Impact of Building Orientation & Lighting Sensors on Annual Lighting Load

Purohit Viraj, Mori Mitesh, Thakkar Utsav

***Abstract:** In India Building sector use about 33% of entire electrical energy use, out of that 25% is used by the residential sector. We can reduce it by applying daylighting as a necessary component for building design procedure. Here in this study, sustainability of energy through daylighting is investigate with respect to performance of daylight of a residential apartment in the Gandhinagar city. Daylight Area (DA) is used as performance metric. The effect of building orientation on the daylight area is studied. Behaviour of Occupancy was modelled by applying a useful daylight illuminance threshold of 400 lx. By that we have found that at east orientation building would get 26% daylight area which is highest among all. After that put Occupancy and Dimming sensors on that case and get optimum lighting energy use.*

***Keywords:** Daylighting, Daylight Area, Energy saving, Useful daylight Illuminance.*

I. INTRODUCTION

Rapid urbanization in India is pushing the strength demand at an unpreceded fee of eight % per annum. The sprawling of compact multi-storied excessive upward thrust buildings, currently an archetype to meet urbanization demands, is an increasing number of putting strain in city electricity needs. Moreover, non-stringent constructing bye-legal guidelines and lack of solar law add to the weight. While such development is higher from the factor of minimizing strength usage for transportation, the close proximity of the excessive-ruse limits the sky-component and sunlight hours' penetration. This is turn impacts the pleasant and the amount of daylight received, particularly at the decrease floors, and puts stress on artificial light's needs. Especially in a rustic like India which has prolonged daylight seems vital to have regulatory norms that combine day lights into the housing region. The constructing bye-laws of Indian cities prescribe that every livable room ought to have one or extra apertures like windows, establishing to external environment such that in no case the glazing to ground ratio be less than 10% of all habitable spaces and the prescribed minimal distance among homes is based totally at the "sustained vertical attitude requirement" as in step with NBC-2005 Part eight Sec 1. These legal guidelines have been first advanced inside the UK, in general for low rise terraced homes, which assume that all windows obtain a reasonably desirable amount of "sky thing" and that there may be consistent angle of obstruction some of the homes. Given that Indian towns are growing taller and the windows have varying skyline obstruction, these legal guidelines grow to be much less powerful. The building design itself suffers with no guarantee on daylight availability and performance. This state of affairs requires remedial measures in building bye laws which can meet with the contemporary needs within the developing residential zone. One of the essential function on India is its low socio-economic class pushed urbanization. This has caused a big deficit of cheap housing in India. As a remedial degree, the Government of India has formulated the scheme of "Housing for All-2022", which objectives to construct 20 million less costly houses in the subsequent seven years. Under this pretext it would be really apt to advocate daylight inclusive building bye-legal guidelines for this upcoming housing inventory. Hence this study intends to recommend a route towards daylight inclusive constructing bye-laws and policy formula. First, the examine describes the gaps in modern-day bye-legal guidelines after which estimates the daylight hours performance of an existing building. It they shows the metric of Usable Daylight Illuminance (UDI) for comparing the power saving capability of residential buildings. Finally, an energy management matrix is designed as a method for formulate daytime inclusive constructing bye-laws.
(Bardhan & Debnath, 2016)

II. METHODOLOGY

Method comprises of number of steps to meet specific research objectives.

First step was all about considering an immense literature review about different important domain pertinent to this study, which includes reviews about BIM, Energy analysis software, factors affecting building energy consumption, factors affecting daylight harvesting etc. That would guide to the suitability of use of BIM and daylight simulation software for this study and provided the base to understand the relation between building orientation and natural daylight harvesting. Secondly, the best suited software for modelling and simulation work for this study were scrutinized for further work. Third step was to implement modelling work and simulation work on the selected case study with enough information about it. It was necessary to choose building with sufficient information as it allows the author to model and simulate the building with enough precision and facileness. That permitted for thoroughly analysis of differently oriented building alternatives in a BIM environment.

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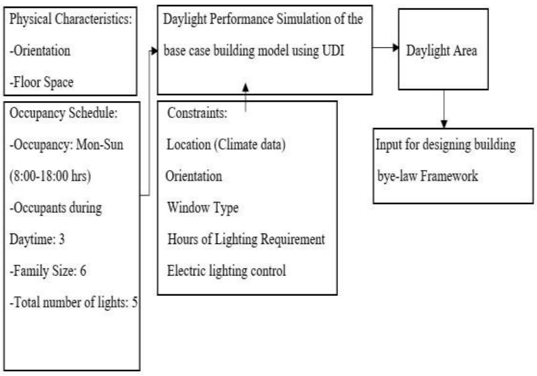
Here after all orientation simulation finally, we get best case for high daylight area, after all of them we get one best result for any specific orientation. On that we have apply occupancy sensor and dimming sensor and get optimum requirement of daylight energy.



- Data Collection
- The building which is taken into consideration for this study is a residential Apartment building. An Eight storey building is situated in Gandhinagar city, Gujarat. Basic details about building are as below,
- Name of Building: Vinayak Life style
- Location: Gandhinagar
- Coordinates: Latitude: 23.0333°,
- Longitude: 72.5833°
- Type of Building: Residential Building
- Occupancy Schedule: 8 AM to 6 PM
- Area: 1532 sqmt
- Floor Height: 3m
- Number of Floor: 8
- Every floor consists of three Bed room, one kitchen, one hall, bathroom and a WC. The choice of the case study is based on the fact that I have connections with the building owner and can readily gain access to the building to reconstitute the drawings and also obtain daylight result bye digital lux meter for validation of results.

III. MODEL MAKING

With the help of this data and 2d plan of building we have made 3d model of building in revit, same as actual with proper material.

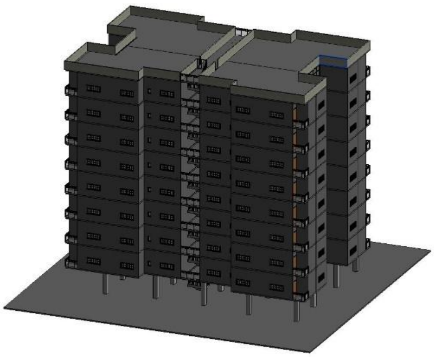


Figure 1 3d Model

Here we have used Rhinoceros 5.0 for daylight simulation, in Rhino we have used Diva for Rhino plug-in. for do simulation first we have to export Revit (.rvt) file into AutoCAD (.dwg) file with perspective view. Then After in Rhino we have to import that AutoCAD file into Rhino. When we import that file then we have to give some inputs for simulation which are 1) Selection of Whether file. For whether file here we have download the Ahmedabad whether file from energy plus site. 2) Nodes. For that we have select one plan where we want our daylight in illuminance level. So we have to put different node on the surface of the floor where we can get the result of daylight Illuminance in Lux. Here we have make node 0.79 m above the floor and 1.5 m distance from each other. 3) Selection of materials. For this when we import CAD file into Rhino, it creates each component of building as a layer so in rhino we have to give proper material for each layer so we get accurate result. 4) Type of simulation which we want. All this input process are show in below figures.

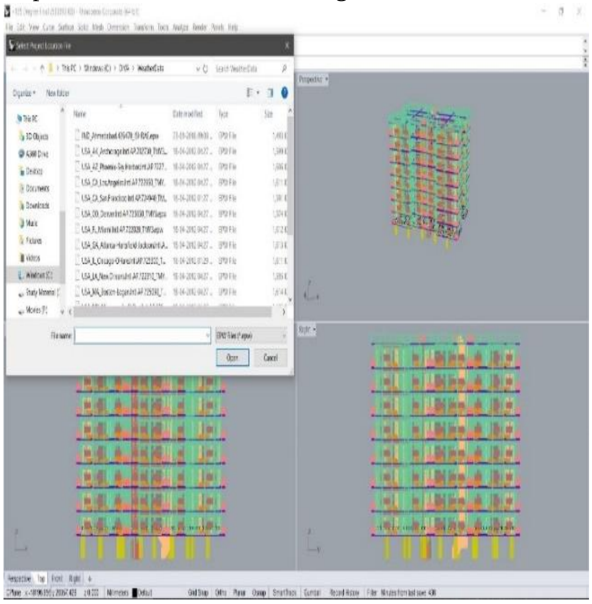


Figure 2 Weather file Selection

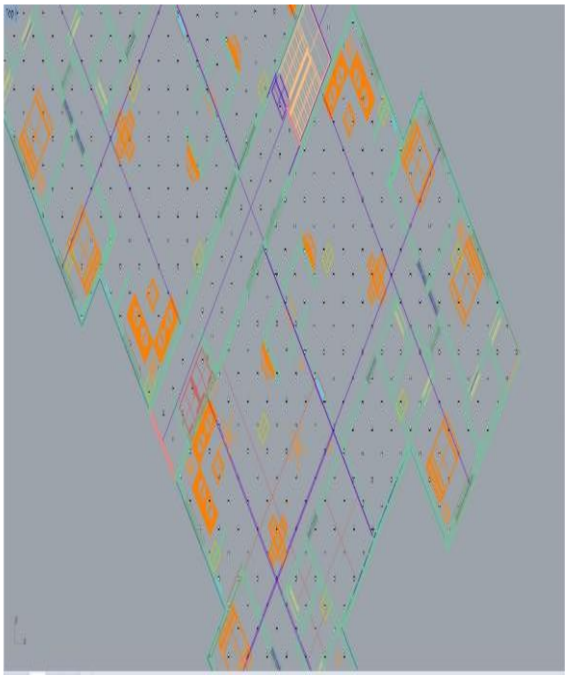


Figure 3 Nodes

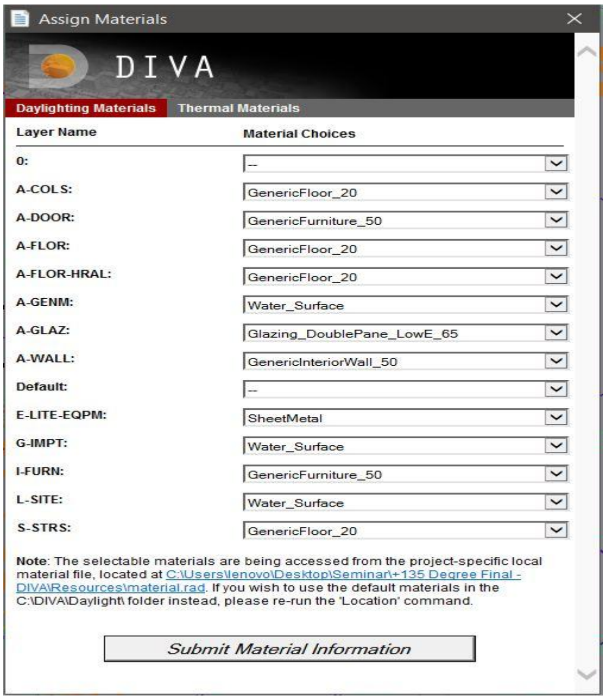


Figure 4 Material Selection

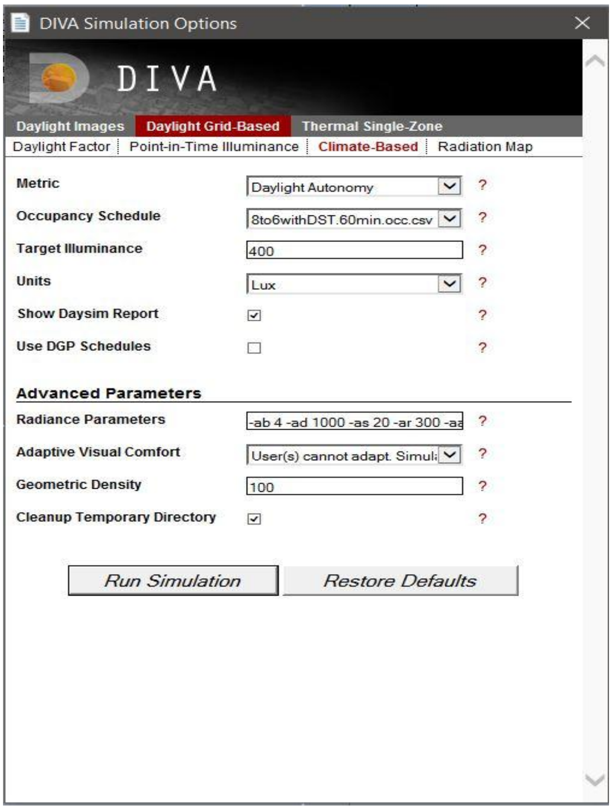


Figure 5 Simulation Metrics

Now first of all we have do simulation for bas case of building which is situated in East-West direction. For that orientation, we have do climate base annual Daylight Autonomy (DA) simulation. After give, all input same like above figure then click on run simulation and the simulation has been start. It takes much time to simulate, approximate 6 to 7 hours, and gives result of daylight area. Here we have do this simulation for every 15 degree rotation, and get different results for daylight area. When we done simulation for base case we got this kind of results

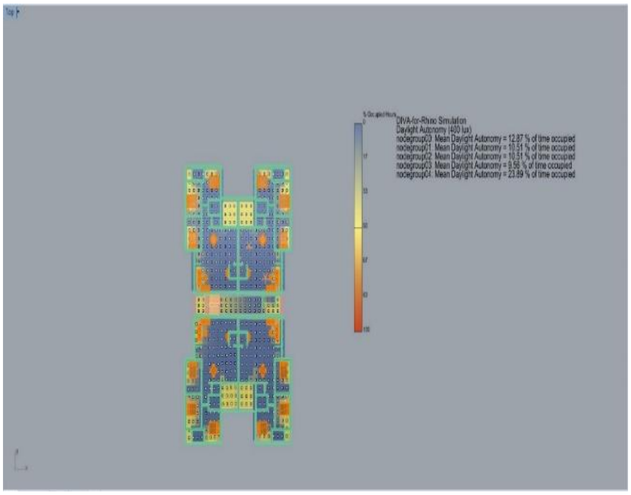


Figure 6 Base Case

Here in fig 6 shows that daylight autonomy at each and every point. In fig where color is dark there the natural daylight is come less, where the color is light there natural daylight is come high. According to this natural daylight harvesting the software give the result of annual which amount of daylight has been come in future according it software give result in daylight Area which is shown in figure, Daylight Area(DA400lux[50%]): Area of the room at which the special daylight autonomy corresponds to at least 50% and that means that at least 50% of the occupied time the daylight level of the point are above the target illuminance

Mean Daylight Factor: The daylight factor (DF) is a very common and easy to use measure for the subjective daylight quality in a room. It describes the ratio of outside illuminance over inside illuminance, expressed in per cent. The higher the DF, the more natural light is available in the room.

So here for base case we have get Daylight area is 11 % and Daylight Factor is 0.7%. This results are shown in figure below. Here we select occupancy schedule as 8 to 6 so total per year 3650 hours which is shown in result that occupancy is 3650 hours per year. Now for other orientation we got this kind of results which are shown in table below,

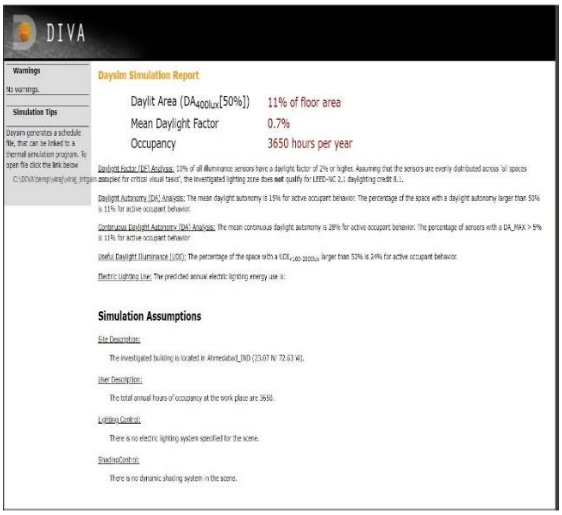


Figure7 Base Case Result

Here after all orientation simulation we get highest 26% Daylight Area in two Orientation which are +30 degree & +90 Degree and that same cases we get daylight factor is 3.2% & 2.2% So by this we have choose +30 Degree orientation from base case is give higher amount of natural light compare to other orientation. Because in daylight factor meaning we have already show that higher factor will give higher natural lightning, so we choose +30 degree compare to +90 Degree rotation. So here we choose +30 degree rotation from base case is a best case for further simulation so we now use it to further daylight simulation with artificial lightning and occupancy sensors and dimming sensors.

Table 1 Simulation Results

Orientation	Daylight Area	Mean Daylight Factor
Base Case	11%	0.70%
+15 Degree	21%	2.90%
+30 Degree	26%	3.20%
+45 Degree	13%	0.70%
+60 Degree	21%	2.90%
+75 Degree	25%	3.10%
+90 Degree	26%	2.20%
+105 Degree	20%	2.80%
+120 Degree	25%	3.10%
+135 Degree	7%	0.60%
+150 Degree	24%	3.10%
+165 Degree	25%	3.10%

We have add artificial light in all rooms, here we have make different group of each room.

In above fig shows the lightning control systems options, First fig shows manual on/off switch control, that means occupants has manually do on and off of the switch of light. In second fig. shows dimming control with occupancy sensors, which means lights will automatically turn off when no one is in home and also dimmed at time when lightning is exceed then set points, here I have set 400 lux for drawing room, 300 lux for bedroom & Kitchen as set point.

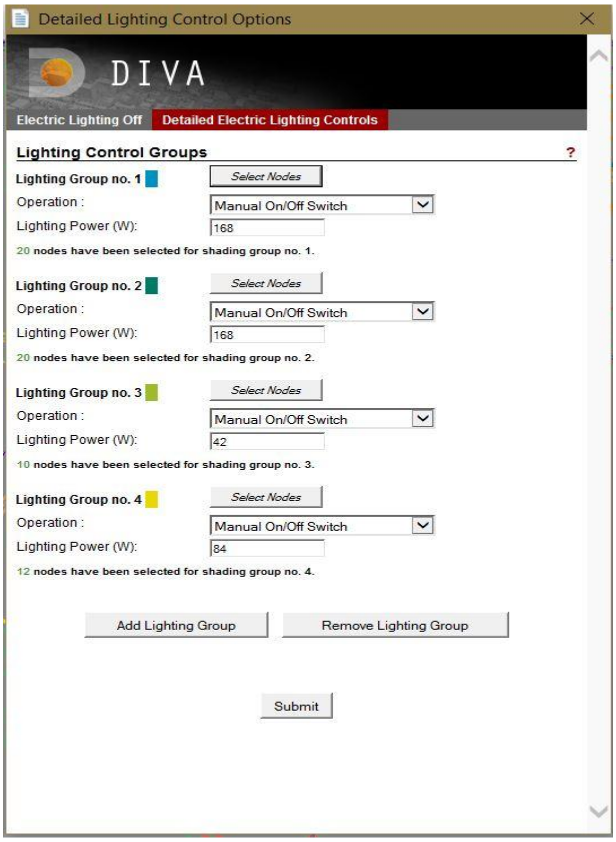


Figure 8 Manual Light Control

Specification for Laminar:

Table 2 Luminas Specification

Specifications	Values
Manufacturer	Zomtobel
Type	LED
Brightness	2970
Life expectancy	21.9 years
Light appearance	6500 k (daylight)
Energy used	42 W
Recommended use	General residential purpose: kitchen, bathroom, living space

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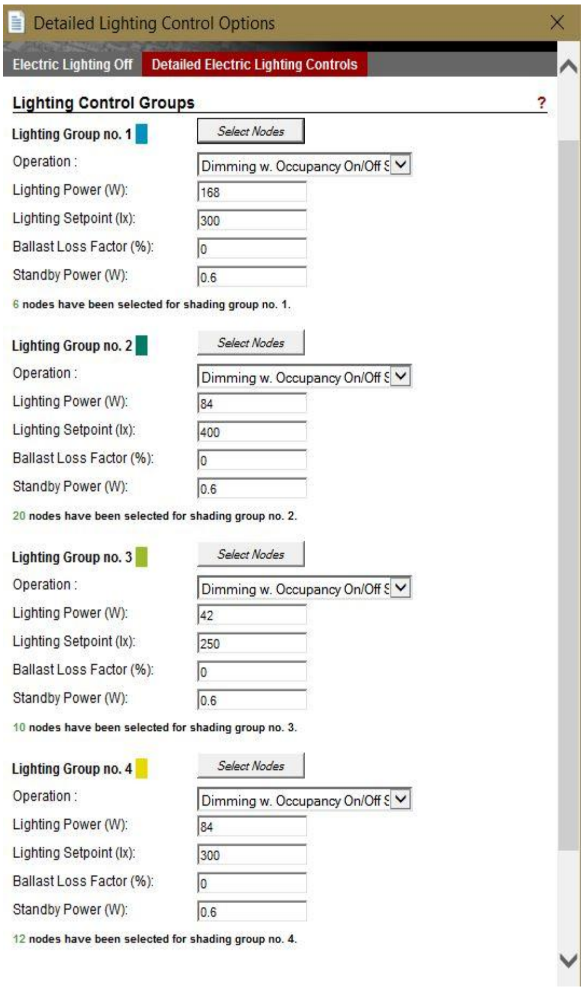

Figure 9 Dimming with occupancy control

IV. RESULT AND DISCUSSION

After that controls we have do simulation so we get this kind of results which are shown below.

For Manual Control:

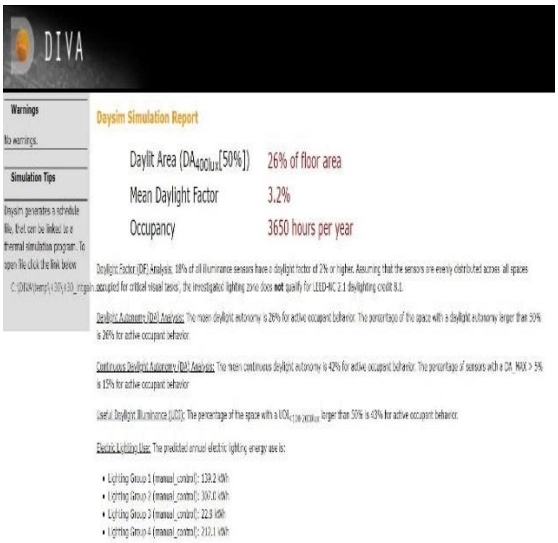

Figure 10 Result of manual control

Here in fig shows how much of electricity has been consume for annual lighting in different rooms for Manual Controls, here it will show different consumption for each group which we have set.

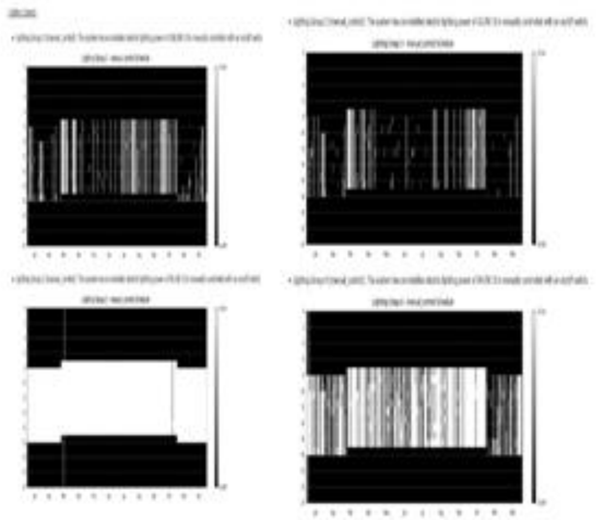

Figure 11 Light on/off Schedule for Manual Control

In above fig shows the Light switch on/off condition for each month for every group.

For Dimming with Occupancy sensor Control:

Figure 12 Result for Dimming with occupancy

Here in fig shows how much of electricity has been consume for annual lighting in different rooms for

Dimming with Occupancy sensor controls, here it will show different consumption for each group which we have set.

In below fig shows the Light switch on/off condition for each month for every group.

Here in above table we can see that with the help of occupancy & dimming sensors we have save INR 842/- rupees per flat for whole building its amount be higher. And when we compare it to bas case it will increase more than that. Here we apply all simulation on best case which we have got from different orientation.

Table 3 Cost Comparison

Sr.(Group)	Req. Electricity for Manual Control	Req. Electricity for Occupancy on/off With dimming control	Differences	Rate of Electricity (INR/kWh)	Cost for Manual Control(INR)	Cost for Occupancy on/off With dimming control(INR)
1	139.2 kWh	35.8 kWh	103.4 kWh	4	556.8	143.2
2	307 kWh	302.5 kWh	4.5 kWh	4	1228	1210
3	22.9 kWh	8.3 kWh	14.5 kWh	4	91.6	33.2
4	212.1 kWh	124.1 kWh	88 kWh	4	848.4	496.4
Total	681.2	470.7			2724.8	1882.8

V. CONCLUSION

In India, more than 40% of total residential electrical energy is used for indoor lighting requirements. The building energy expenditure is rising at a rate of 12% per annum as a result of rapid urbanization in India. However, integration of lighting technologies including natural lighting in buildings can save more residential electrical energy usage. This work showed that estimating the usability of illuminance levels of daylight, in the functional space, is much more effective than solely relying on annual incident illuminance levels as the metric for energy management through day lighting. Here, we have used an annual daylight area that showed the effectiveness of design parameters like building orientation in saving lighting energy through daylight. After applying it we have get 15% more daylight area compare to base case. Here also we have apply occupancy and dimming sensors and got optimum requirements of electricity for lighting. Here we reduce the requirement of electricity by applying occupancy & Dimming sensors.

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