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The Effect of Building Direction and Natural Airing on Yearly Power Utilization

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ABSTRACT

With increasing global warming, the temperature of the atmosphere is also increasing. Given such climate conditions, it becomes compelling to limit the use of artificial energy sources and find ways to help us control the temperature of a place. This paper deals with reducing the energy consumption of a building without affecting its required temperature by combining different building orientations using an information system. It gives a clear picture of the best-suited situation for a particular place. We have used the design software and incorporated factors such as the orientation of the building. It will provide us with the required amount of artificial energy, taking the ideal temperature of the building into account. It will also tell us the difference this setup can make in the long-term cost of the building. If these parameters are taken into consideration before building design, better returns in terms of energy savings and long-term financial benefits can be achieved.

KEYWORDS: *Buildings orientation; passive techniques; Active techniques; Energy consumption*

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I. INTRODUCTION

Nowadays, given high electricity bills, the annual or monthly power consumption of any building is a big deal. Generally, the building's electricity is consumed to experience thermal comfort. In large cities and subway pollution with high population, the number of vehicles, factories, and industry increase the temperature of the local outdoor environment, resulting in thermal discomfort. According to ASHRAE 55-2015, the human thermal comfort temperature should be between 19.44°C and 27.77°C. It is, therefore, advisable to somehow reduce the temperature inside the building to thermal temperature. Human thermal comfort is nothing but a state of mind, which manifests satisfaction with the thermal environment. Given that it affects human productivity and health, keeping this level of thermal comfort for the thermal satisfaction of building occupants. The combination of high temperature and high relative humidity reduces thermal comfort and indoor air quality. By using natural ventilation, thermal comfort temperature can be maintained. Natural ventilation is the process of supplying and removing air from an indoor space without using mechanical systems. Well-designed and naturally ventilated buildings control indoor conditions to the extent that opening windows and using fans in the summer, and wearing extra clothes in the winter, can keep people at a comfortable temperature. This project will help us increase human thermal comfort, which will eventually lead to higher human efficiency and productivity. It will reduce energy consumption and coastal electricity consumption.

A. Building Energy Modeling

Building Energy Modeling is the use of physics-based application software to predict the energy consumption of a building. Whole Building Energy Modeling is versatile and used in a new building design, code compliance, green certification, utility incentive eligibility, and real-time building control. BEMs are also used in large-scale analyzes to develop building energy efficiency codes and inform policy decisions. Energy simulation of Building then uses physics-based equations to calculate the thermal load, the system's response to that load, and the resulting energy consumption, along with associated metrics, such as thermal comfort of occupants and energy costs. The energy simulation of a building consists of maximizing the thermal comfort of a building and reducing energy costs. Hence, this creates economic structures like less electricity consumption building.

B. Design Builder
Design-Builder, having simple interface to use, provides high-level modeling tools. It lets the entire design team use the same software to develop comfortable and efficient building designs from concept to completion. For Energy Reviewers, it's about being profitable and competitive using the fastest and easiest way. Evaluate energy efficiency and carbon efficiency at the start of the design. Visualize sun shading systems and explore designs to maximize the comfort and benefits of daylight and natural ventilation. Design Builder's clean, well-structured layout and intuitive help system make it much easier to learn and use. Compared to other simulation software, creating professional geometry is much easier. Ease of use extends to other areas of the program such as thermal bridge analysis and Heat, Ventilation and cooling system setup.

C. Autodesk
Information modeling software, Autodesk is used by architects, structural engineers, designers, and contractors. It lets users design a building, its structure, and its components in 2D & 3D.

D. Scope
The range will be limited to hot and dry climates (Western Jodhpur, Rajasthan) region.

E. Need Of Study
These days, the annual or monthly power consumption of any building is a big deal. Essentially, the electricity consumption of a building is used to make a comfort climate according to our wish. In large polluted cities or metros with high population density, the number of vehicles, factories & industries increases the local ambient temperature, causing climate discomfort. It is therefore preferable to lower the interior temperature of the building in one way or another in climate temperature. The objective of this project is therefore to increase the climate comfort of people and to save energy in buildings using natural ventilation.

II. Methodology
Methods and Data Collection

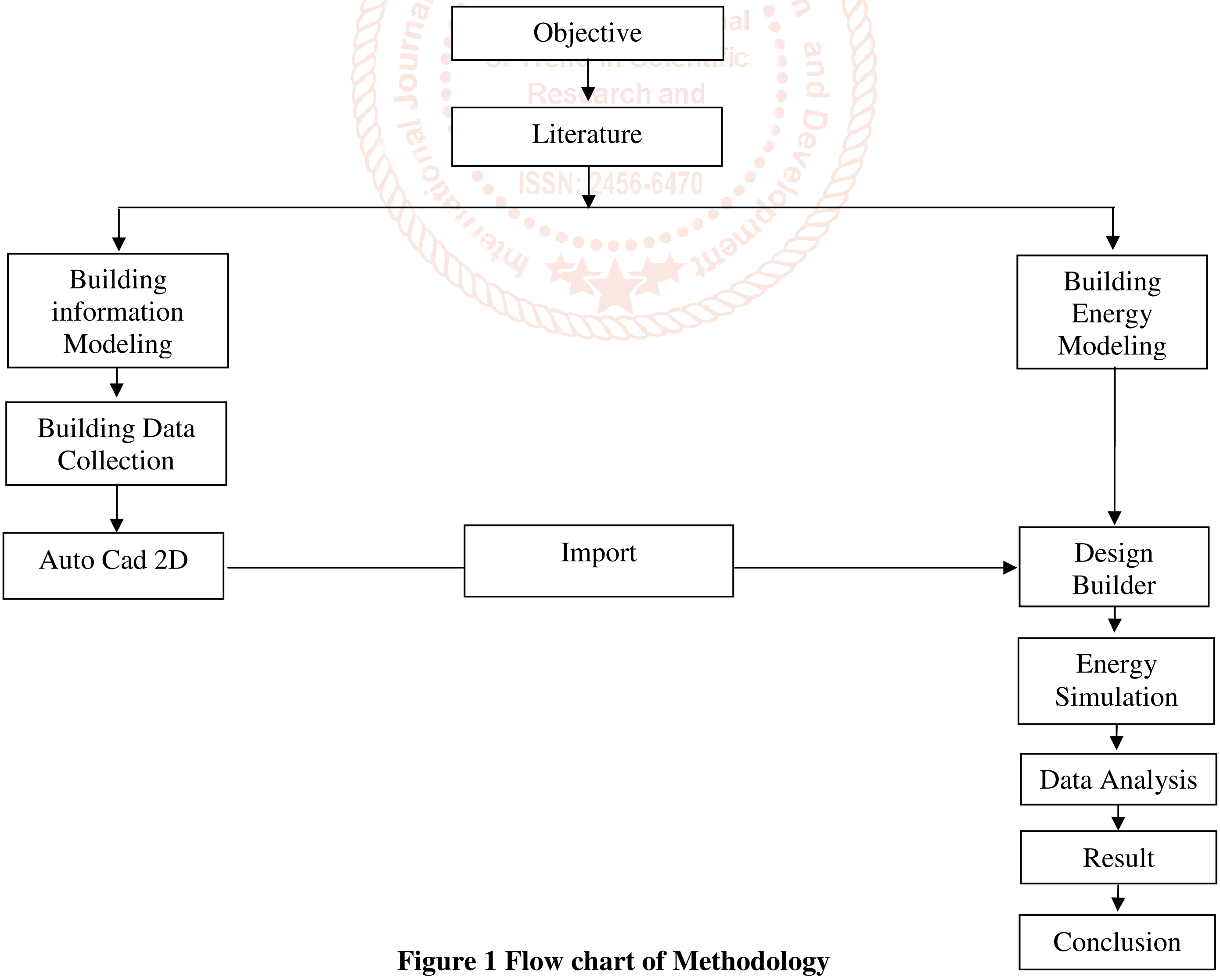


Figure 1 Flow chart of Methodology

1. Building Information Modeling

A building information model is a digital representation of the actual and functional characteristics of a facility. It is a resource for shared knowledge of facilities information, laying a reliable basis for decision-making in the life cycle of an installation; it is defined as existing from the first conception to dismantling. The traditional architectural design relies massively on two-dimensional technical drawings. Building information modeling extends it beyond 3D, adding three main spatial dimensions (w, h & d), fourth dimension is time, and fifth dimension is cost. It also covers relationships, light analysis, geographic information, and the number and assign of building components. Building Information Modeling implies expressing design as a combination of objects, diffuse and undefined, generic or specific to the product, physical forms, or the shape of a room, with their geometric shapes, relationships, and attributes. BIM design tools allow you to extract different views of the architectural model for drawing and other purposes. Based on a single definition of each object instance, these different views are automatically consistent. BIM software can also define objects parametrically; that is, the objects are defined as parameters and relationships with other objects, so if related objects are modified, the related objects will also be changed automatically. It's also able to provide material requirement and cost.

2. Building Energy Simulation

It is done using a computer to represent the building design virtually and perform physics-based calculations. The range of simulation can range from a building component to a group of buildings. For energy simulation, building models and location usage patterns and climate are needed to determine various results, such as peak load, system size, and energy consumption in a given period. This information can be used to estimate utility bills and evaluate the cost-benefit analysis of various design strategies.BEM calculates energy usage based on the description of assets and operations. Predict whether all major inputs are safe.

3. Energy Simulation in Design Builder

We designed the Star Building 4 BHK building model in Western Jodhpur, Rajasthan at design builder. We first obtained meteorological data for a certain location in Western Jodhpur, Rajasthan. Then we made the 2D floor plan of the building in Design Builder. Then do the power simulation, heating design, and cooling design.

4. Data Collection

We collected data from Star Building, which is located in Western Jodhpur, Rajasthan. The plan of the Star Building and other information on the site were taken.

Modeling

A. 2d Modeling

We collect data from Star Building, which is located in Western Jodhpur, Rajasthan. I got the Star Building plan and other information from the Contractor. The architectural plan was created in Auto Cad 2D, taking into account the architectural and structural views.

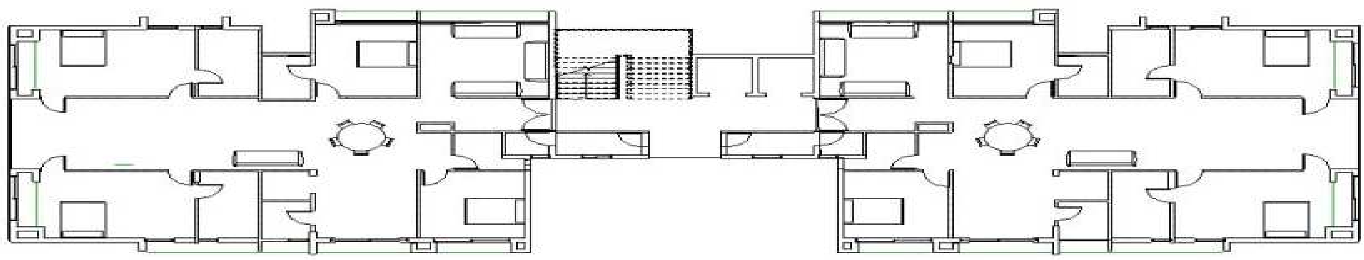


Figure 2: Building Plan

B. Energy Simulation in Design Builder

We designed the Star Building 4 BHK building model in Western Jodhpur, Rajasthan on design builder. First, we obtain weather data from the location in Western Jodhpur, Rajasthan. Then, I made the 2D floor plan of the building in Design builder. Next, perform power simulation, heating design, and cooling design parts.

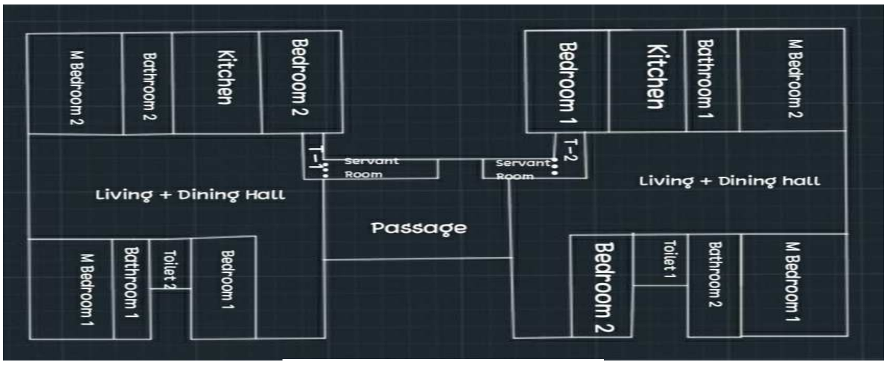


Figure 3: Building Plan

Analysis & Simulation

A. General

In this part, we analyze the building in the Design Builder software and simulate various building components according to the East-West and North-South directions. In this simulation, we obtain hourly data throughout the year based on weather files. In this hourly simulation section, we obtain natural ventilation readings, mechanical ventilation readings, infiltration data, and total air change per hour in the East-West and North-South directions.

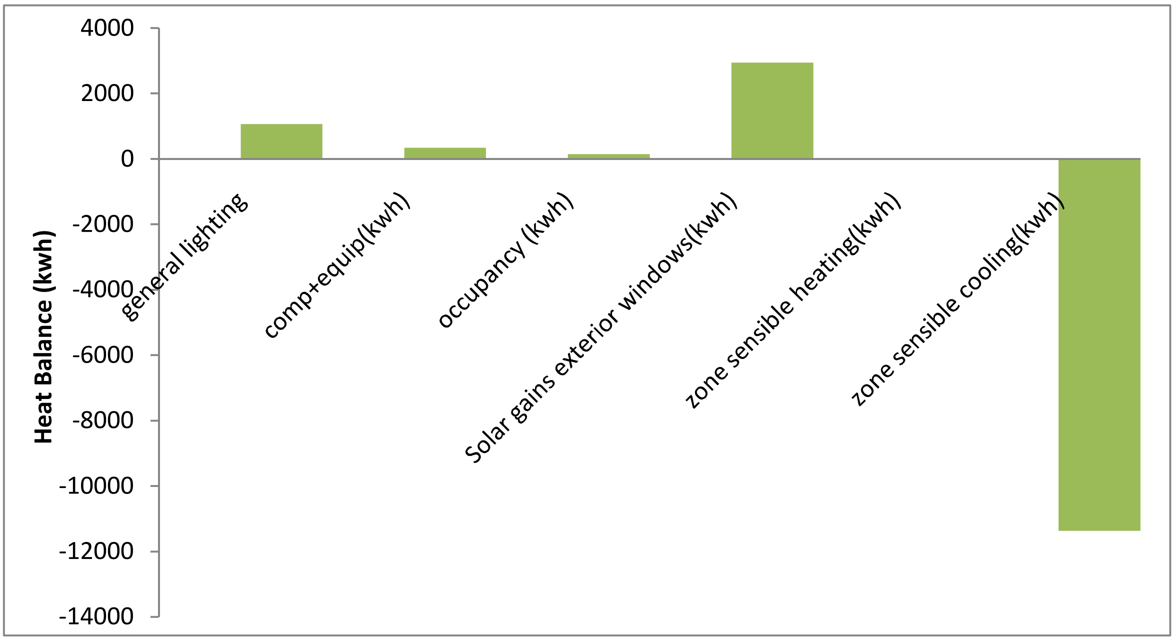
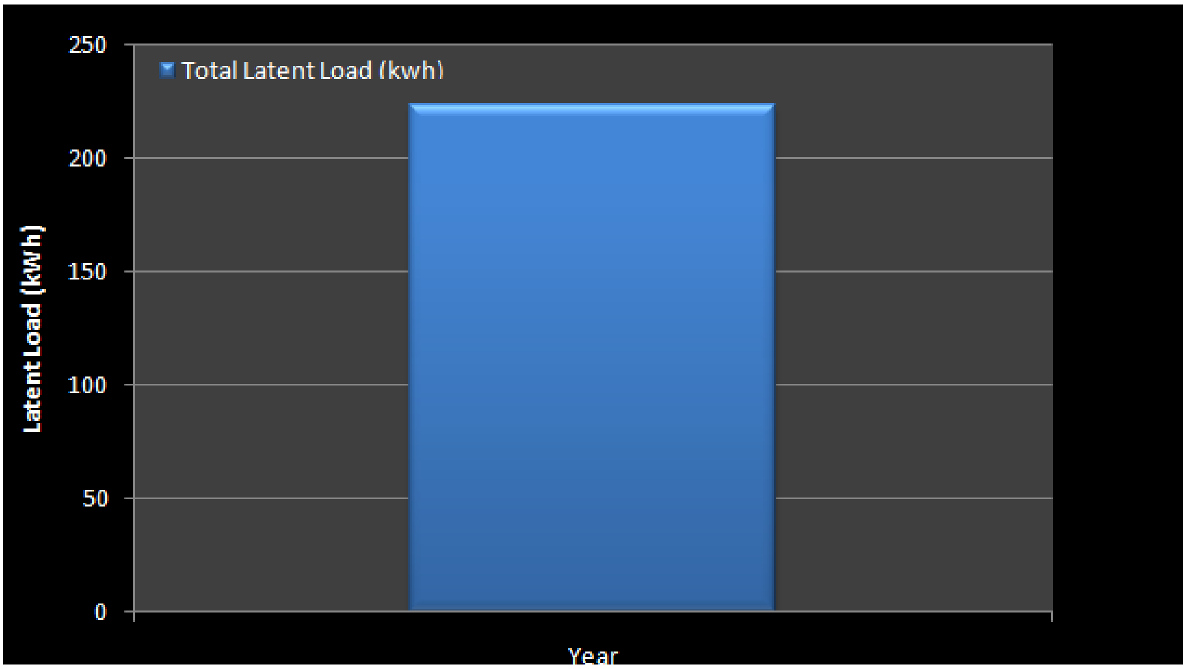


Figure 4: Annual Data from 1st January to 31st December



General Lighting(kWh)	1069.23
Computer + Equip(kWh)	341.11
Occupancy (kWh)	146.21
Solar Gains Exterior windows (kWh)	2947.43
Zone Sensible Heating (kWh)	0.03
Zone Sensible Cooling (kWh)	-11367.17
Total Latent Load (kWh)	223.17

Figure 5: Living & Dining (North-South) mix ventilation internal gains

B. Regional Refrigeration Load Analysis Case

Here, we have performed an analysis of apparent cooling load by zones in two different directions (north-south and east-west) in the combination of mechanical and mechanical & natural ventilation.

The following table shows the annual cooling load values in different regions:

Table A: Only Mechanical Ventilation

North-South	Case 1 (Mechanical)
Room	Zone Sensible Cooling (kWh)
1 Living & Dining	11476.14
1 Master Bedroom 1	4713.73
1 Master Bedroom 2	4726.73

Total Zone Sensible Cooling =20916.6 kWh

Table B: Mixed Ventilation

North-South	Case 2 (Mechanical & Natural)
Room	Zone Sensible Cooling (kWh)
1 Living & Dining	11421.14
1 Master Bedroom 1	4624.73
1 Master Bedroom 2	4636.42

Total Zone Sensible Cooling =20682.29 kWh

Table C: Only Mechanical Ventilation

East-West	Case 1 (Mechanical)
Room	Zone Sensible Cooling (kWh)
1 Living & Dining	11734.36
1 Master Bedroom 1	4934.73
1 Master Bedroom 2	4564.73

Total Zone Sensible Cooling =21233.82 kWh

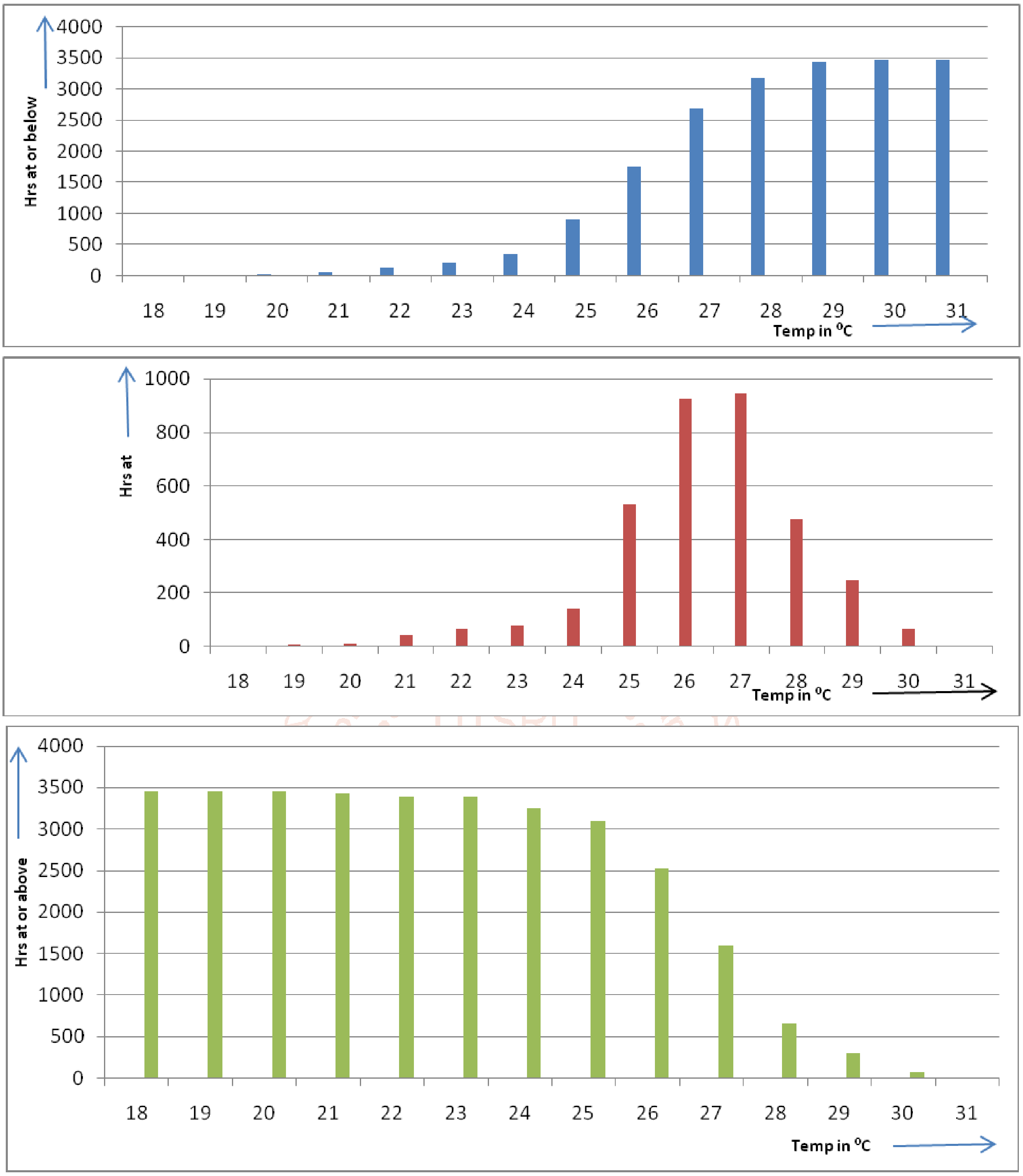
Table D: Mixed Ventilation

East-West	Case 2 (Mechanical & Natural)
Room	Zone Sensible Cooling (kWh)
1 Living & Dining	11564.23
1 Master Bedroom 1	4834.71
1 Master Bedroom 2	4387.35

Total Zone Sensible Cooling =20786.29 kWh

Area-sensitive cooling is the cooling effect of the HVAC system on different areas. Among the four simulated conditions, the best practice is to use the East-West orientation of the mixed ventilation mode. The above conditions require the least area sensitive cooling.

Temperature distribution



Hours at or below	2.0	6.7	18.7	61.0	128.0	205.0	346.0	911.0	1756.5	2698.5	3176.0	3443.0	3467.0	3470.0
Hours at	2.0	4.8	11.7	41.0	64.0	76.0	138.5	530.0	927.0	946.0	474.0	247.0	64.0	2.0
Hours at or above	3456.0	3453.0	3448.0	3435.0	3395.4	3395.4	3249.0	3104.0	2534.0	1600.5	657.0	310.0	73.0	2.0

Figure 6: Living & dinning (North-South) mix ventilation temperature distribution graph

The figure shows the temperature distribution in the north-south direction of the living room and dining room. And the table below shows the temperature distribution values below 25°C, 25°C and above 25°C in different areas of the building.

III. Result & Discussion

Table E: ONLY MECHANICAL VENTILATION

North- South		Case 1 (Mechanical)	
Room	Temp. Distribution below 25^0C (Total Hrs.)	Temp. Distribution at 25^0C (Total Hrs.)	Temp. Distribution above 25^0C (Total Hrs.)
1 Living & Dining	836	485	3187
1 Master Bedroom 1	718.0	411.5	3486
1 Master Bedroom 2	743	415	3409

Total Hrs at 25^0C and below 25^0C= 3609 hrs.

Table F: Mixed Ventilation

North- South		Case 2 (Mechanical + Natural)	
Room	Temp. Distribution below 25^0C (Total Hrs.)	Temp. Distribution at 25^0C (Total Hrs.)	Temp. Distribution above 25^0C (Total Hrs.)
1 Living & Dining	912.0	540.0	3215.5
1 Master Bedroom 1	732.5	465.5	3478.0
1 Master Bedroom 2	815.5	476.5	3548.5

Total Hrs at 25^0C and below 25^0C=3942 hrs.

Table G: Only Mechanical Ventilation

East-West		Case 1 (Mechanical)	
Room	Temp. Distribution below 25^0C (Total Hrs.)	Temp. Distribution at 25^0C (Total Hrs.)	Temp. Distribution above 25^0C (Total Hrs.)
1 Living & Dining	878.0	546.0	3267
1 Master Bedroom 1	545.5	415	3677.5
1 Master Bedroom 2	786.5	515	3548.5

Total Hrs at 25^0C and below 25^0C=3686 hrs.

Table H: Mixed Ventilation

East-West		Case 2 (Mechanical + Natural)	
Room	Temp. Distribution below 25^0C (Total Hrs.)	Temp. Distribution at 25^0C (Total Hrs.)	Temp. Distribution above 25^0C (Total Hrs.)
1 Living & Dining	856	487	3265
1 Master Bedroom 1	546	390.5	3677.5
1 Master Bedroom 2	796.5	426	3543

Total Hrs at 25^0C and below 25^0C=3502 hrs.

Tables E, F, G and H show the temperature distribution in hours at the appropriate temperature. The number of hours with the right temperature in the different areas will allow us to determine the conditions that best suit comfort standards. The temperature distribution of 25 ° C or less is considered the standard for comfort conditions. Among the four cases of different ventilation modes in different directions, the case of mixed ventilation conditions in the North-South direction gives the maximum number of temperature hours throughout the year.

IV. Conclusion

This paper proposes the best direction for existing residential buildings with a mixed ventilation mode of natural ventilation and Heat Ventilation and Cooling control found in Western Jodhpur. The paper's precise goal is to determine a natural ventilation control strategy based on a study of the buildings positioning in terms of annual cooling standards and comfort standards, and also taking into account the accredit of all bedrooms, to determine the best building orientation. This paper presents a simulation method of DESIGN BUILDER to simulate the thermal behavior of buildings. The benefits of a mixed ventilation strategy used by optimized control logic are demonstrated in a case study simulation involving a residential building in the center of western Jodhpur. The analysis of space heating and cooling comfort, in particular reveals that the house's thermal performance has improved, the discomfort time caused by overheating has been greatly reduced, and the demand for cooling energy has been reduced.

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