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DAYLIGHTING ON THE BUILDING

Case Study: Administration Building, Politeknik Negeri Lhokseumawe

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Abstrak

Bangunan merupakan salah satu pengguna energi yang cukup besar dalam rangka meningkatkan fungsi dan kualitas serta kinerja pengguna bangunan. Wujud penggunaan energi dalam bangunan terintegrasi dalam sistem penghawaan, sistem pencahayaan, sistem transportasi vertikal dan sistem pelayanan lainnya dalam upaya optimalisasi fungsi bangunan untuk kenyamanan dan kemudahan pengguna dalam beraktifitas. Ditinjau dari sisi sistem pencahayaan dalam bangunan untuk memberikan penerangan juga banyak menggunakan energi baik siang hari maupun malam hari. Pada kasus ini, sistem pencahayaan untuk penghematan energi dapat dilakukan dengan teknologi "Daylighting" terutama pada siang hari. Konsep dasar daylighting memanfaatkan energi surya sebagai penerangan alami dalam upaya penghematan penggunaan energi penerangan pada siang hari dengan memanfaatkan energi matahari sebagai sumber penerangan. Wujud implementasi Daylighting dapat dilakukan dengan perancangan sistem bukaan bangunan dan meninjau proporsional antara dinding dan bukaan pada setiap sisi dinding. Analisis dilakukan dengan meninjau daylight factor dan component daylight dengan memasukkan Sky component (SC), External Reflective Component (ERC) dan menghasilkan Internal reflective component (IRC). Hasilnya menunjukkan semakin besar bukaan pada dinding yang merupakan objek kajian maka solar koefisien nya semakin besar dan serapan penerangan alami pada siang hari juga semakin besar.

Kata kunci: *Daylighting,Technology, Energy, Performance, Building*

I. INTRODUCTION

The lighting of the building must clearly define to meet the social and physical requirement of the users. It must be firmness and the technology must be sound. Perhaps most of all the lighting must evoke delight and plays its role inducing the desired emotions and creating an appropriate characteristic of the building. All parts of a well-made building contribute to the whole, and the designer of one element-especially an all pervasive one such as lighting-should appreciate the way it interacts with others. In a large building, the extent to which the general working illumination will depend upon daylight and how much upon artificial lighting will have a decisive effect upon the layout and planning of the building as a whole.

Base on the reference, there are the following factors have a positive impact on the reduction of energy consumption, there are sensible control of lighting, use of daylight, use of presence detectors, intelligent consideration of hours of use, energy-efficient lamps, need-based use of luminaries and lighting solutions, specified for the respective application and constant lighting control (maintenance control). In relation with the topic is energy efficient lighting service, we will analyze to use of natural light, or daylight. The topics are of the building.

II. DAYLIGHTING TECHNOLOGIES

Technologies can be defined as the tools that human use to shape the built environment and subsequently to modify the natural environment. Peter McCleary, professor of architecture at the University of Pennyslvania, describes recent shifts in our perceptions of technology: "... a new concept of technology has arisen, one that does not limit itself to building materials and processes, but defines technology more broadly as the understanding (skills and knowledge) of the dialectical relationship between humans and their environments (natural and built) in the production of a new superimposed built environment.

. Peter McCleary brings in an important element of technology in term of relationship between human beings and environment. Our values and choose of using technology will determine the characteristic of what McCleary characterizes as "new superimposed built environment".

Day lighting technologies are generally means to modifying, filtering, or even controlling natural forces. We always use the term of control in discussion of day lighting design, as though light is a force that needs to be restrained, tamed and regulated. Most of the term suggest to dominance over the natural forces. From an ecological perspective, the term control might focusing on how the day lighting can affect the lighting

accurately refer to ways of modifying, altering or shaping daylight.

Research on the environment and human benefits of day lighting, shown that it is common to find electric light as the predominant means of illumination in buildings. The technology needs to be there but it should coordinated with the day lighting design so it can be shut off during the day.

Daylighting technologies can be use to extent into the environment, to respond to the natural forces and to increase the awareness of ecological phenomena and the laws of the nature. While using the daylighting technologies is to reduce the energy, resource consumption and environment impact.

III. DAYLIGHT BASIC

Daylight is one of factor for efficiency of electric consumption on the building, although can only use in a day from the morning until afternoon (working hours), with consider the season at the same time. Therefore, to maximize of daylight on the building should be analyze of average of weather especially and season in generally, because of the source daylight are sunlight.

One measure of the efficiency of a light source is the ratio of the amount of light energy put out by the source for every watt of electric power consumed. This ratio, known as the efficacy of the source, provides a useful comparison of characteristic of daylight is its variability. The amount of daylight and its direction at the window or roof different sources of light. When sunlight enters the space through a window or skylight, it brings not only light energy (whether direct or indirect, but preferably indirect light in building), but also heat energy. Figure 1, describe of relative efficacy of light sources (ratio of number of lumens of light energy per watt of power or rate of heat energy supplied).

These ratio numbers lead to the conclusion that if properly and carefully designed, day lighting techniques can both reduce electric energy demand for lighting as well as minimize loads on the cooling equipment due to lighting. Since sunlight is an intense source and has a substantial amount of heat content, day lighting design must be carried out with great care. Well-designed day lighting should be a design objective for any building project because of the obvious benefits.

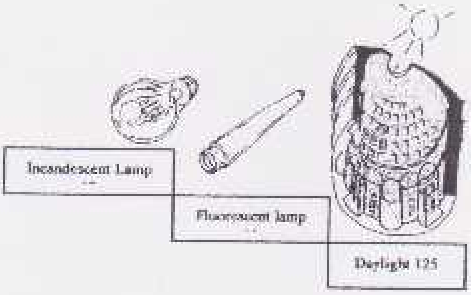


Figure1. Per Square Foot of Horizontal Surface

of a building vary during a typical day as the sun moves.

IV. PHYSICAL CHARACTERISTICS OF DAYLIGHT

Day lighting design begins with an understanding of the physical characteristics of daylight. Controlling it and tailoring it for use in a building requires some knowledge of this energy media that is entering the building. The fact that sunlight is so intense means that the sheer amount of daylight must be carefully limited and manipulated to avoid glare or heat gain problems.

The first requirement for building lighting is to provide enough light to accomplish a visual task such as reading. For daylight, this means tuning the aperture designs to minimize solar heat gain while achieving the foot-candle levels required for visual acuity. The second requirement is that the contrast brightness of other objects within the field of view must not be excessive, such that the building user can view the task comfortably and not become visually fatigued over time.

In daylight design, glare conditions (i.e., when the Brightness ratios of surfaces exceed visual comfort conditions) are avoided through aperture design, exterior sun control components and the placement of adjacent surfaces to balance the nearby surface brightness levels. A typical condition that can be observed in building with relatively poor day lighting design is that electric light fixtures are turned on during the

Day to overcome glare conditions and to balance the brightness light, in coordination with the light available from daylight.

For the case study of day lighting we will analyze one of building on Politeknik Negeri Lhokseumawe, Aceh, Indonesia.

V. DAYLIGHT FACTOR

An indication of the amount of daylight at a point within a room is the ratio of daylight illuminance at the point to the instantenous illuminance outside In general, people prefer variable light in the form of daylight and the connection it provides to the natural environment. However, it is important in building to maintain a relatively constant light level for visual tasks so that short-term variability does not become distracting or inadequate. This is accomplished by using electric light fixtures for what they do well, namely, provide a constant level of comfortable the building from a complete hemisphere of

Another diffuse than on a clear day. On overcast days, the daylight is uniform, though varying in absolute brightness

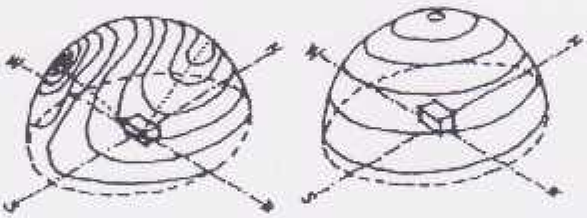


Figure 2. Sky Brigthean Distribution on Overcastand Clear Days

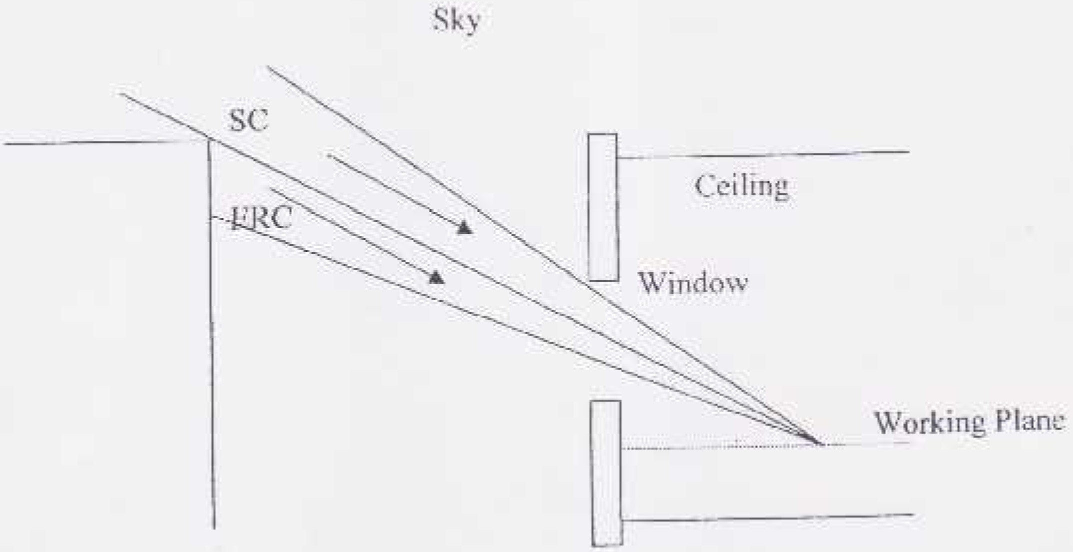
created by windows or roof monitors sky. This ratio is known as daylight factor (DF) and quoted as a percentage.

Daylight Factor =<u>Horizontal illuminance at a point in an interior</u> x 100

Horizontal illuminance at the same instant due to an unobstructed sky

5.1 Component of Daylighting

It is desirable at the design stage of the building to predict the amount of daylighting that will be obtained for a given window configuration. To consider how the daylight reaches a point within the room and this can be done by dividing the illuminance received into three components which shown below. and seasonally as the sun's predominant position in the sky changes. There is additional variation depending on sky conditions. Daylight direction on cloudy days is still variable, though the light is more distribution in the space. somewhat from sunrise to sunset. See Figure 2.



The three components of daylight

Light reaching the point P directly from the sky, known as the sky components (SC) of the daylight. In normal situation, nearby buildings may obstruct the light from the sky to the point P and hence reduce the sky component. The surface outside the building do, however reflect light from other parts of the sky into the room and contribute a little towards the daylight within the room. This component is known as the **external reflective component.**

The final component is due to the light entering the internal room being reflected onto the reference plane. In this case the window could be considered as an area source emitting light onto all of the room surfaces, some of which is reflected onto the reference plane, increasing the illuminance. This component is known as the **internally reflected component (irc)** of daylight.

VI. ANALYZE DAY LIGHTING ON THE BUILDING

Case study	: Administration centre building
Location	: Lhokseumawe, Aceh, Indonesia
Focus	: First floor (lobby area)
Area	: 580 M2
Function	: Public service
Analyze	: Lighting efficiency on working hours

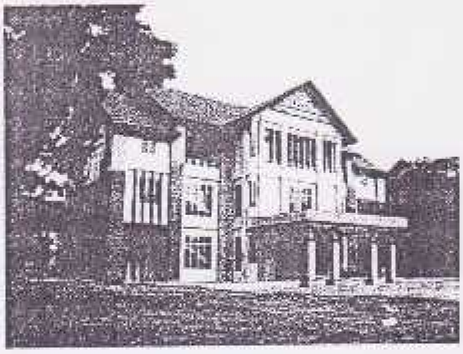
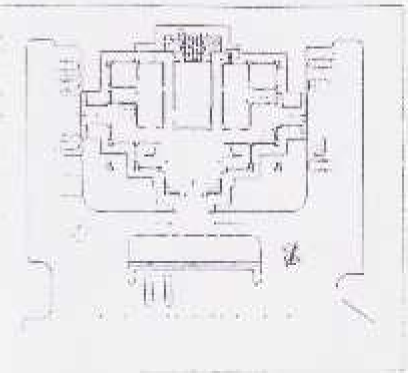


Figure 3. Perspective Of Administration Building



6.1 Building Orientation

A good, cost-effective daylight building design starts with proper orientation. To maximize the opportunity for day lighting, lay out the building on an east-west axis with the majority of spaces facing either south (best) or north (second best). This will be particularly true if you are going to rely on side lighting (versus roof monitors) as a significant day lighting strategy. Here building orientation of case study as shown at the below.

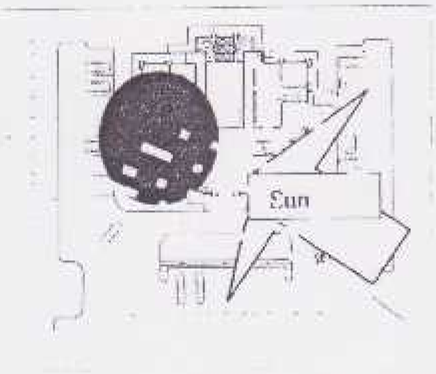


Figure 4. Building Orientation

Figure 4 above, can be describe that day lighting can be maximize in use for lighting service during working hours (morning – afternoon) on building facade. When sunlight enters the space through a window or skylight, it brings not only light energy (whether direct or indirect, but preferably indirect light in building), but also heat energy.

6.2 Light quantity

Base on the drawing design of that building, the light quantity can be shown as below:

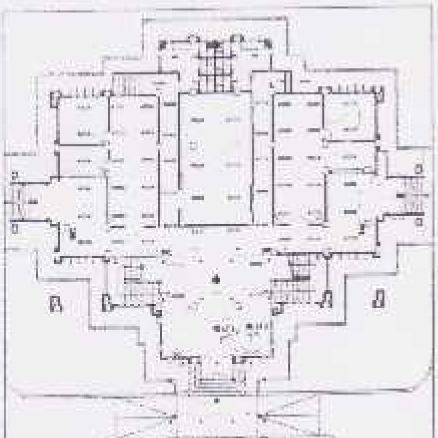


Figure 5. Electrical Plan

Lighting service use fluorescent lamp with specification as shown at the figure below:

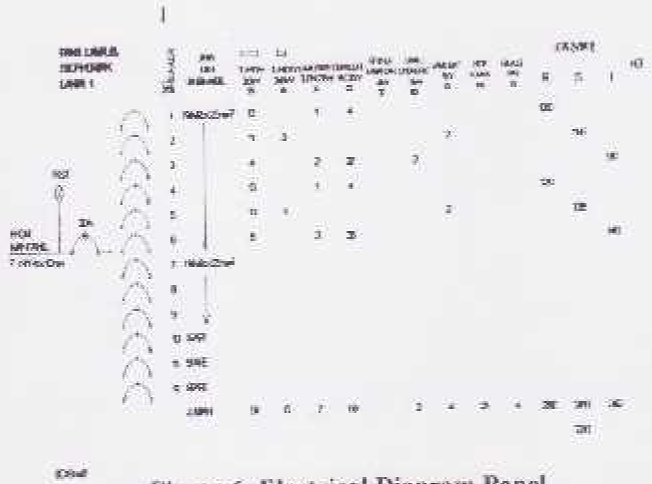


Figure 6. Electrical Diagram Panel

The standard values of illuminance can be refer to the CIBSE 1984 Lightning code for all the usual locations and occupants. These values are necessary to achieve :

a. Satisfactory illuminance of the task
b. An agreeable general appearance of the interior

They are indicated as a standard illuminances, normally on a horizontal working plane. The illuminance value serve as a guide to good practice. In this case we will analyze the minimum using lighting on working hour's consideration efficiency lighting service. That analyze begin from how much sunlight can enter the room pass through windows. With integration of the artificial lighting and day lighting will decrease the use of artificial lighting in daytime.

a. **Designing a general layout.**
The first stage is to decide on the type of luminaries to be used. This decision may seem premature, but, unless using computer programmed, it is difficult to achieve anything without immediate access to specific photometric. Next, the total number of lamp lumen is calculated to achieve the recommended luminance, and finally the layout is planned.

b. **Determination of lumens required**
The formula lumen is

$$\text{Lamp lumens required} = \frac{E \times A}{UF \times LLF}$$

Where
E = standard service illuminance (lx)
A = area of working plane
UF = Utilization Factor
LLF = Light Loss Factor

(i) Utilization Factor
This is measure of the efficiency of the lighting scheme and is the proportion of lamp flux that reaches the working plane. Some will come direct and some will come after reclection from other surfaces.

(ii) Light Loss Factor
When the light fixture is activated, it produces light which must leave the lamp, then the fixture then reach the work plane. Along the way, a number of operating and environmental conditions interfere with the transmission of light, resulting in wasted

lumens. The designer must provide a system that will take into account these conditions so that despite them the lighting system will provide proper quantity of light over time.

These conditions are captured as metrics called the light loss factors. Metrics are used to perform how something behaves. Light loss factors are captured as percentages or decimals

6.3 Daylight Distribution

For good day lighting design, low glare lighting is a principal objective in building. Ideal ratios of brightness levels within the field of view are often described at 10:3:1, for brightness of visual task to brightness of the immediate surround to brightness of the general surround. A building space that largely achieves these ratios can be considered to have a good level of visual comfort and no glare conditions.

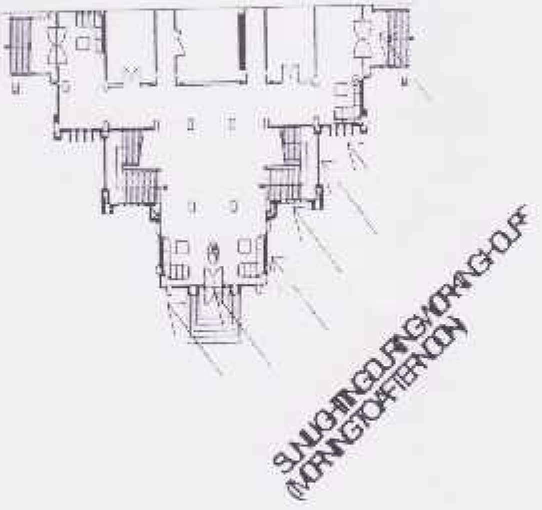


Figure 7. Sunlight Pass through Windows at floor plan

The three fundamental designs Issues in daylight design are:

a. Sun control, to mitigate any increase in the cooling load and to control direct glare.
b. Glare control, to create and maintain comfortable brightness distribution, including no direct views of the bright sky in the normal direction of view.
c. Variation control, to avoid any user perception of insufficient local light levels.

Daylight apertures in walls and roofs are essentially in situ light fixtures using renewable light energy from the sun. The building design team must not only address the three principal issues above for a variable, heat-laden source, but must configure the daylight apertures to reflect and diffuse the light effectively to serve the lighting tasks appropriately.

Daylighting solutions that address the above issues are most successfully executed when focused on providing general background lighting as opposed to specific task lighting, and when augmented by electric lighting in an intelligently controlled and seamless manner.

When used as general lighting, the variability of daylight is more acceptable to users and easier to control. Smooth integration with electric lighting also helps mitigate the variability issue. The following sections treat the three design issues in the context of the types of daylight apertures that are commonly used in building.

6.4 Daylight Apertures : Wall

The perimeter spaces of the building can be effectively day lighted for approximately twenty feet from the exterior wall by using windows and clerestories (high windows). Generally, the taller or higher the window, the deeper will be the daylight penetration into the space.

Clear glass is preferred for day lighting, but this in turn requires carefully designed exterior sun control devices to provide adequate shading. Although internally mounted shades and blinds reduce the high intensity and heat content of direct sunlight, the most effective sun control device is the exterior sunshade. An internal shade, even a light-colored fabric or blind, reduces solar heat gain by about one-third to one-half of the incident solar energy. An exterior shade will create a reduction of 80% of the incident solar energy.

The south-facing window is easiest to protect since the sun is at relatively high angles in the sky for most of the day relative to this orientation. Horizontal sunshades located above eye level easily shade the south-facing window and create the least obstruction to view and Daylight. Highly sophisticated design of south-facing sunshades can be realized by making the sunshade as permeable to daylight as possible, while maintaining the full shading characteristics. A solid horizontal overhang will create full shade from direct sunlight, but the overhang can also be designed with enough depth of structure so that openings can be introduced in the otherwise solid element. The more open sunshade can still provide full shade at the window for the angles of incident light, while reflected daylight can pass through the openings to provide higher levels of light at the window face.

Horizontal sunshade for the south elevation of a building. Note structure that excludes all direct sunlight, but is open to allow diffuse daylight to pass through. Sun control at north-facing windows should not be ignored in hot climates since late afternoon summer sun will penetrate the north-side spaces from May through July. Simple fixed vertical elements are adequate to control this type of direct glare. Many interesting architectural solutions are possible for this condition.

East- and west-facing windows are more difficult to shade since the sun is low in the sky in the mornings and afternoons, and the angle of incident sunlight is almost perpendicular to the glass. For these windows, some kind of vertical device or operable shutter is generally needed. Daylight through east or west windows is always best when the sun is on the opposite side of the building. When it is not, there will be no daylight at window level since the sunshade must be fully employed to screen the perpendicular low angle sunlight. This problem can be solved to some extent through the use of clerestories, or window openings placed high in the wall above the normal window location, and shaping the ceiling as shown in Figure 18 or by adding a light shelf as shown in Figure 19.

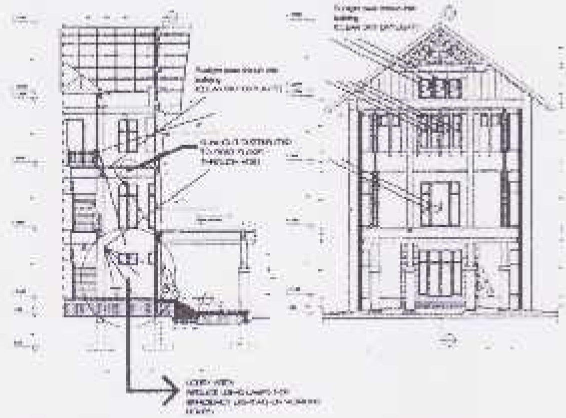


Figure 8. Sunlight Pass through Windows at Elevation Building

The light shelf is a device located at the bottom of a clerestory that captures direct sunlight by reflecting it off the top of a plane that extends into the space, either a mirrored or a diffuse surface. If the plane of the light shelf screens the clerestory window from direct view, there will be no direct glare and the low angle sunlight will be reflected from light shelf and ceiling, and will reach the task level deep in the space as diffuse light. The light shelf can be used on the south-facing walls as well, and the light shelf can be extended to the exterior to form a horizontal sunshade for the lower window.

6.5 Calculation Of Daylight For Efficiency Lighting

That in trying to achieve a minimum DF. With the window become too large will causing more serious glare and heating problem. It may preferable to design to a lower DF and integrate the daylight with the electric light.

6.5.1 Dimension Of Windows

Analyze dimension of windows for lobby area in first floor can describe as shown at the below

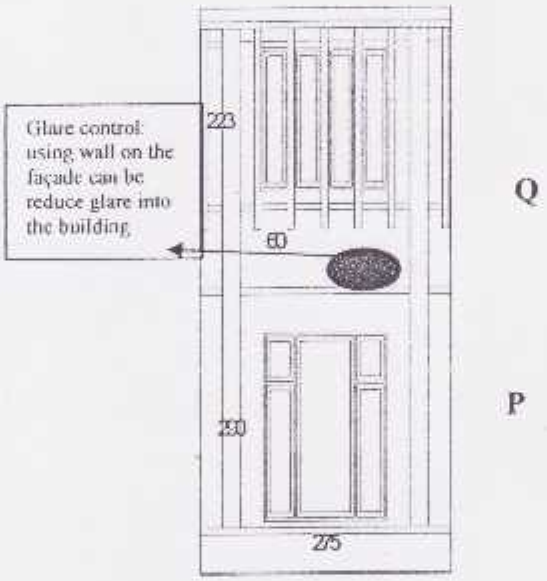


Figure 9. windows dimension

By considering windows solely as admitters of daylight it may seem that the achievement of a certain minimum DF is the main criterion. Electric lighting is often used during daylight hours and it may be the case

a. Calculation of sky component (SC)

Based on the dimension of the window in figure 9, it shown of two different size of the window. Let say the distance from the window to the point of work plane is 2 m.

For Window area P	For Window area Q
H = 2.9 = 1.45 D 2 W = 2.75 = 1.375 D 2	H = 2.23 = 1.16 D 2 W = 2.40 = 1.20 D 2
From the table the SC is 6.6 %	From the table the SC is 5 %

By using the Sky components (CIE standard overcast sky) for vertical glazed rectangular windows. From the calculation it shows that with the bigger size of the window, the percentage of SC will be increase. With two type of window size, the windows P have bigger SC compared with window Q.

VII. CONCLUSION

To design the good lighting in the building has to look into different factors such as type of lighting, building occupants and others. Integration with the daylight or solar energy can enhance the quality of light and reduce the energy waste. By applying the formula

Solution

which are standard guideline by the International, will give a scenario how the designer can get an idea how to plan the lighting in the building.

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