ARCHITECTURE BLDG. SKYLIGHTS

Stack Effect Ventilation

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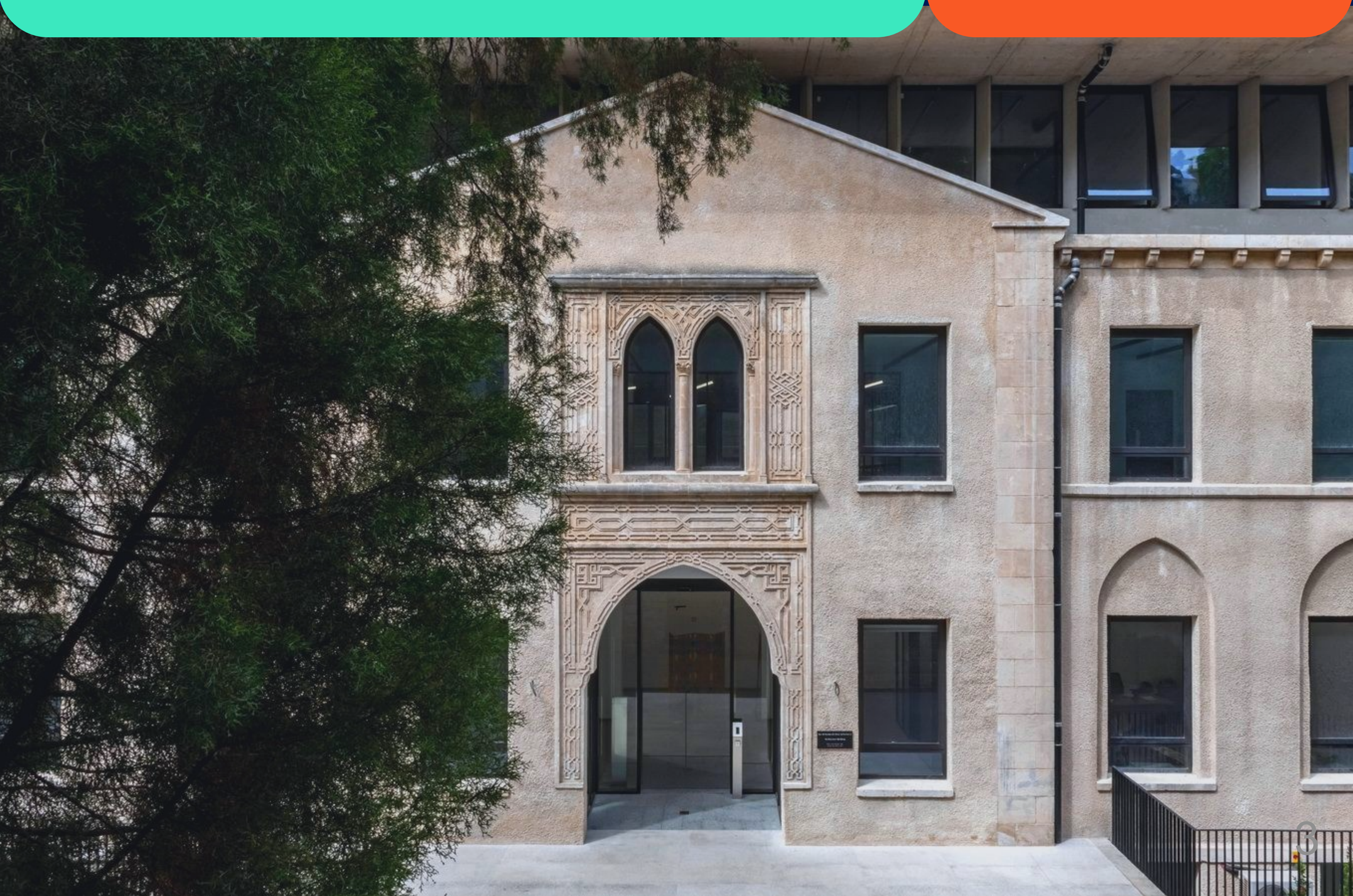
Executive Summary

This proposal aims to address the issue of significant temperature differences within the top floor of the Architecture Building at the American University of Beirut (AUB). The primary objective is to improve indoor thermal comfort and air quality by modifying the existing skylights to enhance natural ventilation. The proposed solution involves converting the existing 20-degree sloped skylights to horizontal windows, which will facilitate better air movement and release of trapped hot air. This report discusses the advantages of the proposed modifications and provides recommendations for implementation.

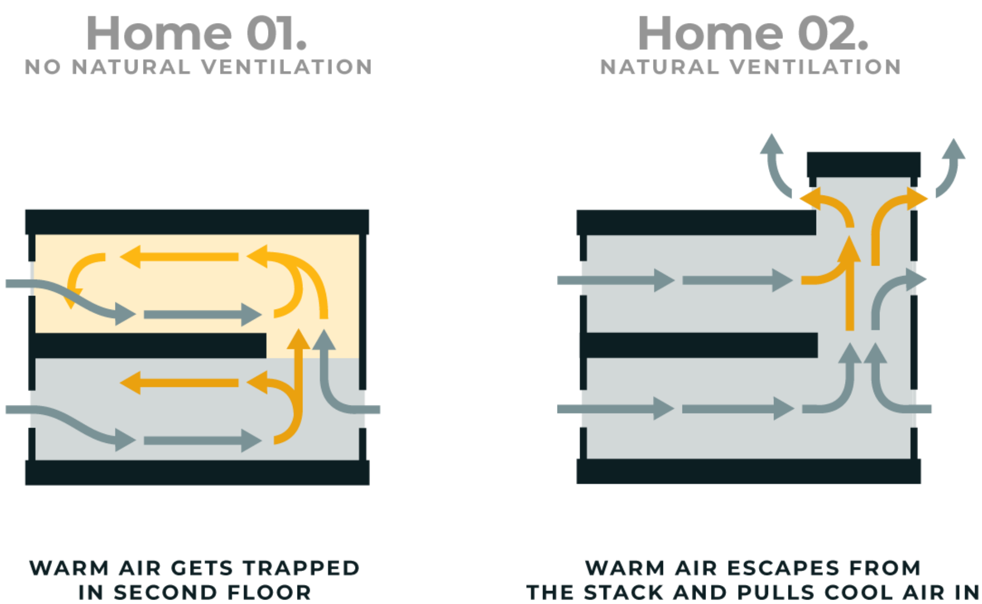


Introduction

Ventilation is an essential aspect of building design, especially in modern architecture, where energy efficiency and sustainability are increasingly important. These systems play a crucial role in improving indoor air quality by removing stale and polluted air and replacing it with fresh outdoor air. This is especially important in buildings that are tightly sealed to conserve energy, as pollutants can accumulate and lead to health problems such as respiratory issues and allergies, and they also contribute greatly to the indoor temperature of the building at hand.

The aim of our study is to implement a more efficient ventilation system for the recently renovated building that was designated for Architecture students at the American University of Beirut (AUB).

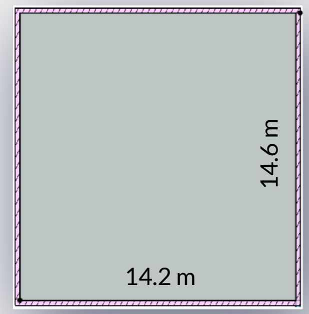
In the Dar Al-Handasah Architecture Building at AUB, the last floor of the building is denoted as an extra study room for students and is designed with very high ceilings and glass exterior windows that provide direct sunlight into the room. To make the room more efficient, a mezzanine, which is a loft-like floor, was introduced at the upmost section of the room. However, the main problem is that due to the floor's structure, there is an accumulation of heat inside of the room, leading to exhaustion and safety hazards of the students present due to the high temperature.



The Study

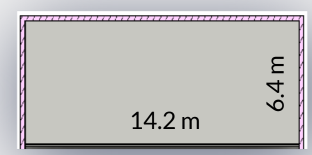
In our study, we discovered that the current ventilation system has created two distinct temperature zones within the room. This is a result of the indoor AC unit's return duct being placed 2 meters above the floor. Zone A, the lower part of the room, remains cool due to the AC, while Zone B, the upper part, collects the excess heat that rises. The ventilation system is designed to keep cool air at the bottom while allowing warmer air to rise to the ceiling. (Note that the room is 3.4 meters high).

The **Study**



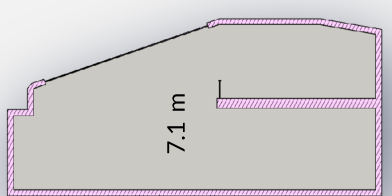
Area = 207 m^2

Lower Floor Plan



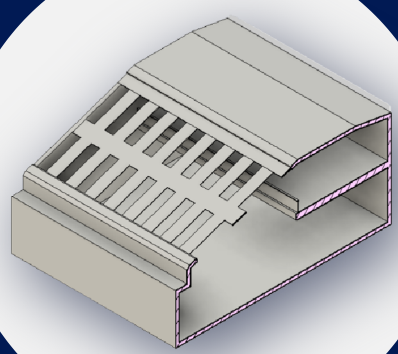
Area = 91 m^2

Mezzanine Floor Plan



Area = 88 m^2

Section View (2 Floors)



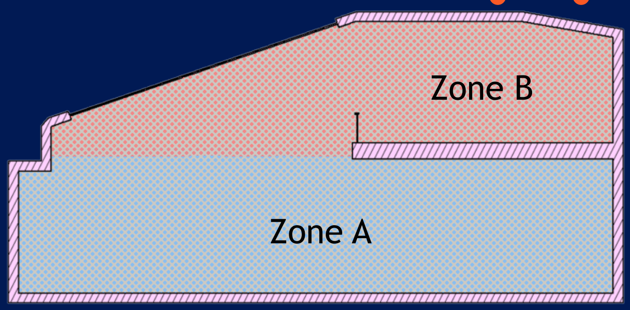
Volume = 1250 m^3

Isometric View

The
Study

As we can see on the right, this is the zoning that is taking place due to the skylights being closed. (Red representing hot air and blue representing cool air)

These data points were collected from temperature sensors fixed above and that are constantly logging to the BMS (Building Management System)



Zone B was recording on average 35ºC while Zone A was being maintained at 25ºC.

This 10ºC difference not only makes the space unusable but also overloads the ventilation system as hot air will start accumulating to affect Zone A.

Now calculating the volume of Zone B which needs to be displaced, we get that it is $34m^2$x14.2m which gives us $480m^3$.

The Physics

The physics behind the temperature differences in a multi-story building involves the principles of buoyancy, convection, heat conduction, solar radiation, radiative heat transfer, and air circulation. By understanding these concepts and addressing the factors contributing to heat accumulation, you can improve the thermal comfort and energy efficiency of your home.

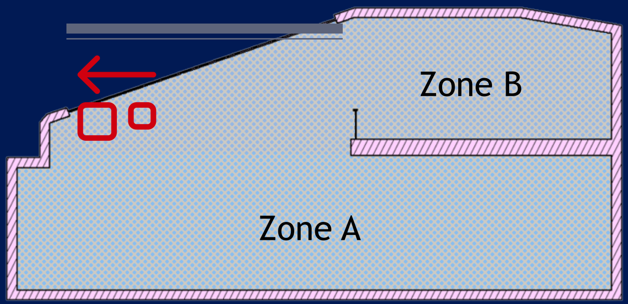
Solution

To address the issue of the upper floor being hotter, we consider implementing the following measures:

1. **Improve insulation**: Check and upgrade the insulation in the walls, roof, and between floors to minimize heat transfer between spaces.
2. **Enhance roof ventilation**: Proper ventilation in the attic can help release trapped hot air, reducing the temperature on the upper floor. Installing ridge vents, soffit vents, or gable vents can improve attic ventilation.
3. **Optimize HVAC system**: Consult with an HVAC professional to evaluate the existing system and make necessary adjustments or upgrades to improve cooling efficiency on the upper floor.
4. **Increase air circulation**: Use ceiling fans or portable fans to help circulate the air and create a more even temperature distribution between the floors. Additionally, consider adding or adjusting vents or windows to facilitate air movement.

By addressing these factors, you can create a more comfortable and even temperature distribution throughout the building. However, coming back to our case, we see that the most suitable solutions for our case are enhancing roof ventilation, as skylights are already available, and to further enhance their effect, roof fans or suction turbines may be added.

Now taking the above into consideration, the skylights must open to become horizontal when ventilation is necessary to decrease the heat in Zone B. After, most or all the hot air had left, the skylights automatically close again.



Calculations

The skylights are currently at a slope of 20^0 from the horizon; as a result opening them horizontally will result in a cross sectional flow area of 2 triangles on the side and a rectangle in the front.

Area of rectangle = width of window x height of opening
= 54cm x 72cm*tanh(20^0)
= 0.14 m^2

Area of Triangles = 0.5 x length of window x height of opening
= 0.1 m^2

So, the total cross sectional flow area for each window is 0.24 m^2 (A = 0.24 m^2).

Now, calculating the amount of energy dissipated when opening the skylights, we are going to suppose that the inside air velocity is 0.25 m/s which is the standard indoor air velocity for an air conditioned room (V = 0.25 m/s).

Q = A x V x Cp x ρ x (Th - Tl)
Q = 0.24 x 0.25 x 1.005 x 1.184 x (35 - 25)
Q = 71.4 W

So applying this solution will result in 71.4 W of saved cooling energy per window.

V: Air Velocity
A: Surface Area
Q: Energy Dissipated
Cp: Specific heat of air
ρ: Density of air
Th: Hot Temperature
Tl: Cool Temperature

All values were taken to be at 25^0C which is the standard room tmperaure

Conclusion

Implementation of such a solution will not only enhance air circulation, lower last floor's temperature to make it habitable, but will also decrease the cooling capacity required to cool the space.

7853 kW

Is the dissipated heat that will result if 11 windows were opened for an hour