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Energy Optimization in Commercial Office Buildings: Use of Glass Facade

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Abstract
In recent years, the prevailing use of the glazing in building facades has been increasing in Kathmandu Valley without having a clear understanding of such trend in terms of various other important dimensions of buildings such as energy use, demand, and the desired comfort level. As evident from several studies, the energy consumption is increasing in commercial buildings with increased use of glazing for aesthetic reasons in different amounts in the lack of empirical understanding of heat loss and gain and its consequences on the overall comfort level and operational costs. This paper aims to highlight the thesis research on the performance level of glazing facade of an office building to save energy consumption as compared to prevailing conventional commercial buildings. A case of office building was taken from the Kathmandu. The experimental research strategy is used in which the building envelope with glazed facades were studied using performance modeling of building envelope. The finding suggested that the annual energy demand could be reduced to 18% to 20.1% according to the alternative wall material chosen. The result is generalized for improving the energy performance of the commercial building that can inform the designers as well as developers.

Keywords
Commercial Buildings Thermal load, Use of Glass Facade, Energy Optimization

1. Introduction

Commercial office building which contains spaces mainly designed to be used for offices. The color, transparency and reflected patterns can change with the time of day and weather. Although appearance is important in architecture design, the traditional purpose of the window was to provide light, view and fresh air for occupants[1] .

The issue of energy consumption in buildings is more important, due to the cold climate in Kathmandu Valley. The use of the glazing in commercial office building facades has been increasing without having a clear understanding of such trend in terms of various other important dimensions of buildings such as energy use, demand, and the desired comfort level.

The energy transmission is studied through the use of glazing facade and energy consumption for heating and cooling load by use of Glazed facade. The need of people is realized to feel comfortable and improvement of heating/ conditioning, ventilation, and natural light. These help to minimize the energy use pattern and avoid dependency on fossil fuel.

As evident from several studies, energy consumption is increasing in commercial buildings with increased use of glazing for aesthetic reasons in different amounts in the lack of empirical understanding of heat loss and gain and its consequences on the overall comfort level and operational costs [2].

The main objective of this study is to check the influence of glass facade in the energy consumption pattern (heating and cooling load) and to prepare an energy optimization model for low operational cost.

2. Methodology

The study used an experimental research strategy in which a simulation of a commercial building was carried out using Ecotech simulation software (2011). Using 10 years data from the Department of Hydrology and Meteorology Nepal, a weather file was generated using Meteonorm software. In-situ study of a commercial building was carried out to identify the orientation, major building features including design and construction materials, technology, occupancy and the equipment used. The different of scenarios were created to evaluate the thermal performance of building such as glazing type and materials. The output data were then analyzed for different scenarios. The result was then generalized for future planning and policies making. The influence of parameters window-to-wall ratio, type of glass and facade setting were evaluated based on the total annual energy consumption. The use of day-lighting and energy consumption for artificial lighting system was not taken into account.

3. Limitation

The research is done for Commercial office building for Kathmandu valley. All the data are secondary to check glass material thermal performance considering other variables are constant or independent.

4. Literature Review

4.1 Heating and cooling Thermal loads

The maximum amount of glass uses on facade for office branding. The use of glass as a component of the building envelope has been significantly grown since its initial introduction as a building material. The glass is necessary for aesthetics, ventilation, and daylight. Despite the many benefits to the building, the glazing still provides the lowest insulating value. Of all envelope components, windows and skylights represent major sources of thermal losses and gains which impact the thermal comfort in buildings. Therefore, window size, type, and design are the most important consideration for reducing the need for space heating and cooling [2].

4.2 Glass Fenestration

The window is one of the most significant elements in the design of any building. Whether present as a small punched opening in the facade or as completely glazed curtain wall which is the dominant feature of a building's appurtenance. The color, transparency and reflected patterns can change with the time of day and weather. Although appearance is important in architecture design, the traditional purpose of the window was to provide light, view and fresh air for occupants [1].

4.2.1 Solar Heat Gain Coefficient or 'g' value

The Solar Heat Gain Coefficient (SHGC), which measures a window's ability to transmit solar energy into a room, is measured in value from 0 to 1. The SHGC is commonly referred to as the g-value or solar factor. The lower a window's g-value, the greater its ability to insulate against solar heat build-up [3].

4.2.2 Low emissivity Glass

Low-emissivity glass is a type of energy-efficient glass designed to prevent heat from escaping through your windows to the cold outdoors. Low-e glass has an invisible coating which dramatically reduces heat transfer and reflects interior heat back into your room [4].

4.2.3 Window Rating

It designed by the British Fenestration Ratings Council to measure the thermal performance of windows. The Window Energy Ratings (WER) scale runs from A to G, with A being awarded to the most energy efficient windows. The WER take into account the U-Value, the solar heat gain (g value) and the air leakage rate of all the components of the fitted window [5].

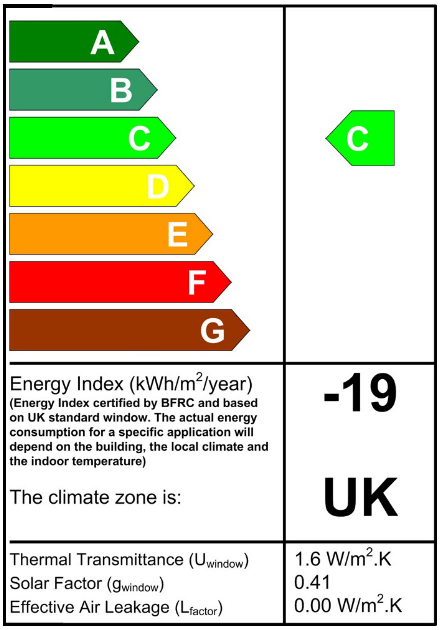

Figure 1: Window Energy Rating Chart [Source: http://www.bwc-ltd.co.uk/ assets/editor/uploaded/1752full.jpg]

4.3 Thermal Comfort

The adaptive approach is defined as people's reactions to changes that produce discomfort, in order to restore their comfort. The adaptive thermal comfort model thus interprets this inclination to maintain comfort by changing or adapting to their environment. respondents to an environment where environmental parameters; air temperature, radiant temperature, humidity, and air velocity can be controlled [6].

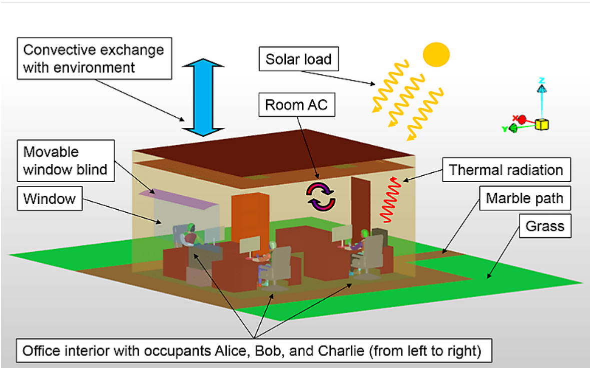

Figure 2: Environmental conditions acting on office space Source: https://www.theseus-fe.com/application-areas/buildings

4.4 Energy Optimization by Simulation

Energy modeling is done in Ecotech (2011). The simulation in different energy scenario to check the thermal performance of glass. The output data are generalized to do optimization of energy consumption. So, Energy can be sensitivity to mitigate unwanted use of energy source. It is considered to forecast the demand for energy and wisely use by long term energy planning management system. The benefits of windows are highly valued and contribute to the satisfaction of health and productivity of building occupant [1]. Insulation - Low–e systems, Double Glazing Units with air, Double Glazing Units with an inert gas, Triple Glazing Units with air, Triple Glazing Units with an inert gas, U-value (3.2 to 1.0) [1].

4.5 Location of buildings

Location and layout should be considered from the beginning of the design process for solar gain, as well as considering location, orientation and window size and placement, it is also important to consider the thermal performance and solar heat gain efficiency of the glazing unit itself. If optimal orientation can be achieved, it will reduce some of the heating requirement, reduce energy costs and reduce greenhouse gas emissions.

4.6 Parameter Analysis

It studies on the thermal performance of glazed facades confirm the importance of proper specification of their elements according to the climate conditions of the building location. The investigation about the influence of Window Wall Ration (WWR), glass type and its thermal transmittance [7].

Table 1: Glass thermal properties(Saint gobin Glass)

Glazing type	Thickness	U-value	Solar Coeff (%)
Single Glazed	15 mm	5.6 Wm^2K	77
Double Glazed	6+15+6	1.88Wm^2K	28

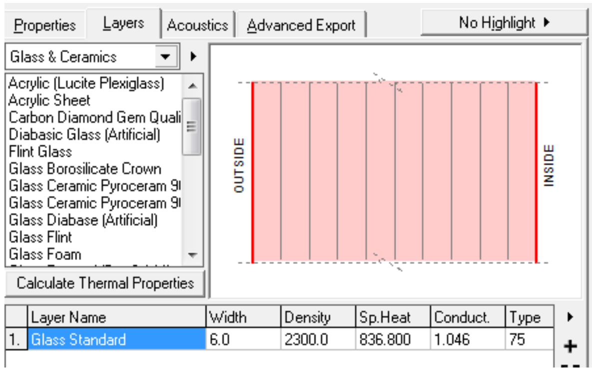

Figure 3: Single Glazing section detail

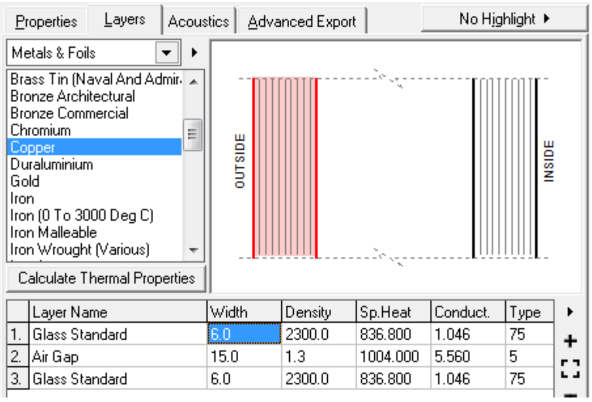

Figure 4: Double Glazing section detail

5. Energy Simulation

Trade Link International (TLI) is engaged with a wide range of business and industrial concerns ranging from supply and installation of machinery equipment, consumer electronics, and computers. We are a single entity of solution to handle feasibility studies of projects related to Hydropower, Roads, Environment, Transportation, Water Resources and Irrigation, Infrastructure and many more. This building is situated in Babarmahal. The length and breadth of building is 30m and 8 m respectively.

Figure 5: Trade link Building, Babarmahal

A base case building has been adopted to research the thermal performance by simulation model in Ecotech (2011), representing a rectangular shaped office building, with open plan spaces, thermal zones, with 5 floors total. Peripheral areas are conditioned and correspond to office spaces.

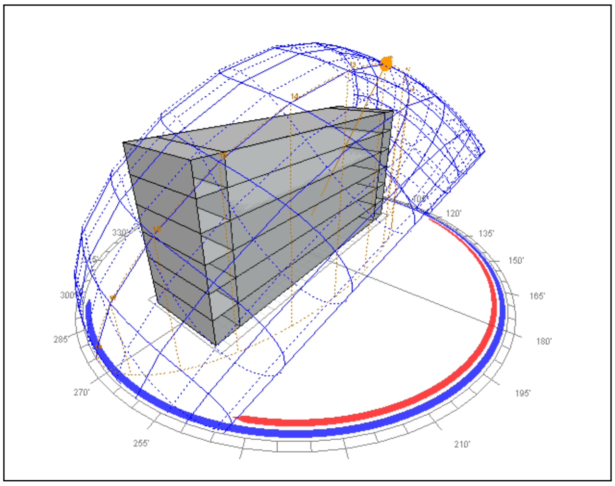

Figure 6: Energy modeling of Trade link building

The total surface area exposed to the outside environment is 4416m^2 and window area is 431.252 m^2 (29.9%). The orientation of the building is south with fully glazed facade.

6. Finding Discussion

The existing building window glass which is single glazed with the thermal properties indicated above is simulative for the base case. It has been overserved that cooling load is comparatively higher than the heating load. The cooling load is a peak in May followed by June and July. The total cooling load contributes 41634.238 kWh whereas Heating Load contributes to 5918.838 kWh. The total energy of 47553.078 kWh consumes for cooling and heating of building.

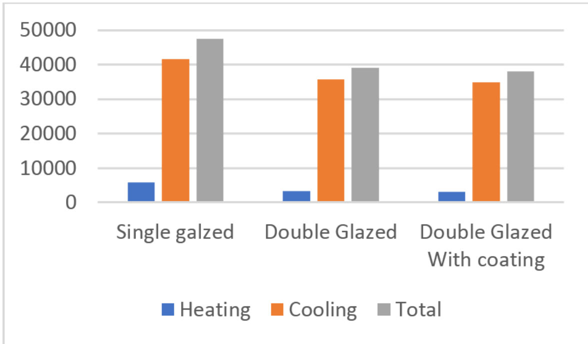

Figure 7: Energy performance of building according to glazed facade type

Table 2: Annual Thermal load)

	Heating (kWh)	Cooling (kWh)	Total (kWh)	Eff.
Single galzed	5918	41634	47553	
Double Glazed	3265	35721	38987	18%
Double Glazed With coating	3087	34894	37982	20.1%

There is the possibility of energy saving by reducing cooling and heating load. Data of energy consumption of the set of cases simulated with conventional facade are presented. The figure 7 shows clearly that the total energy consumption pattern is more in single than double glazed. Its show that double glazed system is 18 to 20.1% more efficient than single glazed. Thus, the influence of the glass thermal conductance in building energy performance is dependent.

Table 3: Comparison of U-value with different window types

Glass	Base Case	Alternative-1	Alternative -2
	Single Glazed	Double Glazed	Double Glazed with coating
Model	Evolite	Refectsol	Refectsol
Shade	Neutral	Light gold	Light Gold
Thermal Properties	U= 5.0 W/m^{2}K SHGC = 0.58	U= 2.8 W/m^{2}K SHGC = 0.49	U= 1.8 W/m^{2}K SHGC = 0.43

7. Conclusion

Annual Electricity consumption in an existing building is 47553.078 kWh/year. Electricity consumption in design building by use of double glass facade is 38987.453 kWh/year i.e. 18% of annual energy consumption will save.

The energy consumption for cooling was confirmed linearly dependent on the window area for all climates under analysis. But the level of influence of the glazed area on energy consumption depends on other factors, such as the type of glass and type of facade covering. Selective glazing systems, with lower Solar Heat Gain Coefficient have provided better energy performance for the building envelope.

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