Optimizing high solar reflective paint to reduce heat gain in building

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ABSTRACT

This paper reports the developing the optimal paint formula (Beger Cool Ultra Violet Shield) with color pigments to reduce the heat transfers and minimize the cooling energy consumption of a small building coated. The experimental result shows the different of heat performance and energy consumption of two building, which are coated with conventional paints (colors), and coated with High Solar Reflective Paint (Beger Cool Ultra Violet Shield). In the experimental setting up, the color was applied on the envelop surface of building and using two shades of color namely white and white grey color, 9 hours (08.00 -17.00 in local time) for 9 days was set up, totally 18 days. It was found that the small building that coated with high Solar Reflective Paint (Beger Cool Ultra Violet Shield) has less electric energy consumption due to it can reflect the sun light or infrared ray well. It can help reducing the transfer of heat into the building and can reduce the energy loss in cooling the building. Those cause to low in surface temperature of envelop (roof and wall) and room temperature about 3-4^{o}C when comparing with conventional color coated. Beger cool have mainly a composition of reflectivity and refractivity pigment such as: Titanium dioxide, IR reflective and microsphere ceramic. Thus, at building scale, the use of cool colored coatings with increased solar reflectance and refractive can improve building comfort and reduce cooling energy use, and at city city-scale it can contribute to the reduction of the air temperature due to the heat-transfer phenomena and therefore improve outdoor thermal comfort and reduce the heat-island effect.

Keywords: *Beger cool ultar violet shield, high solar reflective paint, energy consumption, heat performance*

1. Introduction

Heat Islands contribute to global warming and affect human health and although urban heat islands are distinctly different from the phenomenon of climate change [1-3]. On the one hand, there are physical characteristics of the actual households and the electric devices they handle, mainly the air conditioning consumed. Mitigation of the heat island effect can be achieved by the use of cool materials. Cool materials are new complex inorganic color pigments that exhibit dark color in the visible spectrum and high reflectance in the near infrared portion of the electromagnetic spectrum. The new pigments increase the near infrared reflectance of exterior paints, thereby dropping the surface temperatures (reducing heat gain) of roofs and walls, which, in turn, reduce the cooling-energy demand of the building. From the previous study, at present there are many researches and development about the energy saving technology by coating the surface of materials or buildings with the insulators. When the small building was coated by the heat insulated paint that has the ceramic atom as a main composition [4], the building coating with this paint can save the energy consumption of air condition system because it can reduce the heat energy transferred through the building and the load of air conditioner. Moreover, the heat-insulated paint can reduce the heat absorption and can reflect sunlight and infrared ray [5]. The temperature on the surface is quite low when comparing with the materials coated with natural paints. Cool colored paint formulations produced significantly higher NIR reflectance than conventional paints of similar colors, and that the surface temperatures were more than 10^{o}C lower than those of conventional paints when exposed to infrared radiation [6]. From the study of previous researches, we found that if we use the materials with insulation property, has low heat absorption, can reflect the sun light or infrared ray well and has the hollow shape as the additive in the paint, we should have the paint that can distribute and reflect the heat well and if we use it to paint on the roof and walls of the building, we expect that it can help reducing the transfer of heat into the building and can reduce the energy loss in cooling the building. Therefore, the objective of this research will focus on developing the optimal paint formula (Beger Cool Ultra Violet Shield) with color pigments to reduce the heat transfers and minimize the cooling energy consumption of a small building coated. The test result will show the different of heat performance and energy consumption of two building, which are coated with conventional paints (colors), and coated with High Solar Reflective Paint (Beger Cool Ultra Violet Shield).

2. Methodology

The prototype coating color, the High Solar Reflective Paint (Beger cool Ultra Violet Shield), was tested to compare with conventional coating colors, as shown in Fig. 1. The colors were applied on the small buildings (size 4 m. x 4 m. x 2 m) , the gypsum models represent to general buildings, shown in Fig. 2

	Beger Cool UV Shield	**Conventional Color**
White Color		
White Grey Color		

Figure 1 High Solar Reflective Paint (Beger cool Ultra Violet Shield) prototype and conventional color.

Figure 2 Small buildings coated with different paint system

Heat performance measurement is purpose within 3 cases, the building without coating, with conventional coating color and with high solar reflective paint (Beger Cool Ultra Violet Shield). In each case, the color was applied on the outer walls and using two shades of color namely white and white grey color (except the first case). The heat performance, the effect from the outside heat load which receives from solar radiation through the buildings to the air conditioner in each buildings was investigated (be not interested in inside heat load). When the walls and roofs receive solar radiation, the temperature difference between inside and outside are produced that cause of the heat transfers to inside buildings. From this result, air conditioner load was built. Thus, the important parameter of this research is the temperature both inside and outside buildings in order to determine the heat load that transfers through inside buildings. Measurement temperature within building is carried out using a data logger with an accuracy of ± 1 ^{o}C connected to 1 mm-diameter, type-K thermocouples cable that calibrated with ASTME 220-07a by comparison with reference thermometer.

Moreover, other measuring factors of this experiment are ambient temperature, relative humidity, air velocity and electrical consumption of air conditioner. For each color shade, 9 hours (08:00 -17:00 in local times) for 9 days was set up, totally 18 days. Thus, it must be acquired the temperature from every sides of the building at the same time. 7 positions were installed to measure consisted of inside temperature, both inside and outside surface temperature in the North and East direction, and the ceiling surface temperature of inside and outside together. So, Fig. 3 and 4 represent a difference of temperature measuring positions. As aforementioned, these are the parameters that identify the heat transfers through buildings and also can be used to reflect and scatter the solar heat energy.

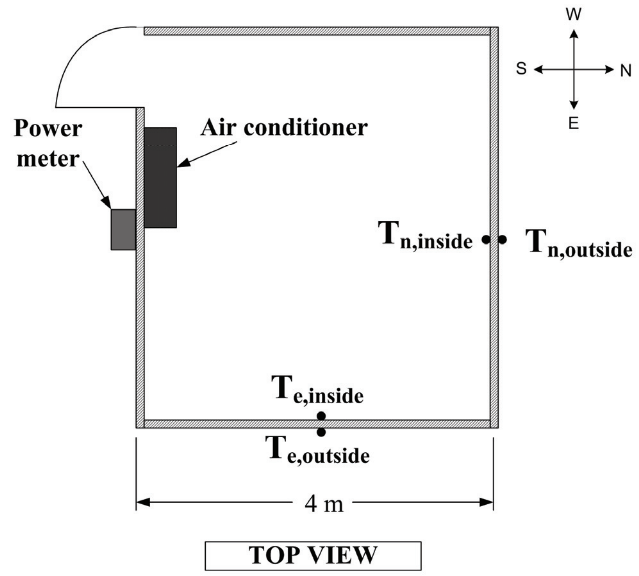


Figure 3 The measuring positions from top view

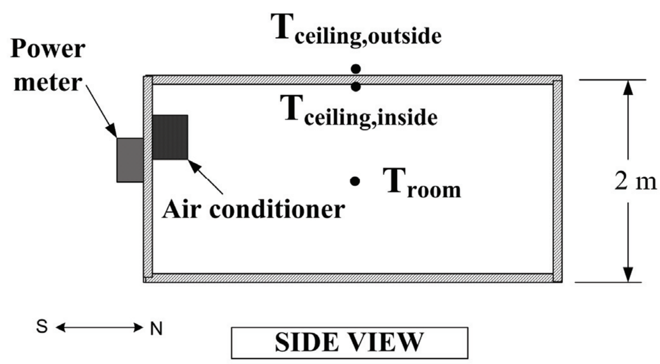


Figure 4 The measuring positions from side view

2.1 The composition of the Beger Cool Ultra Violet Shield

The composition of the Beger Cool Ultra Violet Shield shows in table 1. The reflectivity and refractivity of color can consider from the percentile of pigment category. The Titanium Dioxide (TiO_2) is used to opacify paint films by diffusely reflecting light. White pigment scatters or bends light strongly and causes this reflection. All visible light will strike the white pigment and be reflected, thus the film will appear opaque, white and bright. Infrared reflective pigments have solar reflectance values higher than those of standard coatings. Microsphere ceramic improve the thermal resistance of those materials.

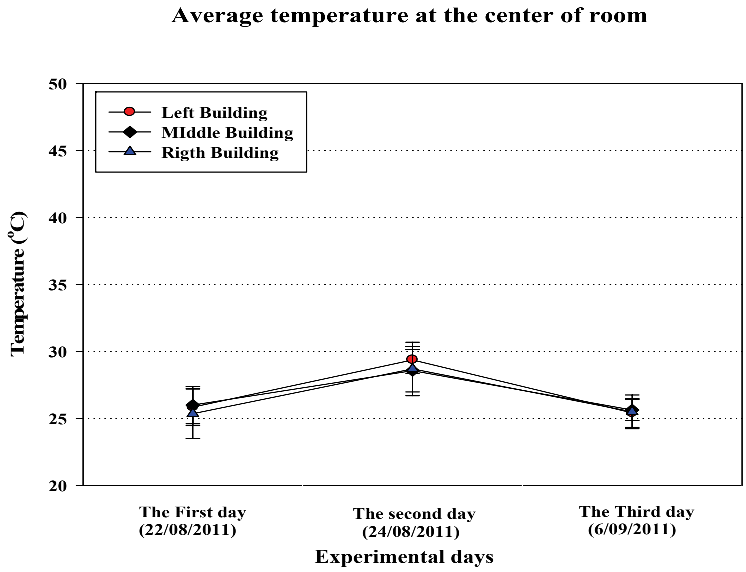
Table 1 show the composition of the Beger Cool Ultra Violet Shield

No.	Category	Chemical	%
1	Binder	Pure Acrylic Latex	35-45
2	Additive	Silicone, UV Absorber, Biocide	2-4
3	Pigment	Titanium Dioxide	18-22
4	Pigment	IR Pigment	1-5
5	Pigment	Microsphere Ceramic	1-5
6	Filler	Extender	5-10
7	Solvent	Water	15-25

3. Result and discussion

The results are divided into 4 parts; 1) the effect of building location on envelop surface and of room temperature (Based case), 2) and 3) the different of heat performance and energy consumption of two building, which are coated with conventional paints (colors), and coated with High Solar Reflective Paint (Beger Cool Ultra Violet Shield). These cases are used the two shades of colors namely white and white grey color, 4) the effect of color shade which compares the energy consumption during white and white grey color cases. These results are as follows:

3.1 The effect of building location on roof surface and of room temperature (Based case)



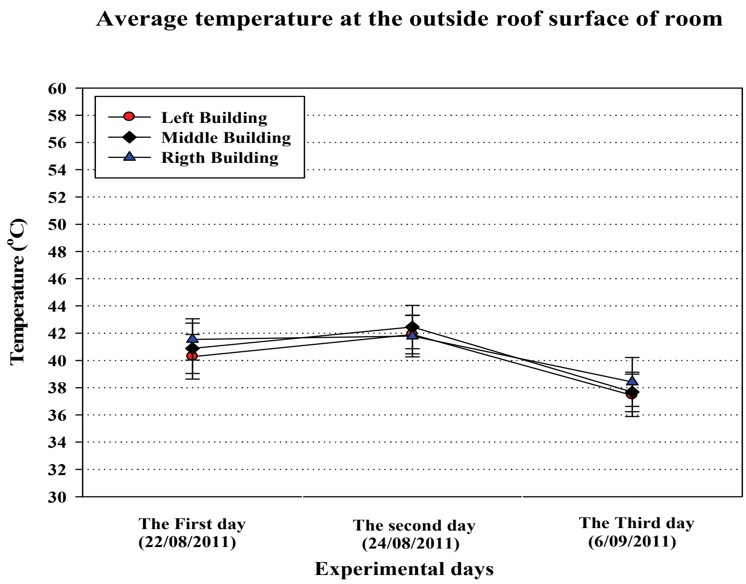


Figure 5 the effect of building location on roof surface and of room temperature (Based case).

Although the three small buildings are built in same area but the physical environment such as solar direction and convection velocity are not the same. Therefore, it is important to make sure that the physical values of each building location of three small buildings are not significant to experimental result. In experiment, the three small buildings are not coated color on envelop surface of small building. The results of the temperature are presented in Fig. 5. It shows that the building location is not effect on the roof surface and room temperature of small buildings. The temperature of all surfaces is nearly equal in every experimental day. These show that three small buildings have got a nearby thermal load and convection velocity transfer.

3.2 Envelop surface (roof and wall) and room temperature of small building coated with High Solar Reflective Paint, conventional color and uncoated

The envelop surface and room temperature, as shown in Fig. 7, are compared only the maximum of saving energy percentile of each color shade (white and white grey color) because it observe obviously in surface temperature different. When considering the room temperature comparison of buildings which the High Solar Reflective Paint, conventional paint coating and uncoated, as shown in Fig. 7(e-f), found that the room temperature of the coated building, both white and white grey color case, is less than another. The average temperature of the heat solar reflective paint coated building is 24.8 ^{o}C, while the conventional paint coated building temperature is 25.9 ^{o}C. Moreover, when compare with the uncoated building found that the uncoated building has the highest temperature, 26.8 ^{o}C.

Fig. 7(a-d) are surface temperature comparison of each wall of the buildings with the High Solar Reflective Paint, conventional paint coating and uncoated. The High Solar Reflective Paint coated building is a little less wall surface temperature than the conventional paint coated building. Especially, the roof surface temperature of the High Solar Reflective Paint coating building is less than the conventional paint coating building 2-4 ^{o}C. When compare with the uncoated building, the wall surface temperature of the uncoated is higher than the High Solar Reflective Paint coating building. The highest temperatures of the roof during 11 am to 2 pm are about 45-47 ^{o}C, more than the temperature of heat insulated coating building about 5-7 ^{o}C. At the eastern wall of building, the highest temperatures are 42-43 ^{o}C in the morning, more than the temperature of heat insulated coating building about 10 ^{o}C. This result is caused by the uncoated building has low sunlight reflect performance, so, the almost heat energy from the sunlight can pass through the inside. The coating with the higher values of solar reflectance demonstrated the lower surface temperature. We can therefore conclude that the main factor affecting the thermal performance of samples during the day is their solar reflectance. The High Solar Reflective Paint coated building can reflect about 69-73% of sunlight energy, as shows in Fig. 6, when it incidents into the building, as well emit the heat. With these reasons, the average room and roof surface temperatures, both inside and outside, of the coated building is less than the conventional paint coated and uncoated.

Another reason, The Beger cool have mainly a composition of reflectivity and refractivity pigment such as: Titanium dioxide, IR reflective and microsphere ceramic. Thus, at building scale, the use of cool colored coatings with increased solar reflectance and refractive can improve building comfort and reduce cooling energy use, and at city city-scale it can contribute to the reduction of the air temperature due to the heat-transfer phenomena and therefore improve outdoor thermal comfort and reduce the heat-island effect.

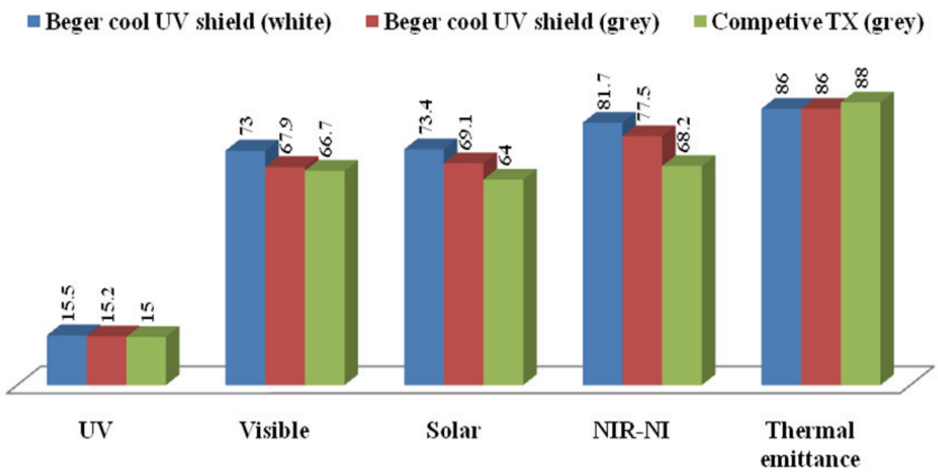


Figure 6 The percentile of thermal reflectant and emittance of color

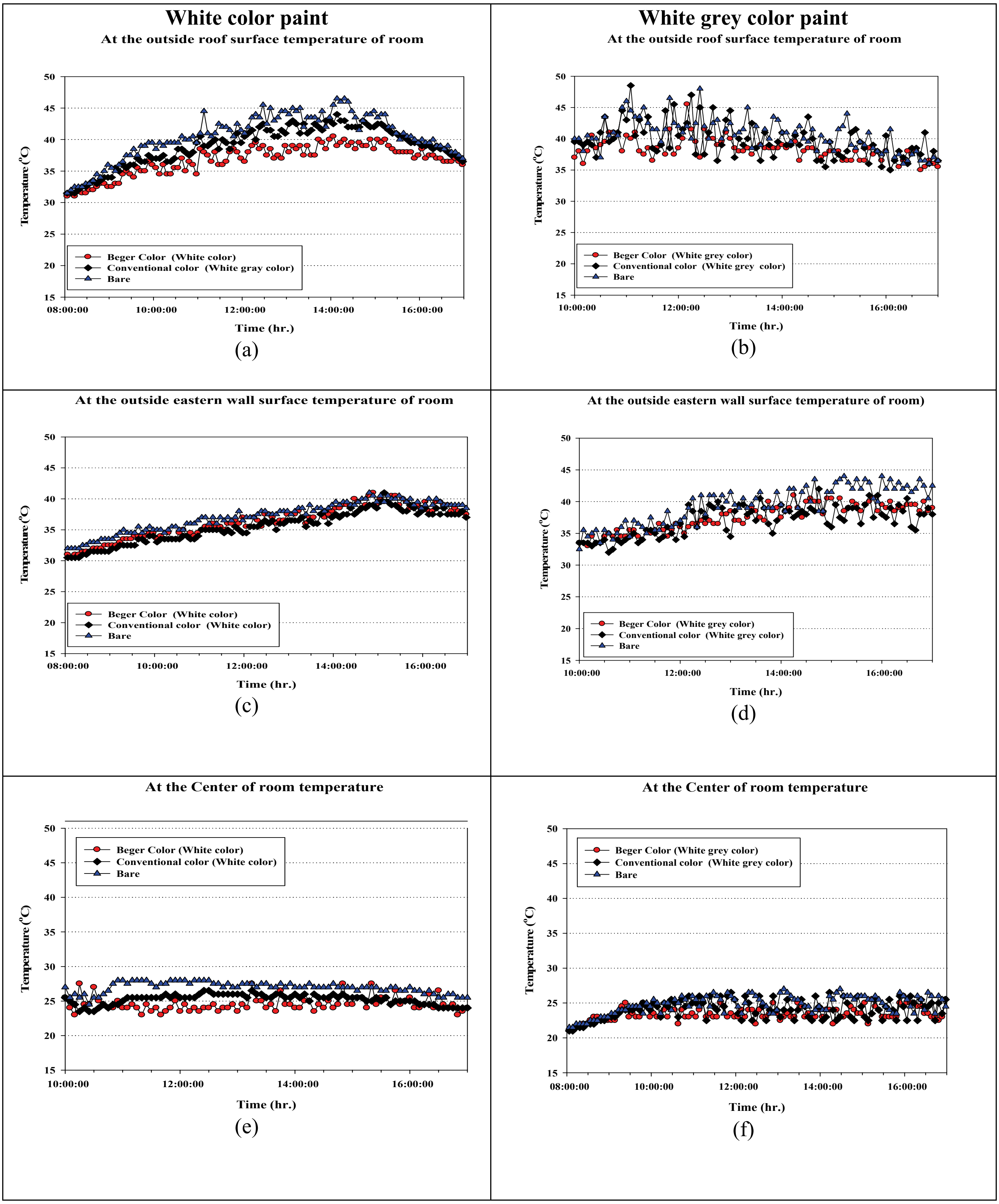


Figure 7(a-f) comparing envelop surface (roof and wall) and room temperature of small building coated with High Solar Reflective Paint, conventional color and uncoated.

3.3 The percentile of saving energy of small building coated with white and white grey color.

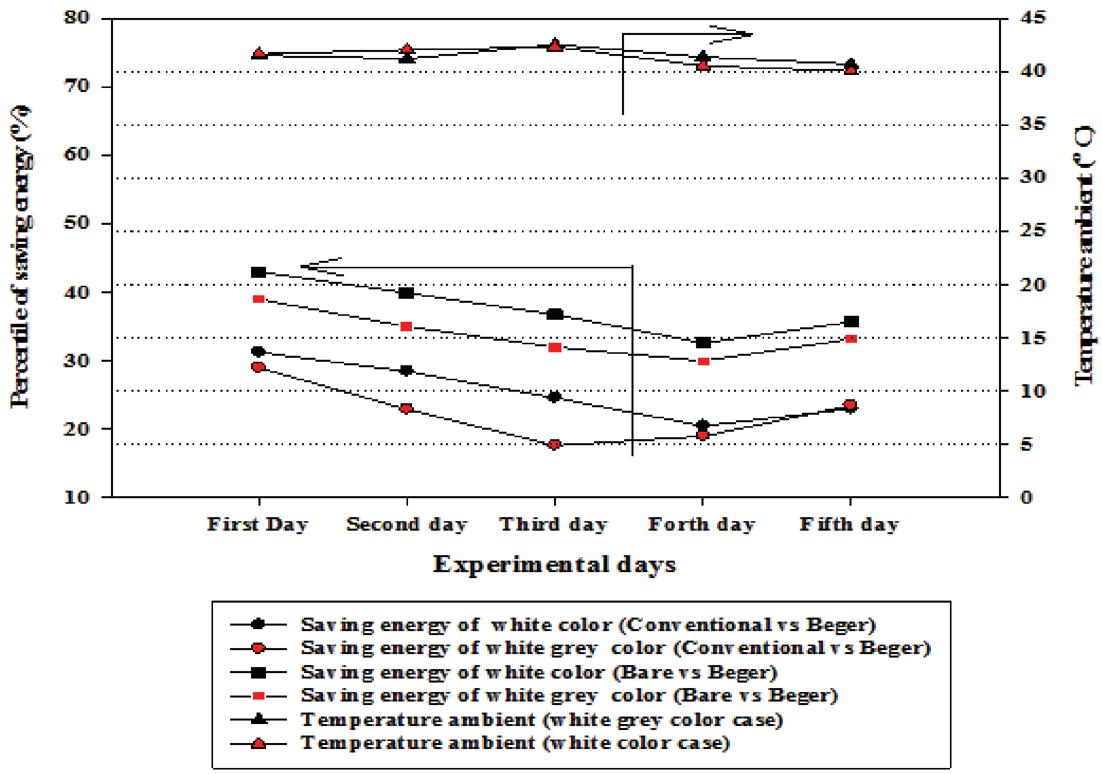


Figure 8 the comparing percentile of saving energy of small building coated with white and white grey color**.**

The percentile of saving energy of small building can be calculated from

$$\frac{Energy_{consume\_Conventional} - Energy_{consume\_Beger}}{Energy_{consume\_conventional}} \times 100 \text{ ; \%}$$

where $Energy_{consume\_beger}$ is energy consumption of the high solar reflective paint (Beger Cool Ultra Violet Shield) coated building, kW-h and $Energy_{consume\_conventional}$ is energy consumption of the conventional paint coated building, kW-h,

The electric energy consumptions of building with the High Solar Reflective Paint coating are compared with the conventional paint coated (white and white grey color shade) and uncoated building. These results are compared from experimental day that have a same temperature ambient from all operating condition, as shown in Fig. 8. The High Solar Reflective Paint coating building obviously uses the electric energy less than the conventional coated and uncoated building. The electric consumption is lower than another coated building because of high sunlight reflecting performance. The lower heat energy that transfers to the building causes the lower load of the air conditioner. When comparing the saving energy during small building coated with white and white grey color found that the percentile of saving energy of small building which coated with white color has a higher value than white grey color in all condition cases because of high efficiency in reflect the solar ray. White high Solar Reflective Paint coated building can save the electric energy range 25-30% of the conventional paint coated building consumption and range 35-40% of the uncoated building consumption. For the white grey, the high Solar Reflective paint coated building can save the electric energy range 19-30% of the conventional paint coated building consumption and range 30-38% of the uncoated building consumption.

Therefore, we can conclude that the small building that coated with high Solar Reflective Paint (Beger cool Ultra Violet Shield) has less electric energy consumption due to it can reflect the sun light or infrared ray well. It can help reducing the transfer of heat into the building and can reduce the energy loss in cooling the building. Those cause to low in surface temperature of envelop (roof and wall) and room temperature about 3-4^{o}C when comparing with conventional color coated.

4. Conclusion

In an effort to contribute to the mitigation of the heat island effect, which is becoming increasingly intense in urban areas, and at the same time not to compromise on the aesthetics of a building or other urban structure, Beger cool colored coatings were created, using High Solar Reflective color pigments, and tested in comparison to conventionally pigmented color matched coatings. The result show that the envelop surface and room temperature of the high Solar Reflective Paint, both white and white grey color case, is the least of all. The average temperature of envelop (roof and wall) and room about 3-4^{o}C when comparing with conventional color coated. The energy consumption of the Beger cool building is lower than other building about 5-7% at all experimental condition.

The results of this study indicate significant success in developing cool colored coatings. The use of cool colored coatings is not limited to their direct application on building envelopes and other surfaces of the urban environment; they can also be used to manufacture other cool colored building materials. In the quest of adopting heat island mitigation strategies and energy efficient technologies, it is very important to also enhance the aesthetic appeal of such products.

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