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TO EVALUATE THE IMPACT OF BUILDING ORIENTATION AND NATURAL VENTILATION ON ANNUAL ENERGY CONSUMPTION

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Abstact - *With the increasing global warming, the temperature of the atmosphere is rising considerably. With such climatic conditions there falls a great need to curb the usage of artificial energy sources and also find ways which aid us in keeping the temperature of a place under control. Our research is based on how energy consumption of a building can be reduced without compromising its required temperature by combinations of a various orientation of the building with using natural ventilation with mechanical ventilation. This gives a clear picture of the best suitable situation of any particular building. This simulation is done in design-builder software with energy plus plug-in and we have incorporated factor such as building orientation. This will provide us with how much artificial energy would be required keeping in mind the ideal temperature of the building. As the final result, this will give us the difference this setup can make in long-term costing of the building. If these parameters are checked before designing the building, better output in terms of energy savings and long-term financial benefits could be obtained.*

1. INTRODUCTION

Now a day, yearly/monthly power consumption of any building is the big issue. Mostly, power consumption of the building is used to feel the thermal comfort. In mega/metro pollutant cities having large population, numbers of vehicles, factories/industries increase the outside local environment temperature which leads to thermal uncomforting. According to ASHRAE standard 55-2015, human thermal comfort temperature should be between 19.44°Cto 27.77°C. So, it's better to reduce somehow the indoor temperature of building in thermal temperature.

Human thermal comfort is the condition of mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation (ANSI/ASHRAE Standard 55). Maintaining this standard of thermal comfort for occupants of building's satisfaction with the thermal environment is important for its own sake and because it influences productivity and health. Office workers who are satisfied with their thermal environment are more productive. Thermal discomfort has also been known to lead to sick building syndrome symptoms. The combination of high temperature and high relative humidity serves to reduce thermal comfort and indoor air quality.

This thermal comfort temperature can be maintained by using natural ventilation system. Natural ventilation is the process of supplying air to and removing air from an indoor space without using mechanical systems. It refers to the flow of external air to an indoor space as a result of pressure differences arising from natural forces. Properly designed, naturally ventilated buildings keep indoor conditions within the range where opening windows and using fans in the summer, and wearing extra clothing in the winter, can keep people thermally comfortable.

From this project, human thermal comfort will increase, ultimately which leads to the higher efficiency and productivity of human. It will reduce the energy consumption and coast of power consumption.

A. BUILDING ENERGY SIMULATION

Building energy simulation, also called building energy modelling (BEM) is the use of physics-based software to predict the energy use of a building. Whole-Building Energy Modelling (BEM) is a versatile, multipurpose tool that is used in new building and retrofit design, code compliance, green certification, qualification for tax credits and utility incentives, and real-time building control. BEM is also used in large-scale analyses to develop building energy-efficiency codes and inform policy decisions.

A typical building energy model has inputs for local weather; building geometry; building envelop characteristics; internal gains from lighting and plug loads; heating, ventilation, and cooling (HVAC) system specifications; operation schedules and control strategies. A building energy simulation then uses physics-based equations to calculate thermal loads, system responses to those loads, and the resulting energy use, along with related metrics such as occupant thermal comfort and energy costs. Building energy simulation is maximizing the thermal comfort of the building and reduces the energy cost. So, it creates economical structures as a green building.

B. DESIGN BUILDER

Design Builder provides advanced modelling tools in an easy-to-use interface. This enables the whole design team to use the same software to develop comfortable and energy-efficient building designs from concept through to completion.

For Energy Assessors, it is to be cost-efficient and competitive by using the quickest and easiest way. Assess energy efficiency and carbon performance during early stage design. Visualise solar shading and explore designs to maximise comfort and the benefits of day lighting and natural ventilation.

Design Builder's clear, well-structured layout and intuitive help system makes it a much simpler tool to learn and use, and compared to other simulation packages the creation of professional-looking geometry is much easier. The ease of use extends to other areas of the program such as thermal bridging analysis and setting up HVAC systems, and the capability to easily model adjacent ground conditions is very useful.

C. REVIT

Autodesk Revit is building information modelling software for architects, structural engineers, designers and contractors. It allows users to design a building and structure and its components in 3D, annotate the model with 2D drafting elements and access building model's database.

D. SCOPE

The Scope will be limited to hot & dry climate (Ahmedabad-Gandhinagar) region.

E. NEED OF STUDY

Now a day, yearly/monthly power consumption of any building is the big issue. Mostly, power consumption of the building is used to feel the thermal comfort. In mega/metro pollutant cities having large population, numbers of vehicles, factories/industries increase the outside local environment temperature which leads to thermal uncomforting.

So, it's better to reduce somehow the indoor temperature of building in thermal temperature. So, the aim of this project is to increase the human thermal comfort, saving the energy consumption in building using natural ventilation system.

2. METHODOLOGY AND DATA COLLECTION

METHODOLOGY

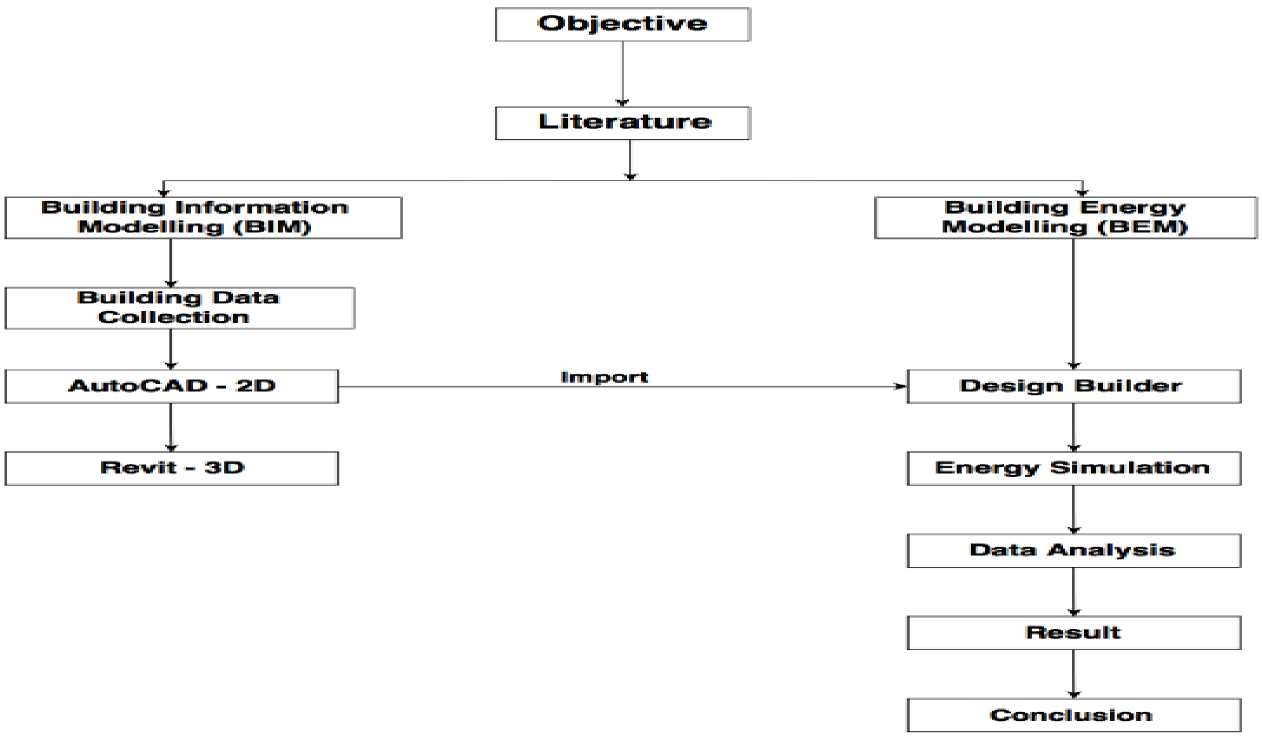

Fig.1.Methodology flow-chart

In methodology, we used a BIM, and BEM for the analysis and desirable output.

A. BUILDING INFORMATION MODELLING (BIM)

Building Information Modelling (BIM) is a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition.

Traditional building design was largely reliant upon two-dimensional technical drawings (plans, elevations, sections, etc.). Building information modelling extends this beyond 3D, augmenting the three primary spatial dimensions (width, height and depth) with time as the fourth dimension (4D) and cost as the fifth (5D). BIM therefore covers more than just geometry. It also covers spatial relationships, light analysis, geographic information, and quantities and properties of building components (for example, manufacturers' details.)

BIM involves representing a design as combinations of "objects" – vague and undefined, generic or product-specific, solid shapes or void-space oriented (like the shape of a room), that carry their geometry, relations and attributes. BIM design tools allow extraction of different views from a building model for drawing production and other uses. These different views are automatically consistent, being based on a single definition of each object instance. BIM software also defines objects parametrically; that is, the objects are defined as parameters and relations to other objects, so that if a related object is amended, dependent ones will automatically also change. Each model element can carry attributes for selecting and ordering them automatically, providing cost estimates as well as material tracking and ordering.

B. BUILDING ENERGY SIMULATION (BEM)

Building energy simulation is performed using a computer to virtually represent a building design and perform physics-based calculations. The simulations can range from a building component to a cluster of buildings. For energy simulation, the building model along with the usage pattern and the weather of the location are required to determine various outputs, such as peak loads, system sizing, and energy consumption for any given period. This information can be utilized for estimating the utility bills, for evaluating cost–benefit analysis of various design strategies.

BEM calculates energy use from description of assets & operations Predictive if all major inputs are certain. There are multiple software used for BEM such as Energyplus, OpenStudio, Building Energy Modelling Project Portfolio.

BEM has multiple use cases, both established and emerging.

Design: architecture, HVAC system selection & sizing.

Operations: HVAC fault diagnosis, dynamic control & demand response.

Market: code development & compliance, ratings, incentives, M&V, policy, etc.

C. ENERGY SIMULATION IN DESIGN BUILDER

We designed a model of Sparsh Divine 4 BHK building which is located in Ahmedabad in design builder. We first, took the weather data of a Ahmedabad location. Then, we made a 2D plan and 3D plan of that building in Design Builder. Then, simulation of energy, heating design, cooling design part is done.

D. DATA COLLECTION

We collected data of Sparsh Divine-2, which is situated at Near Radha Swami Satsang Byas, B/H Balaji Villa, Near Tapovan Circle, Chandkheda, Ahmedabad. We took plan of Sparsh Divine-2 building and other information of site.

3. MODELLING

A. REVIT MODELING

- We designed a model of sparsh divine 4 BHK building which is located in Ahmedabad in design builder.
- This building plan created in Revit-3D considering Architectural and Structural views.

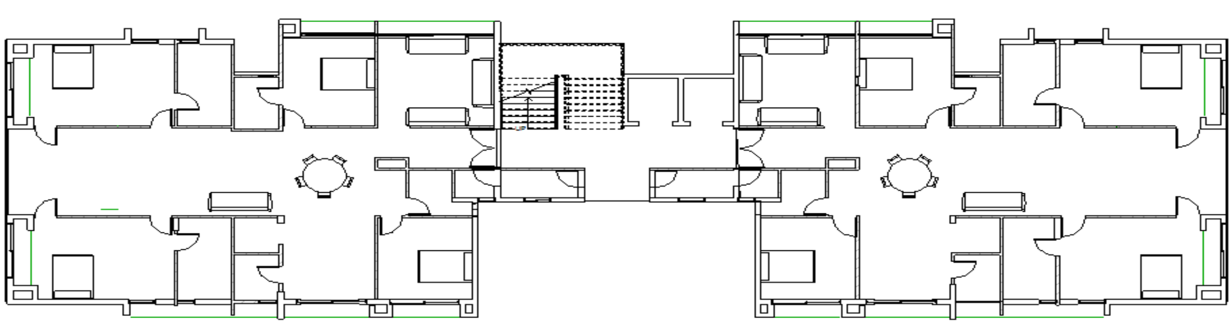

Fig.2. Plan of building

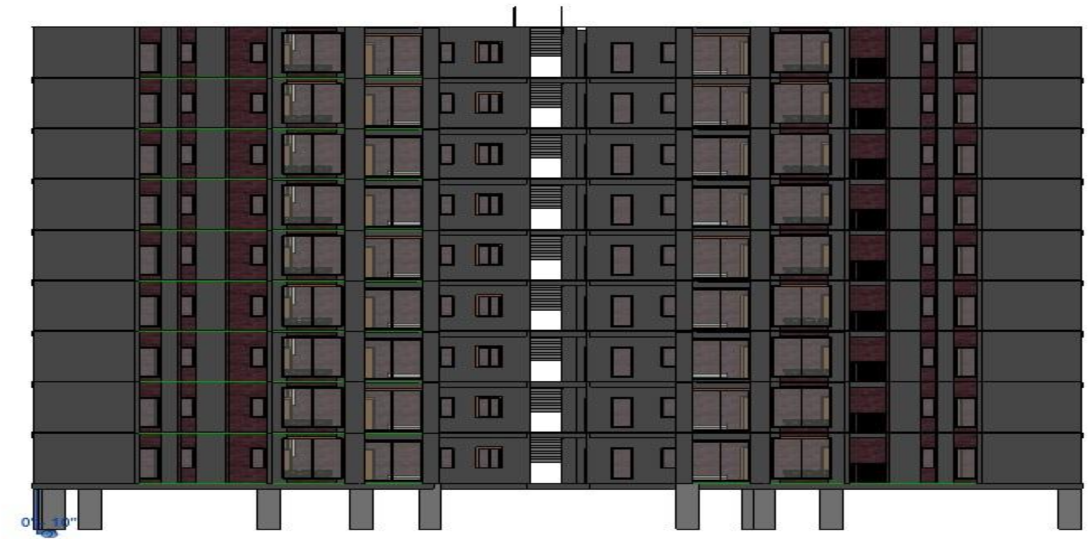

Fig.3. Elevation of building in Revit

B. **4.2 Energy Simulation in Design Builder**

- We designed a model of sparsh divine 4 BHK building which is located in Ahmedabad in design builder.
- We first, took the weather data of Ahmedabad location. Then, made a 2D plan and 3D plan of that building in design builder.
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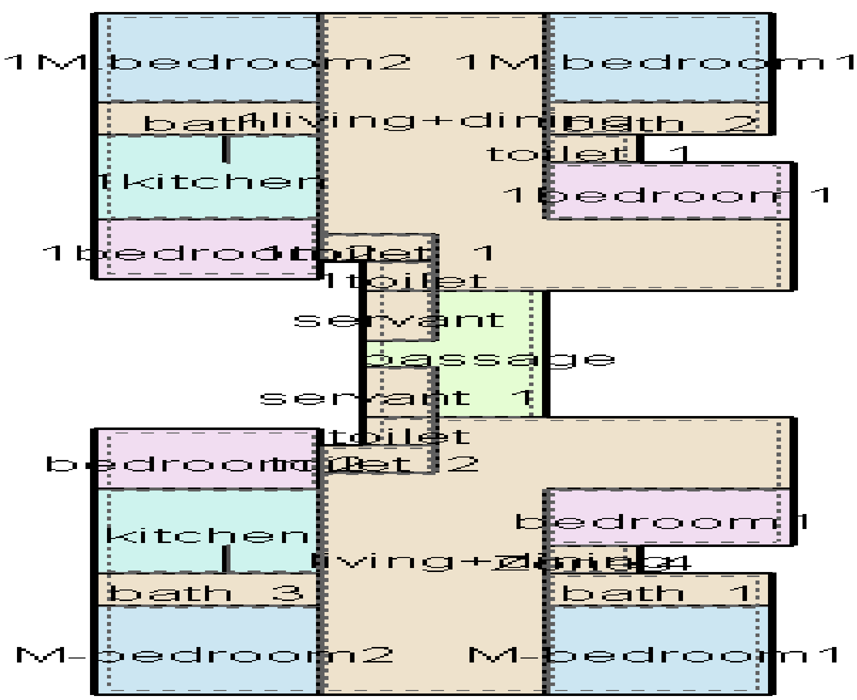


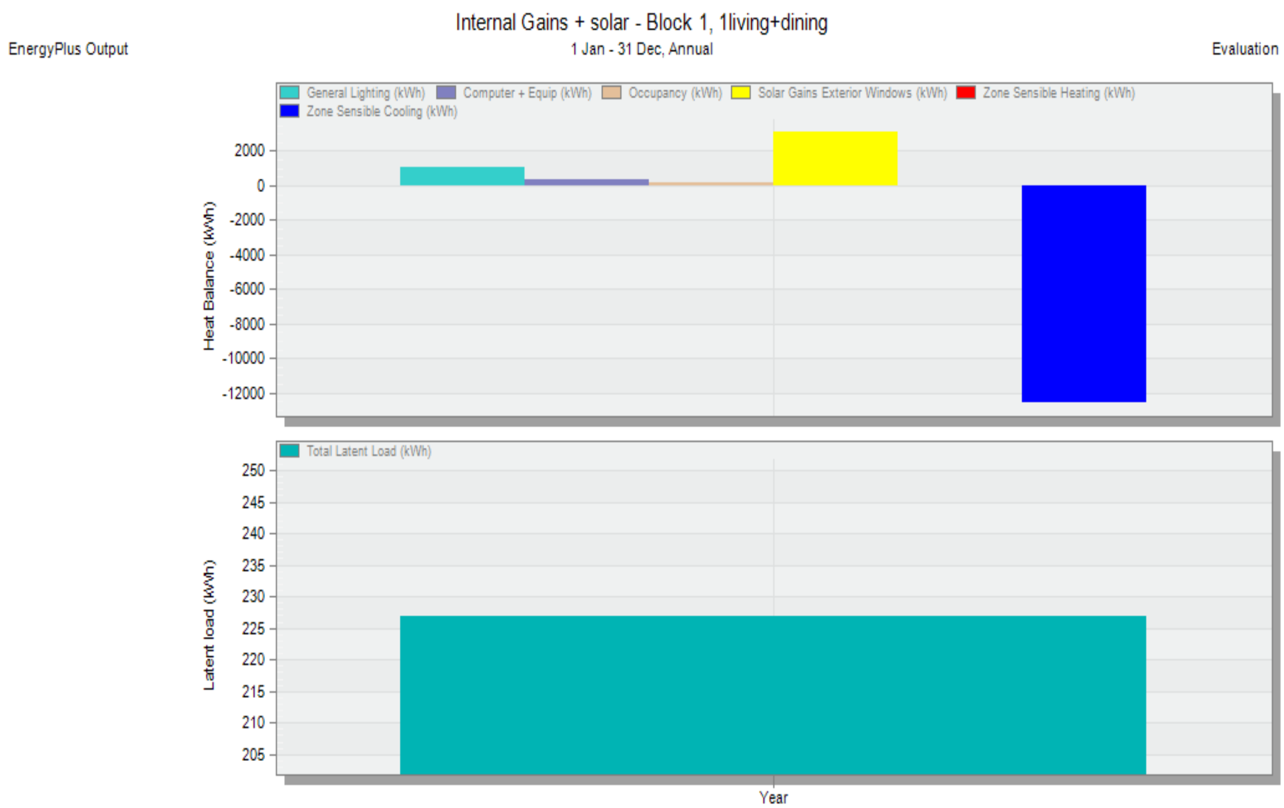
Fig.4.Detailed plan of building

4. Analysis & Simulation

A. General

In this portion, we analyzed the building in Design Builder Software and simulated various components of building in accordance to E-W & N-S directions.

In this simulation we took hourly data of whole year according to weather file. In this hourly simulation part, we took Natural ventilation readings, Mechanical ventilation readings, Infiltration data and total Air changes per hour (Ac/h) in both E-W & N-S Direction.



General Lighting (kWh)	1079.13
Computer + Equip (kWh)	351.91
Occupancy (kWh)	178.29
Solar Gains Exterior Windows (kWh)	3085.84
Zone Sensible Heating (kWh)	0.03
Zone Sensible Cooling (kWh)	-12537.77
Total Latent Load (kWh)	226.87

Fig.5.Living +dinning (N-S) mix ventilation internal gains

B. Cases of zone sensible cooling load analysis

- Here, we did a zone wise sensible cooling load analysis in a different two direction (North-South & East-West) in combination of mechanical and mechanical + Natural ventilation.
- Here given below tables showing values of annual cooling load in different zones

Table1: ONLY MECHANICAL VENTILATION

N-S	CASE1(MECH)
ROOM	ZONE SENSIBLE COOLING(kwh)
1 living+dining	12550.55
1m bedroom1	5934.81
1m bedroom2	5955.81

TOTAL ZONE SENSIBLE COOLING = 24441.17KWH

Table2: MIXED VENTILATION

N-S	CASE2(MECH+NATURAL)
ROOM	ZONE SENSIBLE COOLING(kwh)
1 living+dining	12537.77
1m bedroom1	5802.48
1m bedroom2	5828.54

TOTAL ZONE SENSIBLE COOLING = 24168.79KWH

Table 3: ONLY MECHANICAL VENTILATION

E-W	CASE1(MECH)
ROOM	ZONE SENSIBLE COOLING(kwh)
1 living+dining	12735.80
1m bedroom1	6245.02
1m bedroom2	5663.48

TOTAL ZONE SENSIBLE COOLING = 24644.3KWH

Tabel 4: MIXED VENTILATION

E-W	CASE2(MECH+NATURAL)
ROOM	ZONE SENSIBLE COOLING(kwh)
1 living+dining	12687.17
1m bedroom1	6087.18
1m bedroom2	5540.95

TOTAL ZONE SENSIBLE COOLING = 24315.3 KWH

- Zone sensible cooling is the cooling effect of HVAC system on the different zones. Among the four simulated conditions the best practice to employ is the orientation of E-W with mixed mode of ventilation. The above conditions require the least amount of zone sensible cooling.

5. Temperature distribution

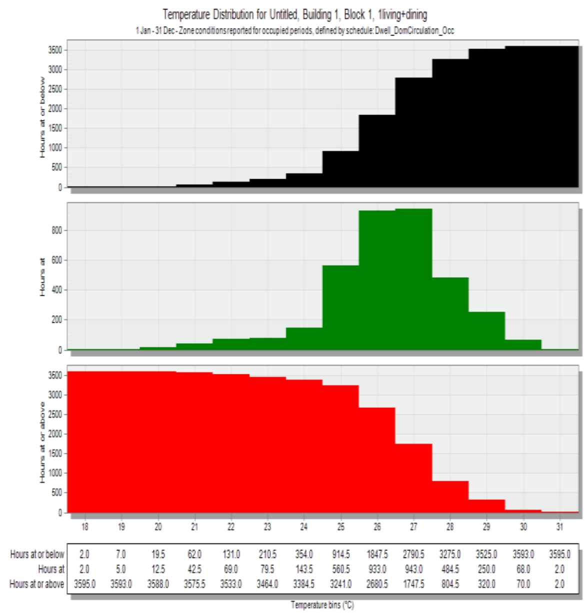


Fig.6.Living +dinning (N-S) mix ventilation temperature distribution graph

- Figure shows a temperature distribution in living and dining in north-south direction. And below tables show a values of temperature distribution below 25c, at 25c, and above 25c of a different zones in a building.

Table 5: ONLY MECHANICAL VENTILATION

N-S		CASE1(MECH)	
ROOM	TEMPERATURE DISTRIBUTION BELOW 25 °C(TOTAL HOURS)	TEMPERATURE DISTRIBUTION AT 25 °C(TOTAL HOURS)	TEMPERATURE DISTRIBUTION ABOVE 25 °C(TOTAL HOURS)
1 living+dining	874	501	3222
1m bedroom1	728.5	441.5	3571
1m bedroom2	774	434	3518

TOTAL HOURS AT 25 C AND BELOW 25 C = 3753hrs

Table6: MIXED VENTILATION

N-S		CASE2(MECH+NATURAL)	
ROOM	TEMPERATURE DISTRIBUTION BELOW 25	TEMPERATURE DISTRIBUTION AT 25 °C(TOTAL	TEMPERATURE DISTRIBUTION ABOVE 25

	°C(TOTAL HOURS)	HOURS)	°C(TOTAL HOURS)
1 living+dining	914.5	560.5	3241.5
1m bedroom1	742	481.5	3597.5
1m bedroom2	794.5	486.5	3550

TOTAL HOURS AT 25 C AND BELOW 25 C = 3979.5hrs

Table7: ONLY MECHANICAL VENTILATION

E-W		CASE1(MECH)	
ROOM	TEMPERATURE DISTRIBUTION BELOW 25 °C(TOTAL HOURS)	TEMPERATURE DISTRIBUTION AT 25 °C(TOTAL HOURS)	TEMPERATURE DISTRIBUTION ABOVE 25 °C(TOTAL HOURS)
1 living+dining	890	554	3259
1m bedroom1	598.5	431	3690.5
1m bedroom2	796.5	501	3562.5

TOTAL HOURS AT 25 C AND BELOW 25 C = 3771hrs

Table 8: MIXED VENTILATION

E-W		CASE2(MECH+NATURAL)	
ROOM	TEMPERATURE DISTRIBUTION BELOW 25 °C(TOTAL HOURS)	TEMPERATURE DISTRIBUTION AT 25 °C(TOTAL HOURS)	TEMPERATURE DISTRIBUTION ABOVE 25 °C(TOTAL HOURS)
1 living+dining	845	499	3249
1m bedroom1	576	401.5	3683.5
1m bedroom2	777	439	3520

TOTAL HOURS AT 25 C AND BELOW 25 C = 3537.5hrs

- The table 5, 6, 7, 8, shows temperature distribution in hours at suitable temperatures. The number of hours in which the different zones will be having the suitable temperature will allow us to decide the most suitable condition for comfort criteria. The temperature distribution at 25 °C and below it is considered as the comfort condition criteria.
- Among the four cases of different orientation with different modes of ventilation the case with the N-S orientation with mixed mode of ventilation condition gives the maximum number hours of that temperature during the whole year.

CONCLUSIONS

This thesis proposes a Best orientation of pre-existed residential building for the mixed mode of ventilation with natural ventilation and HVAC control which is situated in the Ahmedabad. In particular, the objective of the thesis is to determine a natural ventilation control strategy on the basis of the following issues: i)To study the building orientation on annual cooling criteria and comfort criteria; ii) To find out the best orientation of building by considering comfort criteria for all the bedrooms. This thesis proposes simulation approach by DESIGN BUILDER for simulating the thermal building behaviour.

A case study simulation, considering a residential building located in central Ahmedabad, shows the benefits of the mixed ventilation strategy applied by the optimized control logic. In particular, the thermal comfort and energy analysis show the improvement of dwelling thermal performances with significant reduction of overheating discomfort hours and reductions of energy needs for cooling.

Future developments will concern the study of window openings control optimized for the whole dwelling, and combined with solar shading activation logics. Moreover, further research will focus on the ventilation control logic applied to hybrid systems also to minimize the energy consumption.

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