Appraising Building Envelope for Existing Academic Building at SVNIT, Surat

Bhagyashri H. Sisode, Dr. Krupesh A. Chauhan

Sardar Vallabhbhai National Institute of Technology, Surat, Gujarat, India

Abstract:

Purpose- The building envelope helps to create a physical barrier between the outer and inner climate of a location. In the case of an institutional building, it is often noted that the actual functional hours are only during the day time, from early morning to sun-down. The Purpose of this paper is to analyse, how an existing institutional building, located in Surat, Gujarat behaves under the Hot and Dry climate conditions and if the envelope performance of the building fulfils the basic requisite of its functions.

Design/ Methodology- This research study undertakes a comparison of the present conditions of the building with the basic standards of Energy Conservation Building Codes, 2017 to identify the gaps in the building design. The focus is to understand if the indoor conditions of the building are good for working in all weathers of the city and identify the gaps which can be improved for better indoor ambience.

Findings- The findings of this research can be classified into two parts, namely aspects that cause drawbacks in building envelope performance and identification of possible changes in existing envelope to improve the performance to optimize the energy demand of the building.

Originality/ Value- The research work will help to identify possible changes for the existing institutional buildings, which can be implemented on a larger scale of campus level, thereby creating an energy efficient area.

Keywords- Building Envelope Performance, Passive Design, Building Performance, Day lighting, Solar Radiation.

Paper Type- Analytical Research Paper.

Introduction

With the growth of population and the increasing need for more habitable spaces for different purposes, the demand for energy for the functioning of these spaces is also ever-increasing. This energy demand requires us to find alternate sources of energy that causes less effect on the environmental conditions and naturally help in recharge of energy. Buildings sector across the world has a demand of roughly 40% of the worldwide energy utilization, and over 50% of the global electricity demand (Güçyeter & Günaydin, 2012). The building energy evaluation is a method of help overcome the wastages of energy and ensures cost effective efficient opportunities for the building functions (Zheng et al., 2010).

There are multiple methods of evaluating the energy demand of a building; however, the major classification is termed as “Active Design” and “Passive Design” strategies:

- The *Active Design* strategies tries to meet the human comfort by taking into account the Heating, Ventilation and Cooling (HVAC) Systems and lighting systems by modification of electrical-mechanical equipments.
- The *Passive Design* strategies looks more towards the structural, architectural and aesthetical designs of the building involving factors like building envelope, shading devices, natural ventilation, etc.

This study is oriented towards the existing institutional academic building, by analysis of factors affecting the building envelope performance. The building envelope in any building is the physical barrier between the inner and outer climate, providing the users a conditioned and safe indoor habitable space (Li et al., 2020). The envelope performance of a building considers elements like roof, subfloor, exterior walls, windows, shading devices and any other exterior openings along with many other features in a building (El-Darwish & Gomaa, 2017; Li et al., 2020). The heat transfer characters including walls, floors, windows, doors, roofs and the sunlight penetrating into the interior living or work spaces strongly influence the heating/ cooling load of the building (Zheng et al., 2010).

Although the general information about passive design and active designs helping to save energy are known to most, very few of the information is being implemented to retrofit or rectify these brownfield development, thus only majorly focusing on saving them through structural or aesthetic measures (Sozer, 2010). The fact of ignorance towards the retrofitting of these buildings often results from the lack of information regarding the amount of financial investments required and the amount of energy saving s that can be achieved from these rectifications (El-Darwish & Gomaa, 2017).

Institutional buildings across the world operate in the Morning and afternoon hours, usually between 8:00 am to 6:00 pm (10hours). In the case of an institutional academic building, located in a hot-dry climate, it is very much necessary to control the amount of heat that is entering the indoor spaces of the building, while maintaining the cooling requirements. The objective is to limit the thermal losses during the winter, whereas to prevent thermal gain in summer (Praditsmanont & Chungpaibulpatana, 2008).

Appraising the building envelope performance determines the efficiency of the building helps in identifying the grey areas where the building suffers from performance failures (Saidur & Masjuki, 2008). The study tries to analyse the existing building for Civil Engineering Department at the Sardar Vallabhbhai National Institute of Technology, Surat, Gujarat, through the common building envelope features like Use of Building, Building Orientation, Shape coefficient, Useful Daylight Illuminance (UDI), Window-Wall Ratio, Window-Floor Ratio, Thermal transmittance of the Roof and Natural Ventilation (Sharif & Hammad, 2019; Saikia et al., 2020 ; Saidur & Masjuki, 2008).

Study Area

The study area selected is located in Surat, Gujarat, India, as shown in Figure 1. Surat is the eighth-largest city and the ninth largest urban agglomeration of India, being famous for the Diamond and Textile Industries. The city of Surat falls under the "Hot-Dry" climate type as defined by National Building Code -2016. The day time temperature varies between 20-35ºC, whereas the night time temperature varies between 20-30ºC. The annual rainfall of the city sums up to an average of 1200mm per year, and relative humidity ranges between 70-90%.

The academic institute under study, Sardar Vallabhbhai National Institute of Technology, earlier known as Regional Engineering College (REC) was established in 1961. The building for the Department of Civil Engineering is one of the oldest buildings (60 years) in the campus and is easily accessible, being only 200m away from the Main Entry gate of the Campus.

Table 1. Building Description

Building Information	**Description**
Location	Latitude: 21.166139° N
	Longitude: 72.784073° E
Orientation	East-West
Environment	Shadow from closely located other academic buildings, Landscape ,etc.
Climate Type	Hot-Dry
Total Number of Floors	G+1
Floor Area (m^2)	Ground Floor: 968.48
	First Floor: 958.58
	Total : 1970.61
Floor Height (m)	4.0
Volume (m^3)	8812.76 m^3
Façade Surface Area (m^2)	3326.50 m^2
Glazing Area (m^2)	344.74 m^2
Operative Hours	Monday to Friday (8:00am to 8:00 pm)
	Saturday (9:00 am to 5:00 pm, occasionally)

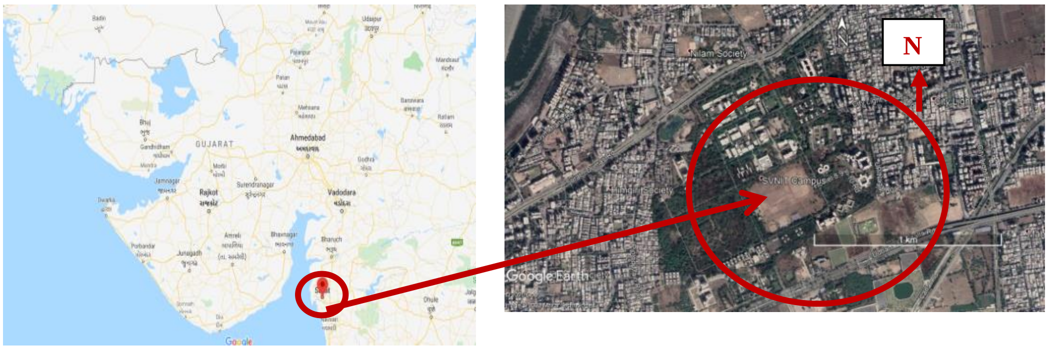


Figure 1. Location of SVNIT, Surat

Methodology

The study was done by manual analysis through measured drawings of the building floor plates and the comparison of the building design with the standard recommended values for various aspects under the Energy Conservation Building Code, 2017; published by the Bureau of Energy Efficiency, India.

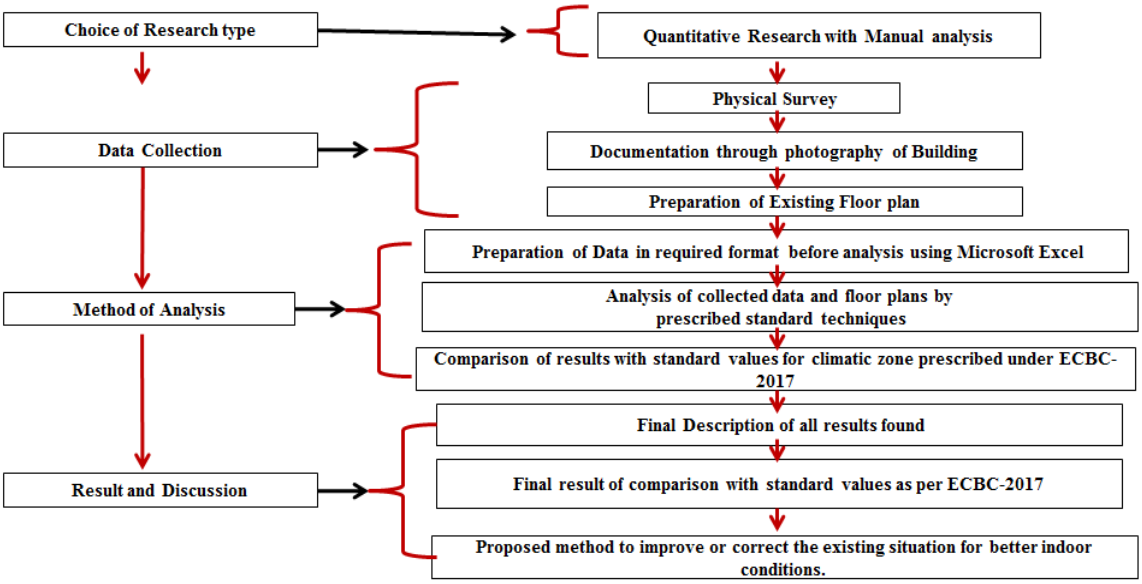


Figure 2. Methodology

Results

A. <u>Use of Building:</u>

The building has two floors, on which different academic activities and spaces have been segregated. The ground floor is used for the purpose of classes, laboratory functions, faculty cabins and departmental office use. The first floor consist the department library, research scholar’s workplaces, seminar room, laboratory and faculty cabins. The building operates between 8:00 am to 6:00 pm (Monday-Friday) and occasionally on Saturdays.

Figure 3 Building Floor Plans

B. Climate Type at Study Area:

The study area of building of the Department of Civil Engineering (CED) falls under the "Hot-Dry" climate zone, as per National Building Code-2016. Out of the total working hours, only 9.6% of the time comfortable conditions, therefore, the sun is an enemy in this climate condition, therefore uprising a need for thermal comfort oriented design.

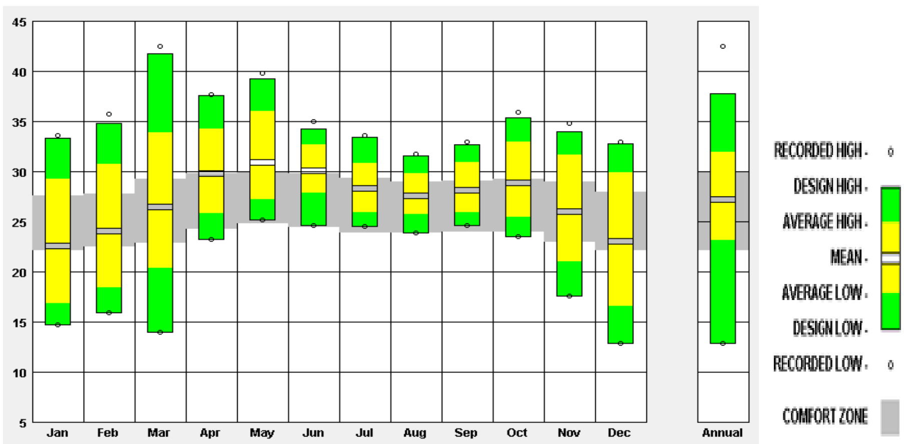
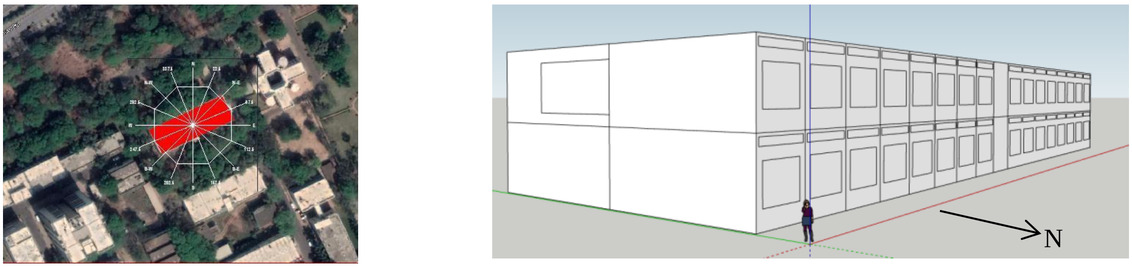


Figure 1. Climate Details

C. Building Orientation:

The building orientation has the major axis of the building on North-East (67.5^{O}) - South-West (247.5^{O}). As per the prescribed values for the orientation factor (NBC, 2016), the study area falls under the < 23.5 °N category. The orientation design improves the use of daylight in the indoor spaces longer façade is towards East-West axis.

Figure 5. Building Orientation



D. Shape Coefficient:

The shape coefficient of a building defines the impact of the building shape on the heating and cooling of the indoor spaces. In case of hot climate areas, the cooling load is directly proportional to the shape coefficient (Pathirana et al., 2019).

$$C_f = \frac{S_e}{V} \quad (m^2/m^3)$$

Here S_e is the envelope surface area, and V is the inner volume of the building
Shape coefficient for the study area =

C_f = (3326.50 m^2 / 8812.75 m^3) = 0.3774 = **37.74%**

As the shape coefficient of the building is slightly high, it shows that there is higher need of cooling in the building to achieve thermal comfort.

E. Useful Daylight Illuminance:

As per ECBC 2017, Educational Buildings should have a minimum of 40% of the daylight requirement. The UDI (Useful Daylight Illuminance) area is calculated (as shown in Table 1), for the building using the manual method mentioned in ECBC, 2017.

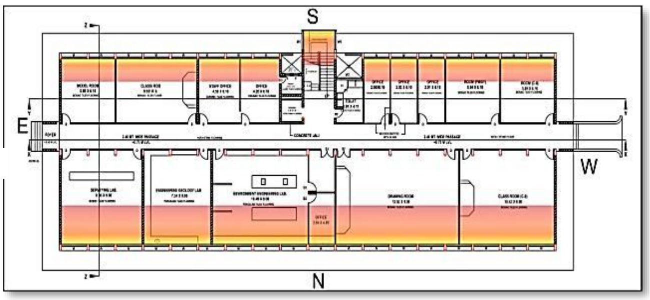


Figure 2. UDI for CED Building

The analysis for the UDI has been done in the following way:

Orientation	PF	DEF (VLT <0.3)	Window/ Fenestration Width(m)	X m (Distance perpendicular to fenestration	Y m(distance parallel to fenestration	(X x Y) sq.m.
North	< 0.4	2.4	50.40	3.48	51.40	178.872
South	< 0.4	2	50.40	2.90	51.40	149.06
East	< 0.4	1.3	4.27	4.23	5.27	22.26575
West	< 0.4	0.6	4.27	1.95	5.27	10.2765
Total daylight area per floor meeting UDI requirement during 90% of the year						**360.47425**
Total daylight area in building meeting UDI requirement during 90% of the year (360.47 * 2)						**720.9485**
Total Floor area (sq. m.)	1970.61					**0.365850422**

Table 2: UDI Analysis for CED

F. <u>Window- Wall Ratio:</u>

In the case of Surat city, the climate is mostly hot, with a high level of humidity throughout the year. As higher humidity reduces the indoor comfort and causes a sense of stuffiness in the rooms, it is important to provide good amount of natural ventilation, while controlling thermal heat gain. The window to wall ratio of CED Building, as per the analysis of physical survey and floor layout preparation was found to be:

Wall Side	Representing Image	Wall Area (2 x L x H) (Sq. m.)	Total Window Area (Sq. m.)	WWR= (Window area / Wall Area)	% WWR
North-South		462.81	317.16	**0.69**	**69%**
East-West		159.96	27.58	**0.17**	**17%**

Table 3. WWR Analysis

G. <u>Window- Floor Area Ratio:</u>

The ECBC Norms, 2017 recommends a total of 10% Window-to-floor area ratio, for buildings being constructed in "Hot and Dry" Climate. Upon inspection and manual analysis, taking into account all aspects of WFR calculation, the WFR of the CED Building was found to be 6.67%, which is satisfactory to control the amount of thermal heat gain into indoor spaces.

H. Thermal Transmittance through Roof:

The roofing of the building is done with waterproofing and covered by China Mosaic tiles for rainwater harvesting. The roof area of the building is 943.55 sq. m. As per ECBC, 2017, the recommended value for the thermal transmittance of the roof is 1.2 W/m^2K. As per the manual analysis of the building, the thermal transmittance of the CED building was found to be 0.47 $W/m^2.K$

Overhead shading is observed due to shadow formed by other buildings located in near vicinity, thus, helping in reduction of thermal heat gain through roof.

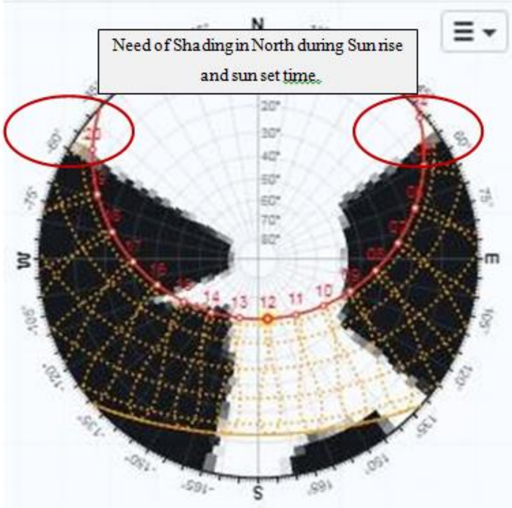


Figure 7. Building Shading

I. Natural Ventilation:

The building has its major axis of the building on North-East (67.5^O) - South-West (247.5^O). The wind direction for Surat city is North-South West for a majority period of the year, with an average wind speed of 5.0km /h. According to the breeze course, and fenestration itemizing, the more extended sides of the structure, with more openings, is given on the North and South faces of the structure, encouraging more air to go into the indoor spaces

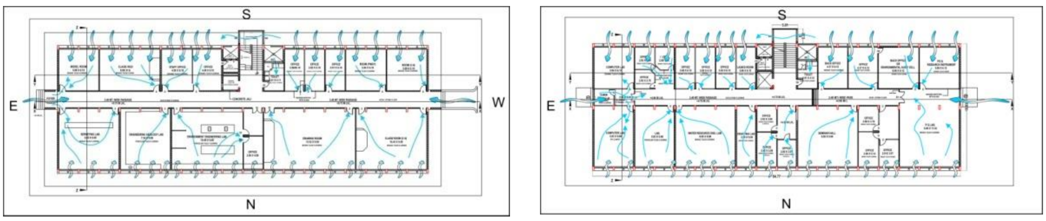


Figure 8. Natural Ventilation

Discussion

- The building does not satisfy the requirements of day lighting, hence need of electrical lighting is present during the day. This leads to addition in the energy used by the building for operations.

- Window to floor ratio proportion of the structure is discovered to be not exactly the base suggested esteem; hence there is less accessibility of natural air into the structure that may prompt awkward conditions in the inward space during summers.
- The Thermal Performance of the rooftop, in view of the climatic state of the investigation region is inside a worthy range, be that as it may, the U-Value of the rooftop is high in contrast with the Roof Assembly U-factor necessities, suggested in ECBC-2017. Along these lines the results of the rooftop isn't according to alluring levels, and there is an admission of unwanted thermal gain, causing a decrease of comfort conditions for the users.
- The Ventilation of the structure is discovered to be satisfactory throughout the winter, however because of less Window-to-floor proportion, the inside in summers feel blistering and blocked, prompting the requirement for mechanical cooling through climate control systems during summer days.

Conclusion

The study shows that the building under analysis faces major issues for the indoor environment due to lack of sufficient day lighting during the day and ventilation during different seasons. As Surat city has a hot-and-dry climate condition, the need of fresh air and ventilation is always required inside a building to create comfort conditions.

The lack of comfort conditions at present situations reduces the efficiency of the students and staff members, hence reducing chances of growth and development in them. The gaps which have been identified can be easily corrected with the help of the above-proposed recommendations.

Therefore there is a need to conduct a detailed energy audit of the building by use of Life Cycle Cost analysis, saving to investment ratio and Discounted Payback methods to retrofit the possible changes so as to create a more energy sensitive built structure for the campus.

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