ANALYSIS OF ENERGY-EFFICIENT RESIDENTIAL BUILDINGS BETWEEN TWO DIFFERENT CLIMATIC ZONES OF INDIA

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1. Abstract

In this research paper, a newly energy-efficient residential building for a single-family between two different regions of India using passive design strategies and sustainable techniques was designed. Here we would create a structure and calculate its energy consumption following the Energy conservation building code (ECBC 2017). We would also check the annual daylighting of the building following ECBC 2017. The main aim of this scientific paper is to design an energy-efficient building that consumes less energy and gives more comfort to the occupants. The building would have better daylighting and improved natural ventilation, which would also emit fewer CO2 emissions as compared to a conventional structure. The building would curtail future energy demands—limiting heat gains during hot climates and heat losses during cold temperatures. By this, our energy-efficient building can also act as a climate-responsive or climate constraint building. We would analyze the U value of the most essential components of the building envelope like exterior walls and roof which are mainly responsible for heat transfer inside the building. Therefore, building structures with good ventilation, lighting, and sound-quality construction material with lower U values can significantly reduce energy consumption.

Keywords- energy consumption, energy efficient, U values, daylighting, quality construction,

2. Introduction

Buildings in India account for 33% of India's electricity consumption. India's sector can grow 7-8 % yearly over the next decade. From 2012 until 2047, the residential building area in India can increase by four times while the non-residential area by 13. (Building energy efficiency project, 2017). The problem statement here arises that everyone needs a home that would be warm in winter and cold in summer with paying minimum bills for the performance and as well as would be energy efficient. India's government plans to build 12 million affordable homes by 2022. (Building energy efficiency, 2021). With the increasing building stock and the intensity of electricity consumption in urban buildings, mainly due to the rapid growth of air conditioning, buildings will soon become the largest electricity consumer in India. Energy consumption in India's new commercial, public, and residential buildings can reduce through energy-efficient and thermally comfortable design and renewable technologies. The Government of India, in December 2018, designed an energy conservation building code ECBC 2017 for all non-residential and residential building sectors. This code is applicable without any additional expertise and time. For an energy-efficient residential building, the building envelope should fulfill the following three minimum requirements: the roof must be well insulated, the walls must be protected, and there should be optimum window design. The energy security scenarios of India identify the building sector as a sector with one of the most enormous energy carbon mitigation potentials. (Building energy efficiency, 2021).

3. Methodology

Buildings are responsible for 40% of energy consumption worldwide and 36% of CO2 emissions, leading to adverse climate change and impacts on global climate. Global buildings sector energy use continues to grow. (Building energy efficiency,2021). The continued population and floor area increase are the principal factors of rising energy demand in buildings. It's also clear that building energy use will increase in the oncoming years if we do not mean our way. The majority of the electricity comes from hydropower plants, generating massive emissions. The buildings and construction sector are critical factors in the fight against climate change. It accounts for 36% of final energy use and 39% of energy process-related emissions as per 2017 statistical data. (United Nations Environment Programme, 2022). Buildings and the construction sector are responsible for significant causes of Air pollution. (EN - dormakaba Blog, 2019).

The share of electricity is growing, but the use of traditional biomass is still substantial in energy economies. The percentage of building energy consumption is increasing day by day. (National Programme Technology of Enhanced Learning, 2022). Hence, all design processes like water management, sewage treatment, waste management, and urban heat island effects (high concentration of hard surfaces, which are impervious). We must use technologies to construct more affordable and durable buildings for the people. The following considerations should be considered for the designing process, ensuring connectivity, indigenous means what has been sustaining for centuries, and design for the future looking at the past. Sustainability is a method for understanding and assessing sustainability and merging projects directed toward socially sustainable outcomes.

6. Results

6.1 Climate of New Delhi and Srinagar

Region one, where the residential building is in New Delhi, the capital territory of India; the coordinates of this location are 28.64°N, 77.22°E. It's 212 m above the mean sea level. The region has a composite type of climate as per the ECBC 2017 council. This type of climate is very tricky to deal with as we encounter three kinds of weather: winter, summer, and monsoon, with a warm, humid climate. The temperature during summer is 32°C- 43°C during the day and 27°C- 32°C during the night. In winter, it is 10°C-25°C during the day and 4°C-10°C at night

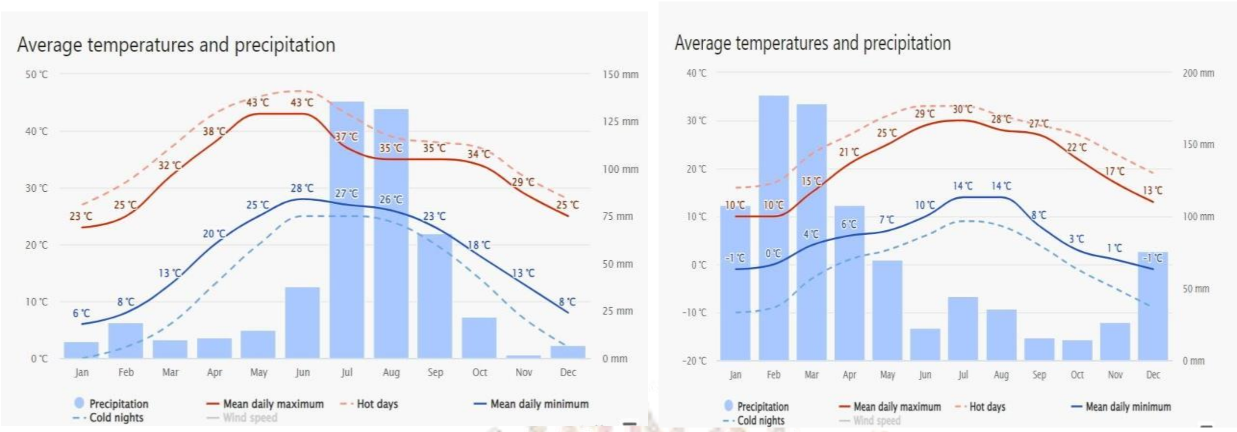

Figure 1- Average Temperature and Precipitation for the New Delhi and Srinagar region
Image source-
https://www.meteoblue.com/en/weather/historyclimate/climatemodelled/newdelhi_india_1261481

Region second is Srinagar, the capital city of Jammu and Kashmir, a union territory of India. It is 1589 m above the mean sea level. The coordinates for this location are 34.09° N, 74.81°E. Srinagar has a cold type of climate as per the ECBC 2017 council. For this type of climate main concern or emphasis is laid on having a sound heating system inside the building. There is typically a lower temperature in this region. In summer, it is 17°C-24°C to 20°C-30°C during the day, while during the night, it is 4°C-11°C to 17°C-21°C.

6.2 Psychrometric chart with designed strategies for New Delhi

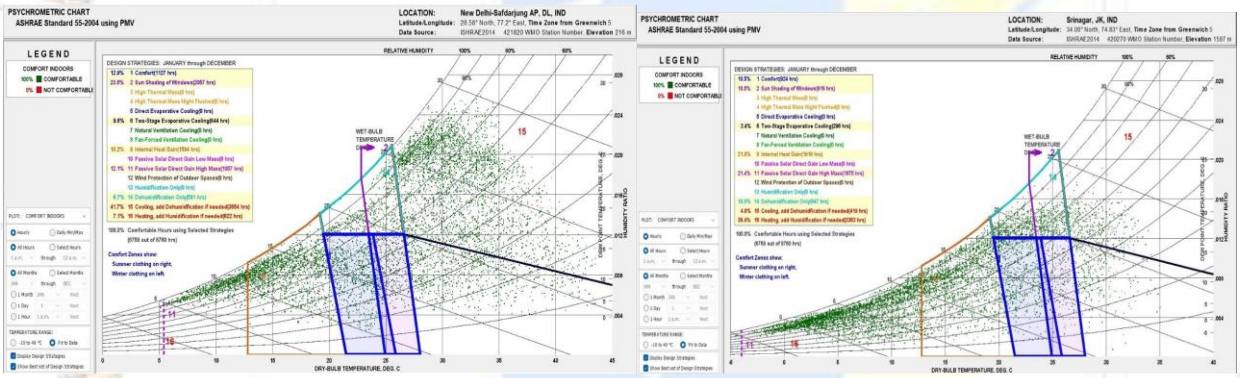

Figure 2- Psychrometric chart with passive design strategies for New Delhi and Srinagar region retrieved from climate consultant software 6.0

The Psychrometric chart of New Delhi with the best design strategies suggested having sun shading of windows with 23.5%. Internal heat gains of 18.2%. Passive solar direct payment high mass of 12.1% that has better thermal insulation for exterior walls, and rooftop of the building, cooling, and dehumidification of 41.7%, is required, which states that air conditioning would be necessary. Still, its use can be to minimize overheating inside the building. Cooling and dehumidifying for the New Delhi region contribute to almost 40 to 50% of the total comfort hours indoors.

The psychrometric chart analysis with choosing the best design strategies for the Srinagar region was to have 10.5% sun shading of windows. Internal heat gains of 21.9%, and Passive solar direct profits of high mass of 21.4%. Heating with little humidification of 38.4%. Hence, we can see that Heating contributes almost 40% of total comfort hours. It implies that providing windows with tight insulation and exterior walls with thick insulation to avoid heat losses during winters.

The cooling only contributes to 4.8% of total comfort hours, using different passive design strategies. This way, we can make our building energy-efficient and reduce the cooling cost inside the building. We would work more on having a better heating facility as we can see this region needs more comfortable hours of Heating rather than cooling. Keep the building small (right sized) because excessive floor area wastes Heating and cooling.

6.3 Building Envelope U values

The U value of all building components used in the proposed and baseline building for both regions would be as below

1. U value of Exterior walls for the baseline building

Figure 3- U value for the Exterior walls in the baseline building retrieved from Design Builder V7.1

1.1 U value of Exterior walls for proposed building

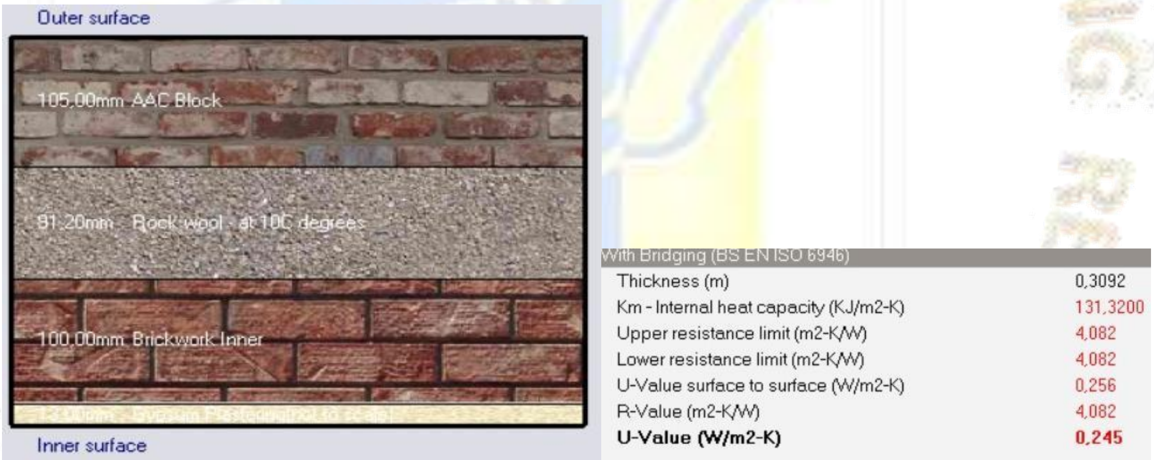

Figure 4 - U value for the Exterior walls in the proposed building retrieved from Design Builder V7.1

2. U value of Roof for baseline building in New Delhi

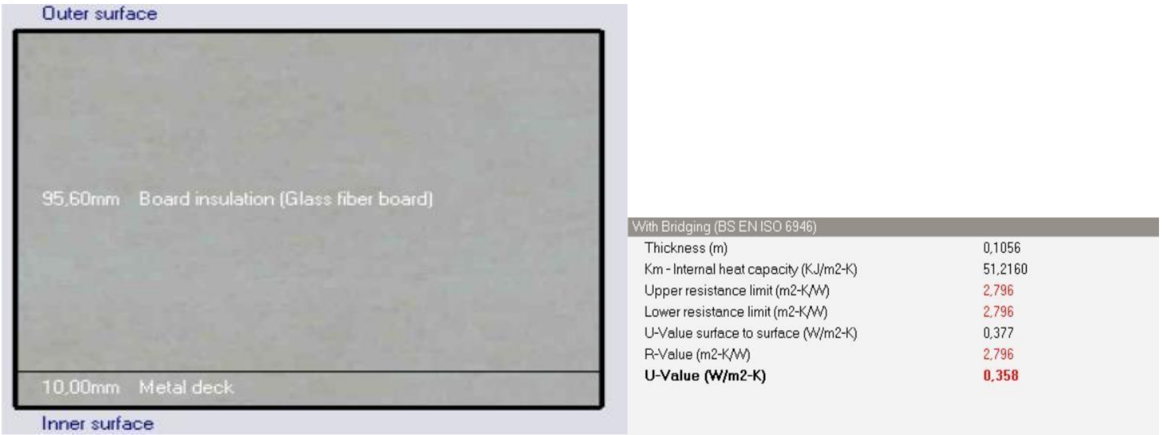

Figure 5- U value for the Roof in the baseline building retrieved from Design Builder V7.1

2.1 U value of Roof for proposed building in New Delhi

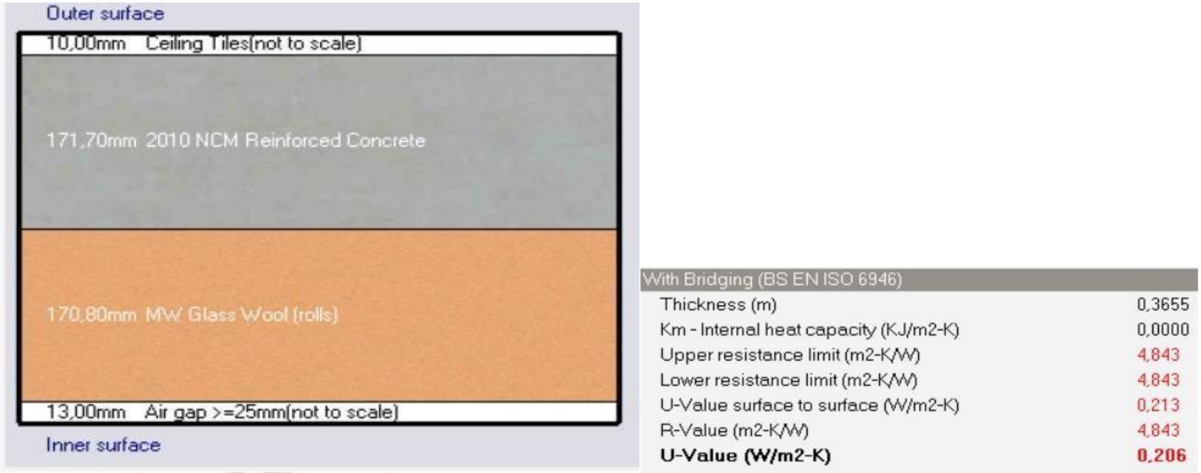

Figure 6 - U value for the roof in the proposed building retrieved from Design Builder V7.1

3. U value of Roof for baseline building in Srinagar

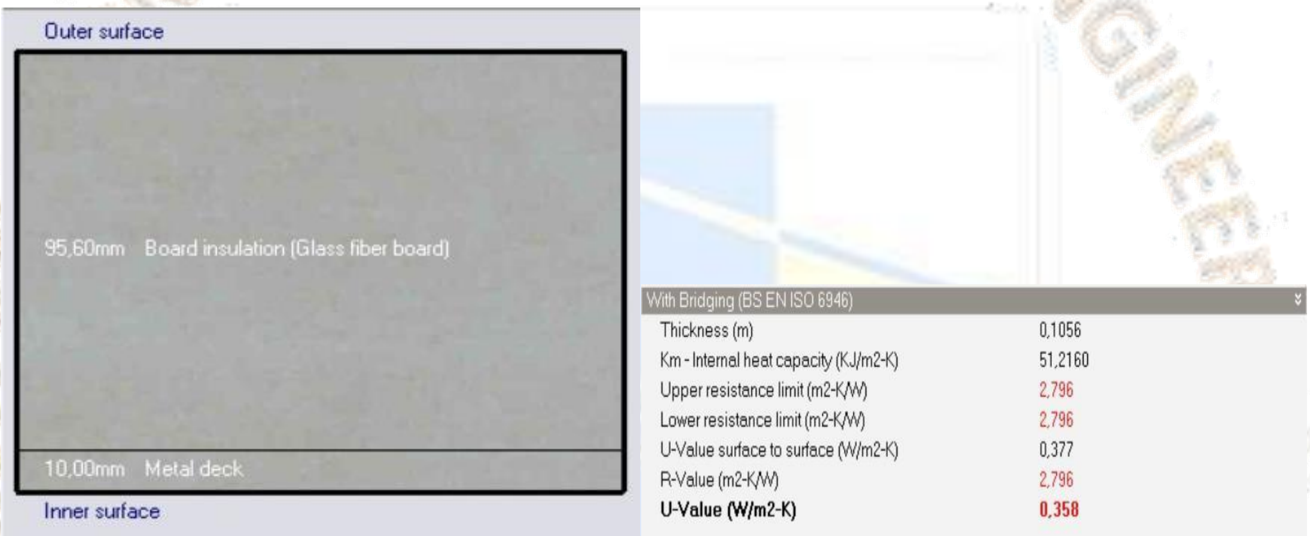

Figure 7- U value for the roof in the baseline building retrieved from Design Builder V7.1

3.1 U value of Roof for proposed building in Srinagar

Figure 8- U value for the roof in the proposed building retrieved from Design Builder V7.1

6.4. Energy consumption between the Baseline and a Proposed building for New Delhi and Srinagar

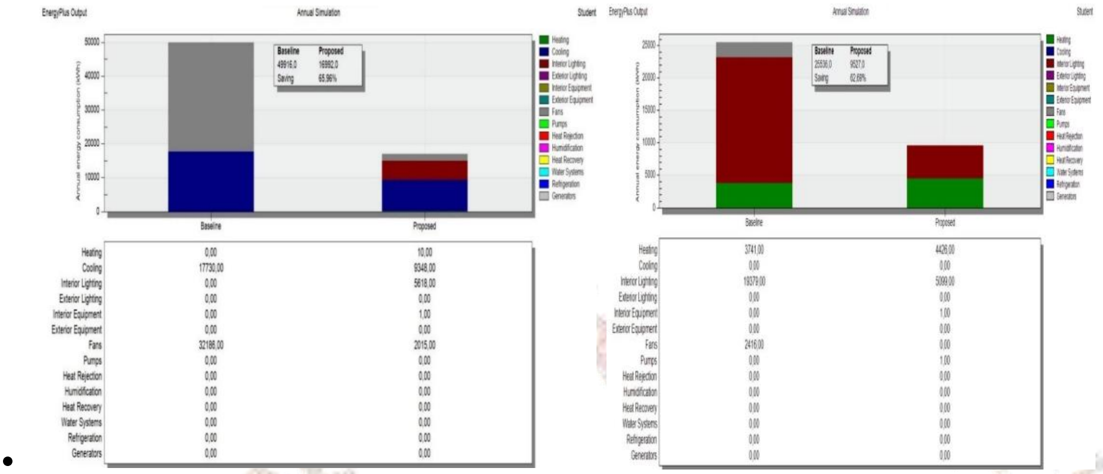

Figure 9- Annual Energy consumption for baseline and a proposed building for New Delhi and Srinagar retrieved from Design Builder v7.1

6.4.1 Illuminance levels

Sunny clear day in the month of June for the baseline and proposed building in New Delhi

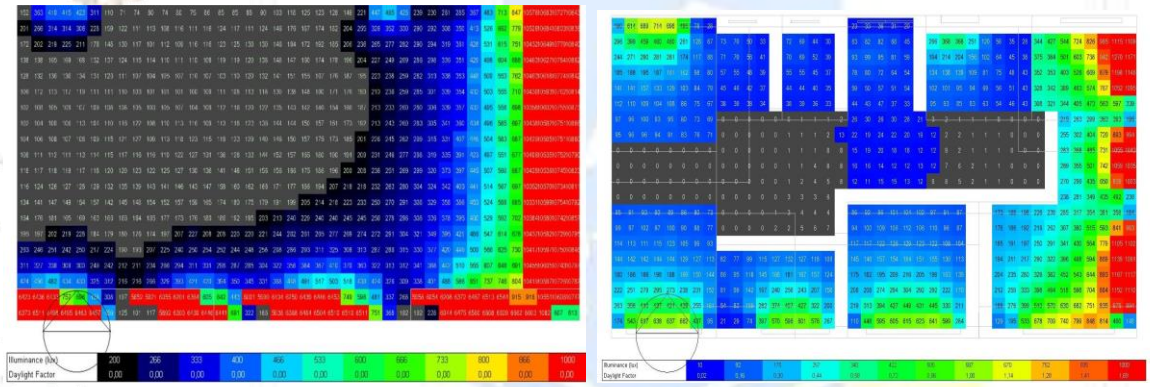

Figure 10- Daylighting illuminance for sunny clear day in baseline and proposed building ground floor retrieved from Design Builder v7.1

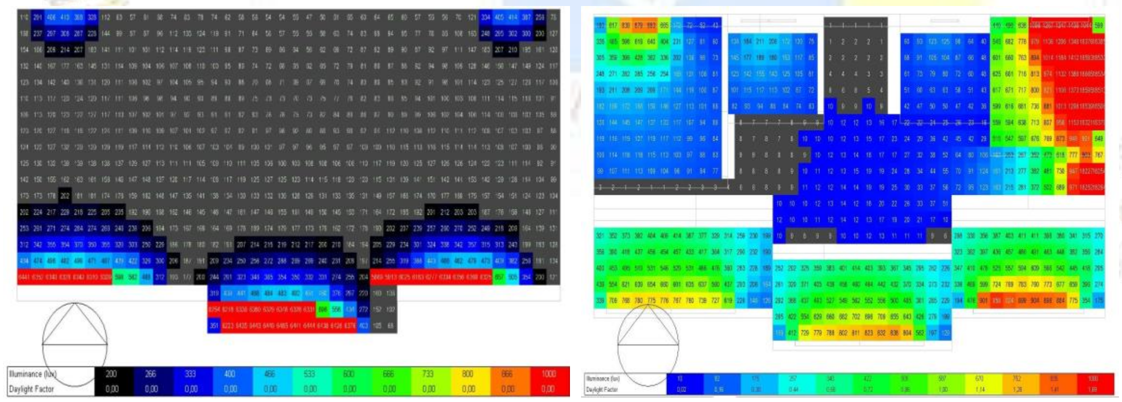

Figure 11- Daylighting illuminance for sunny clear day in baseline and proposed building first floor retrieved from Design Builder v7.1

6.4.2 Illuminance levels

Sunny clear day in the month of June for the baseline and proposed building in Srinagar

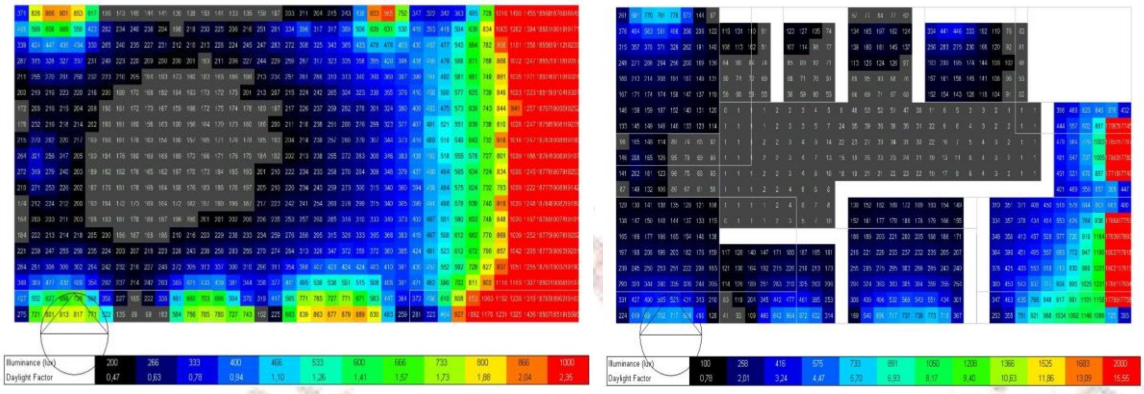

Figure 12- Daylighting illuminance for sunny clear day in baseline and proposed building ground floor retrieved from Design Builder v7.1

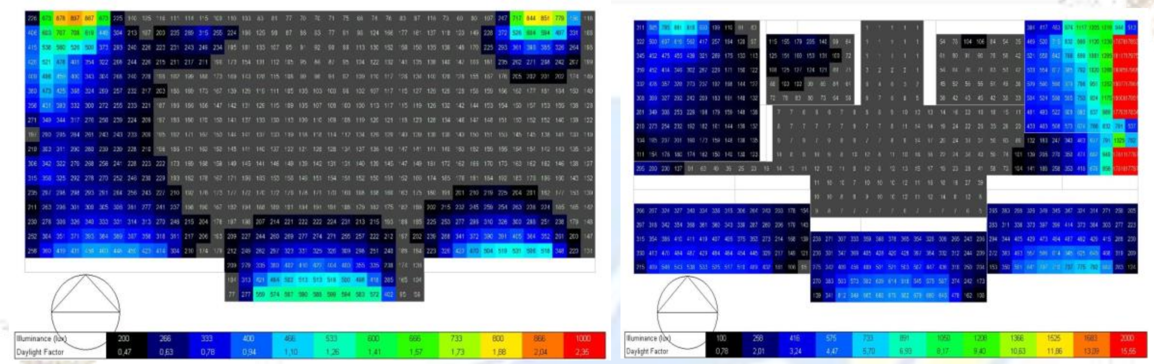

Figure 13- Daylighting illuminance for sunny clear day in baseline and proposed building first floor retrieved from Design Builder v7.1

7. Discussion

The above results show how a residential building is analyzed based on different parameters. We design sustainable buildings adopting all the passive design strategies. Like without using these tools, constructing the building may lead to more energy consumption and lot of CO2 emissions leading to global warming problems worldwide. The further limitation of this research paper would be to have a more detailed analysis of materials used in the proposed building with some other software programs like WUFI which is mostly used for moisture simulations to check for possible solutions for interstitial condensation occurring in roof materials for both regions. Therefore, we can say it is better to spend more costs in the beginning construction process of the house. In the longer run, we do not have to face the problems of more energy bills, which are ultimately hotter in summers and colder in the winters inside the constructed building. The analysis carried out in this research project was all research-based, though it may again require further research and a more scientific approach in a detailed manner.

8. Conclusion

In this research paper, we could design an energy-efficient building whose annual energy consumption came out in the desired range suggested by ECBC for both regions. We also got a desired and balanced daylighting potential in the building. However, we cannot rely entirely on all the results discussed in this research paper. Here the main aim was to give knowledge and an idea to the people on how an energy-efficient building can be designed from the initial phase of construction project. As we are not an expert, We might again need further research to analyze all the results by sustainable green consultant engineers or architects, which can include optimizing the energy of the building in the future terms.

This research paper can conclude that having a green sustainable residential building in the future can provide better comfort to occupants in terms of energy, water, and indoor environmental quality. Through this paper, we could design a residential building located in different regions of India having the same building type, which has better comfort, a well-insulated roof, and an improved daylighting. We adopted these techniques using a different sustainable scientific approach and other green building methods. Though there can be a further deduction of research for this paper as all the results and implementations were based purely on research methodology studies carried out in the past and with the different building physics approaches applied worldwide.

9. References

- Atkinson, R., & Jacobs, K. (Eds.). (2020). What Do We Know and What Should We Do About Housing? *SAGE Publications Ltd.* https://doi.org/10.4135/9781529712889

- BEEP. (2021, December 21). Eco Niwas Samhita – ECBC 2017, *Energy conservation building code 2017*- BEEP. https://www.beepindia.org/eco-niwassamhita/

- Design Builder 7.1. (n.d.). Design Builder Version 7.1. https://designbuilder.co.uk/download

- Dr.A.J. Marsh. (2021, April 26). PD: Psychrometric Chart. https://drajmarsh.bitbucket.io/psychro-chart2d.html

- Dronacharya.info. (2022, April 24). Dronacharya Group of Institutions in Greater Noida/Delhi-NCR (Official Website), https://gnindia.dronacharya.info/events/Workshop_Green_Buildings_2015.aspx

- EN - dormakaba Blog. (2019). Gaining Green Stars: *Benefits of Green Building Certifications*. https://blog.dormakaba.com/gaining-green-stars-benefits-of-green-building-certifications/

- Energy Plus. (2022, March 30). https://energyplus.net/

- Giovani Psychometric chart. (2020). Weather data from a station located in New Delhi.

- Green Home Guide | *Supporting LEED homes*. (2022, April 10). https://greenhomeguide.com/

- Jeong, S.-G., Lee, T., & Lee, J. (2021). Evaluation of Energy Performance and Thermal Comfort Considering the Heat Storage Capacity and Thermal Conductivity of Bio composite Phase Change Materials. Processes, *9(12),* 2191. https://doi.org/10.3390/pr9122191

- Khee Poh Lam, Nyuk Hien Wong, & Sekhar Chandra. The use of multiple building performance simulation tool – A case study in Singapore.

- Mahdavi, A., & Martens, B. (2013). Contributions to building physics: Proceedings of the 2nd Central European Symposium on Building Physics, 9-11 September 2013, Vienna, Austria. *Vienna University of Technology Department of Building Physics and Building Ecology*.
- Maps. (n.d.). 2D View. https://www.google.com/maps
- Mellado Mascaraque, M. Á., Castilla Pascual, F. J., Pérez Andreu, V., & Gosalbo Guenot, G. A. (2021). Evaluation of the Thermal Comfort and Energy Demand in a Building with Rammed Earth Walls in Spain: Influence of the Use of In Situ Measured Thermal Conductivity and Estimated Values. Buildings, *11(12)*, 635. https://doi.org/10.3390/buildings11120635
- Srinagar climate: Average Temperature, weather by month, Srinagar weather averages - Climate-Data.org. (2022, January 11). https://en.climate-data.org/asia/india/jammu-and-kashmir/srinagar-3424/
- Statista. (2022, February 28). India - *cost of state electricity supply 2019* | Statista. https://www.statista.com/statistics/808201/india-cost-of-state-electricity-supply/