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Chronolux plugin sketch up to optimize the placement of vegetation

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Abstract. This study describes the software functions of Chronolux Sketch Up plug in. This software aims to simulate insolation at some point. Insolation areas and sky view factor (SVF) which is integrated as where the initial phase of a design process at an analysis site. Chronolux is proven as the simple tool to help a designer to know the grade of insolation, which then decided the vegetation spot based on the level insolation. Based on this experiment, it is known that north part area is an area with maximum insolation within 10 hours, and west part area is an area with the minimum insolation within 7 hours. From the SVF calculation, it is found that the north part with 77.28% later can reduce the SVF until 42.69% by optimize the placement and determine the characteristic of vegetation. After the placement of vegetation, the solar insolation then is able to reduce from the average 6h5m into 4h35m . The vegetation then is proven as an important aspect to reduce the insolation.

Keywords: Chronolux, SVF, vegetation optimazation

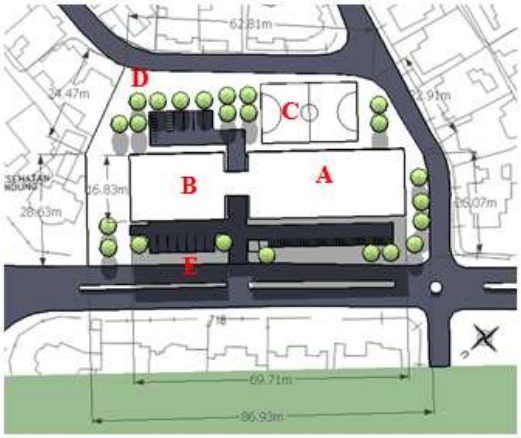
1. Introduction

The building design process is a complex matter that connects various things, including space needs, desire owner, government regulations of the building being in the design and analysis of the site. In order to find common ground to obtain the results of optimal design, an integrated of site analysis is needed. Site analysis is the stage during the design process, which most time-consuming, especially their correspondence between aspects of the site and its responses to obtain the desired output design. In this stage, the planner supposed to consider geo-location, which contributes to the climate aspect.
This paper is focusing on solar radiation which in tropical hot humid climate expose to the urban environmental area longer than any other climate region. The heat intensity in the urban area also reported trapped in the urban surface, such as ground, wall and roof, especially in the high dense area, and its vegetation aspect able to reduce insolation [1]. Thus, the design experiment has been done to find the optimization of vegetation placement on the site, which later able to reduce the insolation toward urban built environment.

Chronolux then, is used as a simple tool to find the length of sun hours. This tool significantly reduces the time to analyze the movement of the sun manually, which able to generate information such as insolation areas and the value of SVF. Chronolux is one additional applications for Sketch Up which simulate and the data, especially for time and duration of insolaton. This calculation also able to

perform sky view factor (SVF) value at the desired point. The need for analysis of insolation and the sky view factor (SVF) in the design process are to produce the optimal design on the site, both of open spaces and the building orientation as well as their layout. Manual calculation is long enough for the insolation and SVF data retrieval which takes the situation of the light of the sun from sunrise to sunset at certain times such as for the hottest temperature. Thus, the Chronolux's simulation is simplified the calculation and reduce the analysis time to find the peak insolation and high SVF value. The simulation based on real time, by set the local time (UTC/GMT), which resulting from the shadow pattern. The relationship between shadow pattern and radiation has been stated by Linberg and Grimmond [2] that vegetation scheme is able to successfully capture the variations of 3-D radiation fluxes and Tmrt. The strategy to control solar radiation also shown by using vegetation to reduce the cooling and improve the indoor and outdoor thermal environment [3]. Meanwhile Spangenberg, et.al. [4] describes the effect of adding shading trees to the street canyon had a limited cooling effect on the air temperature (up to 1.1°C), but led to a significant cooling of the street surface (up to 12°C) as well as a great reduction of the mean radiant temperature at pedestrian height (up to 24°C). Other research in Singapore also reported the use of vertical greenery systems to cool the ambient temperature in building canyons is promising [5]. Learn from the previous experience, this paper examines the Chronolux uses to optimize the placement of vegetation within the insolation area and open space with the high SVF value.

2. Study area



The object study is dormitory building which located at Citarum Street, Cihaur Geulis, Cibeunying Kaler, Bandung with the geographical location is 6^{o} 54' S and 107^{o}37 E and 725.72 m above sea level. The total area about 4,300 m^2, as shown at figure 1.

This building contents four floors with the main orientation is toward northeast to south west. The building coverage is 60% with the open space 40% for sport field and parking. There is no green open space as well as green coverage.

A = Dormitory	D = Garden
B = Office	E = Parking
C = Sports Field	

Figure 1. Site Plan of Dormitory Building

3. Method

The building assessment based on insolation area and sky view factor (SVF) index. Selected six spots of measurement which placed on south east (2), south west (1), north west (2), and north east (1) will be simulated using Chronolux to find the duration of insolation and SVF index. An insolation map from Chronolux simulation then is useful to decide the plantation spot. The optimization of vegetation placement later is able to reduce the duration of insolation.

3.1. Chronolux

Chronolux an additional application for Sketch Up, Chronolux version 1.2 was released in June 2013 and previous versions of vesi 1.0 beta was released in November 2011 by Kirill Bannov [6]. Here's how to use Chronolux and its bar shown at figure 2:

- Real-time interactive insolation of tests and calculations sky view factor (SVF) at the point specified points.
- Graphical representation of the results of the tests of time insolation and sky view factor (SVF).

- A list of points of the process.
- Setting the time period tests and the accuracy of the test.
- Manual tests to obtain the latest results after the design changed.
- Help system.
- Tooltip on the toolbar will appear when the cursor on a computer directed at the tool.

3.2. Insolation

Insolation is an acronym of the incoming solar radiation, "The amount of incoming solar radiation that is received over a unit area of the Earth's surface. Solar energy received over the planet's surface varies according to season, latitude, transparency of the atmosphere, and aspect or ground slope. On average, equatorial areas receive approximately 2.4 times as much insolation as polar areas " [7] The solar radiation reaching the earth's surface it is measured by the amount of solar energy received per square centimeter per minute. Insolation affects temperature, which means the more insolation, the higher the temperature.

Insolation duration at a given point is the period where direct sunlight reaches that point.

Sky view factor (SVF) is how big the sky can be observed at a given point as a proportion of the sky hemisphere [7]. The first research about SVF that connected to long-wave radiative heat loss is Oke [8] by showing canyon geometry in the central portion of a city as measured by the SVF.

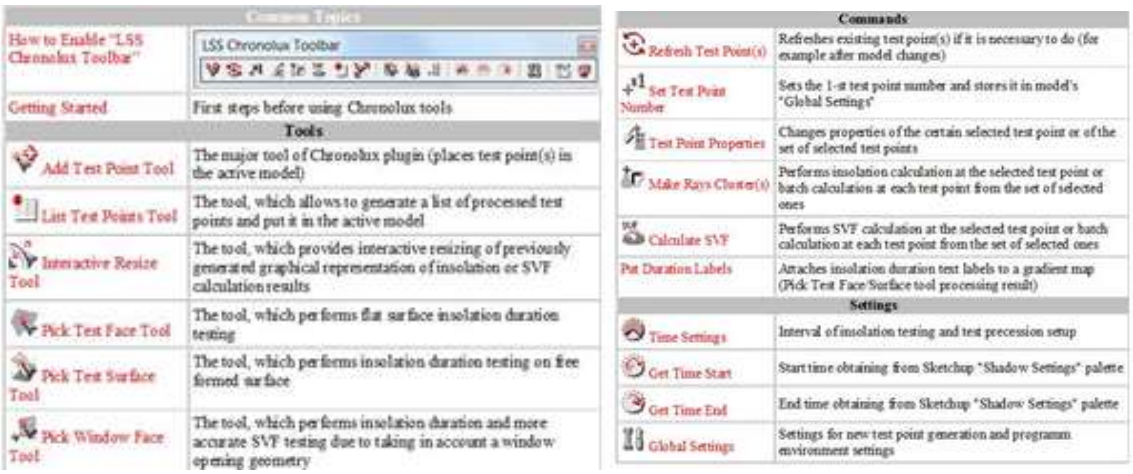


Figure 2. Chronolux task's bar

4. Discussion

4.1. Simulation setup

The selected date to make simulation is on March 8, 2015. Based on the historical data temperature, this date reaches the highest air temperature on 39oC, while the average air temperature is 28oC [9]. Simulation time started from sunrise until sunset, which is at 4:29am to 18:09pm

4.2. Insolation test point

Color can provide information more communicative on this insolation test process and test results depicted with ray cluster (s) in the form of an arch that point color when exposed to sunlight. The curvature given color gradation as desired to describe colors in the morning, noon, afternoon and evening (fig.3).

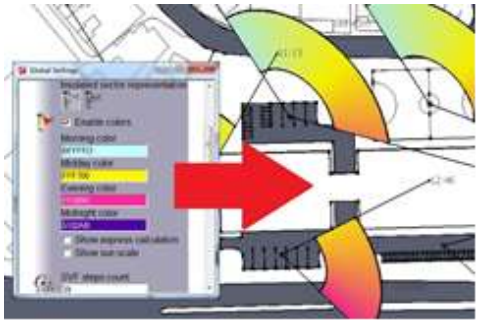


Figure 3. Color scheme of ray cluster

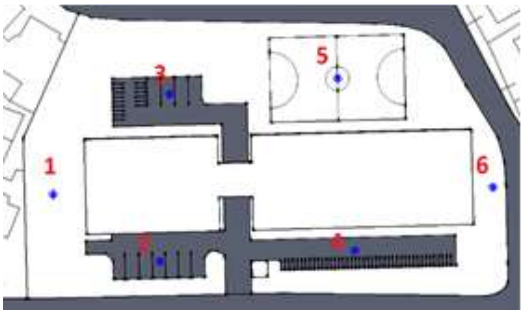


Figure 4. Points of Insolation Test

Figure 4 shows the points of insolation test, later each point describe as shown below.

Point 1

Figure 5. Point 1 of Insolation Test

Point 2

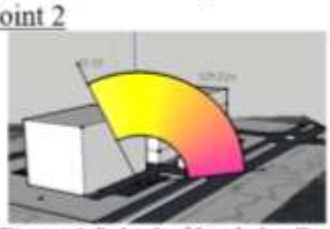


Figure 6. Point 2 of Insolation Test

Point 3

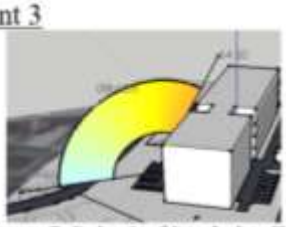


Figure 7. Point 3 of Insolation Test

Point 4

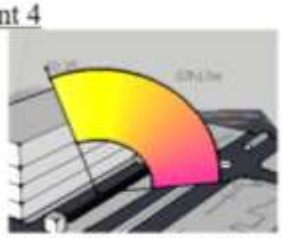


Figure 8. Point 4 of Test Insolation

Point 5

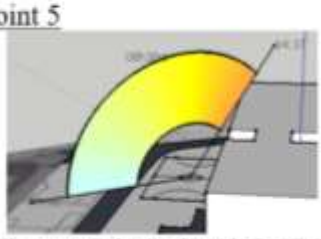


Figure 9. Point 5 of Insolation Test

Point 6

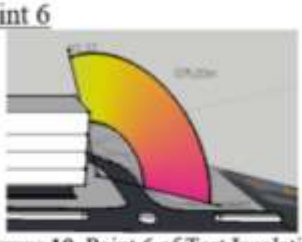


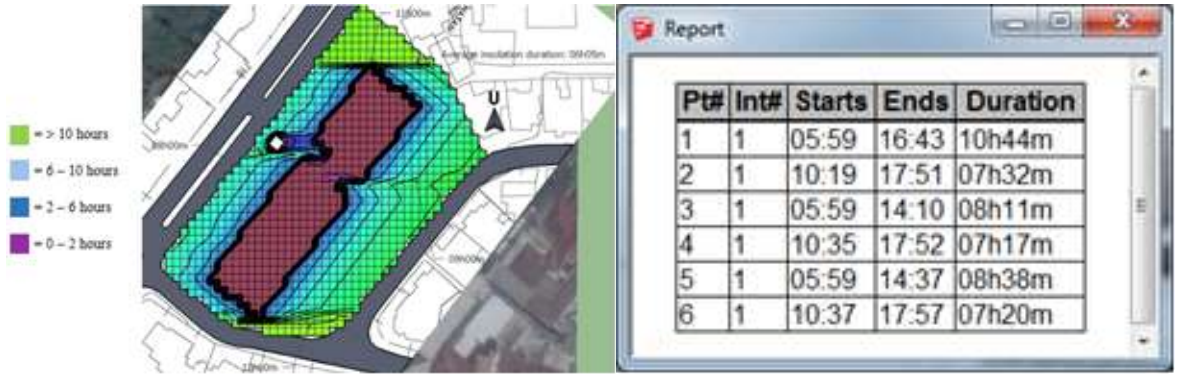
Figure 10. Point 6 of Test Insolation

Later figure 11 explains that point 1 having the longest insolation that is 10hours and 44minutes. It means that north east orientation receive the longest insolation which is also equivalent to the most heated areas. The test results at point 1 (fig.5) shows that this point had been exposed to sunlight within 10 hours 44 minutes that is at 05:59 am until 16:43 pm. The test results at point 2 (fig.6) shows this point had been exposed to sunlight for 7 hours 32 minutes that is at 12:46 pm until 17:55 pm. The test results at point 3 (fig.7), it had been exposed to sunlight for 8 hours 11 minutes that is at 5:59 am until 14:10 pm. The test results at point 4 (fig. 8), it had been exposed to sunlight for 7 hours 17 minutes at 10:35 pm until 17:52 pm. The test results at point 5 (fig.9), it had been exposed to sunlight for 8 hours 38 minutes at 5:59 am until 14:37 pm. The test results in point 6 (fig. 10), it had been exposed to sunlight for 8 hours 38 minutes at 5:59 am until 14:37 pm.

4.3. Insolation area

Insolation test areas described with grid which contain 2 x 2 m or 1 grid is equivalent of 4 m2. The grid is used in units of a particular area and in the intervening time how long the lines will be drawn insolation (in seconds). An interval for lines of insolation is every 3600 seconds (s) or equivalent to one hour.

Figure 11 shows the insolation test area for dormitory and office building. From this figure it can be seen that north area having the insolation longer than any other orientation. These areas have 65 grids which mean the area of 260m2 area facing insolation more than 10hours per day.



Pt#	Int#	Starts	Ends	Duration
1	1	05:59	16:43	10h44m
2	1	10:19	17:51	07h32m
3	1	05:59	14:10	08h11m
4	1	10:35	17:52	07h17m
5	1	05:59	14:37	08h38m
6	1	10:37	17:57	07h20m

Figure 11 (a). Insolation map area; (b) Insolation duration within the site

4.4. Text in figures

Sky view factor (SVF) test in Chronolux describes in the form of half-ball (globe) with a gray mark as a shadow that goes into the specified point and blocks the view to the sky, it is associated with the amount of direct sunlight which expose to the measured point.

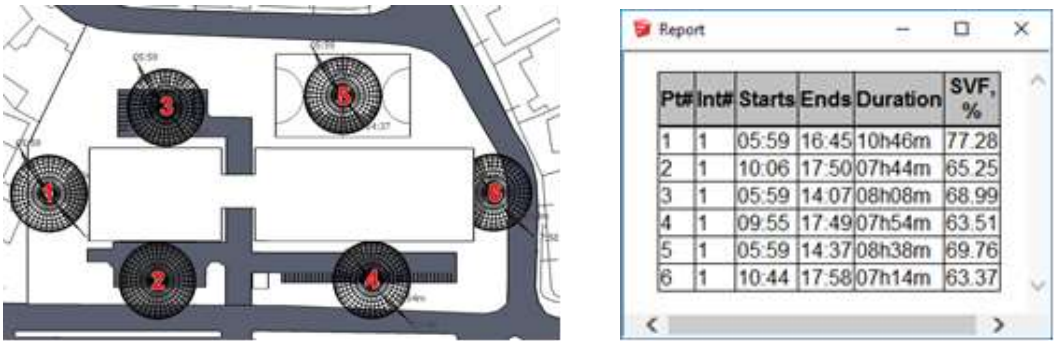


Figure 12. (a) Points of SVF Test **;** (b) Result of SVF Test

The test results sky view factor (SVF) at six points above at figure 12 shows that the average value of SVF is 68.03% and the highest SVF seen at point 1 with 77.28%.

5. Recommendation

5.1. Vegetation Characteristic

The simple ways to define vegetation characteristic is using LAI (Leaf area index), it is a dimensionless quantity that characterizes plant canopies. It is defined as the one-sided green leaf area per unit ground surface area (LAI = leaf area / ground area, m2 / m2) in broadleaf canopies [10].
In conifers, three definitions for LAI have been used [11]:

- Half of the total needle surface area per unit ground surface area
- Projected (or one-sided, in accordance the definition for broadleaf canopies) needle area per unit ground area
- Total needle surface area per unit ground area

5.2. Vegetation Placement based on Insolation Test Areas

Figure 13 shows the vegetation characteristic which used in Chronolux simulation, with 5.38m height and 4.41m width. As mentioned above, that the north orientation receive highest insolation, so the placement of vegetation in this area is prioritized. Besides, the vegetation is also placed in areas that have high levels of insolation over 10 hours. Figure 13 explains that after vegetation placement, it shows less grids with green color (insolation more than 10 hours), which signed that insolation has been reduced.

(a) **(b)** **(c)**

Figure 13. (a) Vegetation characteristic; (b) the placement of vegetation on the site; (c) SVF after the placement of vegetation

6. Conclucion

Chronolux has been demonstrated its ability to measure an incoming solar radiation (insolation). It is important to find the duration of insolation, by the insolation test area and later to know the SVF value.

Northern part area is known as the area that received the longest radiation compare than any other orientation, followed by East, South, and finally West orientation.

The longer an area exposed to solar radiation, it is directly proportional to the level of heat received. By mapping the insolation area, it can be described the locations that have a duration of solar radiation. This mapping later is important to determine areas for vegetation placement, which aims to reduce insolation. Vegetation characteristic also give the significant influence to optimize the radiation reduction.

By optimizing the placement of vegetation, it is able to reduce insolation from average insolation of 06 hours 05 minutes into 04 hours 35 minutes. Meanwhile, the result of SVF test shows the highest SVF reached at 77.28% is able reduced into 42.69%.

Finally, this paper shows that Chronolux is a simple tool that able to measure an insolation as well as to determine the vegetation placement to reduce the solar radiation.

Acknowledgments

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