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Daylighting in Urban Context

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***Abstract*—** Daylight is the combination of all direct and indirect sunlight during the daytime. This includes direct sunlight, diffuse sky radiation, and (often) both of these reflected by the Earth and terrestrial objects. The penetration of Daylight in the building is not only important for energy conservation context, but also for health and hygiene of the residents. This study has suggested a guideline of access spaces between the different urban buildings. The simulation was done on the Ecotect Analysis software& DIALux lighting software. The different height of the buildings which is considered are 8ft, 15ft, 39ft & 87ft. The dates which are fixed for the experiment were 21st March, 21St June, 22nd September & 21st December. The simulation is done on 8:00 AM, 12:00PM & 4:00PM. The proposed method can greatly assist in improving the urban lifestyle of the people. The results if implemented in a correct way can save some amount of space and the penetration of correct amount of sunlight can be calculated.

***Keywords*—** Ecotect simulation, Extrenally Reflected Component (ERC), Inter Building spaces, Urban Buildings

I. INTRODUCTION

Daylight data is necessary to predict daylight availability through out a year at a particular location. There are different daylighting systems, viz., skylights, windows, sawtooth roof etc. Depending on the orientation of the openings, daylight illuminance (global, diffused) either at horizontal plane or at vertical plane are useful for the prediction of daylight penetration into interior space. The total illuminance or commonly known as Global illuminance is the contribution of both sky and sun. Diffused illuminance is the contribution of the sky whereas Direct illuminance is the contribution of sun.

There are two kinds of daylight models – 1. Daylight Efficacy Model and 2. Sky Luminance Distribution Model. Since, solar radiation database is available for different location in India, the daylight efficacy models are applied to determine the corresponding daylight illuminance values. Presently, Perez daylight efficacy models are most commonly used for the above purposes. Perez also developed sky luminance distribution model based on the measured solar radiation database. DIALux software simulates daylighting schemes by using Perez ―All-weather sky model‖ which is based on solar radiation database. However, CIE proposed Standard Sky Luminance Distribution (SSLD) models based on measured daylight data and these SSLD is internationally accepted sky luminance model. There are two types of daylight prediction tools are available for the availability of daylight over working plane. These are: 1. Relative prediction: Relative prediction tool is applied for measuring Daylight Factor. This is the oldest tool used in European Country. 2. Absolute prediction: Absolute prediction tool is applied for Daylight co-efficient method. In Daylight co-efficient method, the EP (illuminance over the working plane) is related with the luminance of the sky patch visible through the window from the point under consideration. The total DF can be calculated as : DF= SC+ERC+IRC; where DF= Daylight Factor, SC= Sky Component, ERC= Externally Reflected Component and IRC= Internally Reflected Component. The first non uniform CIE standard for the luminance distribution on the overcast sky was suggested by Moon and Spencer (1942). The changes of luminance from horizon to zenith were described by the following relation:

$L\gamma / Lz = (1+2\sin\gamma)/3$ (1)

where, $L\gamma$ is luminance of a sky element in cd/m^2, Lz is the zenith luminance in cd/m^2,

γ is the elevation angle of a sky element above the horizon,

z is the angular distance between a sky element and the zenith, $z=90^0-\gamma$.

This paper focuses on finding a optimum distance between the buildings so, that the first floor of all the cases can get the optimum level of daylight through the whole daylength throughout the year.

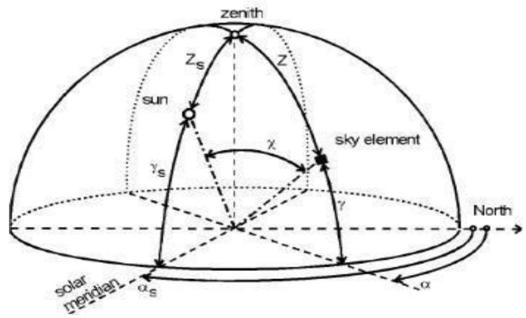

Figure 1. Angles defining the position of the sun and a sky element

The expression of Extrenally reflected component is given by:

(2) $$E_p = \bar{L} \int_{\gamma_3}^{\gamma_4} \int_{\alpha_3}^{\alpha_4} sin\gamma cos\gamma \; d\gamma d\alpha$$

Where $\bar{L}$= average luminance of the opposite wall facing towards the window.

α = solar azimuth angle ,

The (Luminance) can be derived further as:
L □ dI/dA_p□□□

Where I= Intensity of the source at a particular direction and, dA_p= Finite source area.
Here distance is integrated inside the projected area; with the change in distance the projected area changes, which practically changes the value of luminance. So if the Luminance changes the Externally Reflected Component also changes.

Reflection of daylight depend upon the area which is outside the working plane, or in practical case the building which is just outside the window. This distance could be controlled if the spaces between buildings can be predicted. This spacing could also help in penetration of the daylight through the windows of the buildings.

II. METHODOLOGY

Four dates have been selected throughout the year i.e. 21stJune, 21st March, 22nd September, 21st December. These dates have astronomical as well as geographical importance. 21st March & 22nd September is Vernal Equinox and Autumnal Equinox simultaneously. 21st June & 21st December is Summer Solstice and Winter solstice simultaneously. Ecotect software and DIALux software is used in the study. Four different building is considered for this study.

Table 1. Height of Different Levels

LEVEL	HEIGHT(FT)
G	8
G+1	15
G+4	39
G+10	87

A total 9 buildings is considered all having the same building height. This is taken because in a modern society concept all the buildings have same height. Firstly the buildings were built in Ecotect Analysis 2011software. Kolkata weather file is taken, so the results obtained can be applicable for Kolkata climate. Then the sun path is considered for each of the plan. Different spacing is given between the building and the shadow is observed.

For each study the different space is given ,the process is continued till the ground floor of the building is shadow free, exception is only for ground level, where only one floor is considered. After getting the range of the spaces that should.be given between the building. Then the files of different buildings are implemented in DIALux4.13 lighting simulation software.
Each building array is implemented with different spaces that are obtained from Ecotect software and the average illumination is measured.

The average illuminance (E_{avg}) measured by placing the calculation surface at the first floor of the building . Other than G level , for all the building the from the first floor the illuminance level is considered. Because the ground floor of the building is considered here as garage. So, the daylight penetration is not needed. The above figure shows the placing of the calculation grid around the buildings. The calculation is done for all type of buildings i.e. G,G+1,G+4 & G+10.

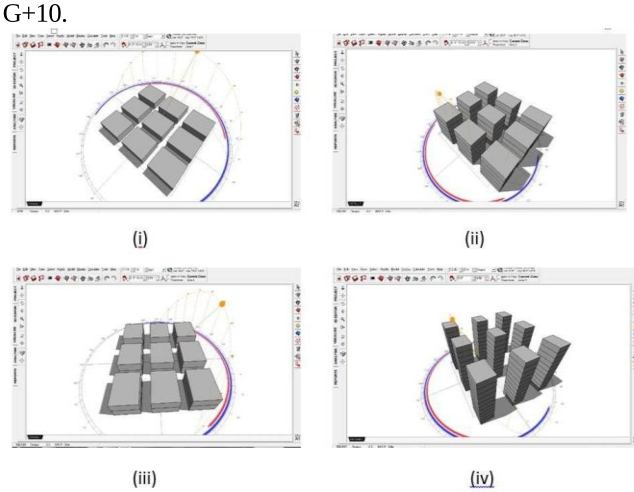

Figure 2. Ecotect software images of different case studies.(i)Ground level (ii) G+1 level (iii)G+4 level(iv)G+10level

The calculation is done for each case on 21st March, 21St June, 22nd September & 21st December. The values are taken at 8:00 AM, 12:00PM & 4:00PM. These 4 specific time slots are taken maximum change of daylight illuminance can be seen during this time. After getting all the values from each surfaces from different dates. The values is average by total number of calculation surfaces.The range of the space for each of the cases are decided from the Ecotect and DIALux simulation software results.

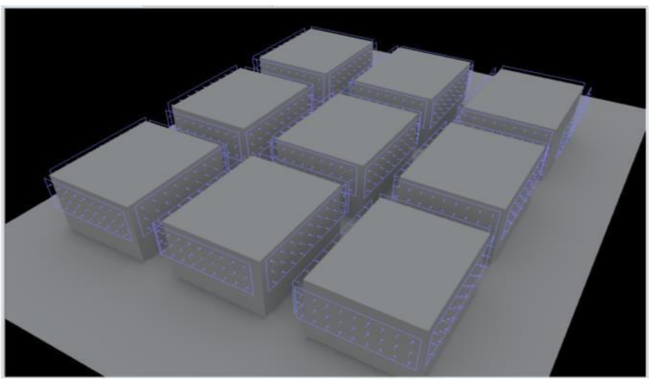

Figure 3. DIALux file of G+1 structure. The blue boxes that are visible in the picture are the calculation surface

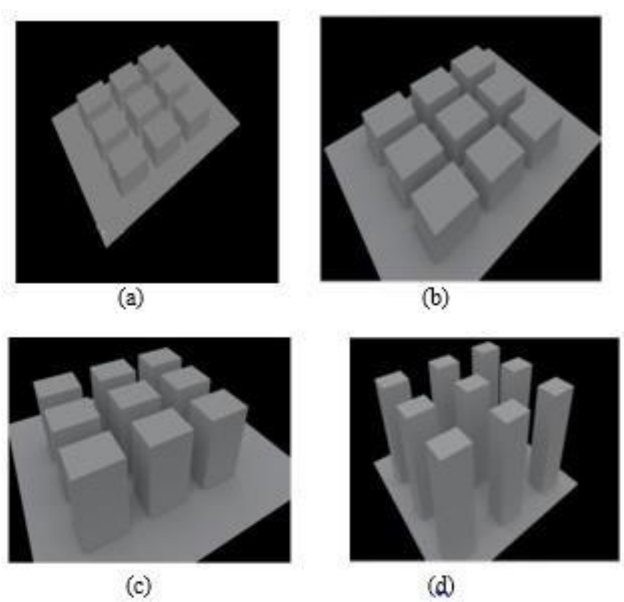

Figure 4. This 4 structure created in DIALux simulation structure. (a):G –level, (b) G+1,(c):G+4,(d):G+10

III. RESULTS AND DISCUSSION

Four types of cases have been considered of G, G+1, G+4 and G+10 of nine building blocks each. The calculation surfaces are taken at the first floor of the buildings except for the G building (where only one floor is present). Four dates have been selected throughout the year 21st March, 21stJune, 22nd September and 21st December. The simulation have been done at 8:00AM, 12:00PM & 4:00PM. The average illuminance of each surface have been shown with varying inter building distances.

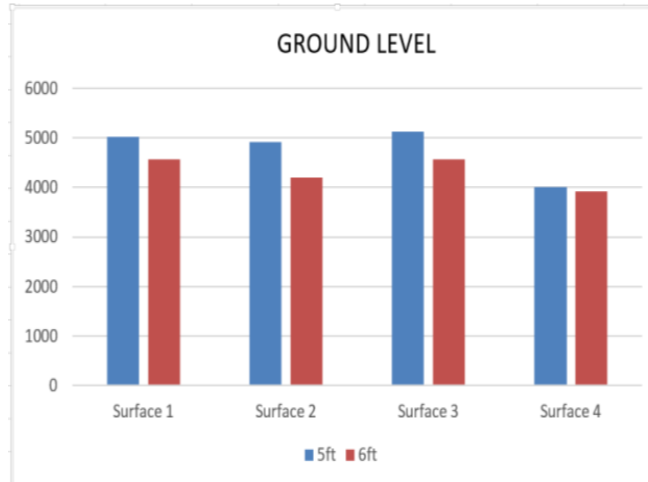

Figure 5. Graph showing the average illuminance values of Ground level building for all the four surfaces throughout the year with inter building distance of 5ft and 6ft

Figure 5 is showing the average illuminance level at four surfaces of Ground Level building with inter building distance of 5ft and 6ft. From this graph it can be inferred that for Ground level building, inter building distance of 5ft to 7ft can produce great result of ground floor be shadow free throughout the day time throughout the year.

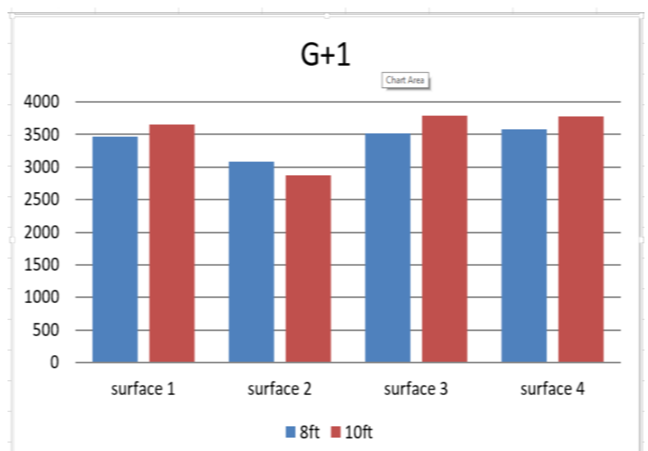

Figure 6. Graph showing the average illuminance of G+1 building of the four surfaces throughout the year with inter building distance of 8ft and 10ft

Similarly, for G+1 building the results are showing that first floor of the building produces shadow less daylight throughout the year for the inter building space of between 9ft to 11ft.

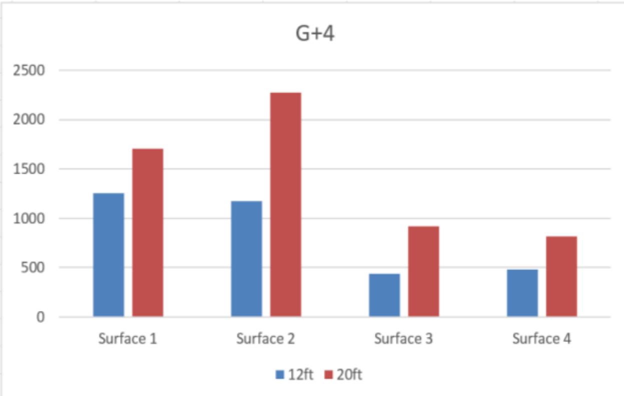

Figure 7. Graph showing the average illuminance of G+4 building of the four surfaces throughout the year with inter building distance of 12ft and 20ft

Similarly, for G+4 building the results are showing the first floor of the building produces shadow less daylight throughout the year for the inter building space of between 14ft to 20ft.

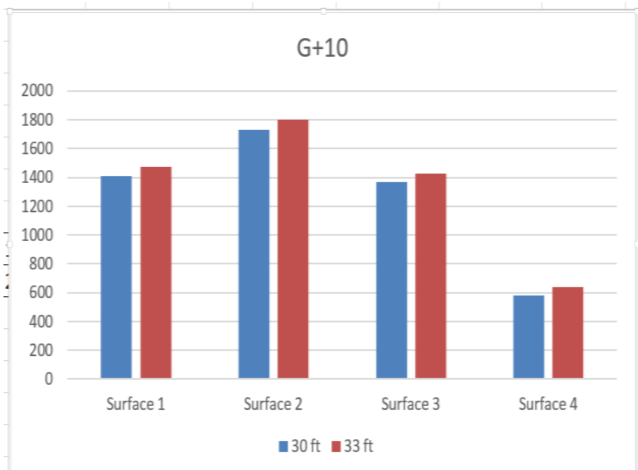

Fig 8: Graph showing the average illuminance of G+10 building of the four surfaces throughout the year with inter building distances of 30ft and 33ft

Similarly, for G+10 building the results are showing the first floor of the building produces shadow less daylight throughout the year for the inter building space of between 30ft to 34ft

IV. CONCLUSION AND FUTURE SCOPE

The space that are obtained from the experimental data are enough for the penetration of the daylight in the buildings. If this space is available then from the first floor it will be shadow free. Government of West Bengal, Development Department has few guidelines over giving spaces between the buildings. These guidelines are implemented for the planned city of Rajarhat under West Bengal. The results of the experiment come under those parameter, so we can conclude that the experiment is successful. The main difference of our results with the guidelines of West Bengal is that the amount of spaces that are given there is pretty more, so if we can maintain the spaces that it is the outcome of our experiment it will beneficial of the occupants. It will also save the amount of extra spaces.

The results of this paper are obtained by simulation considering the Kolkata weather database file. The authors are interested to carry out this practically in Kolkata area considering the same factors and calculating the daylight factor

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