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# Analysis Of Energy Conservation For A Building Model Of Research Institute, (Using Design Builder Simulation Software)

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**Abstract**

In this paper a Research Institute Building model is chosen for energy simulation. In order to achieve this aim, building energy simulation 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. To evaluate the energy consumption compared base case building model and ECBC building model and it is found that yearly energy consumption can be reduced by approximately 27.3% by designing ECBC buildings.

**Keywords:** Design Builder, ECBC code

## INTRODUCTION

The Indian energy requirements are likely to grow at a much higher rate than the world growth rate of 2%. More than one third of energy is consumed in building, therefore existing building offer one of the greatest potentials in contributing to energy conservation. India has limited energy reserves and therefore it will need to increase its energy efficiency, in addition to reevaluating its existing building stock.

Energy efficient building is critical for India because of the following reason:

Rapid Urbanization: More than 215 million people are expected to migrate from rural areas into crowded cities. This influx and overall rise in living standards, building construction and energy demand. Efficient buildings are essential to assure sustainable urban environments.

Energy Security: India's energy demand is projected to double or triple by 2030. India already imports 68 percent of oil, 25 percent of natural gas, and 13 percent of coal of its requirement, according to the Energy Information Administration. Building efficiency will enable India to meet its increasing consumption with the same, or even lower, amount of energy than its current usage, easing India's reliance on foreign supplies of expensive fuels.

Reducing Power Cuts and Addressing Climate Change: India already faces a national electrical shortage of 9.9 percent and a peak demand shortage of 16.6 percent, according to the Central Electricity Authority. This gap results in frequent power outages with buildings especially hard-hit, and over 20 percent peak demand shortages in some states. The Government of India estimates that economy-wide efficiency measures will prevent an increase in demand that is equivalent to 19,598 megawatts, or some 30 mid-sized power plants.

From the energy saving point of view a research institute is chosen in which, energy consumption and energy saving is analysis by building energy simulation. Research institute are constantly faced with optimizing limited budgets to ensure maximum payback for facilities. By the energy simulation program we can save anywhere between 5- 20% on energy bills.

### Scope of Energy Efficient Building in India:

India is committed to improving building efficiency. In 2009, the Central Government approved the National Mission for Enhanced Energy Efficiency. Among other goals, the Ministry of Power and the Bureau of Energy Efficiency (BEE) has adopted the Energy Conservation Building Code (ECBC), a minimum building standard developed in 2007. Although the ECBC is currently voluntary, the Ministry of Urban Development and BEE will work with state and local governments to make the code mandatory within the next two years. The Ministry of Environment and Forests also already requires largenew building projects to comply with the code as part of the environmental impact assessment.

## SIMULATION OF BUILDING

The energy performance of a building depends on how a building has been design from an energy efficiency perspective and how well system integration issues have been addressed. The way a building behaves and performs is governed through envelope design (walls, window, roofs etc) to meet the thermal and visual comforts of occupants and other working requirements.

### Energy conservation building code (ECBC):

Energy conservation building code (ECBC) is prepared by ministry of power, government of India to define norms and standard of energy consumption of the buildings. The purpose of ECBC is to provide minimum requirements for energy efficient design and construction of buildings and their systems.

Estimates based on computer simulation models indicate that ECBC complaint buildings can use 40 to 60% less energy than conventional buildings. The code is applicable to buildings or building complex that have a connected load of 500 kW or greater. Generally buildings or complex having conditioned area of 1000 $m^2$ or more will fall under this category.

## PROFILE OF RESEARCH INSTITUTE BUILDING MODEL

Research institute building model is choosing for the case study.

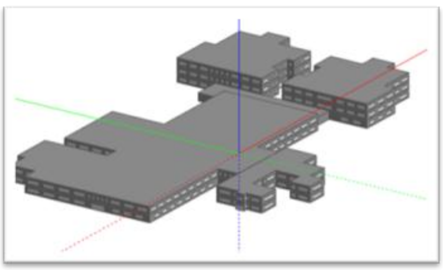

**Figure 1:** Model of Building

This building is rectangular in shape. Area of this institute is 10998.402 $m^2$. The whole 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.

Research building is used for education and research purpose. This research institute has 2418.626 $m^2$ wall areas, window area is 725.58$m^2$., which is approximate 30% of wall area and windows used in this model is single glazing window type, and ceiling height of both first and second floor is 3.5 m. Different building section, their area and working profile are shown in table. Working profile shows that particular building sections are used in a week.

**Table 1**

| Building section | Area ($m^2$) | Working profile (no. of day in week) |
|---|---|---|
| Class rooms | 190.12 | 5 |
| Conference room | 275 | 5 |
| Office | 725.47 | 5 |
| Staff room | 209.18 | 5 |
| Visitor room | 53.91 | 5 |
| Hostels | 500 | 7 |
| Canteen | 850 | 7 |
| Mess | 810 | 7 |
| Kitchen | 150 | 7 |
| Sport room | 910 | 7 |
| Gymnasium | 910 | 7 |
| Facilities | 120 | 5 |
| Lab rooms | 592.38 | 5 |
| Library | 850 | 7 |

## METHODOLOGY AND INPUT PARAMETER OF DESIGN BUILDER

### Methodology:

The methodology use in research work is divided into three phase. Phase one is for the data collection, second phase for simulation and third phase is the analysis for improvement and energy consumption in building. Descriptions of all the five cases are shown in the following table. Case A is base case for the building model; Case B is based on the ECBC (Energy Conservation Building Code). In case A and B differences are in U values of roof, walls, floors, glazing and lighting and both cases are simulated in Jaipur. Whereas the case C, case D and case E are based on the change in location. Changes in location causes change in climates and in different climate required different types of input parameter in glazing, facing, operating temperature etc. Building model is simulated in three different cities Chennai, Mumbai and Ahmedabad. Simulation of building model for case C, D and E were done on ECBC building model.

**Building parametric study for energy consumption analysis:**

Simulations were conduct on the building case using material properties shown in tables 4. To achieve energy efficient building case, several building cases were considered with respect to the influence of building envelope, window type, size and direction, ventilation, together with infiltration rate.

Building case studies were modelled using the computer simulation program **Design Builder** with required specific building input parameters,which

**Table 1:** Building model cases for thermal analysis

| Case | Building Description |
|---|---|
| Case A | Simulation of actual building model |
| Case B | Simulation of building model using ECBC |
| Case C | Simulation of building model in Chennai |
| Case D | Simulation of building model in Mumbai |
| Case E | Simulation of building model in Ahmedabad |

**Table 3**

| S.N. | Activity template | Occupancy | | All gains (W/m2) | | Metabolic | Clo value (m2 0C/W) | | Working profile (days in week) | DHW |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Density (people/m2) | Schedule (hours) | | Activity | Factor | Winter clothing | Summer clothing | | |
| 1 | Class room | 0.5300 | 8:00-16:00 | 4.4 | Reading seated | 0.90 | 1.00 | 0.50 | 5 | OFF |
| 2 | Corridor | 0.0090 | 8:00-18:00 | 0.14 | Walking | 0.90 | 1.00 | 0.50 | 5 | OFF |
| 3 | Canteen | 0.0470 | 8:00-18:00 12:00-17:00 (for weekend) | 1.69 | Eating/drinking | 0.90 | 1.00 | 0.50 | 7 | OFF |
| 4 | Facilities | 0.1608 | 8:00-16:00 | 1.28 | Standing/ Walking | 0.90 | 1.00 | 0.50 | 5 | OFF |
| 5 | Hostel | 0.0717 | 0-24:00 | 3.3 | Bedroom | 0.90 | 1.00 | 0.50 | 7 | ON |
| 6 | Lab room | 0.1600 | 8:00-16:00 | 0.16 | Performance | 0.90 | 1.00 | 0.50 | 5 | OFF |
| 7 | Kitchen | 0.1400 | 6:00-14:00 16:00-20:00 | 5.2 | Light manual work | 0.90 | 1.00 | 0.50 | 7 | OFF |
| 8 | Mess | 3.3000 | 7:00-20:00 | 2.7 | Eating/drinking | 0.90 | 1.00 | 0.50 | 7 | OFF |
| 9 | Office | 0.0413 | 8:00-18:00 | 4.1 | Light manual work | 0.90 | 1.00 | 0.50 | 5 | OFF |
| 10 | Staff Room | 0.0500 | 8:00-18:00 | 2.86 | Reading/ seating | 0.90 | 1.00 | 0.50 | 5 | OFF |
| 11 | Conference | 0.18 | 10:00-16:00 | 2.8 | Reading/ seating | 0.90 | 1.00 | 0.50 | 5 | OFF |
| 12 | Visitor Room | 0.20 | 9:00-18:00 | 6 | Seated quite | 0.90 | 1.00 | 0.50 | 5 | OFF |
| 13 | Reception | 0.0676 | 8:00-18:00 | 5 | Office activity | 0.90 | 1.00 | 0.50 | 5 | OFF |
| 14 | Sport Room | 0.0527 | 14:00-20:00 | 3 | Exercise /sport | 0.90 | 1.00 | 0.50 | 7 | OFF |
| 15 | Gymnasium | 0.0627 | 8:00-20:00 | 3 | Exercise /sport | 0.90 | 1.00 | 0.50 | 7 | OFF |
| 16 | Staff Room | 0.0500 | 8:00-16:00 | 3 | Reading/ seating | 0.90 | 1.00 | 0.50 | 5 | OFF |

**Table 4** Thermo physical building materials of the building case components

| Building components | Material(layers) | Thickness (m) | Th.cond. | Density | Th.cap. | U-value for base case | U-value for ECBC ase |
|---|---|---|---|---|---|---|---|
| External walls | Plaster (dense) | 0.0100 | 1300 | 0.05 | 1000 | 2.167 | 0.492 |
| | Brick(outer leaf) | 0.2280 | 1700 | 0.84 | 800 | | |
| | Plaster (dense) | 0.0100 | 1300 | 0.05 | 1000 | | |
| Internal wall | Plaster (light weight) | 0.0100 | 600 | 0.16 | 1000 | 0.707 | 0.366 |
| | Brick (inner leaf) | 0.1143 | 1700 | 0.62 | 800 | | |
| | Plaster (light weight) | 0.0100 | 600 | 0.16 | 1000 | | |
| Floor | Earth gravel | 0.1524 | 1750 | 1.3 | 1000 | 2.167 | 2.167 |
| | Plaster (light weight) | 0.0254 | 600 | 0.16 | 1000 | | |
| | Marble | 0.0150 | 2180 | 1.5 | 910 | | |
| Roof | Cement Plaster (Dense) | 0.0508 | 1300 | 0.05 | 1000 | 2.713 | 0.529 |
| | Concrete | 0.1524 | 2100 | 1.4 | 840 | | |
| | Cement Plaster(Dense) | 0.0254 | 1300 | 0.5 | 1000 | | |

**Operating schedule:**

Table illustrates the schedule of occupancy in class room, lab room, staff room, office, conference room, corridor and canteen. On occupancy schedule the energy consumption are depend.

**Table 5:** Input data for the building model required by Design Builder.

| **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 |

**Table 6:** Operating schedule for different activities

| S.No | Activity | Occupancy Schedule | |
|---|---|---|---|
| | | Weekday | Weekend |
| 1 | Class Room | 8:00-16:00 | off |
| 2 | Lab Room | 8:00-16:00 | off |
| 3 | Staff Room | 8:00-16:00 | off |
| 4 | Office | 8:00-18:00 | off |
| 5 | Conference | 10:00-16:00 | off |
| 6 | Corridor | 8:00-18:00 | off |
| 7 | Canteen | 8:00-18:00 | 12:00-17:00 |

**Table 7:** Energy analysis for all five cases

| Case | Peak energy consumption (kWh) | Monthly total energy consumption | Annual total energy Consumption | Annual energy consumption with respect to case 2 |
|---|---|---|---|---|
| Case A | 4140.46 | 128354.34 | 727363.17 | 27.3 |
| Case B | 2922.72 | 78203.79 | 527104.98 | 0 |
| Case C | 2778.84 | 76844.11 | 718172.81 | 26.6 |
| Case D | 2500.86 | 68226.79 | 640746.53 | 17.7 |
| Case E | 2838.32 | 91088.03 | 708539.34 | 25.6 |

**Table 8:** Peak and annual total energy consumption per square meter

| Case | Peak energy consumption (kWh) | Peak energy consumption per area | Annual total energy consumption per area (kWh) | Annual total energy consumption ($kWh/m^2$) |
|---|---|---|---|---|
| Case A | 4140.46 | 0.37 | 727363.17 | 66.18 |
| Case B | 2922.72 | 0.26 | 527104.98 | 47.96 |
| Case C | 2778.84 | 0.25 | 718172.81 | 65.35 |
| Case D | 2500.86 | 0.22 | 640746.53 | 58.31 |
| Case E | 2838.32 | 0.26 | 708539.34 | 64.48 |

## RESULTS

### Energy consumption for the building cases:

Energy consumption of all the five cases are shown in Table 7, and comprise the hourly peak energy consumption, monthly total energy consumption an annual total energy consumption, all for space cooling. Energy consumption is based on the total heat absorbed in the building through the walls, window glazing and roofs.

### Peak energy consumption for all building case:

Peak energy consumption shows the energy consumed in the building model on the daily basis. Energy consumption for all the cases is shown in graph. For base case A peak energy consumption is 5140.46 kWh whereas for case B value is decrease 2922.72 kWh. Data shows that by using ECBC peak energy consumption is reduced. For case C, D and E value is 2778.84 kWh, 2500.86kWh and 2838.32 kWh respectively differences in value is due change in climates.

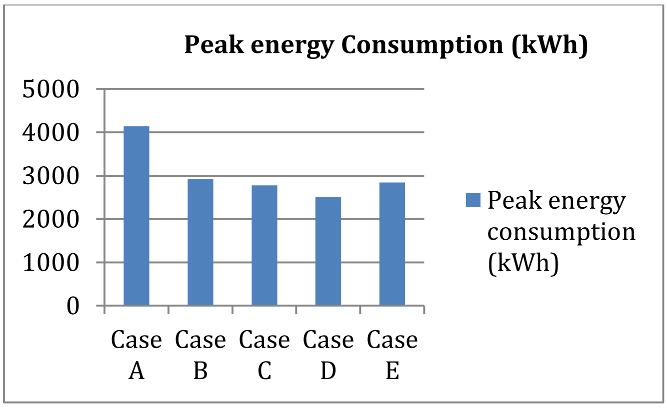


**Figure 2:** Peak energy consumption for all building case

### Monthly energy consumption for all building case

Monthly energy consumption shows the maximum energy consumed in a month. From the graph it is seen that energy consumed in Case A is maximum then the other cases. It can by reduced by the 39.07 % by using case B. Monthly energy consumption for case C, D and E are 76844.11 kWh, 68226.79 kWh and 91088.03 kWh.

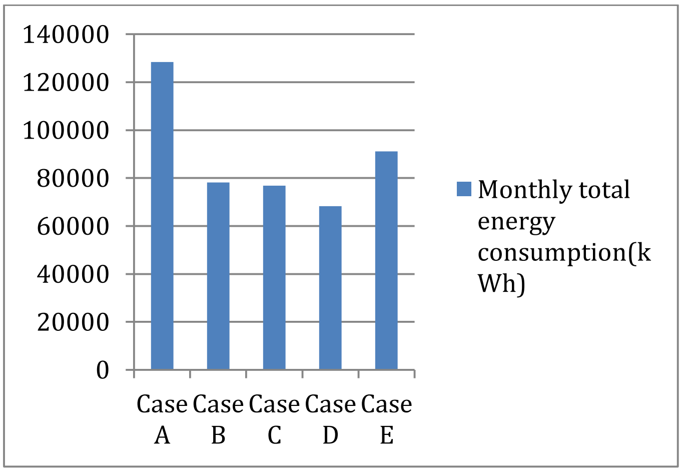


**Figure 3:** Monthly energy consumption for all building case

### Annual energy consumption for all building case

Annual energy consumption shows the total heat absorbed through the building envelope (walls, glazing and roofs) in a year. Annual energy consumption of base case A is 727363.17 kWh and in case B its value is 527104.98 kWh, which is reduced by 27.3% in case B. Annual energy consumption for case C, case D and case E are 718172.81 kWh, 640716.53 kWh, 708539.34 kWh respectively.

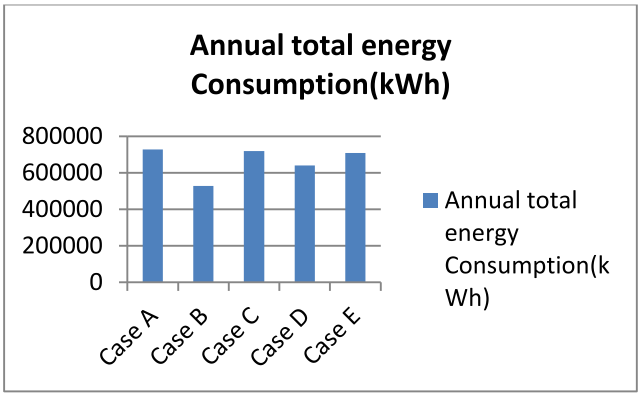


**Figure 4:** Annual energy consumption for all building case

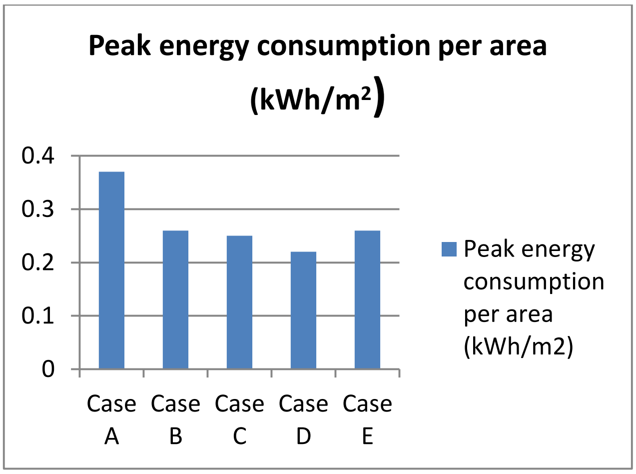


**Figure 6:** Annual total energy consumption per square meter

### Peak and annual total energy consumption per square meter (area of floor plan):

Peak energy consumption and annual energy consumption per floor area are shown in following table. Peak energy consumption per area for case A is 0.37kWh/$m^2$ and for case B is 0.26 kWh/$m^2$. Annual energy consumption per area for case A is 66.18 kWh/$m^2$ and for case B it will be 46.98 kWh/$m^2$. This shows that by using ECBC in building we can save 29.7% energy in peak consumption and 27.5 % in annual consumption.

## CONCLUSIONS

### Conclusions:

Energy analysis has been done by using Design Builder of the Building done for base case and building model using ECBC case. The energy analysis has been done using ECBC case for three different cities Chennai, Mumbai and Ahmedabad to simulate the effect of climate conditions.

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

For any simulation analysis, effect of weather is very important parameter because each locationhas different climate conditions; according to theseconditions comfort condition is achieved. For that we simulated building model in three different climate condition Chennai, Mumbai, Ahmedabad and it was found that most favourable condition for this building model is Mumbai. Maximum energy consumption is reduced by 17.7 % in Mumbai compared to other cities.

**Suggestions:**

According to the results obtained from the simulation analysis. The U value of the external wall and internal wall should be 0.492W/m$^2$-K and 0.366 W/m$^2$-K; whereas U value for the roof should be 0.529W/m2-K. In case of opening to reduce direct heat gain from the window double glazing or triple glazing type window can be used. Proper infiltration rate provide better thermal comfort. So that it desirable to analysis of energy through simulation software to find out energy saving opportunity before construct the building.

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