

Assessing Thermal Comfort on Different Floors of Educational Buildings in Egypt.

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Abstract

Achieving high levels of indoor environmental quality is critical for designers because it can lead to increased occupant productivity, enjoyment, economic benefits, and better sustainability outcomes. This means it has lately emerged as a popular research topic in developing countries. This analysis focuses on Cairo's educational buildings because they have a significant impact on people's thermal comfort and the city's overall energy consumption. The Egyptian Energy Code was searched for information on the various building materials used to assess the present level of thermal comfort in these structures. The relationship between floor height and thermal comfort was then investigated using computational modelling.

The goal of this study is to look at the impact of floor height on the thermal comfort of building envelopes in Egypt, with a particular emphasis on how it may affect the building's overall performance and energy efficiency. The study technique will be developed by integrating computer-based queries with extensive literature studies. The Design-Builder tool will be used to simulate the thermal properties of all approved materials defined in Egypt's energy code for building envelopes. The data will be evaluated and interpreted to determine the best floor in the same building.

introduction

Individuals must devote up to 90 percent of their time to indoor activities in order to carry out their daily chores. Individuals must feel at ease and comfortable in these defined places to achieve the best results. The study of interior thermal comfort is dependent on physical characteristics such as temperature, humidity, air currents, and radiation. Indoor temperature and humidity levels are often adjusted for maximum comfort using air conditioning, albeit at the expense of higher energy usage. Given the rising global energy costs, it is critical to investigate solutions that can reduce energy consumption while also improving thermal comfort.

Egyptian residential structures account for around 40% of total building energy usage. As a result, discovering effective techniques to reducing energy demand in residential buildings can help to mitigate the rising cost of energy consumption. Thermal comfort for pupils is an important issue that educational institutions must address. Examining such buildings in densely inhabited urban regions can highlight the significance of this research. The Arab Academy for Science and Technology and Maritime Transport building provided an interesting case study for examination because to its location and purpose as an educational center. Given Egypt's arid and heated climate, air conditioning is frequently used to regulate thermal comfort physical characteristics, albeit at a high energy cost. This method may efficiently manage ambient temperature and provide a comfortable indoor environment for people while reducing the demand for air conditioning. However, constructing thick wall layers needs a large land area, which incurs huge costs in Egypt. Thus, it is necessary to minimize the thickness of walls while retaining the advantages of having thick wall layers (Morsy et al., 2017).

The choice of an adequate floor is critical in achieving optimal thermal comfort, which may assist decision makers in selecting a floor that is more suited for certain activities. The current study uses Design Builder, a well-known software for conducting environmental assessments, to evaluate the thermal performance of five floors within the AASTMT facility: one underground and four above ground. Thermal comfort assessments will be undertaken on

each floor of the structure. The research will also include an analysis of the floors' rankings from best to worst, regardless of thermal insulation.

Literature Review

There are several definitions for thermal comfort, but they all express fundamentally the same idea. For example, thermal comfort is defined as "a mental state that reflects contentment with the thermal environment." "(Yao et al., 2009). According to the definition given above, thermal comfort is a highly interdisciplinary field of study that encompasses many aspects of various scientific fields. We might also get a definition of "that state of mind that transmits contentment with the thermal environment" by studying ASHRAE Standard (ASHRAE, 2017).

Due to the significant physiological and psychological differences between persons, it is difficult to satisfy everyone in a given location. Individuals have different preferences for comfortable environments. Nonetheless, a large amount of laboratory and field data has been collected, providing the critical statistical information needed to determine thermally acceptable settings for a certain percentage of the population. Thermal comfort can be monitored and preserved using both quantitative and qualitative methods. The measurable characteristics of thermal comfort are widely classified into three main groups: air, surface, and human-induced factors (Kumar et al., 2018).

3.1. Thermal comfort models

As comfort index-based control has become the standard in the process of developing indoor thermal comfort conditions, the fundamental assumptions of thermal sensation/comfort models are being called into question due to the absence of a definitive correlation between thermal preference and thermal feeling. However, the relationship between the temperature of the environment and the level of comfort experienced by individuals has resulted in the development of two distinct concepts:

- a) The heat balance approach. b) The adaptive approach(Aydin Gezer, 2003)

The inception of these models can be attributed to Nevins et al. (Nevins, 1966) provided the illustrations of empirical projections relevant to heat sensation ratings were supplied. Fanger carried out a number of research that are largely acknowledged as being among the most influential in the profession. His goal was to design a universal equation that could be used to the utilization of prediction models for the purpose of determining the level of thermal comfort experienced inside.

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3.2. Energy and thermal comfort using simulation tools.

Both computer simulation and assessment tools are utilized in the process of carrying out the empirical studies that are included in this work. The principal program that is employed is DesignBuilder 4.5, which is one of the Building Performance Simulation (BPS) solutions that includes more than 389 different tools (Attia et al., 2011). According to what Attia has claimed, DesignBuilder may be utilized throughout the course of the design process. In addition to this, it has a user interface that was designed with the language of architects in mind and is focused on being visually appealing. Modeling and updating of the case study were accomplished with the help of the program Design Builder. After that, the findings were imported into the apps that are part of Microsoft Office for the purpose of providing a visual representation in the form of tables and charts (Attia, 2011).

Methodology and Building model

The simulation tool known as DesignBuilder was utilized in order to carry out the tests that are described in this publication. It makes it possible to conduct simultaneous evaluations of the performance of all building components, such as window glazing, heating, ventilation, and air conditioning (HVAC) systems, controls, indoor

air quality, human thermal comfort, and energy consumption, in addition to the construction of the facade and walls.

The model that was used in all of the simulations consisted of a central module of a college building that was five stories tall and had offices and lecture halls on the bulk of the building's levels. As a result of the actual condition of the building, all of the building data were collected through the actual inspection and collection methods, and it was then used as input data for the building model. The building layout and three-dimensional shape that was created using DesignBuilder are depicted in figure 1.

The following input data for the building was validated:

Due to the fact that it has the greatest number of zones, the first floor has been replicated for all of the levels. This is because it is necessary to have the same floor plan in order to prevent any impact from the orientation or the size of the building sides.

There is a possibility that metabolic rates will differ from one zone type to another. These metabolic rates can range from the typical metabolic rate for studying to the metabolic rate of light office work.

The entire construction must have a minimum of 12 litres per square foot of fresh air.

According to the classification of the area, the energy loads are different: computer laboratories have a comparatively high consumption, office zones have a moderate usage, and lecture rooms have a relatively low usage.

In point of fact, the HVAC system that was being utilised consisted of split air conditioning units on the job..

The building construction of the main effective parts was as shown in table 1:

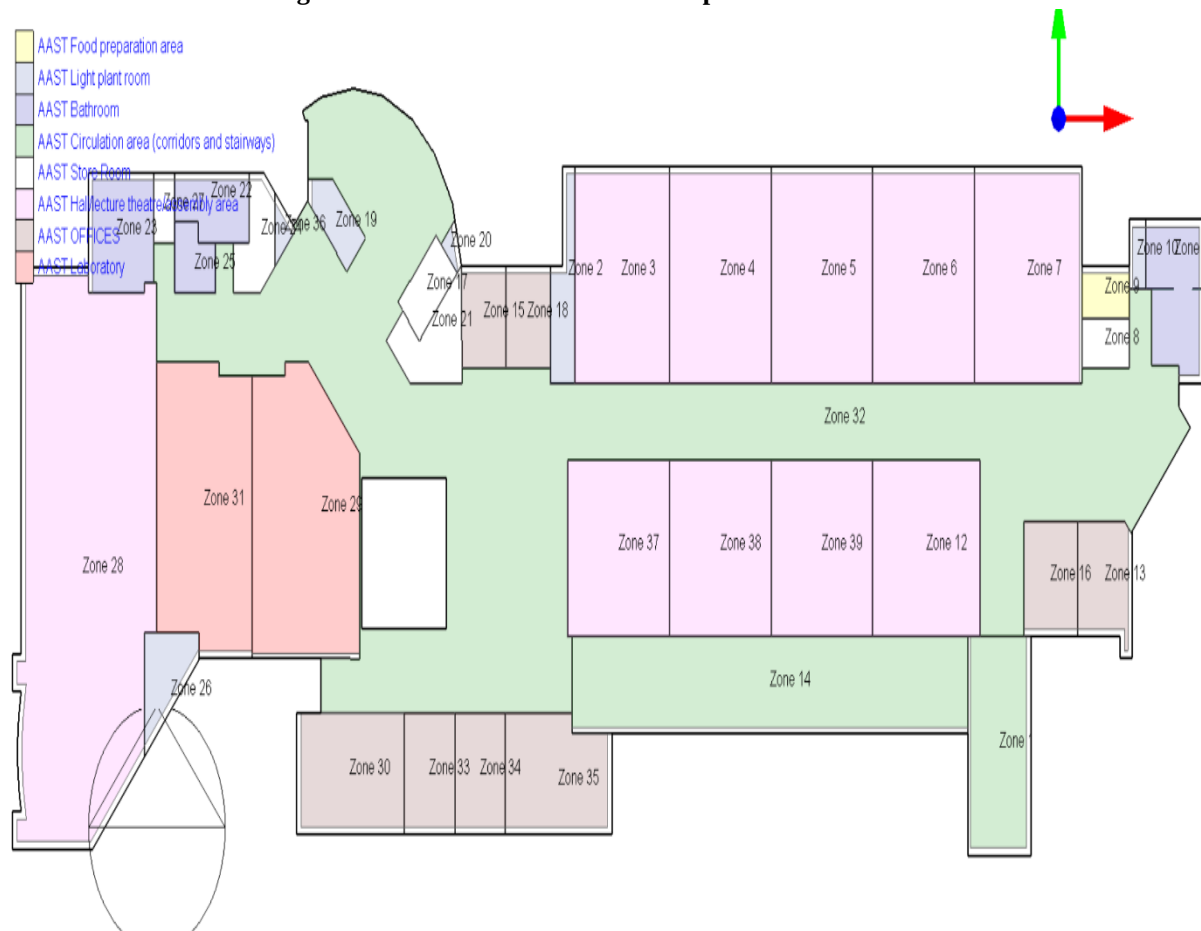


Table 1: Construction materials used in main components of building structure

Number of Layers		1	2	3	4	5	6	7
Thickness	Roof (mm)	50	30	30	30	250	30	5
	Typical slab (mm)	50	30	30	30	250	30	5
	External walls (mm)	5	20	30	250	30	20	5
Construction Material	Roof (mm)	concrete tiles	plasterin g	sand stones	sand stones	concrete slabs	plasterin g	painting
	Typical slab (mm)	concrete tiles	plasterin g	sand stones	sand stones	concrete slabs	plasterin g	painting
	External walls (mm)	finishin g	gypsums plasterin g	plasterin g	wall concret e blocks	plasterin g	gypsums plasterin g	painting finishin g

Figure 1: Ground Floor Plan

Results and Discussion.

The number of hours of discomfort has been utilized to quantify the thermal comfort impact. When it comes to designing a structure, the floor that results in the least amount of pain is the best option for obtaining the desired impact of thermal comfort. The ensuing graphics will provide an illustration of the results of the output. Based on the data, it will be possible to determine which material's influence on thermal comfort begins with the presentation.

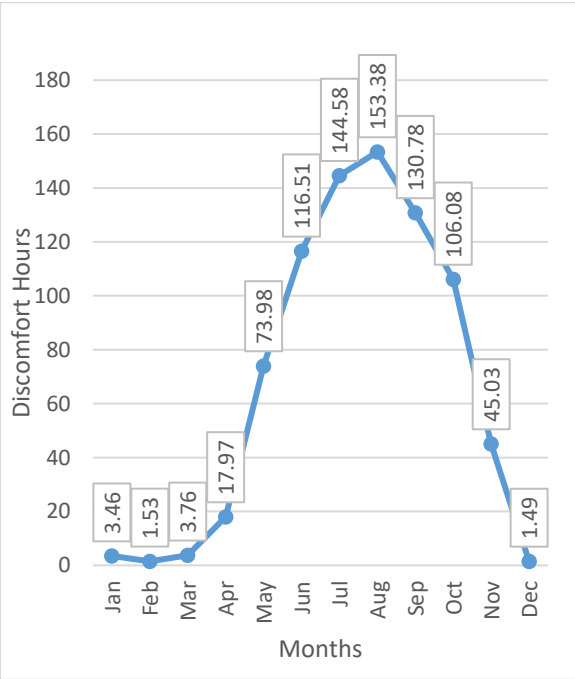


Figure 2:Under-Ground floor discomfort hours

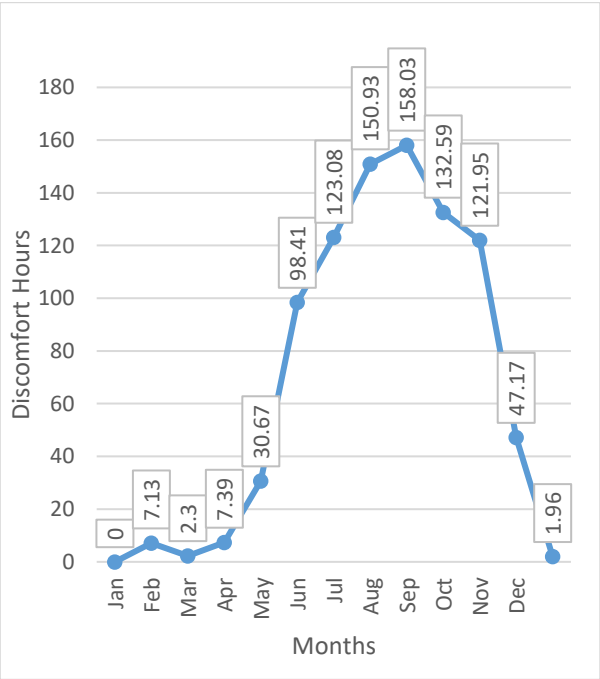


Figure 3:Ground floor discomfort hours

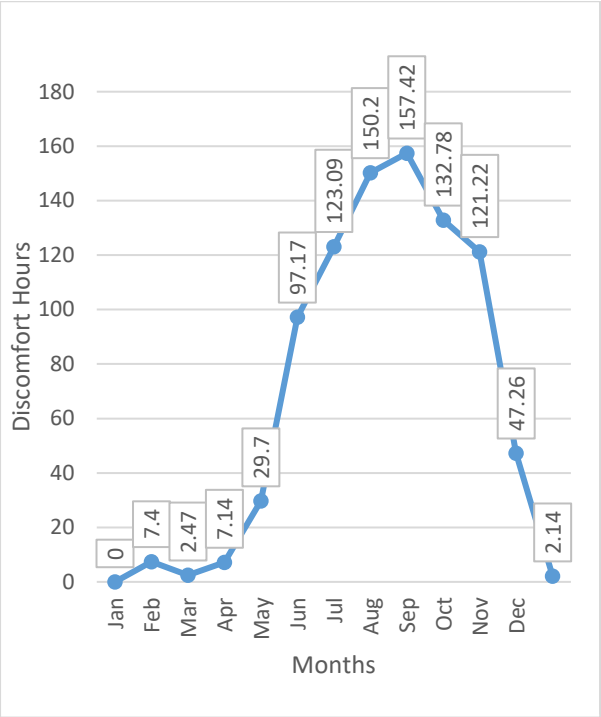


Figure 4:1st floor discomfort hours

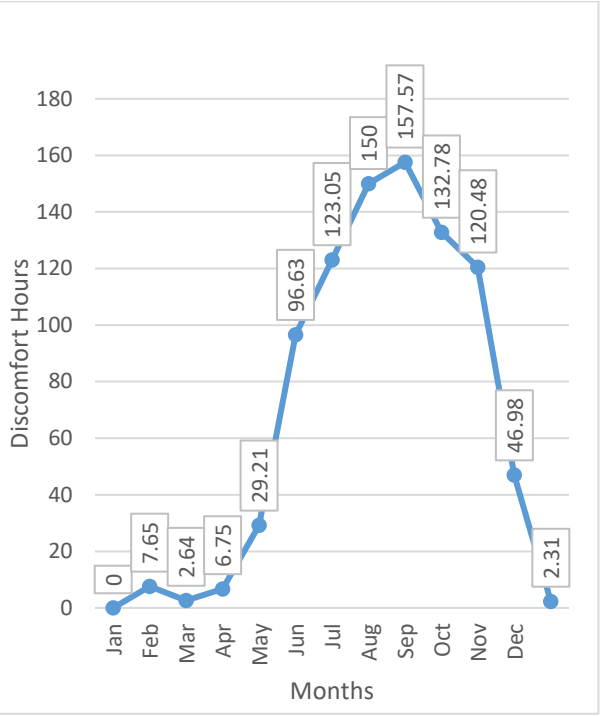


Figure 5: 2nd floor discomfort hours

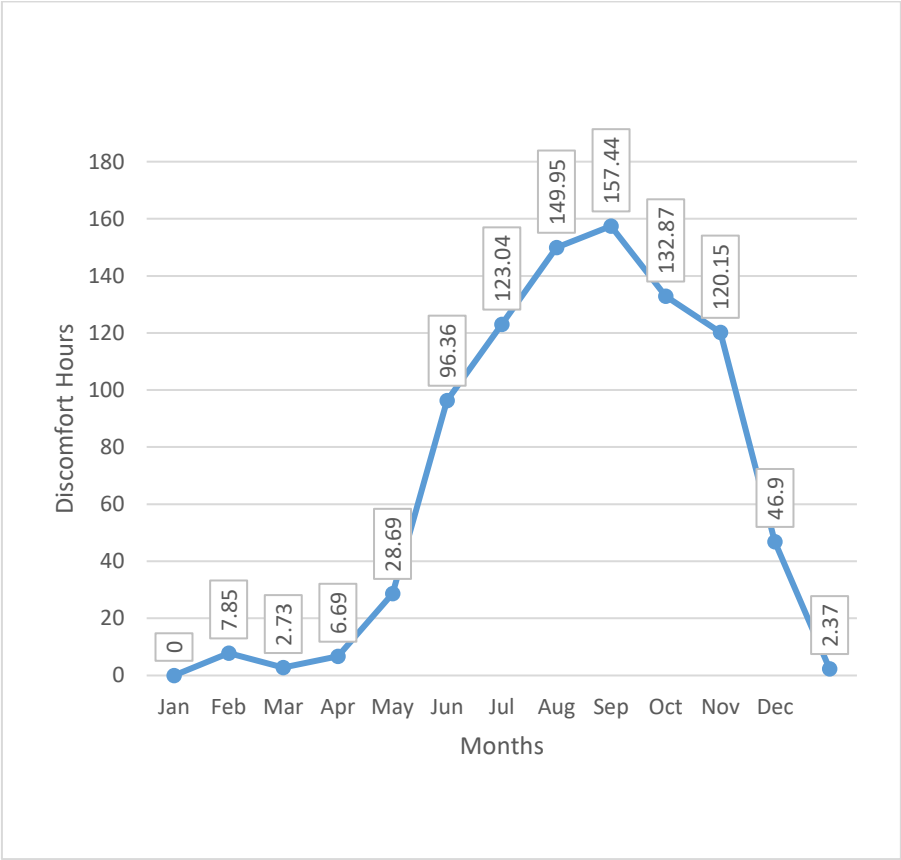


Figure 6: 3rd floor discomfort hours

Figures 1, 2, 3, 4, and 5 all display a behavior that is substantially comparable to one another in terms of the number of hours of pain that are experienced during the course of the year. The summer months are without a doubt responsible for the biggest number of hours of pain, which accounts for around 75 percent of the total hours. This is the case since the summer months are the most painful time of year.

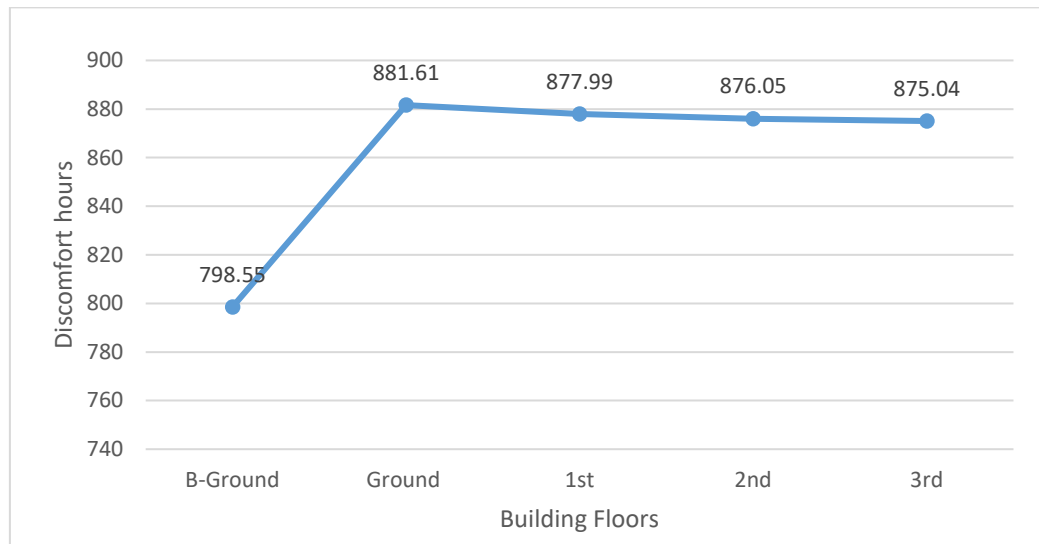


Figure 7: Total yearly Discomfort hours for each floor

The ideal floor is depicted in Figure 6, which unambiguously reveals that the subterranean floor was the most cost-effective option due to the fact that it had the fewest number of pain hours. As a consequence of this, the discomfort hours on the top levels were significantly higher as a consequence of the action of soil, which offers an impact that is equivalent to that of thermal insulation that was not installed on any floor. Taking into consideration the levels above ground, Figure 7 illustrates that the level of thermal comfort increases as one moves up the floors, as evidenced by the data.

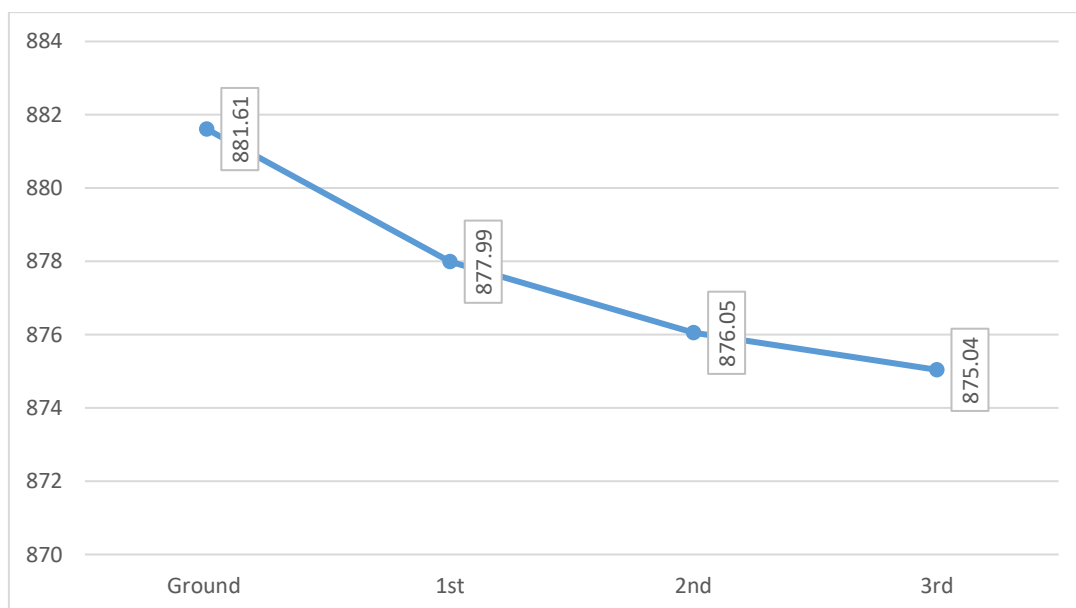


Figure 8: Total Yearly Above ground floors discomfort hours

Conclusion

In conclusion, the findings of our research shed light on the major influence that the placement of the floor has on the degree of thermal comfort that is experienced within high-rise buildings. The findings that are shown in Figure 6 make it plainly evident that the subterranean floor is the most cost-effective solution. This is because, in comparison to the upper levels, the underground floor suffers the least number of pain hours. It is largely due to soil-induced repercussions, which are comparable to the absence of thermal insulation, that this variation in the number of hours that people suffer pain may be attributed to. Figure 7 illustrates a distinct pattern of rising thermal comfort with increasing altitudes above ground level. This is occurring as the previous information is being presented. According to the statistics, there is a progressive increase in thermal comfort metrics across the board as elevation increases. The fact that the temperature is going up is evidence of this.

When it comes to the development of future buildings, the utilization of cutting-edge thermal insulation technologies has to be given significant attention in order to achieve the highest possible degree of thermal comfort across all levels. Reducing the effects of external temperature may be performed by improving thermal insulation, which can effectively ease pain, particularly in higher levels. This is especially true in situations when the temperature is increasing. Through the utilization of these insights and the pursuit of advancements in thermal insulation, it is feasible for architects and engineers to proactively address issues regarding thermal comfort. At the end of the day, this will lead to increased levels of occupant happiness as well as greater building sustainability in vertical urban settings.

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