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Analytical Study of Natural Light and Ventilation in Admistrative Building of PCNTDA, Pune Region

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ABSTRACT

As one of the significant parts in the building design, use of natural light and ventilation which reflects one important factor of energy conservation to some extent. To ensure that decreasing use of energy resources to the maximum extent in constructions and make buildings harmonize with their surroundings, which has become important pursuing for inhabited building, at present, integrated design is to highlight natural ventilation and natural light use as main component of building design.

Urban areas continuously pollute the air in cities which affects the human health and the environment sustainability. This work analyses the provisions done in the Administrative Building for Pimpri-Chinchwad New Town Development Authority (PCNTDA) for utilizing natural light and natural ventilation to make the occupants and users much more comfort as compare to conventional building which are not taking care of natural light and ventilation phenomenon. The provision made in the building and saving due to provisions is calculated in this research work.

Keywords: *Natural Light, PCNTDA Building, Natural Ventilation*

1. INTRODUCTION

In 2019, India's total population stood about 1.3 billion and its share in the world population was around 17.84%. Globally, economic growth seemed to have picked up acceleration and expected to further improve in 2020-21. For India to achieve development objectives, its economy should continue to grow.

But for a country like India, where development is an imperative, environmental consequences can be substantial as it will place serious constraints on natural resources such as land, water, minerals, and fossil fuels, driving up energy and commodity prices. The extent to which its economy will "grow green" will depend on its ability to reduce the quantity of resources required over time to support economic growth that leads to enhancement of social equity and balance between productions where green growth could play an important role in balancing these priorities. [1]

In the face of pressing economic and environmental challenges, national and international efforts to promote green technology as a new source of growth have been intensifying in recent years. Building on this momentum can help to accelerate progress towards sustainable development; can achieve more sustainable use of natural resources, efficiencies in the use of energy, and valuation of ecosystem services.

Today, buildings worldwide account for up to 40% of total end-use energy. Building heating and cooling are the most energy-intensive activities, followed by electricity use for lighting and appliances (Harvey, 2009). The increasing demand for residential and commercial building spaces in developing countries like India will further push up energy consumption from building. Therefore, the purpose of this study is to examine the use of natural light and ventilation in residential building. [2&3]

A. Need of Study

As per the study by International Panel on Climate Change (IPCC) that CO_2 emissions from buildings (including through the use of electricity) could increase from 8.6 billion tonnes in 2004 to 15.6 in 2030 under a high growth scenario. The need and solution of today's scenario is green technology like using natural light and ventilation, which is an environmentally friendly technology developed and used in a way that protects the environment and conserves natural resources.

B. Study Objective

The research objectives for the execution of the thesis are as follows:

1. Use of Natural Light & Ventilation in Building with India contest.
2. To reduce the rate of growth of energy consumption while enhancing economic development.

2. LITERATUREREVIEW

The Effect of Natural Ventilation and Daylighting on Occupant's Health in Malaysian Urban Housing

In this research paper author analysed terraced houses which account for 44% in Malaysia of the existing urban housings. The spatial characteristics of natural ventilation and daylighting have been studied by author. The analysis shows the design causes indoor thermal and visual discomforts due to gloomy indoor spaces, low air change rate and poor indoor air quality. As per the research paper indoor environmental stressor can produce negative stress on occupants' health, the effect of natural ventilation and daylighting on occupants' comfort and health in the terraced houses was investigated.

The findings demonstrated significant linear relationships between indoor comfort and health. However, occupant's behaviour did not give significant impact on comfort and health. Besides, the effects of natural ventilation and daylighting performances on specific health issues were also studied. The findings concluded that the by-law requirement of 5% window-to-floor ratio for natural ventilation is inadequate for occupant's comfort and health, thus further review is needed.

A Literature Review of the Effects of Natural Light on Building Occupants

This paper presents summary information from a noncritical literature review on daylighting in buildings. In this research paper author compile a listing of the literature that is commonly cited for showing the impacts of daylighting in buildings.

According to the Department of Energy's Office of Building Technology, State and Community Programs (BTS) 2000 Data book, commercial buildings consumed 32% of United States electricity in 1998, of which 33% went to lighting. Not only is electrical lighting responsible for a significant amount of the electrical load on a commercial building, but it can also cause excessive cooling loads. Utility costs for a building can be decreased when daylighting is properly designed to replace electrical lighting.

Along with the importance of energy, author has demonstrated the non-energy related benefits of daylighting. Quantitative studies and qualitative statements are used to summarize the use of daylighting in buildings, its effects on occupants, and its potential economic benefits.

Parametric Study of Light-Well Design for Day-Lighting Analysis under Clear Skies

Author carried out the study of Light wells which are vertical spaces used in multi-storey buildings to illuminate spaces without direct day light access. Light wells become an integral part of the design especially in sites with min frontage and multi-storey residential buildings. Design requirement based solely on the dimensions and area neglects several aspects that may affect the performance of the light well. Reflectivity, windows area and aspect ratio, building orientation, and the aspect ratio of the light-well itself are important factors in determining the performance. RADIANCE (Radiance is a type of glowing) simulation models and an automated process using LUA (programming language) code were used to perform the parametric variations. A physical building model was used to calibrate the RADIANCE simulation.

Daylighting estimation and analysis in residential apartment building: GIS based approach

In this paper author related the opening and light quantum in building. According to author, the openings in the building envelope have a great influence on daylighting in the internal area of the building spaces. The amount of opening area, its orientation, outside obstruction & positioning of building affects the inside illumination. This paper aims to provide a simplified analytical and GIS based approach to evaluate the potential of daylight inside the room under clear sky conditions. The work evaluates the intensity of internal illumination in residential apartment building from available outside external illumination.

Using passive cooling strategies to improve thermal performance and reduce energy consumption of residential buildings in U.A.E. buildings

The aim of author for this study is to test the usefulness of applying selected passive cooling strategies to improve thermal performance and to reduce energy consumption of residential buildings in hot arid climate settings, namely Dubai, United Arab Emirates. One case building was selected and eight passive cooling strategies were applied. Energy simulation software – namely IES – was used to assess the performance of the building. Solar shading performance was also assessed using Sun Cast Analysis, as a part of the IES software. Energy reduction was achieved due to both the harnessing of natural ventilation and the minimising of heat gain in line with applying good shading devices alongside the use of double glazing. Additionally, green roofing proved its potential by acting as effective roof insulation. The study revealed several significant findings including that the total annual energy consumption of a residential building in Dubai may be reduced by up to 23.6% when a building uses passive cooling strategies.

Natural ventilation in buildings: An overview

According to author, natural ventilation is a sustainable design strategy. Natural ventilation is of a great environmental advantage, compared to the mechanical ventilation strategy. This has encouraged several researches on natural ventilation implementation in buildings, considering its main objective of providing buildings with the required air quality and quantity.

A review of human thermal comfort revealed that natural ventilation has a high potential for improving thermal comfort in hot climates, implementing wind-induced ventilation, and in cold climates, implementing temperature-induced ventilation. Natural ventilation affects different heat transfer mechanisms between human body and its ambient environment. This mostly occurs in the form of sensible heat, by convection and radiation, and the form of latent heat, by evaporation of moisture on the skin.

The Effects of Void on Natural Ventilation Performance in Multi-Storey Housing

It is very crucial to consider the configurations of voids in the buildings for enhancing natural ventilation, especially for multi-storey housing. In this study, Malaysian Medium Cost Multi-Storey Housing (MMCMSH), which is an example of multi-storey housing located in a suburban area, has been selected in this study. This study aims to investigate the potential of void for enhancing natural ventilation performance in multi-storey housing by the comparison of two different void configurations. This study revealed that the provision of void can enhance natural ventilation performance in multi-storey housing with an increase in the value of Q, from 3.44% to 40.07%, by enlarging the void's width by 50% compared to the existing void.

Natural Ventilation of Buildings through Light Shafts: Design-Based Solution Proposals

In this research paper author analyses how the built environment affects the quality of the air to be introduced into buildings from light shafts. The main objective of research by author focuses on the impact of standardized architecture design in the quality of the indoor air dependent on the air change in the light shaft. The air change capacity of the outdoor space is numbered analysed using the concept of air change efficiency (ACE).

The longer the light shaft in the wind direction is, the better the ACE is compared with other options. Light shafts up to 12 metres high are the most suitable in order to obtain acceptable efficiency results. Other studied cases verify that assumption. Different simplified tools for the technicians to evaluate the design of buildings containing light shafts are proposed. Some strategies of architectural design of buildings with light shafts to be used for ventilation are presented.

The application of natural ventilation of residential architecture in the integrated design

According to author, to ensure that decreasing use of energy resources to the maximum extent in architectures and make architectures harmonize with their surroundings, which have become important pursuing gradually for residential architecture, at present, integrated design of residential architecture should not only highlight natural ventilation technique, but also should integrate natural ventilation and main feature of local climate, etc. What's more, designers shall carry out unified analysis on the base of taking all factors into consideration. This point is more important. By this way, architecture technique can be more comprehensive and complete. With the guidance of sustainable development concept, natural ventilation as one of ecological technologies is applied extensively in many architecture designs owing to its economic effect and health benefit.

3. METHODOLOGY

The Primary data will be obtained from the literature review and case study of building in which natural light and ventilation is used and applied in basic design of building and the collected data will be correlated with the present investigation.

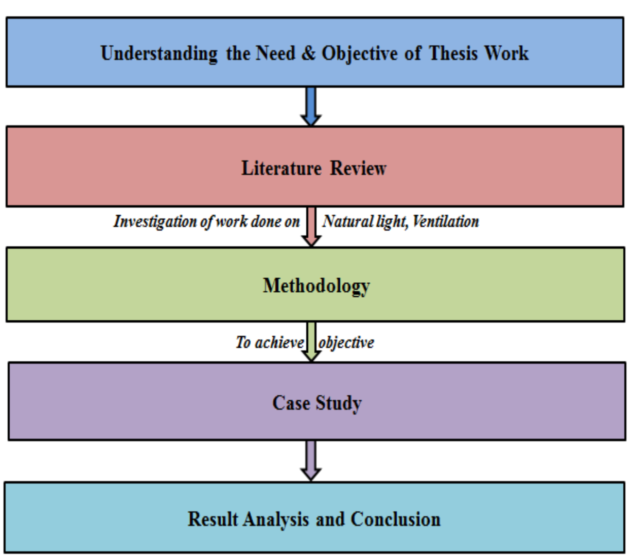

Figure No 1: Overall Methodology Process

4. CASE STUDY

A. Case Study Brief

Project	Administrative Building For Pimpri-Chinchwad New Town Development Authority (PCNTDA)
Location	Pune, Maharashtra, India
Momentary of Building	G+6 green building, five star rating received from GRIHA
Cost	40 Crore
Area	1.4 Lakh Square feet
Concern Authority / Client	Pimpri-Chinchwad New Town Development Authority
Architects and PMC	Landmark Design Group
Electrical Consultants	Federal Engineering
Plumbing and sanitation and fire-safety consultants	MCCE
Environment and energy audit	TERI
Structural consultants:	Gensys technologies
Landscape Architects:	Kshitija Kolhatkar
Contractor	VMM Infrastructures Pvt Ltd
Present status	Work Completed in 30 November 2012 and Building is in use from February 2013.

B. Case Study Location

Pune also called Poona, the official name until 1978 is the second largest city in the Indian state of Maharashtra, after Mumbai. Pune city is known on the world map because of its scenic beauty and rich natural resources as well as its educational institutions. Akurdi is a village in India, situated within Mawal taluka, in Pune district, in the state of Maharashtra. The latitude and longitude of study area Administrative Building for PCNTDA is 18°64'94" and 73°76 '89 ".

C. Practice of Sustainability in Building

The case study building is located in Pimpri-Chinchwad, a twin city of Pune. The Pimpri Chinchwad new Town Development Authority guides and directs the development of a sizeable part of this city. The new administrative building for PCNTDA had of course to be iconic; however, it ought to make a statement, though in a meaningful sense. Pune, though classified as part of the humungous 'warm and humid zone' in the ECBC climate map, has a rather moderate climate, except for the 2.5-3 months of summer. Westerly wind is actually cool sea breeze from the Arabian Sea that travels about 100 km inland, having climbed up the steep Western Ghats, and losing quite a bit of its moisture reroute. It is well known fact that when it is really warm, air movement can provide relief and comfort.

The building form was a resultant of the functional requirements put side by side with solar passive principles. This involved orienting and locating the various (functional components) with respect to the sun for thermal comfort, enhancing this by enabling cross ventilation and maximizing daylight without ending up with heat gain. Pune being located at approximately 18.5 degrees north latitude north is the most appropriate orientation for daylight. So we have these two narrow, about 14 metre wide northward, (actually NNE) facing earth-coloured blocks, that rise up starkly to nearly 30 metres from the ground, staggered so that daylight is achieved and views are unhindered. The triangular spaces in plan house lifts, staircase blocks and toilets. The narrow easterly and westerly facades are scooped out in the wind flow direction, the resulting form almost inviting the wind to flow in. The fenestration is more of a textural treatment, with shading devices designed appropriate to each orientation.

The east and west walls have large openings, shaded with horizontal louvers to block direct radiation, but to allow for free flow of wind across.

Figure No. 2: North orientation for day light

Many small but significant features are incorporated in the case study building such as perforations in the parapet to carry away hot air that stagnates at the surface of the roof, or stack ventilation for the toilet blocks, that prevents odour spreading to the rest of the building.

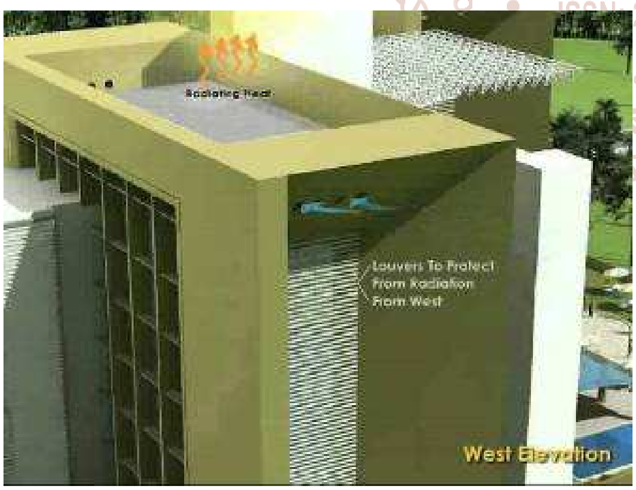

Figure No. 3: East west cross ventilation through louvered openings and Terrace top ventilated to remove heat

Evaporative cooling is achieved for the canteen area located above the parking block, by means of westerly wind blowing over fountains in a waterbody on the terrace garden. The energy and comfort simulations were carried out by TERI, and they predicted that just using ceiling fans, the building would have unsatisfactory comfort conditions for only 4% of the annual habitable hours.

Figure No. 4: Evaporative cooling through Westerly Wind

This has been (amply demonstrated), now that the building is in use for nearly 7 years now. Since there is very little air-conditioning, the energy footprint is so low that the entire building of nearly 1.4 lakh sqft is run entirely on an online 100 Kw Solar PV system.

Figure No. 5: 100 Kw Solar PV system

A light shelf is a horizontal surface that reflects daylight deep into a building. Light shelves are placed above eye-level and have high-reflectance upper surfaces, which reflect daylight onto the ceiling and deeper into the space.

Light shelves are typically used in high-rise and low-rise office buildings, as well as institutional buildings. This design is generally used on the equator-facing side of the building, which is where maximum sunlight is found, and as a result is most effective. Not only do light shelves allow light to penetrate through the building, they are also designed to shade near the windows, due to the overhang of the shelf, and help reduce window glare. Exterior shelves are generally more effective shading devices than interior shelves. A combination of exterior and interior shelves will work best in providing an even illumination gradient.

Architectural light shelves have been proven to reduce the need for artificial lighting in the case study buildings.

Figure No. 6: Light shelf for enhancing daylight

D. Design Calculation

Simple calculations as illustrated in the following section helped to understand the 'naturally ventilated and day light' building was the right choice and much better saving other than conventional buildings.

i. Air Conditioning

In a conventional office building 100% carpet area is covered by air-conditioning.

Conventional building:

Carpet area to be air-conditioned	=63072 Sq. ft
Required capacity of Air-conditioning	=460 TR
Average power consumed in 8 hr cycle	=460X1.2X8 hrs
(Mean of summer, monsoon and winter	=4416 units
	Cooling load)
Net power consumption for 270 working days	
	=11, 92,320 units

Design Used in Case Study Building:

Carpet area to be air-conditioned	=11237 sft
Installed capacity of air-conditioning	= 82TR
Average power consumed in 8 hr cycle	= 82X1.2X8 hrs
	=787.20 units
No. of ceiling fans	=180 no.s
Avg no. of hours of ceiling fan use	= 6 hrs per day
Average power consumption per fan (in 8 hr Cycle)	= 0.5 units

Total power consumption by ceiling fans per day =90 units

Total power consumption for air conditioning and ceiling fan combination
= 877.2 units

Net power consumption for 270 working days
=236844 units

Net savings in unit terms per year =955476 units

Present cost per unit (commercial) =Rs 5.50

Net savings per year in Rupees due to maximization of natural ventilation =Rs55,55,118.00

ii. Day Light

Conventional building:

- No.of fittings (3 X 36w CFL tube 600mmX600mm)required =1200 no.s
- Average power consumption per fitting per day (8 hrs) = 0.9 units
- Total no. of working days in a year = 270 days
- Total no. of overcast days = 80 days
- Total no. of clear days = 190 days
- No. of fittings in use in a conventional building on
- A clear day (considering 15% daylighting) = 85% i.e. 1020 fittings
- Power consumption for 190 days = 174420 units
- No. of fittings in use in a conventional building on overcast day
- (considering 0% daylighting) = 100% i.e. 1200 fittings
- Power consumption for 80 days = 86400 units
- Total annual power consumption for lighting = 2, 60,820 Units

Design Used in Case Study Building:

No. of fittings (3 X 36 w CFL tube 600mmX600mm) required =1200 no.s

- Average power consumption per fitting per day (8 hrs) = 0.9 units
- Total no. of working days in a year = 270 days
- Total no. of overcast days = 80 days
- Total no. of clear days = 190 days
- No. of fittings in use in our building on clear day
- (considering 90% daylighting) = 10% i.e. 120 fittings
- Power consumption for 190 days = 20520 units
- No. of fittings in use in our building on overcast day
- (considering 0% daylighting) = 100% i.e 1200 fittings
- Power consumption for 80 days = 86400 units
- Total annual power consumption for lighting =106920 units
- Net savings in unit terms per year = 153900 units
- Present cost per unit (commercial) = Rs 5.50
- Net savings per year in Rupees due to maximization of Daylighting = Rs 8, 46,450.00

5. CONCLUSION

The learning outcome from the comprehensive study of Administrative Building for PCNTDA is that the building is designed and executed to make a strong pro-environment statement by making a model green building. Considering the almost moderate climate of the Pune city with only four months of extreme weather in the summer, effort was made to maximize naturally cooled spaces and minimize artificially conditioned spaces. Building orientation was important, with maximum length of the building façade towards north and south. The maximum glazing was provided on the north to make best use of the diffused natural light. A combination of horizontal and vertical shading devices were used cut down direct solar gain. Light shelves for deeper daylight penetration, evaporative cooling with the help of strategically placed water bodies and ventilated under surface of roof to disseminate heat are few other methods adopted to reduce energy consumption. With these initiatives, artificial conditioning is only used in 11,237 sqft of the building's carpeted area (out of a total 63,072sqft) which lead to the annual saving of 55.5 lakh per year in air conditioning.

It is also observed that GRIHA was used as a guiding tool in the entire design and construction process to achieve the desired target. Since 1% renewable energy integration is mandatory in GRIHA, the project opted for solar photovoltaic. Eventually, with additional 30% subsidy on solar panels by MNRE, the project installed solar photovoltaic of 100kWp capacity that would generate energy equivalent to the consumption of the entire building which will again save the money.

REFERENCES

[1] Egyptian Ministry of Housing, Utilities, and the Urban Development, Central Agency For Public Mobilization & Statistics Data Cairo, Kasr El Ainy, Cairo, Egypt.

[2] M. D. Egan and V. W. Olgyay, Architectural Lighting, 2nd ed. McGraw-Hill: New York, 2002, pp. 27–30.

[3] H. Kotani, M. Narasaki, R. Sato, and T. Yamanaka, "Environmental assessment of light well in high-rise apartment building," Building and Environment, vol. 38, no. 2, pp. 283–289, 2003.

[4] Z. Kristl and A. Krainer, "Light wells in residential building as a complementary daylight source," Solar Energy, vol. 65, no. 3, pp. 197–206, 1999.

[5] N. Lechner, Heating Cooling, Lighting, 2nd ed. Wiley: New York, 2001, pp. 368–369.

[6] Y.-H. Su et al., "Evaluation of a lightwell design for multi-storey buildings," International Journal of Energy Research, Int. J. Energy Res. (2010), Wiley Inter Science Published Online: 14, Jan 2010.

[7] I. Diego et al., "Daylight factor simulations – how close do simulation beginners „really" get?" in Proc. Eleventh International IBPSA Confe. Glasgow, Scotland, July 27-30, 2009.

[8] J. Mardaljevic, "Simulation of annual daylighting profiles for internal illuminance," Lighting Research & Technology, vol. 32, no. 2, pp. 111-118, 2000.

[9] C. F. Reinhart and M. Andersen, "Development and validation of a Radiance model for a translucent panel," Energy and Buildings, vol. 38, no. 7, pp. 890-904, 2006.

[10] C. F. Reinhart and O. Walkenhorst, "Dynamic RADIANCE-based daylight simulations for a full-scale test office with outer venetian blinds," Energy & Buildings, vol. 33, no. 7, pp. 683-697, 2001.

[11] Hopkinson R G, Petherbridge P and Longmore J 1966 Daylighting, Heinemann, London

[12] Harvey J Bryan 1979 A simplified procedure for calculating the effects of daylight from clear skies Lawrence Berkeley Laboratory, University of California Berkeley, California