Building Envelope Performance Evaluation for an Existing Academic Building of MMMUT, Gorakhpur

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Abstract

This research study focuses to make an appraisal of the Building Envelope Performance of the academic building of MMMUT, Gorakhpur, Uttar Pradesh. established in 1961 (59 Years old). The study areafalls under the "Hot and Dry" climate type as per the Climate classification of National Building Code-2016.The main aim of this research study is to investigate the existing academic building envelope and assess itsperformance based on the climatic requirements of the warm and humid climate. The Hot andDry climate zones generally have a mean monthly temperature < 30^{O}C and relative humidity < 55%.The studyis based on the investigation of present usage of the building, the orientation of the building, window-to-wallratio, window-to-floor area ratio and, ventilation analysis of the building. This research study undertakes acomparison of the present conditions of the building with the basic standards of Energy Conservation BuildingCodes, 2017 to identify the gaps in the building design. The focus is to understand if the indoor conditions ofthe building are good for working in all weathers of the city and identify the gaps which can be improved forbetterindoorambiance.ThisresearchstudystrivestoprovideStudents, Architects, Planners, and Civil Engineering consultants an example to achieve a basic understanding of green approach for Building designing.

Keywords: Building Envelope,Fenestration,Passive Architecture,Building Performance.

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1. Introduction

The concept of a building envelope refers to the physical cover, which creates a link between the conditionedindoor spaces and the unconditioned outdoor spaces around a building. It includes the roof, subfloor, exteriorwalls, windows, shading of windows, and exterior doors of the building. This is a significant factor thatdecides the indoor ambiance of the building during different weather; therefore, it needs to be climate appropriate for different temperatures and weathers, structurally sound to support loads exerted on the building , and aesthetically pleasing to enable better habitable space.

2. Need of Study

Thebuildingenvelopecreatesaphysicalbarrierbetweentheouterandinnerweatherandambiance,providing the inner area protection from the outer area along with the purpose of privacy. Studying thebuilding's inner environment during different conditions provides us with a clear idea of the energy consumedby the building and the comfort level of its users in various conditions. With the growth of population and theincreasing need for more habitable spaces for different purposes, the demand for energy for the functioning ofthese spaces is also ever-increasing. This energy demand requires us to find alternate sources of energy that causeless effect on the environmental conditions and naturally help in recharge of energy. The largest amount of energy consumption in the world is done by the building sectors. Therefore it is a basic need to create energy-smart buildings, which consume less energy and help conserve the natural conditions.

3. Study Area

Selection of the study area is done on the basis of its location, climatic conditions and ease of access to building for data collection purposes. Gorakhpur is a city along the banks of the Rapti river in the Purvanchal region of the Indian stateof Uttar Pradesh.As of 2011 Indian Census, Gorakhpur had a total population of 673,446, of which 353,907 were males and 319,539 were females. According to a 2020 report, 31 villages have been incorporated in the municipal corporation limits increasing the population to over 1 million. The city area has also increased from 145.5 km2 in 2011 to 226.6 km2

In Gorakhpur, the climatic condition is hot a temperate, The summers are short and sweltering; the winters are short, cool, and dry; and it is mostly clear year round. Over the course of the year, the temperature typically varies from 45°F to 107°F and is rarely below 40°F or above 114°F

Precipitation here is about 1169 mm | 46.0 inch per year. The average Relative Humidity of Gorakhpur is around 68% although it vary from around 38% during Summer (May) to 84% during the Monsoon (August). The most humid month of the year is August with humidity varies from 59.9% to 97.2%. The least humid month is of the year is May, with humidity varies from 14.0% to 73.6%.

3.1 About CED building

The academic institute under study is Madan Mohan Malviya University of Technology ,earlier known as Madan Mohan Malviya Engineering college established in 1962.Civil engineering department (CED) is one of the oldest departments in the university established in 1962.Block 2 of CED has orientation of northwest(NW) - southeast(SE), with NW side facing towards the jai krishan seminar hall as front. The total build-up area of the building is 1647.97 sq.m, divided within two floors (G+1).There is total 23 rooms on the ground floor as shown in figure, including a seminar hall, water resource laboratory, public health engineering laboratory, environmental engineering laboratory geotechnical laboratory, structural mechanics laboratory, concrete technology laboratory, one library, 10 faculty cabins, 4 toilets (2 each for ladies & gents) & 1 store room. First floor as shown in figure includes 2 laboratories & a conference hall with a pair of toilets for ladies and gents.

Themainobjectivesofthestudyareasfollows:

I. Tostudytheexisting ADM BuildinginthecontextofBuildingEnvelopeperformance.
II. Toidentifytheissuesoftheexistingbuildingenvelope.
III. Toanalyzeandprovidetheplanningproposalforupgradingenvelopemeasuresforthe CivilEngineeringDepartmentbuilding.

4. Literature Review

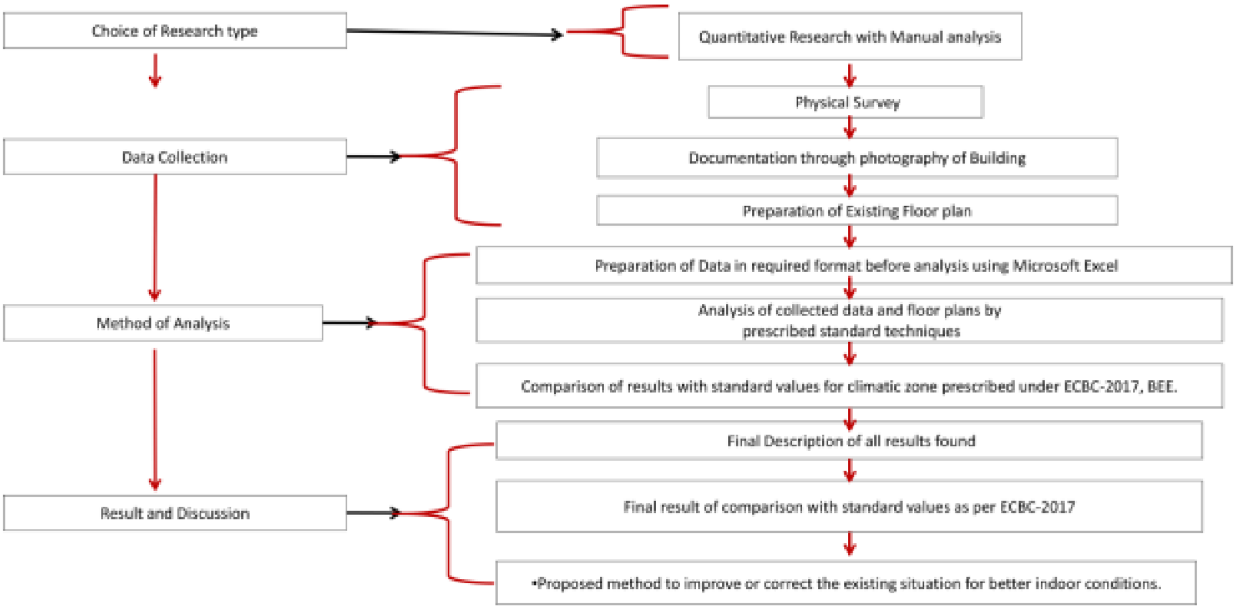
The Global Status Report, 2017 by UN Environment, International Energy Agency states that Buildings andconstruction sectors together account for 36% of global final energy use and 39% of energy-related carbondioxideemissions. The International Energy Agency targets a need for improvement of 30% by 2030inglobalbuildingsectorsto be back on track to meet the global ambitions set in the Paris Agreement.

There are various green building rating systems present across the world, that try to create a rating systembased on the performance-oriented markings and point system for each new target achieved by the buildings in the conservation of various energy sources like electricity, water, energy, natural environment, etc.

In India, rating systems of GRIHA, TERI; IGBC, and LEED India are acceptable for the green buildingsrating system. The Energy Conservation Building Code -2017 by the Bureau of Energy Efficiency is the mainregulatory law that is complied with for the analysis of all building types with a connected load of 100kW orgreater or acontractloadof120kVAorgreater.

5. Methodology:

The methodology used for the choice of research type, data collection, analysis, and formulation of theproposalwasdone asfollows:



6. Analysis:

Theanalysisofexisting Academicbuildingfor,MMMUT,Gorakhpurisasf ollows:

6.1. Useof Building:

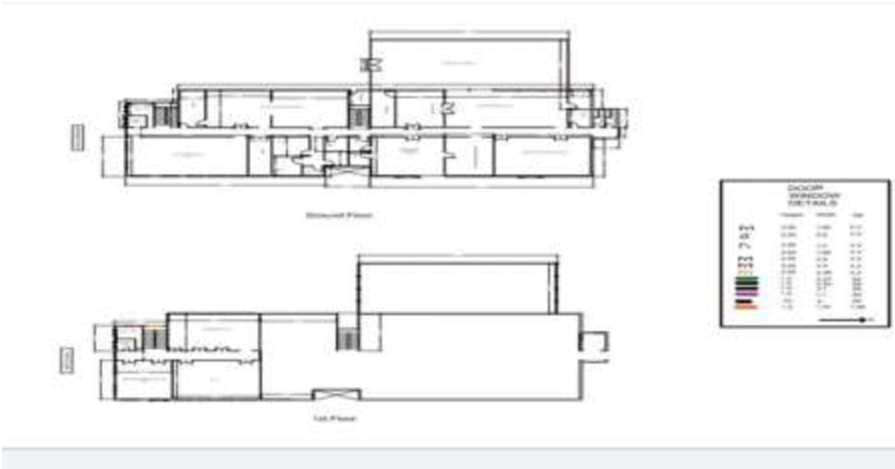
.The building is used for academic purposes, and consists of laboratory, classrooms, faculty rooms and department office on the ground floor; classrooms, laboratory, research scholars' cabins and seminar room on first floors.The building operates from 8:00 to 5:00 pm during Monday to Friday and 9:00 am to 1:00 pm on Saturdays occasionally

Total built-up Area	1647.97
Building floor wise Area	1992.95
Height of ground floor	3.04
Height of extension block.	6.32m

6.2. Orientation

It is a measure of the amount of the direct and diffused solar radiation that is received on the vertical surface in a specific orientation. This factor accounts for the fact that solar radiation falling on different orientations of walls is not the same.

333 degrees NW & 156 degrees SE (approximately) (with the major axis of the building



6.3. Window to Floor Area ratio:

The ECBC Norms, 2017 recommends a total of 10% Window-to-floor area ratio, forbuildings being constructed in "Hot and Dry" Climate. Upon inspection and manualanalysis, taking into account all aspects of WFR calculation, the WFR of the CEDBuildingwas foundtobe 6.67%

Water resources engineering lab	16.21%
Public health engineering lab	14.56%
Environment engineering lab	18.88%
Cabin 1.	13.06%
Cabin 2	29.88%
Cabin 3	0%
Cabin 4	40.20%
Cabin 5(Vinay Kumar Singh Sir)	8.94%
Cabin 6)(Madan Chandra Maurya Sir)	31.18%
Cabin 7	62.50%
Library	11.79%
Jai krishna Hall	17.11%
Extension block.	38.11%
FIRST FLOOR	
M.O.S Lab	20.99%
Lab	13.47%
Conference Hall	13.54%

	OUTER BUILDING WALL	***INNER BUILDING WALL***
Structure mechanics lab	18.36%	0%
Concrete lab.	46.35%	0%
Store room (concrete)	44.67%	13.13%

Geotechnical engineering lab	43.71%	0%
S.M.Ali jawed Sir Cabin	46.92%	0%
S.K Chaudhary Sir cabin	0%	0%
Cabin Structure lab.	48.21%	0%
Store room	0%	0%
Toilet (Men)	30.06%.	9.55%(North)
Toilet(Women)	5.13%.(North)	0%(North)

6.4. *Windows wall Ratio*

The window wall ratio of any building is the measurement of the percentage areadetermined by dividing the building's total glazed area by its exterior envelope wallarea. The need to define the window to wall ratio is to determine the amount of fresh air that can be made available to the users of the building at a given point of Time during the day. In the case of Gorakhpur city, the climate is mostly hot, with a high level of humidity throughout the year. In this way the requirement for new wind stream to make comfort conditions inside the structure rooms is significant. The window to wall ratio of CED Building, as per the analysis of physicalsur vey and floor layout preparation was found to be

	INNER BUILDING WALL	***OUTER BUILDING WALL***
Water resources engineering lab.	*46.22%*	*7.01%(North)*
Public Health engineering lab.	*46.42%*	*0%*
Environment engineering lab	*44.36%*	*4.50%*
Cabin 1	*15.41%*	*0%*
Cabin 2	*35.63%*	*0%*
Cabin 3	*0%*	*0%*
Cabin 4	*49.34%*	*0%*
Cabin 5	*0%*	*13.99%*
Cabin 6	*48.47%*	*0%*
Cabin 7	*48.15%*	*0%*
Library	*37.51%*	*0%*
Jai Krishna hall	*35.05%*	*23.46%*
Extension Block	*43.53%*	*38.09%*
FIRST FLOOR		
M.O.S Lab	*30.09%*	*24.28%*
Lab	*38.67%*	*0%*
Conference Hall	*37.53%*	*0%*

7. Results and Discussion

- According to the ECBC 2017 standards, the most extreme measure of WWRsuggestedis 60%..
- Nonetheless,onaccount ofCED working, astheWWRon theEastandWestexteriors are under20%, in this way the expansion of 9% in WWR on theNorth-South sides encourages the requirement for natural air in the inwardspacesofthe structure.
- The building doesn't satisfy the base daylight necessity need of 40%, thusthere is a requirement for extra artificial lighting during the day time,

causinganexpansionofvitality devouredbythestructure.

TheWindowtofloorratioproportionofthestructureis discoveredtobenotexactly the base suggested esteem; hence there is less accessibility ofnatural air into the structure that may prompt awkward conditions in theinwardspace duringsummers

ANALYSIS PARAMETER	OBSERVATION	ECBC-2017	REMARKS
Window to Wall Ratio	North-South 38.35 East-West 21.21	Maximum 60% Minimum 30%	Within Suitable Range in both N- S&E-W
Window to FloorArea(Daylight)	28.9% area of floor area covered	Minimum 40% for educational buildings	Does not fulfil requirements

8. Proposal:

8.1. BuildingIndoor Air Quality:

The indoor air nature of any structure legitimately alludes to the accessibility ofoutside air, rich with oxygen, which can expand the efficiency of the users of thestructure. As the CED Building is a scholastic structure, the requirement for highprofitability and mindful brain condition is an essential prerequisite for both theunderstudies just as the employees that educate them. Accordingly the requirementfor good air quality is an absolute necessity for the structure inside.According to theinvestigation, despite the fact that the window-to-wall ratio conforms to thesuggestions of the ECBC Norms, the window-to-floor area proportion is not exactlythe necessary levels. This issue can be understood by instilling indoor plants, whichcan give a wellspring of natural air inside the structure, just as draw in more air fromoutsidethestructure.

9. Conclusion

The Building envelopes are the physical separators or barriers constructed for thepurposeofcreatinganenclosed spaceandprivacyfor theusers ofthe building spaces. Day lighting is a very important aspect for any building, which hasbeen designed for academic purpose, as the common occupancy hours of thesebuildings are during day-time, hence creating a large scope and opportunity for thepurpose of energy savings from use of daylight. The quantity and intensity of thedaylight availability gets defined by the characteristics like building's geographicallocation, local climate conditions, building orientation, etc.The requirement fordaylight is an essential and should be accommodated for the better presentation andprofitability of study halls and personnel rooms present in the CED Building. Thebuilding, working in its current conditions doesn't follow the base prerequisites of thedaylight required, because of which artificial lighting fixtures are being utilized duringday time.Thus sensor-based daylighting frameworks are required for the structure,which can decrease the energy utilization of the structure insides. Additionally, a pre-timed system for guideline of switches of lights and devotees of the structures can beutilizedtoforestallneglectof turningoff ofthelightandfanapparatuses.

- Provisionofroofwhitetoreducethermaltransmittance.
- PaintingroofwithhighSRIpainttocreatereflectivesurface
- Creatinganotherfalseroof aboveexistingroof leveltoreducethermaleffect.

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