | Sports and Entertainment - Health club/aerobics room |
| Multi-functional | ASHRAE | Educational Facilities - Multi-use assembly (%200 population of conference/meeting room) |
| Conference hall | ASHRAE | Exh/w Assumed Occ/Rp/Ra - WC-public (continous operation>25 - (%50 L/(s*unit) |
| Gallery | ASHRAE | Public Assembly Spaces - Museum/gallery |
| Elevator shafts/ Staircase/ facilities/parkings,... | Libraries | Circulation area (corridors and stairways) - non public |
| Classrooms | ASHRAE | Educational Facilities - Classroom (+9) |
| Conference room | ASHRAE | General - Conference/Meeting |
| Prayers room | ASHRAE | General - Conference/Meeting |
| Administration+ student associations | ASHRAE | Office Buildings - Office--Enclosed |

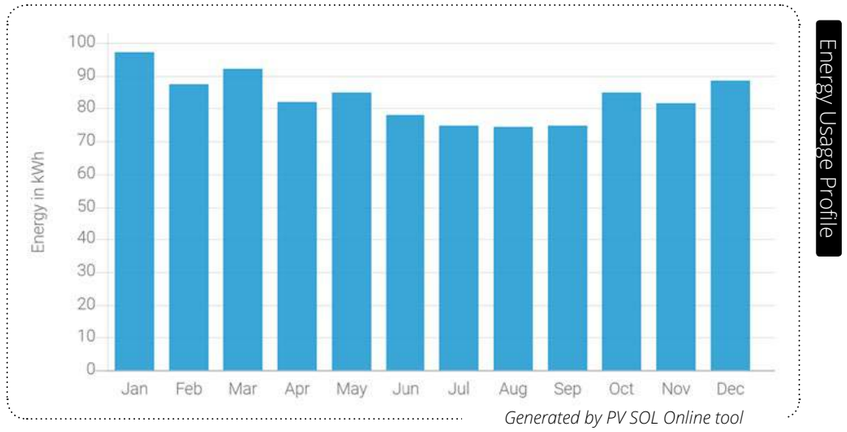
## Energy and Comfort Results

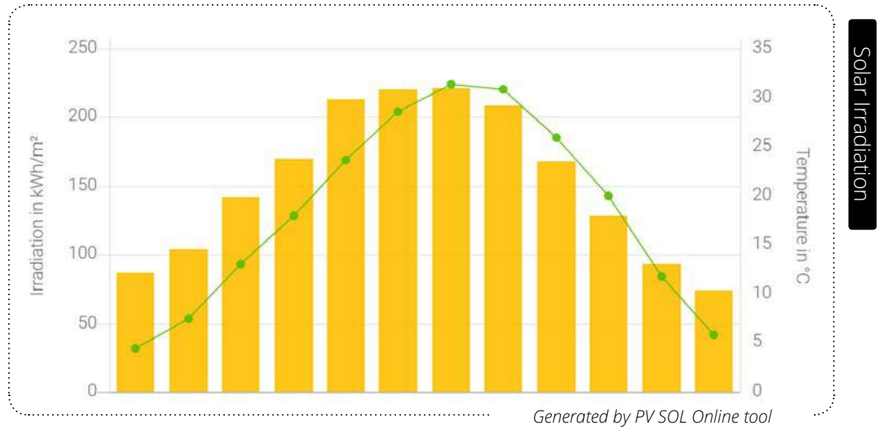
| | | |
|---|---|---|
| Thermal Comfort | Overheat[% of Occ Times] | 34.66 |
| | Underheat[% of Occ Times] | 23.53 |
| | Comfortable[% of Occ Times] | 41.81 |
| | Weighted Overheat[% of Occ Times] | 7534 |
| Energy | Total Cooling Energy[kWh/m2] | 23.3 |
| | Total Heating Energy[kWh/m2] | 16.35 |
| | Energy Use Intensity[kWh/m2] | 80.7 |
| | Primary Energy[kWh/m2] | 250 |



## Photovoltaic System design

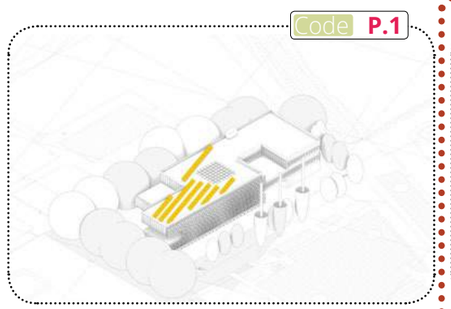


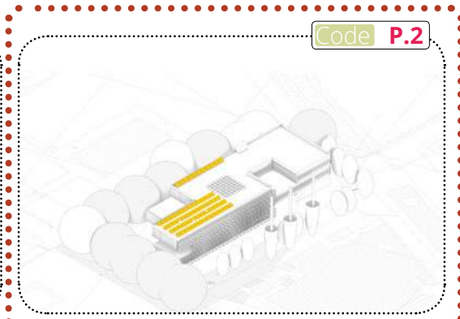



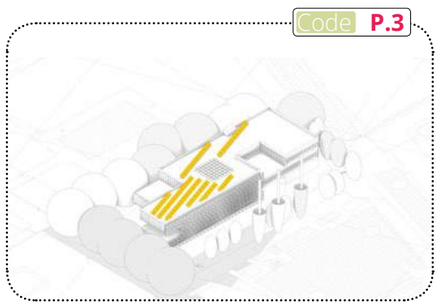



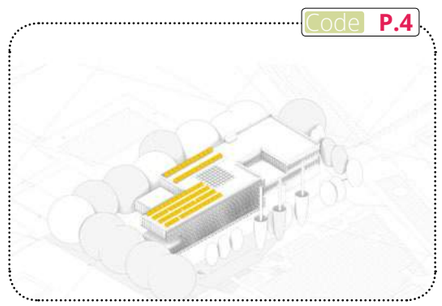

**PV key Assumptions**

| | |
|---|---|
| Efficiency[%] | 15 |
| DC to AC derate factor | 0.85 |
| Module Active Area[%] | 90 |
| module material | Crystalline Silicon (S-ci) |
| Temperature Coefficient[%] | 0.5-/C |



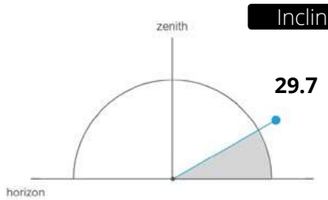

| | | P.1 | P.2 | P.3 | P.4 |
|---|---|---|---|---|---|
| General | PV panels Total Area[m2] | 180 | 180 | 219 | 219 |
| | Covered Roof Area[%] | 45 | 52.1 | 48 | 55.5 |
| | Orientation | 180 | 160 | 180 | 160 |
| | Inclination | 29.7 | 29.7 | 29.7 | 29.7 |
| | Nominal Power[kW] | 30 | 30 | 35 | 35 |
| Energy | Annual Electricity Generation [kWh] | 37006.02 | 36614.25 | 43467.39 | 43007.21 |
| | Annual Electricity Generation [kWh/m2] | 8.30 | 8.21 | 9.75 | 9.64 |
| | Generation/ Electricity Consumption [%] | 12.86 | 12.73 | 15.11 | 14.95 |
| | Generation/ Primary Energy [%] | 11.95 | 11.82 | 14.03 | 13.89 |
| Costs and Gains | Initial Cost [mT] | 240 | 240 | 280 | 280 |
| | Annual Gain [mT] | 4.07 | 4.03 | 4.78 | 4.73 |
| | Simple Payback Period | 7.12 | 7.2 | 7.07 | 7.15 |

## Final System information and Results

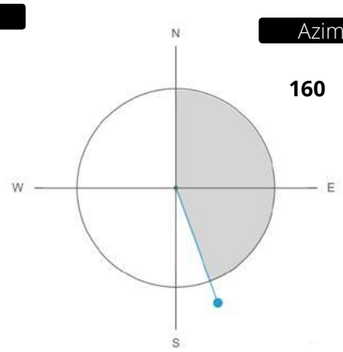
### Assumptions

| | |
|---|---|
| Results | |
| Annual PV energy[kWh] | 44477 |
| Spec. annual yield[kWh/kWp] | 1425.55 |
| Performance ratio[%] | 8357 |
| Annual PV energy | 44477 kWh |
| **General Information** | |
| Latitude | 35.74241 ° |
| Longitude | 51.57958 ° |
| Annual global irradiation | 1828.4 kWh/m² |
| Average temperature | 18.4 ° |
| Load profile | BDEW load profile business (G2) |
| pv modules total nominal power[kWp] | 31.2 |
| Modules Company | Shinsug Solar Eergy Co Ltd. |
| Model | SS-BM261 |
| Module Power [Wp] | 260 |
| Efficiancy[%] | 16.3 |
| Type | Mono |
| No. of Modules | 120 |
| Total PV power [kWp] | 31.2 |
| Inclination | 29.7 |
| Orientation | 160 |
| Installation type | Mounted-roof |
| Albedo[%] | 20 |
| Shadowing[%] | 12 |
| Soiling[%] | 5 |

### Inclination




### Azimuth

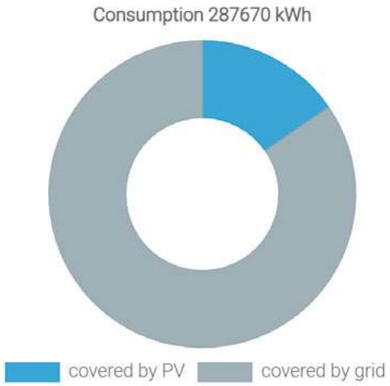



*Generated by PV SOL Online tool*

| | |
|---|---|
| Inverter | Donfoss Solar Inverters |
| Manufacturer | 20 |
| No. of Inverters | |
| **Configuration info** | **«3 x FLX Pro 9 (Danfoss Solar Inverters) MPP 1 :1 x 20 - MPP 1 :2 x 20»** |

### Results

| | |
|---|---|
| Consumption[kWh] | 287670 |
| covered by PV[kWh] | 44362 |
| covered by grid | 243308 |
| Solar fraction [%] | %15.40 |
| Avoided CO2 emissions [kg/year] | 23795 |

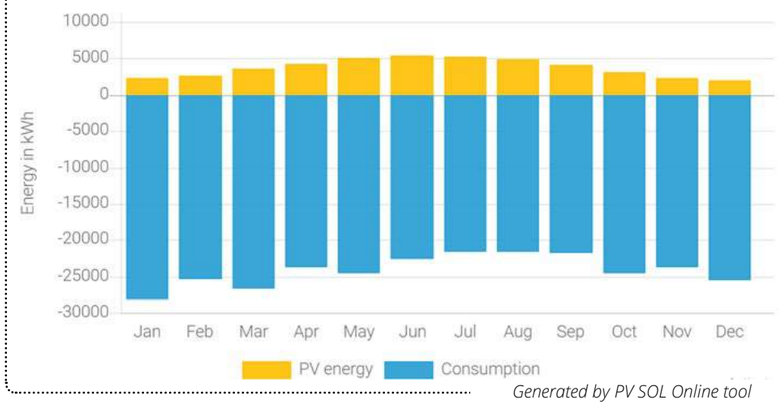



*Generated by PV SOL Online tool*

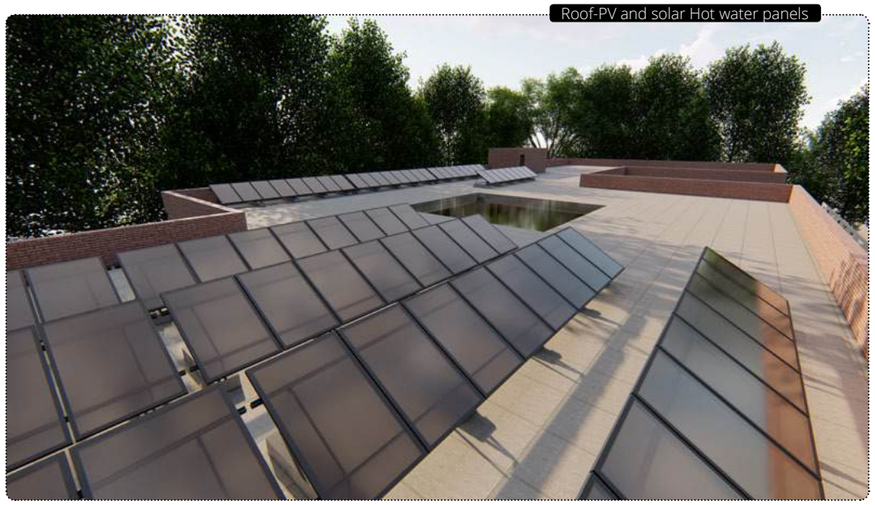
### Dimentioning factor




### Energy gains and Consumption




*Generated by PV SOL Online tool*



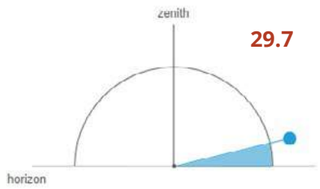

### Final Energy Consumption

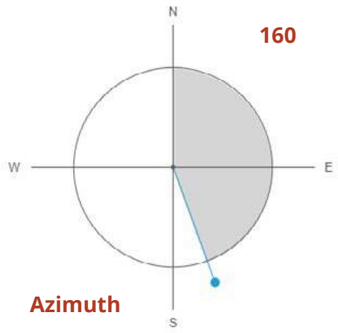
| | |
|---|---|
| Total Cooling Energy[kWh/m2] | 23.3 |
| Total Heating Energy[kWh/m2] | 16.35 |
| Total Electricity[kWh/m2] | 54.6 |
| Energy Use Intensity[kWh/m2] | 70.76 |
| Primary Energy[kWh/m2] | 220 |
| Annual financial gain[mT] | 4.8 |

## **Step2 -** Orientation Improvement

### Base Case

23 Sep to 23 Mar

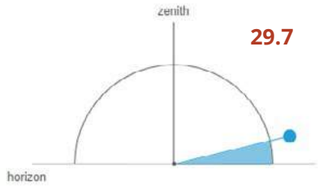


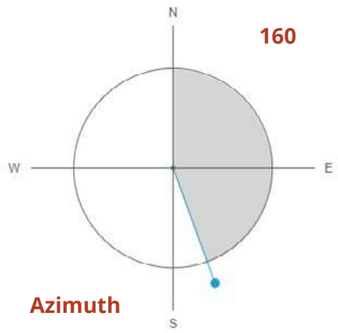




**Tilt** **Azimuth**

*Generated by PV SOL Online tool*

23 Mar to 23 Sep

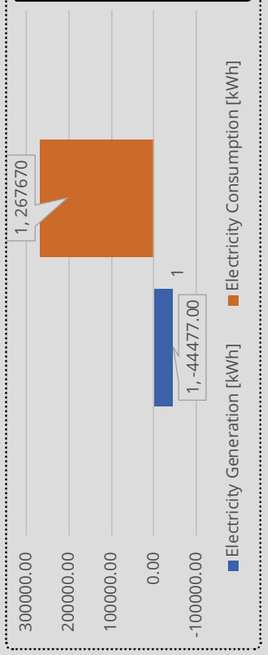



**Tilt** **Azimuth**

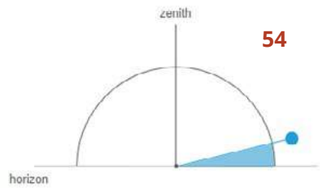
*Generated by PV SOL Online tool*

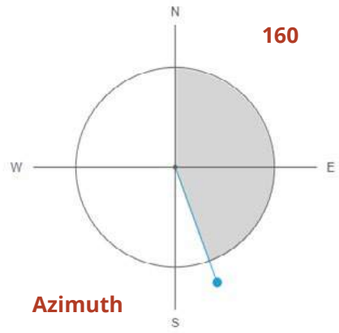
Annual Generation




### Proposed Case

23 Sep to 23 Mar

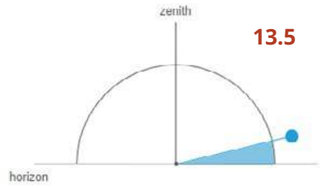


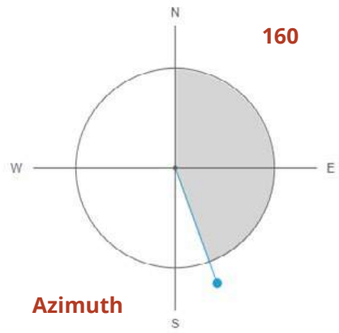




**Tilt** **Azimuth**

*Generated by PV SOL Online tool*

23 Mar to 23 Sep

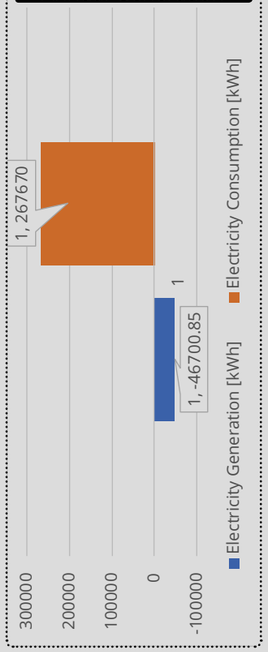



**Tilt** **Azimuth**

*Generated by PV SOL Online tool*

Annual Generation




### Final Results

| | |
|---|---|
| PV panels Total Area[m2] | 180 |
| Covered Roof Area[%] | 52.14007782 |
| Orientation | 160 |
| Inclination | 29.7 |
| Nominal Power[kW] | 31.2 |
| Annual Electricity Generation [kWh] | 44477.00 |
| Annual Electricity Generation [kWh/m2] | 9.972421525 |
| Generation/ Electricity Consumption [%] | 16.62 |
| Initial Cost [mT] | 240000000 |
| Annual Gain [mT] | 40474070.00 |
| Simple Payback Period[years] | 5.93 |
| IRR[%] | 15 |
| NPV[T] | (IRR 21,450,235.73) |
| NPV (%25- investment cost)[T] | (IRR 15,995,690.27) |
| NPV (%25+ investment cost)[T] | (IRR 26,904,781.18) |

### Final Results

| | |
|---|---|
| PV panels Total Area[m2] | 180 |
| Covered Roof Area[%] | 52.14007782 |
| Orientation | 160 |
| Inclination | 13.5 hot season- 54 cold season |
| Nominal Power[kW] | 31.2 |
| Annual Electricity Generation [kWh] | 46700.85 |
| Annual Electricity Generation [kWh/m2] | 10.4710426 |
| Generation/ Electricity Consumption [%] | 17.45 |
| Initial Cost [mT] | 240000000 |
| Annual Gain [mT] | 42497773.50 |
| Simple Payback Period[years] | 5.65 |
| IRR[%] | 16 |
| NPV[T] | (IRR 21,431,838.42) |
| NPV (%25- investment cost)[T] | (IRR 16,328,514.24) |
| NPV (%25+ investment cost)[T] | (IRR 26,886,383.88) |

| | Name | Type | Location | Climate | Predicted annual consumption of potable water for all uses, excluding process water | Is potable water used for irrigation? | Predicted peak month consumption of potable water for outdoor | Percent of rainwater that can be managed on site | Actual annual consumption of process water (e.g. cooling towers) | Is greywater or blackwater captured for re-use? | Water quality for any stormwater leaving the site | Is rainwater captured for use by the project? | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **Amherst College New Science Center** | Education – College/ University (campus-level), Laboratory | Amherst, Massachusetts | Dfb | 3,156 gals/ occupant; 41 percent reduction from LEEDv4 baseline | no | n/a | 58 % | 1,537,700 gallons | no | 80 percent of TSS removal | n/a |  |
| 2 | **Daniels Building at One Spadina Crescent** | Education – College/ University (campus-level) | Toronto, Ontario | Dfb | 29 gals/occupant | no | n/a | %100 | n/a | n/a | n/a | yes |  |
| 3 | **Frick Environmental Center** | Education – General, Office – 10,000sf, Public Assembly – General | Pittsburgh, Pennsylvania | Cfa | 29,870 gallons; 0.37 gallons per visitor annually (75,000 annual visitors); 40 percent reduction compared with EPA guidelines. | no | n/a | %100 | 0.6 gallons per visitor annually (44,685 total gallons divided by 75,000 visitors annually) | no | 80 percent of TSS removed from stormwater runoff based on the TSS removal percentages from the PA Stormwater BMP Manual located in Chapters 5 and 6. | yes |  |
| 4 | **Oregon Zoo Education Center** | Education – General | Portland, Oregon | Csb | Indoor water use: 322 kGal/year, 56 percent reduction from federal standards | yes | 0.17 gallons/sf | 75 % | 208,186 gallons | no | 84 percent of TSS removed from stormwater runoff | yes |  |
| 5 | **Tashjian Bee and Pollinator Discovery Center** | Education – General | Chaska, Minnesota | Dfa | 39 percent | yes | 0.05 gallons/ sq ft | %100 | n/a | n/a | 97 percent of TSS removed | n/a |  |

## Baseline Calculation

| | Monthly Rainfall (mm) | Monthly ETo (mm) | Watering Demand (mm) |
|---|---|---|---|
| January | 16 | 1 | -15 |
| February | 11 | 2 | -9 |
| March | 5 | 4 | -9 |
| April | 21 | 6 | -9 |
| May | 3 | 8 | 5 |
| June | 5 | 8 | 3 |
| July | 4 | 8 | 5 |
| August | 0 | 7 | 7 |
| September | 14 | 6 | -8 |
| October | 7 | 4 | -3 |
| November | 18 | 1 | -17 |
| December | 26 | 1 | -25 |

| | |
|---|---|
| Peak watering month | **August** |
| Peak watering demand (mm) | **7** |
| Peak watering month ETo (mm) | **7** |
| Landscape water allowance (l/month) | **274** |
| Landscape water baseline (l/month) | **391** |

## LandScape Water Requierements

Average monthly rainfall for the site's peak watering month (mm/month) **0**

| Zone ID | Hydrozone or Landscape Feature Area (sq m) | Plant Type | Water Requirement | Landscape Coefficient (KL) | Irrigation Type | Distribution Uniformity (DULQ) | LWRH(l/month) |
|---|---|---|---|---|---|---|---|
| Entrance | 40 | Trees | Medium | 0.5 | Drip (press comp) | %90 | 158 |
| FoodCourt | 15 | Shrubs | Medium | 0.5 | Drip (press comp) | %90 | 59 |

| | |
|---|---|
| Total hydrozone or landscape feature area (s.q.m.) | 55 |
| Landscape water requirement based on the site's peak watering month (l/month) | 217 |

## Summary

| | | |
|---|---|---|
| Landscape water baseline (l/month) | **391** | |
| Landscape water requirement (LWR) (l/month) | **217** | |
| Percentage reduction from baseline (%) | **%44** | (Must be at least %30) |

## Outdoor Water Management

### Pressure Compensating Drip Irrigation System

PC emitters deliver a precise amount of water regardless of changes in pressure due to long rows or changes in terrain. They can simplify the designing of a system and greatly reduce maintenance since they rarely get plugged. Inside the emitter is a flexible diaphragm that regulates the water flow and tends to flush particles from the system (self-flushing). Using this system, irrigation water usage will be reduced from 391 to 271 liters per month. (%44 reduction %14 above Target)

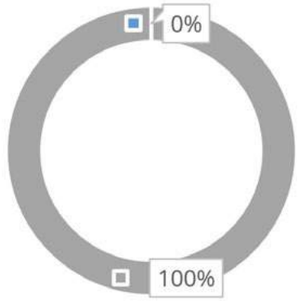


## Rain water Collection Potential Calculation

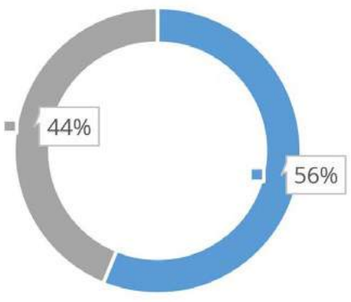
| | |
|---|---|
| Roof Area[s.q.m.] | **1285** |
| Total Annual Rainfall[mm] | **130** |
| Total Rain Water Collection Potential[lit/y] | **169,620** |

## Final Results

| | |
|---|---|
| Landscape water baseline (l/month) | **391** |
| Landscape water requirement (LWR) (l/month) | **217** |
| Percentage reduction from baseline With Drip Irrigation (%) | **%44** |
| Percentage reduction from baseline Using RainWater (%) | **%100** |




reduction from baseline Using Rain water and Drip Irrigation System

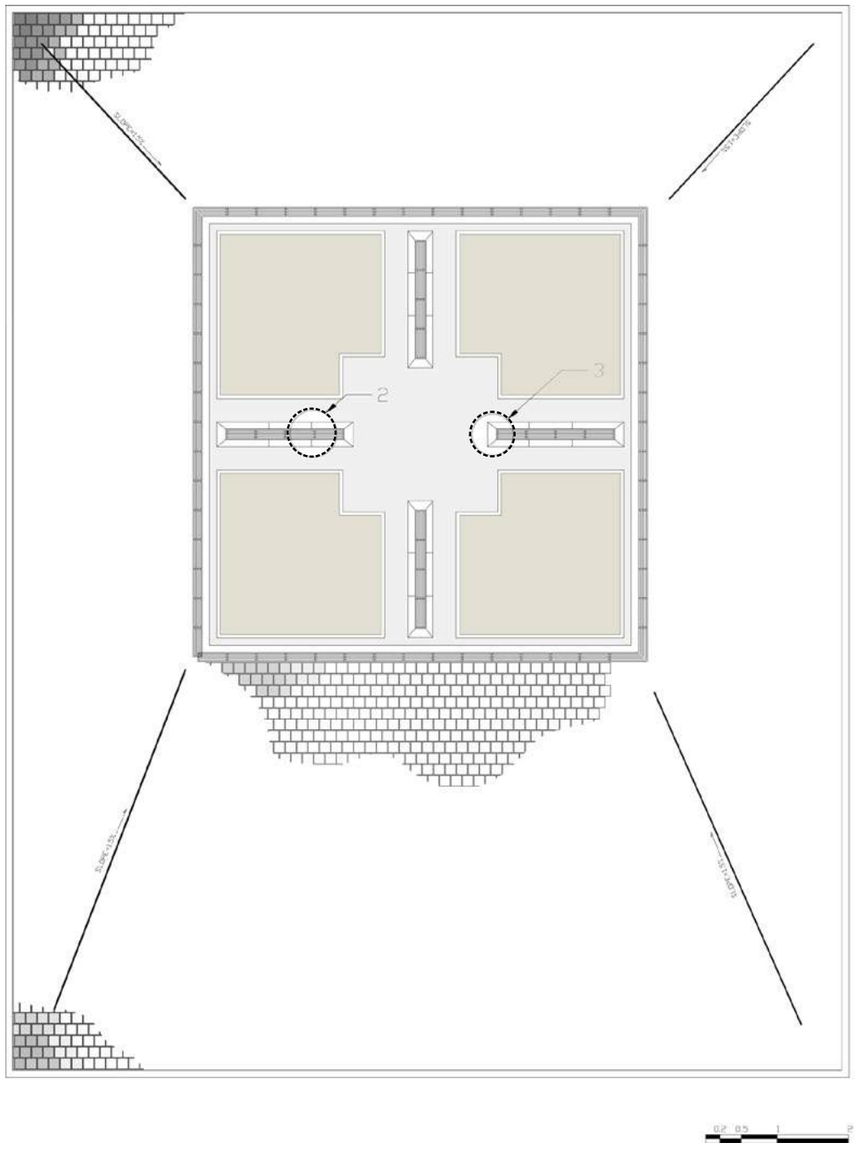



Reduction from baseline With Drip Irrigation

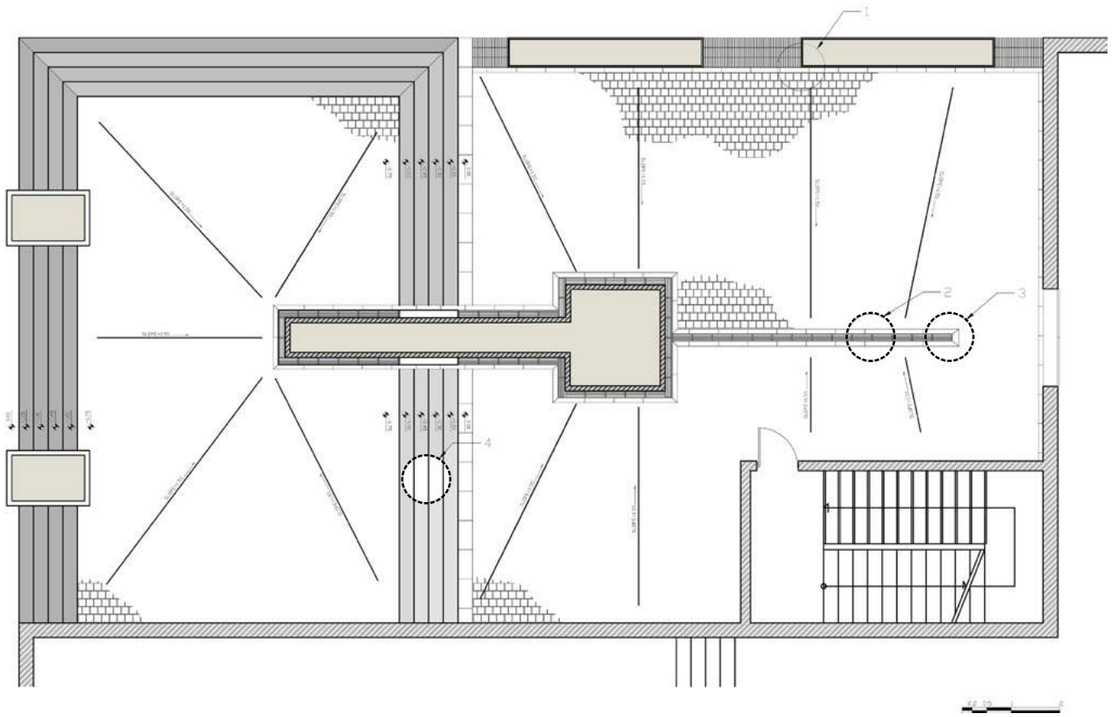
*Data Generated with LEED v. 4.0 Water management Spreadsheets -Plots With Excel*

## Landcape Layout

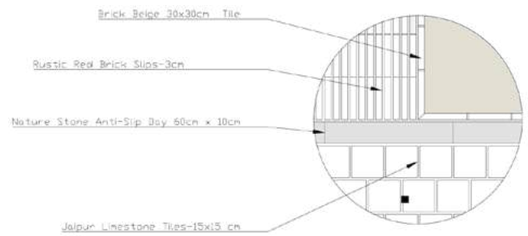
### Conference Hall Entrance Area



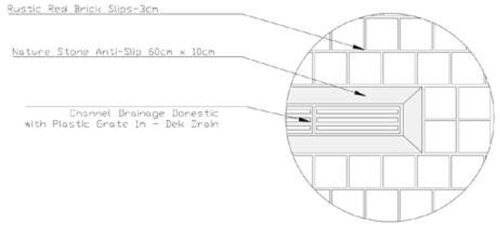

### FoodCourt Area



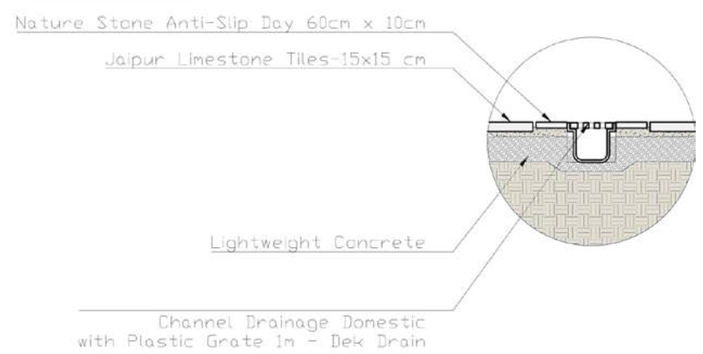

Code **Detail.1**




Code **Detail.2**




Code **Detail.3**

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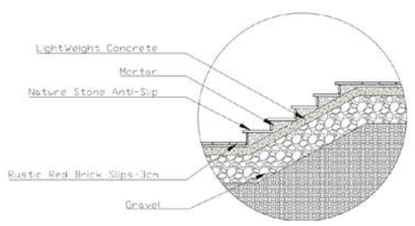
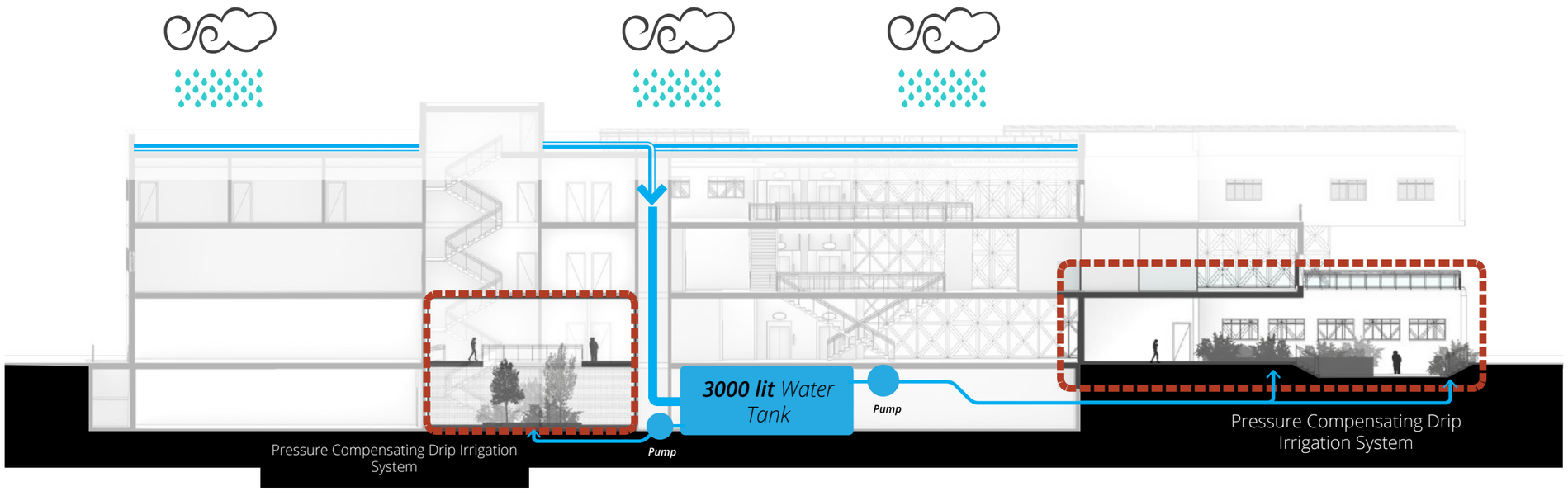







## Indoor Water Management

**Fixture Information** | **Flush Rate** | **% Occupants**

| Fixture ID | Fixture Family | Fixture Type | Baseline Flush Rate (lpf) | Design Flush Rate(lpf) | % Occupants |
|---|---|---|---|---|---|
| **T-M** | **Toilet (male)** | **Low-Flow Water Closet** | **6.00** | **3.00** | **100** |
| **T-F** | **Toilet (female)** | **Low-Flow Water Closet** | **6.00** | **3.00** | **100** |

| | |
|---|---|
| Baseline case annual flush volume (liters/year) | **650,310.00** |
| Design case annual flush volume (liters/year) | **325,155.00** |

**Group Name** | **Baseline Case (liters/year)** | **Design Case (liters/year)**

| | Annual Flush Volume | Annual Flow Volume | Annual Consumption | Annual Flush Volume | Annual Flow Volume | Annual Consumption |
|---|---|---|---|---|---|---|
| WCs | **650,310.00** | **102,965.75** | **753,275.75** | **325,155.00** | **86,708.00** | **411,863.00** |

| | |
|---|---|
| Annual baseline water consumption (liters/year) | **753,275.75** |
| Annual design water consumption (liters/year) | **411,863.00** |
| Percent water use reduction (%) | **%45.32** |

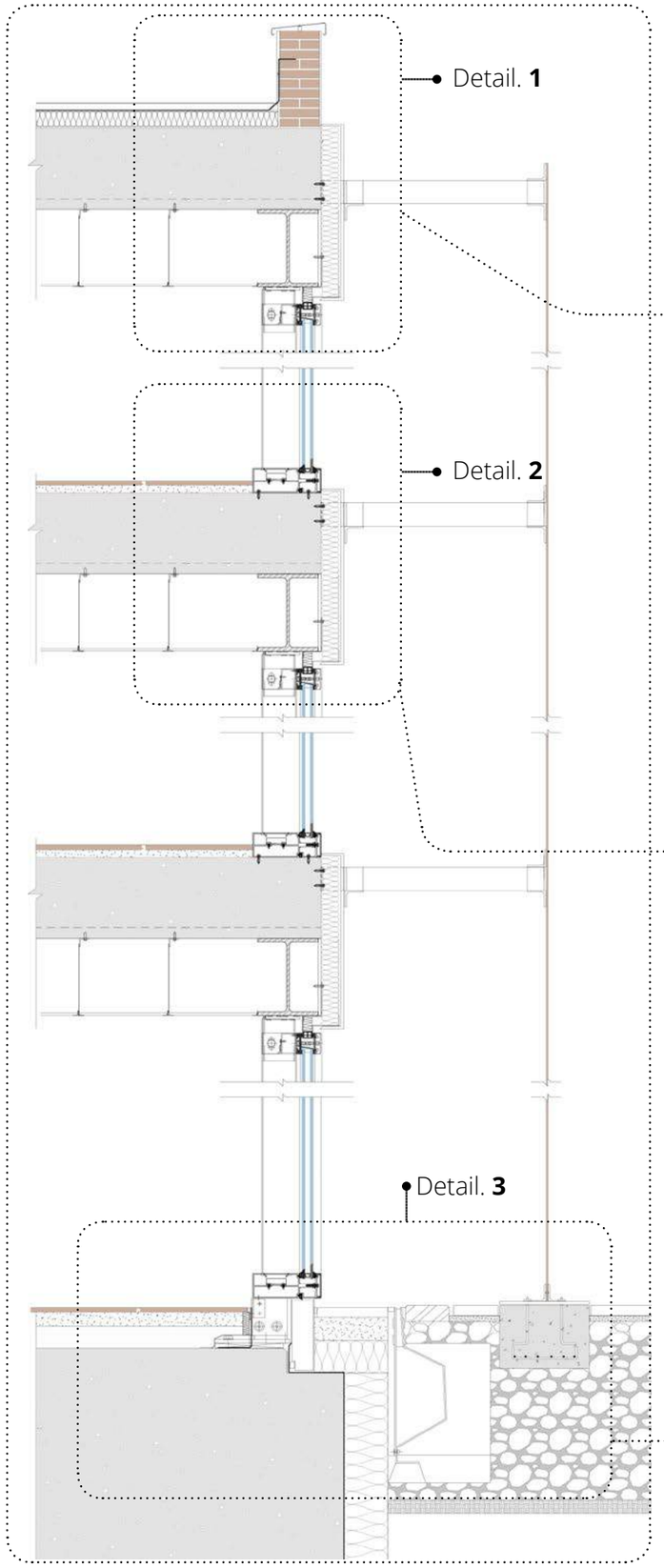
**Building Information**

| Occupancy Type | Employees (FTE) | Visitors | Gender Ratio [%] |
|---|---|---|---|
| Total | 28 | 650 | %100 |
| Male | 14 | 450 | %68 |
| Female | 14 | 200 | %32 |

Annual days of operation **265**

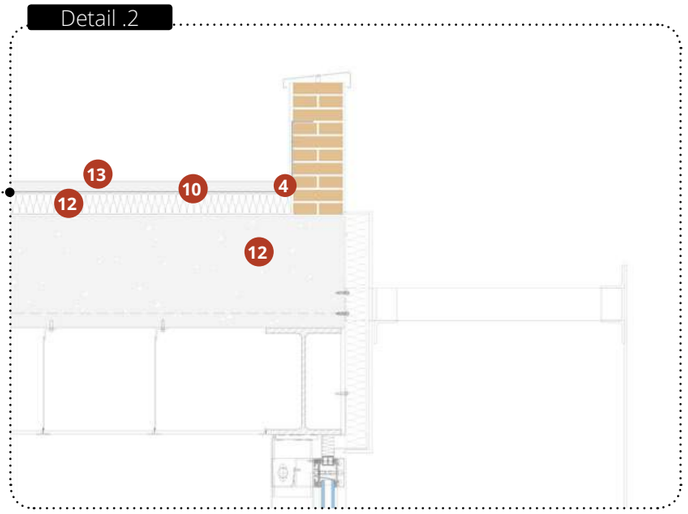
**Total Daily Usage of Water**

| Baseline(liters) | Design (liters) |
|---|---|
| 1,602.00 | 801 |
| 52.00 | 426 |

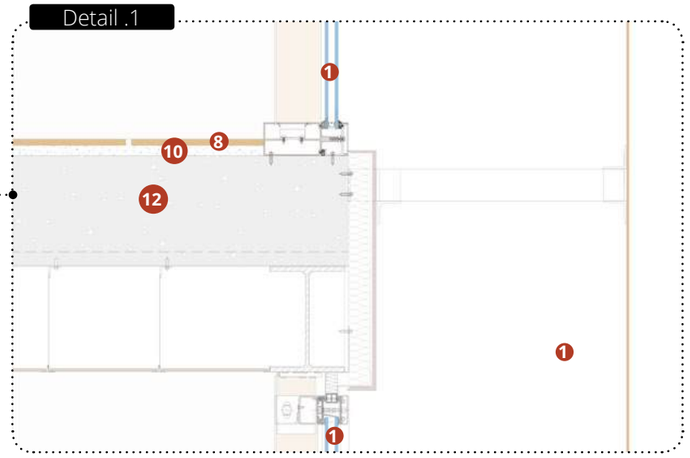



**Facade Heat Transfer And Details**

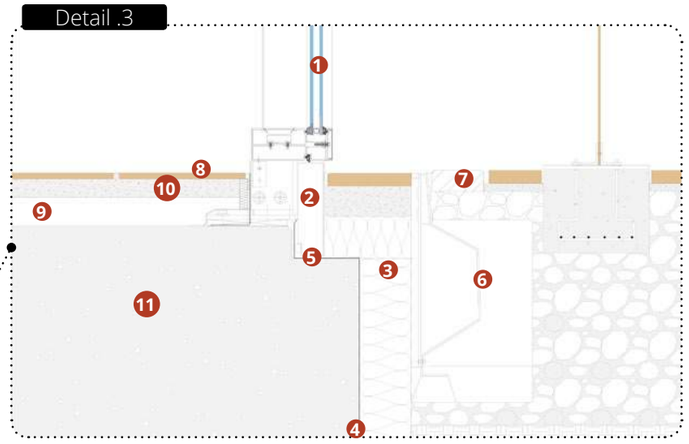
Detail .2




Detail .1




Detail .3




1. Venus V-Cool Aluminum curtain wall Profile; fixed to concrete ground floor slab with steel bracket; NBS ref;
2. PPC coated Insulation panel set below curtain wall to prevent thermal bridging, sealant applied between PPC panel and floor slab to prevent water ingress

3. Knauf Thermal floor slab; Glass Wool insulation; thickness 100mm around perimeter of concrete slab to meet the PPC panel for continuous insulation. NBS ref; NBS ref P20/10

4. Visqueen Ecomembrane; 1500 gauge; DPM set below slab to return to internal area; / Roof humidity insulation

5. Sealant applied PPC panel and DPM lapped; Internal face of cut concrete in order to increase watertightness around perimeter.Reinforced concrete Floor slab

6. Gantic Facade-slot drain situated perimeter of the building
7. Permeable Paving
8. Slate Floor Covering, typical dimentions of Slab; 300 x 300 x 12mm, Weight per unit 3.38 kg, Manufacturer: Welsh Slate, Product Code: Colour:Heather Grey Penrhun, Finish: Riven,Characteristics ; non-fading, AA Fire Rating - non combustible
9. Glaster Screed; thickness: 55mm. Type: NHL3.5 or NHL1 5,Ratio: 2.5 Sand *: Hydraulic Lime Premixed,

10. Lime mortar, Thickness: 45 mm, Type : NHL3.5 or NHL5, Ratio 2.5 Sand, 1 Hydraulic Lime Premixed, Colour/ texture: It is the aggregate/sand That precominantly effects the colour and texture.

11. Concrete Ground bearing slab to conform to BS -8500 2 Standardised Prescribed mix ST2. Reinfoced

12. XPS thermal insulation to prevent Thermal Bridging

13. Cool-Coating

## Facade Heat Transfer And Details**(Thermal Bridges)**

### Base Case

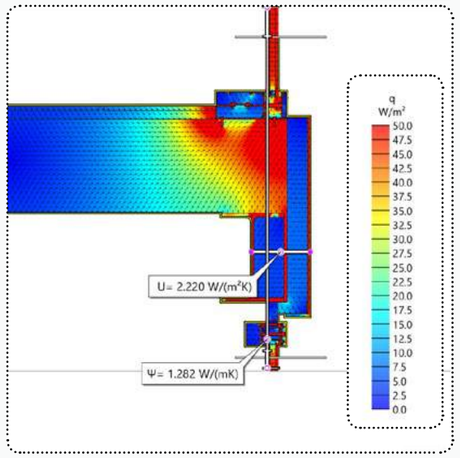
U-Value

2.22 W/(m2/K)

Psi-Value

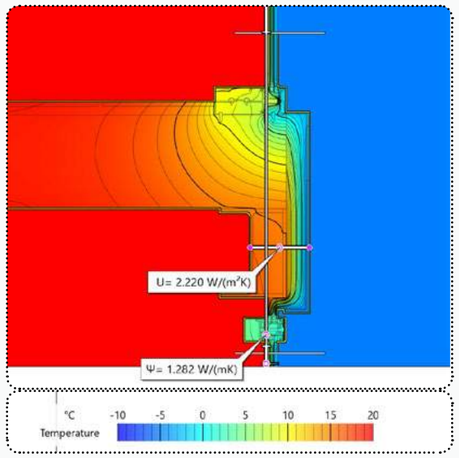
1.28 W/(m/K)

Heat Flux



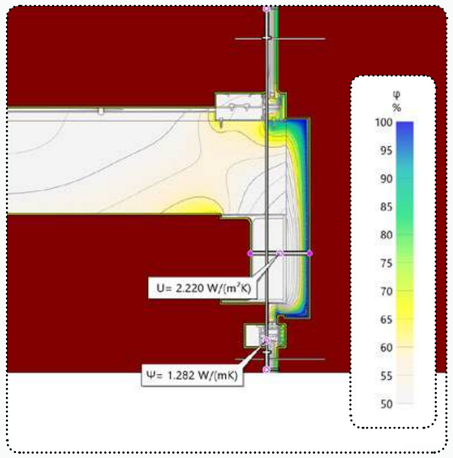

*Generated by HTflux*

Temperature



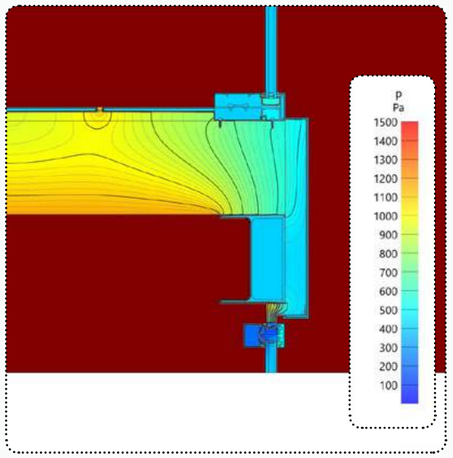

*Generated by HTflux*

Humidity




*Generated by HTflux*

partial pressure




*Generated by HTflux*

### Improved Case

I- Cavities filled with Thermal Insulation
II- Vertical Insulation Extended to the level of curtainwall upper profiles

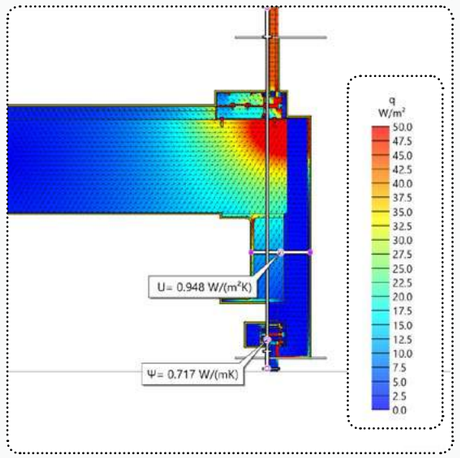
U-Value

0.948 W/(m2/K)

Psi-Value

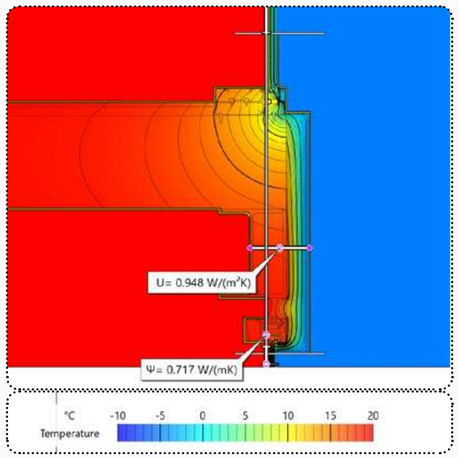
0.717 W/(m/K)

Heat Flux



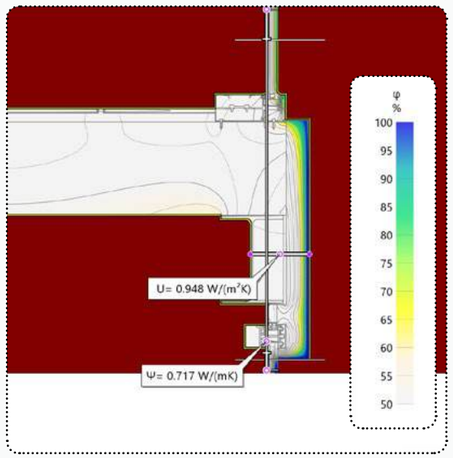

*Generated by HTflux*

Temperature



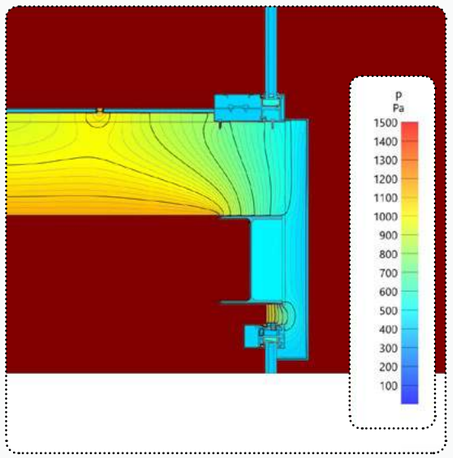

*Generated by HTflux*

Humidity




*Generated by HTflux*

partial pressure




*Generated by HTflux*

# Facade Heat Transfer And Details**(Thermal Bridges)**

## Base Case

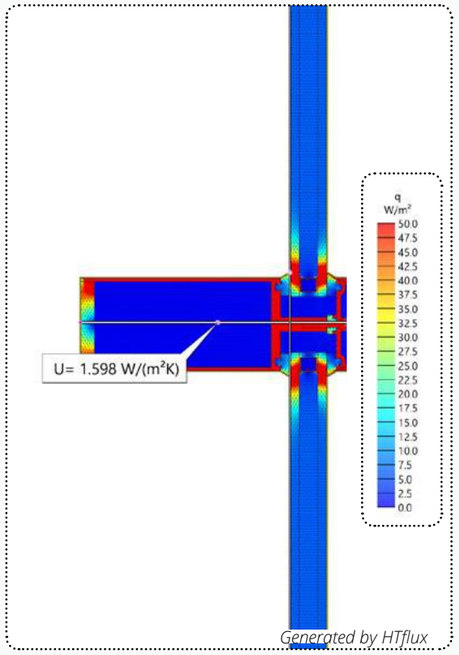
U-Value

1.598 W/(m2/K)

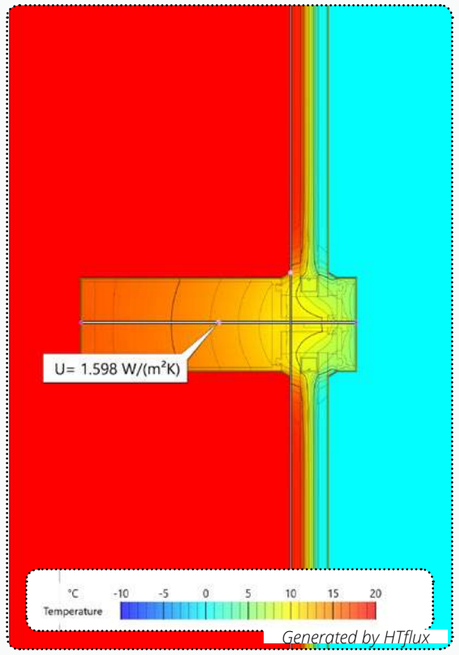
Psi-Value

1.12 W/(m/K)

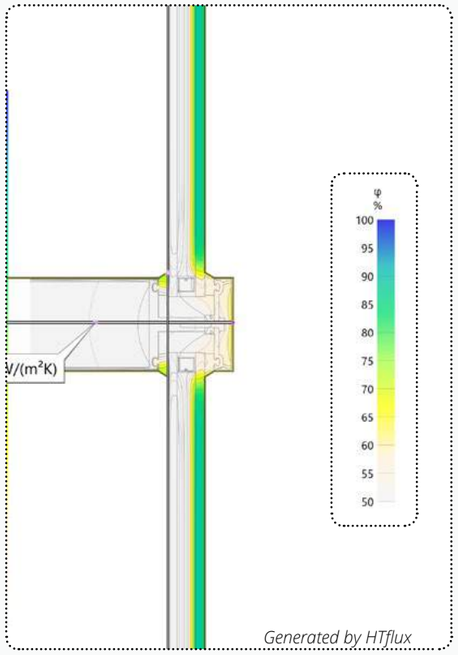
Heat Flux



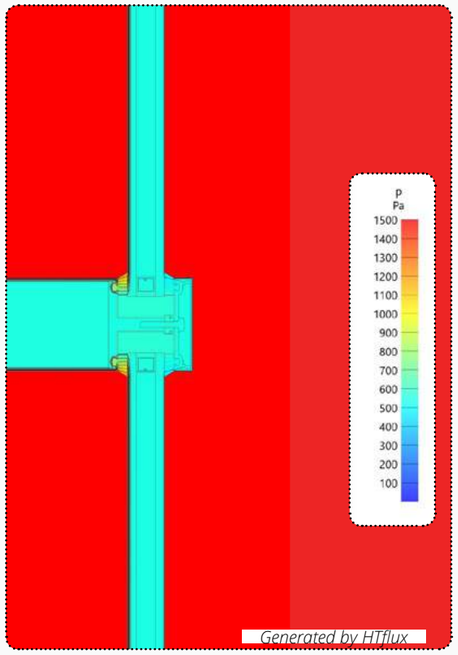

Temperature




Humidity




partial pressure




## Imrpved Case

I- Cavities filled with Thermal Insulation

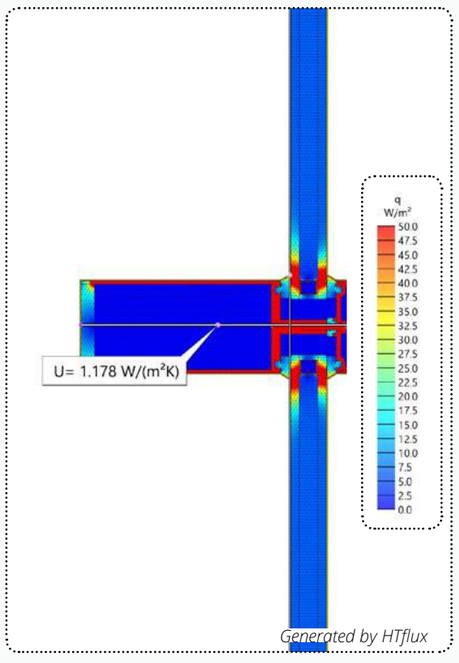
U-Value

1.178 W/(m2/K)

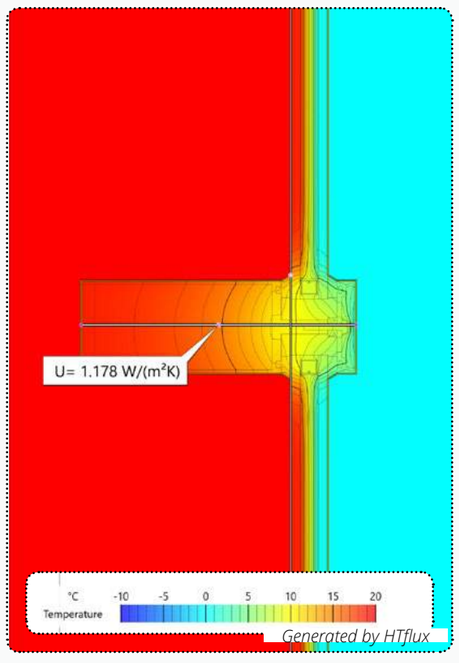
Psi-Value

0.721 W/(m/K)

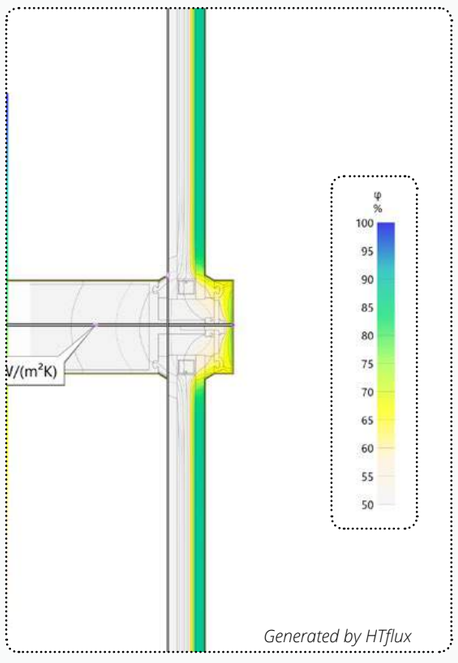
Heat Flux



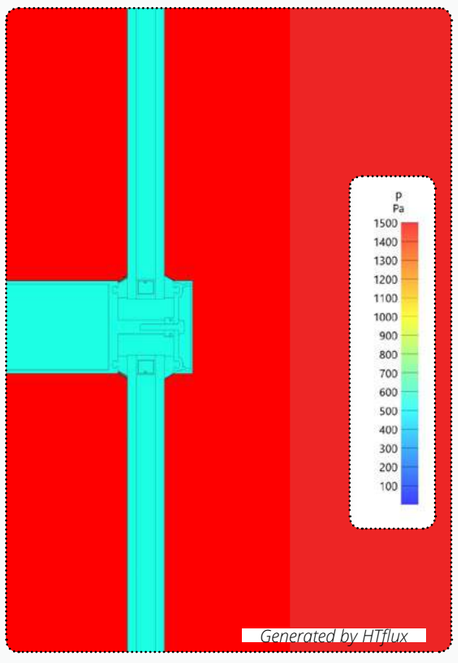

Temperature




Humidity




partial pressure

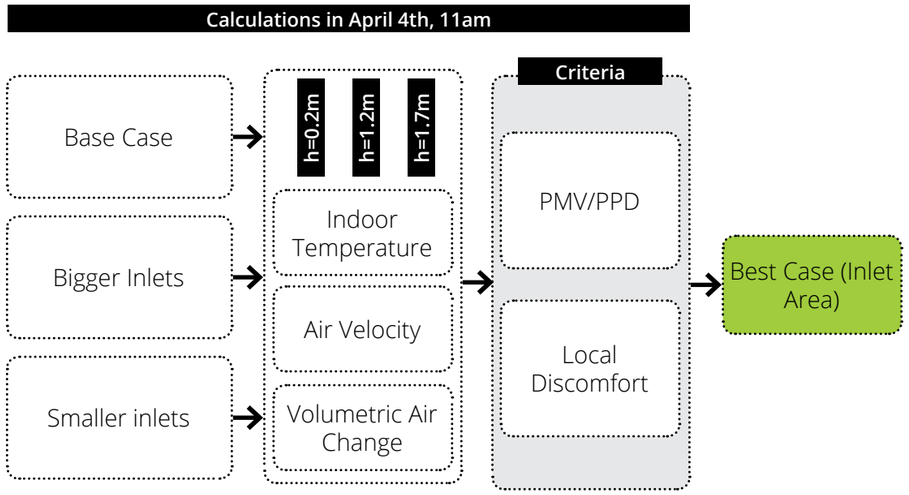


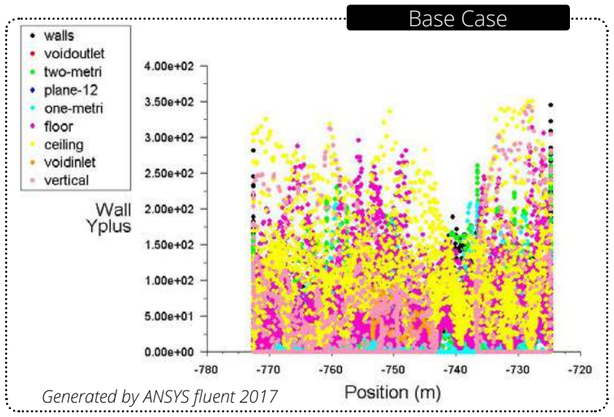
## Modelling Key Assumptions

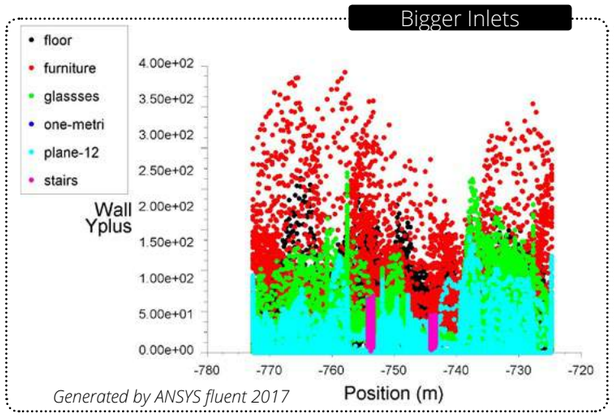
| | | |
|---|---|---|
| **Meshing** | Edge Sizing | 0.35 m |
| | solver preference | Fluent |
| | size function | Curvature |
| | Relevance Center | Coarse |
| | Smoothing | Medium |
| | Min size | 0.0267 m |
| | max size | 2.67 m |
| | Max Tet Size | 5.34 m |
| | Growth Rate | 1.2 |
| **Statistics** | Nodes | 42133 |
| | Elements | 205898 |
| Setup | solver | Pressure-based |
| | Time | Steady |
| | Velocity formulation | Absolute |
| | model | Viscous |
| | type | k-epsilon |
| | K-epsilon Model | Realizable |
| Near-Wall Treatment | Model Constants | «C-2 Epsilon:1.9TKE Prandtl Number: 1» |
| Reference Values | Area [m2] | 1 |
| | Density[kg/m3] | 1.225 |
| | Enthalply[j/kg] | 0 |
| | Length [m] | 1 |
| | Pressure [Pascal] | 0 |
| | Temperature [k] | 288.16 |
| | velocity[m/s] | 1 |
| | Viscosity[kg/m-s] | 1.79E05- |
| | Ratio of Specific Heats | 1.4 |

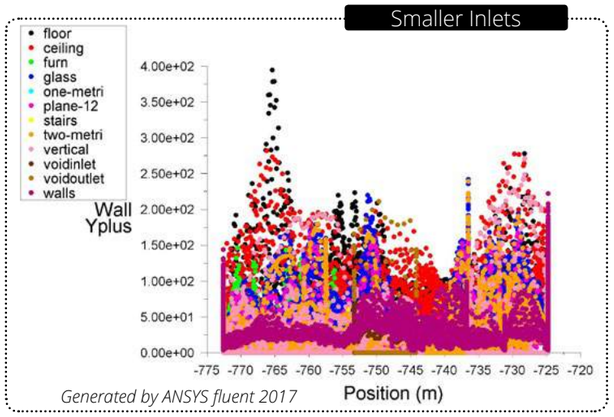
## Natural Ventilation
Analysis (CFD)

| | Base Case | Bigger Inlets | Smaller Inlets |
|---|---|---|---|
| Space Volume (m3) | 3438 | 3438 | 3438 |
| Inlet Area(Each) (m2) | 0.58 | 1.23 | 0.29 |
| Outlet Area(Each) (m2) | 0.17 | 0.17 | 0.17 |
| Total Inlet Area (m2) | 8.65 | 18.45 | 4.35 |
| Total Outlet Area(m2) | 2.16 | 2.16 | 2.16 |




## Modelling Key Assumptions

| Surface | Temperature | Surface Material | Density(kg/m3) | Specific heat(J/kg x K) | Thermal Conductivity(W/m x K) |
|---|---|---|---|---|---|
| South inlets | 24 | - | - | - | - |
| North Outlets | 25 | - | - | - | - |
| Void Inlet | 24 | - | - | - | - |
| Void Outlet | 24.6 | - | - | - | - |
| Walls | 20 | Gupsum | 800 | 950 | 0.17 |
| Floor | 22 | Timber Flooring | 650 | 1200 | 0.14 |
| Ceiling | 22 | Gypsum | 800 | 950 | 0.17 |
| Glazings | 23 | Glass | 2500 | 840 | 0.2 |
| Furniture | 22 | Wool | 198 | 1360 | 0.06 |
| Stairs | 22 | Timber Flooring | 650 | 1200 | 0.14 |

## Modelling Key Assumptions

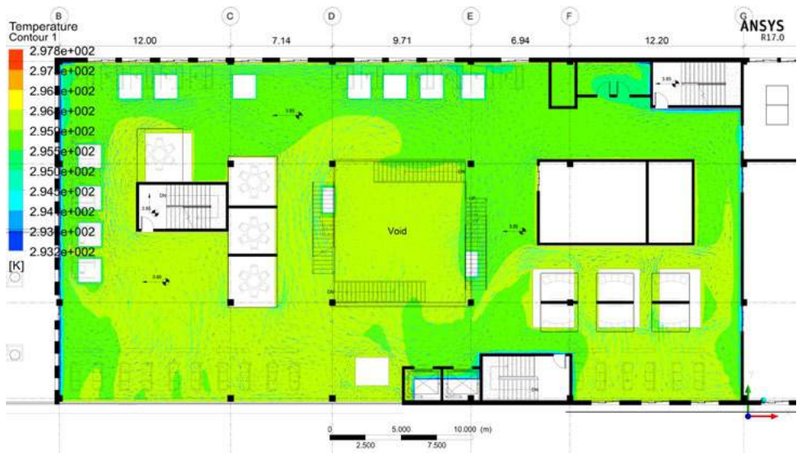
| | | |
|---|---|---|
| **Boundary Conditions** | Inlets (South windows) Velocity Magnitude [m/s] | 1.3 |
| | Void inlet Velocity Magnitude [m/s] | 0.2 |
| | Outlets (north windows) Gauge Pressure | 0 |
| | Void outlet Gauge Pressure | 0 |
| | Other surfaces Roughness constant | 0.5 |
| **Solution Methods Spatial Discretization** | Scheme | Simple |
| | Gradient | Least Squares Cell Based |
| | Pressure | Second Order |
| | Momentum | Second order upwind |
| | Turbulent Kinetic Energy | First order Upwind |
| | Turbulent Dissipation Rate | First Order Upwind |

Base Case

Bigger Inlets

Smaller Inlets

Temperature- 1.2m




*Generated by ANSYS fluent 2017*

Temperature- 1.2m



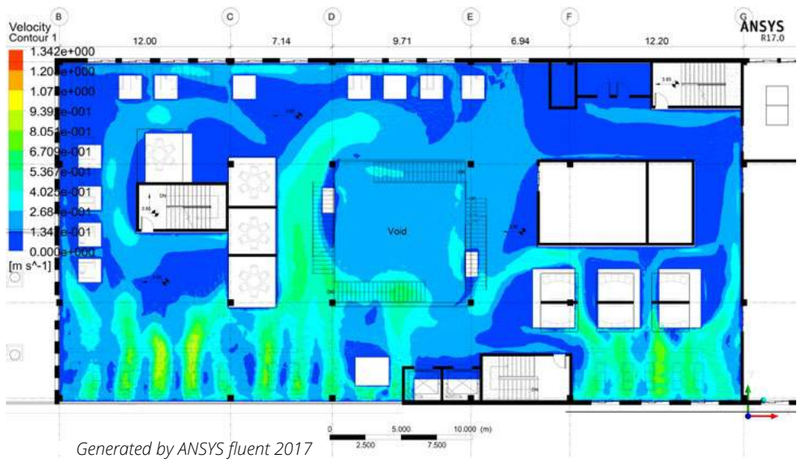

*Generated by ANSYS fluent 2017*

Temperature- 1.2m



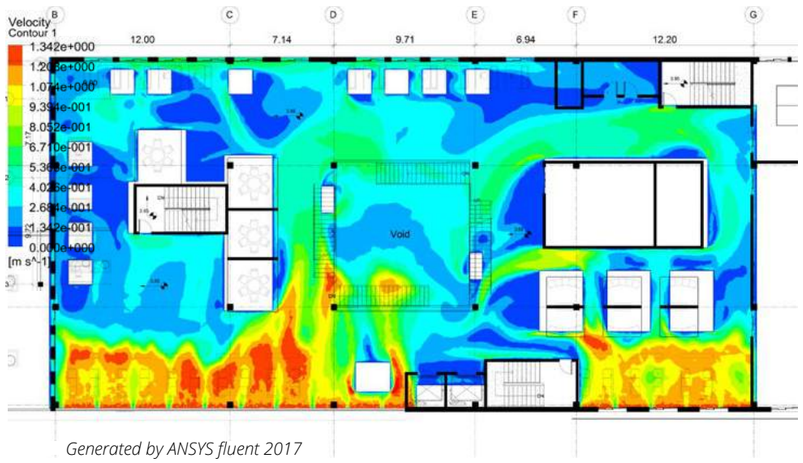

*Generated by ANSYS fluent 2017*

Velocity- 1.2m



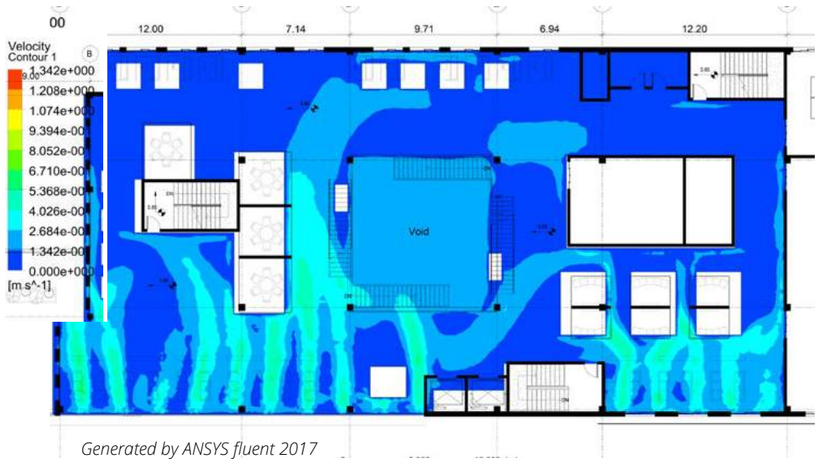

*Generated by ANSYS fluent 2017*

Velocity- 1.2m




*Generated by ANSYS fluent 2017*

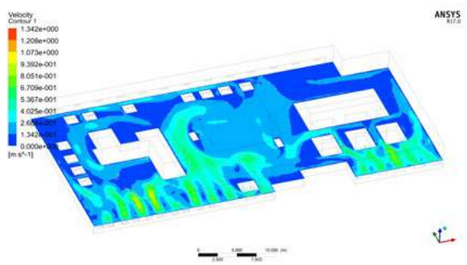
Velocity- 1.2m




*Generated by ANSYS fluent 2017*

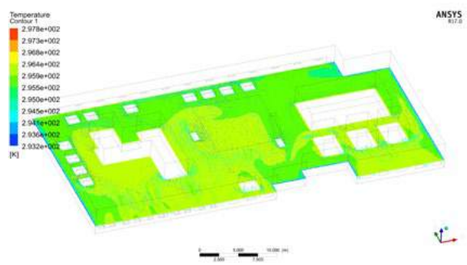
## **Natural Ventilation**
Analysis Results

Velocity- 1.2m



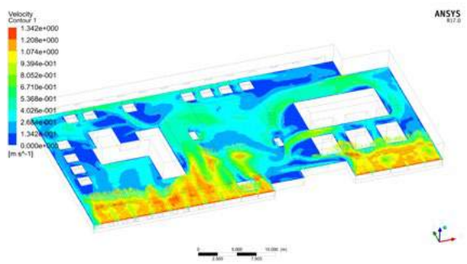

*Generated by ANSYS fluent 2017*

Temperature- 1.2m



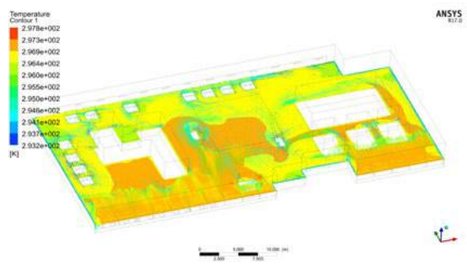

*Generated by ANSYS fluent 2017*

Velocity- 1.2m



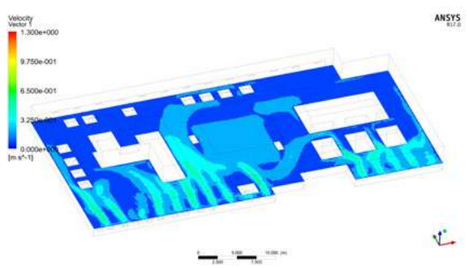

*Generated by ANSYS fluent 2017*

Temperature- 1.2m



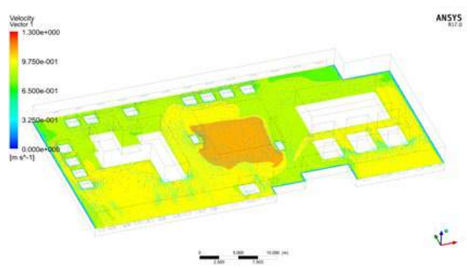

*Generated by ANSYS fluent 2017*

Velocity- 1.2m




*Generated by ANSYS fluent 2017*

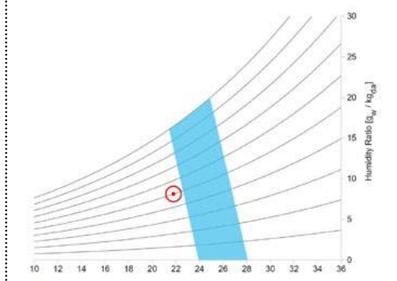
Temperature- 1.2m




*Generated by ANSYS fluent 2017*

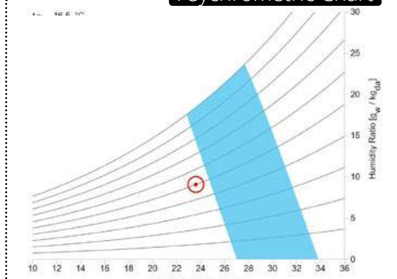
| SET | Dry-bulb temp at still air | Cooling effect | Sensation | Compliance | PMV with elevated air speed | PPD with elevated air speed |
|---|---|---|---|---|---|---|
| 23.2 | 21.90 | 0.8 °C | Neutral | ☒ | - 0.56 | %12 |
| 22.6 | 21.9 | 1.7 °C | Slightly Cool | ☒ | - 0.68 | %15 |
| 24 | 23.10 | 0.2 °C | Slightly Cool | ☑ | - 0.32 | %7 |

Psychrometric Chart



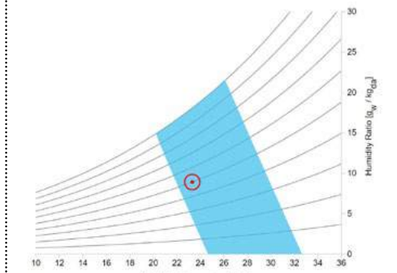

*Generated by CBE Thermal Comfort online Tool*

Psychrometric Chart




*Generated by CBE Thermal Comfort online Tool*

Psychrometric Chart




*Generated by CBE Thermal Comfort online Tool*

| Case | Caclucation Height(m) | Relative Humidity(%) | Air Velocity(m/s) | Metabolic Rate (MET) | Clothing Level (Clo) |
|---|---|---|---|---|---|
| Base Case | 22.68 | 50 | 0.20 | 1.1 | 0.8 |
| | 22.73 | | 0.22 | | |
| | 22.73 | | 0.20 | | |
| Bigger Inlets | 23.55 | | 0.36 | | |
| | 23.65 | | 0.48 | | |
| | 23.64 | | 0.42 | | |
| Smaller Inlets | 23.24 | | 0.15 | | |
| | 23.35 | | 0.16 | | |
| | 23.35 | | 0.13 | | |

| Case | Draft | Ankle Draft | | | Vertical air temperature difference | Floor surface temperature |
|---|---|---|---|---|---|---|
| | | PPD | PMV | OK? | | |
| Base Case | ☒ | %21 | - 0.5 | ☒ | ☑ | ☑ |
| Bigger Inlets | ☑ | %26 | - 0.4 | ☒ | ☑ | ☑ |
| Smaller Inlets | ☑ | %16 | - 0.4 | ☑ | ☑ | ☑ |

→ Does not comply with ASHRAE Standard -55 2017,The air speed value selected is outside the range defined by the ASHRAE 55 standard for occupants with no local air speed control

## **Lighting** Design

Arrangement 1




Arrangement 2

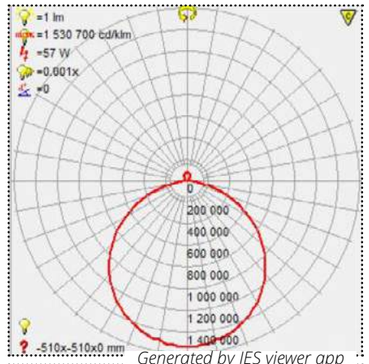



**Light option1**

Type:
***LED***

***1 530 700*** cd/klm

***57*** *W*



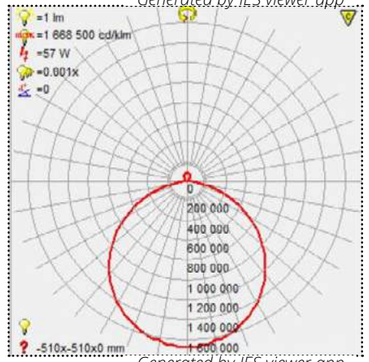

*Generated by IES viewer app*

**Light option2**

Type:
***LED***

***1 668 500*** cd/klm

***57*** *W*



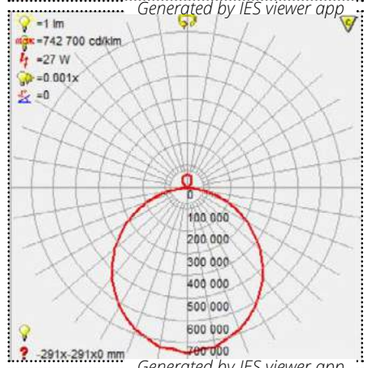

*Generated by IES viewer app*

**Light option3**

Type:
***LED***

***742 700*** cd/klm

***27*** *W*



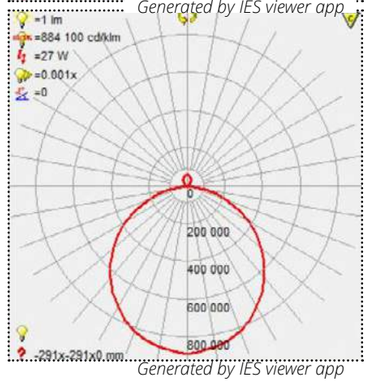

*Generated by IES viewer app*

**Light option4**

Type:
***LED***

***884 100*** cd/klm

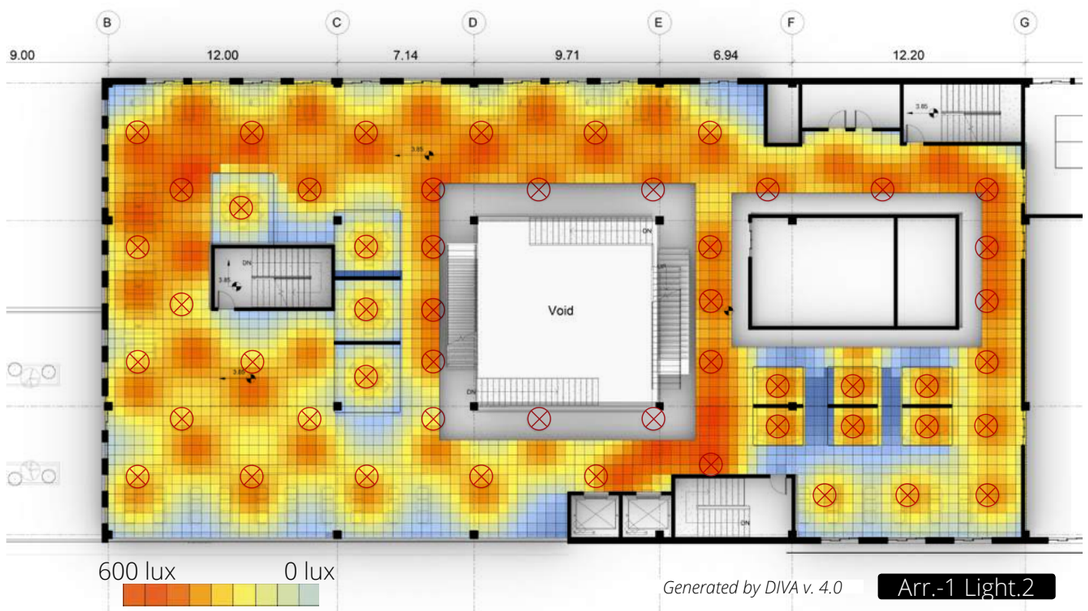
***27*** *W*

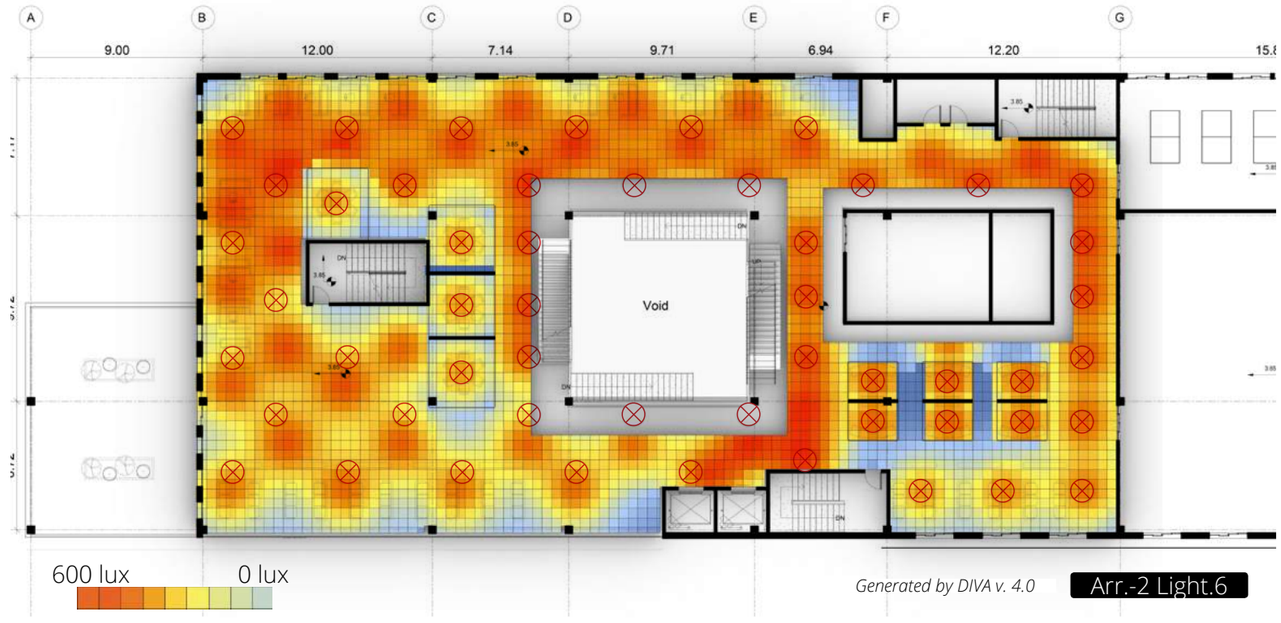


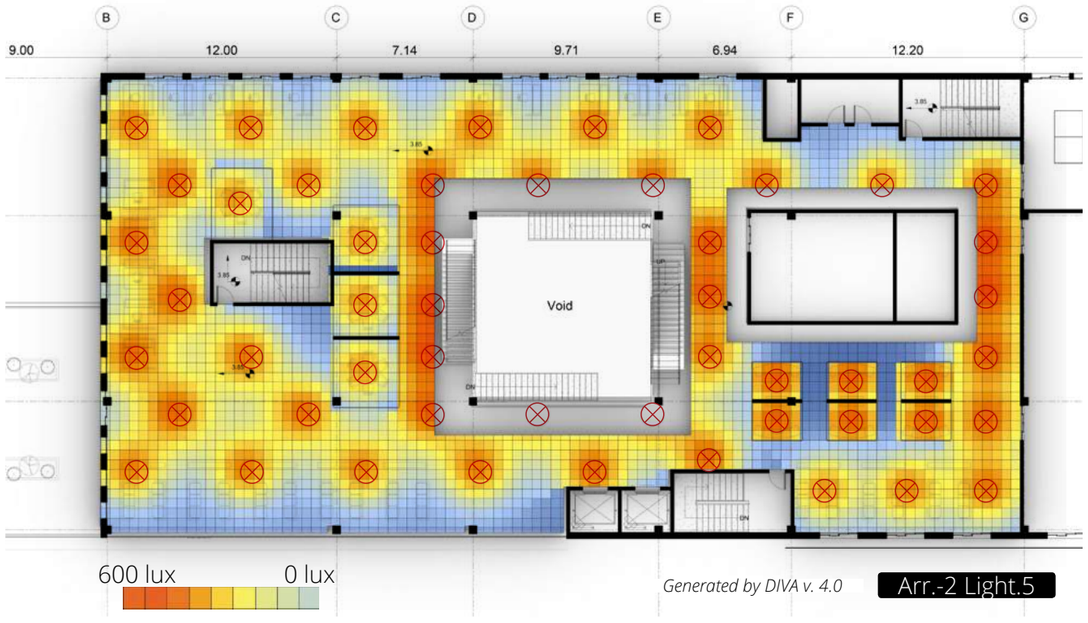

*Generated by IES viewer app*

## **Lighting** Design

| Case | Arr.-1 Light.1 | Arr.-1 Light.2 | Arr.-1 Light.3 | Arr.-1 Light.4 | Arr.-2 Light.1 | Arr.-2 Light.2 | Arr.-2 Light.3 | Arr.-2 Light.4 |
|---|---|---|---|---|---|---|---|---|
| number of Sensors >300lux | 581 | 846 | 1 | 1 | 1418 | 1743 | 1 | 1 |
| number of Sensors <150lux | 830 | 685 | 2869 | 2340 | 341 | 254 | 2102 | 1433 |
| between 150 and 300 lux | 1949 | 1829 | 490 | 1019 | 1601 | 1363 | 1257 | 1926 |
| % of Sensors >300lux | %17.29 | %25.18 | %0.03 | %0.03 | %42.20 | %51.88 | %0.03 | %0.03 |
| % of Sensors <150lux | %24.70 | %20.39 | %85.39 | %69.64 | %10.15 | %7.56 | %62.56 | %42.65 |
| between 150 and 300 lux | %58.01 | %54.43 | %14.58 | %30.33 | %47.65 | %40.57 | %37.41 | %57.32 |



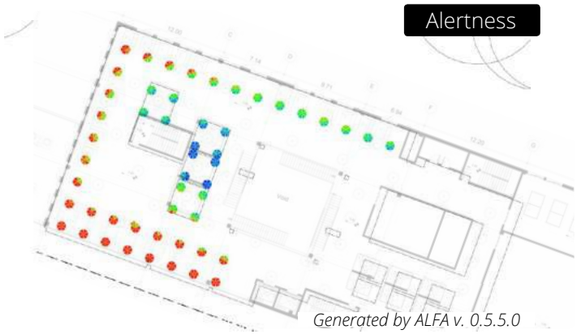



## **Circadian** lighting Analyisis

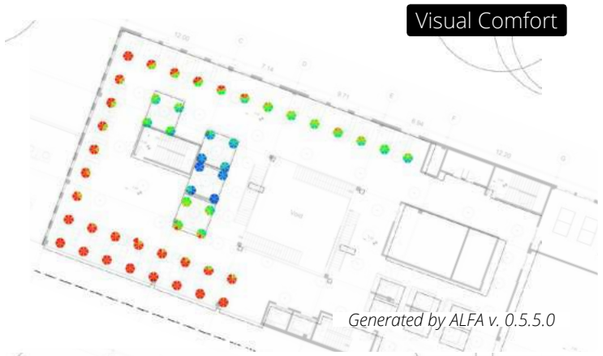
*Daytime no lighting(April,4th- 9:00 AM)*

Alertness



*Generated by ALFA v. 0.5.5.0*

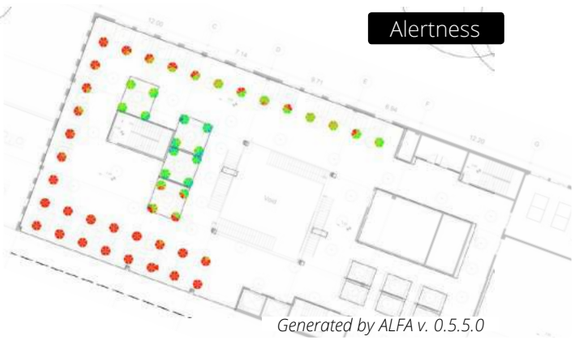
Visual Comfort



*Generated by ALFA v. 0.5.5.0*

*Daytime With lighting (April,4th- 9:00 AM)*

Alertness



*Generated by ALFA v. 0.5.5.0*

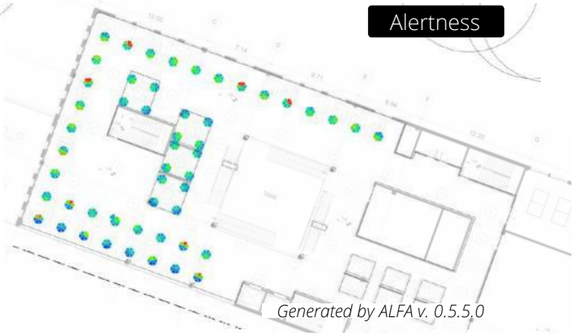
Visual Comfort



*Generated by ALFA v. 0.5.5.0*

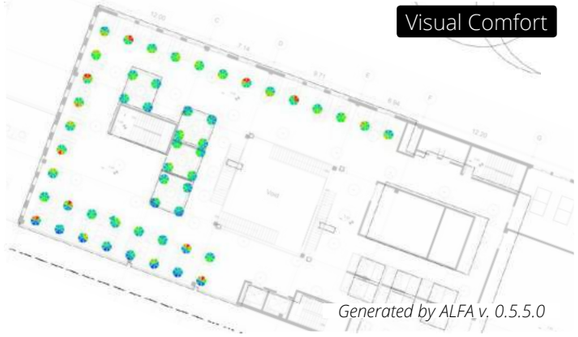
*Nighttime With lighting*

Alertness



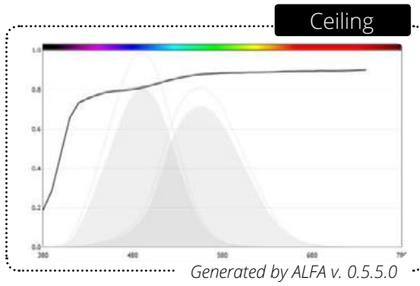
*Generated by ALFA v. 0.5.5.0*

Visual Comfort



*Generated by ALFA v. 0.5.5.0*

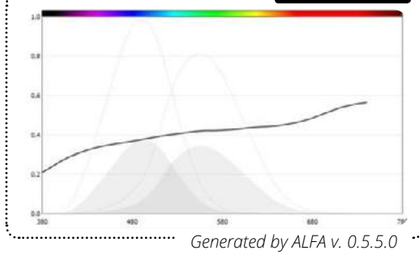
Ceiling



*Generated by ALFA v. 0.5.5.0*

| | |
|---|---|
| Color | White |
| Specularity | 0.5 |
| R(photonic) | 87.2 |
| R(Scotopic) | 81.8 |
| M/P | 0.94 |

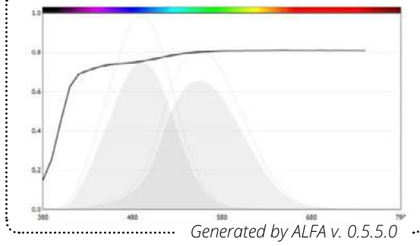
Floor



*Generated by ALFA v. 0.5.5.0*

| | |
|---|---|
| Color | Grey |
| Specularity | 0.2 |
| R(photonic) | 41.8 |
| R(Scotopic) | 37.6 |
| M/P | 0.90 |

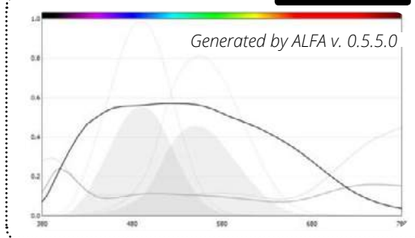
Walls



*Generated by ALFA v. 0.5.5.0*

| | |
|---|---|
| Color | white |
| Specularity | 0.4 |
| R(photonic) | 79.8 |
| R(Scotopic) | 75.8 |
| M/P | 0.95 |

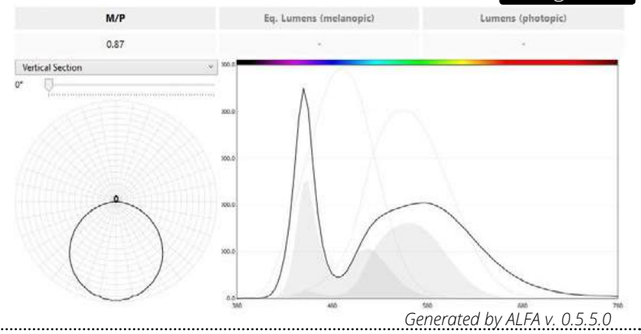
Windows



*Generated by ALFA v. 0.5.5.0*

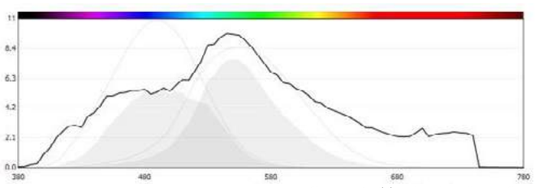
| | |
|---|---|
| RF(pho) | 9.9 |
| RF(mel) | 10.7 |
| RB(pho) | %11.00 |
| RB(mel) | %11.20 |
| T(pho) | 52.90 |
| T(mel) | 54.9 |
| M/P | 1.04 |

Lights




*Generated by ALFA v. 0.5.5.0*

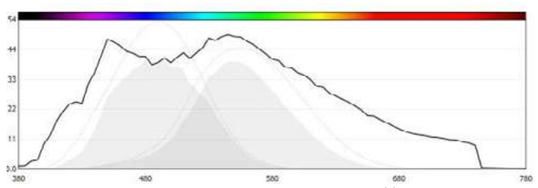
*Daytime no lighting(April,4th- 9:00 AM)*



*Generated by ALFA v. 0.5.5.0*

| M/P | Melonopic Lux | photopic Lux |
|---|---|---|
| 0.83 | 429 | 515 |

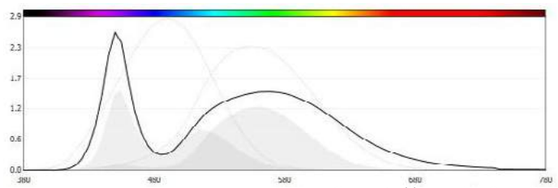
*Daytime With lighting (April,4th- 9:00 AM)*



*Generated by ALFA v. 0.5.5.0*

| M/P | Melonopic Lux | photopic Lux |
|---|---|---|
| 0.92 | 1127 | 1023 |

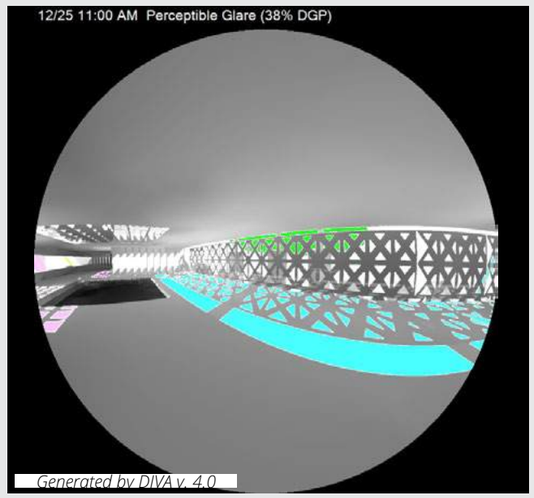
*Nighttime With lighting*



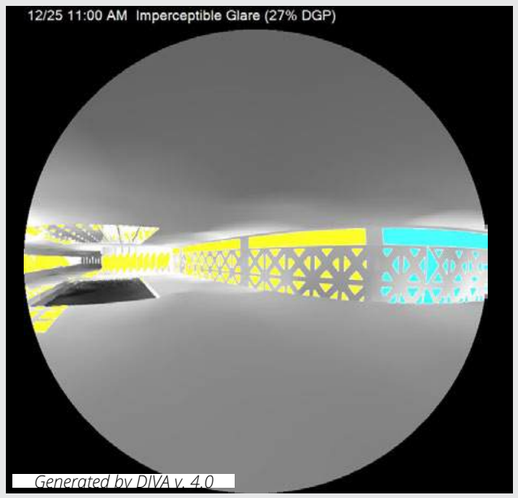
*Generated by ALFA v. 0.5.5.0*

| M/P | Melonopic Lux | photopic Lux |
|---|---|---|
| 0.75 | 69 | 87 |

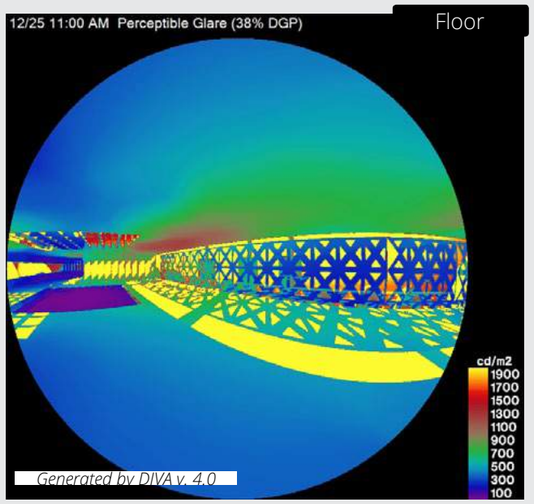
Base Case | *DGP %38*



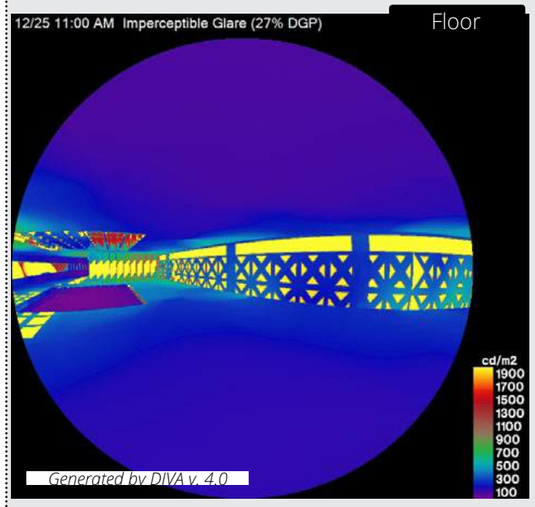

Improved Case | *DGP %27*




Floor

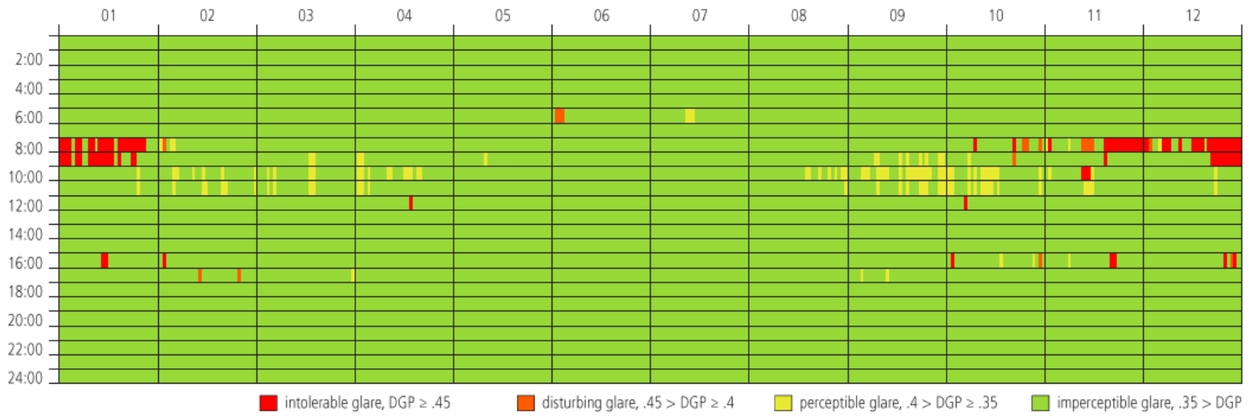



Floor




## **Annual Glare** Analysis

Annual Glare Chart (DGP)




*Generated by DIVA v. 4.0*

**Base Model**

Annual Glare in 2nd Floor Common Area → Critical times

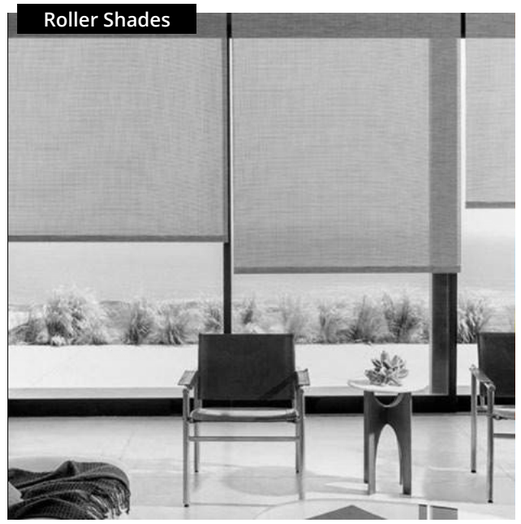
**Improved**

Glare Analysis in Critical Time (*December 25th, 11 A.M.*)

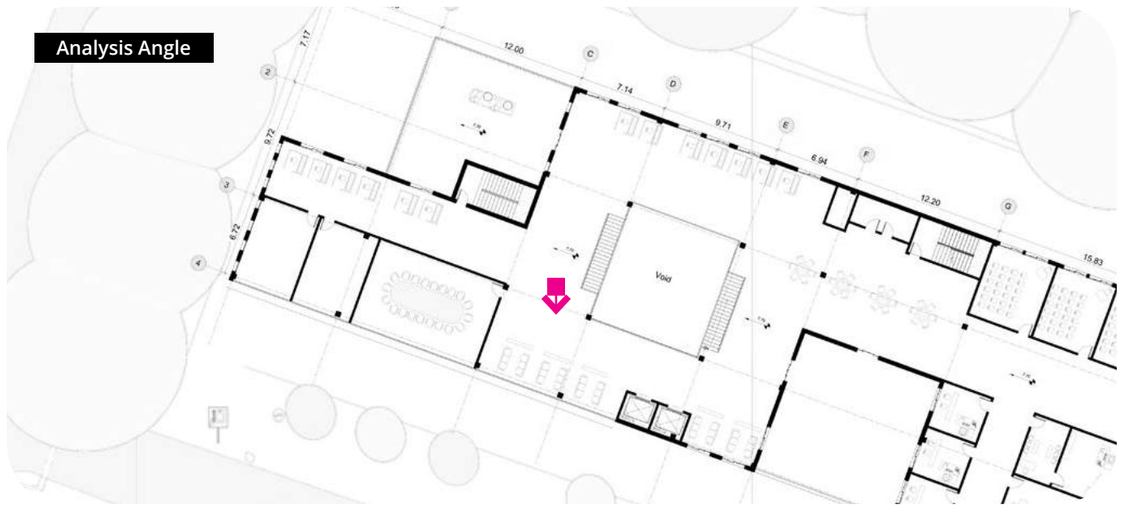
- Base DGP (%38)
- Improved DGP Using Roller Shades

Roller Shades Used for Improving Visual Comfort.
Roller Shade Light Transmittance: 0.2.

Roller Shades

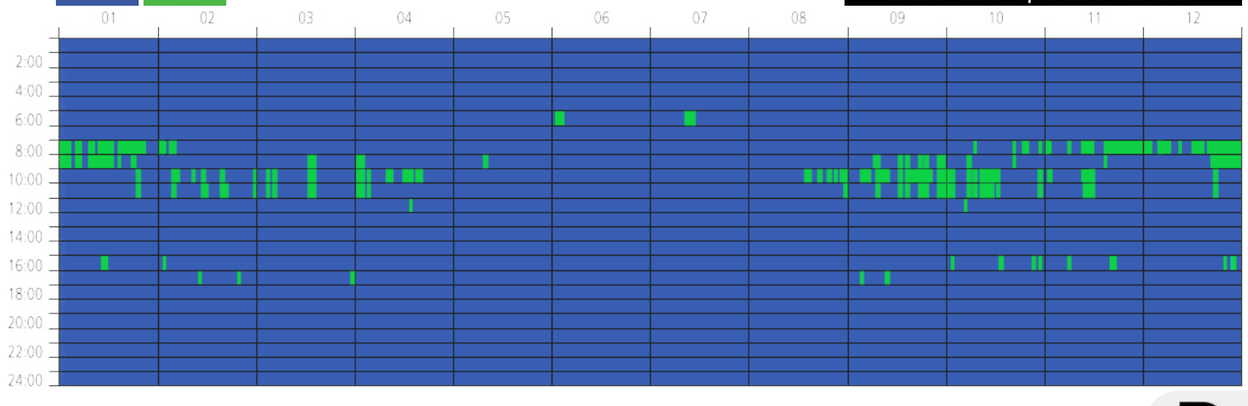


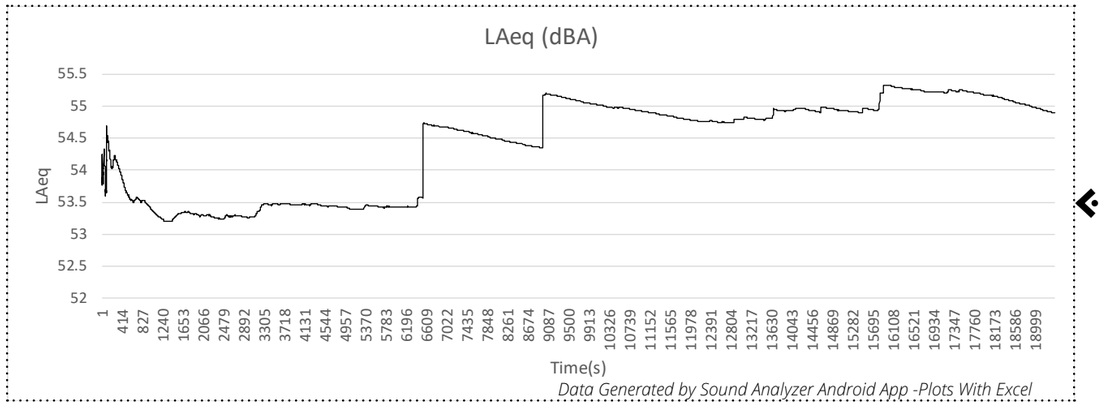
Analysis Angle




Off | On

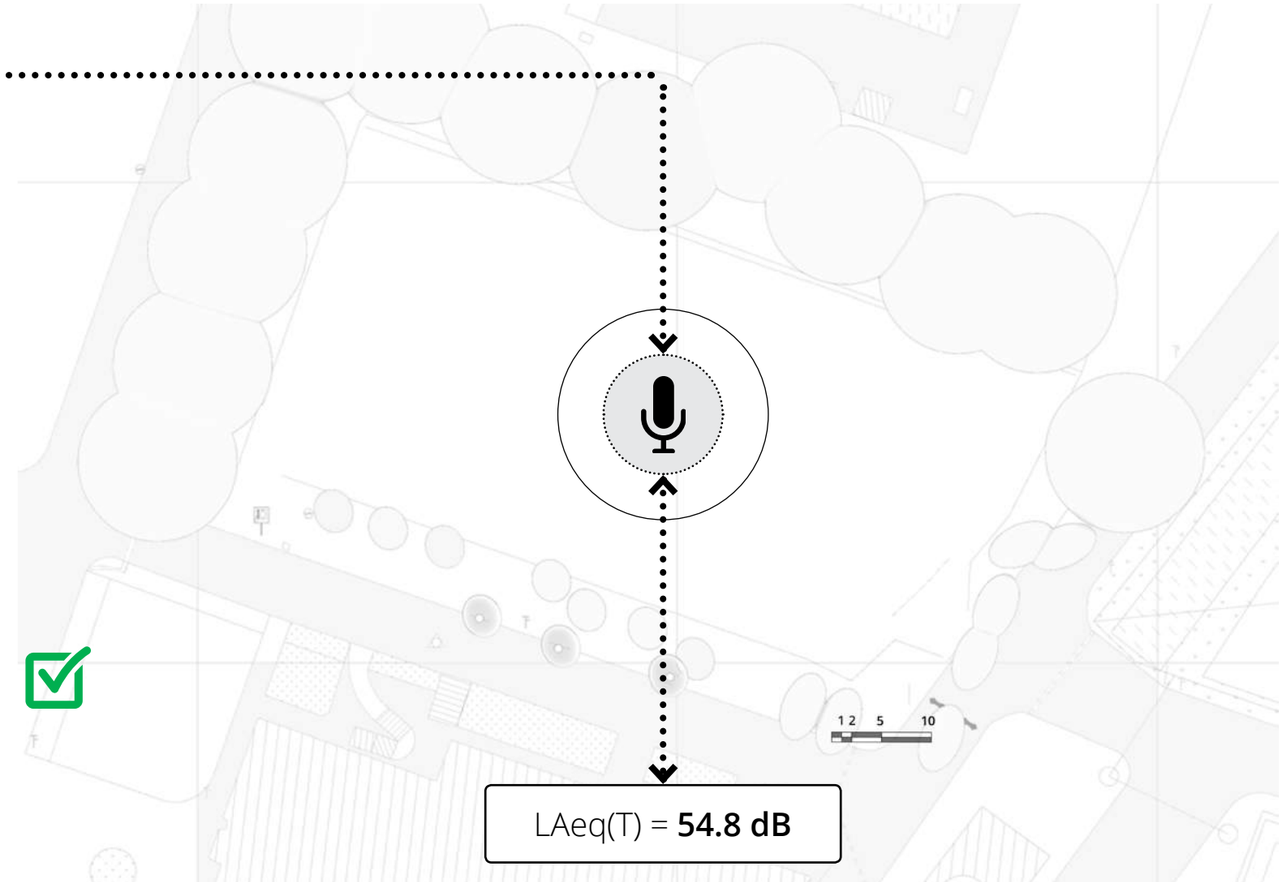
Roller Shade Operation Schedule






## Site Acoustical **Assessment**

| district acoustical type | Background noise level (LAeqT(30) in dB) | | Allowed Building Types |
|---|---|---|---|
| | 7 TO 10 | 10 TO 7 | |
| **Low Background noise** | **55** | **45** | Residential, Tourism Center, Healthcare, Cultural Centers, Sport Centers, Medium Level Buisiness Centers |
| **Medium Background noise** | **65** | **55** | «Educational, Administration, Indoor sports club,Mixed Use buildings(Business, Administration, Residential), Shopping Malls, Bazaars, Exhibition Halls» |
| **High Background noise** | **75** | **65** | Terminals, Storages, Parkings, Outdoor Sports Club, Industrial Buildings, Military Buildings, Airports |




## Views From the Site

**Eastern** Side



**Southern** Side



**Western** Side



**Northern** Side



**Eastern** Side



**Southern** Side



## **Labelling** Acoustic Zones

Zone Acoustical Labels

- **Loud zones:** includes areas intended for appliances, mechanical equipment or amenities (e.g., kitchens, fitness rooms, social spaces, recreational rooms).
- **Quiet zones:** includes areas intended for focused work, wellness, rest, study and/or privacy.
- **Mixed zones:** includes areas intended for learning, collaboration and/or presentation.




**Basement**

**Ground Floor**

## **Labelling** Acoustic Zones

Zone Acoustical Labels

- **Loud zones:** includes areas intended for appliances, mechanical equipment or amenities (e.g., kitchens, fitness rooms, social spaces, recreational rooms).
- **Quiet zones:** includes areas intended for focused work, wellness, rest, study and/or privacy.
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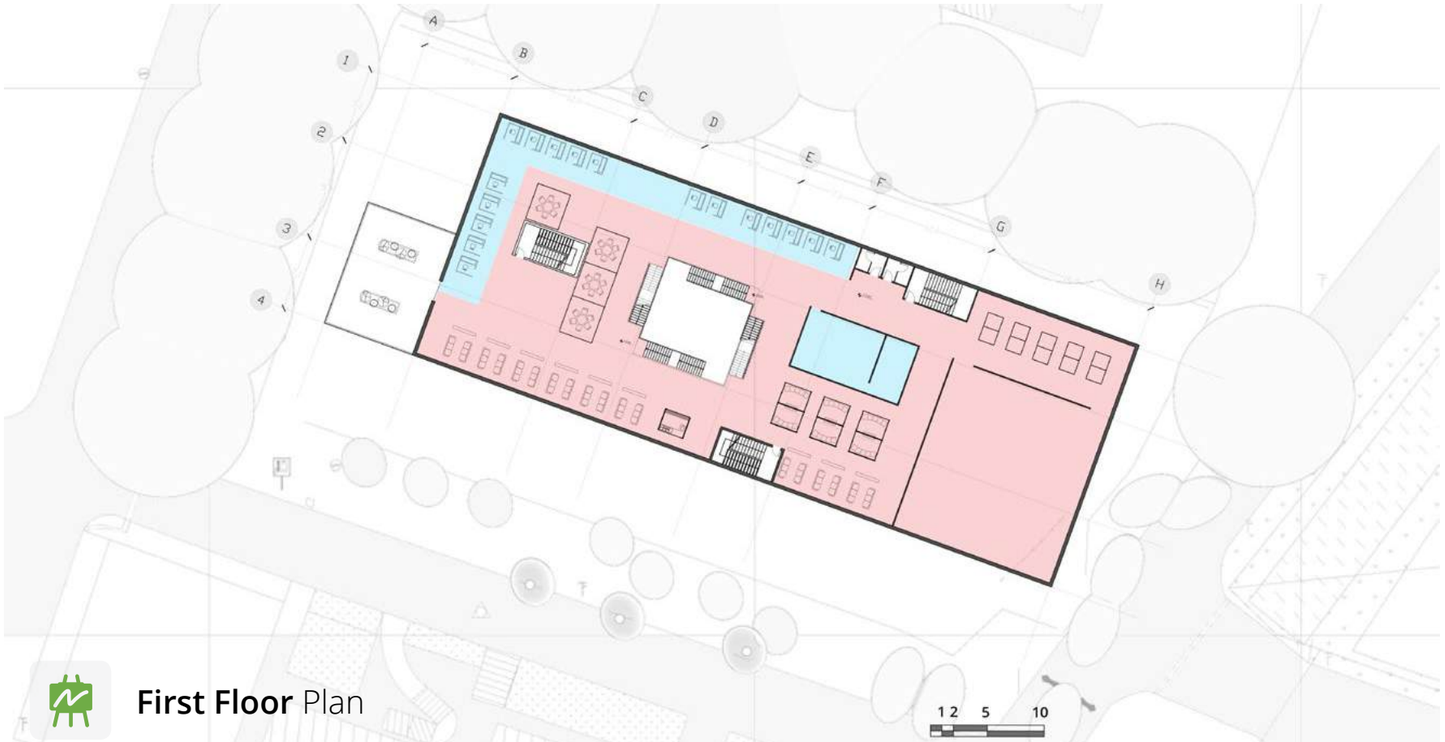



**First Floor** Plan




**Second Floor** Plan

## Acoustic **Requirements**

- Acoustic Requirements for Building Elements and spaces are listed in the table.
- The numbers and limits are determined due to Annex 18 and WELL Certification Criteria.

| | Spaces | Maximum Background noise | | Optimum Reverberation Time[s] | Maximum Background noise | | | | β - Impact Sound Isolation Level (IIC[dB]) | STI |
|---|---|---|---|---|---|---|---|---|---|---|
| | | LAeqT(30) | PNC | | Partition walls | Exterior Walls/Simple | Exterior Walls/ Multiple | Ceilings/ Floors(simple) | | |
| Basenemt | W.C. | 55 | 50 | - | 50 | 40 | 35 | 35 | 60 | - |
| | Conference Hall | 35 | 35 | 0.85 in 1000hz | 50 | 55 | 50 | 50 | 60 | >0.6 |
| | Fire Control Room | 65 | 60 | - | 55 | 40 | 35 | 55 | 60 | - |
| | Electrical/ Systems Control | 65 | 60 | - | 55 | 40 | 35 | 55 | 60 | - |
| | Facility Room | 65 | 60 | - | 55 | 40 | 35 | 55 | 60 | - |
| Ground Floor | W.C. | 55 | 50 | - | 50 | 40 | 35 | 35 | 60 | - |
| | Entrance | 50 | 45 | 1.5 | 45 | 40 | 35 | 45 | 65 | - |
| | Information | 50 | 45 | 1.5 | 45 | 40 | 35 | 45 | 65 | >0.6 |
| | Conference Hall | 35 | 35 | 0.85 in 1000hz | 50 | 55 | 50 | 50 | 60 | - |
| | Food Stall | 55 | 50 | - | 50 | 40 | 35 | 35 | 60 | - |
| | Shop | 45 | 40 | 2 | 45 | 40 | 35 | 50 | 45 | - |
| | FoudCourt Sitting Area | 50 | 45 | 1.5 | 45 | 40 | 35 | 45 | 65 | - |
| | Lounge | 50 | 45 | 1.5 | 45 | 40 | 35 | 45 | 65 | - |
| 1st Floor | W.C. | 55 | 50 | - | 50 | 40 | 35 | 35 | 60 | - |
| | Gallery | 35 | 35 | - | 50 | 45 | 40 | 50 | 55 | >0.6 |
| | Multi-Functional Space | 50 | 45 | 1.1 | 50 | 50 | 45 | 55 | 60 | - |
| | TV Room | 50 | 45 | 1.5 | 45 | 40 | 35 | 45 | 65 | - |
| | Study Hall (Individual) | 35 | 30 | 1.5 | 45 | 40 | 35 | 45 | 65 | - |
| | Study Hall (Group) | 35 | 30 | 1.5 | 45 | 40 | 35 | 45 | 65 | - |
| | Game Room | 50 | 45 | 0.8 | 50 | 50 | 45 | 55 | 60 | - |
| | Book Cafe | 50 | 45 | 1.5 | 45 | 40 | 35 | 45 | 65 | - |
| Second Floor | W.C. | 55 | 50 | - | 50 | 40 | 35 | 35 | 60 | - |
| | Lounge | 50 | 45 | 1.5 | 45 | 40 | 35 | 45 | 65 | - |
| | Study Hall (Individual) | 35 | 30 | 1.5 | 45 | 40 | 35 | 45 | 65 | - |
| | Study Hall (Group) | 35 | 30 | 1.5 | 45 | 40 | 35 | 45 | 65 | - |
| | Class Rooms | 35 | 30 | 1 | 35 | 45 | 40 | 50 | 55 | - |
| | Prayers Room | 35 | 35 | - | 35 | 45 | 40 | 50 | 50 | >0.6 |
| | Management | 40 | 35 | 1.2 | 45 | 40 | 35 | 45 | 65 | - |
| | Administration | 40 | 35 | 1.2 | 45 | 40 | 35 | 45 | 65 | - |
| | Conference Room | 35 | 35 | 0.8 | 35 | 45 | 40 | 50 | 55 | - |
| | Student Association | 40 | 35 | 1.2 | 45 | 40 | 35 | 45 | 65 | - |

Sample
**Spaces**

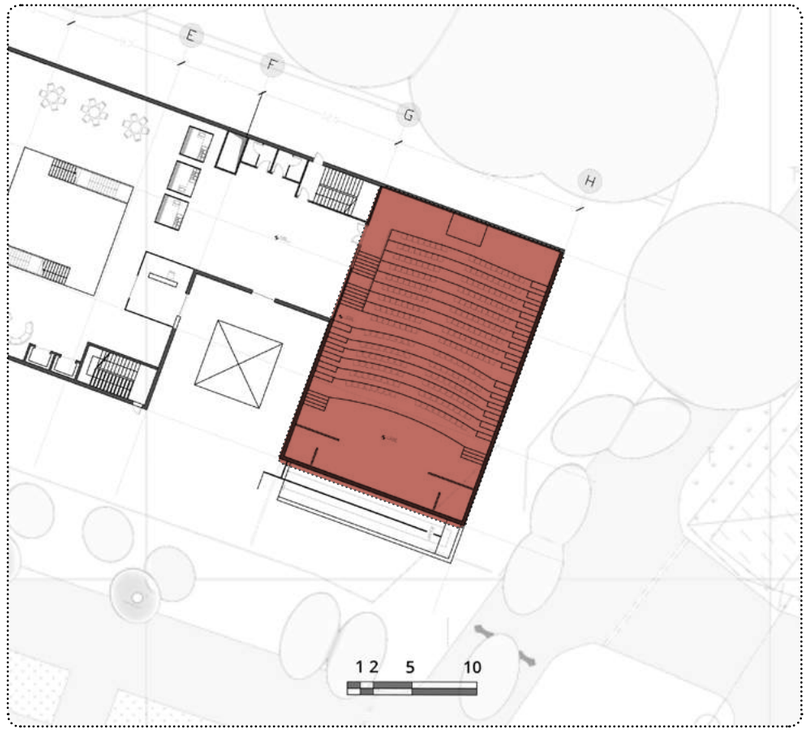
Space name **Conference Room**




| Space Area[m2] | 81 | Space Volume [m3] | 280 |
|---|---|---|---|

| Orientarion | Adjacent Space |
|---|---|
| **South** | Outdoors |
| **North** | Corridor |
| **East** | Lounge |
| **West** | Prayers Room |
| **Top** | Roof |
| **Bottom** | Lounge |

Space name **Conference Hall**




| Space Area[m2] | 371 | Space Volume [m3] | 1930 |
|---|---|---|---|

| Orientarion | Adjacent Space |
|---|---|
| **South** | Ground/Outdoors |
| **North** | Ground/Outdoors |
| **East** | Ground/Outdoors |
| **West** | Outdoors/ Electrical-Systems Control/ Fire Control |
| **Top** | Multi-Functional Space |
| **Bottom** | Ground |

Space name **Class Room**

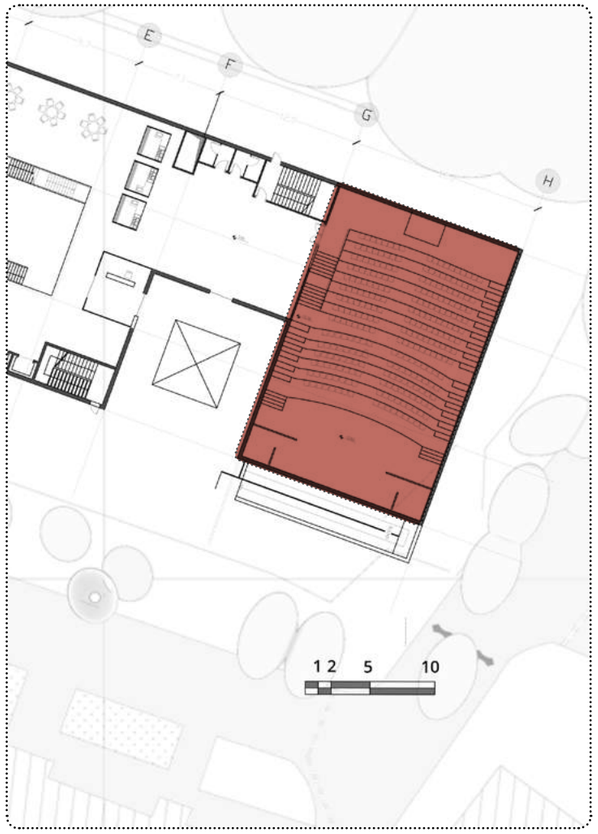



| Space Area[m2] | 30 | Space Volume [m3] | 105 |
|---|---|---|---|

| Orientarion | Adjacent Space |
|---|---|
| **South** | Corridor |
| **North** | Outdoors |
| **East** | Outdoors |
| **West** | Class room |
| **Top** | Roof |
| **Bottom** | Game Room |

| | Spaces | Maximum Background noise | | Optimum Reverberation Time[s] | Maximum Background noise | | | | β - Impact Sound Isolation Level (IIC[dB]) | STI |
|---|---|---|---|---|---|---|---|---|---|---|
| | | LAeqT(30) | PNC | | Partition walls | Exterior Walls/Simple | Exterior Walls/ Multiple | Ceilings/ Floors(simple) | | |
| Sample Spaces | **Conference Hall** | 35 | 35 | 0.85 in 1000hz | 50 | 55 | 50 | 50 | 60 | >0.6 |
| | **Class Rooms** | 35 | 30 | 0.8 | 35 | 45 | 40 | 50 | 55 | - |
| | **Conference Room** | 35 | 35 | 1 | 35 | 45 | 40 | 50 | 55 | - |

Space name **Conference Hall**




## **Air-borne** sound insulation

| *Position* | *Adjacent Space* | *Surface Type* | *Design STC* | *Target STC* | |
|---|---|---|---|---|---|
| South | Ground/Outdoors | External Wall | 55.0 | 55.0 | ☑ |
| North | Ground/Outdoors | External Wall | 55.0 | 55.0 | ☑ |
| East | Ground/Outdoors | External Wall | 45.7 | 50.0 | ☒ |
| West | Outdoors/ Electrical-Systems Control/ Fire Control | Partition Wall | 40 | 50.0 | ☒ |
| Top | Multi-Functional Space | Floor/ceiling | 51 | 50.0 | ☑ |
| Bottom | Ground | Ground | - | 50.0 | ☑ |

## **β-Impact noise** Conrtol

| *position* | *Adjacent Space* | *Separator Surface Type* |
|---|---|---|
| Bottom | Multi-Functional Space | Mosaic-mortar-concrete Slab-false ceiling |

| *Base IIC* | *target IIC* | *Target ΔIIC* | *Floating Floor ΔIIC* | *Final IIC* |
|---|---|---|---|---|
| 34 | 55 | 21 | 22 | 56 |

## Constructions

### Glazings

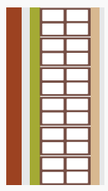
**Dbl Low-E**

| Name | SHGC[%] | VT[%] | VT/SHGC | Total U-value | STC |
|---|---|---|---|---|---|
| Dbl Blue 6mm/13mm Air | 0.598 | 0.789 | 1.29 | **1.786** | **45** |

450,000 T

### External Walls

**AAC Block Insulation L.1**

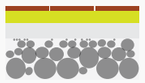


| Layer | Thichness | Conductivity | R-Value | Total U-value | STC |
|---|---|---|---|---|---|
| Inside Air | | | 0.11 | | |
| Gypsum plaster | 0.005 | 0.31 | 0.02 | | |
| Gypsum-sand plaster | 0.02 | 0.59 | 0.03 | | |
| AAC Block | 0.22 | 0.158 | 1.39 | | |
| XPS | 0.030 | 0.004 | 7.50 | **0.10** | **42** |
| Cement-Sand Plaster | 0.025 | 0.44 | 0.06 | | |
| Light Weight Brick | 0.03 | 0.08 | 0.38 | | |
| Outside Air | | | 0.06 | | |

160,000 T

### Ground Floors

**G.F Insulation L.2**



| Layer | Thichness | Conductivity | R-Value | U-value | STC |
|---|---|---|---|---|---|
| Mosaic | 0.22 | 1.65 | 0.13 | | |
| XPS | 0.060 | 0.04 | 1.50 | | |
| Concrete | 0.1 | 0.25 | 0.40 | **0.47** | **42** |
| Hardcore | 0.35 | 3.5 | 0.10 | | |

260,000 T

### Roofs

**Cool Roof+ Insulation L.2**



| Layer | Thichness | Conductivity | R-Value | Total U-value | STC | IIC |
|---|---|---|---|---|---|---|
| Outside Air | | | 0.05 | | | |
| CoolCoating | 0.002 | 1 | 0.00 | | | |
| Polyurethane | 0.010 | 0.25 | 0.04 | | | |
| XPS | 0.090 | 0.04 | 2.20 | **0.406** | **53** | **36** |
| Concrete | 0.220 | 2.5 | 0.09 | | | |
| Inside Air | | | 0.09 | | | |

520,000 T

### Other Surfaces

**Ceilings**



| Layer | Thichness | Total STC | Total IIC |
|---|---|---|---|
| CoolCoating | 0.002 | | |
| Polyurethane | 0.010 | | |
| Mortar | 0.090 | **51** | **34** |
| Concrete | 0.220 | | |

430,000 T

**Partition Walls**



| Layer | Thichness | Total STC |
|---|---|---|
| Gypsum | 0.02 | |
| Bricks | 0.10 | **42** |
| Gypsum | 0.020 | |

90,000 T

Space name **Conference Room**




## **Air-borne** sound insulation

| *Position* | *Adjacent Space* | *Surface Type* | *Design STC* | *Target STC* | |
|---|---|---|---|---|---|
| South | Outdoors | Curtainwall | **45.0** | 45.0 | ☑ |
| North | Corridor | Partition Wall | **39.3** | 35.0 | ☑ |
| East | Lounge | Partition Wall | **42.0** | 35.0 | ☑ |
| West | Prayers Room | Partition Wall | **42.0** | 35.0 | ☑ |
| Top | Roof | Roof | **53.0** | 50.0 | ☑ |
| Bottom | Lounge | Floor/ceiling | **51.0** | 50.0 | ☑ |

## **β-Impact noise** Conrtol

| *position* | *Adjacent Space* | *Separator Surface Type* |
|---|---|---|
| Top | Roof | Concrete-XPS-polyurthane-coolcoating |

| *Base IIC* | *target IIC* | *Target ΔIIC* | *Floating Floor ΔIIC* | *Final IIC* |
|---|---|---|---|---|
| 36 | 55 | 19 | 22 | 58 |

| *position* | *Adjacent Space* | *Separator Surface Type* |
|---|---|---|
| Bottom | Lounge | Mosaic-mortar-concrete Slab-false ceiling |

| *Base IIC* | *target IIC* | *Target ΔIIC* | *Floating Floor ΔIIC* | *Final IIC* |
|---|---|---|---|---|
| 34 | 55 | 21 | 22 | 56 |

## Constructions

### Glazings

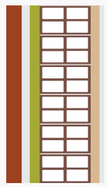
**Dbl Low-E**

| Name | SHGC[%] | VT[%] | VT/SHGC | Total U-value | STC |
|---|---|---|---|---|---|
| Dbl Blue 6mm/13mm Air | 0.598 | 0.789 | 1.29 | **1.786** | **45** |

450,000 T

### External Walls

**AAC Block Insulation L.1**

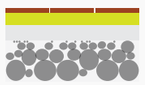


| Layer | Thichness | Conductivity | R-Value | Total U-value | STC |
|---|---|---|---|---|---|
| Inside Air | | | 0.11 | | |
| Gypsum plaster | 0.005 | 0.31 | 0.02 | | |
| Gypsum-sand plaster | 0.02 | 0.59 | 0.03 | | |
| AAC Block | 0.22 | 0.158 | 1.39 | **0.10** | **42** |
| XPS | 0.030 | 0.004 | 7.50 | | |
| Cement-Sand Plaster | 0.025 | 0.44 | 0.06 | | |
| Light Weight Brick | 0.03 | 0.08 | 0.38 | | |
| Outside Air | | | 0.06 | | |

160,000 T

### Ground Floors

**G.F Insulation L.2**



| Layer | Thichness | Conductivity | R-Value | U-value | STC |
|---|---|---|---|---|---|
| Mosaic | 0.22 | 1.65 | 0.13 | | |
| XPS | 0.060 | 0.04 | 1.50 | **0.47** | **42** |
| Concrete | 0.1 | 0.25 | 0.40 | | |
| Hardcore | 0.35 | 3.5 | 0.10 | | |

260,000 T

### Roofs

**Cool Roof+ Insulation L.2**



| Layer | Thichness | Conductivity | R-Value | Total U-value | STC | IIC |
|---|---|---|---|---|---|---|
| Outside Air | | | 0.05 | | | |
| CoolCoating | 0.002 | 1 | 0.00 | | | |
| Polyurethane | 0.010 | 0.25 | 0.04 | | | |
| XPS | 0.090 | 0.04 | 2.20 | **0.406** | **53** | **36** |
| Concrete | 0.220 | 2.5 | 0.09 | | | |
| Inside Air | | | 0.09 | | | |

520,000 T

### Other Surfaces

**Ceilings**



| Layer | Thichness | Total STC | Total IIC |
|---|---|---|---|
| CoolCoating | 0.002 | | |
| Polyurethane | 0.010 | **51** | **34** |
| Mortar | 0.090 | | |
| Concrete | 0.220 | | |

430,000 T

**Partition Walls**



| Layer | Thichness | Total STC |
|---|---|---|
| Gypsum | 0.02 | |
| Bricks | 0.10 | **42** |
| Gypsum | 0.020 | |

90,000 T

Space name **Class Room**




## **Air-borne** sound insulation

| Position | Adjacent Space | Surface Type | Design STC | Target STC | |
|---|---|---|---|---|---|
| South | Corridor | Partition Wall | 38.6 | 35.0 | ☑ |
| North | Outdoors | External Wall | 44.7 | 40.0 | ☑ |
| East | Outdoors | External Wall | 44.7 | 40.0 | ☑ |
| West | Class room | Partition Wall | 42 | 35.0 | ☑ |
| Top | Roof | Roof | 53 | 50.0 | ☑ |
| Bottom | Game Room | Partition Wall | 51 | 50.0 | ☑ |

## **β-Impact noise** Conrtol

| position | Adjacent Space | Separator Surface Type |
|---|---|---|
| Top | Roof | Concrete-XPS-polyurthane-coolcoating |

| Base IIC | target IIC | Target ΔIIC | Floating Floor ΔIIC | Final IIC |
|---|---|---|---|---|
| 36 | 55 | 19 | 22 | 58 |

| position | Adjacent Space | Separator Surface Type |
|---|---|---|
| Bottom | GameRoom | Mosaic-mortar-concrete Slab-false ceiling |

| Base IIC | target IIC | Target ΔIIC | Floating Floor ΔIIC | Final IIC |
|---|---|---|---|---|
| 34 | 55 | 21 | 22 | 56 |

## Constructions

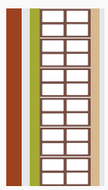
### Glazings

**Dbl Low-E** — 450,000 T

| Name | SHGC[%] | VT[%] | VT/SHGC | Total U-value | STC |
|---|---|---|---|---|---|
| Dbl Blue 6mm/13mm Air | 0.598 | 0.789 | 1.29 | **1.786** | **45** |

### External Walls

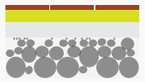
**AAC Block Insulation L.1** — 160,000 T



| Layer | Thichness | Conductivity | R-Value | Total U-value | STC |
|---|---|---|---|---|---|
| Inside Air | | | 0.11 | **0.10** | **42** |
| Gypsum plaster | 0.005 | 0.31 | 0.02 | | |
| Gypsum-sand plaster | 0.02 | 0.59 | 0.03 | | |
| AAC Block | 0.22 | 0.158 | 1.39 | | |
| XPS | 0.030 | 0.004 | 7.50 | | |
| Cement-Sand Plaster | 0.025 | 0.44 | 0.06 | | |
| Light Weight Brick | 0.03 | 0.08 | 0.38 | | |
| Outside Air | | | 0.06 | | |

### Ground Floors

**G.F Insulation L.2** — 260,000 T



| Layer | Thichness | Conductivity | R-Value | U-value | STC |
|---|---|---|---|---|---|
| Mosaic | 0.22 | 1.65 | 0.13 | **0.47** | **42** |
| XPS | 0.060 | 0.04 | 1.50 | | |
| Concrete | 0.1 | 0.25 | 0.40 | | |
| Hardcore | 0.35 | 3.5 | 0.10 | | |

### Roofs

**Cool Roof+ Insulation L.2** — 520,000 T



| Layer | Thichness | Conductivity | R-Value | Total U-value | STC | IIC |
|---|---|---|---|---|---|---|
| Outside Air | | | 0.05 | **0.406** | **53** | **36** |
| CoolCoating | 0.002 | 1 | 0.00 | | | |
| Polyurethane | 0.010 | 0.25 | 0.04 | | | |
| XPS | 0.090 | 0.04 | 2.20 | | | |
| Concrete | 0.220 | 2.5 | 0.09 | | | |
| Inside Air | | | 0.09 | | | |

### Other Surfaces

**Ceilings** — 430,000 T



| Layer | Thichness | Total STC | Total IIC |
|---|---|---|---|
| CoolCoating | 0.002 | **51** | **34** |
| Polyurethane | 0.010 | | |
| Mortar | 0.090 | | |
| Concrete | 0.220 | | |

**Partition Walls** — 90,000 T



| Layer | Thichness | Total STC |
|---|---|---|
| Gypsum | 0.02 | **42** |
| Bricks | 0.10 | |
| Gypsum | 0.020 | |

## Sound Transmission Class Calculation for Multiple Partitions

Base

| Spaces | Surface location | Adjacent Space | Separator Surface Type | Sub-surface type | Main Surface STC (dB) | Total surface area (m2) | main surface area(m2) | Sub-surface STC (dB) | Sub-surface type | Sub-surface area (m2) | Main surface τ | sub-surface τ | total τ | Total STC | Target STC | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Conference Room | **East** | Lounge | Partition Wall+ door | door | 42 | 26.95 | 24.97 | 31 | Wooden door-thickness=4.5cm-solid-Surface Density=24.5 kg/m2 | 1.98 | 6.31E-05 | 7.94E-04 | 1.17E-04 | 39.3 | 35 | ☑ |
| Conference Hall | **East** | Ground/ Outdoors | Partition Wall+ door | door | 53 | 144 | 140.04 | 31 | Wooden door-thickness=4.5cm-solid-Surface Density=24.5 kg/m2 | 3.96 | 5.01E-06 | 7.94E-04 | 2.67E-05 | 45.7 | 50 | ☒ |
| | **West** | Outdoors/ Electrical-Systems Control/ Fire Control | Partition Wall+ door | door | 42 | 144 | 136.08 | 31 | Wooden door-thickness=4.5cm-solid-Surface Density=24.5 kg/m2 | 7.92 | 6.31E-05 | 7.94E-04 | 1.03E-04 | 40 | 50 | ☒ |
| Class Room | **South** | corridor | Partition Wall+ door | door | 42 | 19.6 | 17.65 | 31 | Wooden door-thickness=4.5cm-solid-Surface Density=24.5 kg/m2 | 1.98 | 6.31E-05 | 7.94E-04 | 1.37E-04 | 38.6 | 35 | ☑ |
| | **North** | Outdoors | External Wall+ Windows | Windows | 53 | 19.6 | 13.76 | 40 | Laminated double clear windows-sealed | 5.9 | 5.01E-06 | 1.00E-04 | 3.35E-05 | 44.7 | 40 | ☑ |
| | **East** | Outdoors | External Wall+ Windows | Windows | 53 | 23.1 | 16.17 | 40 | Laminated double clear windows-sealed | 6.93 | 5.01E-06 | 1.00E-04 | 3.35E-05 | 44.7 | 40 | ☑ |

Improved

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Conference Hall | **East** | Ground/ Outdoors | Partition Wall+ door | door | 57 | 144 | 140.04 | 60 | All Steel Acoustic Swing Doors | 3.96 | 7.94E-06 | 1.00E-06 | 7.75E-06 | 51.1 | 50 | ☑ |
| | **West** | Outdoors/ Electrical-Systems Control/ Fire Control | Partition Wall+ door | door | 51 | 144 | 136.08 | 60 | All Steel Acoustic Swing Doors | 7.92 | 2.00E-06 | 1.00E-06 | 1.94E-06 | 57.1 | 50 | ☑ |

## **Improvement** options details

Floaing floor

### SoundBuffer
### Universal Sound Reducing Flooring Underlayment

Product Information
Made from %100 virgin latex rubber, SoundBuffer is CRI (Carpet and Rug Institute) certified and residential and commercial rated for under a variety of overlying flooring products. Featuring excellent acoustical ratings, SoundBuffer exceeds the standard for high-rise flooring installations. Thanks to its specific density and compression set characteristics, SoundBuffer helps minimize impressions and indentations that can mainly occur with luxury vinyl.

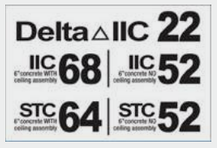
*Can be used with a variety of floating floor types.*

*Allows fasteners to penetrate through it.*

*Allows adhesives to adhere for glue down application.*

*Provides excellent acoustical performance, when compared to traditional polyethylene foam underlayment.*

*Dense material will minimize the amount of denting and telescoping conformity the planks or tile can have to the subfloor.*







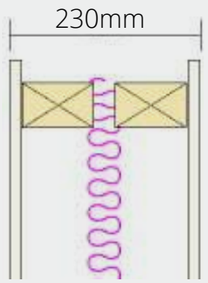

ΔIIC: ***22dB***

*Source:* ***mpglobalproducts.com***

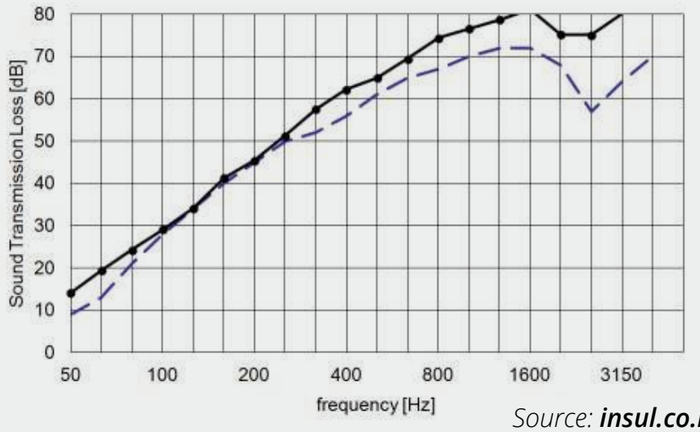
Conference Hall-west Wall

### Twin framed wall

1 layer of 16mm fire rated plasterboard each side of separate 90mm studs. Cavity depth of 200mm. 90mm fibreglass blanket in cavity (16kg/m3).




STC: **57 dB**

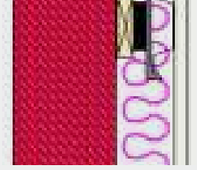



*Source:* ***insul.co.nz***

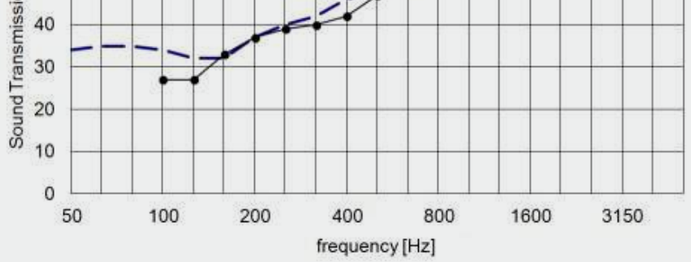
Conference Hall-east Wall

### Lined Brickwork

Clay brick (90mm thick) with 1 layer of 16mm plasterboard fixed to acoustic clip and 25mm fibreglass blanket in cavity.




STC: **51 dB**




*Source:* ***insul.co.nz***

Conference Hall-east Doors

### All Steel Acoustic Swing Doors

CDL Acoustical metal swing doors are made from steel and provide superior strength and insulating properties, making them suitable as sound barriers (acoustic doors) up to STC57. Available as single or double leaf door, CDL steel hinged acoustic swing doors come complete as a door set with door leaf, frame and hardware factory fitted. Fire ratings are optional up to two hours to UL10c.

### Product Features

- Independently tested acoustical doors up to STC 60
- Fire Ratings to UL10c
- Proprietary door hinge with integrated thrust bearing for ADA pull force compliance
- Factory finished with a Polyester Powder Coat Paint, in your choice of RAL color
- Delivered as a complete assembly, including door frame and all finish hardware
- Supervised installation

### Configurations

Single leaf
Double leaf
Bi-Fold
Unequal leaves

### Accessories & Custom Features Available

Vision Lites
Sports Hall Hardware
Corten Finish
Stainless Steel Finish
Prepared for Cladding

STC: **60 dB**

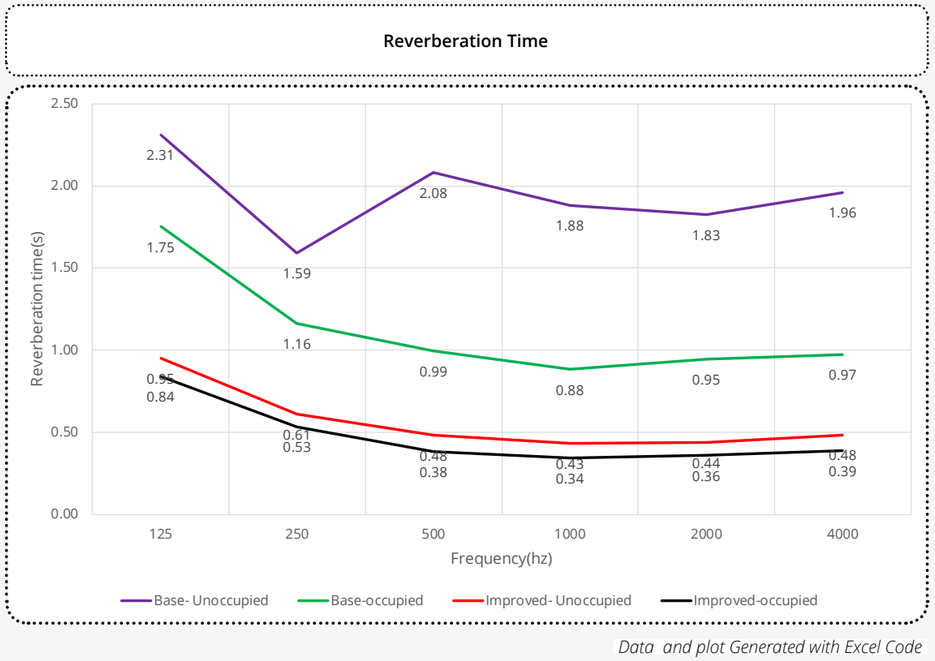


*Double Doors with door closer and vision panels*

*Source:***cdldoors.com**

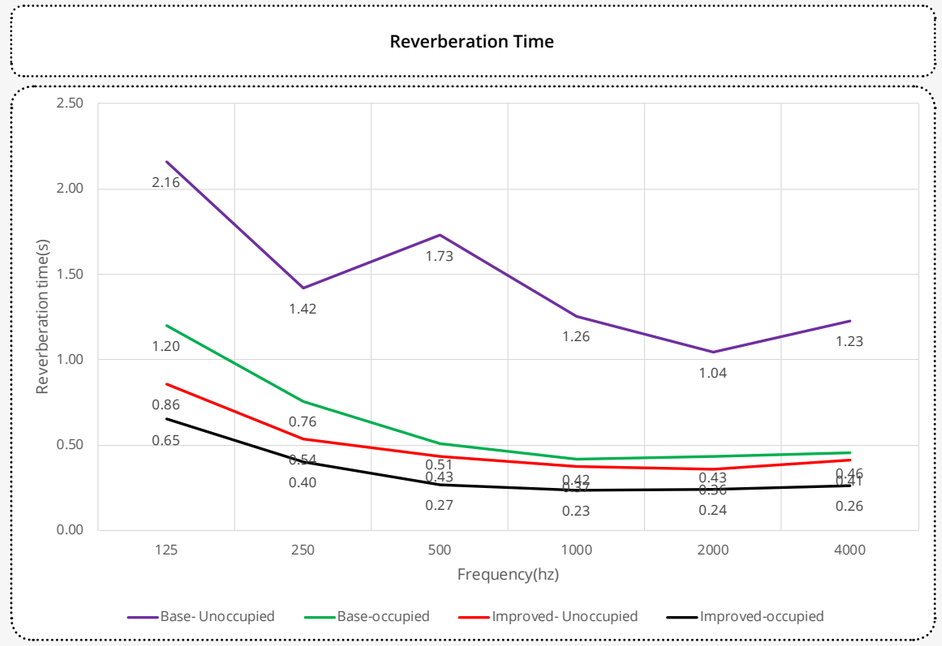
## reververation Time
Calculations

| Space | Surface | Separator Surface Type | Area/ number | Absorption Coefficient 125 | 250 | 500 | 1000 | 2000 | 4000 | volume (m3) |
|---|---|---|---|---|---|---|---|---|---|---|
| Conference Room | South | Curtain Wall | 42.46 | 0.15 | 0.3 | 0.18 | 0.05 | 0.15 | 0.05 | 279.45 |
| | North | Partition Wall | 40.48 | 0.01 | 0.02 | 0.02 | 0.03 | 0.01 | 0.04 | |
| | East | Partition Wall | 29.26 | 0.01 | 0.02 | 0.02 | 0.03 | 0.01 | 0.04 | |
| | West | Partition Wall | 29.26 | 0.01 | 0.02 | 0.02 | 0.03 | 0.01 | 0.04 | |
| | Top | Roof | 81.2 | 0.01 | 0.02 | 0.02 | 0.03 | 0.01 | 0.04 | |
| | Bottom | Floor/ceiling | 81.2 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.02 | |
| | Door | wooden door | ` 1.98 | 0.14 | 0.1 | 0.06 | 0.1 | 0.14 | 0.1 | |
| | table | - | 28 | 0.18 | 0.12 | 0.1 | 0.08 | 0.18 | 0.07 | |
| | Unoccupied plastic chairs | - | 0/30 | 0.06 | 0.1 | 0.1 | 0.3 | 0.06 | 0.2 | |
| | Occupied plastic chairs | - | 30/0 | 0.24 | 0.4 | 0.78 | 0.96 | 0.24 | 0.87 | |
| | *Wall Absorbers* | - | *30/0* | 0.45 | 0.75 | 0.8 | 0.7 | 0.65 | 0.6 | |
| | *Ceiling Absorbers* | - | *0/35.3* | 0.24 | 0.4 | 0.78 | 0.98 | 0.96 | 0.87 | |
| | other furniture | - | - | | | | | | | |




*Data and plot Generated with Excel Code*

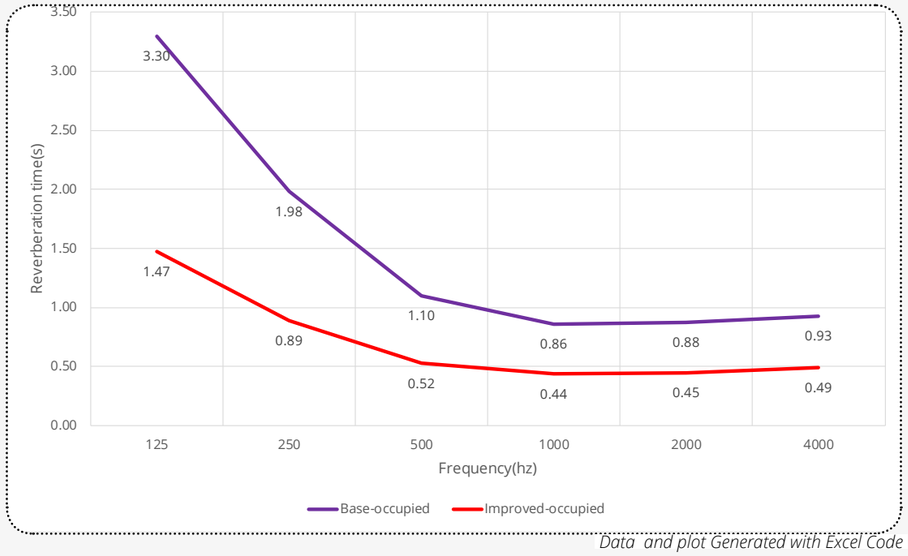
| Space | Surface | Separator Surface Type | Area/ number | Absorption Coefficient 125 | 250 | 500 | 1000 | 2000 | 4000 | volume (m3) |
|---|---|---|---|---|---|---|---|---|---|---|
| Class Room | South | Curtain Wall | 6.97 | 0.01 | 0.02 | 0.02 | 0.03 | 0.03 | 0.04 | 105 |
| | North | Partition Wall | 13.7 | 0.01 | 0.02 | 0.02 | 0.03 | 0.03 | 0.04 | |
| | East | Partition Wall | 16.2 | 0.01 | 0.02 | 0.02 | 0.03 | 0.03 | 0.04 | |
| | West | Partition Wall | 23.1 | 0.01 | 0.02 | 0.02 | 0.03 | 0.03 | 0.04 | |
| | Top | Roof | 30.6 | 0.01 | 0.02 | 0.02 | 0.03 | 0.03 | 0.04 | |
| | Bottom | Floor/ceiling | 30.6 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | |
| | Door | wooden door | ` 1.98 | 0.14 | 0.1 | 0.06 | 0.08 | 0.1 | 0.1 | |
| | Windows | - | 12.8 | 0.15 | 0.3 | 0.18 | 0.1 | 0.05 | 0.05 | |
| | Whiteboard | - | 2 | 0.42 | 0.21 | 0.1 | 0.08 | 0.06 | 0.06 | |
| | Unoccupied plastic chairs | - | 30 | 0.06 | 0.1 | 0.1 | 0.2 | 0.3 | 0.2 | |
| | Occupied plastic chairs | - | 0 | 0.24 | 0.4 | 0.78 | 0.98 | 0.96 | 0.87 | |
| | *Wall Absorbers* | - | 0/15 | 0.45 | 0.75 | 0.8 | 0.7 | 0.65 | 0.6 | |
| | *Ceiling Absorbers* | - | 0/23 | 0.24 | 0.4 | 0.78 | 0.98 | 0.96 | 0.87 | |
| | other furniture | - | | | | | | | | |




*Data and plot Generated with Excel Code*

## reververation Time
Calculations

| Space | Surface | Separator Surface Type | Area/ number | Absorption Coefficient 125 | 250 | 500 | 1000 | 2000 | 4000 | volume (m3) |
|---|---|---|---|---|---|---|---|---|---|---|
| Conference Hall | South | External wall | 84 | 0.01 | 0.02 | 0.02 | 0.03 | 0.03 | 0.04 | 279.45 |
| | North | External wall | 46.2 | 0.01 | 0.02 | 0.02 | 0.03 | 0.03 | 0.04 | |
| | East | External wall | 108 | 0.01 | 0.02 | 0.02 | 0.03 | 0.03 | 0.04 | |
| | West | Partition Wall | 108 | 0.01 | 0.02 | 0.02 | 0.03 | 0.03 | 0.04 | |
| | Top | Floor/ceiling | 96 | 0.01 | 0.02 | 0.02 | 0.03 | 0.03 | 0.04 | |
| | Bottom | Ground | `138.24 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | |
| | Doors | Woodendoor | 12 | 0.14 | 0.1 | 0.06 | 0.08 | 0.1 | 0.1 | |
| | Acoustic Chairs | - | 288 | 0.24 | 0.4 | 0.78 | 0.98 | 0.96 | 0.87 | |
| | Wall Absorbers | - | *0/115* | 0.45 | 0.75 | 0.8 | 0.7 | 0.65 | 0.6 | |
| | Ceiling Absorbers | - | *0/288* | 0.24 | 0.4 | 0.78 | 0.98 | 0.96 | 0.87 | |
| | other furniture | - | - | | | | | | | |




*Data and plot Generated with Excel Code*

### Improvements

| Conference Hall | Class Room | Conference Room |
|---|---|---|
| **Ceiling** covering %75 of area with Acoustic panels with the NRC of 0.7<br><br>**Vertical Surfaces** covering %25 of area with Acoustic panels with the NRC of 0.8 | **Ceiling** covering %75 of area with Acoustic panels with the NRC of 0.7<br><br>**Vertical Surfaces** covering %25 of area with Acoustic panels with the NRC of 0.8 | **Ceiling** covering %75 of area with Acoustic panels with the NRC of 0.7<br><br>**Vertical Surfaces** covering %25 of area with Acoustic panels with the NRC of 0.8 |

| Targets | | Base | | Improved | |
|---|---|---|---|---|---|
| Target RT (Annex 18) | Target RT (WELL) | WELL Credit | Annex 18 Credit | WELL Credit | Annex 18 Credit |
| 1 | 0.6 | ☒ | ☒ | ☑ | ☑ |
| 0.8 | 0.6 | ☑ | ☒ | ☑ | ☑ |
| 0.85 | 0.7-0.3 | ☒ | ☒ | ☑ | ☑ |

Acoustic tiles
details for Ceilings

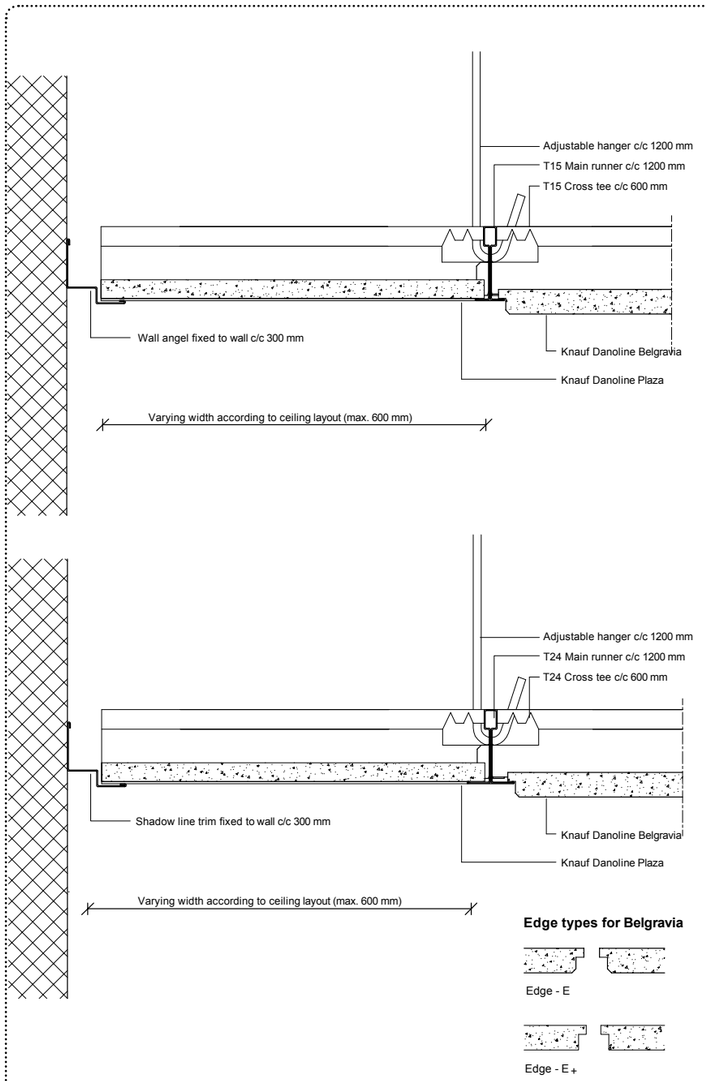
***INSTALLATION***

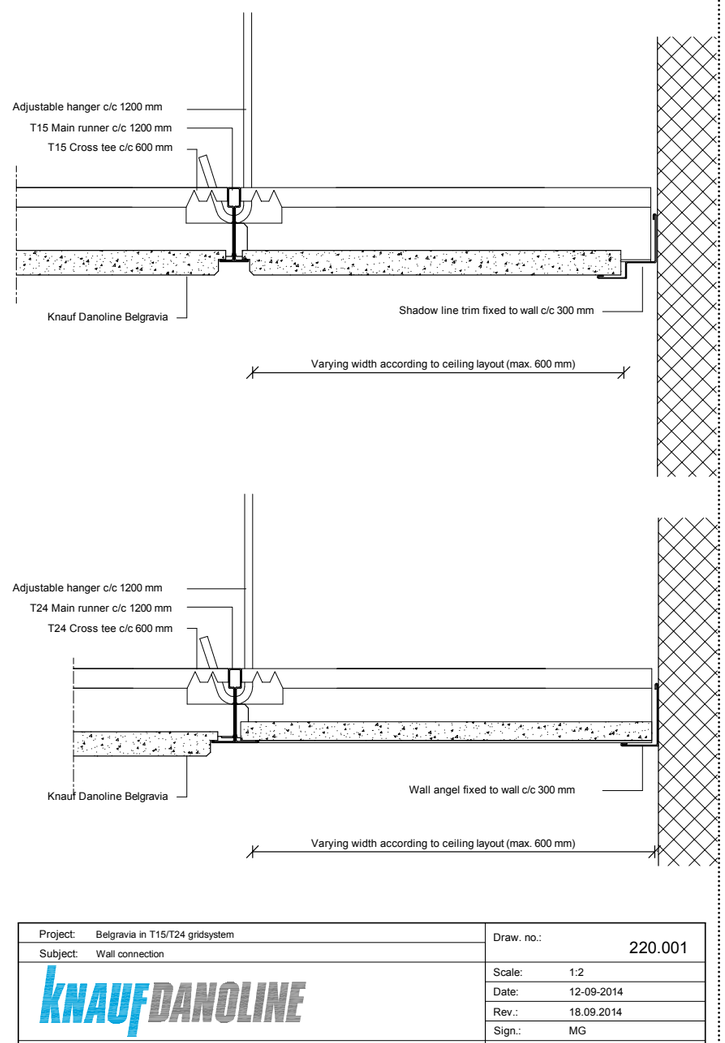
Suspension: Recessed grid system

- Distance between hangers ≤ 1200 mm.
- Distance from wall to first hanger in direction of load-bearing section ≤ 400 mm.
- Distance between load-bearing sections ≤ 1200 mm.
- Distance from wall to first load-bearing section ≤ 600 mm.
- Sub-division executed with cross-sections length 1200 and 600 mm.
- Screw spacing for attachment of edge section: max. 300mm c/c
- In the case of fittings, loads must be taken up directly by the concrete deck or via the grid system and extra hangers.

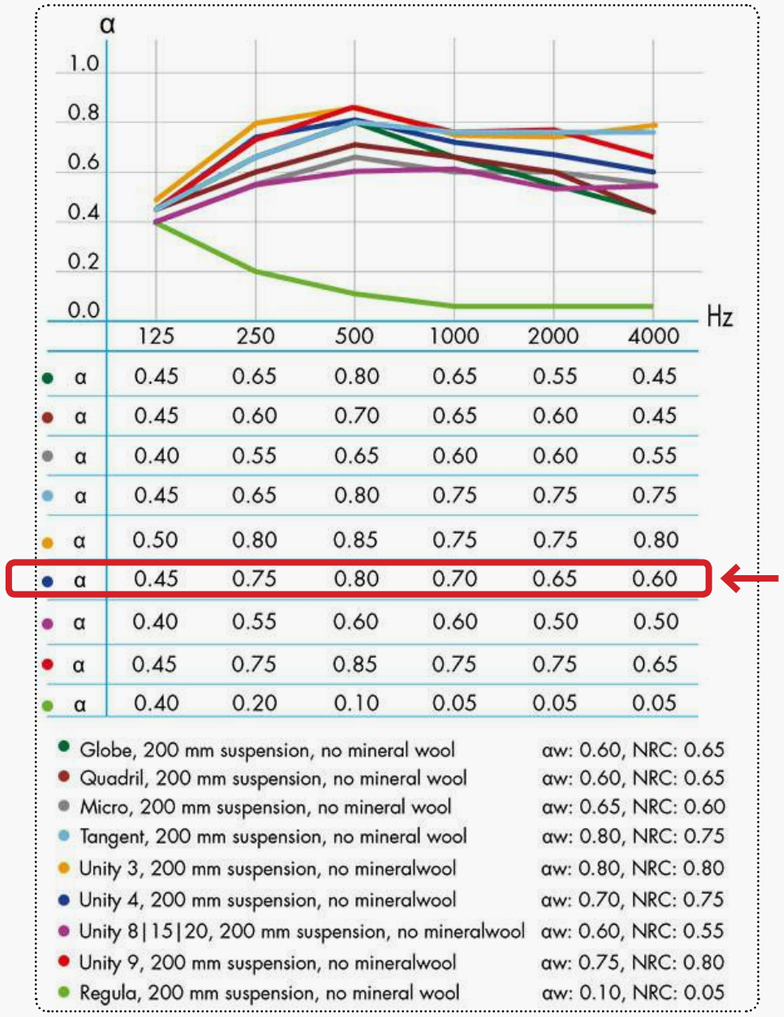
***MATERIAL***

Material: Perforated plasterboard
Board type: Ceiling tile
Length x width x thickness:
600 x 600 x 12.5
Edge: E+, recessed grid system (8 mm recess)
Perforation: Square 3.5x3.5mm holes, c/c 8.33 mm
Perforation to edge
Perforation percent:
17.2 %
Surface: Water-based acrylic paint
Colour: White NCS 0701 Y24R, RAL 9003; gloss 5
Attachment: 15 mm OR 24 mm T-grid system
Edge section: 20x24 mm angled profile
15+15 x 25+8 mm cornice moulding




| | |
|---|---|
| Project: Belgravia in T15/T24 gridsystem | Draw. no.: 220.001 |
| Subject: Wall connection | |
| KNAUF DANOLINE | Scale: 1:2 |
| | Date: 12-09-2014 |
| | Rev.: 18.09.2014 |
| | Sign.: MG |
| Knauf Danoline A/S Klavermarksvej 6, DK-9500 Hobro<br>T: +45 9657 3000 F: +45 9657 3001<br>www.knaufdanoline.com - info@knaufdanoline.com | Project no.: |
| | File: |




| | 125 | 250 | 500 | 1000 | 2000 | 4000 |
|---|---|---|---|---|---|---|
| α | 0.45 | 0.65 | 0.80 | 0.65 | 0.55 | 0.45 |
| α | 0.45 | 0.60 | 0.70 | 0.65 | 0.60 | 0.45 |
| α | 0.40 | 0.55 | 0.65 | 0.60 | 0.60 | 0.55 |
| α | 0.45 | 0.65 | 0.80 | 0.75 | 0.75 | 0.75 |
| α | 0.50 | 0.80 | 0.85 | 0.75 | 0.75 | 0.80 |
| α | 0.45 | 0.75 | 0.80 | 0.70 | 0.65 | 0.60 |
| α | 0.40 | 0.55 | 0.60 | 0.60 | 0.50 | 0.50 |
| α | 0.45 | 0.75 | 0.85 | 0.75 | 0.75 | 0.65 |
| α | 0.40 | 0.20 | 0.10 | 0.05 | 0.05 | 0.05 |

| | |
|---|---|
| Globe, 200 mm suspension, no mineral wool | aw: 0.60, NRC: 0.65 |
| Quadril, 200 mm suspension, no mineral wool | aw: 0.60, NRC: 0.65 |
| Micro, 200 mm suspension, no mineral wool | aw: 0.65, NRC: 0.60 |
| Tangent, 200 mm suspension, no mineral wool | aw: 0.80, NRC: 0.75 |
| Unity 3, 200 mm suspension, no mineralwool | aw: 0.80, NRC: 0.80 |
| Unity 4, 200 mm suspension, no mineralwool | aw: 0.70, NRC: 0.75 |
| Unity 8\|15\|20, 200 mm suspension, no mineralwool | aw: 0.60, NRC: 0.55 |
| Unity 9, 200 mm suspension, no mineralwool | aw: 0.75, NRC: 0.80 |
| Regula, 200 mm suspension, no mineral wool | aw: 0.10, NRC: 0.05 |

**SIZE (MODULE)**
600 x 600 x 12.5 mm

**SURFACE**
Standard white painted surface NCS 0701 Y24R (RAL 9003).

**Gloss 5.**
Other colours available on request.

**WEIGHT KG/M²**
Indicative tile weight: 9.90 – 9.20.
All according to type of perforation.

*Source:**knaufdanoline.com***

Acoustic tiles
details for walls

***Description*** 12.5 x 600 x 600 mm high grade, glass fibre reinforced acoustic, painted gypsum boards with acoustic special Kino-perforation.
Kinopanels are with edge B for wall mounting and shall be installed by screw fixing to a special support framework with max c/c 300 mm.

***Colour***: Black RAL 9001 (Other colours available from NCS and RAL colour palettes.).

***Paint type:*** Water based acrylic polyurethane combination paint that hardens to an enamel type finish.
Smooth and hard surface finish that is highly robust and dirt resistant and exceptionally easy to clean.

***Properties:*** Light Reflection: %5,5

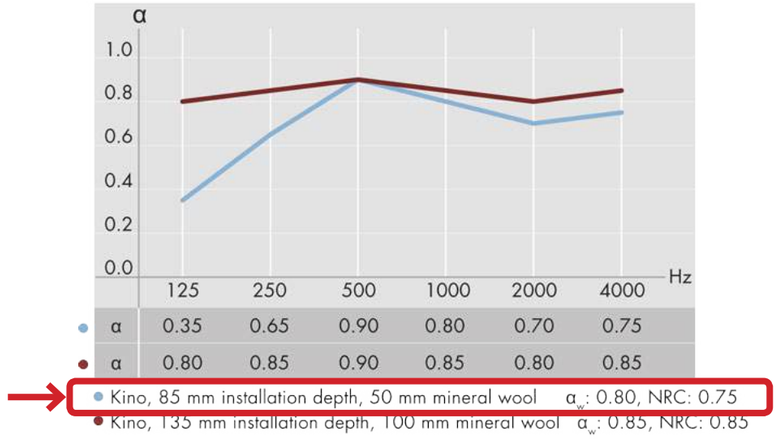
***Acoustic properties:***
Kino: αw: 0.80; NRC: 0.75
Installation depth: 85 mm with 50 mm mineral wool backing

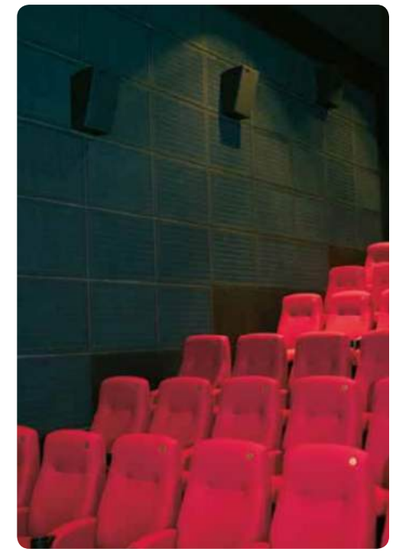
***Fire Class:*** A-2s1,d0

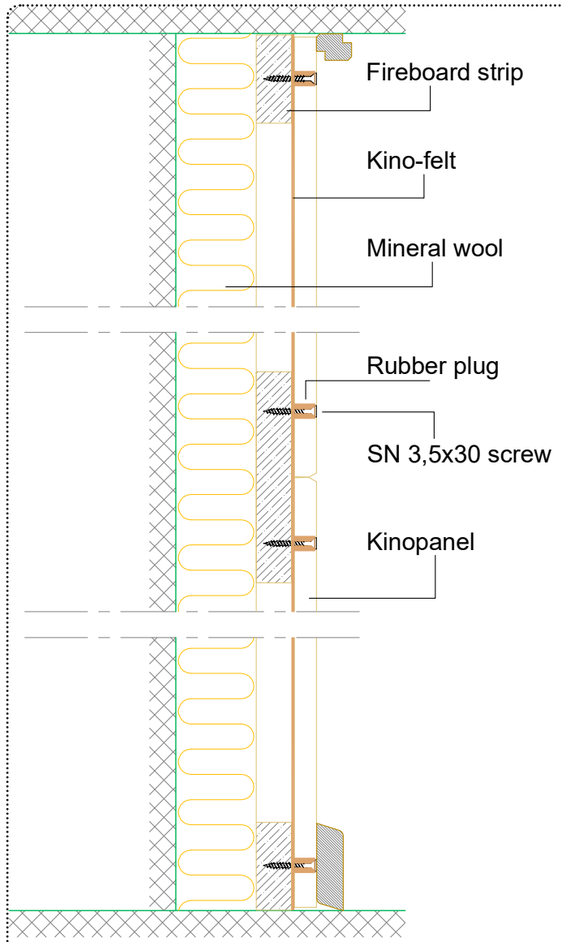
***Suspension:*** The Kinopanels are wall mounted using a minimum of 8 screws per 600 x 600 mm section. The screws can either be screwed directly through the panels or acoustic rubber plugs can be used.

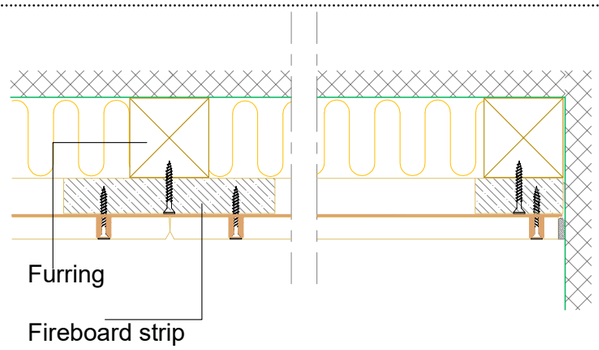
***Characteristics:*** The panels shall be:
- Manufactured from high grade non-combustible glass fibre reinforced gypsum board produced according to EN 520.
- Tested to meet the safety requirements of EN 14190.
- Tested in accordance with EN 1-13501 to achieve minimum fire classification A-2s1,d0.
- Resistant to %90 RH and short term exposure for higher humidity.
- Non hazardous and fully recyclable.








**SIZE (MODULE)**
600 x 600 x 12.5 mm

**SURFACE**
Standard black painted surface NCS-S--9000N.

**Gloss 5.**
Other colours available on request.

**WEIGHT KG/M²**
Tile weight: 6.2
Transportation weight: 8.0

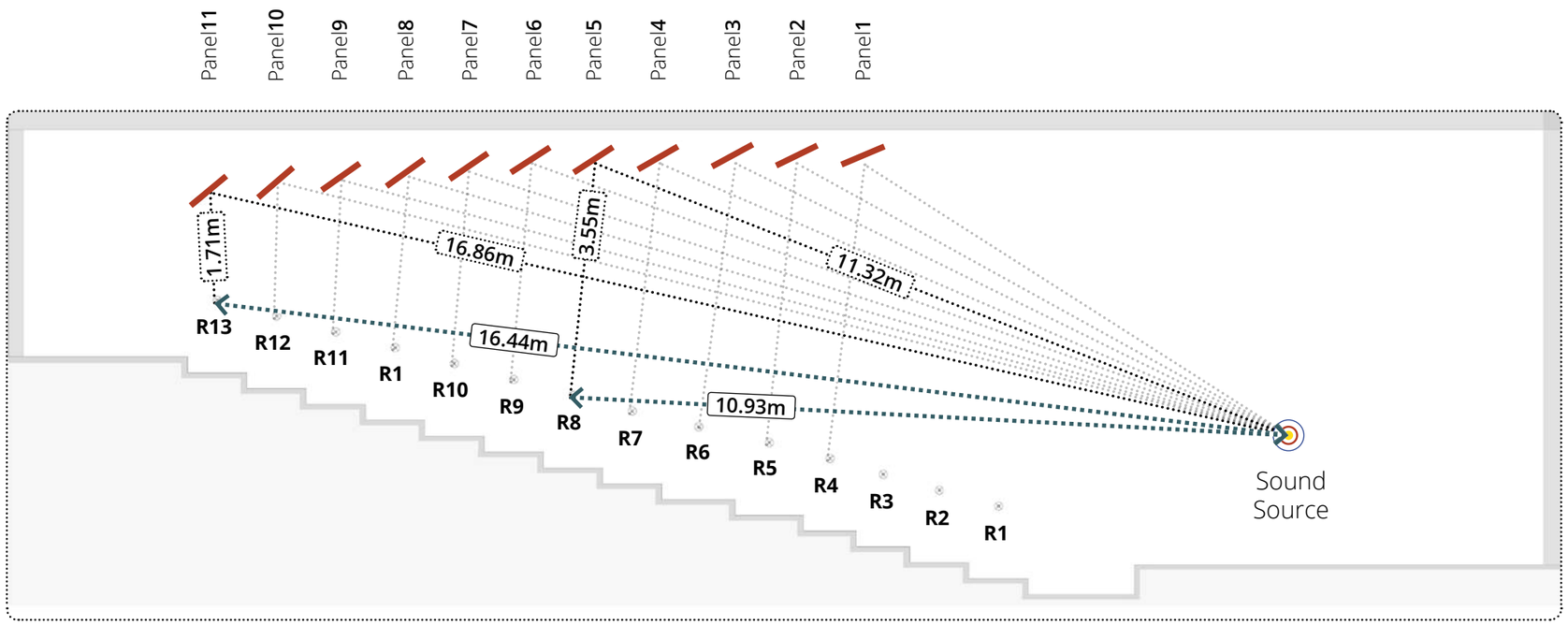
| | |
|---|---|
| Project: Kinopanel | Draw. no.: 130924-608-001 |
| Subject: Amfipanel on furring | Scale: 1:2 |
| KNAUF DANOLINE | Date: 24.09.2013 |
| | Rev.: |
| | Sign.: KJ |
| Knauf Danoline A/S Kløvermarksvej 6, DK-9500 Hobro<br>T: +45 9657 3000 F: +45 9657 3001<br>www.knaufdanoline.com - info@knaufdanoline.com | Project no.: |
| | File: |

*Source:**knaufdanoline.com***

Conference Hall

Space name | **Conference Hall**




| Panel Code | source to panel distance(a) in meters | panel to receiver distance(b) in meters | source to receiver distance(c) in meters | a+b-c (should not be more than 17 meters) |
|---|---|---|---|---|
| panel 1 | 7.64 | 4.53 | 7.03 | 5.15 |
| panel 2 | 8.51 | 4.28 | 7.94 | 4.85 |
| panel 3 | 9.38 | 4.06 | 9.01 | 4.42 |
| panel 4 | 10.41 | 3.80 | 10.02 | 4.19 |
| panel 5 | 11.32 | 3.55 | 10.93 | 3.94 |
| panel 6 | 12.26 | 3.31 | 11.84 | 3.73 |
| panel 7 | 13.06 | 2.97 | 12.76 | 3.27 |
| panel 8 | 13.72 | 2.65 | 13.68 | 2.70 |
| panel 9 | 14.84 | 2.42 | 14.60 | 2.67 |
| panel 10 | 15.77 | 2.10 | 15.52 | 2.35 |
| panel 11 | 16.86 | 1.71 | 16.44 | 2.13 |

*Data Generated with Grasshopper Code*

## Sound Masking

Open offices, libraries, cafeterias, corridors/hallways: 45 48 - dBA

Enclosed offices and quiet zones identified through S01: Sound Mapping, Part 3: Label Acoustic Zones: 42 - 40 dBA

Soundmasking generator, low pass filter, and amplifier – all in one compact housing
* Internal digital White Noise soundmasking signal
* -70Volt distributed output
* Powerful -25Watt Amplifier
* Low pass filter allows tuning of the soundmasking spectrum
* Accessible 3A fuse protection
* Barrier Post and RCA (phono) plug output jacks
* Can power zones up to 6,000sq.ft.
* Rated for %100 duty cycle commercial usage
* Easy to use controls

American Sound Masking ASM1042- Soundmasking Conditioner is a soundmasking generater, low-pass filter, and power amplifier in an easy to use neutral toned enclosure. The ASM1042- is designed for use in soundmasking applications that require centralized control, yet space and/or economy are a consideration. The unit features a simple and clearly labeled controls for ease of use. It offers many of the most popular features usually found on larger centralized soundmasking systems, taking the place of various rack-type components.

The ASM1042- is effective in supplying dedicated soundmasking for up to 8,000 sq.ft. zone.
This unit is for Sound Masking only. To include Paging, Emergency Evacuation Paging, Music and/or a Miccrophone, see the ASM1092- viewed below.



*Source:**americansoundmasking.com***

Zone Acoustical Labels

- **Loud zones:** includes areas intended for appliances, mechanical equipment or amenities (e.g., kitchens, fitness rooms, social spaces, recreational rooms).
- **Quiet zones:** includes areas intended for focused work, wellness, rest, study and/or privacy.
- **Mixed zones:** includes areas intended for learning, collaboration and/or presentation.




**Basement**

**Ground Floor**

## Sound Masking

Open offices, libraries, cafeterias, corridors/hallways: 48 - 45 dBA

Enclosed offices and quiet zones identified through S01: Sound Mapping, Part 3: Label Acoustic Zones: 42 - 40 dBA



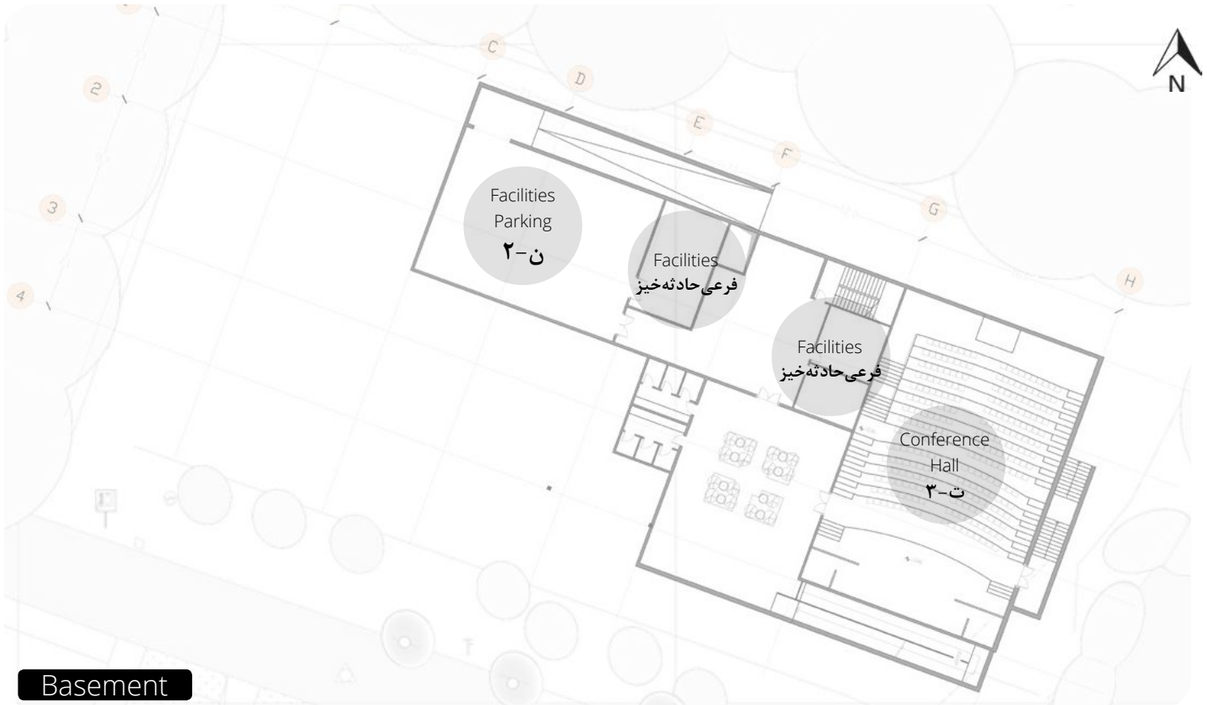

**First Floor** Plan

**Second Floor** Plan

Zone Acoustical Labels

- **Loud zones:** includes areas intended for appliances, mechanical equipment or amenities (e.g., kitchens, fitness rooms, social spaces, recreational rooms).
- **Quiet zones:** includes areas intended for focused work, wellness, rest, study and/or privacy.
- **Mixed zones:** includes areas intended for learning, collaboration and/or presentation.

## **Building Type** Determination




Basement




First Floor Plan




Ground Floor




Second Floor Plan

## Allowed **exit Distances**

### Basement



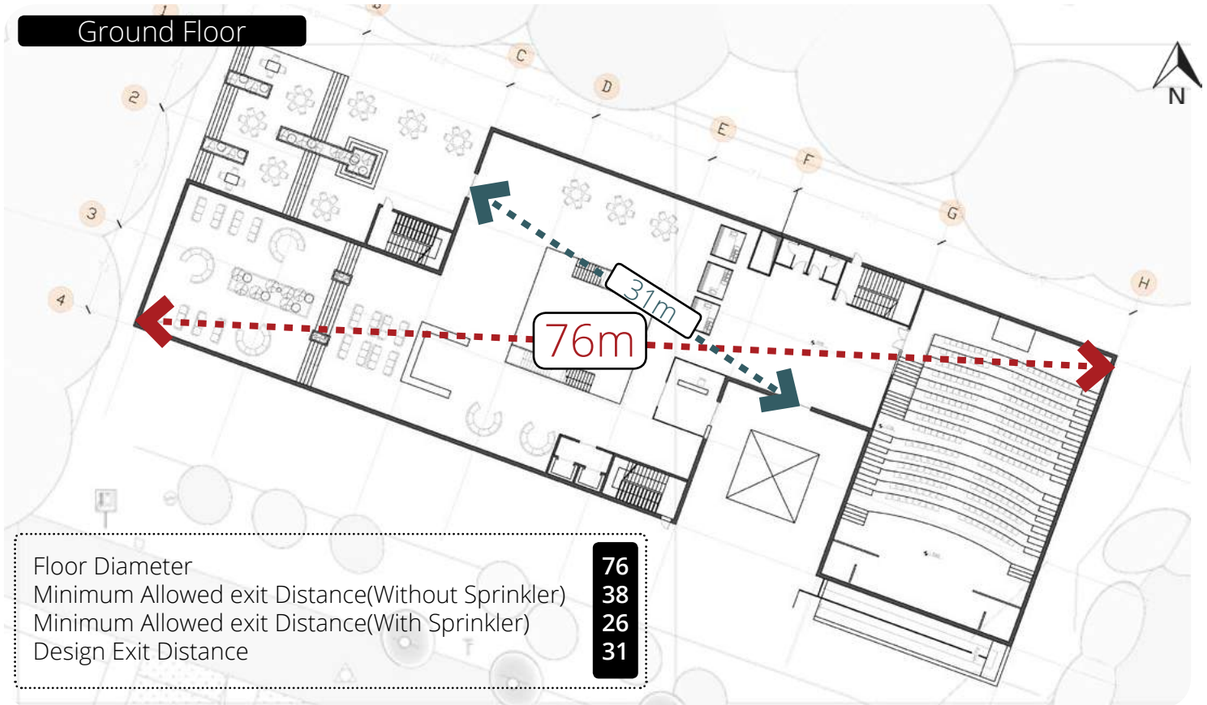

| | |
|---|---|
| Floor Diameter | 59 |
| Minimum Allowed exit Distance(Without Sprinkler) | 30 |
| Minimum Allowed exit Distance(With Sprinkler) | 20 |
| Design Exit Distance | 24 |

### First Floor Plan



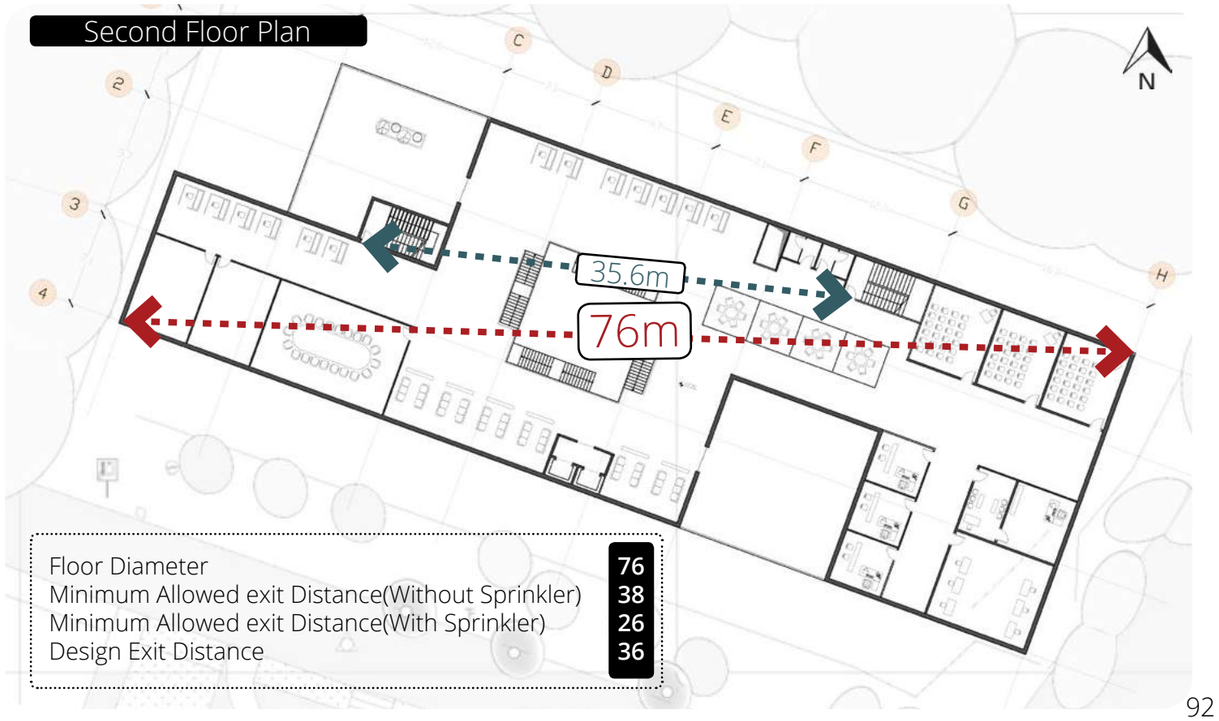

| | |
|---|---|
| Floor Diameter | 68 |
| Minimum Allowed exit Distance(Without Sprinkler) | 34 |
| Minimum Allowed exit Distance(With Sprinkler) | 23 |
| Design Exit Distance | 36 |

### Ground Floor




| | |
|---|---|
| Floor Diameter | 76 |
| Minimum Allowed exit Distance(Without Sprinkler) | 38 |
| Minimum Allowed exit Distance(With Sprinkler) | 26 |
| Design Exit Distance | 31 |

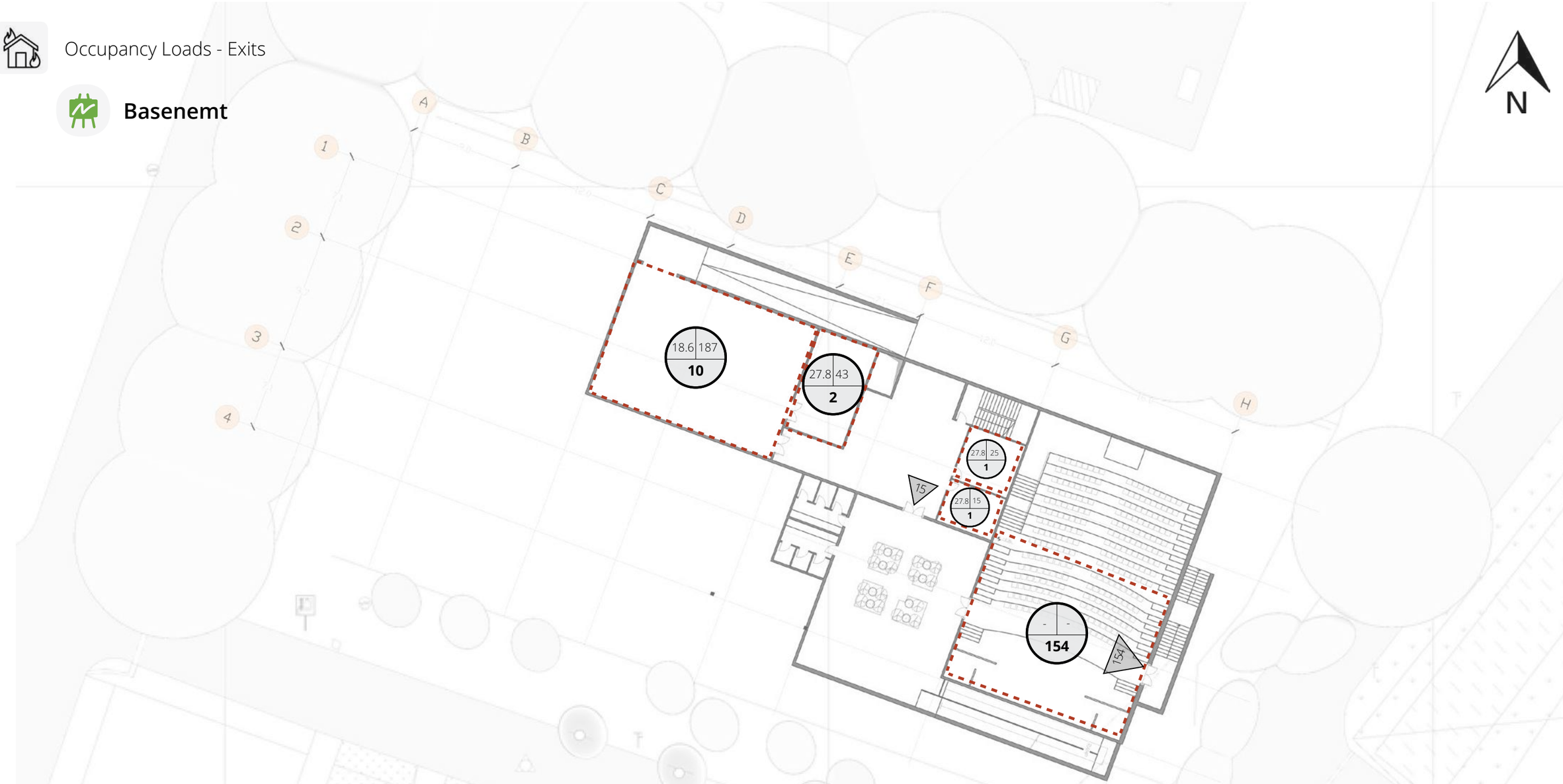
### Second Floor Plan




| | |
|---|---|
| Floor Diameter | 76 |
| Minimum Allowed exit Distance(Without Sprinkler) | 38 |
| Minimum Allowed exit Distance(With Sprinkler) | 26 |
| Design Exit Distance | 36 |

Occupancy Loads - Exits

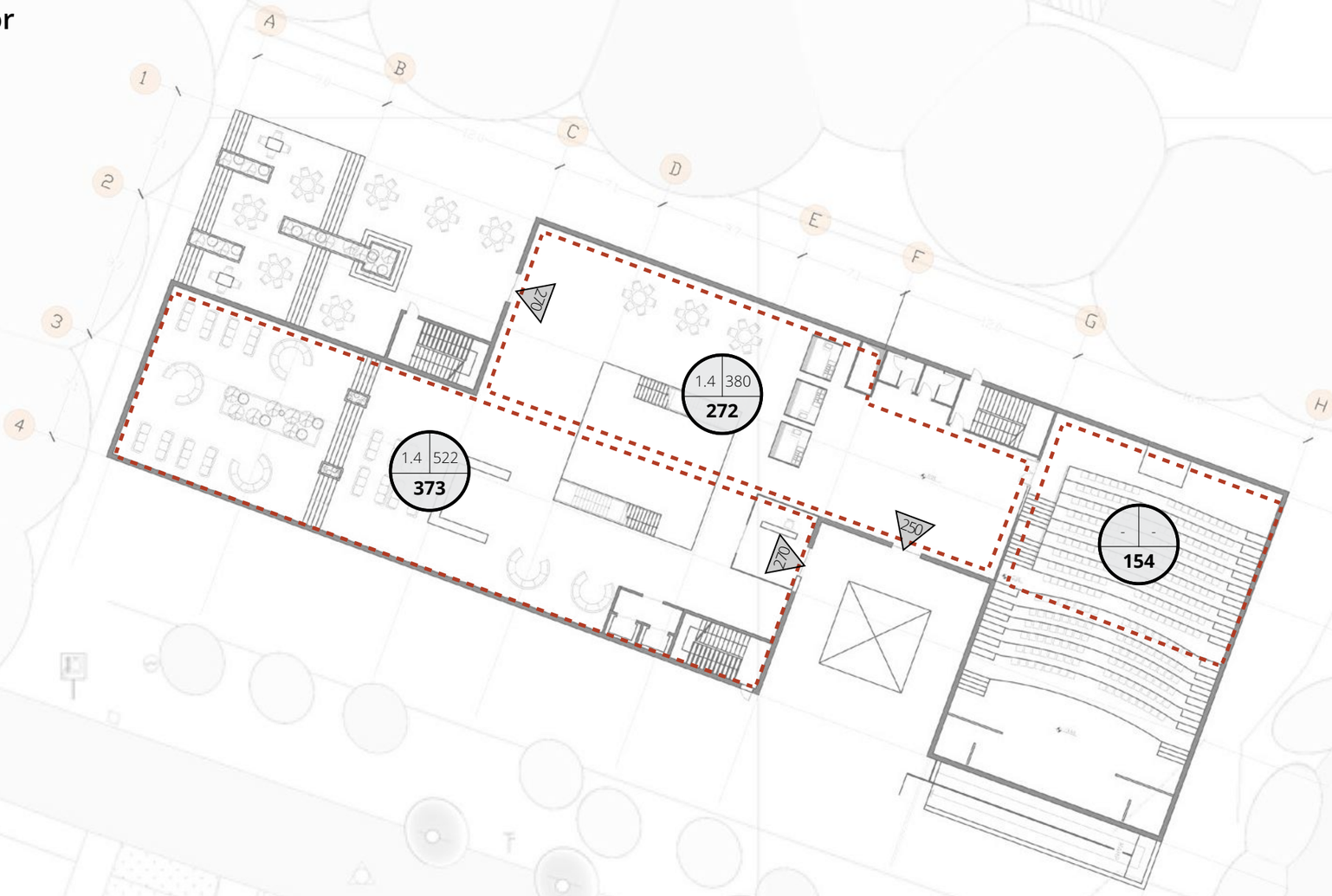
## Basenemt




| Spaces | Space Area | Area per capita | Type | Occupancy Load | Floor Total Occupancy Load |
|---|---|---|---|---|---|
| **Basenemt** | | | | | |
| Conference Hall | - | - | - | 154 | **189** |
| Fire Control Room | 15 | 27.8 | Pure | 1 | |
| Electrical/ Systems Control | 25 | 27.8 | Pure | 1 | |
| Facility Room | 145 | 27.8 | Pure | 5 | |
| Facility Parking | 187 | 18.6 | Pure | 10 | |
| Floor area remainder | 95 | 4.6 | - | 21 | |

Occupancy Loads - Exits

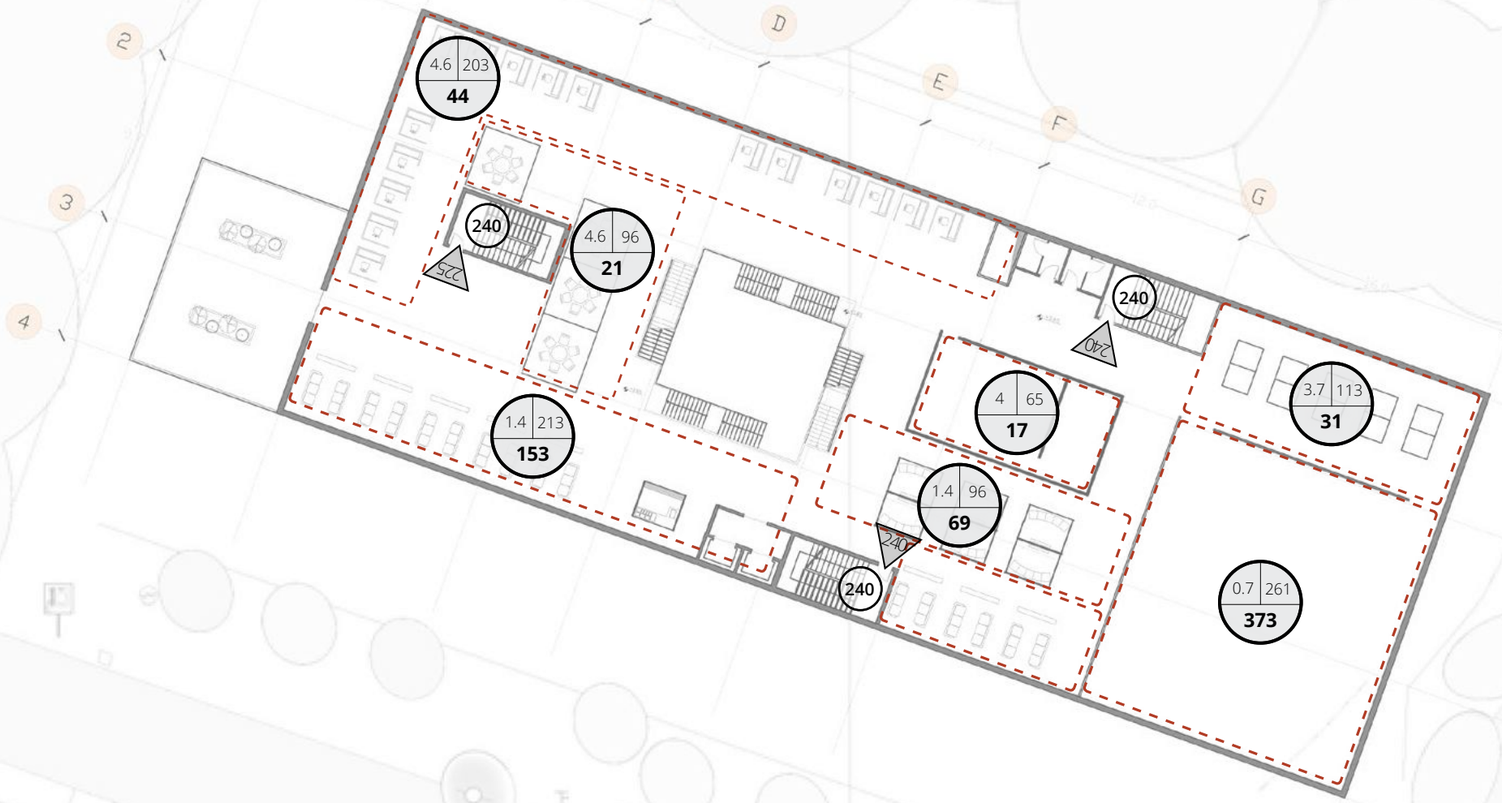
## Ground Floor




| | Spaces | Space Area | Area per capita | Type | Occupancy Load | Floor Total Occupancy Load |
|---|---|---|---|---|---|---|
| GF | Conference Hall | - | - | - | 154 | 799 |
| | FoudCourt Sitting Area | 380 | 1.4 | Pure | 272 | |
| | Lounge+ Entrance + Shop | 522 | 1.4 | Pure | 373 | |

Occupancy Loads - Exits

## First Floor




N

1 2 5 10

| | Spaces | Space Area | Area per capita | Type | Occupancy Load | Floor Total Occupancy Load |
|---|---|---|---|---|---|---|
| First Floor | Gallery | 65 | 4 | Pure | 17 | 740 |
| | Multi-Functional Space | 261 | 0.7 | Pure | 373 | |
| | TV Room | 96 | 1.4 | Pure | 69 | |
| | Study Hall (Individual) | 203 | 4.6 | Pure | 44 | |
| | Study Hall (Group) | 96 | 4.6 | Pure | 21 | |
| | Game Room | 113 | 3.7 | Gross | 31 | |
| | Book Cafe+Lounge | 213 | 1.4 | Pure | 152 | |
| | Floor area remainder | 145 | 4.6 | - | 32 | |

Occupancy Loads - Exits

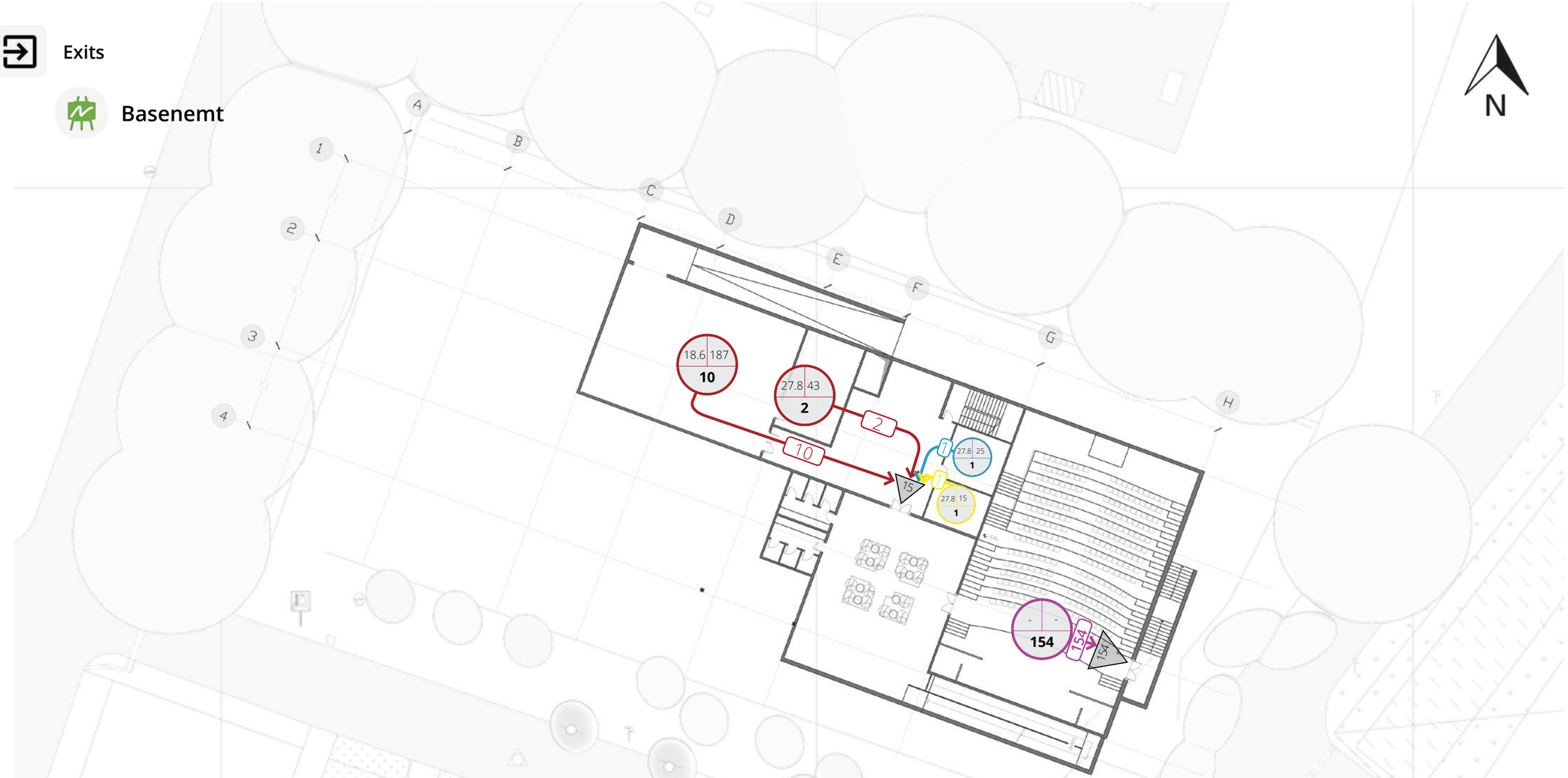
## Second Floor




| Spaces | Space Area | Area per capita | Type | Occupancy Load | Floor Total Occupancy Load |
|---|---|---|---|---|---|
| Second Floor | | | | | |
| Lounge | 166 | 1.4 | Pure | 119 | 393 |
| Study Hall (Individual) | 205 | 4.6 | Pure | 45 | |
| Study Hall (Group) | 118 | 4.6 | Pure | 26 | |
| Class Rooms | 96 | 1.9 | Pure | 51 | |
| Prayers Room | 77 | 1.4 | Pure | 55 | |
| Admin+Asso+Management | 150 | 9.3 | Gross | 16 | |
| Conference Room | 82 | 1.4 | Gross | 59 | |
| Floor area remainder | 101 | 4.6 | - | 22 | |

Exits

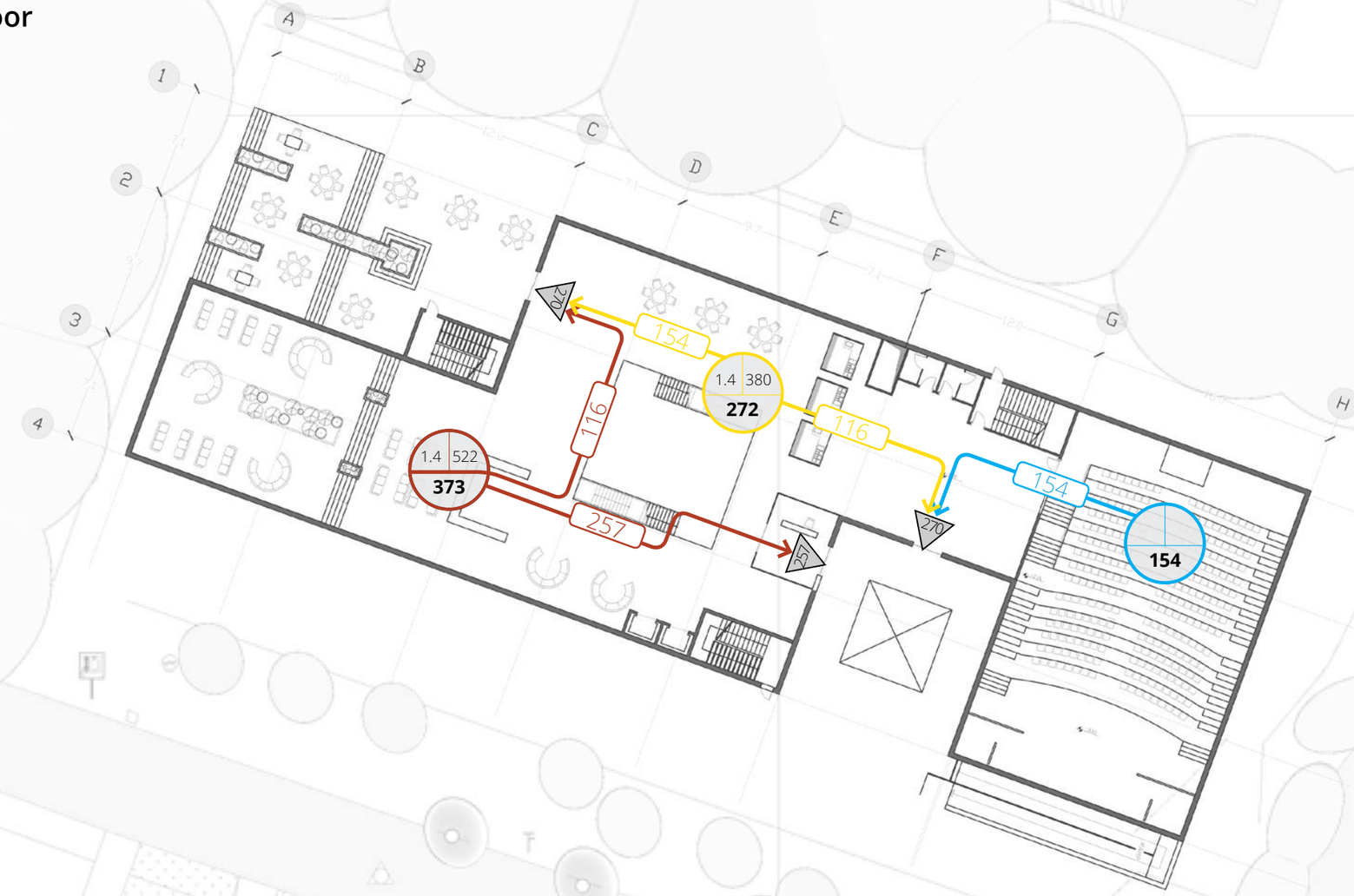
Basenemt




| | Exit Name | Stair width (mm) | Door Width (mm) | Capacity | predicted number of occupants to use the corresponding exit |
|---|---|---|---|---|---|
| Base -ment | Conderence Hall- west exit | - | 1600 | 400 | 154 |
| | North exit- Stair | 1200 | 800 | 240 | 0 |
| | Main exit- Lobby | - | 1600 | 400 | 15 |

**Exits**

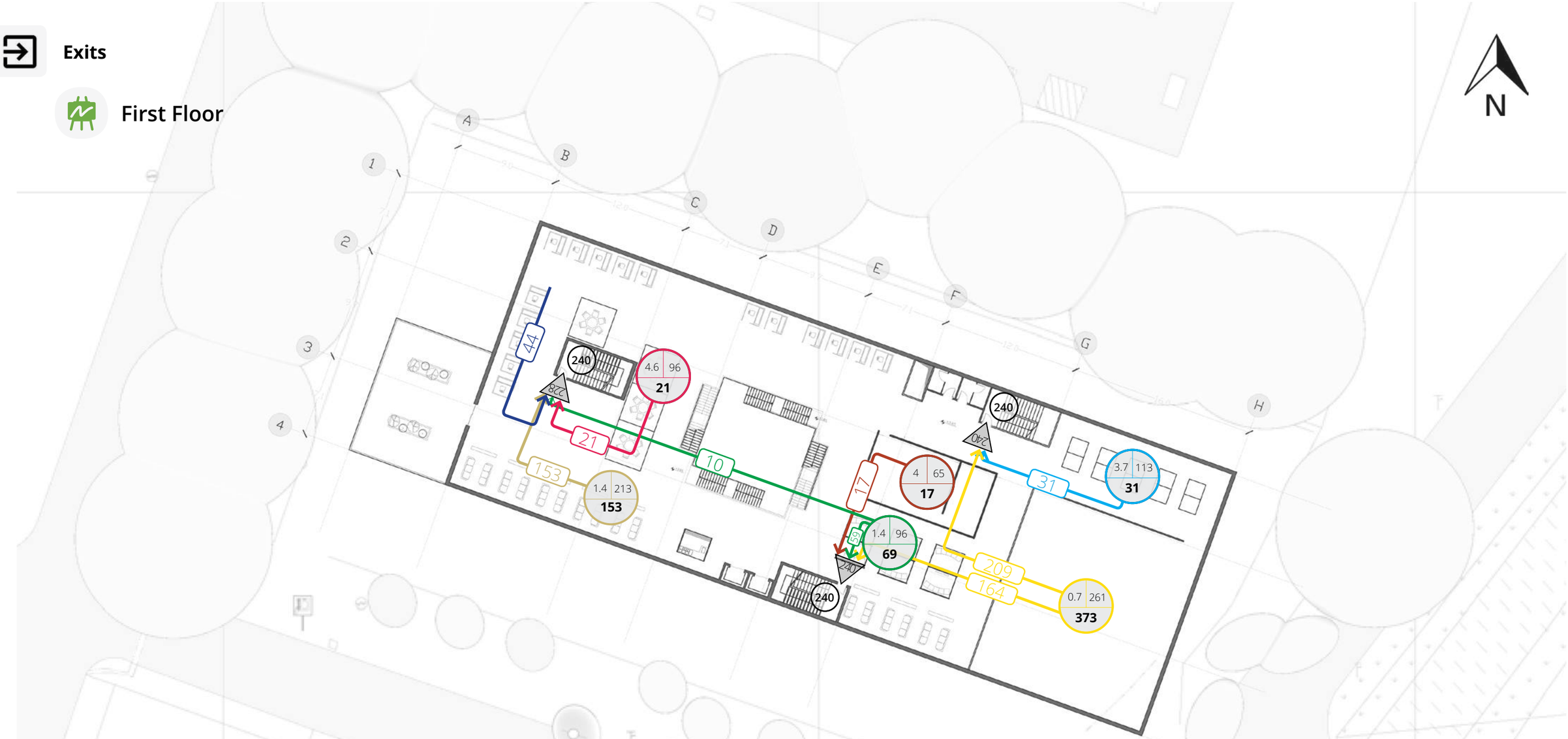
## Ground Floor




| | Exit Name | Stair width (mm) | Door Width (mm) | Capacity | predicted number of occupants to use the corresponding exit |
|---|---|---|---|---|---|
| GF | **Foodcourt exit** | - | 2000 | 500 | 270 |
| GF | **main exit-** next to Conference Hall | - | 2000 | 500 | 270 |
| GF | **main exit-** next to lounge and information | - | 2000 | 500 | 257 |

**Exits**

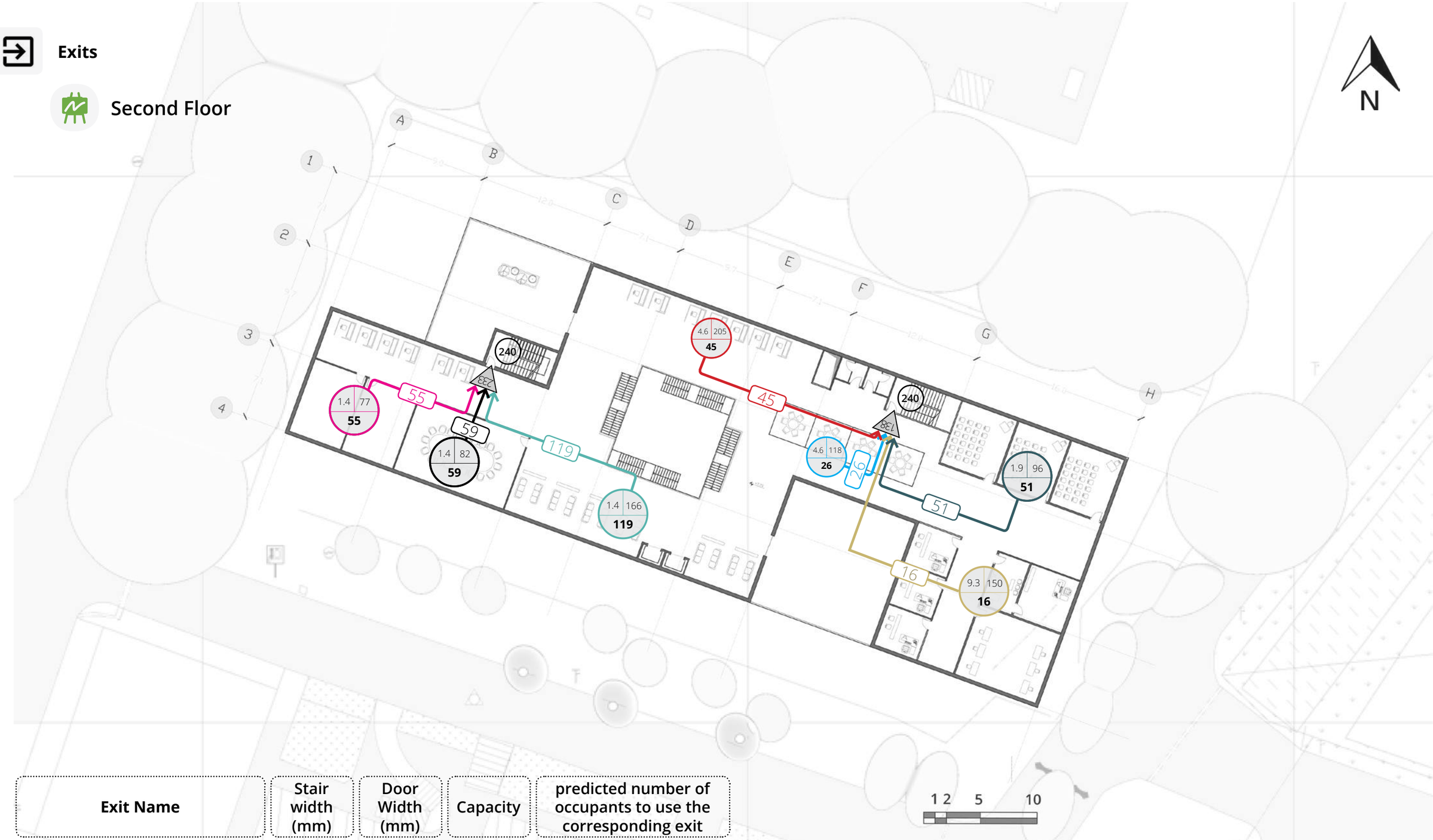
**First Floor**




| | Exit Name | Stair width (mm) | Door Width (mm) | Capacity | predicted number of occupants to use the corresponding exit |
|---|---|---|---|---|---|
| 1st | North exit- Stair | 1200 | 800 | 240 | 240 |
| | South exit- Stair | 1200 | 800 | 240 | 240 |
| | West exit- Stair | 1200 | 800 | 240 | 228 |

**Exits**

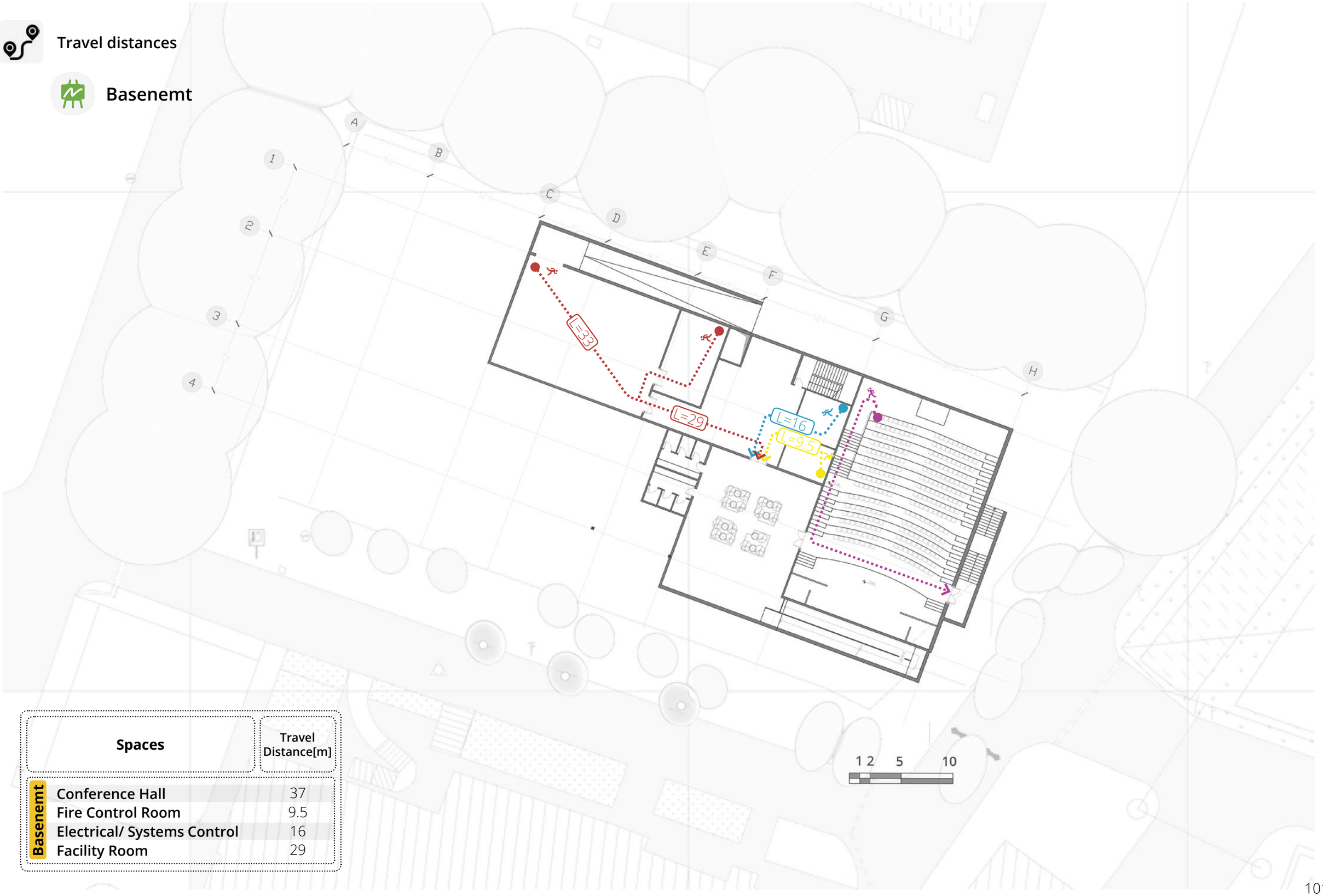
## Second Floor




| Exit Name | Stair width (mm) | Door Width (mm) | Capacity | predicted number of occupants to use the corresponding exit |
|---|---|---|---|---|
| 2nd North exit- Stair | 1200 | 800 | 240 | 138 |
| 2nd West exit- Stair | 1200 | 800 | 240 | 233 |

## Travel distances

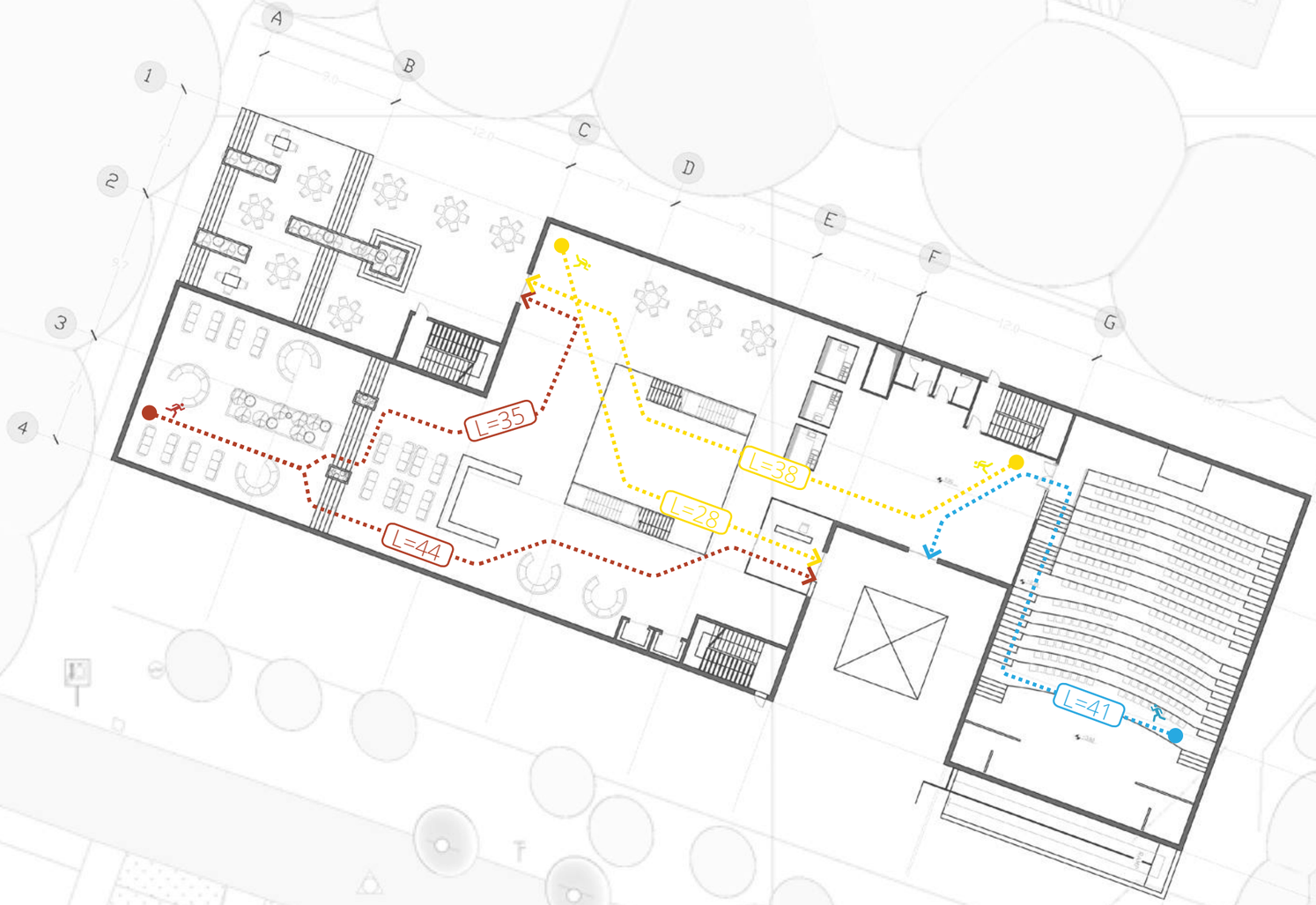
### Basenemt




| Spaces | | Travel Distance[m] |
|---|---|---|
| Basenemt | Conference Hall | 37 |
| | Fire Control Room | 9.5 |
| | Electrical/ Systems Control | 16 |
| | Facility Room | 29 |

## Travel distances

### Ground Floor

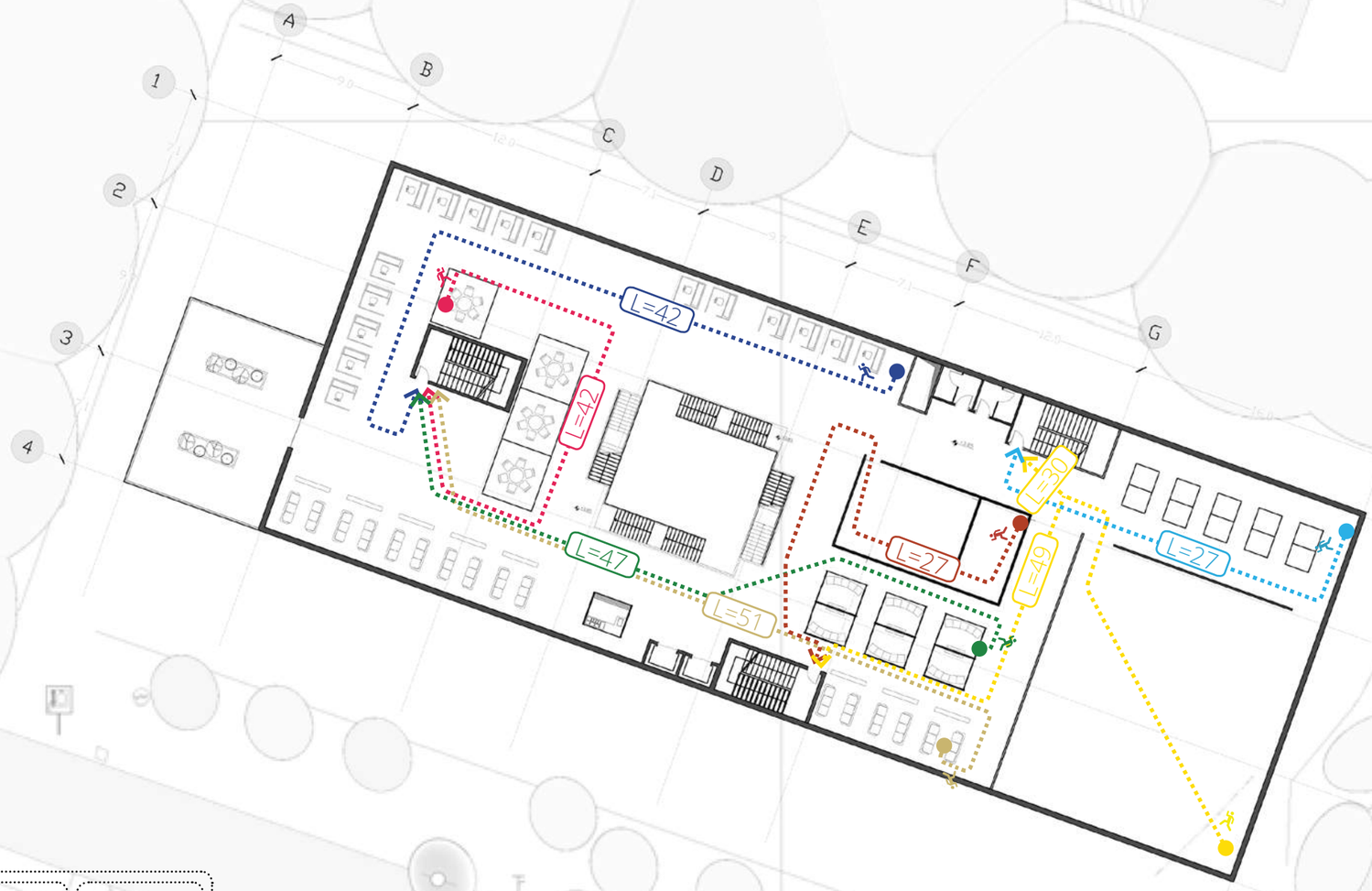



| | Spaces | Travel Distance[m] |
|---|---|---|
| GF | Conference Hall | 41 |
| | FoudCourt Sitting Area | 38 |
| | Lounge+ Entrance + Shop | 44 |

1 2 5 10

## Travel distances

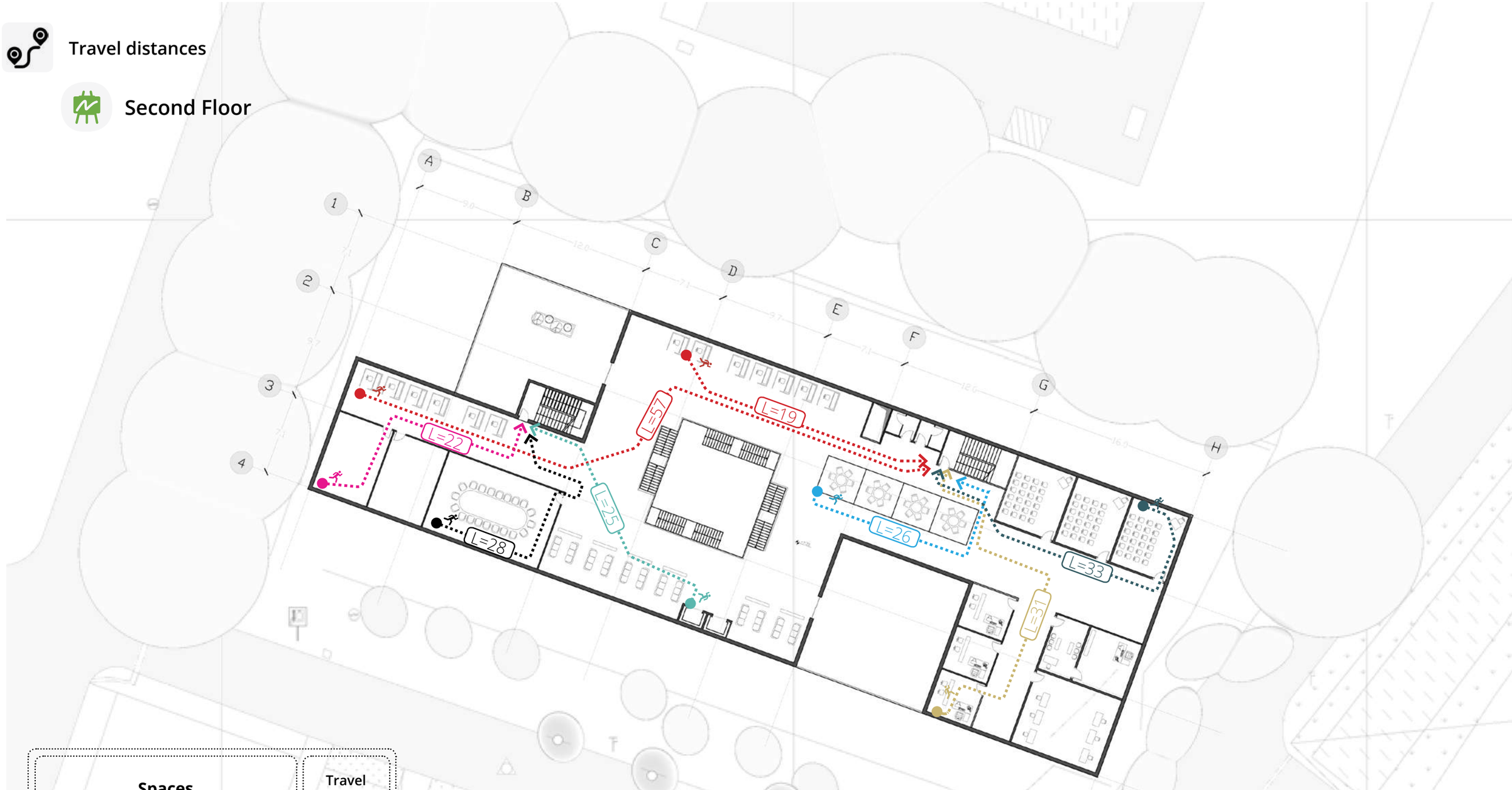
### First Floor




| | Spaces | Travel Distance[m] |
|---|---|---|
| 1ST Floor | Gallery | 37 |
| | Multi-Functional Space | 49 |
| | TV Room | 47 |
| | Study Hall (Individual) | 42 |
| | Study Hall (Group) | 38 |
| | Game Room | 27 |
| | Book Cafe+Lounge | 51 |

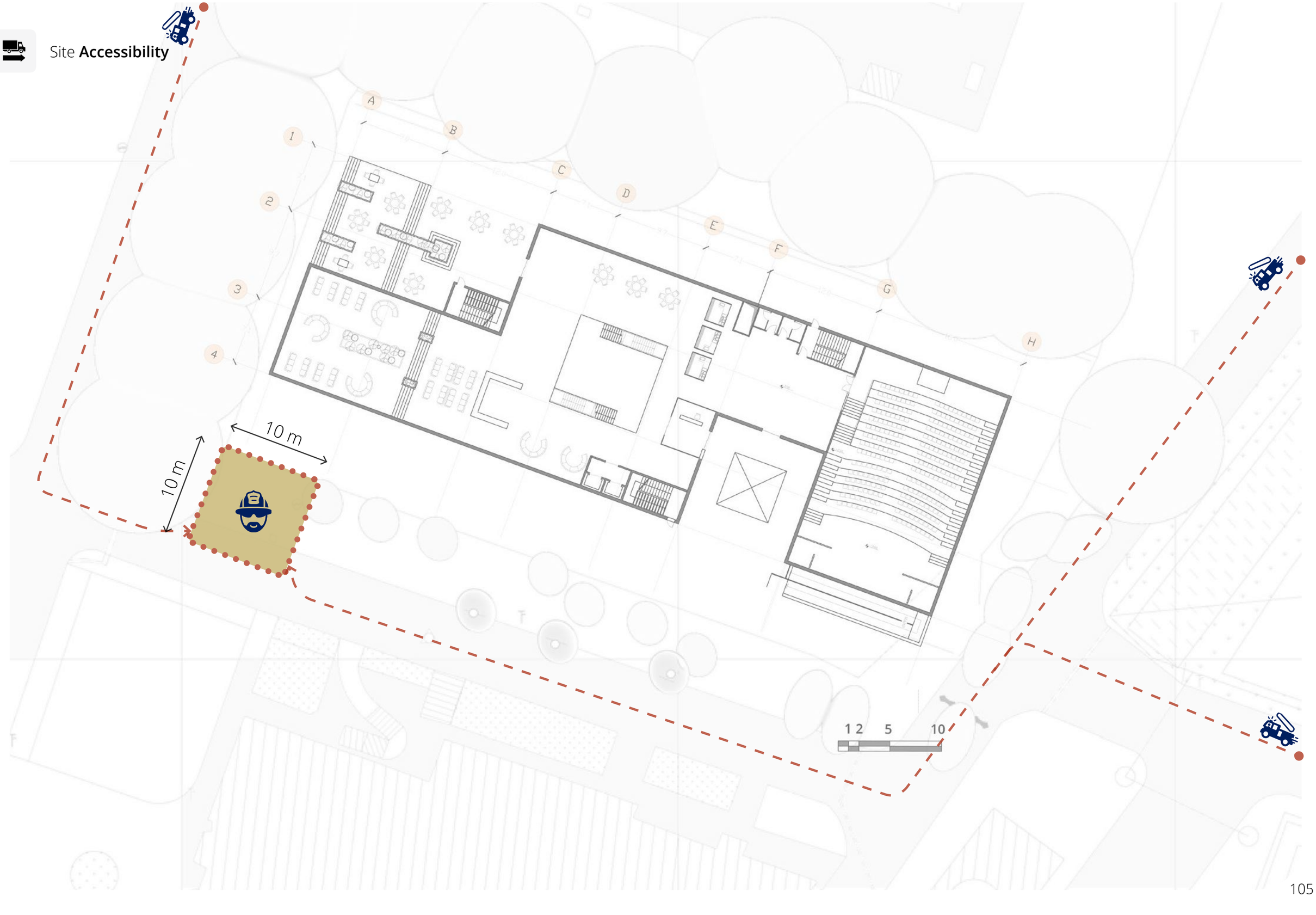
## Travel distances

### Second Floor




| Spaces | | Travel Distance[m] |
|---|---|---|
| 2nd Floor | Lounge | 25 |
| | Study Hall (Individual) | 57 |
| | Study Hall (Group) | 26 |
| | Class Rooms | 33 |
| | Prayers Room | 22 |
| | Admin+Asso+Management | 31 |
| | Conference Room | 28 |

## Site **Accessibility**



## Requiered **Fire Ratings-Walls**

Basement




First Floor Plan




Ground Floor

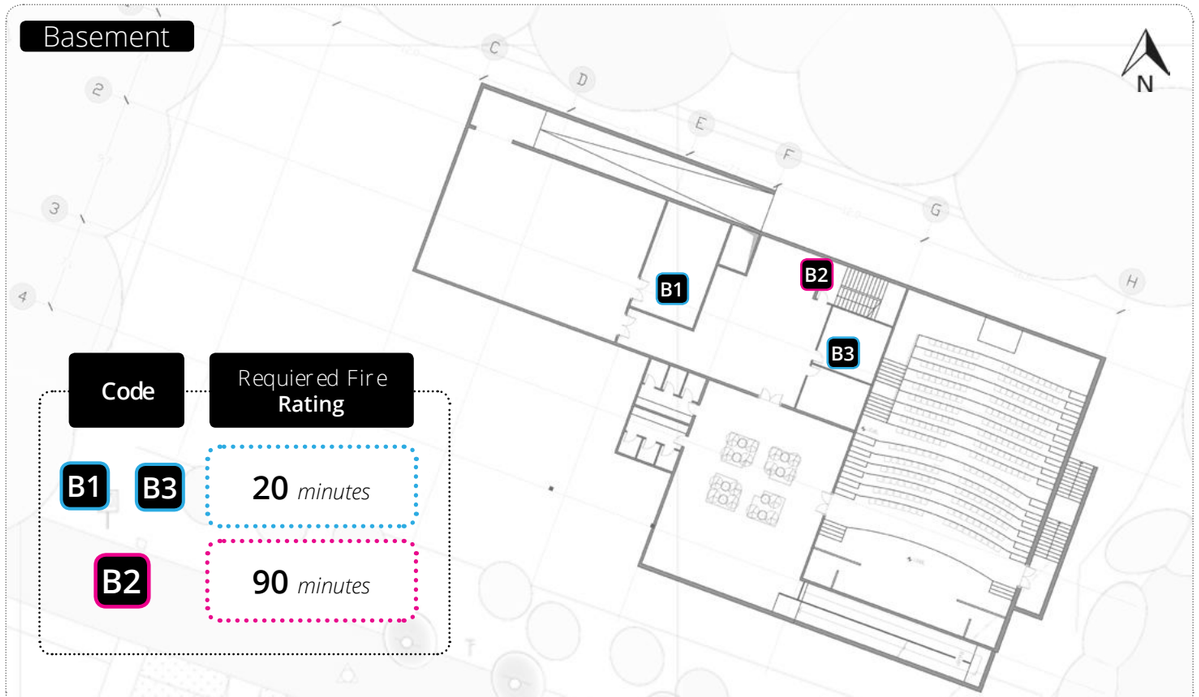



Second Floor Plan



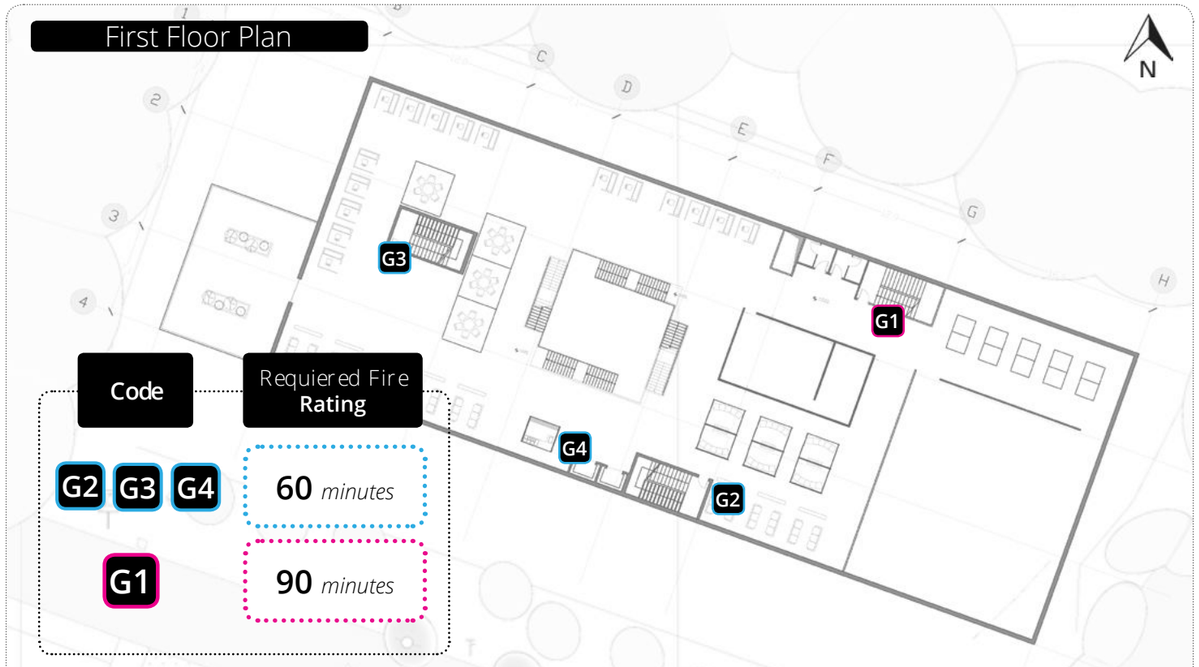
## Requiered **Fire Ratings-Doors**

### Basement



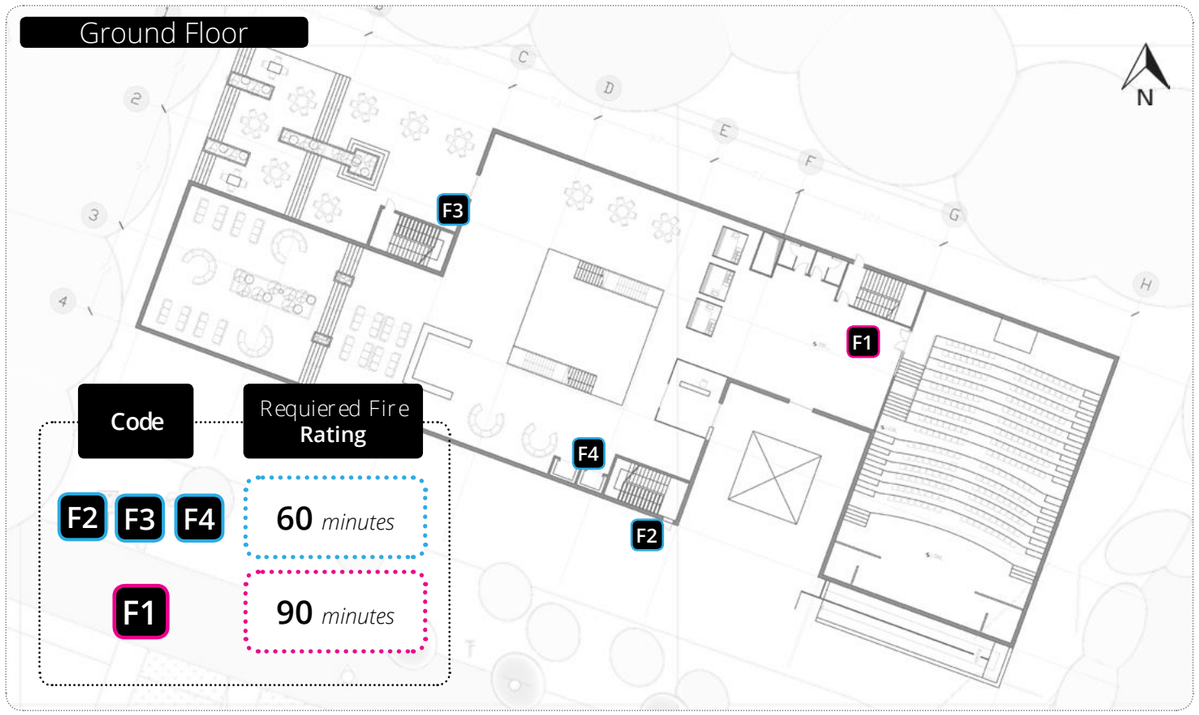

| Code | Requiered Fire Rating |
|---|---|
| B1 B3 | 20 *minutes* |
| B2 | 90 *minutes* |

### First Floor Plan



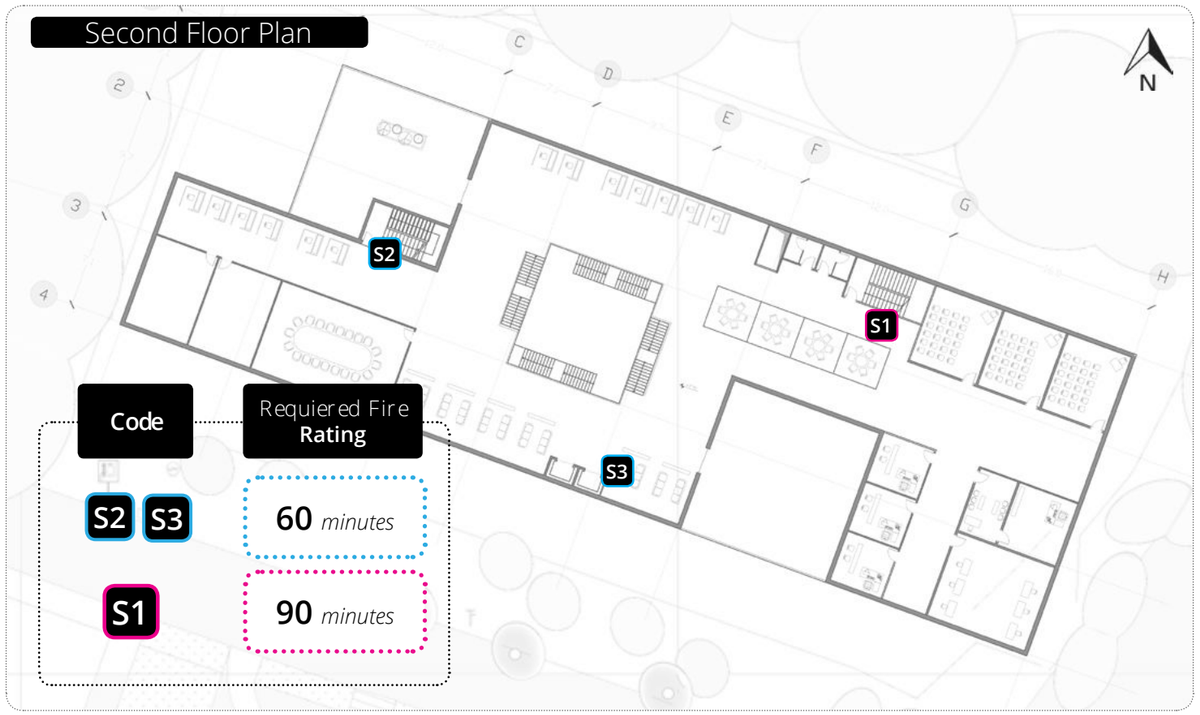

| Code | Requiered Fire Rating |
|---|---|
| G2 G3 G4 | 60 *minutes* |
| G1 | 90 *minutes* |

### Ground Floor




| Code | Requiered Fire Rating |
|---|---|
| F2 F3 F4 | 60 *minutes* |
| F1 | 90 *minutes* |

### Second Floor Plan

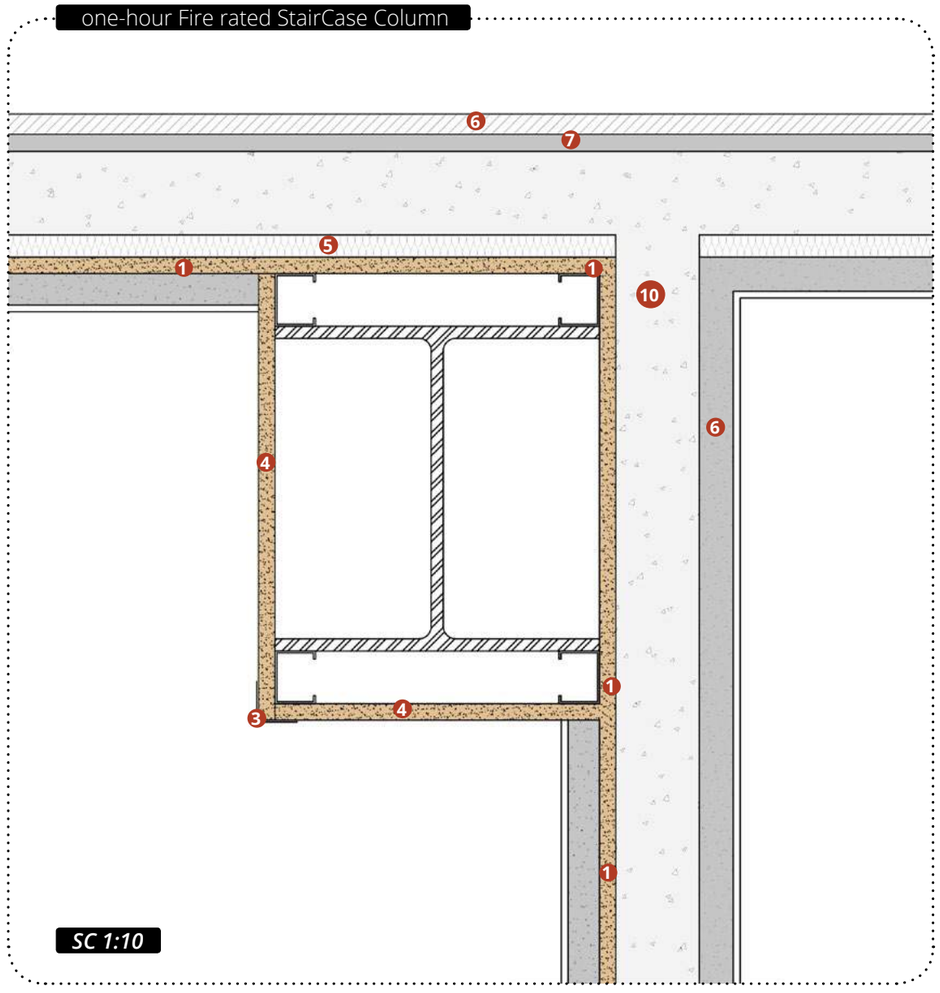



| Code | Requiered Fire Rating |
|---|---|
| S2 S3 | 60 *minutes* |
| S1 | 90 *minutes* |

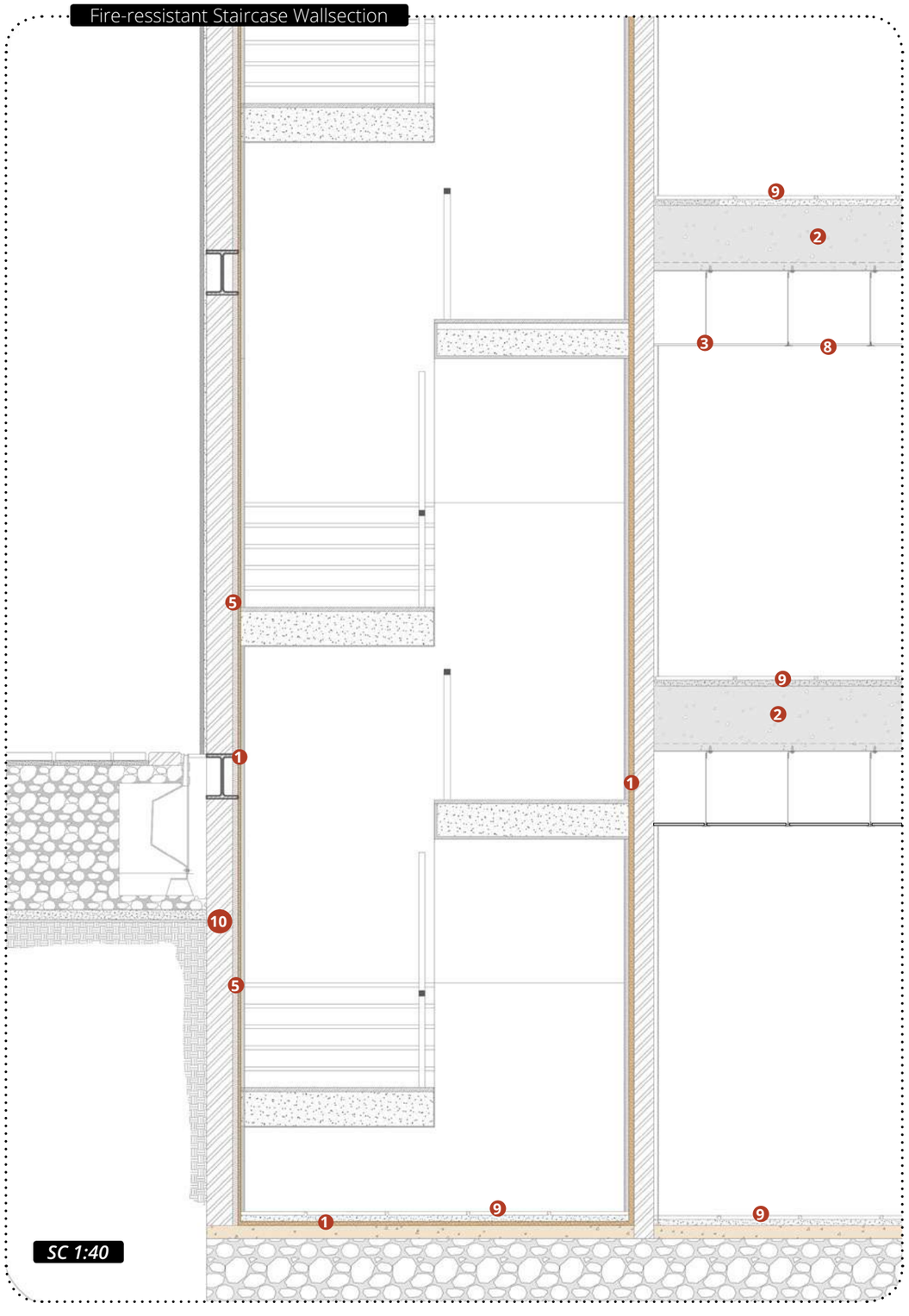
## Construction details
Drawings

1. Spray applied fire resistive material providing flat surface 1cm from bottom of flutes
2. Concrete on Fluted Steel deck
3. 2.5x5 Steel angle
4. 2 layers 1.6cm fire-shield gypsum board
5. XPS thermal insulation
6. Brick Facade
7. Cement-sand Mortar
8. Acoustic tiles for false-ceiling
9. Musaic Flooring
10. Concrete Wall

one-hour Fire rated StairCase Column

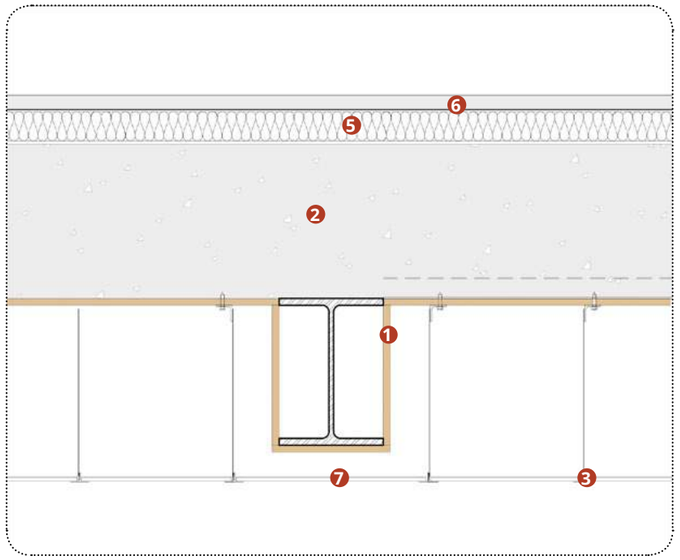



Fire-ressistant Staircase Wallsection



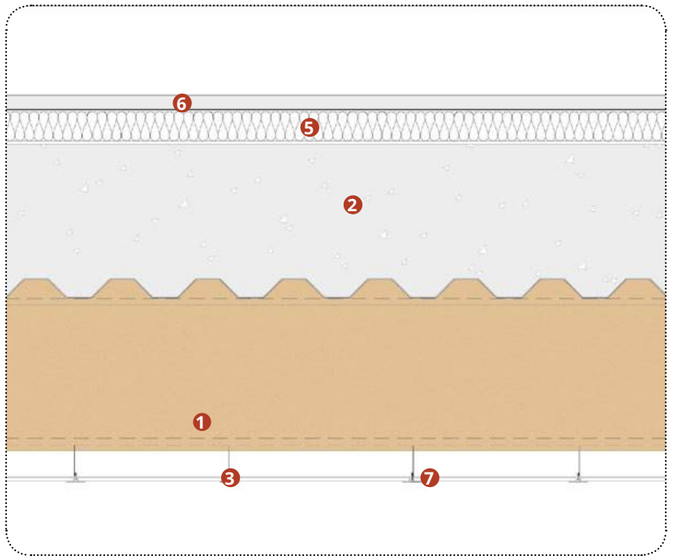
## Construction details
Drawings

one-hour Fire rated Beam- Roof



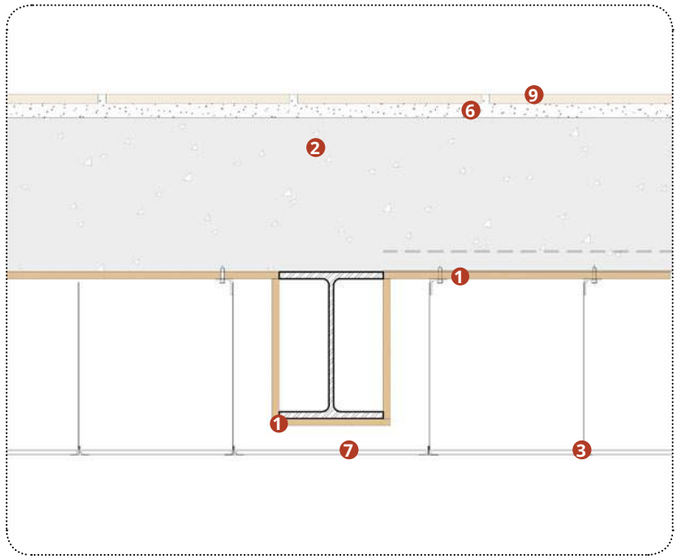

SC 1:5

one-hour Fire rated Beam- Roof



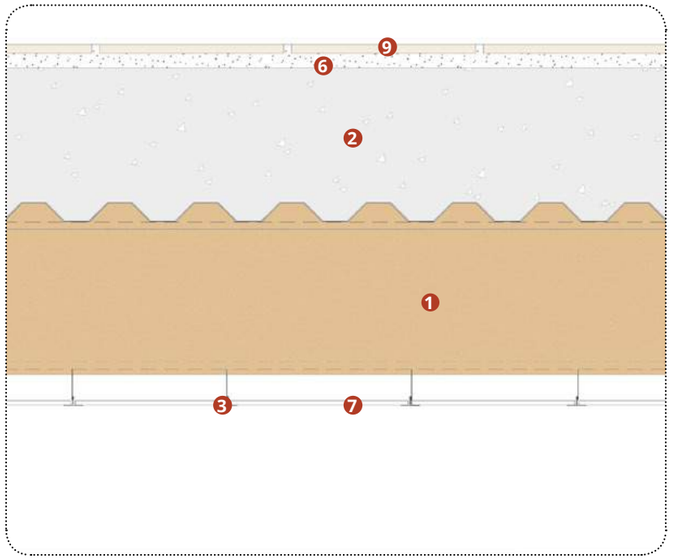

SC 1:5

one-hour Fire rated Beam- Ceiling




SC 1:5

one-hour Fire rated Beam- Ceiling




SC 1:5

Key

1. Spray applied fire resistive material providing flat surface 1cm from bottom of flutes
2. Concrete on Fluted Steel deck
3. 2.5x5 Steel angle
4. 2 layers 1.6cm fire-shield gypsum board
5. XPS thermal insulation
6. Brick Facade
7. Cement-sand Mortar
8. Acoustic tiles for false-ceiling
9. Musaic Flooring
10. Concrete Wall

## Construction details
Drawings

1. Spray applied fire resistive material providing flat surface 1cm from bottom of flutes
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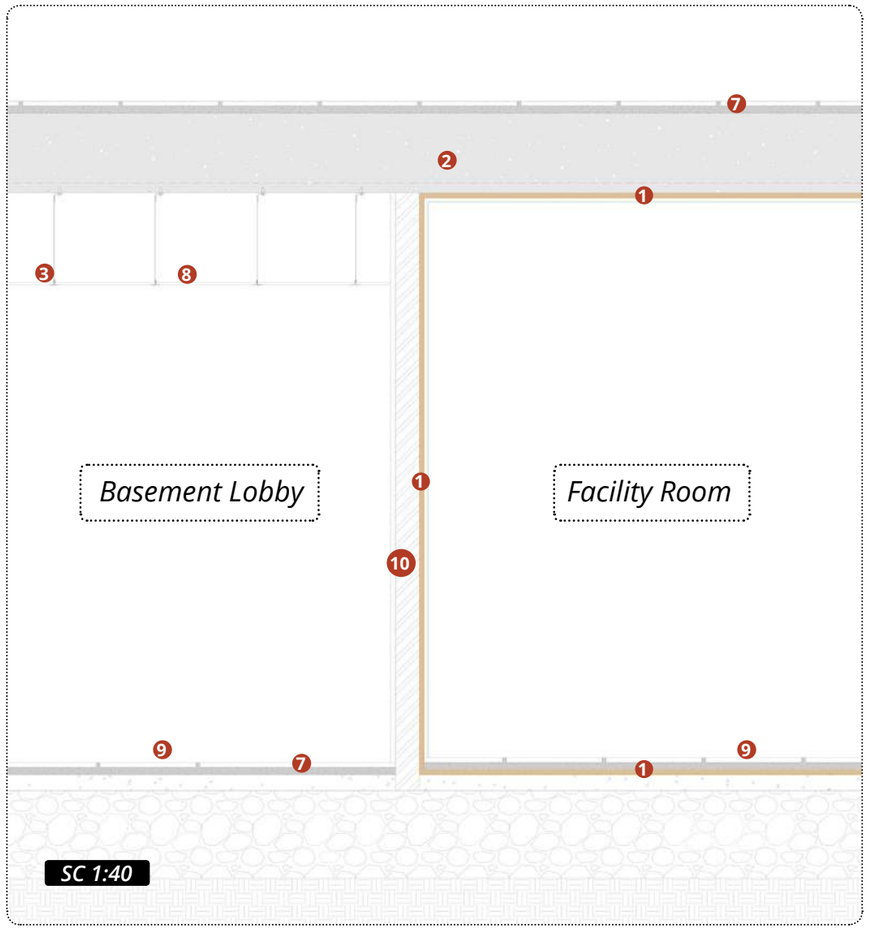
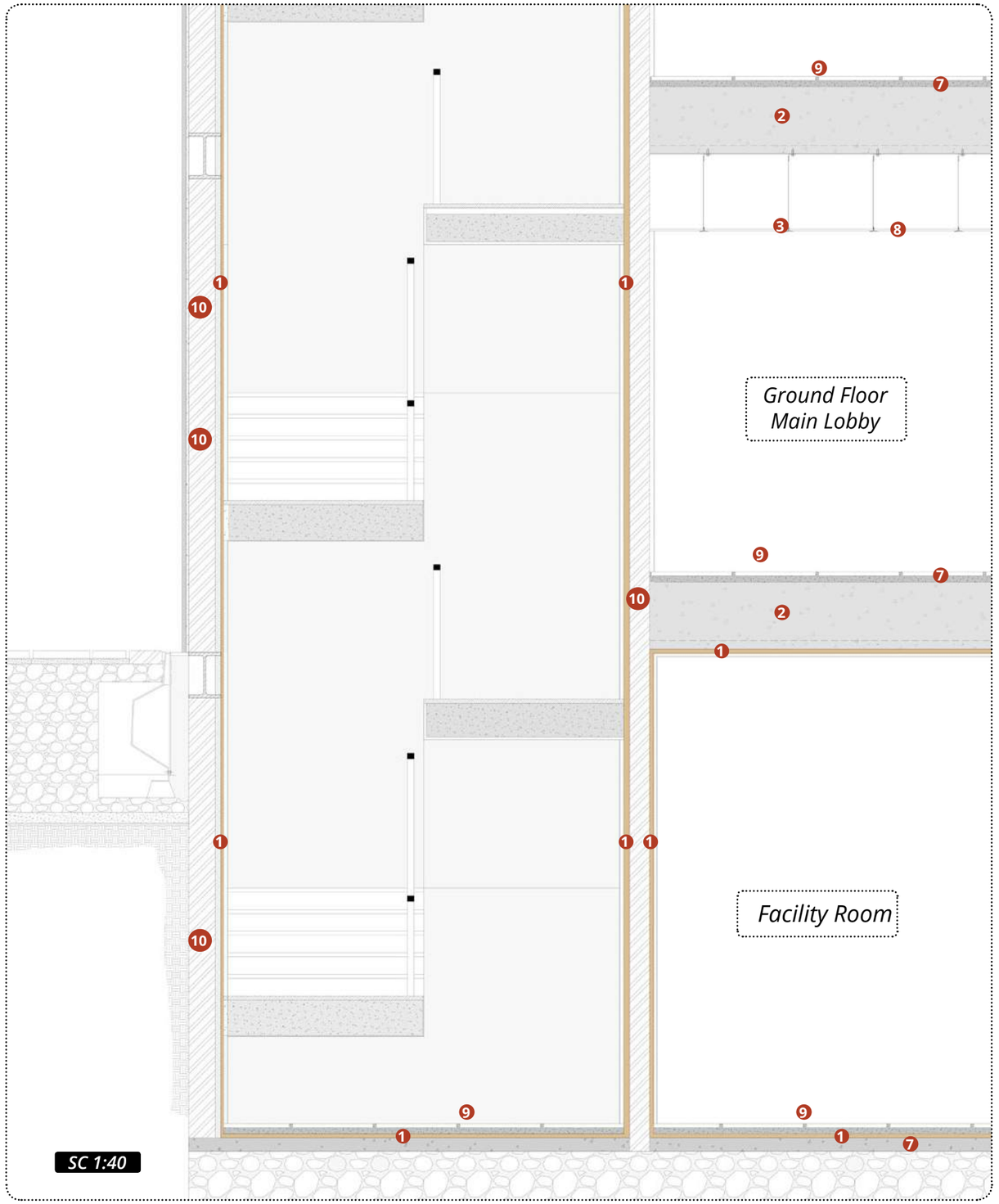
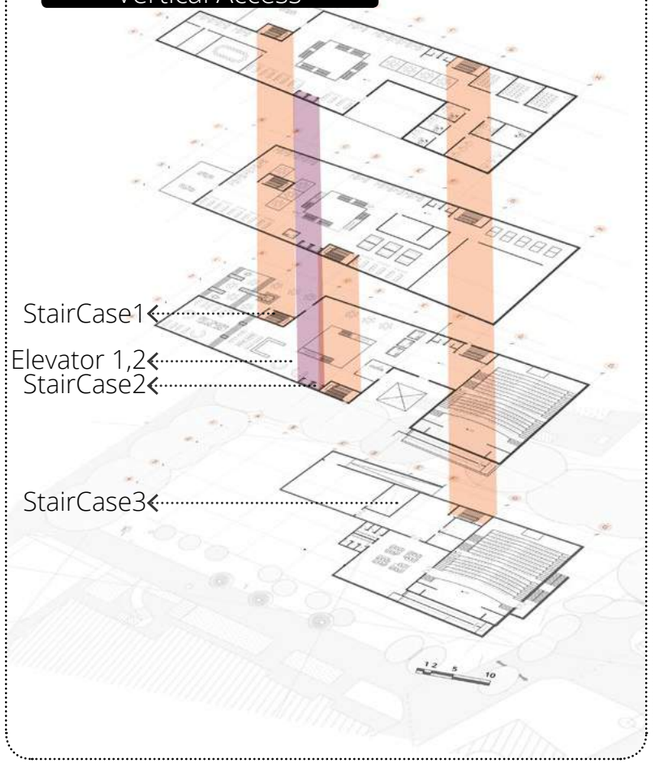
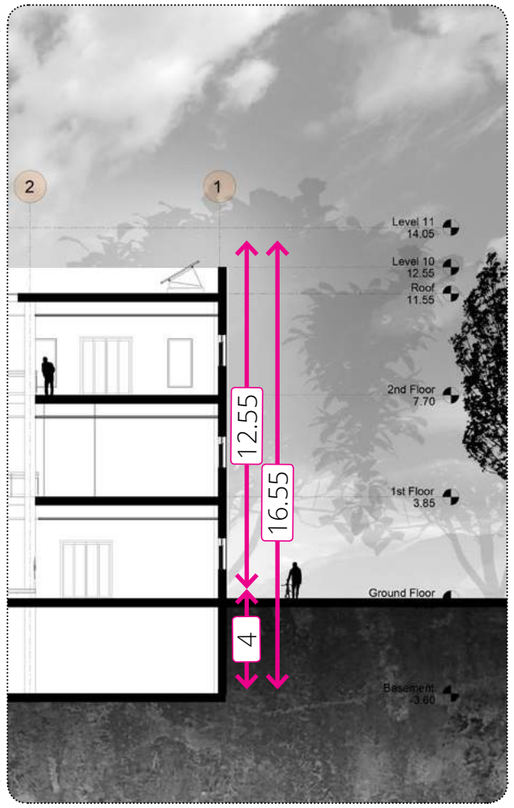
10. Concrete Wall



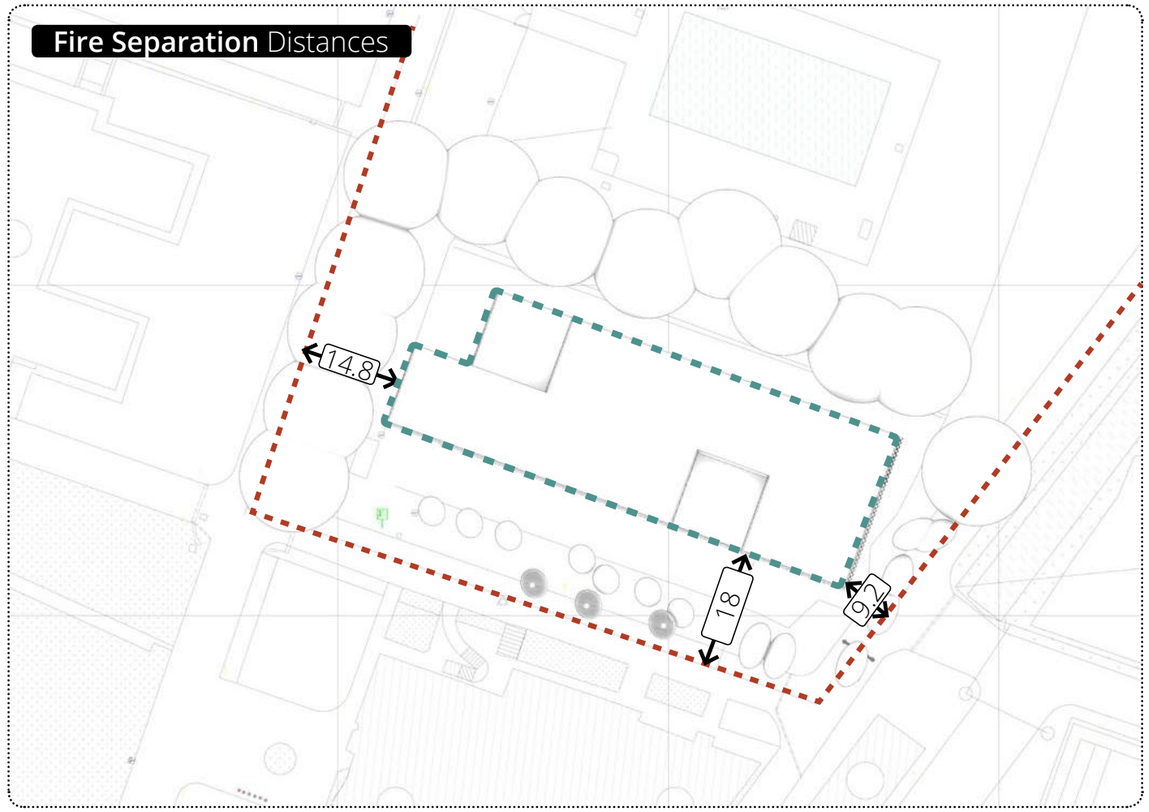



## Vertical Access

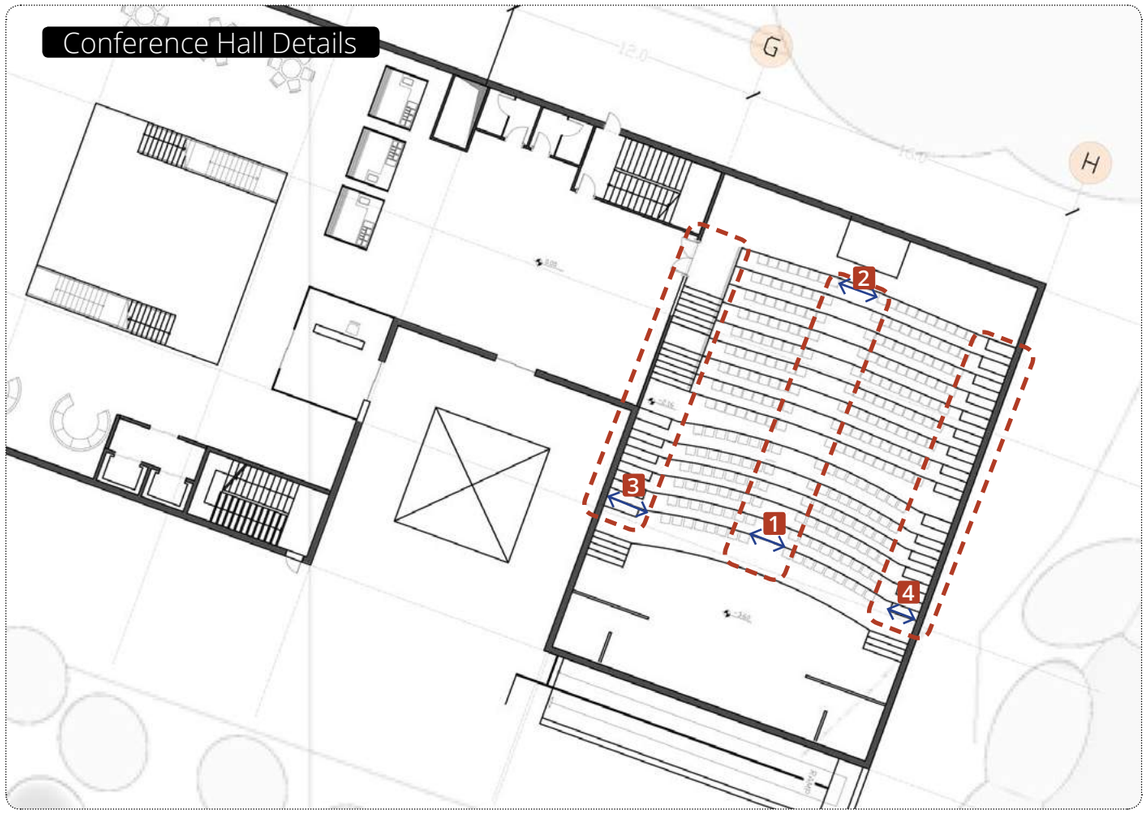


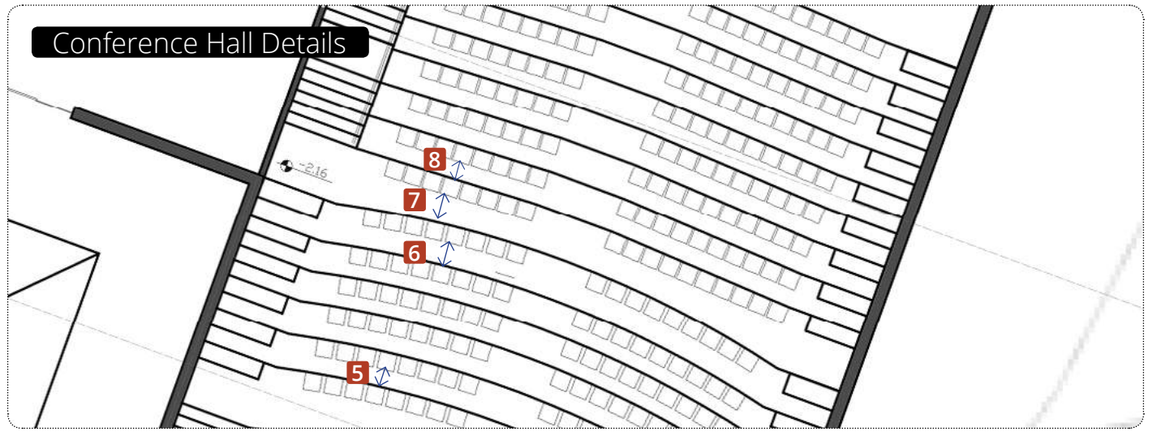

## **Fire Separation** Distances




## Conference Hall Details




## Conference Hall Details




| Number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| **Requiered Width(cm)** | 120 | 120 | 90 | 90 | 30 | 30 | 30 | 30 |
| **Design Width(cm)** | 170 | 200 | 160 | 129 | 45 | 60 | 77 | 45 |

# 04 Final **Performance Results, Assessments** and **Documentations**

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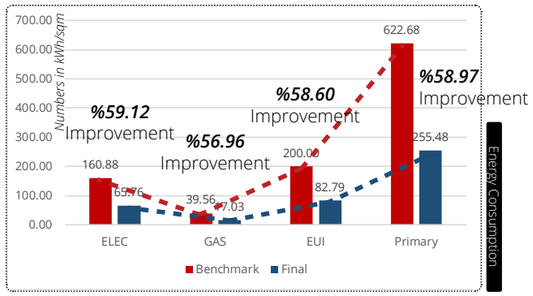



EC++ (Annex19) | LEED 3 point for daylight | sDA %81 | ASE %23

AbbasPour **Student Center**
*High Performance Building Design*
***Instructor:*** Dr.Zomorodian
***Student:*** Nima Forouzandeh
***Winter 2020***




**Lighting System**

| | |
|---|---|
| Power density [W/m2] | 2.5 |
| Return Air Fraction | 0 |
| Radient Fraction | 0.42 |
| Visible Fraction | 0.18 |
| Lighting Control | On |
| Control type | Stepped |

LED+ Linear off

Certified

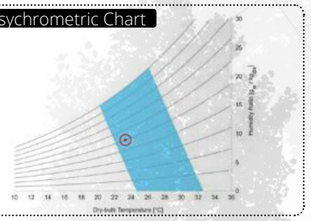
*Total CO2 Reduction (annual) [kg]* **167,645** 36 X

**PV Panels**

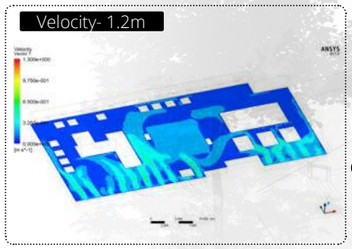
| | |
|---|---|
| Consumption[kWh] | 287670 |
| covered by PV[kWh] | 44362 |
| covered by grid | 243308 |
| Solar fraction [%] | %15.40 |
| Avoided CO2 emissions [kg/year] | 23795 |

*Acceptable Ventilation rate and PPD range ( %7) inSpring.*

Psychrometric Chart

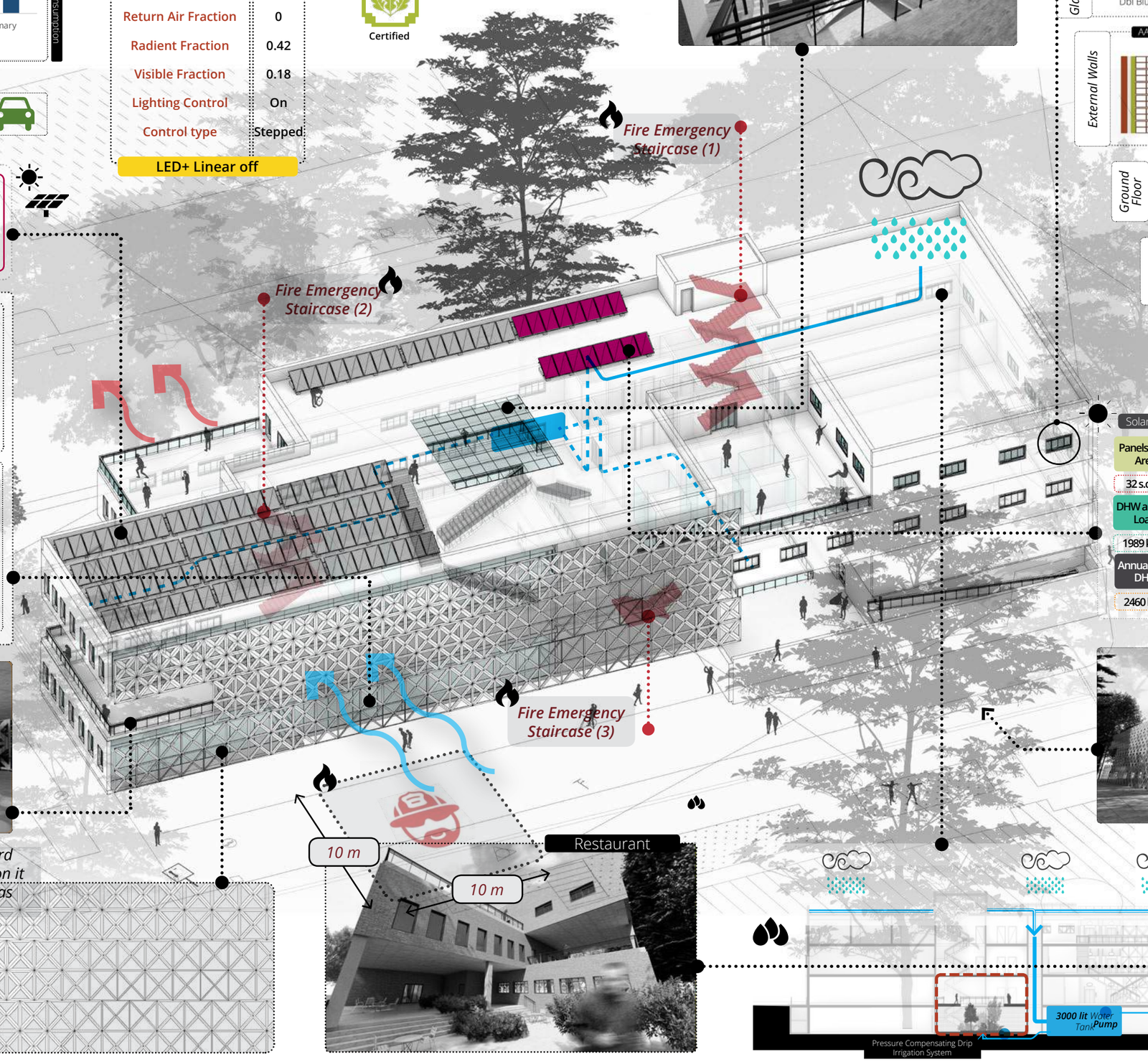


Velocity- 1.2m





*Parametric Facade Designed in with regard to the spaces need for Daylight, in addition it controls overheating of the common areas behind it.*







**Roofs**

Cool Roof+ Insulation L.2

| Layer | Thichness | Conductivity | R-Value | Total U-value | STC | IIC |
|---|---|---|---|---|---|---|
| Outside Air | | | 0.05 | | | |
| CoolCoating | 0.002 | 1 | 0.00 | | | |
| Polyurethane | 0.010 | 0.25 | 0.04 | 0.406 | 53 | 36 |
| XPS | 0.090 | 0.04 | 2.20 | | | |
| Concrete | 0.220 | 2.5 | 0.09 | | | |
| Inside Air | | | 0.09 | | | |

**Glazings**

Dbl Low-E

| Name | SHGC[%] | VT[%] | VT/SHGC | Total U-value | STC |
|---|---|---|---|---|---|
| Dbl Blue 6mm/13mm Air | 0.598 | 0.789 | 1.29 | 1.786 | 45 |

**External Walls**

AAC Block Insulation L.1

| Layer | Thichness | Conductivity | R-Value | Total U-value | STC |
|---|---|---|---|---|---|
| Inside Air | | | 0.11 | | |
| Gypsum plaster | 0.005 | 0.31 | 0.02 | | |
| Gypsum-sand plaster | 0.02 | 0.59 | 0.03 | | |
| AAC Block | 0.22 | 0.158 | 1.39 | 0.10 | 42 |
| XPS | 0.030 | 0.004 | 7.50 | | |
| Cement-Sand Plaster | 0.025 | 0.44 | 0.06 | | |
| Light Weight Brick | 0.03 | 0.08 | 0.38 | | |
| Outside Air | | | 0.06 | | |

**Ground Floor**

| Layer | Thichness | Conductivity | R-Value | U-value |
|---|---|---|---|---|
| Mosaic | 0.22 | 1.65 | 0.13 | |
| XPS | 0.060 | 0.04 | 1.50 | 0.47 |
| Concrete | 0.1 | 0.25 | 0.40 | |
| Hardcore | 0.35 | 3.5 | 0.10 | |

**Ceilings**

Ceilings

| Layer | Thichness | Total STC | Total IIC |
|---|---|---|---|
| CoolCoating | 0.002 | | |
| Polyurethane | 0.010 | 51 | 34 |
| Mortar | 0.090 | | |
| Concrete | 0.220 | | |

**Partition Walls**

Partition Walls

| Layer | Thichness | Total STC |
|---|---|---|
| Gypsum | 0.02 | |
| Bricks | 0.10 | 42 |
| Gypsum | 0.020 | |

**Solar DHW**

Panels Total Area: 32 s.q.m.

DHW annual Load: 1989 kWh

Annual Solar DHW: 2460 kWh

**System Sizing and Details**

Hot Water Supply
Gas Boiler
Chilled Water Supply
Air Cooled Chiller
Terminals
VAV + Reheat / Communal Spaces
Fan Coil Units/Small Spaces
Energy Conservation Systems
Heat Recovery

Heating Load: 653.8 kWh (Design Margin 1.25)

Cooling Design Capacity: 563.1 kWh (Design Margin 1.15)

Design Flow Rate: 35.6 m3/s

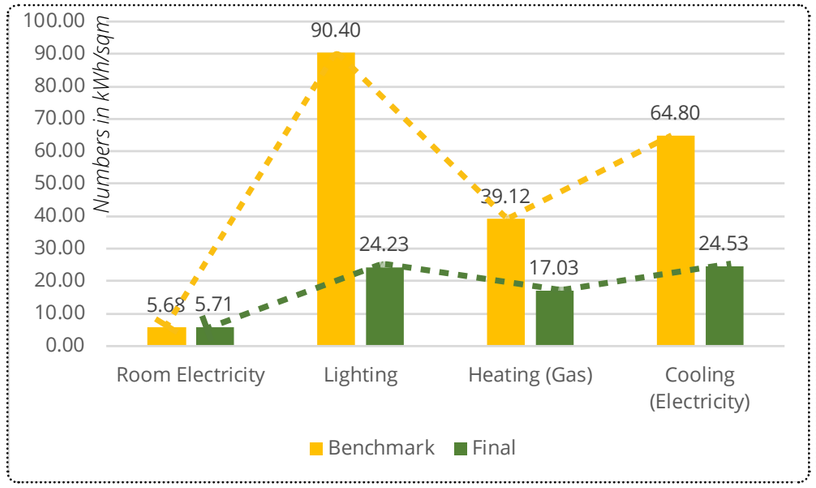


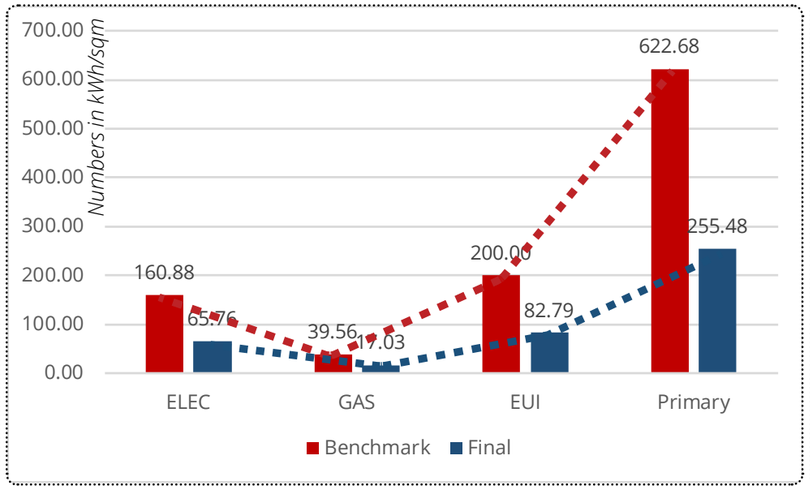

**Water use reduction**

Indoor water use reduction: %45.5

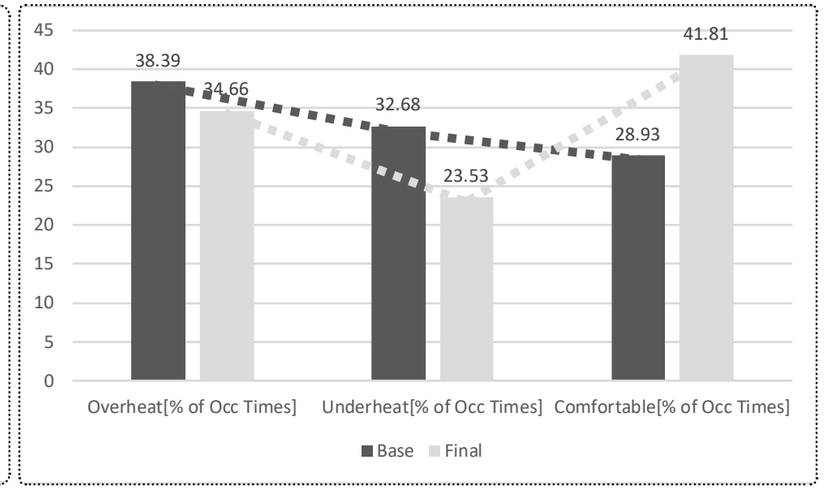
Outdoor water use reduction: %100

## Energy




## Thermal Comfort




**-%60.59** Improvement

**%73.19** Improvement

**%56.47** Improvement

**%62.14** Improvement

**%59.12** Improvement

**%56.96** Improvement

**%58.60** Improvement

**%58.97** Improvement

**%3.73** Improvement

**%9.15** Improvement

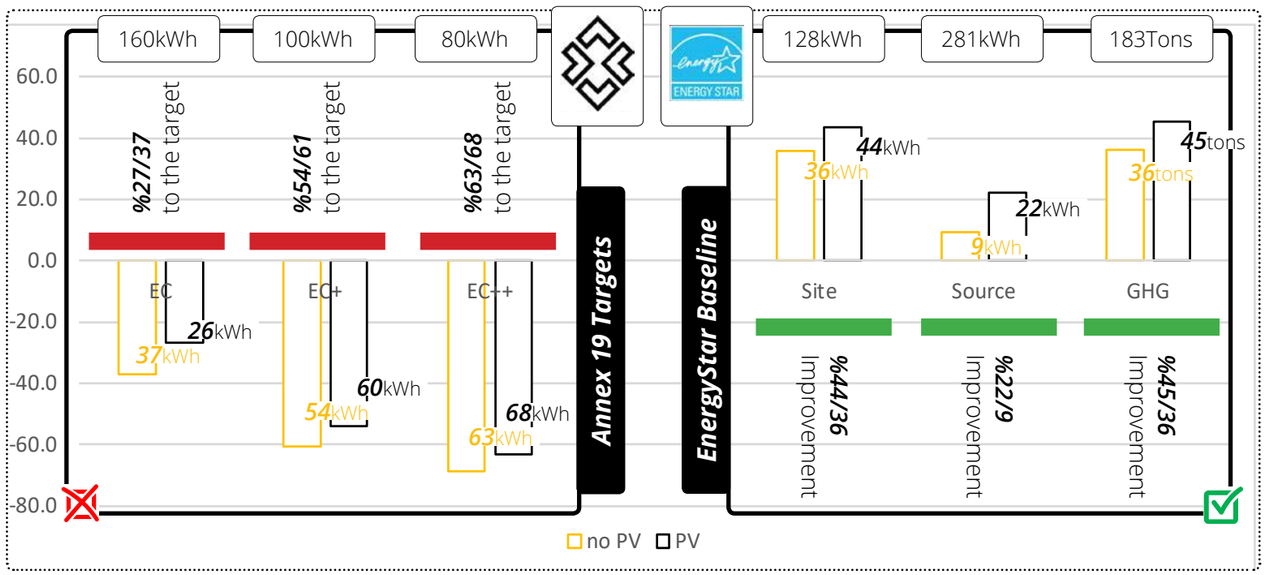
**%12.8** Improvement

## Carbon

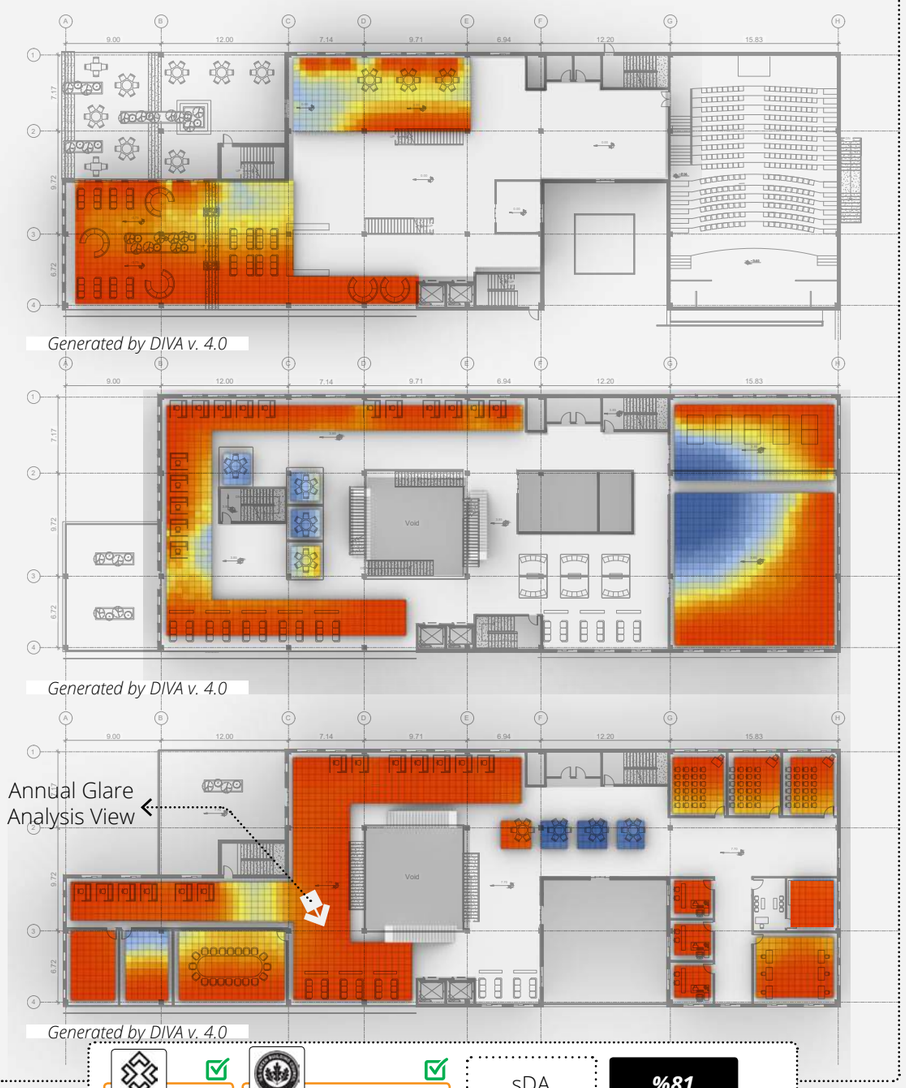
*Operational Carbon Emmition*

| | Electricity | Gas | Total | |
|---|---|---|---|---|
| Baseline CO2 Production (annual) [kg] | 252251 | 32495 | ***284,746*** | 61 X |
| Design CO2 Production (annual) [kg] | 103114 | 13987 | ***117,101*** | 25 X |

***Total CO2 Reduction (annual) [kg]*** ***167,645*** 36 X

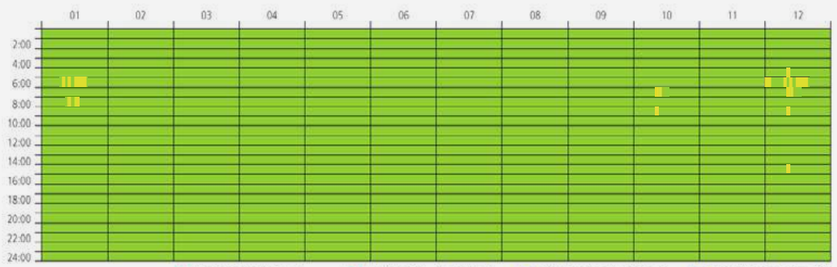


## Daylight and Glare




EC++ (Annex19) ☑ | LEED 3 point for daylight ☑

| | |
|---|---|
| sDA | %81 |
| ASE | %23 |



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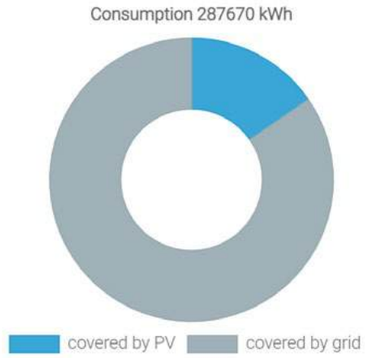
## Water

| | | |
|---|---|---|
| Annual baseline water consumption (liters/year) | 753,275.75 | Indoor |
| Annual design water consumption (liters/year) | 411,863.00 | |
| Percent water use reduction (%) | %45.32 | |
| Landscape water baseline (l/month) | 391 | Outdoor |
| Landscape water requirement (LWR) (l/month) | 217 | |
| Percentage reduction from baseline With Drip Irrigation (%) | %44 | |
| Percentage reduction from baseline Using RainWater (%) | %100 | |

## PV Generation

| | |
|---|---|
| Consumption[kWh] | 287670 |
| covered by PV[kWh] | 44362 |
| covered by grid | 243308 |
| Solar fraction [%] | %15.40 |
| Avoided CO2 emissions [kg/year] | 23795 |




## Project evaluation according to leed

40 | 39 | 19 **TOTALS** Possible Points: **110**

**Certified:** 40 to 49 points, **Silver:** 50 to 59 points, **Gold:** 60 to 79 points, **Platinum:** 80 to 110

### Certified — No Cost — ☑

only the Prerequisites must be provided.

***40 points***

### Silver — Low-Cost — +14

1.*Certified* Requirements
2.Light Pollution Reduction
3.Tenant Design and Construction Guidelines
4.Rainwater Management
5.Building Life-Cycle Impact Reduction
6.Cooling Tower Water Use
7.Site Assessment
8.Site Development - Protect or Restore Habitat

***54 points***

### Gold — Mid-Cost — +24

1.*Silver* Requirements
2.Enhanced Commissioning
3.Water Metering
4.Building Product Disclosure and Optimization - Environmental Product Declarations»

***64 points***

### Platinum — Not Eligible — +5

1.*Gold* Requirements
2.Bicyvle Facilities
3.Green Vehicles
4.Indoor Water Use reduction
5.Green POwer and Carbon Offsets

***maximum: 69 points***

## Improvement Proposals

## **LEED** Checklist

| | | | | | |
|---|---|---|---|---|---|
| 5 | 1 | 9 | **Location and Transportation** | | 20 |
| | | | Credit | LEED for Neighborhood Development Location | 20 |
| 1 | | 1 | Credit | Sensitive Land Protection | 2 |
| | | 3 | Credit | High Priority Site | 3 |
| 3 | | 3 | Credit | Surrounding Density and Diverse Uses | 6 |
| | 1 | | Credit | Access to Quality Transit | 6 |
| | | 1 | Credit | Bicycle Facilities | 1 |
| 1 | | 0 | Credit | Reduced Parking Footprint | 1 |
| | | 1 | Credit | Green Vehicles | 1 |

| | | | | | |
|---|---|---|---|---|---|
| 7 | 3 | 1 | **Water Efficiency** | | 11 |
| Y | | | Prereq | Outdoor Water Use Reduction | Required |
| Y | | | Prereq | Indoor Water Use Reduction | Required |
| Y | | | Prereq | Building-Level Water Metering | Required |
| 2 | | | Credit | Outdoor Water Use Reduction | 2 |
| 5 | | 1 | Credit | Indoor Water Use Reduction | 6 |
| | 2 | | Credit | Cooling Tower Water Use | 2 |
| | 1 | | Credit | Water Metering | 1 |

| | | | | | |
|---|---|---|---|---|---|
| 3 | 8 | 0 | **Sustainable Sites** | | 11 |
| N | | | Prereq | Construction Activity Pollution Prevention | Required |
| | 1 | | Credit | Site Assessment | 1 |
| | 2 | | Credit | Site Development - Protect or Restore Habitat | 2 |
| 1 | | | Credit | Open Space | 1 |
| | 3 | | Credit | Rainwater Management | 3 |
| 2 | | | Credit | Heat Island Reduction | 2 |
| | 1 | | Credit | Light Pollution Reduction | 1 |
| | 1 | | Credit | Tenant Design and Construction Guidelines | 1 |

| | | | | | |
|---|---|---|---|---|---|
| 0 | 6 | 0 | **Innovation** | | 6 |
| | 5 | | Credit | Innovation | 5 |
| | 1 | | Credit | LEED Accredited Professional | 1 |

| | | | | | |
|---|---|---|---|---|---|
| 19 | 11 | 3 | **Energy and Atmosphere** | | 33 |
| Y | | | Prereq | Fundamental Commissioning and Verification | Required |
| Y | | | Prereq | Minimum Energy Performance | Required |
| Y | | | Prereq | Building-Level Energy Metering | Required |
| Y | | | Prereq | Fundamental Refrigerant Management | Required |
| | 6 | | Credit | Enhanced Commissioning | 6 |
| 15 | 3 | | Credit | Optimize Energy Performance | 18 |
| | 1 | | Credit | Advanced Energy Metering | 1 |
| | 1 | 1 | Credit | Demand Response | 2 |
| 3 | | | Credit | Renewable Energy Production | 3 |
| 1 | | | Credit | Enhanced Refrigerant Management | 1 |
| | | 2 | Credit | Green Power and Carbon Offsets | 2 |

| | | | | | |
|---|---|---|---|---|---|
| 0 | 12 | 2 | **Materials and Resources** | | 14 |
| Y | | | Prereq | Storage and Collection of Recyclables | Required |
| Y | | | Prereq | Construction and Demolition Waste Management Planning | Required |
| | 4 | 2 | Credit | Building Life-Cycle Impact Reduction | 6 |
| | 2 | | Credit | Building Product Disclosure and Optimization - Environmental Product Declarations | 2 |
| | 2 | | Credit | Building Product Disclosure and Optimization - Sourcing of Raw Materials | 2 |
| | 2 | | Credit | Building Product Disclosure and Optimization - Material Ingredients | 2 |
| | 2 | | Credit | Construction and Demolition Waste Management | 2 |

| | | | | | |
|---|---|---|---|---|---|
| 6 | 4 | 0 | **Indoor Environmental Quality** | | 10 |
| Y | | | Prereq | Minimum Indoor Air Quality Performance | Required |
| Y | | | Prereq | Environmental Tobacco Smoke Control | Required |
| 2 | | | Credit | Enhanced Indoor Air Quality Strategies | 2 |
| | 3 | | Credit | Low-Emitting Materials | 3 |
| | 1 | | Credit | Construction Indoor Air Quality Management Plan | 1 |
| 3 | | | Credit | Daylight | 3 |
| 1 | | | Credit | Quality Views | 1 |

| | | | | | |
|---|---|---|---|---|---|
| 0 | 0 | 4 | **Regional Priority** | | 4 |
| | | 1 | Credit | Regional Priority: Specific Credit | 1 |
| | | 1 | Credit | Regional Priority: Specific Credit | 1 |
| | | 1 | Credit | Regional Priority: Specific Credit | 1 |
| | | 1 | Credit | Regional Priority: Specific Credit | 1 |

| | | | | |
|---|---|---|---|---|
| 40 | 39 | 19 | **TOTALS** | Possible Points: 110 |

**Certified:** 40 to 49 points, **Silver:** 50 to 59 points, **Gold:** 60 to 79 points, **Platinum:** 80 to 110

## Prerequisites

1. Construction Activity Pollution Prevention
2. Outdoor Water Use Reduction
3. Indoor Water Use Reduction
4. Building-Level Water Metering
5. Fundamental Commissioning and Verification
6. Minimum Energy Performance
7. Building-Level Energy Metering
8. Fundamental Refrigerant Management
9. Storage and Collection of Recyclables
10. Construction and Demolition Waste
11. Management Planning
12. Minimum Indoor Air Quality Performance
13. Environmental Tobacco Smoke Control

## Improvement Proposals

### Certified

No Cost

only the Prerequisites must be provided.

***40 points***

### Silver +14

Low-Cost

1. *Certified* Requirements
2. Light Pollution Reduction
3. Tenant Design and Construction Guidelines
4. Rainwater Management
5. Building Life-Cycle Impact Reduction
6. Cooling Tower Water Use
7. Site Assessment
8. Site Development - Protect or Restore Habitat

***54 points***

### Gold +24

Mid-Cost

1. *Silver* Requirements
2. Enhanced Commissioning
3. Water Metering
4. Building Product Disclosure and Optimization - Environmental Product Declarations»

***64 points***

### Platinum +5

Not Eligible

1. *Gold* Requirements
2. Bicyvle Facilities
3. Green Vehicles
4. Indoor Water Use reduction
5. Green POwer and Carbon Offsets

***maximum: 69 points***

## **Basement Floor** Plan




KEY

| | |
|---|---|
| 1 | Entrance |
| 2 | Information |
| 3 | Conference Hall |
| 4 | W.C. |
| 5 | Kitchen |
| 6 | Food Stall |
| 7 | Shop |
| 8 | FoudCourt Sitting Area |
| 9 | Fire Control Room |
| 10 | Electrical/ Systems Control |
| 11 | Facility Room |
| 12 | Facility Access/Parking |
| 13 | Gallery |
| 14 | Gallery-Storage |
| 15 | Multi-Functional Space |
| 16 | TV Room |
| 17 | Lounge |
| 18 | Study Hall (Individual) |
| 19 | Study Hall (Group) |
| 20 | Game Room |
| 21 | Class Room |
| 22 | Prayers Room |
| 23 | Management |
| 24 | Administration |
| 25 | Conference Room |
| 26 | Student Association |
| 27 | Book Cafe |

## **Ground Floor** Plan




KEY

| | |
|---|---|
| 1 | Entrance |
| 2 | Information |
| 3 | Conference Hall |
| 4 | W.C. |
| 5 | Kitchen |
| 6 | Food Stall |
| 7 | Shop |
| 8 | FoudCourt Sitting Area |
| 9 | Fire Control Room |
| 10 | Electrical/ Systems Control |
| 11 | Facility Room |
| 12 | Facility Access/Parking |
| 13 | Gallery |
| 14 | Gallery-Storage |
| 15 | Multi-Functional Space |
| 16 | TV Room |
| 17 | Lounge |
| 18 | Study Hall (Individual) |
| 19 | Study Hall (Group) |
| 20 | Game Room |
| 21 | Class Room |
| 22 | Prayers Room |
| 23 | Management |
| 24 | Administration |
| 25 | Conference Room |
| 26 | Student Association |
| 27 | Book Cafe |

## **First Floor** Plan




KEY

1 Entrance
2 Information
3 Conference Hall
4 W.C.
5 Kitchen
6 Food Stall
7 Shop
8 FoudCourt Sitting Area
9 Fire Control Room
10 Electrical/ Systems Control
11 Facility Room
12 Facility Access/Parking
13 Gallery
14 Gallery-Storage
15 Multi-Functional Space
16 TV Room
17 Lounge
18 Study Hall (Individual)
19 Study Hall (Group)
20 Game Room
21 Class Room
22 Prayers Room
23 Management
24 Administration
25 Conference Room
26 Student Association
27 Book Cafe

## **Second Floor** Plan




KEY

1 Entrance
2 Information
3 Conference Hall
4 W.C.
5 Kitchen
6 Food Stall
7 Shop
8 FoudCourt Sitting Area
9 Fire Control Room
10 Electrical/ Systems Control
11 Facility Room
12 Facility Access/Parking
13 Gallery
14 Gallery-Storage
15 Multi-Functional Space
16 TV Room
17 Lounge
18 Study Hall (Individual)
19 Study Hall (Group)
20 Game Room
21 Class Room
22 Prayers Room
23 Management
24 Administration
25 Conference Room
26 Student Association
27 Book Cafe

## Elevations

East Elevation




South Elevation



## Elevations

West Elevation

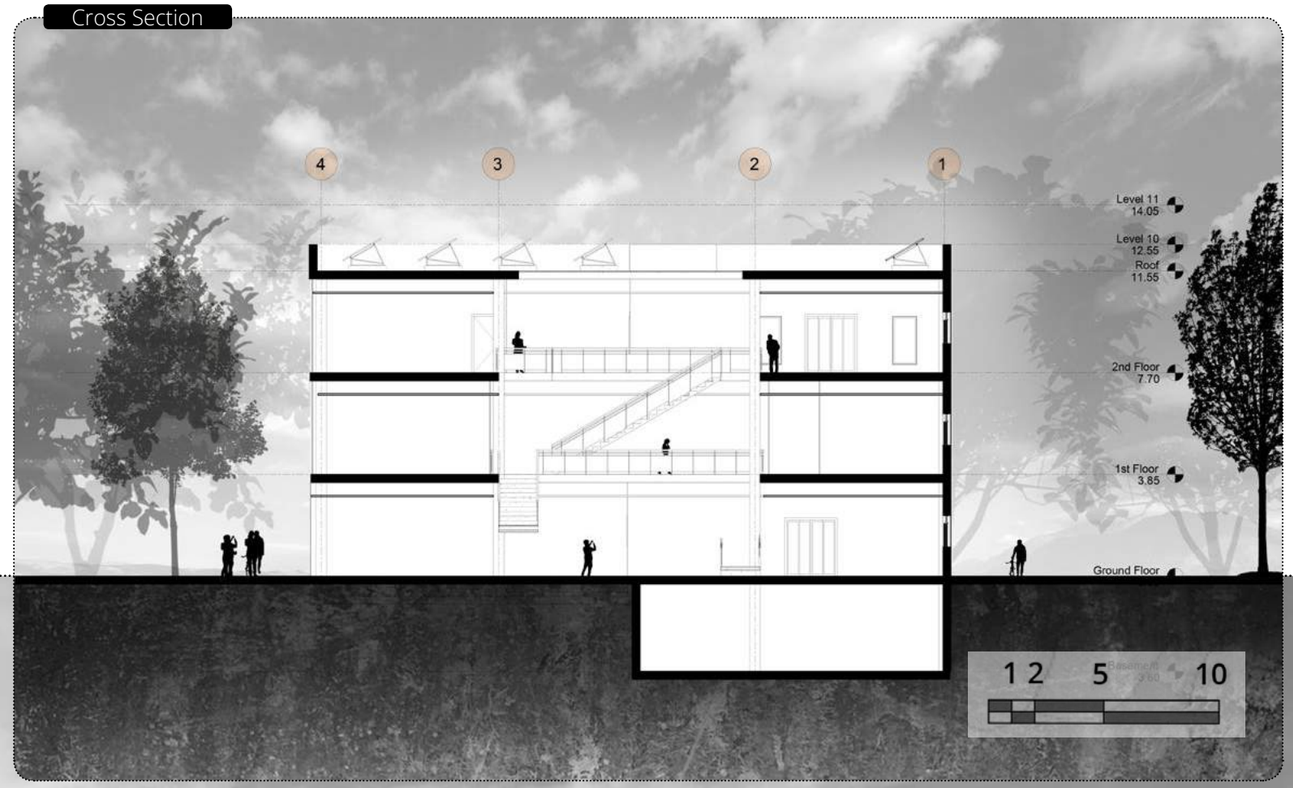



North Elevation



## Sections

Cross Section




Longitunidal Section



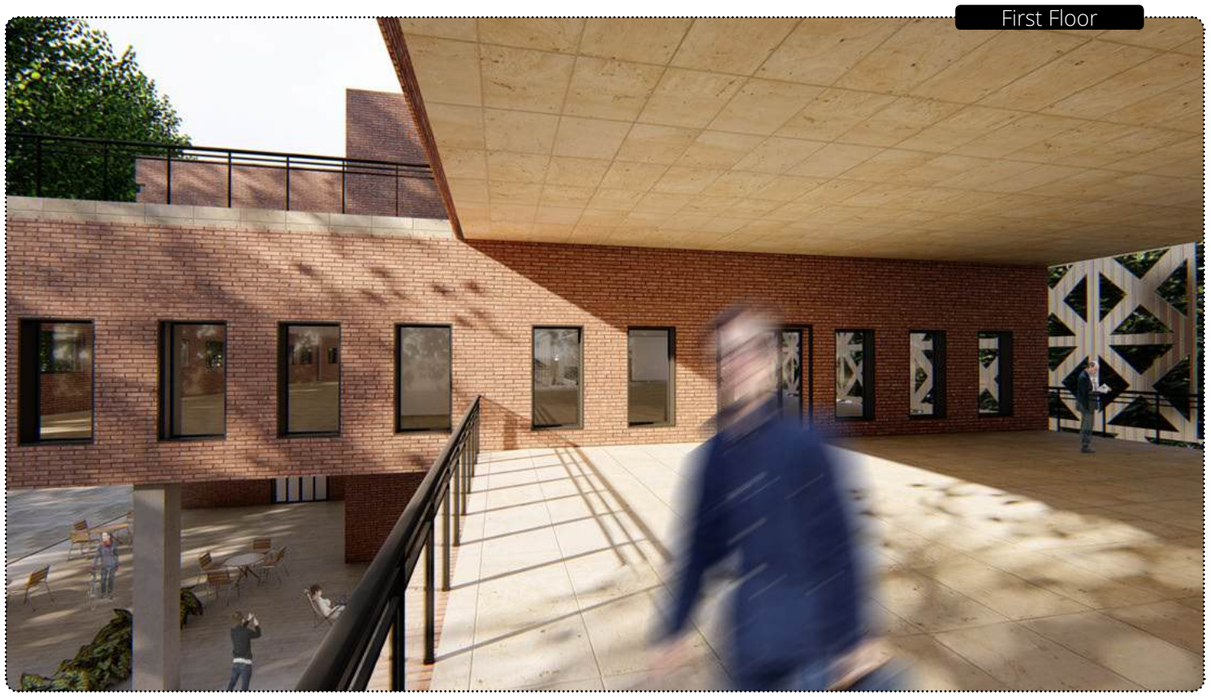
## Sections


Cross Section
1
2
3
4
Level 11
14.05
Level 10
12.55
Roof
11.55
2nd Floor
7.70
1st Floor
3.85
Ground Floor
Basement
-3.60
1 2 5 10

## Sections


Second Floor

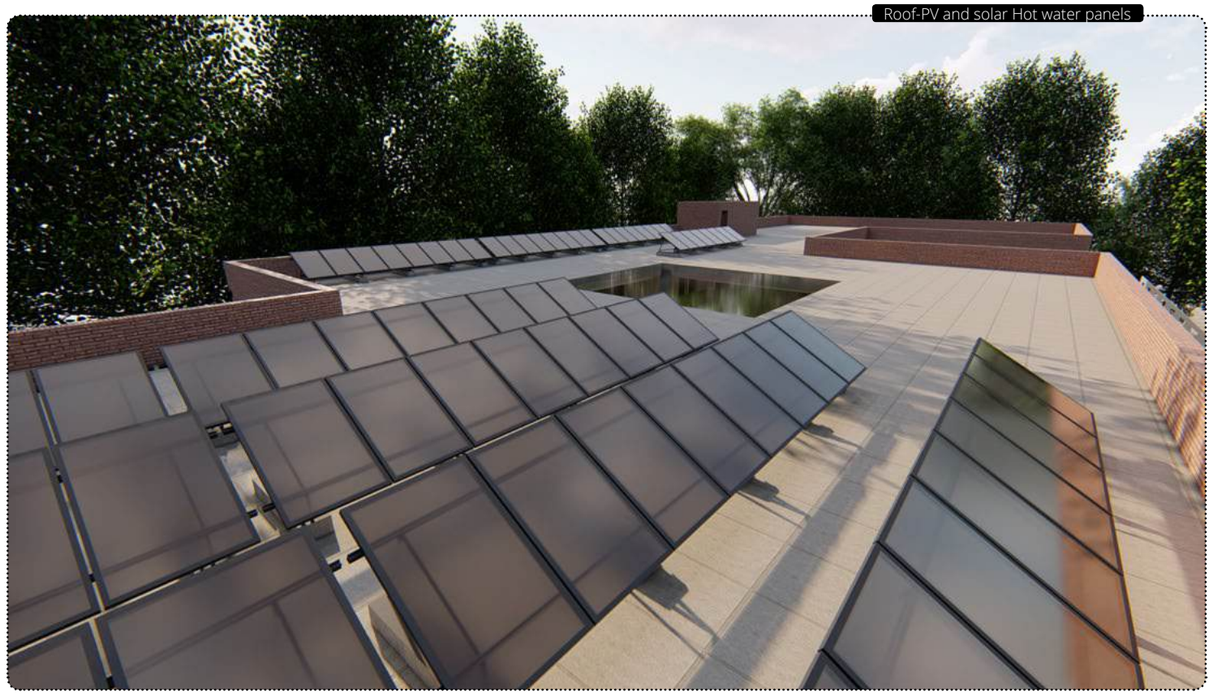

Southern View


First Floor


Second Floor

## Sections


Second Floor


Roof-PV and solar Hot water panels


Restaurant


Study Hall(group)

***List Tools and Software used***

Ladybug v. 0.0.67

RETscreen

EnergyStar Portfolio Manager

Archsim

DIVA v. 4.0

Honeybee v. 0.0.64

Design Builder v. 6.0

PV-Sol Online Tool

LEED Water Reduction Calculator

ANSYS Fluent

HTflux

Insul

Sound analyzer app

CBE Thermal Comfort Tool

ALFA v. 0.5.5.0

Climate Consultant V 6.0

***List of Guides, Rating systems, Standards and codes:***

Iranian National Building Codes Annex 3,4,13,14,19
WELL V.2 Certificate Guidelines
LEED V.4 Guideline
ASHRAE %30 and %50 design Guides
RELi V.2 Guidelines
ASHRAE 55
Ashrae 62.1 (Ventilation for Acceptable Indoor Air Quality)
Ashrae 189.1 (Standard for the design of High Performance Green Buildings)
LEED v4 for D+C - WE Prerequisite Outdoor Water Use Reduction and WE Credit Outdoor Water Use Reduction
LEED v4 for O+M - WE Credit Outdoor Water Use Reduction
LEED for Homes Rating System 2008
(The Irrigation Association, October 2001) Landscape Irrigation Scheduling and Water Management, IA 2005
2009 WaterSense Single-Family New Home Specification
LEED v4 and v4.1 for D+C and v4 for O+M - WE Prerequisite/ Credit Indoor Water Use Reduction
LEED v4 for ND - GIB Prerequisite/Credit Indoor Water Use Reduction and GIB Credit Wastewater Management
ISO 717-1 :2013
Acoustics — Rating of sound insulation in buildings and of building elements — Part 1: Airborne sound insulation
ISO 717-2 :2013
Acoustics — Rating of sound insulation in buildings and of building elements — Part 2: Impact sound insulation

***Nomenclature***

DBT: BryBulb Temperature
TC:Thermal Comfort
SVF: Surface to Volume Factor
OT: Operative Temperature
ACR: Air Change Rate
HSA: Horizontal Shading Angle
VSA: Vertical Shading Angle
mT: million Tomans
kWh:
kWh/m2:
ETo: Evapotranspiration Rate
DU(LQ) or EU*: Water Distribution Uniformity
KL:Plant Type Associated Landscape Coefficient
LWR: Landscape water requirement
Drip (press comp): Pressure Compensating Drip Irrigation System
lpf: Liters per flush


The End