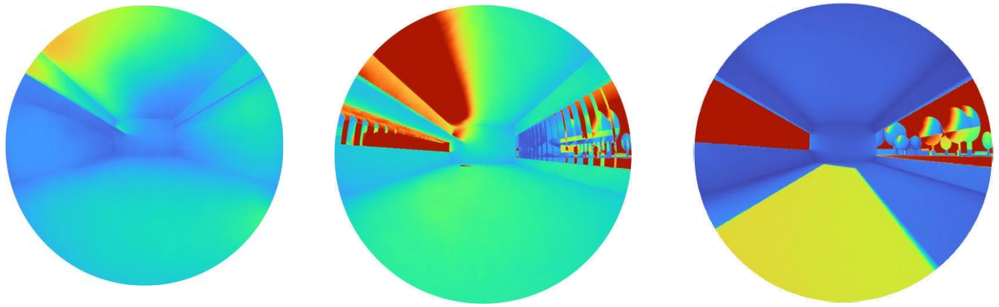
A full-scope renovation for Natural Ventilation - CFD



Academic Project – Detailed Site analysis

Location – Atlanta, USA

Software Used – Rhino, Climate Consultant, Ladybug and Honeybee Tools, Autodesk CFD

This project investigates energy-efficient design strategies for a site in DeKalb, Atlanta (Climate Zone 3A), using building physics simulations. A detailed site and climatic analysis was conducted to understand solar radiation, wind patterns, and humidity impacts. Based on these findings, a daylighting analysis optimized visual comfort, glare control, and solar access through shading devices and material strategies. To enhance thermal comfort, CFD simulations assessed natural ventilation performance, identifying airflow patterns and potential dead zones. By integrating daylighting and ventilation insights, the project proposes passive design solutions that reduce energy demand while improving indoor environmental quality.

PROBLEMS

- Envelope Overheating
- Glare Issues
- Wind Variability
- Ventilation Inefficiency
- Moisture Condensation

OPPORTUNITIES

- Façade Shading
- Passive Gains
- Adaptive Ventilation
- Nocturnal Cooling
- Daylight Utilization

SITE ANALYSIS

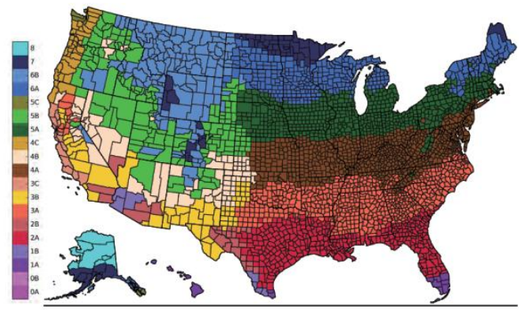
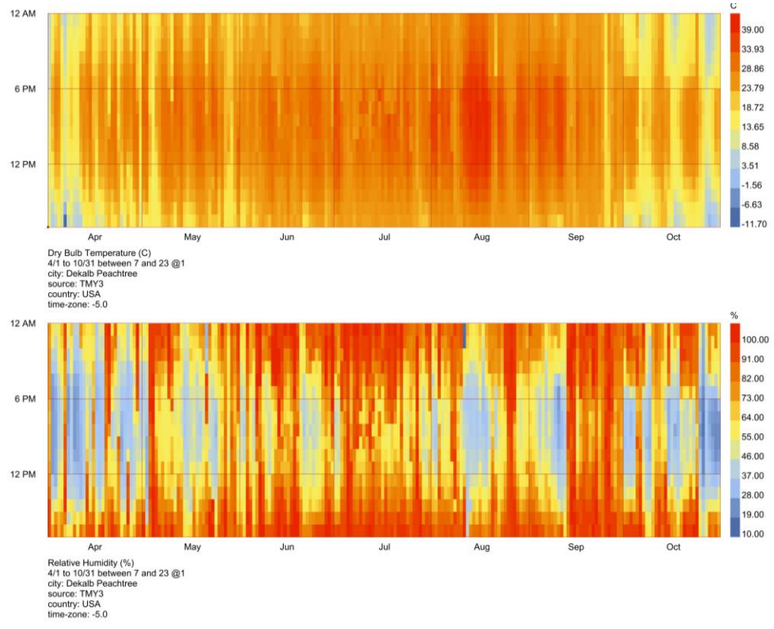


Figure A-2 Climate Zones for United States Counties

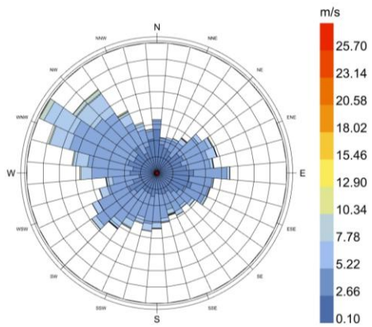
The site is located in DeKalb, Atlanta, Georgia, within **ASHRAE climate zone 3A**, characterized by:
Hot and humid summers: Temperatures often exceed 30°C (86°F) with high humidity levels.
Mild winters: Winters are typically mild without extreme cold conditions.
Year-round rainfall: Precipitation is evenly distributed throughout the year, with no pronounced dry season.

The site is surrounded by public spaces and small commercial areas, and currently there is a post office. To the north, there is a small cluster of coniferous trees.

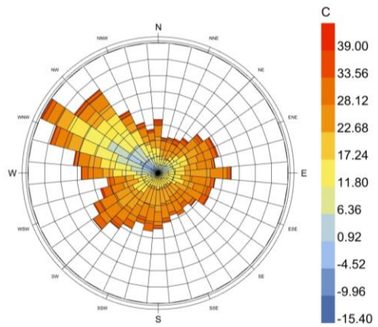


Seasonal Variation: Wide temperature variation suggests the need for both heating in winter and cooling in summer.
Relatively High Humidity: During summer months (June to September) affecting indoor comfort, also increases the condensation rate affecting building materials

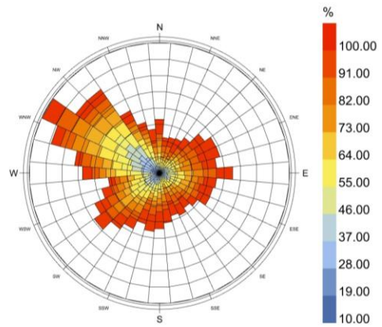
SITE ANALYSIS



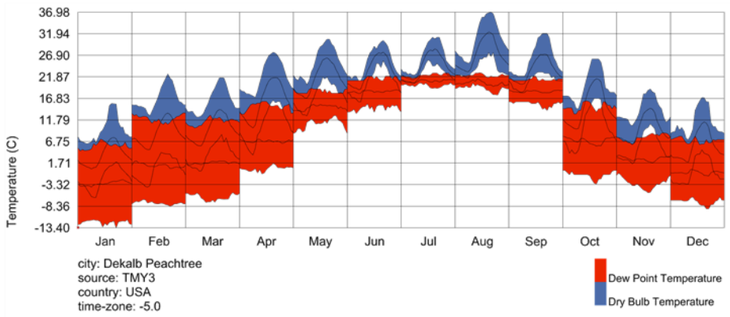
Wind Speed (m/s)
time-zone: -5.0
country: USA
city: Dekalb Peachtree
source: TMY3
period: 1/1 to 12/31 between 1 and 23 @1
Calm for 17.49% of the time = 1468 hours.
Each closed polyline shows frequency of 0.7% = 50 hours.



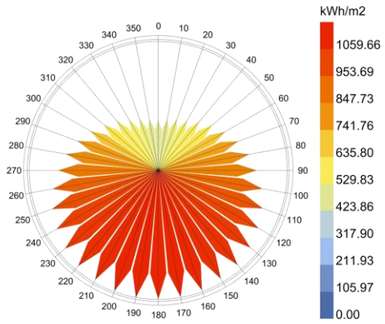
Dry Bulb Temperature (C)
time-zone: -5.0
country: USA
city: Dekalb Peachtree
source: TMY3
period: 1/1 to 12/31 between 1 and 23 @1
Each closed polyline shows frequency of 0.7% = 50 hours.



Relative Humidity (%)
time-zone: -5.0
country: USA
city: Dekalb Peachtree
source: TMY3
period: 1/1 to 12/31 between 1 and 23 @1
Each closed polyline shows frequency of 0.7% = 50 hours.

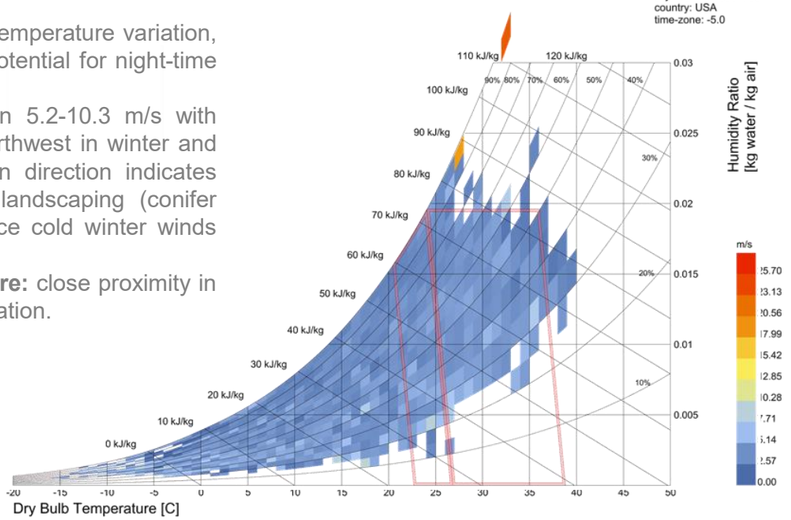


city: Dekalb Peachtree
source: TMY3
country: USA
time-zone: -5.0

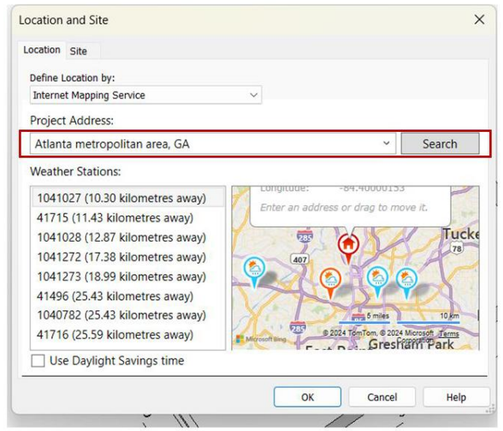


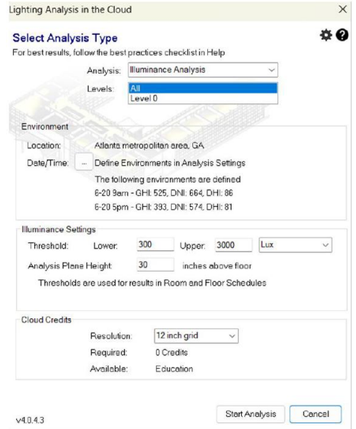
Total Radiation
01 Jan 00:00 - 31 Dec 23:00
time-zone : -5.0
source : TMY3
city : Dekalb Peachtree
country : USA

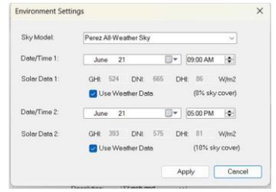
Diurnal Variation: Moderate diurnal temperature variation, especially in summer, indicates the potential for night-time cooling strategies.
Moderate Wind Velocities: Between 5.2-10.3 m/s with different prevailing winds from the northwest in winter and the southeast in summer. Change in direction indicates different ventilation strategies. Use landscaping (conifer trees) on the northwest side to reduce cold winter winds and decrease heating loads.
Dew Point and Dry Bulb Temperature: close proximity in temperature will lead to early condensation.



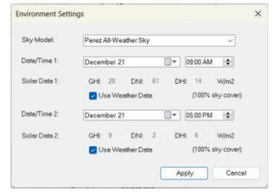
ASSUMPTIONS FOR DAYLIGHTING





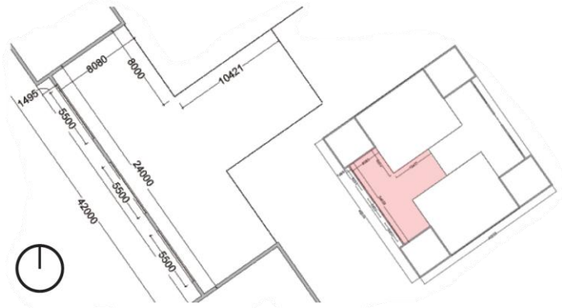


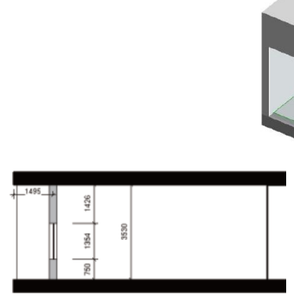
Summer Solstice

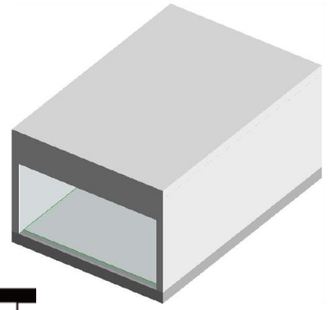


Winter Solstice

Annual working hours: 9:00 am to 5:00 pm
Lighting Metric Requirements as per ASHRAE 90.1 for livable areas
Illuminance Requirements: 300-500 lux

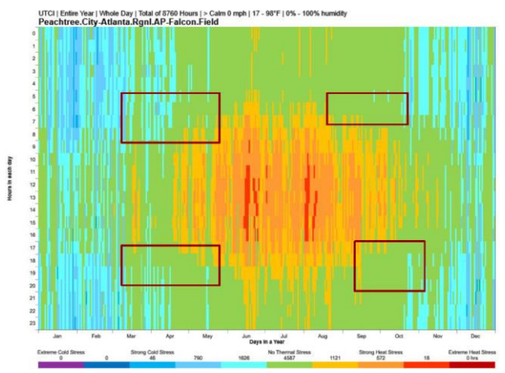


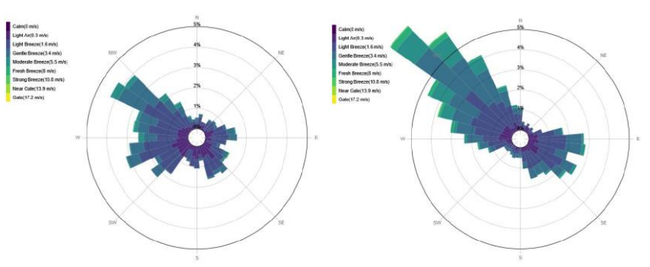




ASSUMPTIONS FOR NATURAL VENTILATION

In the mornings or afternoons of Spring and Autumn





WindRose: Spring

WindRose: Autumn

The wind speed in Spring or Autumn can reach up to 8 m/s (26.25 ft/s), with the lowest 3 m/s (9.84 ft/s)

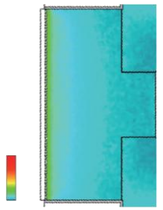
DAYLIGHTING ANALYSIS

DAYLIGHT FACTOR REQUIREMENT - *of the annual working hours*

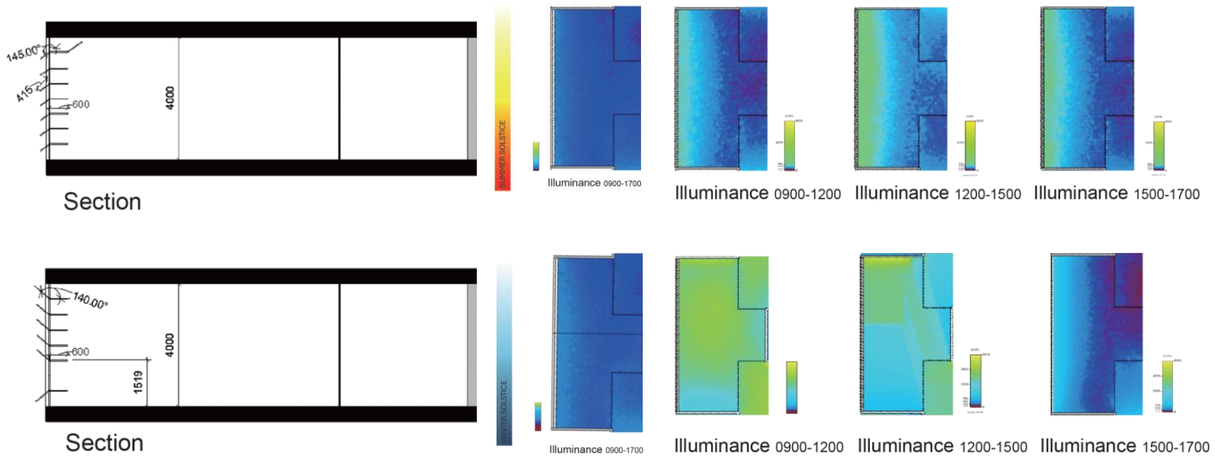
Description Zone	Optimum mean	Range
Target Percentage	2.7 %	2 – 5 %

ILLUMINANCE REQUIREMENT - *of the annual working hours*

Description Zone	Optimum	Range
Target Illuminance	300 Lux	270 – 750 Lux



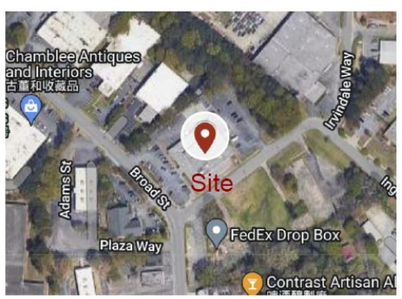
Daylight Factor

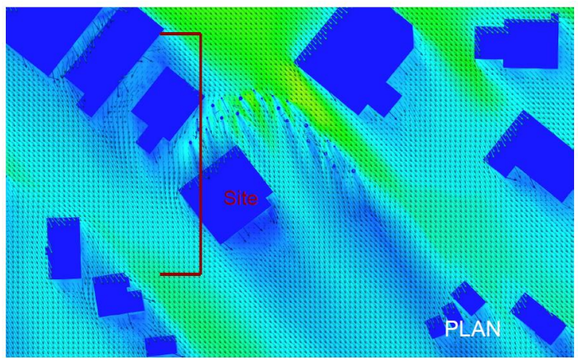


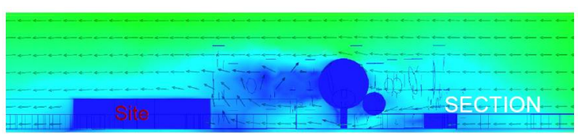
NATURAL VENTILATION – SITE CFD

The wind speed can reach up to 8 m/s (26.25 ft/s), with the lowest 3 m/s (9.84 ft/s)

Wind Speed: 6m/s, 19.7 feet/s
Wind Directions: 45 degrees west of north

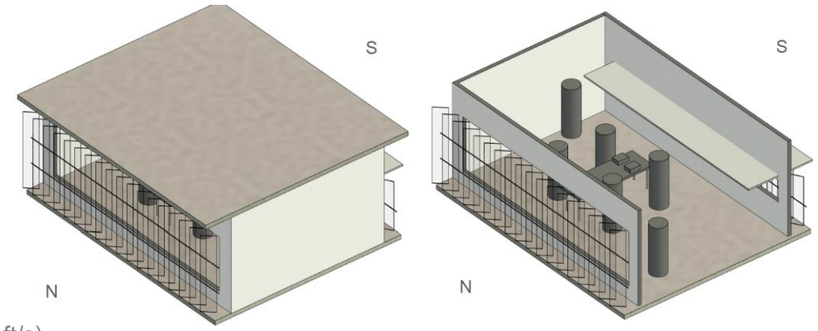




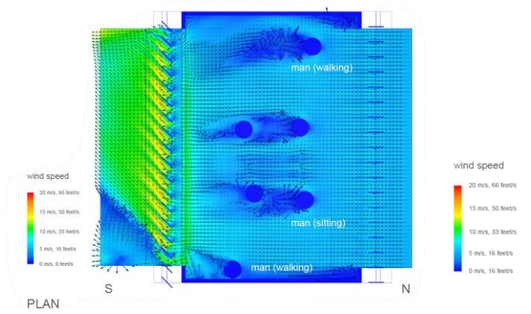


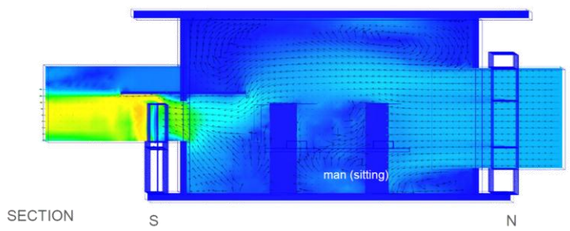
CFD ANALYSIS

CFD Model:
People: 4 seated, 2 walking
Computers: 4

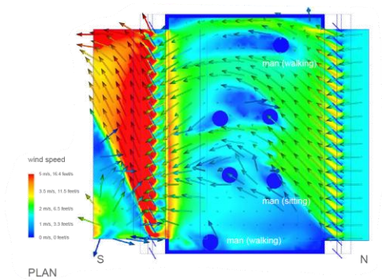


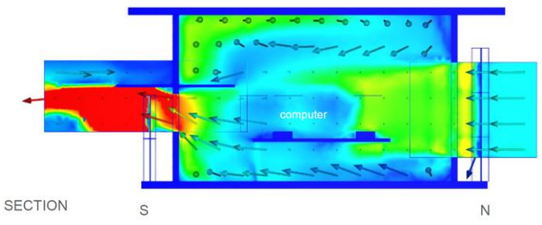
case I: wind speed 6 m/s (19.7 ft/s)





case II: wind speed 3 m/s (10 ft/s)





It can be observed that adjusting the angle of the shading device can also increase wind speed. However, it can be observed that this type of ventilation is directional.