ANALYSIS OF ENERGY CONSERVATION OF AN INSTITUTIONAL BUILDING USING DESIGN BUILDER SOFTWARE

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Abstract: Buildings contribute impact on CO₂ emission and energy consumption. Electric energy consumption in buildings is about 40% of the total energy consumption of India. In this work building simulation technology is used to evaluate a variety of envelope thermal characteristics and low carbon technology in an integrated manner at the early design stage itself to assist the delivering of sustainable green buildings with a high rating of performance and energy consumption. Building simulation enables designer to identify the key energy loads, test their strategies and compare permutation of design strategy in order to optimize the energy consumption.

Design Builder (DB) software is used to carry out a series of sensitivity analysis on set of design parameters, with an aim to achieve a comfortable and energy efficient building. Several parametric studies have been conducted to enable building designers to carry out analysis of energy efficient building model related to building orientation, construction, air infiltration, natural ventilation, window type, openings, and lighting. To calculate the energy saving, basic condition of building model is compared with Energy Conservation Building Code (ECBC) building model. Consider basic condition of building is case A and condition of building according to ECBC is case B.

Keywords: Energy conservation, Design Builder, Institutional building, ECBC (Energy Conservation Building Code)

1. Introduction

India required 2% more energy than the total growth of world [8]. Approximately one third part of energy is consumed in building so that conservation of energy is become very important and urgent need. To conserve energy it is essential to make energy efficient building and re-examine and modify the existing building.

Energy efficient buildings are provides direct profit to vendor and developer. Developer may reduce their electricity expenses and taxes.

Buildings with improved efficiency create up to 15% more profits and 4 % higher tenure rates than without energy efficient buildings. Retrofitting can save owners 10 to 50% in energy expenses and energy-efficient investments in lighting are as high as 85 percent [26]. In addition to savings, building venders are expecting a payback time on their efficiency investments of three years or less. Energy efficient buildings are more advantages for developers and employees. [26].

2. Literature review

Energy simulation software determines and evaluates the energy demand and the indoor climates in a building are changes with environment and condition like temperature set point. For low transmission losses windows of less heating are needed [23]. The assessment of energy performance of buildings depends on a number of factors associated with local climate. In cold countries the assessment of building depends on heating dispersions. In these countries buildings requires to highly insulating openings and frames so that capture the solar energy throughout frames and walls [15].

Daylight from the sky and the natural light incoming a building depends on both internal and external condition. Indoor condition includes the dimension and location of the windows, the depth and profile of the rooms and the colours of the surfaces. The light reflected from the floor and opposite facades are essential sources of interior lighting [21].

Building energy management depends on the surroundings. The idea of the analytical control and execution of optimum control strategy reduce the energy consumption and increased comfortable condition in buildings [29].

Building is made of a concrete envelope and roof is insulated with glass and the ventilated façade each office. The set-point temperature is 21⁰C during the working time, and an 19⁰C setback is applied during no working time on weekdays [28].

3. Scope of energy efficient building in India

India is working in direction of increasing building efficiency. In 2009, Government approved the National Mission for Enhanced Energy Efficiency. Ministry of Power and the Bureau of Energy Efficiency (BEE) has adopted the Energy Conservation Building Code (ECBC) and in 2007 minimum building standard is established [4]. ECBC is at present voluntary and the Ministry of Urban Development and BEE will work with state and governments to consider these codes mandatory in upcoming years. The Ministry of Environment and Forests also take project on environmental impact assessment.

The Indian Government provides and is growing the scope of financial incentives for upcoming efficient buildings. The Ministry of New and Renewable Energy's certified green rating for integrated habitat assessments (GRIHA) for buildings and developers get cash prize of Rs. 2.5 lakhs for a 3 energy star rating building, and Rs. 5.0 lakhs for a 4 energy star and municipal corporations may get up to Rs. 50 lakhs for 5 energy star rating.

Energy simulation tools provides designers to

- Assume the building as a single integrated unit
- Calculate the effect of natural and artificial light inside the building
- Model the effect of wind pattern and ventilation in the building
- Calculate the effect of various building envelop and predict resulting conditions
- Evaluate energy consumption through sensitivity analysis with respect to building geometry and materials, components etc.
- Calculate thermal behavior of buildings with respect to indoor and outdoor condition

- Calculate approximately the size/capacity of equipment required for thermal comfort

4. Energy conservation building code (ECBC)

For standardization of building, Energy conservation building code (ECBC) is prepared by ministry of power, government of India. The function of ECBC is to offer minimum requirements for energy efficient buildings and their systems.

These estimates based on simulation models and shows that ECBC buildings use 40 to 60% less energy than non ECBC buildings. The ECBC code is applicable to buildings or building complex that has associated with load of 500 kW or more. Generally buildings or complex having area of 1000 m² or more will come under this group [4, 5].

5. Simulation of building

The building shown in figure 1 is considered for energy simulation. It is rectangular in shape. Area of this building is 10.998 km² and it is used as an educational institute. Building is divided into two parts. One is main block and another is administrative block. Administrative block is two floor building and in main block office building is two floors with identical plan and hostels buildings are three floors. Office building and administrative building is day time use building and hostels building are full time use building.

Figure 1: Energy model 3D view of an institutional building

Table 1: Input data for building required by design software

Required Data	Input Data
Floor plan shape	Rectangular
Wall area	2418.626 m ²
Floor area	10988.402 m ²

Window area	725.58 m ²
Building volume	38459.407 m ³
Window type	Single glazing, Double glazing
Ceiling height	3.5 m
U- value of the window	3.30W/m ² -K, 3.157W/m ² -K
Internal shading factor	Nil
Infiltration air change	0.7AC/h, 0.5AC/h

6. Result

6.1 Energy analysis:

Energy consumption for both cases are shown in Table 2, and comprise the peak energy consumption per area, monthly total energy consumption per area and annual total energy consumption per area, all for space cooling. Energy consumption is based on the total heat absorbed in the building through the walls, window glazing and roofs.

Table 2: Energy analysis of case A and case B for

Case	Peak energy consumption per area (kW/m ²)	Monthly total energy consumption per area (kW/m ²)	Annual total energy Consumption per area (kW/m ²)	Annual energy consumption with respect to case 2 (1- case2/case)*100
Case A	0.37	11.67	66.18	27.3
Case B	0.26	7.11	47.96	0

Figure 2: Energy analysis of case A and case B for

6.2 Effects of building envelop

The energy consumption of building model depends on building envelop like walls, floors, ceiling, window glazing. Energy consumption for different cases is shown in table. Case B is ideal case where the values of energy consumption of envelop is reduced for all aspect. This is achieved by the using insulating layer on the facade to reduce the heat entered in building.

Table 3: Effect of building envelop on entering energy in different cases

Case	Walls (kWh)	Roof (kWh)	Floor (kWh)	Ceiling (kWh)	Glazing (kWh)
Case A	295985.2	530237.4	-931515.1	931772.8	-98859.32
Case B	203124.9	241835.7	-814342.4	814553.7	203124.9

Figure3: Effect of building envelop on entering energy in cases A and B

6.3 Effect of air infiltration, solar heat gain and discomfort hours in all cases

Infiltration component of the building play important role in energy consumption, to reduce energy consumption decrease the amount of uncontrolled air exchange through unintentional opening such as windows gap, door cracks and wall cracks. In case A infiltration value is 0.7 AC/h and in case B filtration value is 0.5 AC/h.

Solar heat gain is the value of heat entered through the external window of the building. Annual solar heat gain for case A is 904876.3 kWh and for case B its value is reduced to 376666.3 kWh. Effects of glazing option have an important influence on energy needs. Single glazing window is used in case A gives insufficient solution for both heating and cooling seasons.

So that double glazing window instead of single glazing. Double glazing window reduce the value of solar heat gain by 41.6% annually. While we change location according to the weather condition the solar heat gain is change in different place.

Table 3: Effect of air infiltration, solar heat gain and discomfort hours in case A and case B

Case	Air Infiltration (AC/H)	Air Temperature(⁰ C)	Discomfort (Hours)	Solar Heat Gain (kWh)
Case A	0.7	26.05	2511.66	904876.3
Case B	0.85	24.4	2477.75	376666.8

7. Conclusions

Energy analysis has been done by using Design Builder software for base case and ECBC. When we use insulation on external walls, internal walls and roofs, use double glaze windows instead of single glass windows, change the air infiltration rate and keep natural ventilation in ECBC case than annual energy consumption is reduced from 72.736MWh to 52.710MWh, monthly energy consumption is reduced from 128.35MWh to 78.203MWh and peak energy consumption reduced from 5.140MWh to 2.992MWh.

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