Journal of Advanced College of Engineering and Management

Energy Performance Evaluation of Domestic Airport Departure Hall Tia, Kathmandu

Ritu Shrestha*[1], Sanjeev Maharjan[2]

[1,2]Department of Mechanical and Aerospace Engineering, Pulchowk Campus, T.U.

*Email: ritushresthaa30@gmail.com

Abstract

This research focuses on the energy performance of the building envelope of an Airport Terminal Building in Kathmandu, Nepal. This study explores how to improve thermal comfort Energy analysis through a quantitative analysis of the effect of thermal characteristics of the building envelope. Development of base model Revit and duplicated in Autodesk Insight. This study is about the operational electricity consumption, Peak Heating/cooling load and Energy use intensity of the building at domestic departure hall at Tribhuvan International Airport, Building envelops systems pose a great scope to reduce the energy consumption and consequently improve building efficiency. This research is concern with reduction of operational electricity consumption on Heating and cooling system Most part of the energy consumption is occupied by HVAC system and this consumption needs to be optimized to reduce whole energy consumption of the buildings.

Keywords: *Building energy analysis, TIA, Airport terminal building, Heating load, Cooling load*

1 Background

Tribhuvan International Airport (TIA), located at Gauchar-Kathmandu, established in 1949 A.D, is situated 5.56 km east of the central Kathmandu. The TIA has an operational land area of about 2,320,000m^2 and total built up area is about 31,000 m^2 including International Terminal Building (ITB), Domestic Terminal Building (DTB), Operations and Airlines building, Cargo, VVIP, and other associated buildings. The single 3.2 Km long airport runway caters to both international and domestic flights and, along with taxiway, covers about 230,000m^2 of land. The Apron area covers about 7,000 m^2 of international terminal and about 5,000 m^2 of domestic terminal. The capacity of international terminal apron is 11 medium and wide body category aircrafts and that of domestic terminal apron being 17 small aircraft and 13 Helicopters. The TIA services also include air traffic control services (aerodrome control, approach control and area control), aeronautical communication service and aeronautical Information services. TIA received International Civil Aviation Organization (ICAO) compliance. Every year millions of passengers travel through Tribhuvan international airport come from a variety of climate fears. As long as passengers are waiting at the airport, it is necessary to create a comfortable atmosphere. To provide comfortable interior spaces and precise air control of multiple zones, these buildings need a strong air conditioning system and should be able to ensure a high comfort throughout the year. An air conditioner is required in airport to maintain the passengers comfort zone as well as to prevent the overheating of various machines and equipment connected to the airport.

It should be maintained smooth operation of air condition system at multiple zones of the airport to keep comfortable temperature and humidity to the passengers. Most part of the energy consumption is occupied by HVAC system and it needs to be optimized to reduce whole energy consumption of the buildings. Electricity consumption in airport can be improved by optimizing HVAC system. Passengers are coming and going throughout the operation hour. Since there are passengers coming and going, all the doors should be kept open during the operation hour. There is a runway on the north side of this building and a ticket counter on the south side. The ticket counter is not air conditioned.

2 Research Methodology

This research focuses on the energy performance of the domestic airport departure hall in Kathmandu, Nepal. It explores how to improve thermal comfort through quantitative analysis of the effect of thermal characteristics of the departure hall. The base model will develop in Revit and building annual energy simulations modeling. The study summarizes the potential energy saving of air infiltration rate to the buildings. This study will define annual saving of building electricity from the simulation results which turn helps to improve thermal comfort. The overall process flow of energy analysis includes the following activities: initial contact, start-up meeting, data collection, field work, analysis, report and final meeting. The current work aims is to analysis phase by providing a comprehensive process for building energy modelling, energy performance assessment, identification of energy losses area and technically feasible energy efficiency measures to reduce the energy use intensity. A flowchart of the methodology is shown in Figure. The methodology that is following during the project is shown in the flowchart below.

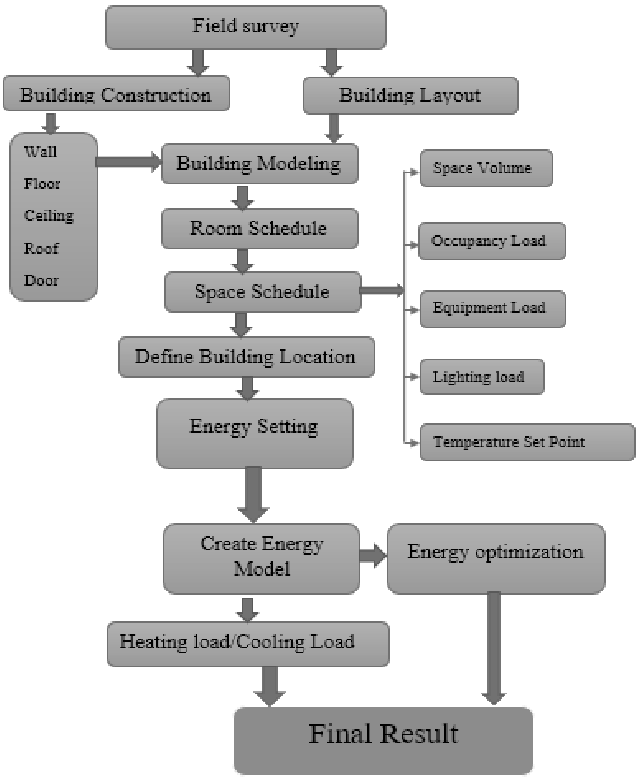

Figure 1: Building Energy Simulation Flowchart

Building layout

Domestic airport terminal building layout provided by TIACAO.

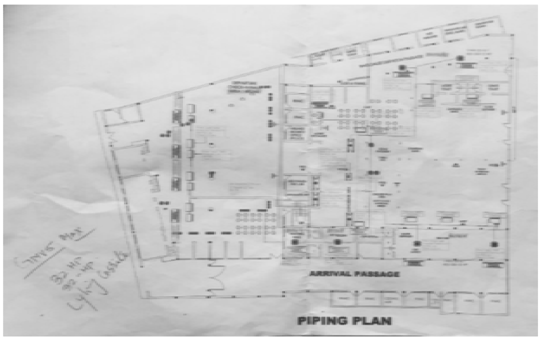

Figure 2 : Domestic airport departure hall piping plan and Ducting HVAC plan

Building modeling

This 3D Building model of TIA domestic departure hall build in Revit Autodesk platform. It includes 2 compartments. One is security check-in area and another is passenger waiting hall. It has 12" wall made with brick and cement mortar, corrugated galvanized iron (CGI) sheet with gypsum false celling and partial slab casting roof, Plane cement Concrete (PCC) flooring with ceramics marble tile, metal frame with single transparent glass windows and doors. After collecting of primary and secondary data of the building infrastructure the building modeling id done in Autodesk Revit platform. TIA Domestic Departure Hall Building Model built in Revit Autodesk.

Figure 3:North face of the Domestic airport terminal Building

Room scheduling

After completion of building modeling in Revit Autodesk room scheduling was done. Airport Terminal Building have multiple building (space) types, such as Security check-in area, café, Airlines shop, breast feeding room, VIP waiting room, smoking zone, toilet, restroom and other support areas. Airport terminal building have energy consumption patterns complicated due to the complexity of space types and operational characteristics. Although the reports did not provide any clear patterns of energy consumption, we can conclude that EUI The differences are due to factors such as Building geometry, characteristics of building (space). Types, operations, and different business models Each Airport terminal building. In addition, the structure of Building (space) type Airport terminal building should be analyzed to define characteristics. Airport terminal building includes different categories as define below.

Name	Area m^2	Volume m^3
Security check in area	543	4189.88
Passenger waiting hall	1276	5991.52

Café	34	154.85
Airlines Shop	30	133.55
Breast feeding room	30	137.06
VIP room	64	286.94
Smoking Zone	14	54.84
Toilet 1	44	199.7
Toilet 2	23	114.2

Table 1:Room Schedule TIA Domestic Terminal building

Building location

For the weather data and temperature profile of the building location setting is important. This airport terminal building is located in north side of Kathmandu.

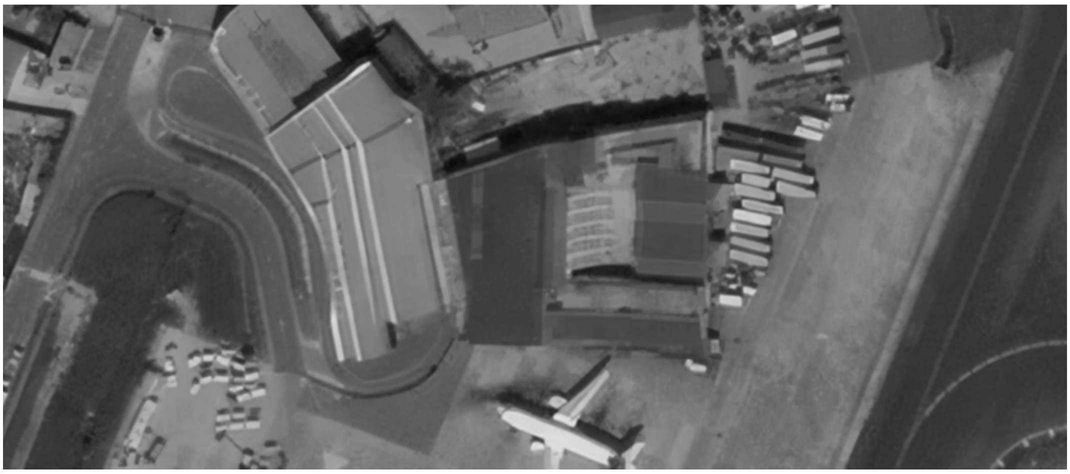

Figure 4:TIA domestic terminal building in google map

2.1.1 Airport location and profile

TIA situated 5.56 km east of Kathmandu city is in the heart of Kathmandu Valley. TIA is at the confluence of three ancient cities namely Kathmandu, Bhaktapur and Lalitpur, vibrantly rich in art and culture, with breathtaking temples and pagodas, inhabited by smiling men and women, the pride of the nation. TIA has flourished not only as the main hub for ever expanding business interests of Nepal but also has opened up windows to various domestic and international destinations and airlines.

Profile

Coordination	274150N-0852128E
Elevation	4390 ft. AMSL (Average Mean Sea Level)

2.1.2 Monthly temperature record and weather profile

Maximum temperature of Kathmandu is recorded 33˚c in summer season and the minimum temperature of Kathmandu is recorded 2˚c in winter season. This temperature profile is records of the Kathmandu weather station. Monthly temperature variation of the Kathmandu is illustrated in figure

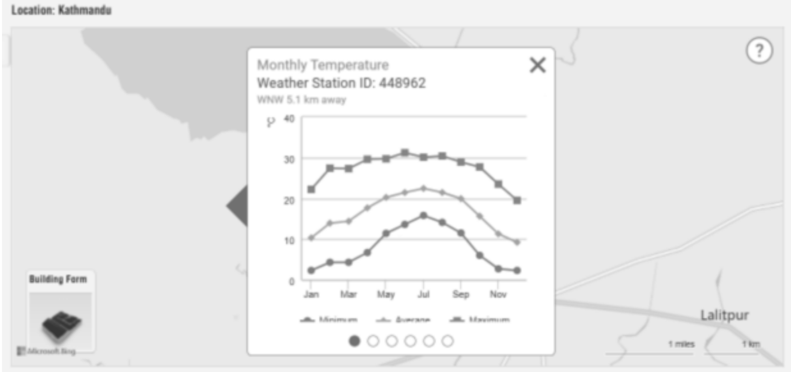

Figure 5:Temperature variation of Kathmandu recorded by Kathmandu weather station

Maximum temperature in summer	34˚c
Minimum temperature in winter	2.3˚c

2.1.3 Energy model

Based on the input provided by Revit Like location, weather data, and thermal properties, the energy model is generated as base color codes for various components in order to be simulated by Insight.

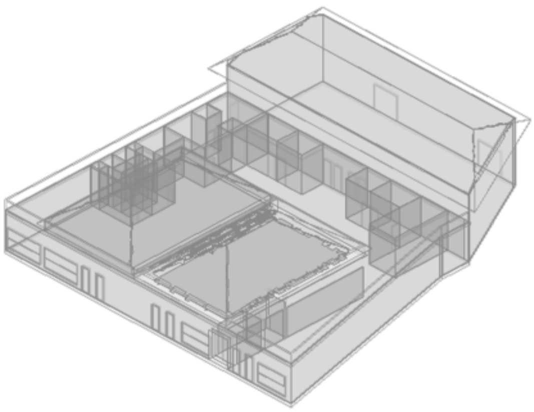

Figure 6:Building energy model build in REVIT Autodesk

This is an energy model created on Revit Autodesk after energy setting completion. Energy setting includes the site location, building construction material, building orientation and the analytical materials. It is a building energy model ready for the energy analyses.

Human comfort zone

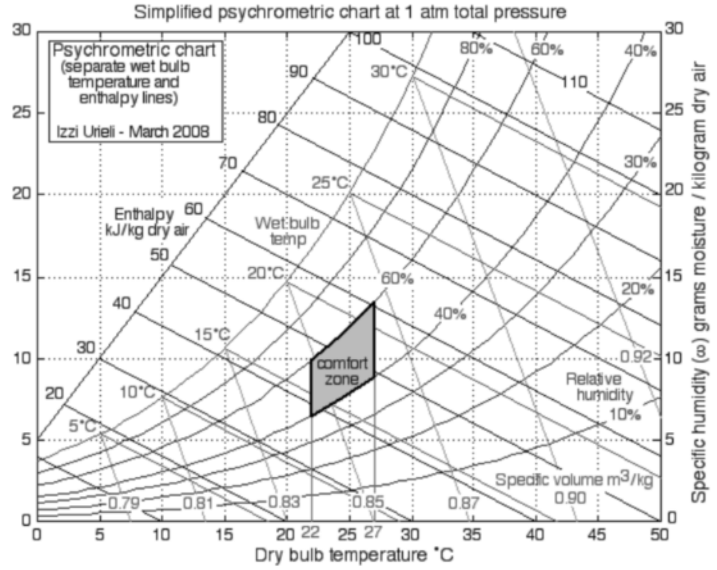

Figure 7:psychometric chart defines the comfortable zone

The boundaries for different passive and active designs will be determined using bioclimatic techniques chart. From the simplified psychrometric chart at 1 atm total pressure human Comfort zone is between temperature is 22˚C to 27˚C and Relative humidity is 40% to 60%. It reveals That passive measures such as thermal mass effect and can be an effective way to provide air movement Comfortable area inside. In humid climates, Air circulation seems more important. Summer Heat requires active cooling. during winter, can be beneficial due to passive solar heating Available solar radiation.

3 Result and Analysis

Heating and cooling load

From the simulation results, it can be seen that the building consumes approx. 398kWh/$\boldsymbol{m^2/yr}$. In this study building energy simulation of TIA domestic departure hall has been taken. According to the simulation result of Autodesk REVIT and INSIGHT 360 building heating peak load is less than building cooling peak load. Due to the transportation building, there is a lot of passenger movement, so the cooling peak load is high. From this study, the role of roof construction, windows glass and infiltration rate has been studied to minimize energy consumption and building energy use intensity. According to the Figure 8,9,10 mentioned above, when the infiltration rate reaches 0.7 ACH from 2 ACH, The EUI decreases from 398 to 370 KWH/m^2/yr. when R60 insulation placed in Uninsulated roof construction, the EUI decreases from 398 to 370 kWh/m^2/yr. similarly, when keeping double low-E glazing than when keeping single clear glass, building EUI decreases from 398 to 394 kWh/m^2/yr. there is a huge energy reduction potential of infiltration rate. Total peak cooling load of the terminal building is 259732W and the total heating load of the terminal building is 39802W.

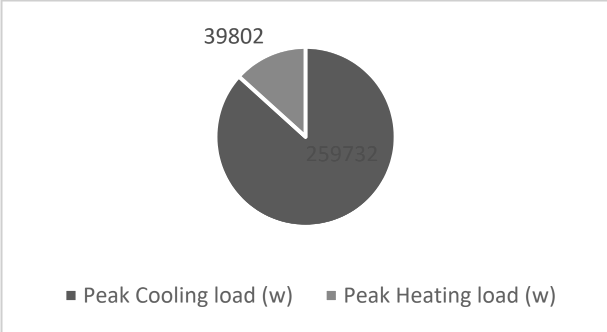

Figure 8: Peak Cooling and Heating Load of Departure Hall, TIA

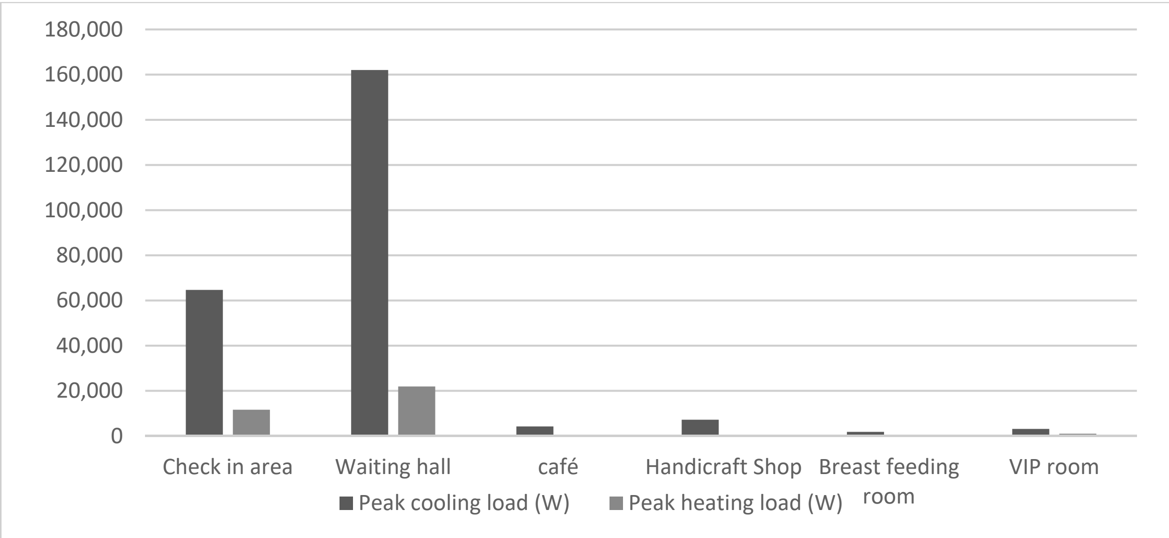

Figure 9: Peak heating and cooling load of different area of the building

Area of Energy Saving Through Infiltration

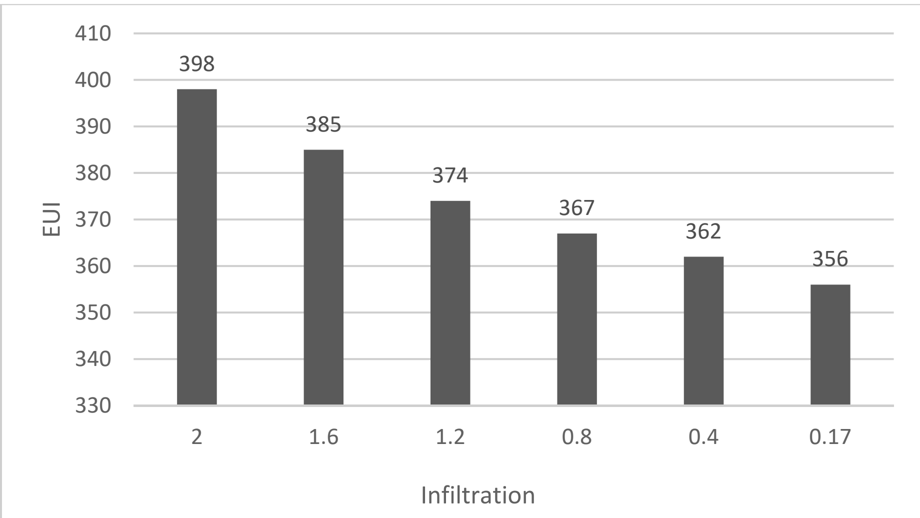

Figure 10:Area of energy saving through infiltration rate

Infiltration (ACH) is Air Change per hour. Hourly ventilation rate divided by the building volume. All doors and window kept closed during the analysis. Infiltration is greatly affecting the energy consumption of the building. According to the chart mentioned above, when the infiltration rate reaches 0.7 ACH from 2 ACH, The EUI decreases from 398 to 370 KWH/m2/yr.

Amount of Energy Saving Through Roof construction

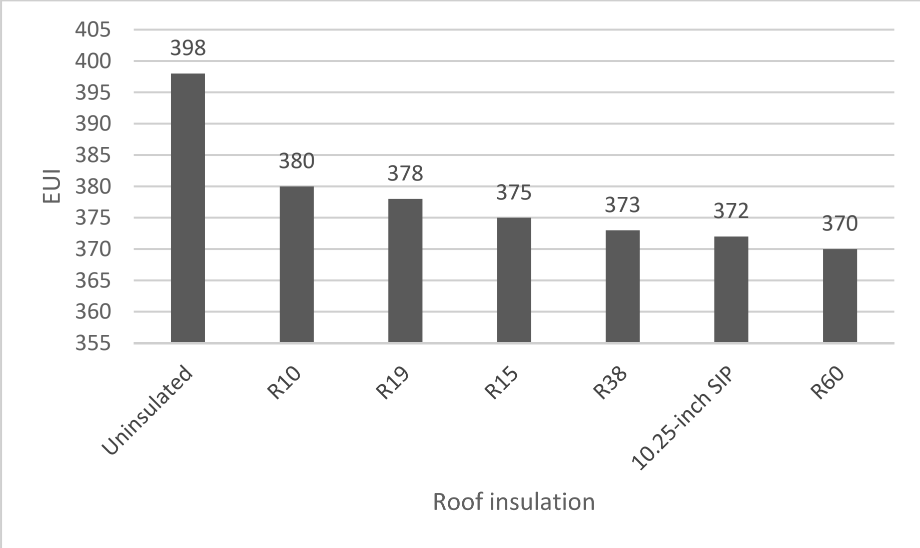

Figure 11:Amount of energy saving through roof construction

Roof is constructed by corrugated galvanized iron CGI sheet with gypsum false celling and partial slab casting. Roof construction has great potential to reduce energy load. When R60 insulation placed in Uninsulated roof construction, The EUI decreases from 398 to 370 KWH/m2/yr.

Area of Energy Saving Through Window glass

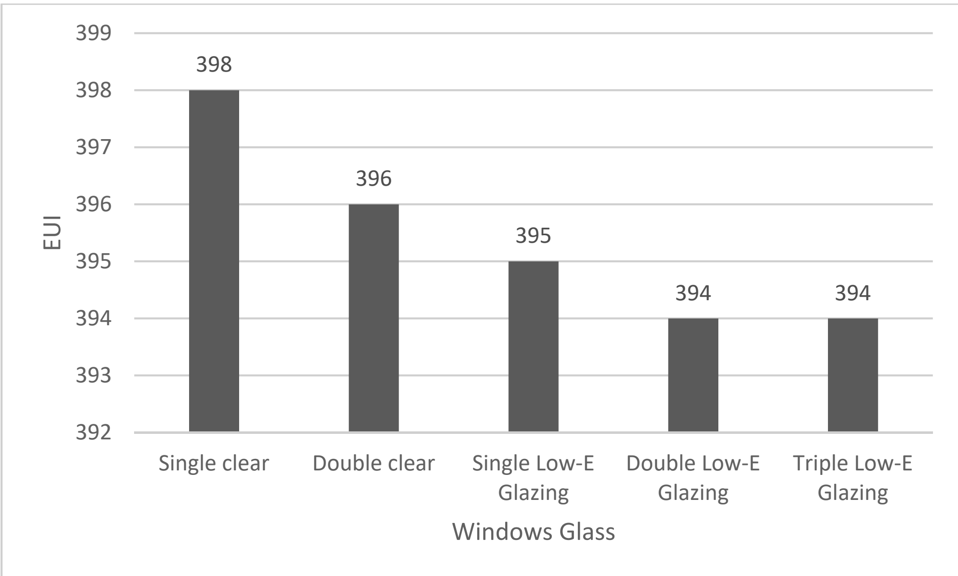

Figure 12:Amount of energy saving through window glass types

In this building model windows glass material has slightly less energy saving potential. In case of single clear glass, it will add 9.27 kWh/m^2/yr more energy on building energy intensity. In case of triple

Low-E Glazing it will reduce 0.87 kWh/m^2/yr energy on building energy intensity. Using Triple-E glazing than when keeping single clear glass, building EUI decreases to 394 kWh/m^2/yr from 398 kWh/m^2/yr.

4 Conclusions and recommendations

Conclusion

Based on studies and analysis, there are many factors that contribute to energy consumption in a building.

These energy consumption factors can be reduced by using appropriate technology to design the building envelope, which plays an important role in energy consumption in the building. From the simulation results it is concluded that proper use of Roof and infiltration rate helps in reducing energy consumption where windows glass has shown low energy benefit.

The analysis carried out during the study highlights the importance of reducing heat gain from the building envelope and improving thermal comfort levels and energy efficiency in Airport Terminal Buildings in Kathmandu, Nepal.

The nature of the building envelope determines the amount of energy required for heating and cooling the building and therefore needs to be optimized to keep heating and cooling loads to a minimum, which is a key factor to consider when designing a building.

Recommendation

Roof construction and infiltration rate carry huge potential of energy consumption on Transportation building. At a broader policy level, uniform codes need to be developed to be incorporated into the Building Code and the National Building Code. It is essential that new Terminal building stock in Nepal adhere to minimum standards of thermal comfort and energy efficiency.

References

1. Alba, S. O., & Manana, M. (2016). Energy research in airports: A review. *Energies*, *9*(5), 1–19. https://doi.org/10.3390/en9050349
2. Corrado, V., Ballarini, I., Paduos, S., & Tulipano, L. (2017). A new procedure of energy audit and cost analysis for the transformation of a school into a nearly zero-energy building. *Energy Procedia*, *140*, 325–338. https://doi.org/10.1016/j.egypro.2017.11.146
3. GIZ. (2015). *Integrated Company Report*. 68. https://www.giz.de/en/downloads/giz2015-en-Integrated-Company-Report.pdf
4. *Investigation of the Impact of Building Entrance Air Curtain on Whole Building Energy Use Short Summary Investigation of the Impact of Building Entrance Air Curtain on Whole Building Energy Use Executive Summary BACKGROUND*. (n.d.).
5. Liu, C., Zhao, T., Zhang, J., Chen, T., Li, X., Xu, M., & Yang, X. (2015a). Operational Electricity Consumption Analyze of VRF Air Conditioning Sys-tem and Centralized Air Conditioning System Based on Building Energy Monitoring and Management System. *Procedia Engineering*, *121*, 1856–1863. https://doi.org/10.1016/j.proeng.2015.09.167
6. Liu, C., Zhao, T., Zhang, J., Chen, T., Li, X., Xu, M., & Yang, X. (2015b). Operational Electricity Consumption Analyze of VRF Air Conditioning Sys-tem and Centralized Air Conditioning System Based on Building Energy Monitoring and Management System.

Procedia Engineering, *121*, 1856–1863. https://doi.org/10.1016/j.proeng.2015.09.167

7. Mellek, Y., & Kaya, A. (2020). *Elsevier Enhanced Reader.pdf*.
8. Pyakurel, S., Prasad, R., & Karki, M. (2021). *A Case Study of Pokhara Industrial Estate to Estimate Cost of EENS and Perform Reliability Worth Analysis*. *8914*, 88–96.
9. Qian, M., Yan, D., Liu, H., Berardi, U., & Liu, Y. (2020). Power consumption and energy efficiency of VRF system based on large scale monitoring virtual sensors. *Building Simulation*, *13*(5), 1145–1156. https://doi.org/10.1007/s12273-020-0670-x
10. Tang, Y., Tao, Q., & Zheng, J. (2022). Performance analysis of air curtains on indoor environment and dehumidification energy consumption in a low humidity plant. *Journal of Asian Architecture and Building Engineering*, 1–16. https://doi.org/10.1080/13467581.2022.2097240
11. TIA_EA Draft Report_15April2014.
12. Uprety, P., Uprety, S., & Shrestha, B. (2021). Energy Performance Evaluation of Rammed Earth Construction. *Proceedings of 10th IOE Graduate Conference*, *8914*, 440–445.
13. (2010). Airport Energy Efficiency and Cost Reduction. In *Airport Energy Efficiency and Cost Reduction*. https://doi.org/10.17226/14413