KARYA TULIS

“WATER-FILLED WINDOW” CONSTRUCTION TO PROTECT SUNLIGHT HEAT PROPAGATION INTO THE ROOM

Fermanto Lianto

Jakarta, Maret 2018

KATA PENGANTAR

Puji syukur dan terima kasih kepada Tuhan Yang Maha Esa, serta kepada semua pihak yang telah membantu baik secara materi maupun non materi, sehingga karya tulis berjudul: *"WATER-FILLED WINDOW" CONSTRUCTION TO PROTECT SUNLIGHT HEAT PROPAGATION INTO THE ROOM* ini dapat terselesaikan dengan baik. Penulis menyadari masih ada kekurangan dalam penulisan ini, sehingga membutuhkan masukan, kritik dan saran untuk menyempurnakannya.

Akhir kata semoga karya tulis ini dapat bermanfaat bagi kita semua, Terima Kasih. Berkah Dalem.

Jakarta, 16 Maret 2018

Penulis,

Fermanto Lianto.

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"WATER-FILLED WINDOW" CONSTRUCTION TO PROTECT SUNLIGHT HEAT PROPAGATION INTO THE ROOM.

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Abstract

The Earth's surface Temperatures is increasing from year to year. Many things can cause a temperature rise on earth, like the sun's rising temperatures, global warming process, and the destruction of the ozone layer. There are several things that can cause damage to the ozone layer, one of which is gas CFC (Chlorofluorocarbons) resulting from the use of Air Conditioner (AC) to lower the temperature in the room.
As we know, the use of glass windows in the room, besides penetrating sunlight, is also one of the causes of influx of heat from the sun, so the type, thickness and construction of a glass window that is used will greatly affect the temperature in the room that lead to efficiency in the use of air conditioning. Window construction using clear glass+water+clear glass is believed to protect heat propagation into the room from the sun's heat source, so there is a difference between the outside temperature and the inside temperature in the room. This observation and research window construction using clear glass+water+clear glass as called as "water-filled window" contruction will compare with different thicknesses of glass and water to see the temperature difference, outside and inside the room, and to see the ability of the construction to protect the heat propagation of sunlight into the room, how long the propagation of sunlight is able retained into the room, and calculate how much energy can be saved using the "water-filled window" construction.

Keywords: Clear Glass, Water, Chlorofluorocarbon, kalor, "water-filled window" construction.

INTRODUCTION

The temperature on the earth's surface is increasing from year to year. Many things can cause the temperature of the earth to increase, such as the rising temperatures of the sun, the process of global warming, and the destruction of the ozone layer, thus increasing the amount of sunlight penetrating into the earth's surface. Ozone layer is one layer that is in the earth's atmosphere. This layer is useful to protect the earth from solar radiation directly. When the ozone layer is damaged, the amount of sunlight that enters the earth will rise and eventually raise the temperature of the earth.

Global warming is the increase in temperature on the earth's surface caused by the accumulation of greenhouse gases in the atmosphere. As a result of global warming, there is an increase in the earth's temperature into $0.74 ° C \pm 0.18$ in the last 100 years [1].

Because of the higher temperature, people will tend to create a cool atmosphere. One of the most commonly used solution is to use AC (Air Conditioner), but in the long-term use, air conditioning can give harm to the earth, especially as electricity energy consumption of air conditioning is quite a lot and now the world is in a state of energy crisis. In addition to the increasing need for energy, there has been more power plants built. The clearing of land to build these power plants will worsen the current state of the earth. In addition, the waste product from power plants can also pollute the environment, both the surrounding area and around the world.

One of the waste from power plants that can pollute the environment is carbon dioxide (CO_2). These gases will gather and accumulate in the air. Due to the nature of this compound, sunlight which has been ireflected by the earth into space will be reflected back to earth. This will make the temperature of the earth to rise.

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Therefore, when the temperature in the room can be reduced, then the use of air conditioning will decrease. This of course can prevent the increased severity of the energy crisis in the world and the further degradation of the environment.

The heat of the sunlight will enter the room through the windows made of glass, where the glass is needed so that the room gets natural light from the sun into the room, so the room does not require artificial lighting during the day. To avoid excessive heat coming into the room, the characteristics of the glass material used as window coverings are needed to be studied, so that in the room temperature becomes lower and can reduce the use of air conditioning.

RESEARCH OBJECTIVES

Due to the things mentioned above, the researcher is interested to produce a product that is "*water -filled window*" construction, in this case a glass window design with formation of clear glass+water+clear glass, which can withstand the heat propagation in order to lower the temperature in the room. Thus, the use of electricity for air conditioning can be reduced.

In addition, this study also aims to determine the effectiveness of the glass window design with a certain thickness of the glass and water in the most optimal capability to withstand the heat so as to reduce the temperature in the room.

LIMITATION

This study focuses on the design of specially made glass window consists of a layer of a glass, water, and a glass with thickness variation of the glass "clear" or transparent and water (H_2O) which form a unity called "*water-filled window*" construction, to resist the propagation of the incoming heat from sunlight into the room through a glass window, so that it can lower the temperature in the room optimally and efficiently.

PROBLEM

There are several types of glass and glass thickness that can be used as window coverings for sunlight to enter the room, and of course will also bring heat into the room so the things that can be observed are:

1. What is the thickness of the clear glass+water+clear glass (as called as "*water-filled window*" construction) which is optimal to reduce the heat climbed from sources of sunlight entering through the window?
2. How long can the "*water-filled window*" construction keep temperature of the room lower?

SCOPE OF RESEARCH

To limit the scope of the study, this paper will focus on two issues:

1. Observing differences in temperature outside and inside the room which has glass windows (as called as "*water-filled window*" construction), made from clear glass with 3mm and 5 mm thickness variation and fill with water 3mm, 5mm and 7mm thickness variation, which is made of the composition as below:
   a. Window type-1: 3mm clear glass+3mm water+3mm clear glass
   b. Window type-2: 3mm clear glass+5mm water+3mm clear glass
   c. Window type-3: 3mm clear glass+7mm water+3mm clear glass
   d. Window type-4: 5mm clear glass+3mm water+5mm clear glass
   e. Window type-5: 5mm clear glass+5mm water+5mm clear glass
   f. Window type-6: 5mm clear glass+7mm water+5mm clear glass

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2. Light source used is direct sunlight on to a window glass in a mockup sample of softboard shaping a miniature house.

METHODOLOGY

In this research, some mockups samples were made of a 18 mm thick softboard material, shaped in miniature/scale model of a house 30 x 30 x 30 cm3 sized with a glass window measuring 20 x 20 cm2 of clear glass and water with a different thickness (using a "*water-filled window*" construction), and without ventilation to facilitate the process of observation.

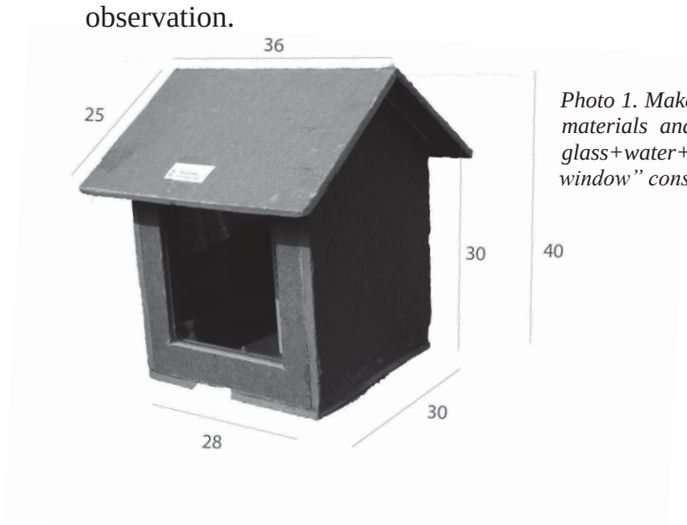

Photo 1. Maket size (in cm) with a house model made from softboard materials and has the same size of windows, covered by clear glass+water+clear glass with a different thickness ('water-filled window" construction).

Then the mockups were put in the open space, facing east so that they faced the sun. Each day between 09.00 AM to 4.00 PM in a period of more than one month (30 days) they were observed the data collection was done hourly to record temperatures with mercury thermometer which is placed on the outside of the mockups, indoor side, and in the water for the water thickness 7 mm.

Photo 2. Mockups with a model home which has a glass window placed in an open space facing east, illuminated by the sunlight, ready to be used for data retrieval temperature indicated on the thermometer mercury at each hour from 09.00 AM until 16.00PM, for approximately one month (30 days).

Photo 3. Mockups facing east.

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LOCATION AND TIME OF RESEARCH.

Residential Taman Surya II, Block D1/02, Cengkareng, West Jakarta. Data collection was first performed in the open space on September 3rd, 2010 until October 14th, 2010 for 30 days by using the sunlight as a heat source. Temperature data were taken from 09.00 AM to 04.00 PM with a time interval of data collection every one hour.

THEORITICAL FRAMEWORK

1. GLASS [2]

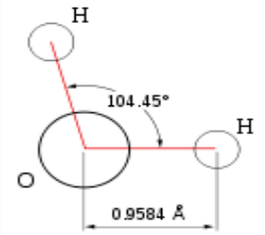
Glass is translucent and transparent materials which is usually derived from a mixture of silicon dioxide or silicon material (SiO2), which is chemically similar to quartz. It is usually made from silica sand and soda. The melting temperatures reach 2000 ^{o}Celsius. Glass is one of the products of chemical industries that are most familiar with the daily lives. In terms of physics, the glass is "liquid" which is very cool. It is because of the structure of the constituent atoms are far from each other as in a liquid, but in fact are solid. This occurs due to the cooling process (which is) very quickly, so the silica atoms do not arrange themselves on a regular basis.

2. WATER [3]

Water is a substance or material or elements that are important to all known forms of life on earth to this day, but not on another planet. Water covers nearly 71% of the earth's surface. There are 1.4 billion cubic kilometers (330 million cubic miles) available on the earth. Most of the water are in the ocean (salt water) and in the layers of ice (in polar and mountain tops), but can also present as clouds, rain, rivers, freshwater face, lakes, water vapor, and sea ice. Water in the moving objects follow a water cycle, namely: through evaporation, rain, and water flows over the land surface (runoff, including springs, river, estuaries) to the sea.

Properties and physical-chemical properties of water:

WATER



INFORMATION and PROPERTIES	
Name	Water
Alternatif Name	Aqua, dihidrogen monoksida, Hidrogen Hidroksida
Molecular Formula	H_2O
Molar Mass	18,0153 g/mol
Phase and Dencity	0,998 g/cm³ (melt on 20 °C) 0,92 g/cm³ (solid)
Melting point	0 °C (273,15 K) (32 °F)
Boiling point	100 °C (373,15 K) (212 °F)
Heat Specific	4.184 J/(kg·K) (melt on 20 °C)

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Table 1. Information and properties of water [3]

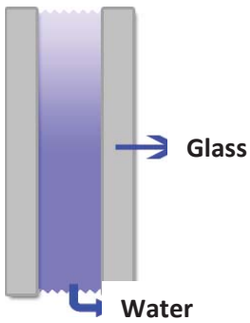

Figure 1. "Water filled window" construction, consist of clear glass+water+clear glass

3. "*WATER-FILLED WINDOW*" CONSTRUCTION.

"*Water-filled window*" construction in this experiment was created from a basic material containing clear glass window with a certain thickness combined with water in a certain thickness to dissipate the heat that is put in the middle between two pieces of clear glass and in the lid (seal) with sealant so as not to spill and evaporate at the time exposed to the sun's heat.

4. GREENHOUSE GAS (Carbon Dioxide and Methane) [3]

Greenhouse gases are caused by rising concentrations of carbon dioxide (CO_2) and other gases in the atmosphere. The increase in CO_2 concentration is due to the increase in the burning of fuel oil, coal and other organic fuels which exceed the ability of plants and sea to absorb. These gases will rise into the atmosphere as if to form a layer. This coating will reflect sunlight that has been reflected by the earth. Direction of this reflection is to the earth again, so that the earth will become hot again.

According to the simulation calculations, the greenhouse effect has increased the Earth's average temperature into 1°C to 5 °C. When the trend of increasing greenhouse gases remain as it is now, it will cause an increase in global warming between 1.5 °C to 4.5 °C around the year 2030. With increasing concentration of CO_2 in the atmosphere, the more heat waves reflected from the Earth's surface is absorbed by the atmosphere. This will cause the earth's surface temperature to rise. It may result in increased temperature of the Earth and will result in a very extreme climate changes on Earth. This can lead to disruption of forests and other ecosystems, thereby reducing its ability to absorb carbon dioxide in the atmosphere. Although it has the negative impact, the greenhouse effect has a positive effect as a tool for heating the earth.

OBSERVATIONS AND DISCUSSION

Here is the data and the results obtained from observations made from 9:00 AM until 4:00 PM in Taman Surya 2 Block D1/02, West Jakarta of each type of mockups with temperature observations recorded every hour every day for 30 days of observation.

Given that the temperature recorded an increase and decrease in accordance with the incident light angle changing, and the heat of the sun according to the changes of time from the morning, afternoon and evening, and the propagation of different heat on glass, water, and glass entering through the glass window into the mockups room due to different thicknesses of glass and water, then an average temperature that is recorded for each day for each type of mockups can be seen from the following results:

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Temperature observation data of the source of sunlight

Window type										
Date	Time	Outside temp (°C)	1	2	3		4	5	6	
			3-3-3 mm	3-5-3 mm	3-7-3 mm		5-3-5 mm	5-5-5 mm	5-7-5 mm	
			Room temp (°C)	Room temp (°C)	Water temp (°C)	Room temp (°C)	Room temp (°C)	Room temp (°C)	Water temp (°C)	Room temp (°C)

Data suhu dari sumber sinar matahari

Tanggal	Jam	Suhu Luar (°C)	Jenis Kaca							
			1	2	3		4	5	6	
			Kaca 3-3-3 mm	Kaca 3-5-3 mm	Kaca 3-7-3 mm		Kaca 5-3-5 mm	Kaca 5-5-5 mm	Kaca 5-7-5 mm	
			Suhu Ruang	Suhu Ruang	Suhu Air	Suhu Ruang	Suhu Ruang	Suhu Ruang	Suhu Air	Suhu Ruang
3-Sep-10	9:00	50	43	50	42	47	45	49	41	43
	10:00	50	42	43	44	43	43	42	44	41
	11:00	50	43	43	43	45	44	43	43	44
	12:00	48	43	43	42	45	44	43	43	44
	13:00	47	44	44	42	46	44	43	42	45
	14:00	48	43	43	42	45	43	42	42	43
	15:00	42	43	43	41	45	43	42	41	44
	16:00									
rata-rata		43	43	44	42	45	44	43	42	43
4-Sep-10	9:00	50	42	50	44	46	48	49	43	44
	10:00	50	42	43	44	43	44	43	42	44
	11:00	50	42	42	43	43	44	43	44	42
	12:00	50	43	43	42	44	44	42	42	43
	13:00	50	44	44	42	45	45	43	42	44
	14:00	44	45	44	42	46	45	43	42	45
	15:00	40	40	44	42	47	45	43	42	44
	16:00	37	44	43	41	45	44	41	41	43
rata-rata		46	43	44	43	45	45	43	42	44
5-Sep-10	9:00	34	32	32	32	33	32	32	32	34
	10:00	35	33	34	34	34	33	33	33	34
	11:00	38	38	37	37	38	37	37	37	38
	12:00	47	39	38	38	40	39	38	38	39
rata-rata		39	36	35	35	36	35	35	35	36

Data suhu dari sumber sinar matahari

Tanggal	Jam	Suhu Luar (°C)	Jenis Kaca							
			1	2	3		4	5	6	
			Kaca 3-3-3 mm	Kaca 3-5-3 mm	Kaca 3-7-3 mm		Kaca 5-3-5 mm	Kaca 5-5-5 mm	Kaca 5-7-5 mm	
			Suhu Ruang	Suhu Ruang	Suhu Air	Suhu Ruang	Suhu Ruang	Suhu Ruang	Suhu Air	Suhu Ruang
7-Sep-10	9:00	44	35	36	35	35	36	36	35	36
	10:00	43	36	37	36	36	37	37	36	36
	11:00	50	39	44	45	45	40	40	40	39
	12:00	50	42	42	41	43	43	41	40	42
	13:00	35	36	36	36	36	36	36	36	37
	14:00	35	35	35	35	35	35	35	34	36
	15:00	32	33	33	34	33	33	33	33	34
	16:00	31	32	32	33	32	32	33	33	33
rata-rata		40	36	37	37	37	37	36	36	37
13-Sep-10	9:00									
	10:00									
	11:00	39	40	41	40	41	41	40	40	41
	12:00									
	13:00	39	43	42	40	41	44	42	41	43
	14:00	38	42	42	40	42	43	42	41	43
	15:00	39	43	43	41	42	43	43	42	44
	16:00	38	41	41	40	40	42	42	41	43
rata-rata		39	42	42	40	41	43	42	41	43
14-Sep-10	9:00									
	10:00	44	40	41	41	44	42	40	42	40
	11:00	41	41	41	42	42	42	41	41	41
	12:00	42	43	43	42	45	43	42	42	43
	13:00	42	45	44	42	45	45	43	42	44
	14:00	43	45	44	43	45	44	44	42	44
	15:00									
	16:00	40	44	43	42	45	44	42	40	44
rata-rata		42	43	43	42	44	43	42	42	43

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Temperature observation data of the source of sunlight

Date	Time	Outside temp (°C)	Window type 1 (3-3-3 mm) Room temp (°C)	2 (3-5-3 mm) Room temp (°C)	3 (3-7-3 mm) Water temp (°C)	3 (3-7-3 mm) Room temp (°C)	4 (5-3-5 mm) Room temp (°C)	5 (5-5-5 mm) Room temp (°C)	6 (5-7-5 mm) Water temp (°C)	6 (5-7-5 mm) Room temp (°C)
15-Sep-10	9:00									
	10:00	36	36	37	36	36	37	37	36	36
	11:00	36	35	36	35	36	36	36	36	37
	12:00	33	35	36	35	35	36	36	35	36
	13:00	33	32	32	33	32	32	32	34	33
rata-rata		35	35	35	35	35	35	35	35	36
16-Sep-10	9:00									
	10:00	36	31	31	32	31	31	32	31	32
	11:00									
	12:00	41	43	42	40	42	42	42	41	43
	13:00	40	43	42	40	42	42	41	41	43
	14:00	37	41	40	39	40	41	40	40	41
rata-rata		39	40	39	38	39	39	39	38	40
17-Sep-10	9:00	40	40	43	35	40	37	44	34	38
	10:00	41	41	42	40	40	42	39	39	39
	11:00	38	39	39	40	39	40	38	39	39
	12:00	37	38	38	38	38	39	38	38	39
	13:00	37	38	38	37	38	39	37	37	38
	14:00	36	38	38	37	38	39	37	37	38
	15:00	37	38	38	37	38	38	37	37	38
	16:00	33	34	34	34	34	38	34	34	35
rata-rata		37	38	39	37	38	39	38	37	38
18-Sep-10	9:00	35	34	37	32	32	36	36	34	34
	10:00	36	36	37	35	34	37	36	36	36
	11:00	40	39	40	38	37	40	39	39	40
	12:00	41	41	41	40	41	42	41	41	42
	13:00	41	45	43	43	45	45	43	43	45
	14:00	42	46	44	44	47	46	44	44	46
	15:00									
	16:00	39	45	43	43	46	45	44	42	45
rata-rata		39	41	41	39	40	42	40	40	41
19-Sep-10	9:00									
	10:00	40	41	41	41	41	41	41	41	40
	11:00	42	43	43	41	43	43	42	42	42
	12:00	40	41	42	41	43	42	41	42	43
	13:00	39	43	43	42	44	43	43	43	44
	14:00	40	41	41	40	42	42	41	42	42
	15:00	37	40	40	39	40	41	40	41	41
	16:00	35	37	37	36	37	38	38	38	39
rata-rata		39	41	41	40	41	41	41	41	42
21-Sep-10	9:00	35	34	37	35	35	34	34	36	35
	10:00									
	11:00	40	36	38	36	37	36	35	37	36
	12:00	42	42	42	41	43	44	42	41	43
rata-rata		39	37	39	37	38	38	37	38	38

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Temperature observation data of the source of sunlight

Date	Time	Outside temp (°C)	Window type 1 (3-3-3 mm) Room temp (°C)	2 (3-5-3 mm) Room temp (°C)	3 (3-7-3 mm) Water temp (°C)	3 (3-7-3 mm) Room temp (°C)	4 (5-3-5 mm) Room temp (°C)	5 (5-5-5 mm) Room temp (°C)	6 (5-7-5 mm) Water temp (°C)	6 (5-7-5 mm) Room temp (°C)
22-Sep-10	9:00	44	38	42	37	38	42	43	37	41
	10:00	47	40	42	41	40	43	41	44	41
	11:00	35	38	38	39	38	39	38	40	39
	12:00	32	33	33	34	34	45	34	34	35
	13:00	33	33	34	32	33	34	34	34	35
rata-rata		38	36	38	37	37	41	38	38	38
23-Sep-10	9:00	46	40	45	38	41	45	49	40	43
	10:00	46	42	44	43	41	45	42	46	42
	11:00	43	43	42	41	43	45	48	43	44
	12:00	43	44	43	42	44	45	43	44	45
	13:00	38	40	40	39	40	41	41	41	43
rata-rata		43	42	43	41	42	44	45	43	43
24-Sep-10	9:00	34	40	42	42	44	44	43	40	41
	10:00	37	38	39	39	40	39	38	39	39
	11:00	37	39	39	39	40	40	39	38	40
	12:00	36	39	39	39	40	39	39	38	39
	13:00	37	40	40	40	42	41	41	39	42
	14:00	35	39	38	38	40	39	39	38	40
	15:00	38	42	41	40	44	44	42	40	44
	16:00	36	40	39	39	40	40	40	39	40
rata-rata		36	40	40	40	41	41	40	39	41
25-Sep-10	9:00	37	37	39	38	38	38	38	37	37
	10:00	38	39	40	40	40	40	39	38	39
	11:00	38	40	40	39	40	40	40	39	44
	12:00	39	42	42	42	40	43	41	40	43
	13:00	37	42	42	41	43	43	42	42	43
	14:00	36	40	39	39	40	40	40	40	41
rata-rata		38	40	40	40	40	41	40	39	41
26-Sep-10	10:00	41	39	36	38	37	37	36	38	37
	11:00	40	42	39	41	42	40	41	41	41
	12:00	41	43	40	41	43	42	40	41	42
	13:00	42	43	41	42	43	43	42	41	43
	14:00	40	44	42	42	45	44	43	42	40
	15:00	38	39	37	40	41	39	38	40	40
	16:00	34	35	34	35	35	34	35	35	36
rata-rata		39	41	38	40	41	40	39	40	40
27-Sep-10	9:00	42	40	41	41	42	40	42	41	41
	10:00	40	42	41	42	43	41	42	42	42
	11:00	39	41	41	42	42	40	42	41	42
	12:00	38	41	40	41	42	40	41	41	42
	13:00	35	38	37	39	39	42	38	40	40
	14:00	37	38	37	40	37	37	38	36	35
	15:00	36	38	38	37	39	38	38	38	40
	16:00	32	34	34	35	35	34	35	35	37
rata-rata		37	39	39	40	40	39	40	39	40

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Temperature observation data of the source of sunlight

Date	Time	Outside temp (°C)	Window type 1	2	3		4	5	6	
			3-3-3 mm	3-5-3 mm	3-7-3 mm		5-3-5 mm	5-5-5 mm	5-7-5 mm	
			Room temp (°C)	Room temp (°C)	Water temp (°C)	Room temp (°C)	Room temp (°C)	Room temp (°C)	Water temp (°C)	Room temp (°C)
28-Sep-10	9:00	41	40	42	44	44	43	43	43	41
	10:00	42	39	40	43	43	42	40	42	40
	11:00	39	42	43	43	44	44	42	42	43
	12:00	40	43	43	43	45	45	43	42	44
	13:00	40	44	44	44	45	45	43	44	45
	14:00	38	43	42	42	45	44	43	42	45
	15:00	37	42	42	41	44	44	43	41	44
	16:00	35	38	38	38	40	39	39	39	40
rata-rata		39	41	42	42	44	43	42	42	43
29-Sep-10	9:00	46	42	39	37	38	40	45	39	42
	10:00	43	41	40	40	40	41	42	42	41
	11:00	43	44	42	42	44	45	44	44	45
	12:00	42	42	42	42	44	45	44	44	45
	13:00	44	45	44	43	46	45	45	44	45
	14:00	42	44	42	41	44	44	43	43	45
	15:00	40	43	42	40	43	44	43	42	44
	16:00	39	42	41	39	42	42	42	41	45
rata-rata		42	43	42	41	43	43	44	42	44
30-Sep-10	9:00	38	40	40	42	41	42	43	43	42
	10:00	41	43	42	44	44	44	44	45	43
	11:00	41	43	42	43	44	44	44	45	45
	12:00	41	44	43	43	45	44	43	44	45
	13:00	40	44	43	44	45	45	42	43	45
	14:00	40	44	45	43	45	45	44	44	45
	15:00									
	16:00	35	39	38	39	41	40	39	40	41
rata-rata		39	42	42	43	44	43	43	43	44
1-Okt-10	9:00	44	41	40	43	45	45	46	42	43
	10:00	43	42	41	45	44	45	44	44	43
	11:00	39	42	41	42	43	43	43	42	45
	12:00	45	45	44	43	45	45	44	43	45
	13:00	40	46	44	43	46	44	45	44	46
	14:00	41	46	45	44	47	46	45	44	47
	15:00	39	46	45	43	47	46	45	44	47
	16:00	37	42	21	41	43	42	42	42	43
rata-rata		41	44	40	43	45	45	44	43	45
2-Okt-10	9:00	44	45	45	41	43	45	45	42	42
	10:00	46	46	47	44	43	47	44	46	43
	11:00	40	43	43	42	42	43	42	42	43
	12:00	38	41	41	40	40	41	40	40	41
	13:00	40	42	42	40	43	43	41	40	43
	14:00	38	40	40	39	40	40	39	39	41
	15:00	36	39	39	38	39	39	38	38	40
	16:00									
rata-rata		40	42	42	41	41	43	41	41	42
4-Okt-10	9:00	40	39	40	40	39	40	39	39	37
	10:00	36	37	37	38	37	38	36	37	36
	11:00	38	38	39	38	38	39	38	37	38
	12:00	40	40	40	39	40	41	40	39	42
	13:00	38	38	39	38	40	39	38	39	40
	14:00	37	38	38	37	38	38	38	39	40
	15:00	36	37	37	35	35	37	37	36	39
	16:00									
rata-rata		38	38	39	38	38	39	38	38	39

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Temperature observation data of the source of sunlight

Date	Time	Outside temp (°C)	Window type 1	2	3		4	5	6	
			3-3-3 mm	3-5-3 mm	3-7-3 mm		5-3-5 mm	5-5-5 mm	5-7-5 mm	
			Room temp (°C)	Room temp (°C)	Water temp (°C)	Room temp (°C)	Room temp (°C)	Room temp (°C)	Water temp (°C)	Room temp (°C)
7-Okt-10	9:00	39	41	43	39	39	42	42	40	40
	10:00	45	43	41	41	41	43	41	43	41
	11:00	42	43	42	42	43	45	45	44	45
	12:00	39	41	39	41	41	41	39	41	42
rata-rata		41	42	41	41	41	43	42	42	42
8-Okt-10	9:00	47	42	42	41	41	40	42	42	40
	10:00	47	43	42	43	42	41	42	44	41
	11:00	42	43	42	42	42	42	42	43	43
	12:00	41	42	42	40	43	42	43	42	43
	13:00	42	44	43	41	44	43	43	43	45
	14:00	40	45	43	41	45	45	44	43	45
	15:00	40	45	44	41	46	45	44	43	46
	16:00	35	40	39	38	40	39	39	40	41
rata-rata		42	43	42	41	43	42	42	43	43
10-Okt-10	9:00									
	10:00	36	40	40	40	38	40	39	39	38
	11:00	45	41	41	40	40	41	41	40	40
	12:00									
	13:00									
	14:00	41	47	45	43	47	47	45	42	46
	15:00	40	45	44	42	47	45	45	42	46
	16:00	38	45	43	41	45	45	44	40	45
rata-rata		40	44	43	41	43	44	43	41	43
	16:00	36	45	44	41	45	44	44	43	46
rata-rata		41	45	45	43	44	46	45	45	45
12-Okt-10	9:00	42	45	45	46	47	48	46	46	43
	10:00	43	45	45	46	45	46	45	47	45
	11:00	42	44	45	45	45	46	44	45	43
	12:00	39	45	44	44	46	45	44	44	45
	13:00	41	45	44	44	47	45	44	44	46
	14:00	39	46	44	43	47	46	45	43	46
	15:00	38	46	45	43	47	46	45	44	47
	16:00	36	43	42	42	44	44	44	42	44
rata-rata		40	45	44	44	46	46	45	44	45
14-Okt-10	9:00	40	50	41	45	47	44	42	42	42
	10:00	45	38	38	40	39	38	37	38	37
	11:00	37	41	42	41	42	41	40	40	40
	12:00	38	42	42	41	43	42	40	40	41
	13:00	40	43	42	42	45	42	42	42	42
	14:00	40	44	42	42	40	45	43	43	45
	15:00	35	38	35	38	39	38	38	38	39
	16:00									
rata-rata		39	42	40	41	42	41	40	40	41

Table 2. Temperature observation data of the source of sunlight

From the 30 days observations above, the average temperature every hour and every day for each type of mockups, the data can be seen in the following observations:

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Average yield temperature observations from sunlight sources

			Window type							
	Time	Outside temp (°C)	1	2	3		4	5	6	
			3-3-3 mm	3-5-3 mm	3-7-3 mm		5-3-5 mm	5-5-5 mm	5-7-5 mm	
			Room temp (°C)	Room temp (°C)	Water temp (°C)	Room temp (°C)	Room temp (°C)	Room temp (°C)	Water temp (°C)	Room temp (°C)
Average	9:00	41.48	40.22	41.57	39.65	40.65	41.43	42.30	39.78	40.04
	10:00	41.82	39.96	40.21	40.46	40.00	40.82	39.82	40.75	39.57
	11:00	41.00	40.93	41.03	40.83	41.41	41.59	41.07	41.00	41.52
	12:00	41.00	41.50	41.14	40.64	42.11	42.46	41.00	40.86	42.21
	13:00	39.73	41.77	41.23	40.46	42.35	42.15	41.12	41.00	42.54
	14:00	39.38	42.50	41.71	40.79	42.58	42.67	41.88	41.13	42.79
	15:00	37.79	41.16	40.79	39.68	42.21	41.74	40.95	40.32	42.53
	16:00	35.89	40.00	38.11	38.72	40.50	40.33	39.83	39.17	41.11
Average of all		39.76	41.01	40.72	40.15	41.48	41.65	41.00	40.50	41.54

Table 3. Average yield temperature observations from sunlight sources

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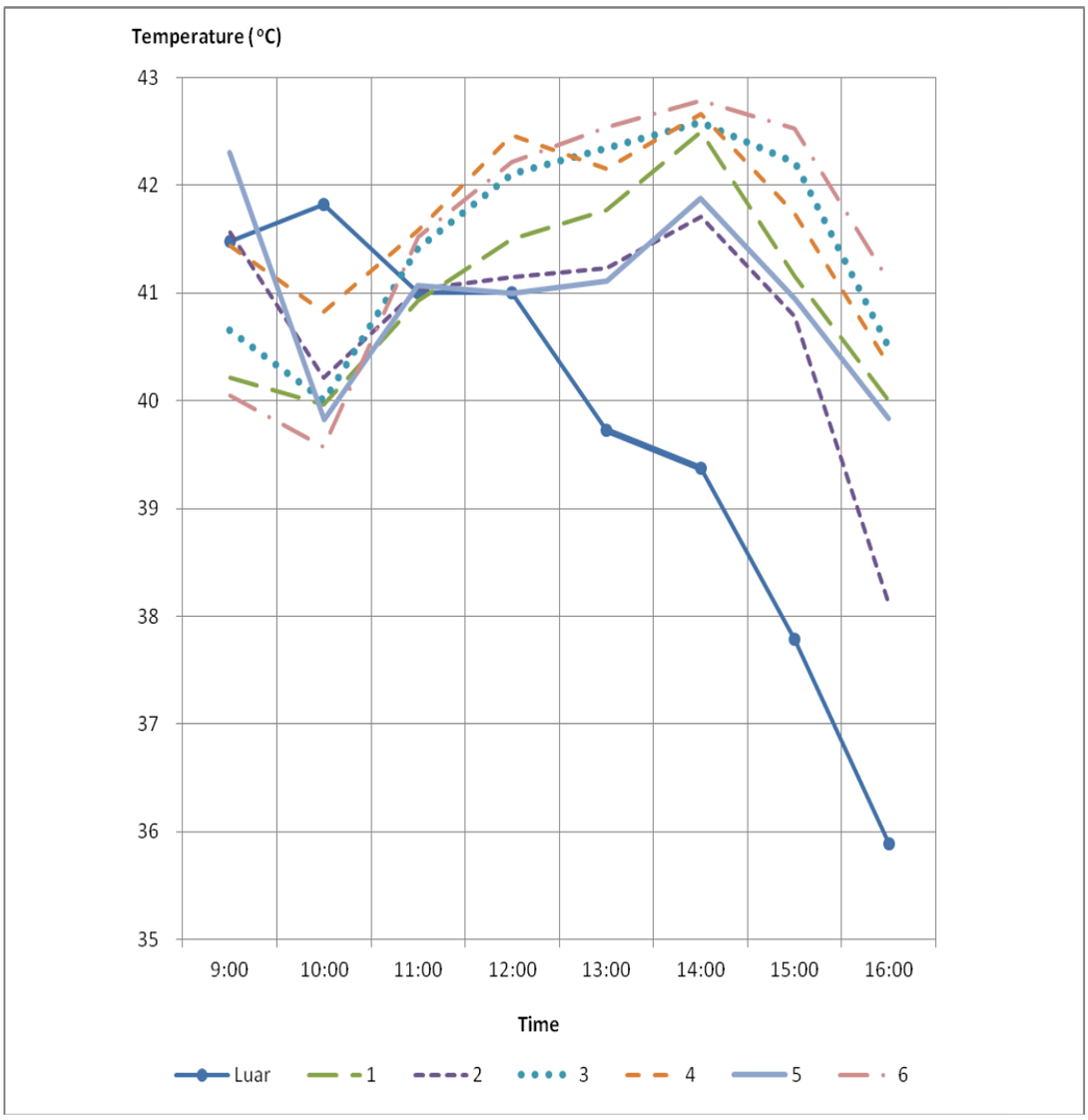
Then the data of room temperature in consolidated into a single graph as follows:



Description : Outside
1 = Window type-1: Clear Glass (3 mm) + Water (3 mm) + Clear Glass (3 mm)
2 = Window type-2: Clear Glass (3 mm) + Water (5 mm) + Clear Glass (3 mm)
3 = Window type-3: Clear Glass (3 mm) + Water (7 mm) + Clear Glass (3 mm)
4 = Window type-4: Clear Glass (5 mm) + Water (3 mm) + Clear Glass (5 mm)
5 = Window type-5: Clear Glass (5 mm) + Water (5 mm) + Clear Glass (5 mm)
6 = Window type-6: Clear Glass (5 mm) + Water (7 mm) + Clear Glass (5 mm)

Graph 1. Consolidation temperature of each type of mockups on average every one hour

From the data of observations, it can be seen that every room has a chart pattern that is relatively the same temperature. At 9:00 AM and 10:00 AM, all the "*water-filled window*" construction can lower the temperature in the room so that the room temperature is lower than the outside temperature. This is because the water in any type of mock-up absorbs most of the heat penetrating into the room, so that the propagation of heat from the sunlight is absorbed by the water causing the temperature in the room to keep stagnant.

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After 11:00 AM on any type of scale model the temperature inside the room is higer than the temperature outside. It can be caused by several factors, such as sudden changes in outside temperature so that the difference in the temperature becomes larges, the accumulation of heat in the room as well as the decline in the ability of "*water-filled window*" in lowering the temperature in the room because the water "*water-filled window*" has reached saturation point. The extreme differences between indoor and outside temperatures can be caused by sudden weather changes, such as changes from hot to "cloudy" or at sunset when the temperatures gradually drops.

Other factors, such as trapped heat in the room and the accumulation of heat in the water can also cause the temperature in the room to be higher than the outdoor temperature. Both of these can cause the water to reach saturation point calorific quickly so that water loses its ability to lower the temperature of the room. Each day, the water will still contain heat energy despite having heat release in the evening. This heat will accumulate in the water and eventually make the time it takes the water to reach the saturation point calorific becomes shorter (the water will quickly saturate to absorb heat). When the temperature in the room is high, the heat of the room will be conducted toward the water, making the water not only absorbs heat conduction from outside the room, but also from inside the room.

Another cause is the absence of ventilation on any type of mockups and mockups walls are made of softboard that make it difficult for the heat in the mockup rooms to get out of the room, so that when the outside temperature drops, the temperature in the room is more difficult and slower to decrease than the outdoor temperature.

On all glass window with water thickness of 3 mm, which are type-1 and type-4, the water will very easily reach saturation point heat/calorific or the point where the water has absorbed heat equal to the calorific value of the saturation point, it is based on the mass of water that is small, the smaller the mass, the less the number of molecules of water to be heated, making the amount of the incoming heat will not be absorbed by the water molecules perfectly because the absorption of heat will be concentrated only on the number of molecules that is very small. However, in the afternoon the water on "*water-filled window*" of this type can easily release the heat it contains because of the small thickness of the water and also the amount of heat that will be released, it is based on the heat of the water saturation point which is small.

At all "*water-filled window*" construction with water thickness of 5 mm in window type-2, and type-5, the water will be difficult to reach the saturation point calorific, this is because the mass of the water is larger, thus the water saturation point on this type of glass becomes larger. The "*water-filled window*" construction with water thickness of 3 mm in window type-1 and type-4, water thickness of 5 mm in window type-2 and type-5, also will decrease in the afternoon heat. However, because of the thickness and the amount of heat that will be released by 5 mm thick of water is more than 3 mm thick of water, then the 5 mm thick of water requires longer time to remove heat when compared with 3 mm thick of water. Therefore, the morning heat that remains in 5 mm thick of water will be more than 3 mm thick of water.

Seen from the discussion above, there are two types of "*water-filled window*"construction that is effective in lowering the temperature in the room when tested with sunlight heat "*water-filled window*" construction in window type-2 and "*water-filled window*" construction in window type-5. But because of the thickness of the "*water-filled window*" construction in window type-2 with "*water-filled window*" type-5 are different, then the effect of lowering the temperature in the room also will not be the same.

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In the "*water-filled window*" construction in window type-2, with a total thickness between the glass, water and glass are 11 mm thick, the heat from the room will be released faster than the "*water-filled window*" construction in window type-5, with a total thickness of 15 mm. This is because the heat will travel a shorter distance in the "*water-filled window*" construction in window type-2 compared to "*water-filled window*" construction in window type-5. Therefore, the temperature in the room at the "*water-filled window*" construction in window type-5 will be higher than the "*water-filled window*" construction in window type-2.

At all "*water-filled window*" construction with water thickness of 7 mm in window type-3 and type-6, the water will be more difficult to reach the saturation point calorific. This is because the heat from the saturation point of 7 mm thick of water is very large, if compared to the mass of 3 mm and 5 mm thick of water. As well as the characteristics of water 3 mm and 5 mm, it also releases heat in the afternoon. However, because the water has a great thickness, the heat will be more difficult to come of the 7 mm thick of water. It will take longer time to release the heat.

Thus, the amount of heat that must be released by 7 mm thick of water to return to the ideal temperature or room temperature (± 30 °C) will be longer than the thickness of the by 5 mm and 3mm thick of water in line with water thickness, because the amount of heat is proportional to mass, then the smaller the mass of the water, the smaller the heat that must be released. The more the amount of heat that must be released by water, the more time it takes the water to return to the ideal temperature. Therefore, the greatest accumulation of heat is contained by the water with a thickness of 7 mm.

Seen from the above discussion, it can be concluded that all the water thickness (3 mm, 5 mm, 7 mm) will experience a situation in which heat will accumulate in the water so that the maximum power of the water in lowering the temperature in the room will decrease (this occurs because the additional heat that will be accepted by the water each day is smaller). Because the larges heat accumulation sequence occurs at 7 mm, then the water can quickly reach saturation point when compared with 5 mm and 3 mm thick of water (this fact can be proved at 02.00 PM until 04.00 PM where all the rooms that 7 mm water have temperature above the other rooms).

The water of 3 mm thick has a small heat saturation point, which means the water could receive less heat from outside. However, the water can easily release the heat at night because of its small thickness and also the maximum amount of heat that will be released is less than the thickness of 5 mm and 7 mm water thickness (if 3 mm, 5 mm, and 7 mm water are heated together and the three are equally reach saturation point, then 3 mm water will released heat more easily than 5 mm water. Similarly, the 5 mm water thick it will be easier to release heat when compared to 7 mm water thickness. This means that heat that will be released by each of the water depends on the saturation point of each glass. Due to the condition that the three reach a saturation point of heat, the heat in the water 3 mm is smaller than 5 mm, and 5 mm is smaller than 7 mm).

While the 5 mm water had a large heat saturation point, it means the water can receive a lot of heat from the outside. Effectiveness in releasing heat at night is between 3 mm of water and 7 mm. While the water at 7 mm clear glass type has a large heat saturation point, which means the water can receive so much heat from outside. However, the effectiveness of water in releasing heat at night is very low (about 3,500 Joules reduced from 7 mm of water after a period of one night).

From the above observations can also be seen windows of "*water-filled window*" able to withstand the rising heat for approximately one hour in the morning between 09.00 AM to 10.00 AM and less than two hours in the afternoon between 02.00 PM to 04:00 PM,

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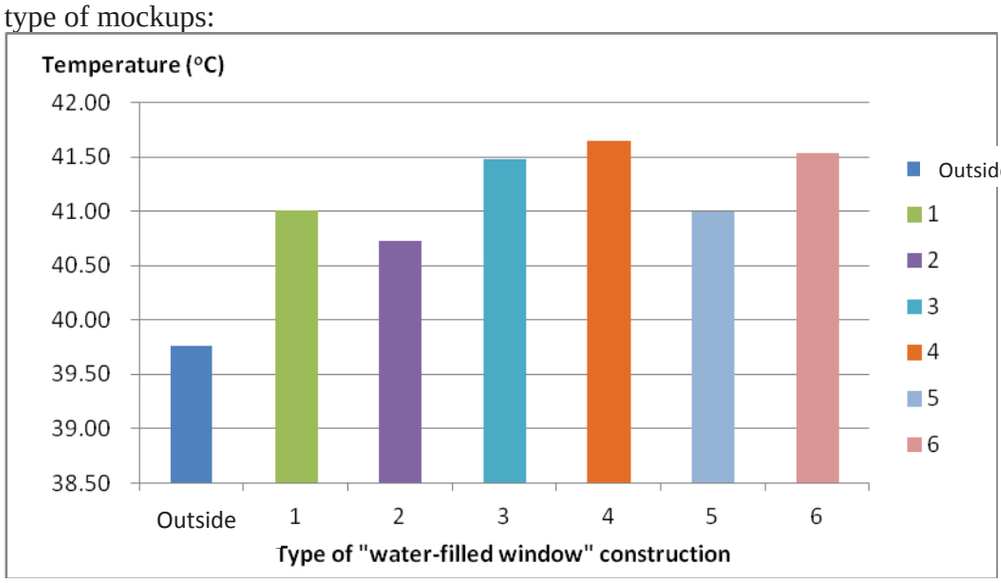
so it can be concluded that the use of air conditioning can be reduced for more than one hour in the morning from 09:00 until 10:00. It will be very helpful for not turning on the AC during these hours because the windows of "*water-filled window*" are able to withstand the heat propagation from the sunlight. The savings that can be done is as much as one hour of use of AC for seven hours of work per day or approximately 14.28 %.

Here is the consolidation of data of the average temperature each day from each type of mockups:



Description :
1 = Window type-1: Clear Glass (3 mm) + Water (3 mm) + Clear Glass (3 mm)
2 = Window type-2: Clear Glass (3 mm) + Water (5 mm) + Clear Glass (3 mm)
3 = Window type-3: Clear Glass (3 mm) + Water (7 mm) + Clear Glass (3 mm)
4 = Window type-4: Clear Glass (5 mm) + Water (3 mm) + Clear Glass (5 mm)
5 = Window type-5: Clear Glass (5 mm) + Water (5 mm) + Clear Glass (5 mm)
6 = Window type-6: Clear Glass (5 mm) + Water (7 mm) + Clear Glass (5 mm)

Graph 2. Average temperature each day from each type of "water-filled window" construction

From the above data it can be proven that the "*water-filled window*" construction of type-2 is 3 mm glass with a thickness of 5 mm water shows the average temperature which is pretty good and also "*water-filled window*" construction at type-5 is glass with 5 mm thick and 5 mm of water. This is the type of "*water-filled window*" construction with a thickness of 5 mm of water. It is also in accordance with Figure 2, where the temperature in the room with the "*water-filled window*" construction containing 5 mm of water has a lower graphics when compared to "*water-filled window*" construction that contains water 3 mm and 7 mm.

CONCLUSION

In observations on mockups placed on the home and exposed to direct sunlight facing east, it can be concluded that the "*water-filled window*" construction with a clear glass thickness of 3 mm, 5 mm water and 3 mm clear glass (window type-2) shows the best result among the other "*water-filled window*" construction, to maximize temperature decrease when tested using a heat from the sunlight. This is because the "*water-filled window*" construction in window type-2, has the ability to absorb heat optimally, and the ability of releasing heat optimally. However, when compared with the "*water-filled*

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window" construction in window type-5, "*water-filled window*" construction in window type-2 will be faster in releasing the heat outside because of its thickness.

This will greatly help to reduce the consumption of AC (Air Conditioner) for one hour, which is at 09.00 AM to 10.00 AM, as the windows of "*water-filled window*" construction will able to withstand the heat propagation from sunlight, in order to get energy savings of 14.28 % every day.

SUGGESTIONS

We suggest that "*water-filled window*" construction can be used in buildings, in order to minimize the use of air conditioning during the one hour time at 09.00 AM to 10.00 AM with window type-2 (3mm clear glass+5mm water+3mm clear glass), in order to get an energy saving of approximately 14.28% to handle the energy crisis that occurs today.

We also suggest that the study on "*water-filled window*" construction can next use the water that can be replaced periodically, so that the water will not quickly reach saturation point calorific, to obtain optimal results in lowering the indoor temperature.

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