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Impact of trees shading on building cooling demands in the tropical climate

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Abstract: *Solar radiation is a phenomenon that affects millions of people in tropical climate regions. The urbanization rate of developing countries like the case in Malaysia is increasingly rising; this has led to the increasing effects of solar radiation in the cities. The solar radiation also leads to increased energy needs due to exposure to uncomfortable outdoor. This study investigates the impact of trees shading on building cooling demands in the tropical climate regions by implementing a passive design method on a small residential building to improve the indoor thermal conditions. A comparative analysis work for two scenario models of a two-story residential building in Kuala Lumpur, Malaysia was conducted in April 2018. The study analyzed possible cooling solutions to suit Malaysia's hot climate. In this research, it was observed that trees shading plays an important role in reducing local temperatures in urban areas. The results obtained from our simulation show that the maximum solar irradiation reduction in April is 29596 W/m2; the roof receives the maximum solar irradiation followed by the east and the west surfaces represented as 47.9%, 33.1%, and 19%, respectively. Our findings revealed trees shading gradually reduces the energy consumption for cooling.*

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I. Introduction

The tropical region is famous with hot and humid climate condition, it lies within the Tropics of Capricorn to Cancer between the latitude of 15°south and 15°north, This region covers the areas of Malaysia, Philippines, Australia, Singapore, Indonesia, India, part of Africa and Latin America[1]. In the Tropics, is considered as a region where the human evolvement and comfort has often been reserved for granted while built environments are progressively becoming a public concerned issue[2]. However, many cities in the region experienced rapid urban growth and development without much reference to the evolving urban environment, this has increased the demand for comfort requirements in the design of buildings[2]. The demand for comfort conditions in buildings has significantly increased as a result of exposure to uncomfortable outdoor climate, this tendency has contributed to putting an enormous pressure on the cooling demand in the cities, and the local climate seriously disturbs the indoor thermal environment in buildings [3]. In tropical climates, buildings absorb heat during the day due to solar irradiation heat gain through the building envelope, mostly due to fenestration openings[4].

From a sustainable design point of view, it requires lowering of indoor daytime temperature below the outdoor temperature using building elements by passive or active systems. The Passive techniques use in this study are the combination of selected building materials and conventional architectural principles including trees shading to ensure that the interiors remain cool in the summer and all year round, thus creating a year-round comfortable environment in passive building design. It should be noted that the passive design does not certainly mean the removal of the standard mechanical system for cooling. However, the passive systems coupled with trees shading impressively reduce the size of the traditional cooling systems and cut the amount of energy consumption needed to sustain comfortable indoor temperature[5]. Trees shade moderate the amount of radiant energy absorbed by building surfaces[6].

Techniques for such thermal modification have been widely addressed in this paper. This study focuses on the impact of trees shading on cooling demands in the tropical climate of low rise residential buildings. The study uses a literature review of the solar irradiation impact of cooling demands. A comparison of two simulations of the solar irradiation and trees shading effect on building energy consumption was conducted, and this study was carried out in Kuala Lumpur, Malaysia.

II. The case study of factors influencing solar radiation

2.1 Case study of Kuala Lumpur climate condition

The typical climate of Kuala Lumpur has the characteristics of very small variation in monthly temperatures, with the highest temperature in the daytime of the hottest months February, March, April and the first half of May is 33°-34°C, whiles the coolest month, December with 31°C, the lowest temperature at night is 23-24°C[7]. The annual relative humidity value ranges from 78% to 86%, during the day, Kuala Lumpur has a completely clear sky ranging from 3.7 to 8.7 hours per day [8].

An expansion that took place urban cities in Malaysia including Kuala Lumpur shows a quite significant role in changing the urban air temperature pattern[9]. The process of expansion changes the thermal stability of an area causing an urban heat island effect, where the cities could be a number of degrees centigrade warmer than the adjacent rural area [10, 11]. This enlarged heat makes the cities uncomfortable places and puts serious health threats during heat waves[11]. The past decade climate change phenomenon has caused a threat to the human environment and their thermal comfort[12]. The most crucial climatic effects in Kuala Lumpur buildings are the high intensity of solar irradiation and high-temperature of daily air[13, 14]. Besides these climatic elements, higher relative humidity and a small amount of wind movement have a significant effect on occupants' indoor thermal comfort[15]. Due to extreme heat and extraordinary hot air temperature, architectural engineers prefer to adopt mechanical systems in building design such as air-conditioning in ensuring required indoor thermal comfort level which increases energy consumption in buildings[8].

Depending on a fully mechanical system instead of considering the passive strategy which has approaches such as planting trees as shade around the building is also a problem which accentuates the uncomfortable indoor condition. Climate is a vital aspect of our life particularly in areas with hot and humid climates such as Kuala Lumpur, where people face a variety of problems related to climate, especially in modern housing. The traditional built environment of Kula Lumpur is considered appropriate for both the climate as well as for social conditions. The modern architecture of western style which has a different climate approach which causes crucial problems in the urban areas[16]. New developments are generally considered inappropriate, particularly because they were introduced without consideration for the local climate.

2.2. Thermal comfort

Comfort can be defined as a state of satisfaction that a person has, however, many factors can contribute to this. For instance, air temperature, air movement, relative humidity, air quality, acoustics, aesthetics, clothing, emotion, perception, and the action of a person[17]. Perhaps, this definition is too general, but the purpose of this paper is to ensure occupants have comfort by providing trees shade around the building. The American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Standard 55 expressed thermal comfort as "the state of mind which expresses satisfaction with the thermal environment[17].

Thermal comfort is achieved when heat generated by the body is balanced and transferred to the surrounding space, the occupant is not aware of this process in any fashion. A healthy person has an internal thermostat at 37°C; this temperature varies between people, season, time of day and what activity the occupant is doing[18]. Hot and humid indoor environment at residential or workplaces may lead to a variety of heat-related symptoms or sicknesses like heavy sweating, weakness, salt imbalance, low blood pressure, dehydration through sweating leading to fainting or reduced mental ability, sharp muscle pain or cramps and even death[19, 20]. The thermal comfort of a building in relation to energy saving is influenced by several aspects, including the thermal-physical properties of the building materials, building orientation, ventilation, building space usage and integration of modern and passive energy saving techniques[15]. The building envelope is not only a separator from the outdoor environment but also a shelter from climatic components affecting the building directly[21]. The indoor thermal comfort is dependent on the properties of materials used for the building, which can be affected by the outside temperature and humidity[22]. Comfort zones described in ASHRAE Standard 55-2013 for summer conditions similar to Malaysian climate estimates a neutrality value of 24.5°C, with a comfort airflow at 0.25 m/s, humidity at 50 % and the temperature ranges between 23.0°C – 26.0°C[17, 23]. The activity level is 0.5 met, clothing value of 0.5 for general sedentary work, with light slacks and short sleeves shirt or blouse[17].

The passive cooling and natural ventilation have traditionally been two important features in tropical climate regions that vernacular architectures applied to achieve thermal indoor comfort[24]. In the tropical climate regions, it has been identified that more than 30% of total energy consumption is used to run mechanical cooling systems[25]. This is not only the case in the hot regions, but there are signs in some other parts of the world. For example, research shows that energy consumption related to cooling during the summer has been recently increasing in cooler climate region like southern Europe[26]. Thermal comfort is always one of the main concerns in hot climate regions such as Malaysia.

2.3. Solar heat gain through the building envelope and its orientation

The building envelope is a core component with respect to solar irradiation heat gain of the entire building and complete heat transfer coefficient which controls solar heat gain through the envelope of the building[27]. An analysis of building energy consumption with reference to Singapore, Hong Kong, and Saudi Arabia shows that the building envelope design accounts for 25%, 36% and 43% of the ultimate cooling load respectively[15]. The design of Building envelope plays a major role in the solar irradiation heat gain and energy performance of high-rise buildings as well as low rise buildings.

A complete design approach of mitigating solar heat gains and energy efficiency of buildings implements passive approaches for building envelope design. It has a significant impact on improving the overall building heat gain behavior and energy performance excluding large-scale buildings[28]. A façade with high-performance that integrates the natural ventilation system, daylighting and trees shade has the potential to significantly decrease energy consumed by building cooling operations[29]. Additionally, building envelope has a major influence on a building aesthetic and visual impact. Envelope design flexibility has to meet several visual and functional aspects. It is an important factor that can encourage clients, architects, and other stakeholders to select one system over others. There is a necessity to establish that this design flexibility not only compromises solar irradiation heat gain and energy performance but also has the potential to enhance it[27].

In Modern buildings, glazed facades are being gradually used to advance the daylight accessibility inside of the building. It offers well external views and also adds to the architectural contrast of the building. However, the increased practice of glazed surfaces is leading to an increase in the solar heat gain inside the building which is becoming a major problem in hot climatic regions[16]. Glazed facade buildings impose itself as a sign for the developing city. This large capacity of glazing in the facade needs to be protected against sun glare and overheating in tropical zones, especially when it faces east or west direction. In Kuala Lumpur for example, every morning and afternoon east and west façades expostulate to direct solar radiation, while north façade slightly faces sun radiation during May, June, July, and August. South façade slightly face it during November, December, January, and February although north and south have got much less than east and west. Therefore, building envelope in tropical regions should have proper shading to distract its interaction with direct sun glare and high temperature wind. In the hot humid regions, the establishment of effective cross ventilation under the local wind direction is a major aspect that could affect the building orientation[15]. Indoor air movements of a building depend not only on outdoor wind velocity but also basically on the architectural consideration parameters[30]. Architectural means for achieving this purpose include conventional design elements such as orientation and position of the building, balcony configuration, roof shape, type of the windows and location, partitions and furniture arrangement.

2.4. Solar heat gain through building orientation and its natural ventilation

Selecting the most optimum orientation of the building is one of the most important ways of mitigating solar radiation effect that could have an influence on building orientation and energy consumption. As it can be used to reduce the direct solar irradiation on the building through fenestration and external walls, it will be most affected for full glazed facade building[15]. A study reported by Jinhua Yu[31] showed that solar irradiation through the exterior fenestrations accounts for 25-28% of the total solar irradiation accumulation to the infiltration. The building surfaces including roof, walls, fenestrations and building layout play a major role in controlling air infiltration[30].

They are major factors and alternatives in ensuring indoor air quality is maintained through a combination of fresh outdoor air and existing indoor air[30]. Claire and Hyde[32] implement an approach of permeable wall-roof design and plan orientation to estimate passive design theories and their impact on thermal comfort. Their research contended that plan dimensions of more 15 m in length reduce the efficiency of natural ventilation and the degree of thermal comfort. Air movement is an essential factor in the overall ventilation procedure when designing the form of the building facade and building orientation[33]. Chen[34] pointed out that humidity, temperature, air velocity, and air flow patterns are significant elements to ruminate when collecting and evaluating data on indoor temperatures and inside air flow quality. Furthermore, outside air velocities can also affect interior air movements and temperatures as a result of alterations in air pressure applied through facades of the building, by proper location of windows and passive design strategies.

III. Methodology

3.1. General approach

The methodology implemented in this paper is based on an analytical literature study and comparative analysis work for two scenarios model of two stories of a residential building in Kuala Lumpur Malaysia as shown in fig. 1. (a, b). The literature study was carried out to investigate and analyze possible cooling solutions to suit Malaysia's hot climate, with a focus on the two scenarios as follows:
Scenario 1: Two story residential building without trees shading
Scenario 2: Two story residential building with trees shading in the east and west sides
The objective of this paper is to use passive techniques to reduce cooling loads of residential buildings in Kuala Lumpur and provide information about the tree-shade impact on buildings energy saving. In order to achieve the main objective, sub-objectives have been established. The first objective is to reduce the energy demand while using a proper material composition of the external surfaces and provide proper windows-wall ratio in the east and west directions. The second is to provide trees as a shade in the east and west directions to block the solar radiation towards the building. The study presumed the energy consumption in buildings will reduce due to the trees-shading. One of the significant inputs for human development and economic growth is energy[35]. Applying trees as building shading device is an efficient passive method of solar control[36]. The study expects that the shaded areas of the building will have lower solar radiation and thermal loads compared to the non-shaded areas. Evaporative cooling from the trees can lower air temperature nearby the shaded wall, and reduce the emissions due to energy savings [37]. Trees can provide substantial enhancements in the quality of the environment, including their ability to reduce urban pollutant, atmospheric CO2 emissions concentrations and noise level[38]. Trees have psychosomatic benefits to aesthetic, human's related passionate and physiological response to vegetated urban landscapes[39].
Many researchers have studied the effect of tree-building location on cooling and heating energy use[40]. In order to consider the impact of trees shade on summertime electricity use, this study assumed a hypothetical typical residential house that is located in Kuala Lumpur. The house consists of two floors. It is 15 m long, 13.8 m wide and 9.3 m high. There are no distributions of trees done in the north and south directions due to the fact that the south side receives no direct solar radiation most of the year although the north side receives, but less solar radiation compare to the east and west directions. The trees were separated 6 m away from the walls; the distance between each tree to another is 7 m but their shadows are very close to each other. The totality of the trees are 4, where 2 of them are on the east side and the other 2 are on the west side. The estimated energy conservation results obtained from scenario 1 and scenario 2 are presented in the form of solar irradiation in Wh/m2.

fig. 1. (a) Scenario 1 the building without trees **Fig. 1. (**b) Scenario 2 the building with trees,

3.2 The composition of external surfaces and simulation software

The analysis of two simulation scenarios on traditional solid walls and roof constituted by structural and architectural materials were considered to the following case studies to represent a typical building practices of Malaysian construction sector. The materials studied were: (1) Concrete, (2) Cement plaster and (3) EPS. The external insulation layer made of EPS was included when a computer simulation showed the necessity of its use, to increase the thermal resistance (R-value) of exterior walls and the roof. Also, an internal insulation wall was provided to resist the indoor penetration of heat in a case the exterior part of the walls fail to prevent it. The proposed external wall composition was compared in case study only. Detailed data of material's thermal behavior are listed in Table 1.

To carry out the thermal behavior analysis, two software namely Autodesk Revit 2016 and Metronome 7.1.6 were used to perform the simulation. The solar radiation plugging tool in Autodesk Revit 2016 was used for the simulation. This plugging tool is an ideal tool suitable for the analysis of complex and expandable models and can easily accomplish all simulation requirements, which can be integrated into the building design process. This software is capable to calculate an accurate thermal behavior analysis at any time[41]. Meteonorm generates and stores weather data using a stochastic method. Data stored in Meteonorm are taken from 8,300 weather stations placed worldwide. The data consist of hourly wet and dry bulb temperatures, relative humidity, wind speed and cloud cover[42]. Autodesk Revit architecture generated the thermal properties of materials that had been used in this project, where solar radiation package in Revit had done the solar irradiation calculation on the external surfaces of the building. In this paper, Meteonorm is used to generate outdoor hourly air temperature in Kuala Lumpur, Malaysia to compare the solar irradiation analysis plugging in Autodesk Revit.

Table 1 Thermal properties materials used in this simulation

Function	Material	Thickness (m)	Density Kg/m³	Specific heat J/(g.c°)	Thermal Conductivity w(m.k)	R-values (m²k)/w	U-values w/(m²k)
Wall	Plaster	0.050	1600	1.085	0.220	0.23	
	Concrete block	0.200	1800	0.840	1.300	0.15	
	EPS	0.050	50	1.200	0.030	1.67	
					∑R= 2.05	0.49	
Roof	Paper	0.005	930	1.300	0.040	0.13	
	Plaster	0.045	1600	1.085	0.220	0.20	
	EPS	0.050	50	1.200	0.030	1.67	
	Concrete cast	0.150	1200	1.000	1.400	0.11	
					∑R= 2.10	0.48	
Window	Glass	0.006	2700	0.840	0.800	0.01	
	UPVC frames	0.075	510	1.350	0.250	0.30	
						∑R= 0.31	3.25

3.3 The trees shading mode

This study has examined the cooling effect of four trees located on the east and west sides of the building. The cooling effect of the trees shading was estimated and evaluated by comparing scenario 1 and scenario 2. In addition, real-time data of solar radiation prediction model is used to provide an understanding of how the specific mechanism of trees shading affects building energy consumption. The trees have different geometrical shapes, so the areas covered by the trees shadows on the surface of the building were calculated in a simplified manner; each one of the trees was simulated separately to get the area covered by its shadow with respect to time. In the east surface, the trees shadows were simulated from morning until the noon, while the trees shadows in the west surface were simulated from noon until afternoon.

The shaded areas of the building surfaces were represented in percentages with respect to the total area of each surface. The selected tree in this study was Royal Poinciana which is well known in hot humid zones. It was chosen due to its rapid growth, larger width to height ratio, mostly use around building[37]. The reduction percentages of solar irradiation on each surface and the total solar irradiation reduction in this paper were calculated based on equations (1)and(2).

$$R_P = P_{S1} - q_{S2} \tag{1}$$

WhereR_P is the reduction percentages of solar irradiation, P_{S1} is the maximum solar irradiation percentages in scenario 1, Q_{S2} is the maximum solar irradiation percentages in scenario 2.

$$S_R = (M_{S1} - N_{S2}) R_P \tag{2}$$

S_R is the total solar irradiation reduction, $M_{S1}$is the maximum solar irradiation in scenario 1
$N_{S2}$is the minimum solar irradiation in scenario 2.

3.4 Simulation setting

The simulation was conducted on April 11th, 2018. The selected day was chosen due to Kuala Lumpur's hottest season which starts from March up to the first half of May, as shown in fig. 2 [43]. The simulation consists of three main stages, where only two of them were considered the trees shading effect.

Stage. 1: the simulation of the solar irradiation of scenario 1 and 2 on the east façade with the time interval from 7:00 to 12:00

Stage. 2: the simulation of the solar irradiation of scenario 1 and 2 on the west façade with the time interval from 12:00 to 17:00

Stage. 3: the simulation of the solar irradiation of scenario 1 on the roof with the time interval from 10:00 to 15:00.

Solar irradiation is the radiation from the sun, while terrestrial radiation is radiation emitted by objects on earth so that the shading effect from trees are very important in adjusting both of them[44]. Trees shade can block the diffused light from the sky and reduce the glare of surrounding surfaces; this will reduce the heat exchange from the building and its nearby areas. In the daytime, trees shade can also indirectly decrease heat gain in buildings by changing terrestrial radiation and eventually reducing ground surface temperature[45]. trees block unwanted solar radiation flowing in the building and after that reduce the cooling load during summer[37, 46].

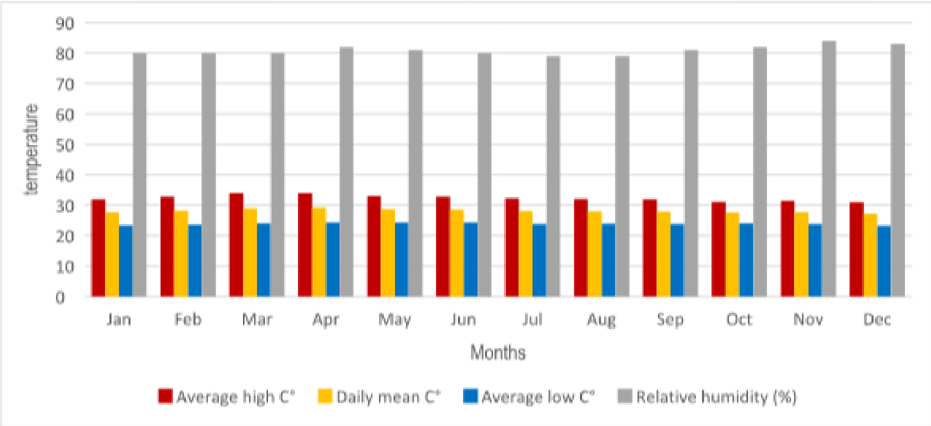

Fig 2. Temperature in Kuala Lumpur.

IV. Results and discussion

4.1. Scenarios on east and west faces

This paper implemented a passive design method on a small residential building to improve the thermal indoor condition and its surroundings. Our proposed method focuses on selecting proper materials for the building external surfaces and then protecting them from direct solar radiation so as to reduce the heat gain and increase the cooling process. A Combination of the calculated results on the east surface are shown in Table 2 (a, b). The first column presents the time upon the calculated solar irradiation, where the second column presents the area of the east surface. The third column is the calculated maximum solar irradiation in hourly, where the rest of the columns are the levels of solar irradiation and their percentages from the entire east surface of the building. In scenario 1, the results obtained for the actual solar irradiation without any trees shading are presented, and in scenario 2, the results obtained for the actual solar irradiation with trees shading are presented as shown in fig. 3. The highest value of the solar irradiation on the east surface in scenario 1 is 752 Wh/m2 and scenario 2 is 714 Wh/m2.

The arrangement of calculated results on the west and roof surfaces are shown in table 3 (a, b) and table 4. The solar irradiation on the west surface is lower compared to the east and roof surfaces. From 15:00 to 16:00 the solar irradiation on the west surface reach the peak value of 490 W/m2 in scenario 1 and 476 Wh/m2 in scenario 2. The roof shows the maximum solar irradiation in all surfaces of 909 Wh/m2 at 12:00. The incident of solar irradiation on the north surface during the noontime is also high, but not as high as that on the east and roof surfaces. The intensity of solar radiation is a function of the angle of incidence, the angle at which the sun's rays strike the Earth's surface, the lower angle also reduces the intensity of the incoming rays[47]. It is a great example to see the impact of solar azimuth angle in daily heat gain of buildings.

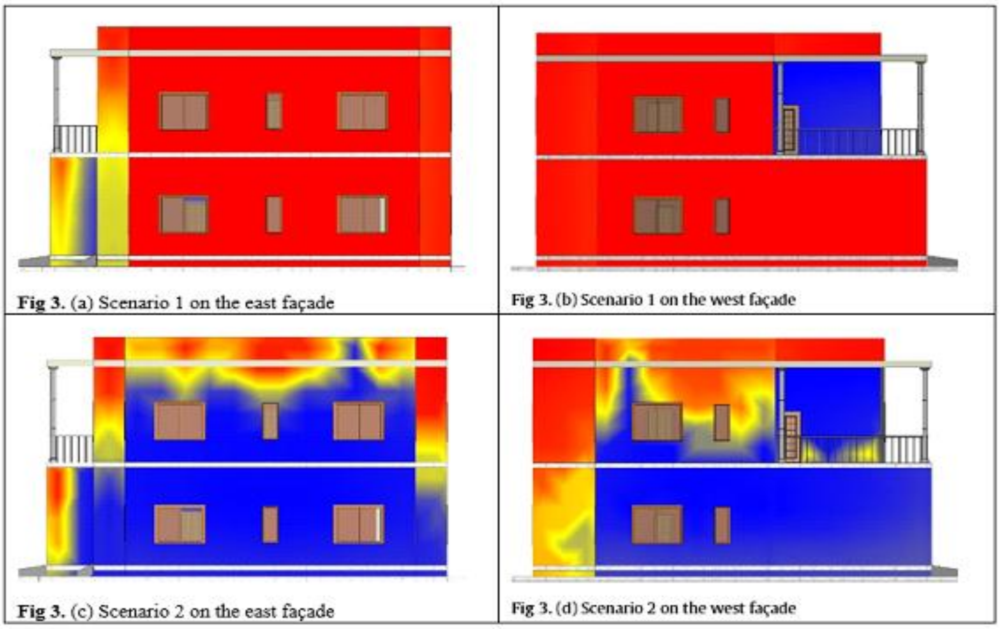

Fig 3. (a) Scenario 1 on the east façade

Fig 3. (b) Scenario 1 on the west façade

Fig 3. (c) Scenario 2 on the east façade

Fig 3. (d) Scenario 2 on the west façade

Table 2. (a)

Scenario 1 solar irradiation values and percentages on the east façade on April 11 2018

Time	façade area (m²)	maximum solar irradiation (Wh/m²)	medium solar irradiation (Wh/m²)	minimum solar irradiation (Wh/m²)	maximum solar irradiation percentages (%)	minimum solar irrad-percent (%)
7:00	135	374	204	33	90	10
8:00	135	681	378	74	90	10
9:00	135	752	423	95	90	10
10:00	135	679	393	106	85	15
11:00	135	516	315	114	85	15
12:00	135	304	209	115	85	15

Table 2. (b)

Scenario 2 solar irradiation values and percentages on the east façade on April 11 2018

Time	façade area (m²)	maximum solar irradiation (Wh/m²)	medium solar irradiation (Wh/m²)	minimum solar irradiation (Wh/m²)	maximum solar irradiation percentages (%)	minimum solar irrad-percent (%)
7:00	135	350	180	11	25	75
8:00	135	637	334	30	30	70
9:00	135	714	383	52	50	50
10:00	135	653	363	74	65	35
11:00	135	497	294	92	75	25
12:00	135	289	201	113	85	15

Table 3. (a)

Scenario 1 solar irradiation values and percentages on the west façade on April 11 2018

Time	façade area (m²)	maximum solar irradiation (Wh/m²)	medium solar irradiation (Wh/m²)	minimum solar irradiation (Wh/m²)	maximum solar irradiation percentages (%)	minimum solar irrad-percent (%)
12:00	135	128	111	95	75	25
13:00	135	186	140	94	75	25
14:00	135	374	230	86	80	20
15:00	135	490	280	70	80	20
16:00	135	480	263	46	80	20
17:00	135	250	134	18	80	20

Table 3. (b).
Scenario 2 solar irradiation values and percentages on the west façade on April 11 2018

Time	façade area (m²)	maximum solar irradiation (Wh/m²)	medium solar irradiation (Wh/m²)	minimum solar irradiation (Wh/m²)	maximum solar irradiation percentages (%)	minimum solar irrad-percent (%)
12:00	135	119	106	93	35	65
13:00	135	177	136	92	70	30
14:00	135	364	224	83	85	15
15:00	135	476	272	67	85	15
16:00	135	463	253	42	40	60
17:00	135	236	125	15	25	75

Table 4.
Scenario 1 solar irradiation values and percentages on the roof on April 11 2018

Time	façade area (m²)	maximum solar irradiation (Wh/m²)	medium solar irradiation (Wh/m²)	minimum solar irradiation (Wh/m²)	maximum solar irradiation percentages (%)	medium solar irrad-percent (%)
10:00	179	680	340	0	80	20
11:00	179	831	416	0	85	15
12:00	179	909	455	0	90	10
13:00	179	902	451	0	90	10
14:00	179	816	408	0	85	15
15:00	179	648	324	0	85	15

4.2 Cooling load reduction with trees shading

Fig. 4. Shows the hourly distribution of solar irradiation on the east surfaces. The highest reduction of solar irradiation of scenario 1 as compared to scenario 2 was 32.5% on the east façade and 21.6% on the west façade. The trees shading showed great performance in the east façade, the maximum solar irradiation in scenario 1 calculated from 7:00 to 12:00 was 3306 Wh/m2 covered 87.5% of total area of the east façade while the minimum was 537 Wh/m2 covered the rest. The base point of our adjustment was minimum solar irradiation, therefore after the difference between the maximum and minimum solar irradiation, we found 2769 Wh/m2. In scenario 2 when the shadows of planted trees covered for about 45% still maximum solar irradiation cover 55% of total area of the east façade, so that, after the differences of two maximum solar irradiation percentages we have got a reduction percentage 32.5% and that give the us total reduction of 900 Wh/m2 on 11th April 2018. The west façade showed a smaller reduction of solar irradiation than the east check in fig. 5. The maximum solar irradiation in scenario 1 was 1908 Wh/m2 and the minimum was 409 Wh/m2 after same procedure as the east we have got reduction 324 Wh/m2 on 11th April 2018.

Our findings revealed the impact of trees shade on summertime energy consumption, trees shading reduces electricity usage for cooling gradually. In hot arid areas denser trees provides expressively additional cooling than moderate or light trees[48, 49]. There is a significant reduction in summertime residential energy consumption, as compared to no shade. This finding has allegations for the species of the tree being planted while realizing the energy savings in the future, a monthly simulation of solar irradiation had shown a rejection of 29596 Wh/m2 on whole month of April see Fig 6, The homeowners will benefit such savings, maximized by tree species with dense leaf canopies during the hot summer months.

On the other hand, the simulation of this study had shown that the roof is the biggest solar receiver in the building as shown in fig 7. In order to reduce heat absorbance, the study used the parameters of a cool roof as suggested by many researchers. adding high albedo makes more protected from absorbing direct solar in the noon time and resulted in the fewest discomfort hours[50]. Akbari and his research colleagues suggested, flat roof with high albedo coating showed to be the most efficiency cool roof approach, also albedo starts to pay for its self as first as possible[51].

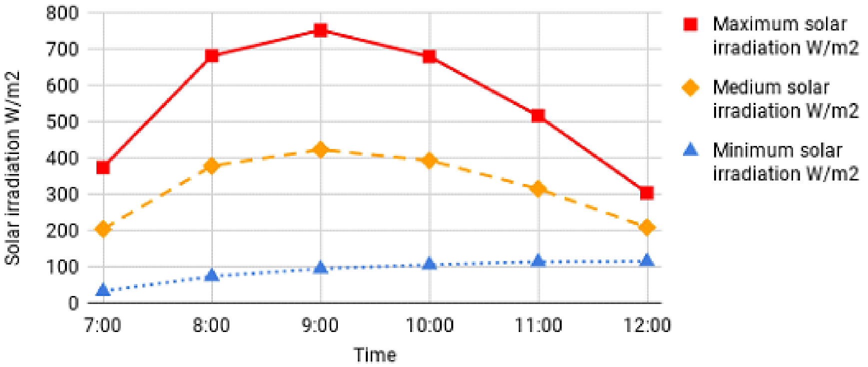

Fig. 4. Scenario 1 solar irradiation values on the east façade

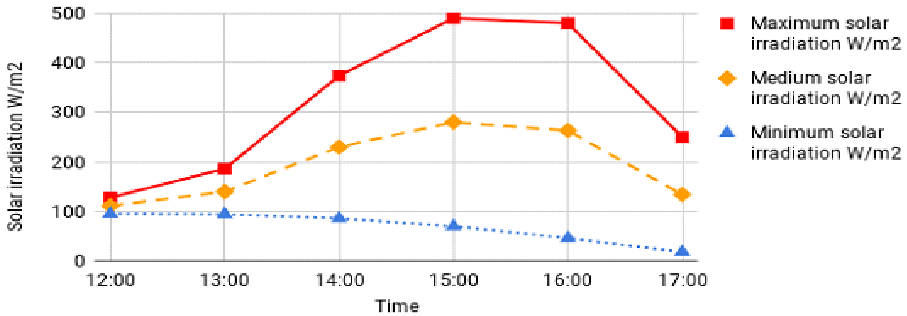

Fig. 5. Scenario 1 solar irradiation values on the west façade

Fig. 6. Monthly solar irradiation values on the roof, east and west surfaces

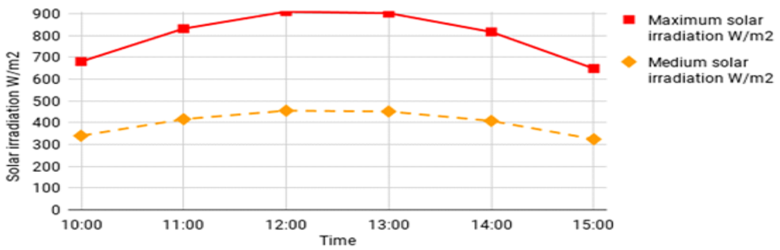

Fig. 7 Scenario 1 solar irradiation values on the roof

V. Constraints and limitations

The current study presents some limitations. First, only the impact of trees shade and thermal behavior have been analyzed, other potential impacts on the environment haven't been considered. Second, this research based on only a small residential building. The model of our study simulation height was 9.3m and its length was 15m. In this case, it's not complicated to arrange the rooms with enough sunshine, proper window direction and windows wall ratio, but in the case of a building above 12m high with a large size, the effect of trees shade will need much consideration. The use of reduction percentages of individual surfaces of hourly solar irradiation was only the most accurate to check the changes of solar intensity with the time rather than over the day or month, where shade will vary with time, size of obstruction and location.

VI. Conclusion

Kuala Lumpur is located in the tropical zone characterized as humid and warm lies within the Tropic of Cancer and Capricorn, this has increased the needs of cooling to reach acceptable indoor thermal condition. Electricity demand has increased intensely in the past few years and extraordinary thermal loads in buildings have directed to the necessity to increase the capacity of a mechanical cooling system. The increase in energy usage is expected to continue unless energy efficient strategy and passive cooling measures are introduced. As mentioned earlier solar irradiation is one the most exposed source of building heat gain and it's most challenging component to protect. Reducing solar heat gain of the external surfaces of the building would probably reduce the energy consumption for space cooling load.

This study investigates trees shading effect on building cooling load based on simulation with two scenarios using solar radiation package in Autodesk Revit 2016, the cooling impact of tree modifications was projected and evaluated by comparison. The simulation was also considered to the subsequent case studies to represent typical construction sector of Malaysian residential buildings, traditional solid walls created by structural and architectural materials such as concrete block, reinforced concrete, cement plaster and an internal insulation layer made of EPS. The paper review various method to obtain the effect of solar on a small residential building in Kuala Lumpur Malaysia. It was revealed that the roof receives maximum solar radiation followed by east and the west surfaces, it accounts for 47.9% 33.1% and 19% respectively. The simulation results of this study showed an optimum solution for Malaysia's hot humid climate condition, however, more detailed and comprehensive researches need to confirm this solution in the future studies.

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