AN EXAMINATION ON DAILY HORIZONTAL ILLUMINANCE DATA IN INDONESIA

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ABSTRACT

The standard value of the horizontal illuminance from unobstructed sky has been considered very essential and fundamental for the energy conservation in the field of lighting design in order to keep the minimum level of the illuminance in interiors. According to the recent progress of the way of thinking on the visual environment and the change of the energy circumstances, many improved models have been proposed for the estimation of the illumination level in interiors. The estimations based on these models proved that the sky illuminances vary in different locations and countries.

In order to investigate daylight availability data in low latitude/tropic area which are extremely lacking at the present stage, a measurement of daylight and solar radiation was done in Makassar–Indonesia.

After the records of the data were strictly inspected, the data of the diffuse illuminance has been rearranged into a classification based upon the sky conditions of the whole day specified by cloud ratios. Based upon the diffuse horizontal illuminance data gathered in Makassar–Indonesia during 1995 to 2000, an examination on the values of the horizontal illuminance from the unobstructed sky by the statistical analysis can be proposed.

Keywords: *daylight and solar radiation, horizontal illuminance, measurement data, sky conditions.*

INTRODUCTION

The standard value of the horizontal illuminance from unobstructed sky has been considered very essential and fundamental for the energy conservation in the field of lighting design in order to keep the minimum level of the illuminance in interiors. According to the recent progress of the way of thinking on the visual environment and the change of the energy circumstances, many improved models have been proposed for the estimation on the illumination level in interiors. The estimations based on these models proved that the sky illuminances vary in different locations and countries.

A study about horizontal illuminance in Indonesia was done by M.U. Adhiwijogo in order to propose the selection of the design sky for Indonesia based on the illumination climate of Bandung. These study based upon the observations and measurements throughout the whole year of 1964. He proposed a result for the blue cloudiness sky and the grayish overcast sky, giving an equivalent illumination of 10,000 lumen/m^2 are to be used as the design sky for Indonesia [1].

Based upon the diffuse horizontal illuminance data gathered in Makassar-Indonesia during 1995 to 2000 a proposal on the values of the horizontal illuminance from the unobstructed sky can be made by the statistical analysis.

SKY CONDITIONS SPECIFIED BY CLOUD RATIO

Two CIE standards, that is, the CIE Standard Clear Sky and the CIE Standard Overcast Sky have been already recommended as the standards of sky luminance distribution. Those skies only represent for two extreme sky conditions, that is, the completely clear sky and the heavily cloud sky. However, most of real sky conditions are not similar to them. They are between both extreme skies above stated, and they are called “intermediate sky”.

In analyzing the measured data of daylight and solar radiation, it is necessary to sort the data by sky conditions. They are divided conveniently in three sky conditions, that is the clear sky condition (including quasi-clear sky), the intermediate sky condition and the overcast sky condition (including quasi-overcast sky). However, the sky conditions were recorded three times a day in a measurement diary (log book), it is not satisfactory to know the sky conditions of the whole day. For purpose, a parameter which can specify the real sky conditions is absolute necessary.

The ratio of the diffuse illuminance and/or irradiance to the global illuminance and/or irradiance is defined and named Cloud Ratio, which have been considered as the most practical and convenient parameter for this purpose.

Definition of Cloud Ratio

The Cloud Ratio has originally been defined as the proportion of the diffuse irradiance to the global irradiance and used for to the estimation of solar radiation, that is, for solution of heating and cooling problems in building interior. A few recent research papers [4-7] are found which applied the ratio of the diffuse illuminance to the global illuminance to the daylight research works.

In this study, the ratio on irradiance is called “Cloud Ratio on Irradiance (Ce)” and the ratio on illuminance is called “Cloud Ratio on Illuminance (Cv)”. Cloud ratio on irradiance can be calculated theoretically by the following equation :

$$Ce = Eed / (Eed + Ees) = Eed / Eeg \qquad ...(1)$$

Where : Eeg is global horizontal irradiance [W/m^2], Eed is diffuse horizontal irradiance [W/m^2], and Ees is direct solar horizontal irradiance [W/m^2].

Cloud ratio on illuminance (Cv) is defined in a similar way to cloud ratio on irradiance (Ce). Cloud ratio on illuminance can be calculated theoretically by the following equation:

$$Cv = Evd / (Evd + Evs) = Evd / Evg \qquad ...(2)$$

where : Evg is global horizontal illuminance [lx], Evd is diffuse horizontal illuminance [lx], and Evs is direct solar horizontal illuminance [lx].

Typical Diurnal Fluctuation of Cloud Ratio

Theoretically the values of both cloud ratios should be equal to 1.0 when the sky is completely overcast of the whole day. Both the cloud ratios on irradiance and illuminance of a clear day of the whole day seem to be dependent on the solar position. Their values were almost constant when the solar altitude was not so low and they increased as the solar altitude became low. The ratios of the overcast day of the whole day were almost equal to 1.0 throughout the whole day. The Examples of both the cloud ratios of an intermediate day of the whole day show the frequent and rapid change of their values throughout the whole day. Their values sometimes seemed to be almost equal to those of the clear condition and instantly move to those of the overcast conditions. Most values of cloud ratio on irradiance were a little smaller than those of cloud ratio on illuminance of the same time.

Sky Conditions

The diurnal fluctuation of cloud ratio on irradiance has been mainly inspected and compare with the cloud ration on illuminance. The measurement diary (log book) was also checked for reference.

The result shows the sky conditions specified by cloud ratios, the clear and overcast days were 318 and 308 days, respectively and the rest, 1449 days had intermediate sky conditions (were: clear sky 15.32%, intermediate sky 69.80%, and overcast sky 14.88%, respectively).

The yearly relative Frequency of occurrence of the three skies in Indonesia has been calculated from the relative sunshine duration and is assumed to be 6 %, 73 %, 21%, respectively [10].

The difference of the results are caused by the different period of calculation. Sky conditions specified by cloud ratios are daily between sunrise to sunset, and sky conditions calculated by sunshine duration are based on 8 hours daily working time.

DIFFUSE HORIZONTAL ILLUMINANCE

Classification of Data Based upon the Sky Conditions

After the records of the data were strictly inspected, the data of the diffuse horizontal illuminance has been rearranged into a classification based upon the sky conditions of the whole day conditions of the whole day specified by cloud ratios. The general tendencies, i.e. the effects of sky conditions to the horizontal illuminance from unobstructed sky have been roughly inquired, for example :

- Under the condition of the clear sky, the values of the horizontal illuminance from unobstructed sky are often smaller than those under the other conditions.
- The values for solar altitude from 0° until 45° are small and increased correspond to the solar altitude.
- The values of the horizontal illuminance from unobstructed sky does not change or reduces inversely, if the solar altitude becomes higher thatn about 45°.

Data of diffuse horizontal illuminance gathered from 1995 to 2000 have been processed by half-hourly intervals and 6-degree intervals. Further, all data were processed into 6-degree intervals and recalculated while based upon the sky conditions of whole day which have been specified by diurnal fluctuations of whole day which have been specified by by diurnal fluctuation of cloud rations.

After strict examination and careful analysis, the relationships between the horizontal illuminance from the unobstructed sky and solar altitude for these three skies conditions cloud be formulated. They were based upon the mean for each 6 of solar altitude and classified by three skies conditions. The proposed equations are as follows:

$$Ecl = 3.0 + 17 \sin^{0.9} ys \quad ....(3)$$
$$Ein = 1.1 + 48 \sin^{1.3} ys \quad ....(4)$$
$$Eoc = 0.6 + 78 \sin^{1.8} ys \quad ....(5)$$

where : the Ecl, Ein, and Eoc are the horizontal illuminance from unobstructed sky for clear sky, intermediate sky and overcast sky, respectively, and ys is the solar altitude.

Many equations have been proposed which show the relation between the horizontal illuminance from unobstructed sky (Ea) and the solar altitude (γs). Nakamura et al. [8-9] have been proposed. the equations of the horizontal illuminance from unobstructed the representative value, respectively. The equations are as follows :

$$Eu = 2.0 + 80.0 \sin^{0.8} \gamma s \quad ...(6)$$
$$Es = 0.5 + 42.5 \sin \gamma s \quad ...(7)$$
$$El = 15.0 \sin^{1.2} \gamma s \quad ...(8)$$

where : Eu and El are the upper limiting value and the lower limiting value of the horizontal illuminance from the unobstructed sky respectively and Es is the representative value of the horizontal illuminance from unobstructed sky.

Figure 1 shows data of the horizontal illuminance from unobstructed sky for the three skies with the curves of the proposed equations (3), (4) and (5), respectively. Also compared to the upper and the lower value proposed by Nakamura.

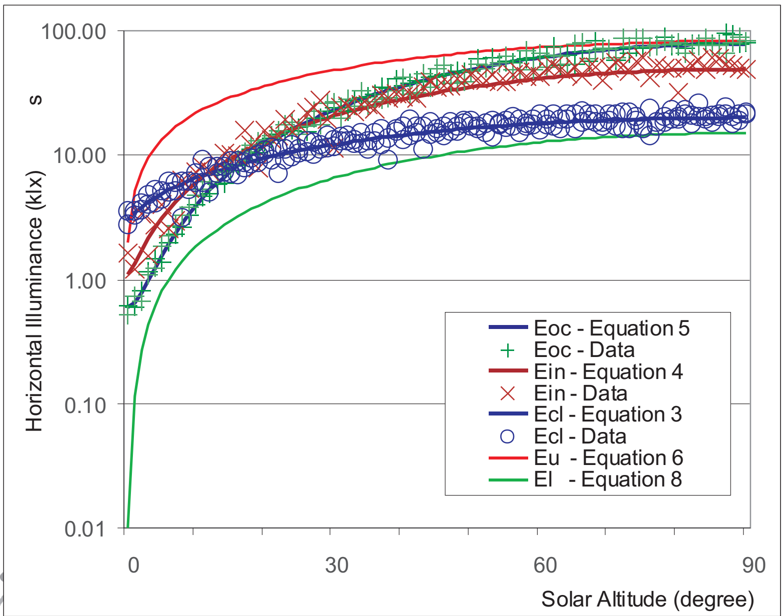

Figure 1
Data of the horizontal illuminance from unobstructed sky for the three skies with the curves of the proposed equations (3), (4) and (5), respectively.

Other equations of the horizontal illuminance from unobstructed sky have been proposed in relation to the sky conditions. The equations are as follows [2,3,11,12] :

- Krochmann $Ea(cl) = (1.1 + 15.5 \sin^{0.5} \gamma_s)$ ...(9)
- Chroscicki $Ea(cl) = \{3 + 0.17 (\gamma_s/^o)\}$ ...(10)
- Krochmann $Ea(oc) = (300+21000 \sin \gamma_s)$ ...(11)
- Kittler $Ea(oc) = 9750 (1 + 3/2 \sin \gamma_s) \sin \gamma_s$ ...(12)
- Feitsma $Ea(oc) = 467 (\gamma_s/^o)$ ...(13)
- Hopkinson $Ea(oc) = 215 (\gamma_s/^o)$ ...(14)

Horizontal illuminance from unobstructed sky both for clear sky and overcast sky also can be derived from the zenith luminance value and CIE Standard Clear Sky or CIE Standart Overcast sky. Figure 2 shows data of the horizontal illuminance from unobstructed sky of the three skies with the curves of the equations (3), (4) and (5) with various equations proposed, respectively.

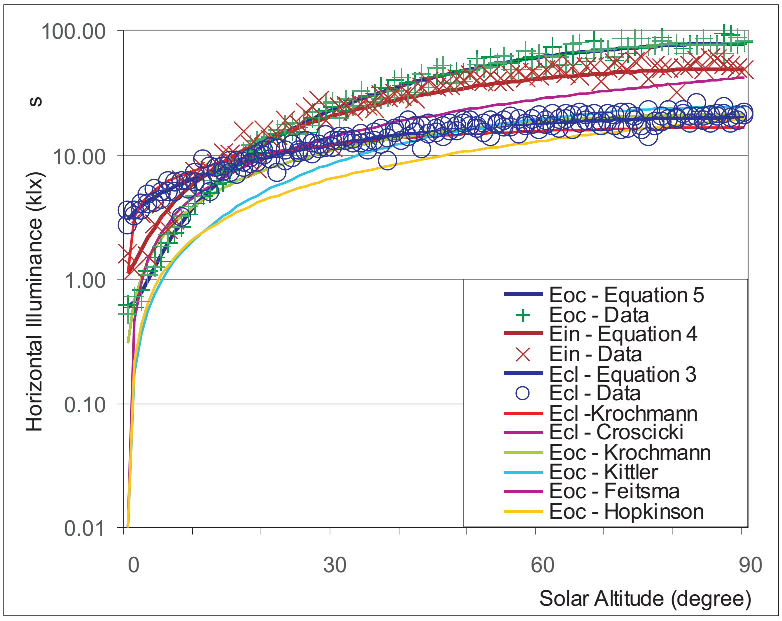

Figure 2
Data of the horizontal illuminance from unobstructed sky of the three skies with various equations proposed, respectively.

It has become necessary to fix conveniently a mean value as representative value corresponding to each solar altitude including the consideration about the distribution. Moreover, it has been desirable that the representative value has been widely applicable to a rather large territory.

The yearly relative Frequency of occurrence of the three skies in Indonesia has been calculated from the relative sunshine duration and is assumed to be 6 %, 73 %, 21%, respectively [10]. Using these frequency of occurrence of the three skies, the representative value of the horizontal illuminance from unobstructed sky (Ea) could be represented as the sum of the products of each values of the horizontal illuminance of the three skies and their frequency of occurrence. The proposed equation is as follows :

$$Ea = [(0.06 \times Ecl) + (0.73 \times Ein) + (0.21 \times Eoc)] \quad ...(15)$$

Figure 3 shows data of the horizontal illuminance from the unobstructed sky and the curve of the equation (15) with the upper and the lower limiting values by equations (6) and (8).

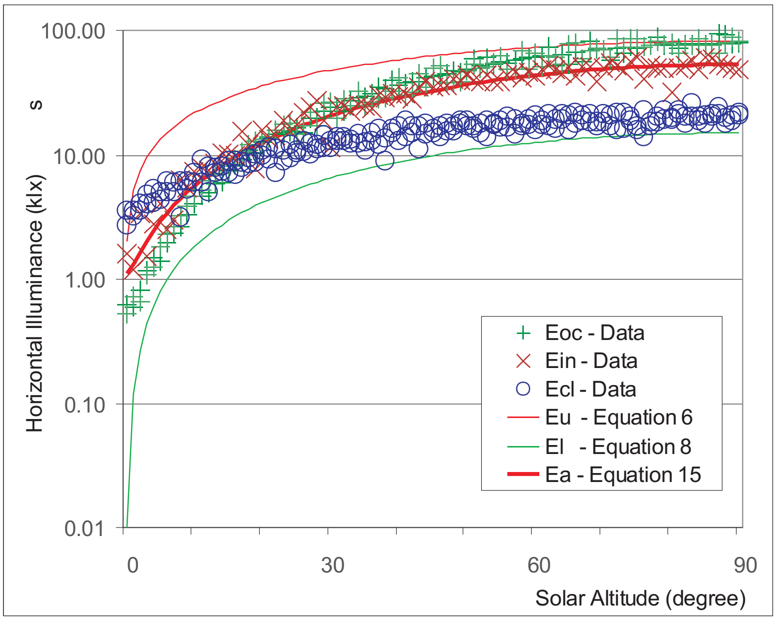

Figure 3
Data of the horizontal illuminance from the unobstructed sky and the curve of the equation (15) with the upper and the lower limiting values

Cumulative frequencies of the Horizontal Illuminance

The standard of the horizontal illumination from unobstructed sky has been inevitably constructed by the statistically treatment with the frequency of occurrence of the solar altitude throughout a year and the distribution of the values of the horizontal illumination from unobstructed sky of the three skies conditions.

The calculation of the percentage and the cumulative percentage of the hours corresponding to the each horizontal illuminance from unobstructed sky to the whole working hours have been performed by the following steps :

- The solar altitude to each representative value has been calculated by the equation (15).
- The frequency of occurrence of the hours to each solar altitude obtained as above to the whole working hours throughout a year has been calculated.
- The frequency occurrence calculated above has been distributed to each mean horizontal illuminance value.
- In order to get the percentage of the hours corresponding to each horizontal illuminance from unobstructed sky to the whole working hours duration, the frequency of occurrence distributed above has been integrated at each horizontal illuminance from unobstructed sky from the value 0 lx to that of 79 Klx.
- The cumulative percentage has been calculated from the percentage obtained as above.
- The value of the horizontal illuminance from unobstructed sky corresponding to each round cumulative percentage has been reversely calculated.

For comparison to other research works on the horizontal illuminance from unobstructed sky, Table 1 shows a review of measured skylight availability data [1-3, 8-12]. Table 2 shows the standard relation between the horizontal illuminance from unobstructed sky and its cumulative percentage of the hours, for which the illuminance level is available to the working hours.

Table 1
Review of measured skylight availability data

Location	Representative Es (Klx)	Reference
Darwin	12.7	Ruck, 1985
Brisbane	7.9	Ruck, 1985
Broken Hill	5.9	Ruck, 1985
Sydney	8.8	Ruck, 1985
Paris	5.0	Fournol, 1951
Kew/Bracknell	3.0	Hunt, 1979
Roorkee	8.0	Narashiman, 1970
Nagoya	13.5	Nakamura, 1979
Pretoria	10.0	Richards, 1959
Cape Town	7.5	Richards, 1959
San Fransisco	5.0	Navvab, 1984
Bandung	10.0	Adhiwijogo, 1969
Makassar	14.35	R.Rahim, 2004

Table 2
Relation between the horizontal illuminance from unobstructed sky
and its cumulative percentage of the hours, for which the illuminance level
is available to the working hours

Cumulative Persentage [%]	Horizontal Illuminance [Klux]	Cumulative Persentage [%]	Horizontal Illuminance [Klux]	Cumulative Persentage [%]	Horizontal Illuminance [Klux]
100.00	6.00	65.00	23.78	30.00	40.53
99.00	7.15	64.00	24.16	29.00	41.14
98.00	8.67	63.00	24.56	28.00	41.76
97.00	9.85	62.00	24.95	27.00	42.42
96.00	10.83	61.00	25.35	26.00	43.09
95.00	11.62	60.00	25.75	25.00	43.76
94.00	12.27	59.00	26.15	24.00	44.45
93.00	12.84	58.00	26.57	23.00	45.15
92.00	13.39	57.00	26.98	22.00	45.88
91.00	13.87	56.00	27.41	21.00	46.63
90.00	**14.35**	55.00	27.84	20.00	47.37
89.00	14.81	54.00	28.28	19.00	48.12
88.00	15.25	53.00	28.72	18.00	48.94
87.00	15.68	52.00	29.17	17.00	49.77
86.00	16.11	51.00	29.62	16.00	50.60
85.00	16.51	50.00	30.07	15.00	51.47
84.00	16.91	49.00	30.53	14.00	52.43
83.00	17.29	48.00	31.00	13.00	53.40
82.00	17.66	47.00	31.47	12.00	54.38

81.00	18.02	46.00	31.95	11.00	55.49
80.00	18.38	45.00	32.43	10.00	56.61
79.00	18.73	44.00	32.93	9.00	57.78
78.00	19.07	43.00	33.42	8.00	59.05
77.00	19.42	42.00	33.92	7.00	60.36
76.00	19.76	41.00	34.42	6.00	61.81
75.00	20.12	40.00	34.94	5.00	63.31
74.00	20.47	39.00	35.46	4.00	65.05
73.00	20.83	38.00	35.99	3.00	66.95
72.00	21.19	37.00	36.53	2.00	69.19
71.00	21.55	36.00	37.07	1.00	72.16
70.00	21.92	35.00	37.62	0.00	79.00
69.00	22.28	34.00	38.18		
68.00	22.65	33.00	38.75	**Latitude : 03°00' S**	
67.00	23.02	32.00	39.34	**Longitude : 120°00' E**	
66.00	23.40	31.00	39.93	**09.00 - 17.00**	

CONCLUSION

One of the crucial problems in predetermining the role of daylighting in energy efficient buildings is the need for reliable local data on daylight availability. Daylight availability can be defined in terms of the external skylight illuminance available on an unobstructed horizontal plane for a certain percentage of daytime working hours or for specified periods (daily, monthly and yearly).Furthermore, one of the basic aims of collecting and measuring daylight and solar radiation levels in many locations on the globe is the mutual comparison and evaluation of available data gathered.

Based upon the diffuse horizontal illuminance data gathered in Makassar-Indonesia during 1995 to 2000, a proposal on the values of the horizontal illuminance from the unobstructed sky has been 14,35 Klx proposed. This proposal has been supposed to be proper that the value at Makassar should be extended as the standard value of the horizontal illuminance from unobstructed sky in Indonesia.

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Thermal performance by the Traditional Roof Section in Bangladesh

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ABSTRACT
The roof is one of the main elements in building envelope that is directly expose to the sky and therefore it receives significant direct solar radiation. This provides an impact to the thermal behaviour of the indoor environment. In Bangladesh, most of the modern building in urban area have flat concrete roof. This roof is normally exposed to the direct solar radiation. The indoor temperature usually will be elevated to above the local comfort level. Active mean of cooling is still very expensive for Bangladesh. It can also create massive load on the electrical energy requirement. During the summer time, it becomes very uncomfortable to stay in the top floor of the building or in single story building. On the other hand, in the Bangladesh traditional houses, double layer roof section is used in which the outer roof material is made of mud tiles or corrugated iron sheet and the internal roof material is of wooden planks. During daytime, this roof section becomes hot but after sunset, it becomes cool in a very short time. Currently, the field study and the data are taken by HOBO data logger. Set of HOBO data logger was installed in one model of traditional Bangladesh house in Dhaka. This research will highlights the thermal performance of the traditional roof section in the context of Dhaka during summer and winter season and this paper highlights the methodology of this research.
Keywords: *Thermal performance, Roof section*

1. Introduction

The roof is the main element of the building envelope that has large exposure to the sun and therefore it also gain high solar radiation. The impact of solar radiation affects the thermal behavior of roof more than any other part of the structure especially for low rise building in tropical countries. In Bangladesh most of the buildings in urban area have flat concrete roof. Roofs are exposed to direct solar radiation and elevate the indoor temperature usually above the local comfort level especially in summer. Mechanical cooling is a very expensive option. In such a context we need to develop passive means of solar control which is important for comfortable living and higher productivity during hot season of the year. Traditional housing is still the typical house in rural area. Traditional house is designed by the user in his spare time and is based on low investment and use of local materials. **Now in Bangladesh reinforced concrete roof is very common but results in uncomfortable living condition at night (Abul Mukim, 2002). On the other hand, traditional houses of Bangladesh are less hot during the daytime, but it becomes comfortable with in short time after** sunset. Therefore the question arise that which type of houses are suitable for thermally comfortable living in Bangladesh. This becomes the main issue for this research.

2. Climate of Bangladesh

In terms of ecological region or biomes described by UNESCO (Lean, 1990), Bangladesh is situated between 20º34?N to 26º33?N and 88º 01?E to 92º 41?E and is in the Indo-Malayan Realm. The climate of Bangladesh based on the widely used classification by Atkinson (Koenigsberger *et al.,* 1973) is categorized as warm and humid. However in general the climate is divided into two; short and dry winters while the summer is long and wet. Although a large part of the country's land mass lie above the Tropic of Cancer, the nature of the climate being tropical is attributed to the regional geographical character. The following figures (fig 1 and 2) show the geographical position of Bangladesh with the change of seasons.

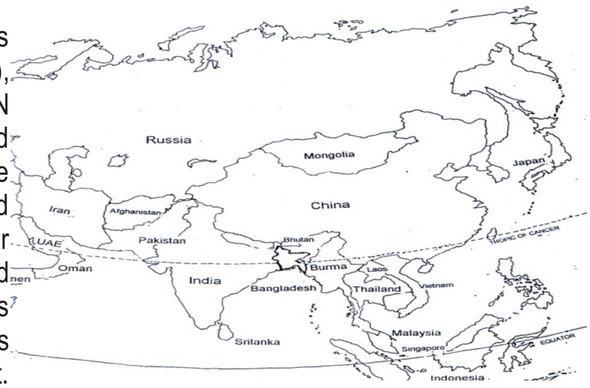

Figure: 1. Tropic of cancer crossing over the middle part of Bangladesh

The Himalayan mountain range and Tibet Plateau being in the north causes a significant amount of rainfall (Hossain and Nooruddin, 1993). The humidity is fairly high throughout the year and especially during the months of June to September when it is often over 80%. The temperature profile of the Dhaka city of Bangladesh indicates a clear congruity with the regional pattern, where highest temperatures are recorded in March, April and May reaching a maximum temperature of 35.4ºC in April. Table 1 shows the climatic data of Dhaka city for all seasons.

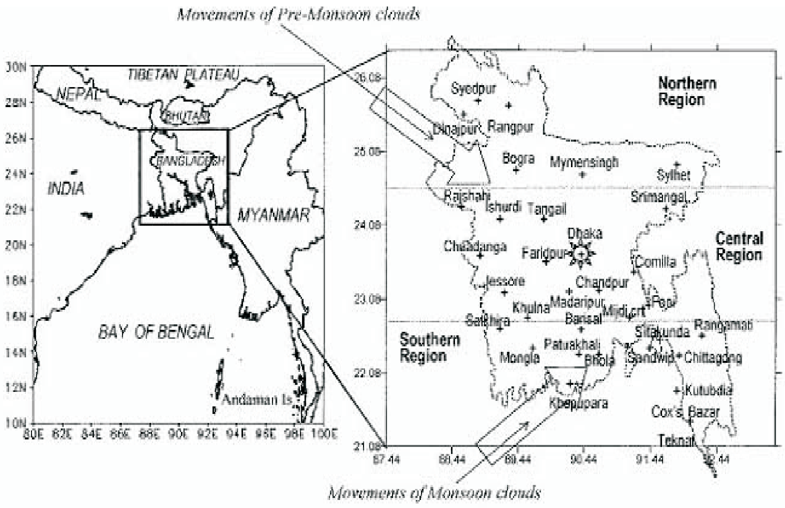

Figure: 2. Regional map showing BMD (Bangladesh Meterological Department radar) radar coverage (solid bold line), rain-gauge locations (plus mark ,right panel) throughout Bangladesh with the station names. The star at the center of Bangladesh shows the location of the BMD radar.

Table 1. Climatic data of Dhaka city for all seasons recorded over 10 years between 1991 to 2000 (Bangladesh Meteorological Department, 2002)

Bangla Calendar Month	Traditional Seasons	Meteorological Seasons	Gregorian Calendar Months	Ave. air Temp For 91-00 (ºC)	Mean RH For 91-00 (%)	Mean Rainfall For 91-00 (mm)	Mean Wind Speed (m/s) & Direction
Chaitra	Bashanta	Pre-monsoon (hot-dry)	March	26.6	63.6	69	2.4 (SW)
Baishakh	Grisha	Pre-monsoon (hot-dry)	April	28.9	70.9	120	2.9(SW)
Jaishtha	Grisha	Pre-monsoon (hot-dry)	May	29.0	78.4	342	2.4(S)
Ashaar	Barsha	Monsoon (hot-wet)	June	29.5	82.3	267	2.3(SE)
Srabon	Barsha	Monsoon (hot-wet)	July	29.1	84.0	371	2.2(SE)
Bhadra	Sharat	Monsoon (hot-wet)	August	29.2	83.6	335	2.2(SE)
Ashin	Sharat	Monsoon (hot-wet)	September	29.0	83.5	293	2.1(SE)
Kartik	Hemanta	Post monsoon (hot-wet)	October	28.0	80.7	197	2.1(N)
Arahayon	Hemanta	Post monsoon (hot-wet)	November	24.5	75.7	26	1.3(NW)
Poush	Sheet	Winter (cool-dry)	December	20.3	74.4	13	1.6(NW)
Magh	Sheet	Winter (cool-dry)	January	18.8	72.4	11	1.4(NW)
Falgun	Bashanta	Winter (cool-dry)	February	21.9	67.0	27	1.9(N)

In the monsoon and post monsoon period, starting from June to October the temperature remains steady at an average of 28.3ºC, while minimum recorded was 11.0ºC in January. The monsoon is the longest season covering the months of June to September. It is a period with torrential rains (781mm to 1499 mm recorded in Dhaka) and with the average relative humidity above 80 % as well as an average temperature of 31ºC. During this period, due to heavy rainfall and the melting of Himalayas ice, flood regularly occurs in Bangladesh for two or three months of every year. This 'borsha' influence the design of traditional Bangladesh house.

3. Traditional houses in Bangladesh

Religion and social characteristics of a society are just as important in the development of traditional architecture as the climate. The rural populace live in villages where groups of houses, usually belonging to one extended family are built together, sharing introverted courtyards, which shut out all male except immediate members of the household. They share ponds and wells from which they draw their water for bathing, washing clothes and pans as well as vegetable, meat and fish for cooking. As there is often no sewage facility at all, toilets are almost always located at a distance place from the main house the waste being disposed on to moving waterways or sunken trenches. Kitchens are normally separate from the main house. Over 65% of rural housing is of straw and bamboo and 21% of mud or unburnt brick. Straw and bamboo are the most popular roofing materials with corrugated iron sheeting over wooden beams trailing as second preference (See Figure: 3).

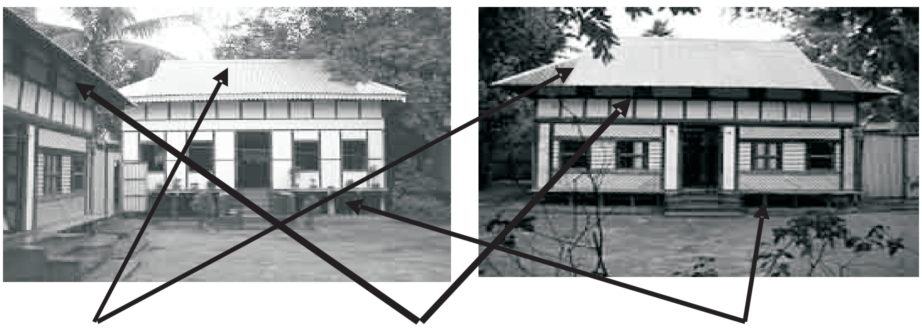

Figure: 3. Traditional houses in Bangladesh (source : Author)

The lack of electricity villages necessitates the use of natural ventilation to the fullest extent. There is no doubt that the modern designer has a lot to learn from traditional or vernacular houses. They have emerged from an effort to satisfy their social and physical needs, of the inhabitants of a region from immemorial time to the contemporary time.

3.1 Upper

In the traditional houses the double roof sections have one exposed roof on top and in bottom wooden plank floor. This space is also use as a store of the house in all seasons and locally known as upper (*Der tala*)

The double layer roof section has a wooden plank ceiling in inside and outside C.I. sheet with wooden frame.
In upper also window are given for cross ventilation.
For access to the upper and maintenance there is a secured wooden door from the main bed area and also using wooden ladder.
Double layer roof section also protects the indoor space from the direct solar radiation and heat.
In flood season all household thing are kept in upper.

4. Traditional and modern roof construction materials

Traditional roof is made of corrugated iron C.I. sheet and wooden plank whereas modern roof is made by r.c.c slab and roof mud tiles. Ventilator opening is the common feature for both traditional and modern houses (See Figure: 4).

Figure 4: opening of the upper (source : Author)

Figure 5: entry of upper (source : Author)

Figure 6 : structure of the upper (source : Author)

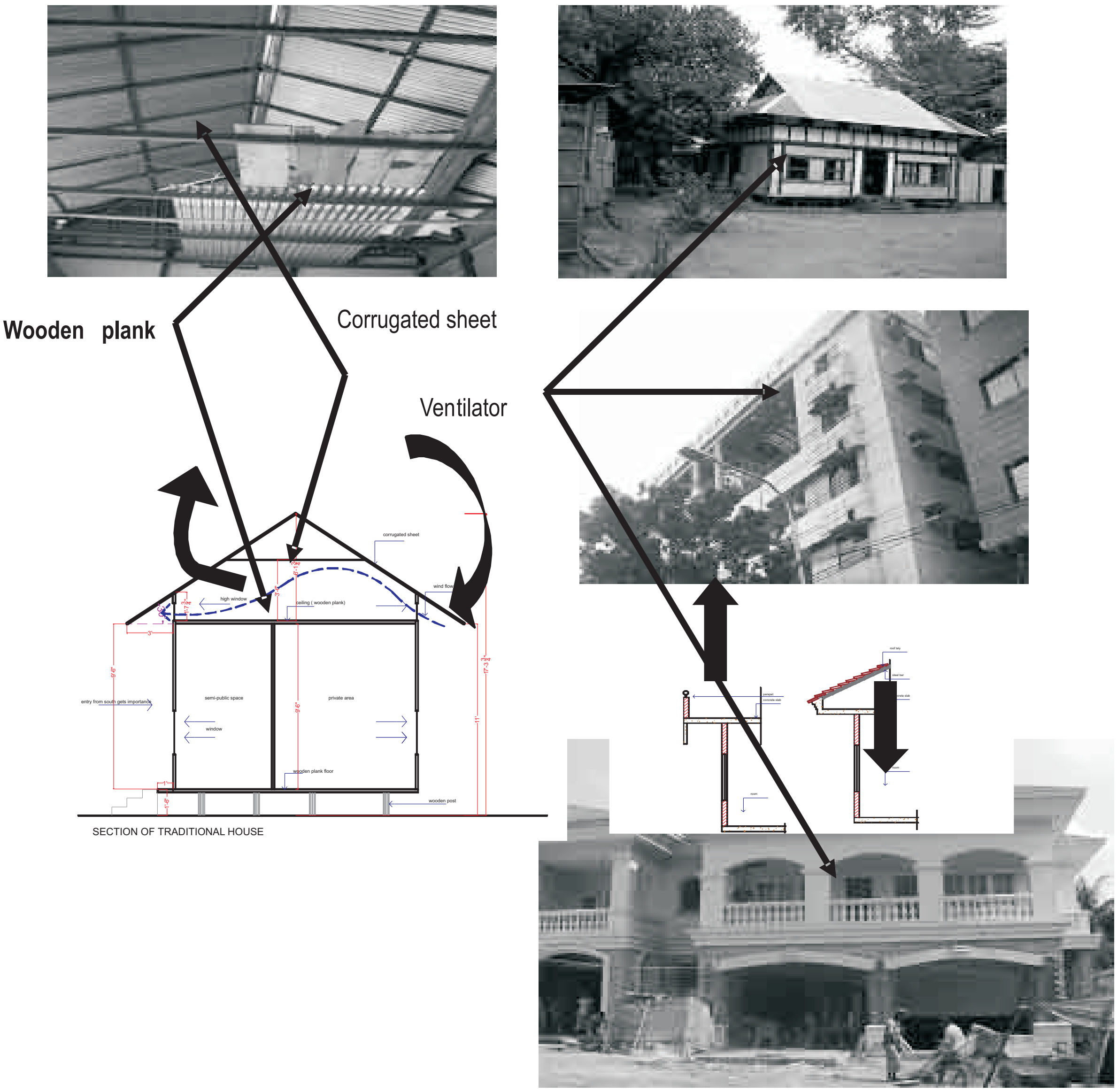

Figure: 7. Change of houses due to new materials and technology(source : Author)

In Bangladesh the temperature difference between rural and urban area is 4ºC to 5ºC (Mallick, 1993). This difference occurs because of the amount of hard surface found in the urban area. In the urban area, most of the building slab is made by R.C.C. There are no standards for roof insulation in the 'Building Codes of Bangladesh' but there are some practices. In many cases flat roofs as cast are not graded properly for water runoff, therefore some roof have a 75mm layer lime terracing to grade it. This provides some degree of insulation but may deteriorate substantially after a number of years and its insulating property may reduce. Moreover, the cost of lime terracing is also going up and the process is time consuming (Mallick, 1993). Modern construction in urban areas is characterized by extensive use of concrete and brick. High-rise buildings are constructed to accommodate ever-increasing population. Although airflow is an important consideration, due to heavy concentration of the buildings, concentration is not always successfully achieved and the concept of prevailing wind direction doesn't work in many instances. Mutual shading protects wall of the buildings in closely placed buildings but roofs are exposed to the direct solar radiation. In

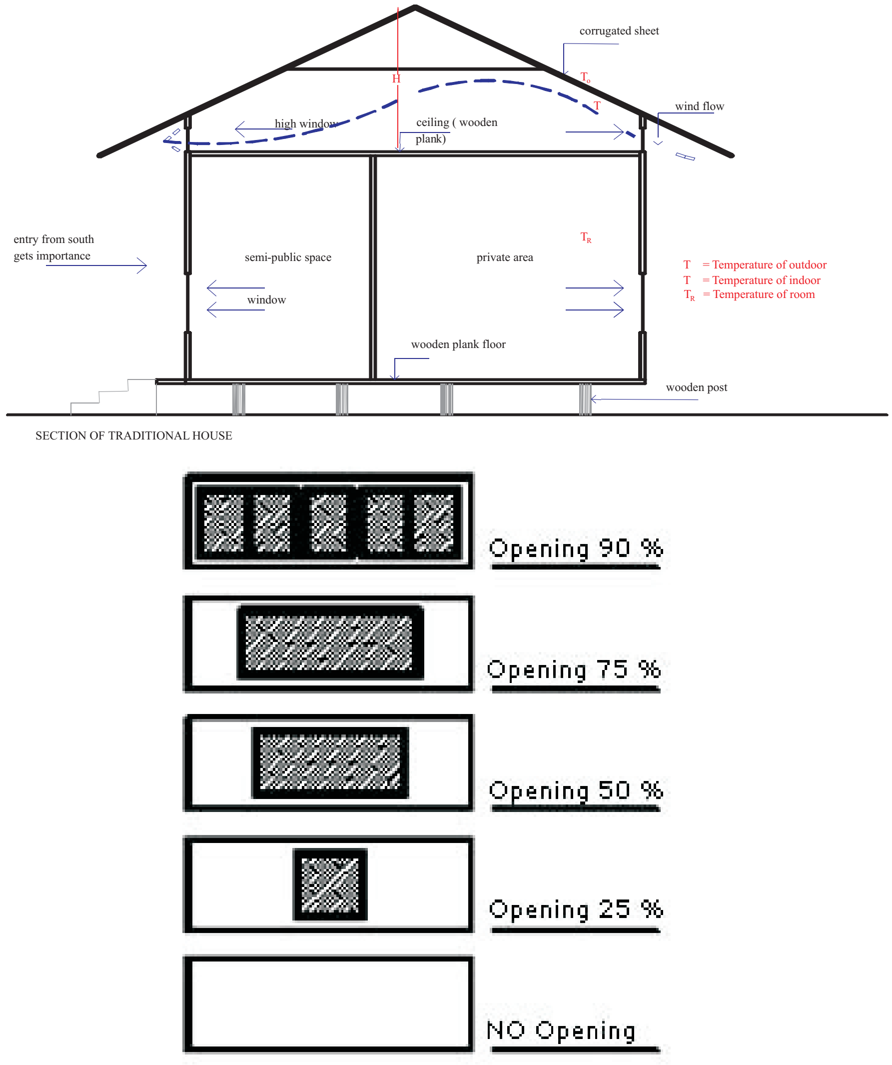

Figure 8: Sketch of the methodology

association of sol-air-temperature, the interior of the upper floor will heat up well above the comfort level. For this reason, nobody wants to live in the top floor the building. So a proper roof section is required. This is the problem that this research is trying to investigate.

6. Challenges

Temperature is the main criteria of human comfort. In Bangladesh, comfortable environment in the indoor space during the daytime and nighttime double layer roof section can be used to provide comfort. Thus, it makes the indoor temperature less than the high outdoor temperature. The double layer roof section can play a important roll and need to be investigated farther.

7. Research methodology

Field study used to measure physical comfort indoor, conductive of performance thermal influence factor identified. Data taker measuring that is: room temperature, room humidity, external air temperature and humidity, the upper temperature and humidity by HOBO data logger during one

hottest period and one coolest period of the year. Data logger with censor laid in room to be measured, protected from direct sun and conductive surface or walls which give heat addition. On file data in logger later can be read (loading) with Box Car Pro software ver. 4.3. Natural design data collecting early with observation to chosen house Dhaka, Bangladesh,

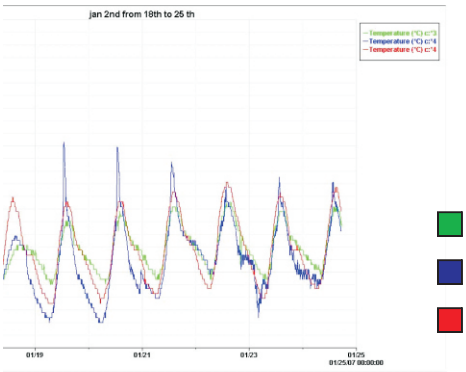

Figure 9: One week graph of January from HOBO data logger

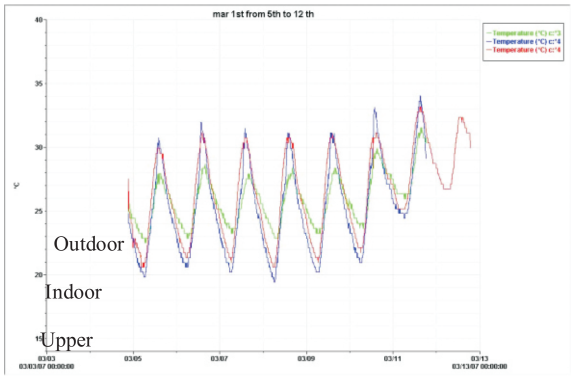

Figure 10: One week graph of March from HOBO data logger

continued with the measurement, photography, arrange environment, house and also is providing with interview. So that with this method of house, architecture quality will be elaborated by explaining found by phenomenon in perception field. January is the coolest month and April is the hottest month for Bangladesh. So the collecting of data started from January 2007 and it will be continue up to June 2007. The percentage of opening of the upper (the double layer roof section) is different in different month. In coolest period in January the opening was totally closed. After March 3rd week the opening was 25 percent. Then after one month the opening of the double layer roof section is 75 percent and it will be like this up to end of data collection.

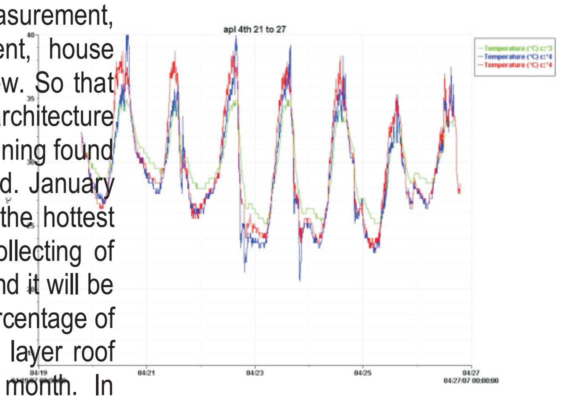

Figure 11: One week graph of April from HOBO data logger

8. Findings

From the above graph we can see the indoor temperature is higher than outdoor temperature in winter season that is in the month January and the upper temperature is higher than the both outdoor and indoor temperature. Again in summer season in the month of April the indoor temperature is lower than the outdoor temperature and the upper temperature is less than outdoor temperature and more than indoor temperature. So the double layer roof section can play a vital performance and better thermal comfort quality in all season.

9. Acknowledgements

The authors gratefully acknowledge the Department of Architecture, Universiti Teknologi Malaysia for their enormous help with this study. We would also extend our sincere appreciation to other faculties and institutions related to this study in Bangladesh.

10. Conclusion

Traditional house in high-density environment at Dhaka. Still has a better ability in providing thermal comfort. On the situation in which outdoor temperature is extremely low, the traditional house can provide higher indoor air temperature. Vice versa when the outdoor temperature is extremely high then the indoor temperature is lower. By keeping the originally of the traditional house ,it can provide the natural thermal comfort for the user although it lies in a high density environment.

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OPTIMIZE DAYLIGHTING ON PRIMARY SCHOOL BUILDING AT REMOTE AREA

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ABSTRACT
The need of primary school buildings is not just limited for the capital area, the remote area also need this building. In capital area, lighting (electricity) not the primary problem but for remote area will be primary problem. Based on this problems, primary school building design at remote area have to considerate based on daylighting usage and optimize, because electricity not yet provided and if they use generator set, it will be expensive.
The problem solving for above problems, day lighting plans with appropriate have to conduct with the best solution, such as considerate about opening area, building orientation toward sun position, skylight design with appropriate, etc. For analyzing all considerate, we are using Ecotect Software V. 5.1 as a building tools with some considerations.
This paper will be discussing primary school building planning that was conducting in Kabupaten Bener Meriah, Nanggroe Aceh Darussalam (NAD) Province based on daylighting optimize (building orientation, opening area, etc). The case study is primary school building at Kabupaten Bener Meriah, NAD.
Keywords: *Primary school building, day lighting, Bener Meriah Regency*

I. PENDAHULUAN

1.1 Back Ground

The development of primary school building in Indonesia will be conducting, including renovation, rehabilitation, reconstruction, and also build new building. The amounts of primary school building are higher than the other building of governments and also have higher damage (small damage up to destroy). The problems solving for new building development including renovation and reconstruction must be capable with technology development, such as energy efficiency, sustainability, and etcetera. One of the concepts that have to develop for primary school building is electrical energy efficiency and using and exploiting solar energy (daylighting).
For primary school building at remote area, mostly not yet have electricity, so the design of primary school building must be thinking daylighting as a solution. Primary school building at remote area has to design with using optimum daylighting (not depend on electricity) when building is used. The constraints that Depdiknas (Department of Education) in primary school building standards 2005, the classroom has to get daylighting with optimum without sun heat (avoiding direct sunlight and skylight). The solution is determinate the measurement and locate of opening (window) and also using the other building and trees as a filter. When daylighting reduce (depend on time), that will be needing lamp without glare (with illumination is 215 lux for classroom, library, and office), or with using 6 TL lamps (@TL lamp has 2x40 watt for each class).

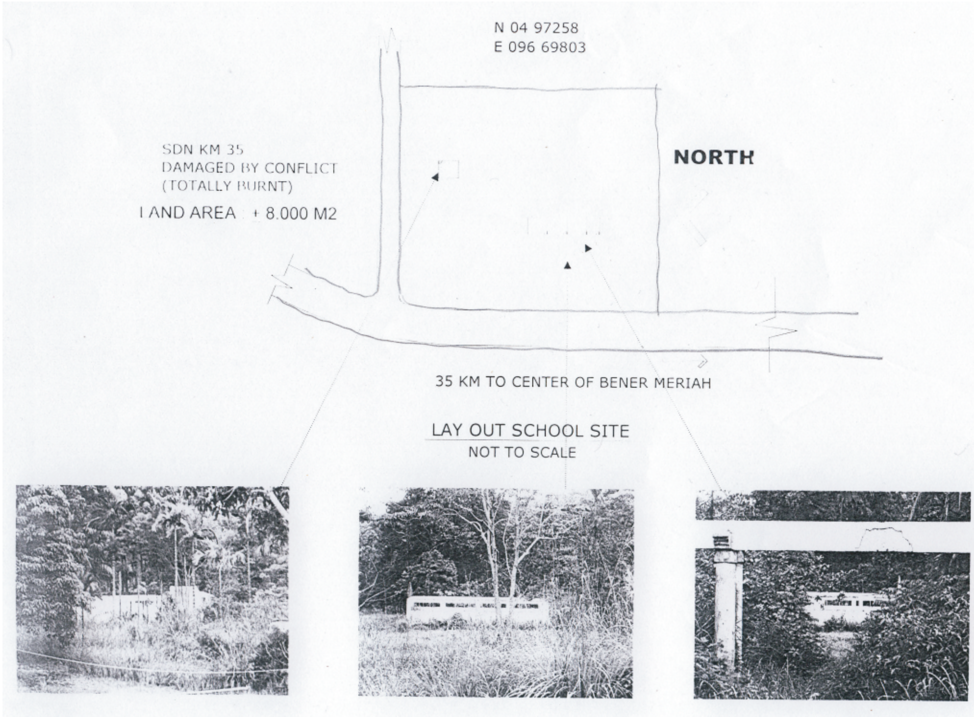


Figure 2: The condition of Primary School Building at Kabupaten Bener Meriah

The examples of using daylighting with optimum are: 1) the sky can be seen by students which sit near by window, 2) opening (wide of window) and bouvenlicth ±20% from wide of floor, 3) the height of window from floor is 1,20 m, 4) the height of ceiling is 3,0 m from the floor.

Primary school building at remote area without electricity has to maximize building design for studying activity with using minimum of daylight is 215 Lux. For getting optimum daylighting, should be using software program for the building to analyze optimum daylighting with some constraints and considerations (such as skylight, location, and etcetera). Analyzes of daylighting is conducting with Ecotect Software Version 5.1 for primary school building and will be discussing at next page.

1.2 Problem

The problems in optimize daylighting as a lighting in classroom with 215 Lux (requirement of standard) is how to design the classroom that according to 215 lux, and how to find the location of primary school building with has implication to the amount of dayligting that will be used.

1.3 Scope and Constraint

Discussion about daylighting in classroom for primary school building at remote area is constrained on primary school building in Kabupaten Bener Meriah, Nanggroeh Aceh Darussalam (NAD). Kabupaten Bener Meriah is a new Kabupaten in NAD with location on E.96°.30' – N.40°.44' which boundaries with Middle Aceh (west side), North Aceh (north side), Bireun (east side), and Middle Aceh (south side). Primary school building that has chosen is SDN KM 35 which location at Negeri Antara Village (sub district: Pintu Rime Gayo, Kabupaten: Bener Meriah).

Discussion are limited also on building orientation (to get optimum daylighting), and opening systems (door, window, skylight, and etcetera) that will be producing daylighting with minimum 215 lux and still get comfort). The analysis is conducting depend on Ecotect Software Version 5.1.

II. THEORIES

Guidelines for good day lighting (Evan, 1981, p.52):

2.1 A void Direct Skylight and Sunshine on Critical Tasks

The easiest way to get plenty of daylight into a space is to use very large openings clear glass windows, clerestories, or skylight with a minimum of controls, but direct sunshine in the vicinity of critical task areas and a direct view of the sky from these areas will expose occupants to excessive brightness differences that will result in poor visibility and discomfort.

2.2 Use Direct Skylight and Sunshine Sparingly in Non-critical Task Areas

Direct sunshine can add excitement to architecture. It provides opportunity for changing patterns of light and shadow on interior surfaces and objects. It can give occupants a sense of well-being, of time, and orientation, but it must be used with discretion or it is likely to cause poor seeing conditions or add excessive heat to a space.

2.3 Bounce Daylight off Surrounding Surfaces

The daylight that reaches our tasks, while originating with the sun, in effect, comes from nearly all surfaces and objects around us by way of reflections. Each time the daylight is reflected from surfaces, it is spread and softened. Light that is spread over large areas and reflected is partially absorbed and, thus, reduced in intensity, but the process spreads and evens the general brightness patterns, increasing visibility and seeing comfort.

2.4 Bring the Daylight in High

The higher the light opening is the deeper daylight will penetrate into the interior space, and the less likely the opening will allow excessive exterior brightness's into the field of view. The light that comes in high is more likely to be softened and spread by surfaces and objects before it gets to task level.

2.5 Filter the Daylight

The harshness of direct skylight and direct sun can be filtered for additional softness and more uniform distribution. Even electric luminaries are not left exposed, naked to the eye. They are surrounded with devices to filter or reflect the light so that its intensity is spread and softened. Trees, scrubs, vines, curtains, reflected "shelves", and louvers are effective tools for filtering daylight as it enters building spaces.

III. ANALYSIS AND DISCUSSION

3.1 Data Colleting

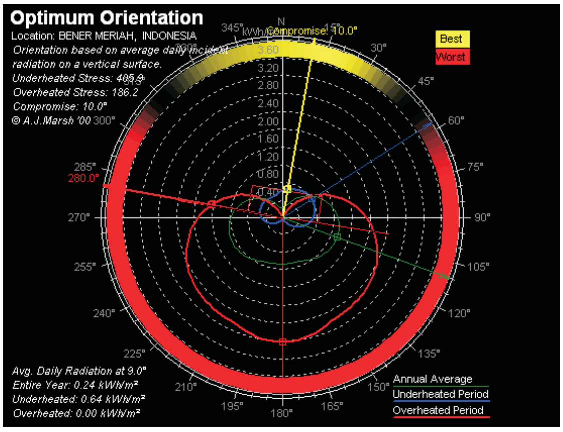
From the data of primary school building location that will be analyzed with data from BMG (Badan Meteorologi dan Geofisika), including: temperature data, wind speed, humidity, solar radiation, and etcetera.

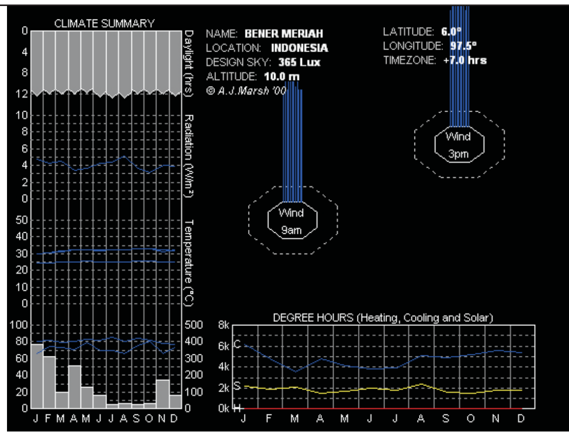
3.2 Analysis Data

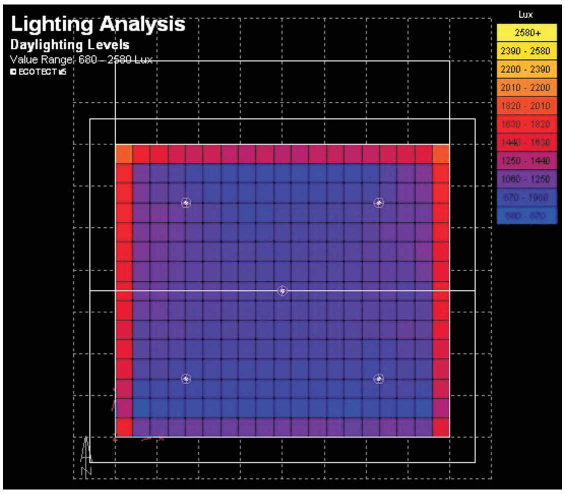
Data from BMG will be inputting to Ecotect Software Version 5.1, and the outputs are chard diagram, curve, and etcetera, about: orientation optimum diagram, prevailing wind diagram, solar radiation chart, and etcetera.

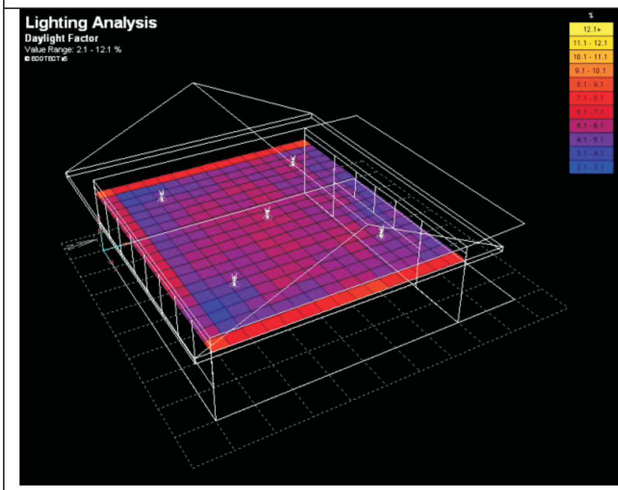
The drawing of primary school building was drawing in Ecotect Softaware before, especially building mass, and layout of interior and exterior of building, roofing, ceiling, and etcetera. The next step is analyzing the building with Ecotect Software that has input data analysis of location, latitude, and altitude of building location.

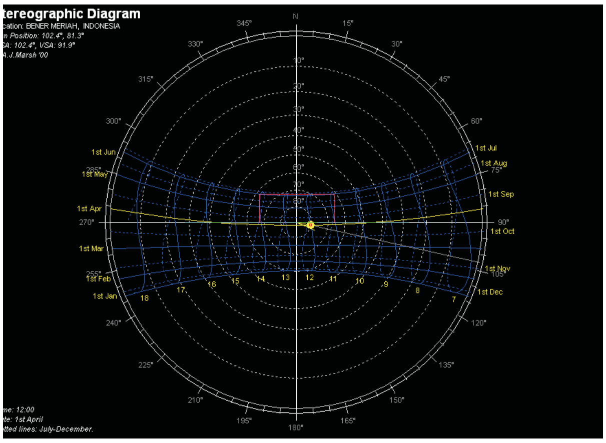
Outputs of this analysis building orientation analysis, lighting analysis diagram, thermal comfort analysis diagram, wind analysis diagram, and etcetera. From the output analysis, the next step is interpreting the outputs.

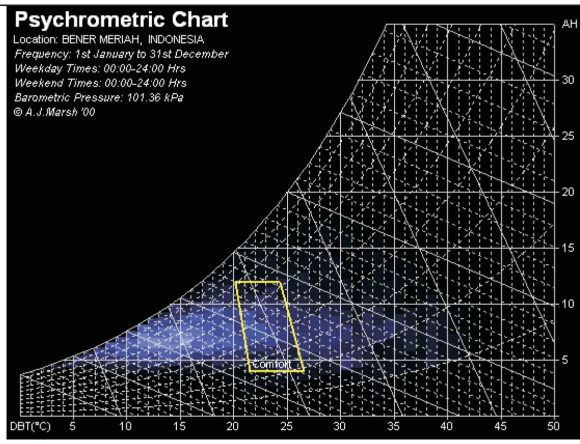

Optimum Orientation
Location: BENER MERIAH, INDONESIA
Orientation based on average daily incident radiation on a vertical surface.
Underheated Stress: 408.8
Overheated Stress: 186.2
Compromise: 10.0°
© A.J.Marsh '00
Compromise: 10.0°
Best
Worst
280.0°
Avg. Daily Radiation at 9.0°
Entire Year: 0.24 kWh/m²
Underheated: 0.64 kWh/m²
Overheated: 0.00 kWh/m²
Annual Average
Underheated Period
Overheated Period


CLIMATE SUMMARY
NAME: BENER MERIAH
LOCATION: INDONESIA
DESIGN SKY: 365 Lux
ALTITUDE: 10.0 m
© A.J.Marsh '00
LATITUDE: 6.0°
LONGITUDE: 97.5°
TIMEZONE: +7.0 hrs
Wind 9am
Wind 3pm
Daylight (hrs)
Radiation (W/m²)
Temperature (°C)
DEGREE HOURS (Heating, Cooling and Solar)
J F M A M J J A S O N D


Lighting Analysis
Daylighting Levels
Value Range: 680 - 2580 Lux
Lux
2580+
2390 - 2580
2200 - 2390
2010 - 2200
1820 - 2010
1630 - 1820
1440 - 1630
1250 - 1440
1060 - 1250
870 - 1060
680 - 870


Lighting Analysis
Daylight Factor
Value Range: 2.1 - 12.1 %


tereographic Diagram
1st Jun
1st May
1st Apr
1st Mar
1st Feb
1st Jan
1st Jul
1st Aug
1st Sep
1st Oct
1st Nov
1st Dec


Psychrometric Chart
Location: BENER MERIAH, INDONESIA
Frequency: 1st January to 31st December
Weekday Times: 00:00-24:00 Hrs
Weekend Times: 00:00-24:00 Hrs
Barometric Pressure: 101.36 kPa
© A.J.Marsh '00
AH
Comfort
DBT(°C) 5 10 15 20 25 30 35 40 45 50

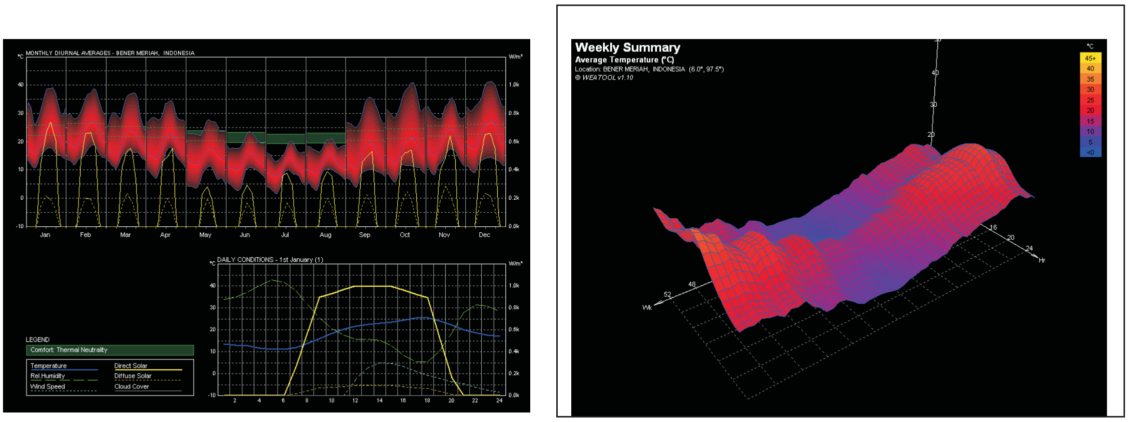


Figure 2: Outputs of analysis from Ecotect Software V.5.1

3.3 The Output of Analysis

1. Building Optimum Orientation
   From the analysis output above is got primary school building orientation, that is 10° from west side to north side. This orientation is the best position for building to get the best comfortable level in room because of climate and solar factors.
2. Thermal Comfort
   From the outputs of analysis above is known thermal comfort for this location, which are:
   - Indoor temperature (12.00) maximum: 28oC.
   - Wind speed (at 12.00): 8m/sec
   - Illumination (at 09.00-13.00) minimum: 331 Lux

   From the outputs of analysis above is known illumination in the room (which requirement is 215 lux) more higher, which is 331 lux, without using electricity but with optimizing of daylighting.

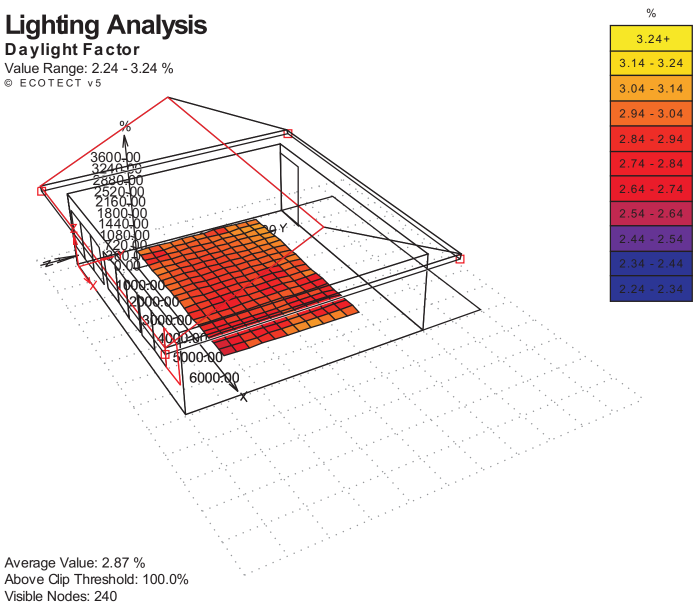


Figure 3: Output of analysis

For remote area (such as the example above) can be conducted optimizing of dayligting to primary school building. This optimizing depend on: 1) building design with appriproate, 2) data of location and data of climate from BMG, and 3) Using Ecotect Software Version 5.1.

Figure 4: The result of design for primary school building in remote area at Kabupaten Bener Meriah

IV. CONCLUSION

Primary school building at remote area is generally not get yet electricity and also not designs yet with using or exploiting daylighting (still with Diknas standard for primary school building). With conducting design approach which is using daylighting for primary school building without electricity, with using analysis of Ecotect Software V.5.1 is the best approach. With the example above, if the analysis is true, hence in the day time will be getting 331 lux (with requirements is 215 lux) can be reached and enough for lighting in the classrooms (same with minimum of 6 TL lamps (@2x40 watt) in classrooms).

In our country, daylighting is easy to get and will never off, the architect should be using daylighting as a design approach to reduce of using electricity.

V. REFERENCES

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Roof Geometry Performance of Javanese Village House

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ABSTRACT

Image of village in the Javanese village houses consists of building characteristics and typology of environment. This house has typical characteristics which can be recognized from the materials used, dimension and building shape. Physically, building shape shows kampung roof style and it can be observed by gajah at the top and èmpèr on its sides. Roof of Javanese village house is a part of building envelopes that separates indoor and outdoor environment and determines thermal comfort in tropical region by the properties and geometry.

This paper discusses performance of roof geometry which is defined by its form. Roof geometry in the Javanese village house has many typologies as invented at the Borobudur temple, Prambanan temple, and the temples in East Java. By approaching the characteristics of kampung roof style, the object study is stated in to five models of roof as variable that will be simulated. The models are Dara Gepak, Srotongan, Gotong Mayit, Céré Gancèt, and Lambang Teplok.

The architectural science software, ARCHIPAK, is used for analyzing effect of solar radiation in to building through each of the roof geometry typology. As result, Srotongan roof obtains the optimal performance and Gotong Mayit model which has the largest perimeter has chance for receiving the heat gains most. The surface area is the main factor which is determining total energy of solar radiation (Wh) and the orientation is the main factor which is determining total surface solar radiation (Wh/m^2).

Keywords: *image of village, Javanese village houses, kampung roof, roof geometry*

1. Introduction

Javanese village house has specific characteristics as an identity. That image can be used as range of design simulation for obtaining thermal performance optimization. It must be done on that range, so the simulation design can not ignore village image. Image of village in the Javanese village house consists of building characteristics and typology of environment. The Components of image of village can be recognized by roof, plan, orientation, and environment exploration. This paper discusses performance of roof geometry which is recognized by its form. Roof geometry in the Javanese village houses has many typologies as invented at the Borobudur temple, Prambanan temple, and the temples in East Java (Ismunandar, 1997). Samodra (2005-a and 2005-b) have presented capability of The Javanese village house roof as the main element of building which is determining the thermal performance because of its largest area. The thermal performance of roof is directed for receiving the solar radiation, so it gives the highest contribution of heat gain in to building (Santosa, 1994). The roof geometry can be defined by the surface area, orientation, and its slope. In this paper, its performance will be discussed in the connection with solar radiation for all surfaces and sides.

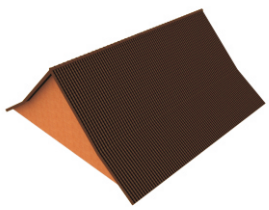
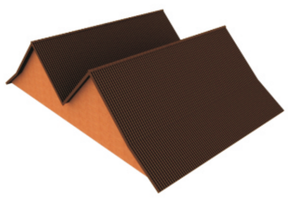
2. Roof Geometry Models

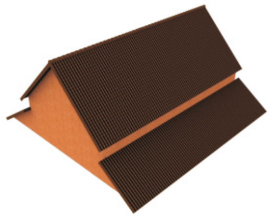
The models in Javanese village house are focused on geometry of roof which is differed by transformation. It develops the configuration of the base form and the other variants that can be defined by the form change. There are four added variants as result of the base form transformation, they are model of reduction, addition, reflection, and stretched form which is shown by *Srotongan, Gotong mayit, Céré Gancèt,* and *Lambang Teplok* (Table 1).

The base form (Figure 1.), *Dara Gepak* roof, has *èmpèr* in all of sides (main orientation) besides the original *kampung* form (*gajah* sector). This model goes through to reduction form as the second model at the left and right sides (*èmpèr*). The reduction model, *Srotongan*, has *èmpèr* at the front and back sides only. The third model, *Gotong Mayit,* has three gajah sectors as addition form of *Srotongan* and *Dara Gepak*. The fourth, *Céré Gancèt*, has reflection form of *Srotongan*, thus the *gajah* sector is recognized in to two parts, front side and the back. The last model is indicated by stretch process which separates the *gajah* and *èmpèr sector* or it makes addition of *tutup keyong* in the front and back side of the roof geometry.

The models of roof geometry are defined by their main orientation as surface position, slope or tilt toward the horizontal line, and the area. The main orientation is stated as *Ngajeng*/Front side (South=180^0), *Tengen*/Right side (West=270^0), Wingking/Back side (North=0^0=360^0), and Kiwa/Left side (East=90^0). The roof slope is fixed by angle of roof surface and the horizontal line. Generally, all models have specific angle for certain typology of surface and sector. The *gajah* sector, the slope of *gajah* surface is 45^0 and *tutup keyong* is always in the 90^0 slope surface. In the *èmpèr* sector, the slope of *èmpèr* surface is 34.5^0 as result of traditional numerology/*pétungan* (Prijotomo, 1995). The area of surface describes the envelope perimeter, it is illustrated by percentage and accumulation of units.

Table 1. Models of Roof Geometry

No.	Transformation Variants	Models	Orientation (^{0})	Surfaces	Slope (^{0})	Area Percentage
1.	Base form 	**Dara Gepak**	180 (Ngajeng)	Gajah	45	58
				Èmpèr	34.5	42
			270 (Tengen)	Tutup Keyong	90	28
				Èmpèr	34.5	72
			0 (Wingking)	Gajah	45	58
				Èmpèr	34.5	42
			90 (Kiwa)	Tutup Keyong	90	28
				Èmpèr	34.5	72
2.	Reduction 	**Srotongan**	180 (Ngajeng)	Gajah	45	62
				Èmpèr	34.5	38
			270 (Tengen)	Tutup Keyong	90	100
			0 (Wingking)	Gajah	45	62
				Èmpèr	34.5	38
			90 (Kiwa)	Tutup Keyong	90	100
3.	Addition 	**Gotong Mayit**	180 (Ngajeng)	Gajah	45	83
				Èmpèr	34.5	17
			270 (Tengen)	Tutup Keyong	90	100
			0 (Wingking)	Gajah	45	83
				Èmpèr	34.5	17
			90 (Kiwa)	Tutup Keyong	90	100
4.	Reflection 	**Céré Gancèt**	180 (Ngajeng)	Gajah	45	77
				Èmpèr	34.5	23
			270 (Tengen)	Tutup Keyong	90	100
			0 (Wingking)	Gajah	45	77
				Èmpèr	34.5	23
			90 (Kiwa)	Tutup Keyong	90	100

5.	Stretched 	**Lambang Téplok**	180 (Ngajeng)	Gajah	45	57
				Tutup Keyong	90	9
				Èmpèr	34.5	35
			270 (Tengen)	Tutup Keyong	90	100
			0 (Wingking)	Gajah	45	57
				Tutup Keyong	90	9
				Èmpèr	34.5	35
			90 (Kiwa)	Tutup Keyong	90	100

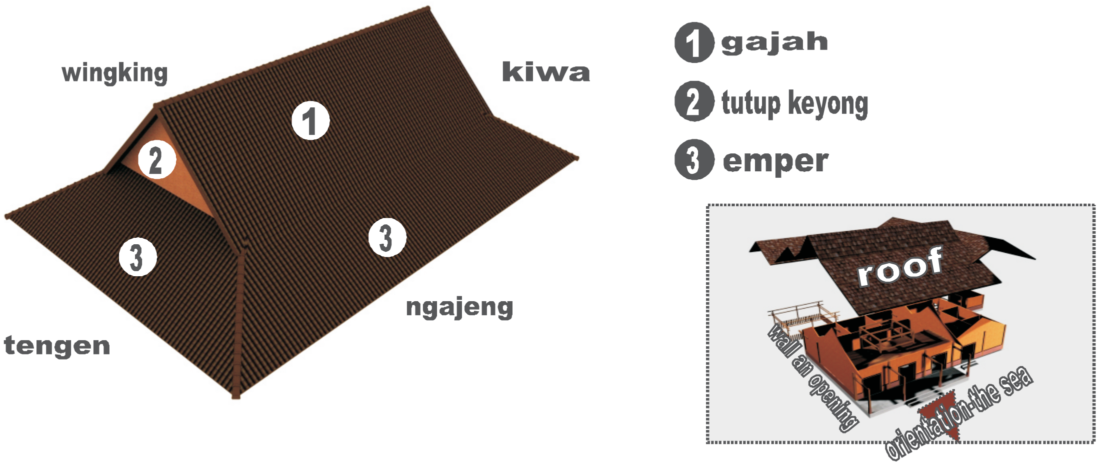


Figure 1. The Base Form of Javanese Village House Roof Geometry

3. Simulation of Models

Geographical altitude determines global irradiance (energy and total solar radiation), and the solar altitude is also keeping the role for that. If geographical altitude and solar altitude are high, the irradiance will be high (Oki and Shiina, 2003). This condition can be predicted and realized as shown in the Figure 2. Physically, in the same value of solar altitude, Javanese village house in upland region have much irradiance problems than in the lowland or coastal areas. By the statements above, the upland has been taken as study location because it has the higher solar radiation value than the others geographical altitude (lowland/coastal). The location of study is Kedawung Village, in the slope of mount Kelud, Blitar, East Java which is determined on the basis of comparable data (2000-2004) obtained from Meteorology and Geophysics Centre of Karangploso, Malang.

The roof Geometry Models are simulated by ARCHIPAK program in the critical month. By data analyzing, the highest global solar radiation month is October. The ARCHIPAK program produces the hourly solar radiation (Wh/m^2) and the total energy (Wh) which are affected by the roof surface area. The simulation shows total energy of solar radiation (Wh) for main orientation or roof geometry sides as presented by Table 2. The lowest value of energy gives possibility or chance of passive cooling most. The optimal model can be determined by this criterion and obtained by *Srotongan* roof with the South side (180^0) as the highest solar radiation energy receiver and the West side (270^0) as the opposite sector (the lowest).

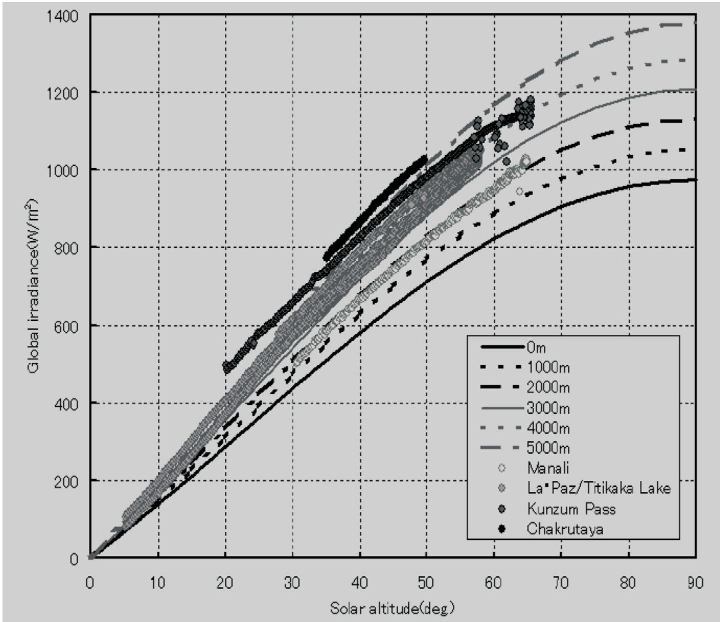


Figure 2. Prediction and Measurement of Global Irradiance
(Source: Oki dan Shiina, 2003: 977)

Table 2. Total Energy of Surface Solar Radiation of Roof Geometry Models

No.	Models	Total Energy of Solar Radiation (Wh)				
		180^0	270^0	0^0	90^0	Total
1	Dara Gepak	774,692	386,972	721,052	385,322	**2,268,038**
2	Srotongan	721,804	228,718	671,188	242,203	**1,863,913**
3	Gotong Mayit	1,583,644	627,130	1,465,060	664,105	**4,339,939**
4	Cere Gancet	1,152,724	427924	1,068,124	453,154	**3,101,926**
5	Lambang Teplok	743,980	272,986	773,246	289,081	**2,079,293**

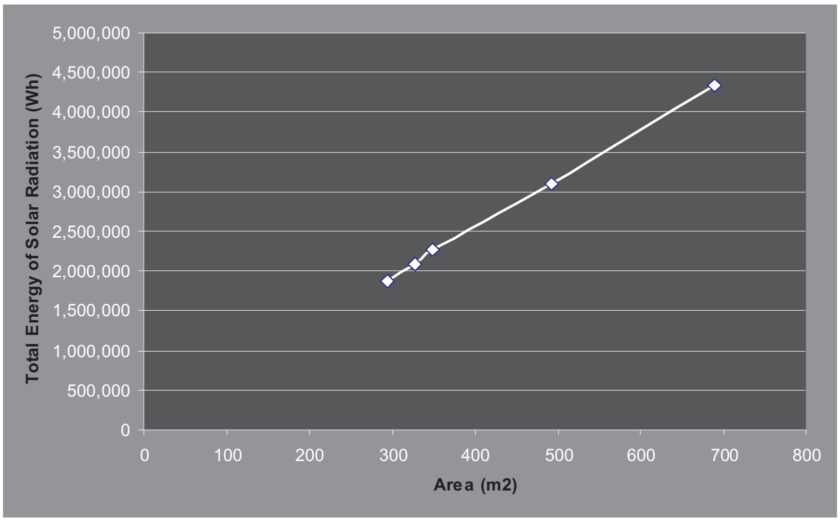


Figure 3. Roof Perimeter Area and Total Energy of Surface Solar Radiation

The connection between roof perimeter area and total energy of surface solar radiation is shown by Figure 3. Roof perimeter area has direct effect in to straight contact to the energy of surface solar radiation. This connection is described by straight line, so the lowest total surface area gives the lowest value of energy and vice versa. Figure 4. and 5. show the performance of roof geometry and the total solar radiation (Wh/m^2). It has difference phenomenon, the slope of roof has connection with energy of surface solar radiation on the contrary formula. This connection is described by the curve line which is slow down from the left top to the right bottom. It means that the contrary connection makes the highest slope has lowest value of total solar radiation, the precipitous roof is potential for receiving the minimum solar radiation and heat gain. This capability is reached by *tutup keyong* surface. The *èmpèr* has critical condition for heat gain because of its slope slightly angle of roof geometry. This directives for all of orientations of side and depend on solar geometry (altitude and azimuth) as Oki dan Shiina (2003) have been predicted it.

By comparing the capability of *èmpèr* surfaces of *Dara Gepak* model for all sides, contributionof orientation can be determined. This explains performance of the roof geometry in the similar area and the same slope. The simulation shows that the surface performance produces total surface solar radiation in to slightly difference. The East side is the highest, following by the West, South, and the lowest, the North side. This phenomenon is indicated by solar geometry, the azimuth especially.

Solar geometry in October is shown by Figure 6. It describes how the solar position is in the South side in the long of day because the altitude (7.75 S) receives the sunlight dominantly in the South region. Because of this reason, the North side has total surface solar radiation is lower than the South has. Why the East side is higher than the West? The answer can be detected by comparing hourly solar radiation in the morning and afternoon (azimuth 0^0 – 180^0 and 180^0 – 360^0). It shows that hourly solar radiation in the morning as shown by the East surface (*kiwa*) is higher than in the afternoon as shown by the West surface (*tengen*), or see Figure 7.

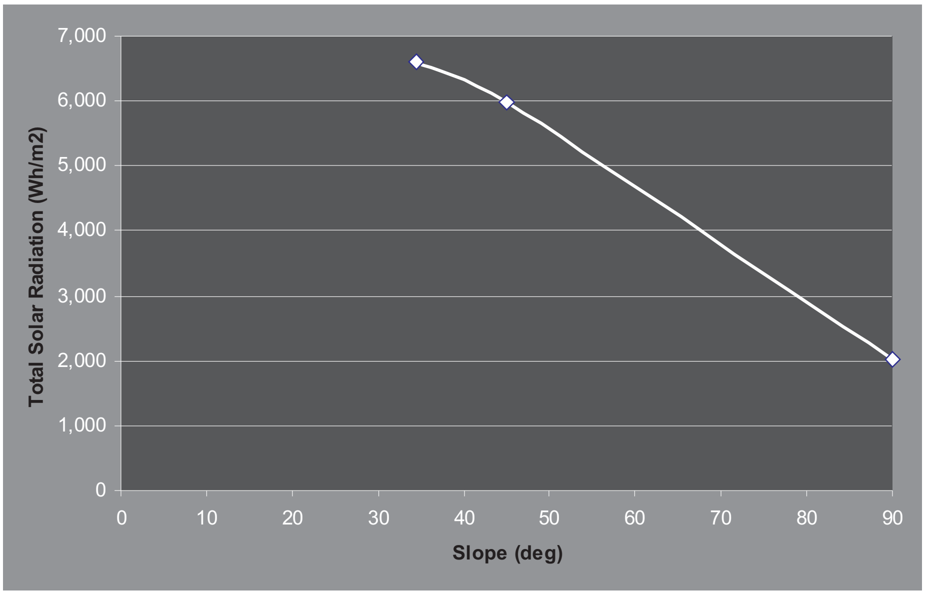


Figure 4. Roof Tilt or Slope and Total Surface Solar Radiation

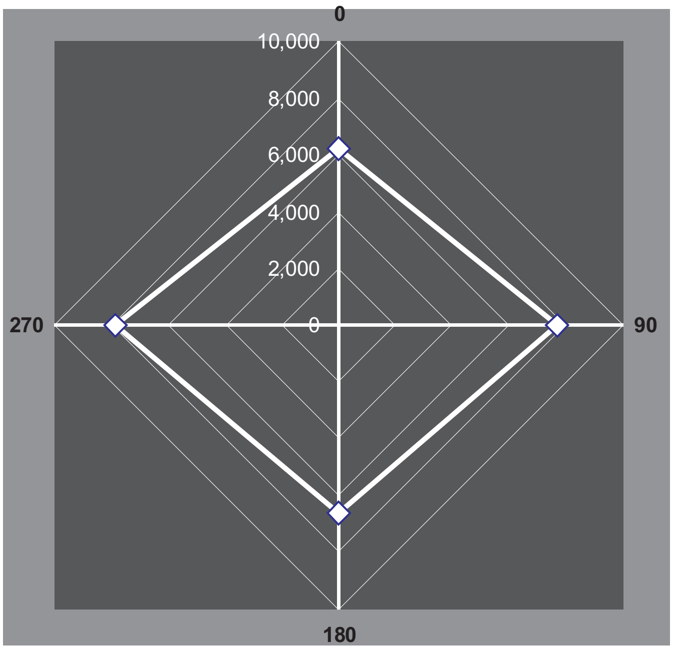


Figure 5. Surface Orientation and Total Surface Solar Radiation

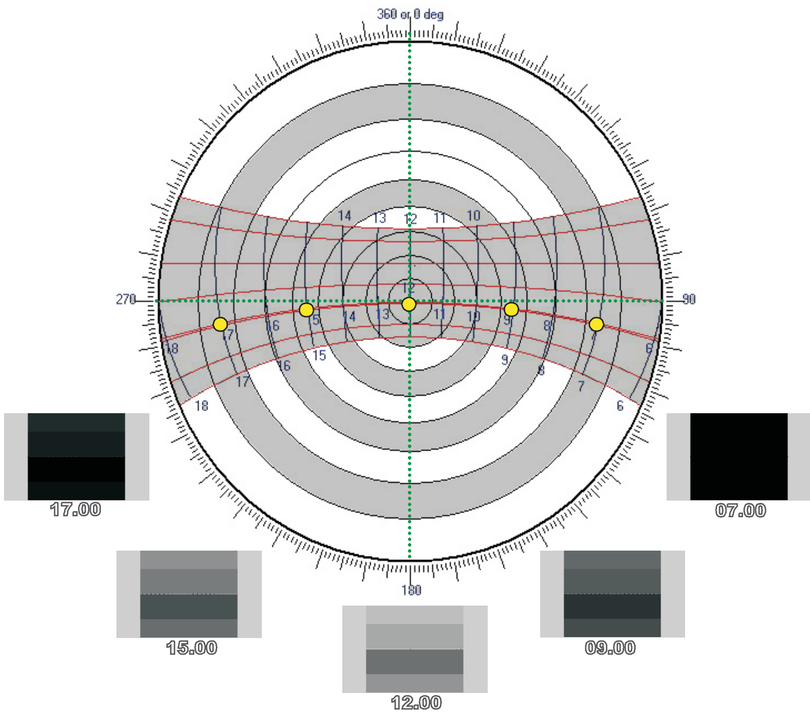


Figure 6. Solar Geometry at the Critical Time

4. Analyzing of the Optimal Model

Srotongan, the optimal model, has the lowest total solar radiation. As explained by connection between surface area and total energy of solar radiation, the lowest total solar radiation can be reached by the limited area which is found on *Srotongan* roof. Solar duration is almost 12 hours per day, the sunrise can be seen at 05.41 (5.69) and sunset at 17.50 (17.84). This result is the calculation of ARCHIPAK program for average day of given month.

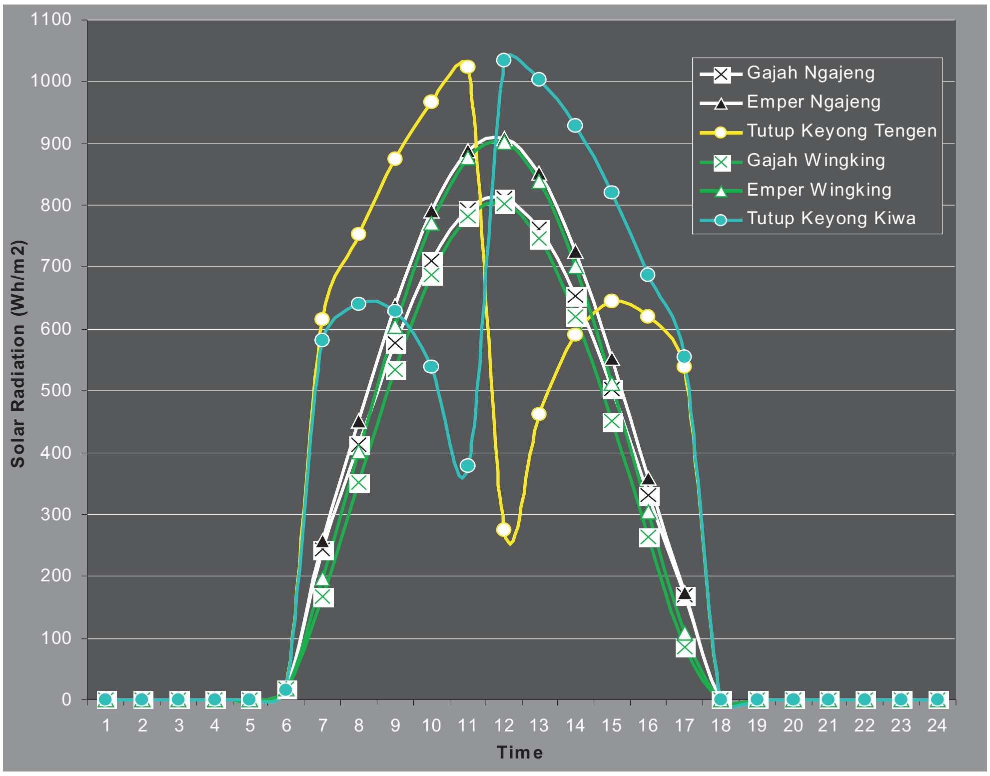


Figure 7. Total Surface Solar Radiation Profile of The Optimal Model
(*Kampung Srotongan*)

The daily sun movement in the October for altitude 7.75 S can be seen in the Figure 8. The illustration of shading area is also determining the capacity and intensity of solar radiation to the roof surface. The shadowed area will receive hourly and global solar radiation in minimum value if it is compared by the un-shadowed one. The time in this illustration is given for clarifying the specific and critical moments in the long of the day. At 07.00, sunlight and solar radiation is received in the minimum value in the morning and it is similar with at 17.00 in the afternoon. This time has slightly slope of solar altitude (07.00 for the East side and 17.00 for the West side), so only the West side is shadowed at 07.00 and only the East side is shadowed at 17.00. The higher altitude can be experienced at 09.00 and 15.00, the solar radiation is also higher than the time before. The East side is shadowed and the West side is slightly shadowed at 09.00. At 15.00, the roof has contrary case performance. The peak of solar altitude is in the noon, at 12.00 exactly, the solar radiation is also highest in this time, both of the East and West sides are fully shadowed. The shadowed side of this geometry model is appropriate with selective mode in the tropical region as offered by Hawkes (1996).

Total energy of surface solar radiation distribution can be re-test by this model. The *Srotongan* roof model, as presented by Figure 9, receives the highest energy at the South side, following by North, East, and the West side. The West side is potential for passive cooling strategy of building, it is sloping colder than the others. By ignoring the surface area, *gajah wingking* surface has the best performance of *Srotongan* roof and *tutup keyong kiwa* is the least (Figure 10.). The slope of *gajah wingking* is lower than *tutup keyong kiwa*, it should make *tutup keyong kiwa* has better performance than *gajah wingking,* but the result shows the contrary performance, so the main factor that determines this case is orientation.

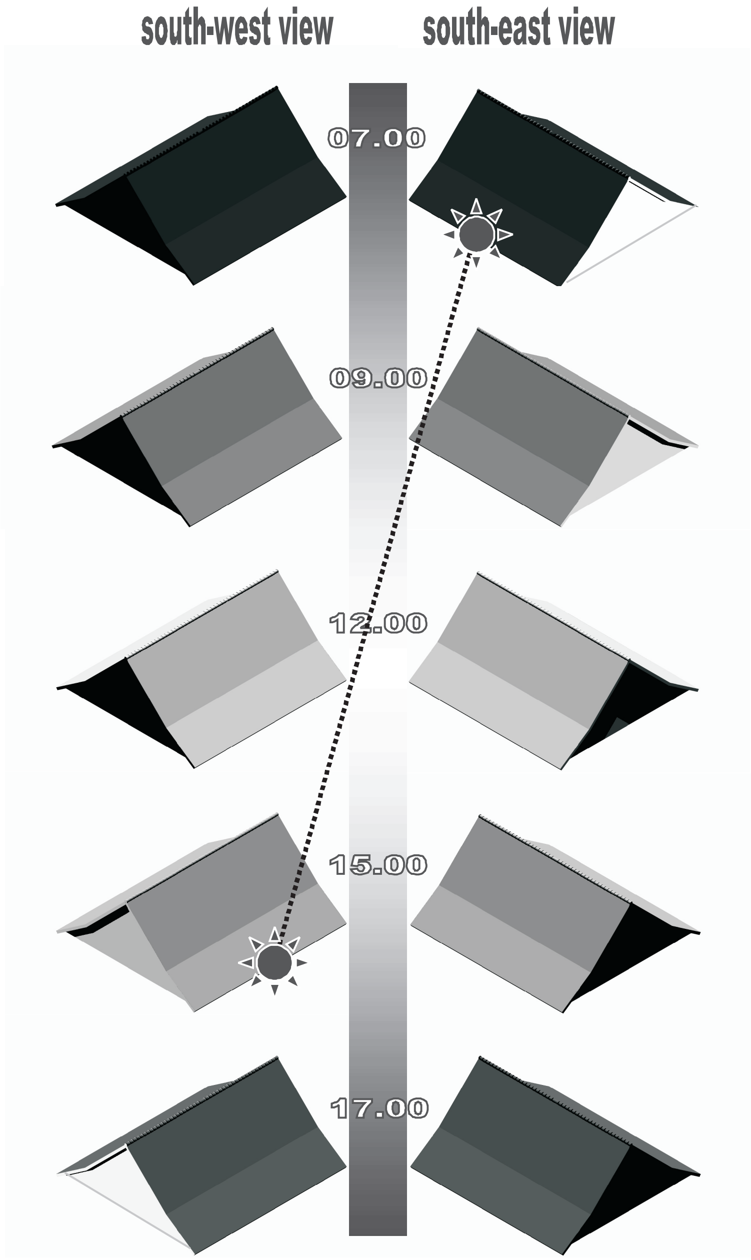
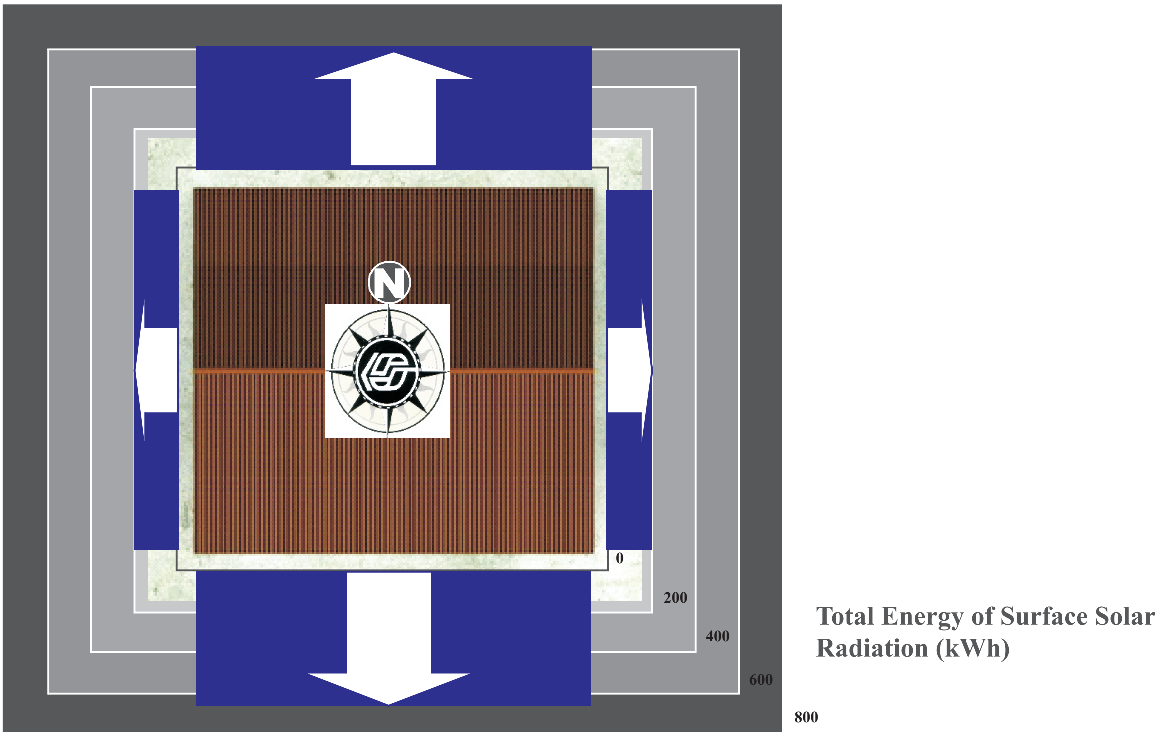


Figure 8. Solar Movement and the Effect to the *Srotongan* Roof



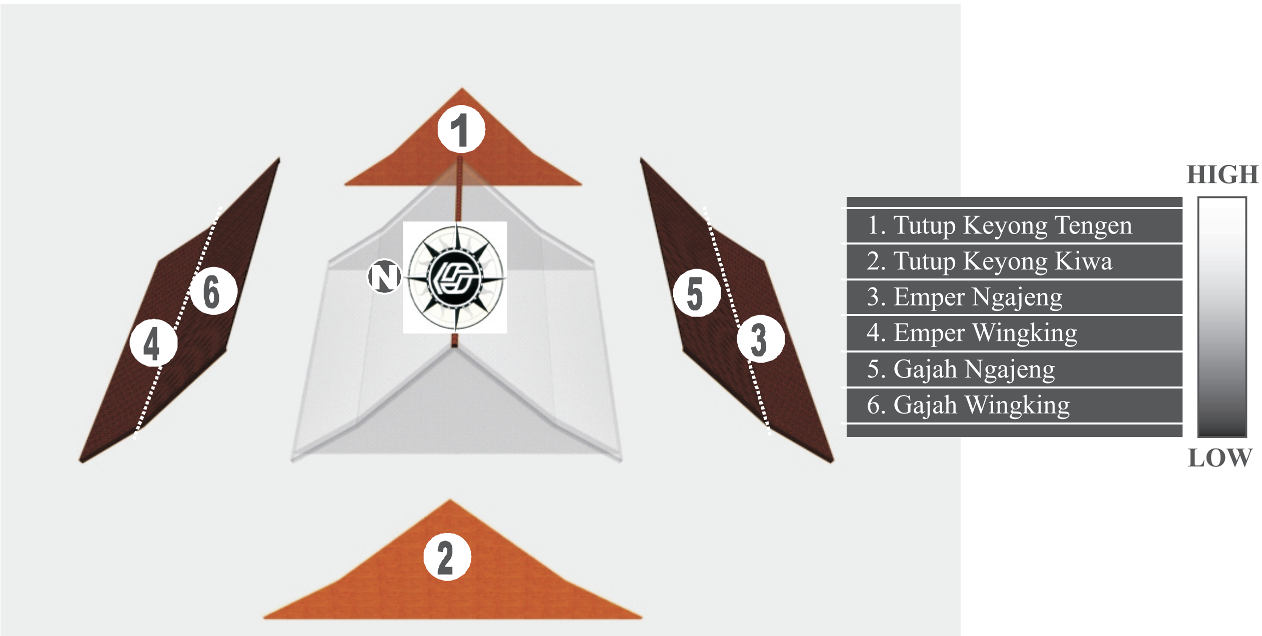


Figure 10. The Performance Order of *Srotongan* Roof Surface in Receiving Solar Radiation

5. Conclusions

After analyzing to the performance of Javanese village house and the environment factor, the concepts roof geometry for this architecture can be determined by following conclusions:

1) *Kampung Srotongan*, the lowest/limited roof surface area, is the best performance or optimal model with *gajah wingking* as the best performance surface.
2) The shadowed roof surface providing the cooling requirement is very extremely affected by solar movement in the long of the day (solar geometry).
3) The performance of roof geometry can be determined by **surface area, orientation, and the slope or tilt** to horizontal line. **The surface area** is the main factor which is determining total energy of solar radiation (Wh) and **the orientation** is the main factor which is determining total surface solar radiation (Wh/m^2).

Acknowledgements

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The Influences of Building Material to Urban Thermal Environment A Case Study of Caringin Market, Bandung, Indonesia

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ABSTRACT
Physical characteristics of a city are determined by many aspects, such as the use of building material, building configuration, orientation etc. We note that new trend in building-material using changes cityscape, while zoning concept of city planning make districts have unique physical characteristic. Trend in using building material is assumed influence thermal environment of city, because of its thermal properties such of conductivity, emissivity, and reflectivity. The aim of this research is to identify the influence the use of building material in a district to its thermal environment. For this purpose, we use remote sensing images from Landsat ETM that take the images in seven bands, included thermal and visible images. This method is quite accurate to calculate thermal environment since it has resolution of 1 pixel equal to 60 x 60 m. It means that more or less one building has one data of temperature. To identify the use of building material and its quantity in some districts we conduct ground survey.
Key words: *Thermal environment, Building material properties, Remote sensing images*

1. Background

The main issue of urban thermal environment is this field has a higher air temperature than its surrounding area. Many researchers had done their research in this area and get difficulties in defining the correlation to its urban air temperature. The common issue is the amount of vegetation area, open spaces, and etc. have correlation with urban air temperature. However, the physical characteristic of the district such as the use of building material is very important to be identified due to its quantity and economic value.
The identification of physical characteristics of a district is aimed for identifying the use of building material, colour of the surface, etc. The idea of this study is to define the influence of the use of building material in a district to its thermal environment. This research is very useful for city planner, architect, ME engineer, etc.

2. Methodology

This study reports thermal environments of Caringin Market in Bandung, using satellite data images. This remote sensing technology can provide information on earth surface, including thermal images. The study uses remote sensing images from Landsat ETM that takes images in seven bands including thermal and visible images. The identification is conducted by visual inspection, in which we categorized the districts based on the use of their building material. This method quite accurate to calculate the thermal environment since the Landsat images has resolution of 1 pixel equal to 60 x 60 m. In order to get information about the influence of the use of building material to its thermal environment, we have to calculate the quantities of all building-material using in the district. There are three aspects to be measured i.e.1) building shape, 2) density of district, 3) type of building material. The measurements consist of ground survey and digitations of district surface.

3. Measurement and Analysis

3.1 Digitations the District Surface

The aim of digitations the district surface is to get three dimensional (3D) image of each building, so that one can measure its length, width and height. This study combines information from the satellite image data and ground survey. Furthermore, the digitations process with 3D Max software divide the image into several layers of roof, wall, opening, etc. The calculation of building material quantity is easily conducted by layer in the 3D image. The digitations process of Caringin Market is shown in Fig.1.

Developing of 3D Image of Buildings

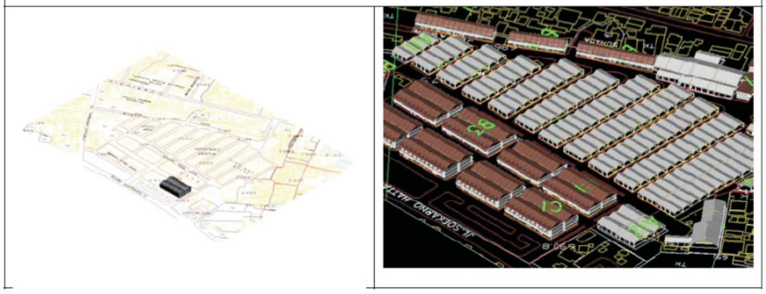


Fig. 1: Digitations of Caringin Market District

3.2 Analysis of Building Shape

In average, buildings in Caringin Market are long and low rise, in consistent with the resulted values of Aspect Ratio and Slenderness of 2.75 and 0.38.

3.3 Analysis of Density of Caringin Market

The density of this district is relatively low, i.e. only 51% of area covered by buildings. The total floor area is about 76% of district area.

Table 1: District Density

Ground floor area (m^2)	Total Floor Area (m^2)	Area of District (m^2)	BC	FAR
50927.2	76353	100442.85	0.51	0.76

The envelope-area analysis at Caringin Market shows that roof area is more dominant than wall area. Approximately 63% of Caringin area covers by roof. It means that in majority the buildings are low rise and single floor.

Table 2: Roof and Wall

Roof Area (m^2)	Wall Area (m^2)	District Area (m^2)	Roof Area/District Area	Wall Area / District Area
63634	33390,73	100442,85	0,63	0,33

3.4 Analysis of Type of Building Material

The use of building materials is divided into two categories, namely heavyweight and lightweight material. In this area the use of heavyweight material is more dominant than lightweight material. The heavyweight material is dominantly used in floor and inside wall, while lightweight material is dominantly used as roof and perimeter wall. The material of building envelope influences the gain of direct solar radiation. It is commonly known that the heavyweight material has bigger thermal capacity than lightweight one. In this case, direct solar radiations dominantly interface with the lightweight material.

Table 3: 'Density' of Heavyweight and Lightweight Material in the District

Building Material	Floor (m^2)	Wall (m^2)	Roof (m^2)	Area of Material (m^2)	Area of Material / Area of District
Heavyweight Material					
Concrete	76353	0	24618	100971	1,005
Brick	0	13438,68	0	13438,68	0,133
				114409,68	**1,14**
Lightweight Material					
Metal	0	2982,75	39016	41998,75	0,42
Glass	0	1826	0	1826	0,02
				43824,75	**0,44**

Ground Survey of Caringin market, as shown in Fig. 2, is conducted to identify the type of building material and land-cover material. The result is divided into there zones based on its physical characteristics, i.e one floors zone, Two floors zone and Three floors zone.

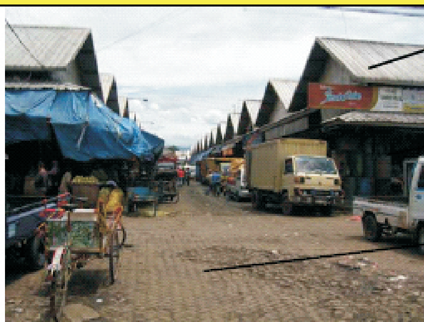
Zones in Caringin Market		Identification of Building Material
One floor zone		Metal Roof Tile Light colour No Wall Paving Street Dark colour
Two floors zone		Concrete Roof Tile Dark colour Brick Wall Light colour Paving Street Dark colour
Three floors zone		Concrete Roof Tile Dark colour Brick Wall Light colour Asphalt Street Dark colour

Fig. 2: Identification of Building Material

4. Discussion

The influence of the use of building material in a district to its thermal environment is shown at Caringin Market district. It could be seen that lightweight metal roof of single floor building makes a lower surface temperature than heavyweight two- and three-floor buildings. The lightweight metal roof has lower thermal capacity than concrete wall and roof tile, so the lightweight one could not absorb and collect much thermal energy.

Furthermore the shiny surface of metal roof reflects most of the direct solar radiation. Open spaces such as street space, parking park, give better influence to thermal environment.

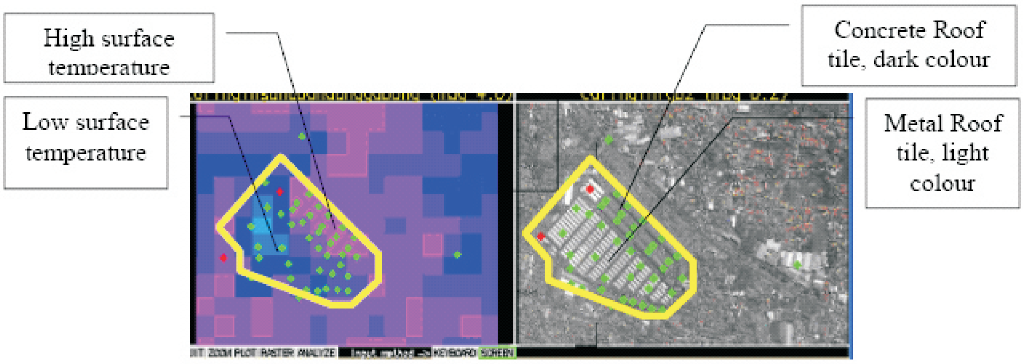


Fig 3: Visual Inspection for Identification of Urban Thermal Environment.
Source: Open source

5. Conclusion

The influence of building material to urban thermal environment is clearly recognized in this study of Caringin market. The use of lightweight material and light color surface give better influence to its thermal environment than heavyweight material and dark color surfaces.

6. Acknowledgment

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Importance of Daylighting Sufficiency on Common Space of Low Cost Flat Housing in Surabaya

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ABSTRACT

Common space of Low Cost Flat is important since it is the only space as gathering place, even doing some activities for flat dwellers. Low Cost Flat Common Space usually located at the centre of mass surrounded by flat units which causes the space is neither lit nor well ventilated. This on going research is inspirited by observation which finds some insufficiency on day-lighting such as: darkness within the space as well as contrast between the brightest and the darkest light. This research aims to evaluate day-lighting sufficiency of common spaces on Low Cost Flat Housing in Surabaya concerning its standard fulfillment, initiated by collecting plans of Low Cost Flat Housing in Surabaya, followed by making models using CAD, continued by simulating each model using "Radiance". Due to limitation of Radiance program, simplification maybe needed before simulating the models. The final result will be common space models complete with its daylight contour on which daylighting sufficiency evaluated against visual comfort standards either concerning its distribution or illumination intensities. The contribution is both as energy saving and as design guidelines for developers

Keywords: *Common Space, Daylight, DF, Luminance and Distribution*

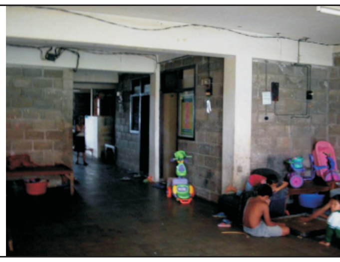
Background

Low Cost Rental Flat Housing is one of the correct alternatives in solving the affordability. The space pattern of Low Cost Flat Housing is a bit different compared to other kind of flats. Here common space that usually used as internal public space includes gathering activities. The existence of common space becoming very important since it may be the only place where dwellers can socialize while release daily bores. Providing affordable houses can be through optimal design including effectiveness of its natural lighting. Also, in order to realize energy saving, natural lighting during daytime should be designed so that reducing the use of artificial lighting assistance. Natural lighting is both more economical and healthier. For common space located remotely at the center of building mass, strategy of day-lighting that mostly can be relied on is that where light comes from roof or usually said as *skylight*. This kind of natural lighting needs large space to cover vertical fenestration from roof top through bottom floor. Besides, sky-lighting strategy is effective only for upper floors, while the floors below should still rely on *side-lighting.* This research aims to evaluate the sufficiency of day-lighting on the common space of Low Cost Flat Housing in Surabaya. Day-lighting sufficiency includes either quantitatively which concern with appropriation on visual comfort, or qualitatively which concern with evenness of Daylight Factor distribution. Day-lighting sufficiency is very important for the common space safety and visual comfort, otherwise darkness within the common space may create bad things including criminals, unhealthy & unpleasant place, dampness which later may cause inhabitability of the flats

Current Common Space Situation

How the common space is really vital to the dwellers is seen from several activities done as well as the crowd within the common space especially by the kids. How the insufficient day-lighting condition is seen from the darkness as well as the great contrast between the brightest and the darkest light dropped within space which create un-comfort visibility

Situation of Sombo



Situation of Penjaringansari

Situation of Menanggal

Situation Dupak Bangunrejo

		
Siuation of Siwalan Kerto		

Theories

The height of migration and urbanization as well as population rate results the increase of housing need especially in urban area. Limitation on urban land causes the development of Low Cost Rental Flat (LCRF). The development of LCRF within the city center is exactly correct in solving the urban marginal housing problems, as well as limitation of land, so there is no way to develop housing horizontally, and this walk-up flat is 4 floors maximum

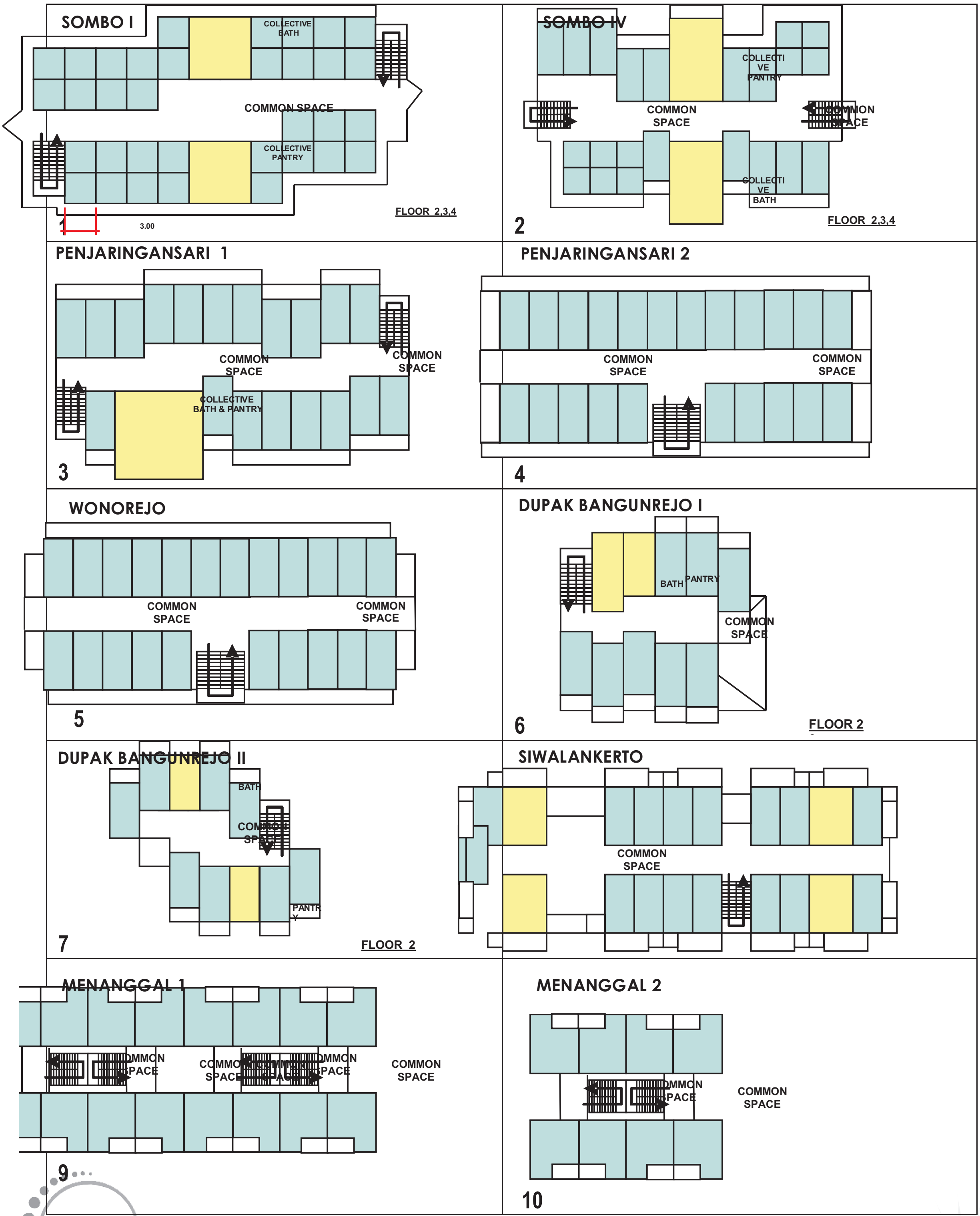
Public Space is a kind of space for public such as hall or whatever space that function for the gathering of community. Dimension can be large or small, and the use can be for working, reading, studying, exhibition, recreation, or waiting room. Requirement for public space can be on safety, comfort and others such as: Easy to enter or to be reached; Easy to exit especially when there is fire or structure collapse, exit ways should be swiftly or smoothly, not located on either crossing of fast stream, narrow or obstructed way (architect should realize when he constructs a building containing people he deals with human life); Easy to reach open space outside the building, so exit way should direct to open space; Flexibility of space when needed for frequently re-function space. Beside psychical requirement, factors considered are: Ventilation, lighting and the influences on the space atmosphere; View, interior–exterior relation through opening of walls to create particular atmosphere; Lighting influence, such as influence of colored glass window, transparent reflection of down or upper daylight that give relax atmosphere and relationship with outdoor; It can also reflect the light through the entire or part of ceiling surface

Indonesia which lies around the equator has an overcast sky. Meaning that the sky condition is diffuse over-bright although fluctuate quite frequently. Accordingly, careful design on natural lighting is on how to avoid the happening of glare. Further, there is a consequence of natural lighting in Indonesia specially concern with heat penetration. This happened since the fenestration for entering the lights is usually act also as the opening for passive cooling, so the entrance of light often followed by heat gain, while in hot humid climate, the principle of passive cooling is as much as possible heat dissipation, as well as shading the internal space from sun heat attack, using screens, devices, overhangs, etc

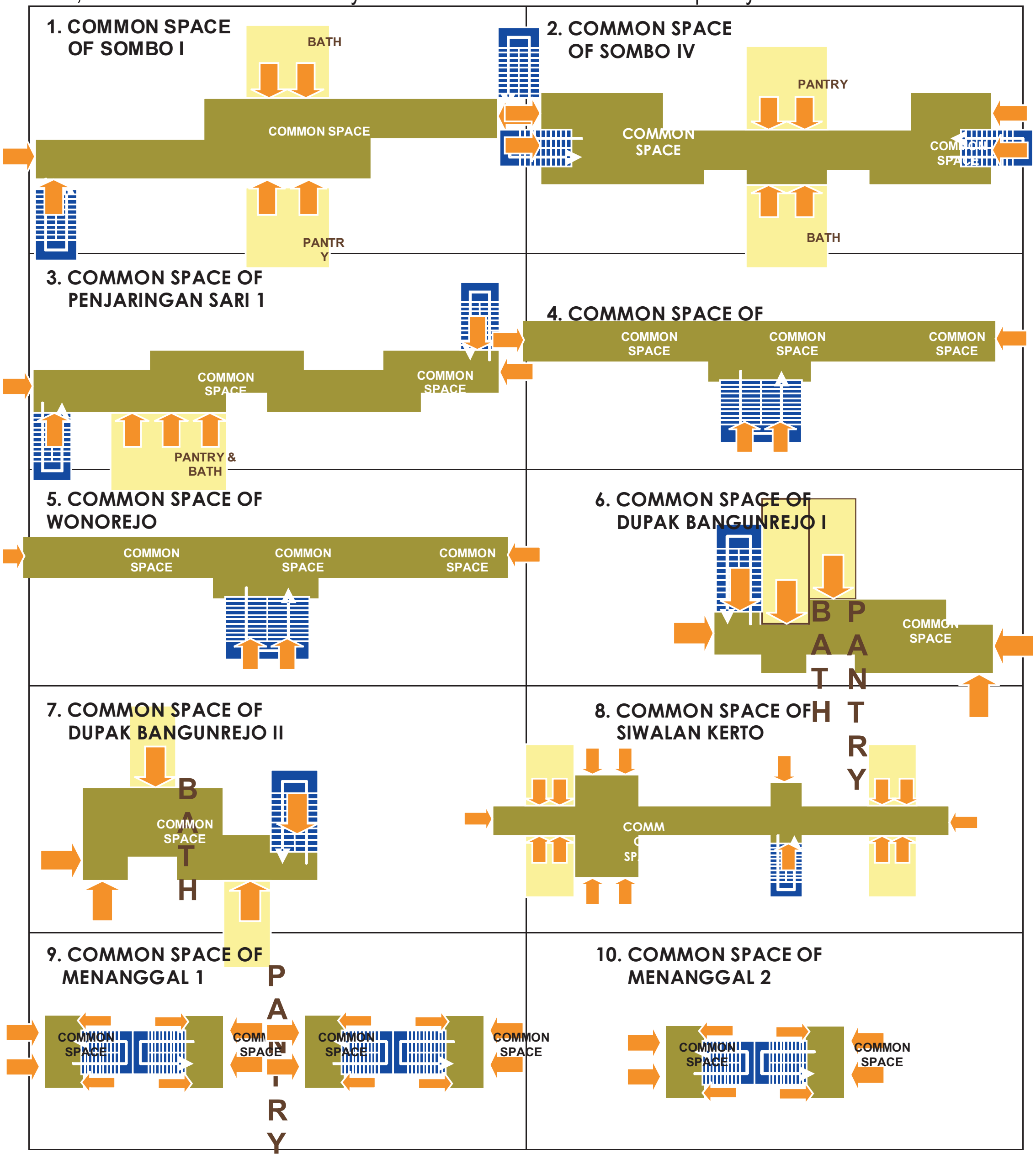
Natural lighting is sourced by the entire bright sky hemisphere, where sky act as the diffuser of sunlight reaching it. The sun is the main natural light source and may reach any point within space in four components: Sky Component (SC); Externally Reflected Component (ERC); Internally Reflected Component (IRC); and Direct Sunlight. According to William MC Lam (Sun-lighting 1966) strategies in entering daylight can be: Entering light through above building namely: roof monitor, clerestory, atria or skylight often mentioned as *Top-lighting*. This is the best strategy in maximizing illumination intensity and the illumination inside the room; *Side-Lighting* is entering light through side walls, namely fenestration or openings, windows, glasses existed on the walls with assistant of reflection from ceiling and walls. This can be a good lighting system for a space / room

The magnitude of natural lighting in space can be collected in two ways: Using quantity of luminous by calculating set of lights dropped (flux of luminance) or Using Daylight Factors (DF is relative) by calculating the ratio of illumination on the measured point inside against illumination happened outside. Concept of Daylight Factor valid only when there is no direct sunlight drop on measured point. In measuring the success of natural lighting within a space, (Moore 1993) and (Baker 2002) using IESNA standard: the distribution of Daylight Factors and the minimum illumination value should be reached on work plane. Evaluation on lighting distribution success determined by the numbers of measured points that qualify illumination standard, while success of illumination determined by average of illumination value within the space. Next, the recommended Daylight Factor for home according to Szokolay S.V is between 1% and 2%, while recommended illumination is 100–200 lux, and the maximum permitted ratio between higher and lower luminance is 10:1

Research Objects

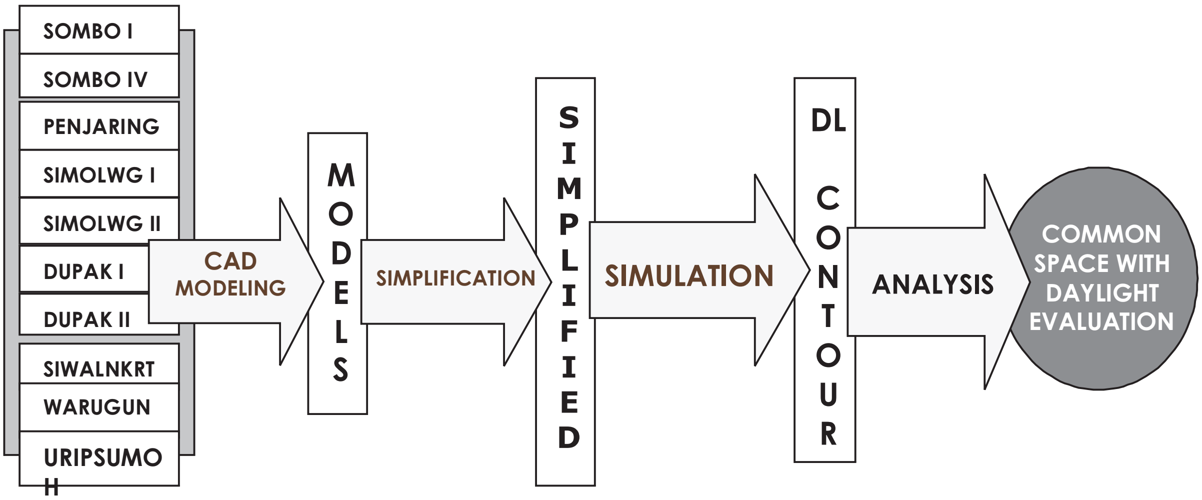


The following are the common spaces of each Low Cost Flat mass in Surabaya. The orange arrow means the possibility of natural side-light sources which averagely comes from access ways, stair void, or collective activities. The yellow blocks are collective bath or pantry



Methods

Data collection will include: documentation, field observation and interview on which research objects are Common Spaces of Low Cost Flats in Surabaya: Sombo I, Sombo IV, Penjaringansari, Simolawang I, Simolawang II, Dupak I, Dupak II, Siwalankerto, Waru Gunung and Urip Sumoharjo
This research is mainly included as simulation. In principle the experiment is replicating real condition into models in which accurateness of input data is important in order to reach the closest condition to the reality (Groat 2002). Research Process is: Plan & Section Collection → CAD Modeling → Simplification → Simulation by Radiance → Analysis - Standard→ Result



Dependent Variables are distribution of daylight factors within the common space as well as the Illumination intensity spread over the working plane which in this case is the floor since there is no furniture within the space.
Independent Variable is the common space geometry of every Low Cost Flat in Surabaya (10 representatives). Parameters are the dimension of common space geometry. Most of geometry shapes can be concluded narrow, long rectangles with enlargement at various place in the middle which averagely functions as collective activities

This research is focused on how day-lighting sufficiency of the common space is influenced by the geometry of its space shape. The basic geometry of space is shaped by interior elements: floor, walls and ceiling. So the dimension of common space elements will be the main factors. It is seen that the opportunity of natural light source possibly created for each floor are from stair void and entrance access. This can be the further improvement effort consideration in case of daylight insufficiency
The corridor width of common space is averagely 2-3 meters, and the average height of ceiling is 3 meter clearly. The section dimension of walk-up flat common space which each mass consists of 4 floors will be 2-3 times 4@3 → 12 meter square averagely, or 4-5 times 12 meter square on enlargement. Looking at the section, there is no more possibility of fenestration for light penetration except from stairs and access as mentioned above

Analysis
Having passed simulation process the result of all common space models (1-10) which are in the form of Daylight Contour Grids, Illumination Intensities, as well as Day-lighting Image set as desired, are ready to analyze. First of all using visual comfort standard for common space which in principle functioned as a hall, day-lighting sufficiency inside the space examined by referring the results to the standard as agreed (between 100 and 200 lux preferable). Next, there will be distinction between sufficient results and insufficient results. The sufficient models are of which average Daylight Factor between 1% and 2%, but the ratio between brightest and the darkest luminance are less than 10. Contrarily, the insufficient models will be those with most Daylight Factors <1%, as well as those of which having the ratio between the brightest and the darkest luminance is more than 10.

Outputs
This is an on going research, so the result is not realized yet. But output will be distinct into sufficient and insufficient models of common spaces complete with its day-light distribution patterns (contour).

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