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A REVIEW OF THE ROLE OF FAÇADE MATERIALS IN MITIGATING THE URBAN HEAT ISLAND.

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ABSTRACT

This paper aimed to review the relationship between UHI and vertical urban material properties. Numerous studies showed the impact of vertical density on increasing UHI intensity, especially in the summer. The thermal and radiative properties of vertical surfaces (or façades) are the main factors responsible for an increase in UHI intensity especially in high density areas. Making changes to or using new advanced façade materials is proven to have an impact in mitigating the UHI. This paper first assesses four selected different advanced façade materials; retroreflective materials, cool materials, green façades, phase change materials, in terms of their properties, types and most importantly their UHI mitigation potentials. Secondly the study assesses the current UHI intensity in the city of Alexandria, Egypt using actual air and surface temperature site measurements. This study can be used to increase the awareness of urban planners, designers and decision makers on the importance of the choice of finishing materials not only for their visual aspect but also on their huge impact on the microclimate of the whole city.

KEYWORDS: UHI Mitigation, Microclimate, Building Façade, Finishing Materials, Material Properties.

1. INTRODUCTION

The term "urban heat islands" refers to the difference in temperature between urban environments and its adjacent rural areas[1]. Studies showed that the temperatures of urban areas can be up to 12°C higher than its surrounding rural areas [1]. Heat islands (HI) is the main cause of urbanization, when roads, buildings, and other urban surfaces gain heat during the day, and is gradually released during the evening this causes urban areas to become hotter than surrounding areas. The vertical and horizontal surfaces contribute to the constant heating of large cities around the world. However, little is done to design these surfaces in a way that improves the microclimate. Instead, the building façade usually acts as a component that focuses only on the indoor thermal comfort, while ignoring its tremendous effects on the exterior of the building [2]. The interaction between buildings and their surrounding environment is not limited to the solar radiation heating up the air or the wind field only, materials used for façades has an effect on the radiative behavior of outdoor spaces and the heat stored in walls or transferred between the inside of a building and the outside. The properties of façades determine the external surface temperature of walls, and therefore has an influence on the external air temperature around the façade [3].

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First, this paper will discuss four advanced façade materials and their potential in mitigating the UHI when applied to building façades in a high-density urban area like most urban areas in Alexandria, Egypt. Secondly, the paper assesses the UHI situation in Alexandria using actual temperature site measurements.

2. LITERATURE REVIEW

2.1 URBAN SURFACES AND UHI

There are two types of densities that have an effect on the urban temperature which are, ‘ horizontal density’ and ‘vertical density’. ‘Vertical density’ is the quantity of vertical surfaces or façades in an urban area, which is related to the average building height, the building typology and geometry [4]. An increase in vertical density is found to be related to an increase in UHI intensity especially during the summer. High solar altitudes and intensities mean higher absorption of solar radiation through the day which is released slowly through the night due to reduced values of sky view factor (SVF) in urban canyons. During the summer these are probably the main causes of UHI intensity in the Mediterranean areas. This describes why the UHI intensity in the summer is the highest in urban areas with high values of ‘vertical density’. This is true since these areas have more façade surfaces and therefore these surfaces absorbe solar radiation and causes heat storage during the day [4].

2.2 PROPERTIES OF FAÇADE FINISHING MATERIALS

The surface energy balance (SEB) is the main characteristic necessary for understanding and predicting surface microclimates. [5]. Urban surfaces such as building façades, sidewalks, roofs and roads that are exposed to solar radiations for extended periods of time suffer from extreme heat gain becasue the solar radiations that fall on these surfaces are not reflected back into the atmosphere due to the high urban structure density of these areas. And since vertical surfaces make up most of high density areas understanding their thermal properties is extremely important in finding an appropriate mitigation technique[6]. A regular heat transfer cycle begins by reflection and absorption at canyon surfaces. The quantity of absorbed heat is ultimately radiated as long wave radiation from all urban surfaces including walls, ground and vegetation. After sunset, all canyon surfaces start to release all the absorbed heat by convection and radiation [10]. Therefore, the properties of any material used for building façades has a huge influence on both the air temperature and the thermal comfort, both inside and outside the building [7].

Besides the basic thermal material properties – convection, conduction, transmittance and density, two important basic characteristics that define the radiative properties of a material are solar reflectance (SR) or albedo and thermal emittance (TE). Both properties are ranked on a scale from 0 to 1, where 1 is reflecting 100% of solar radiation (being most reflective) or 100% emission of heat (being most emissive) [8].

1-Solar reflectance (SR): also known as albedo, this property refers to the reflection of solar energy after coming into contact with the surface of the material [9].

2-Thermal emittance (TE): this property refers to the radiant emittance of heat of a specific object in the form of infrared or thermal radiation and relates to how well a surface cools itself. In other words, Emissivity of a material is the ability of the material to radiate out the heat it absorbed [9]

2.3 ADVANCED FAÇADE MATERIALS FOR UHI MITIGATION

Irrespective of the categorization system used, advanced materials are defined as materials (both new and modified existing conventional materials) precisely designed to have new or improved technical properties - thermal or radiative or environmental features compared to conventional materials used to perform the same functions [10]. This section will discuss the properties of four types of advanced façade materials which are phase change material, cool material, retroreflective materials and green facades.

2.3.1 PHASE CHANGE MATERIALS (PCM)

Phase change materials (PCMs) are innovative environmental friendly passive technologies that can be incorporated in the building fabric to improve heat exchange [11]. These materials have the ability to store large amounts of thermal energy with minimal temperature change. The main advantage of using PCMs is that a very thin layer of PCM can store a large amount of heat. These materials can help in regulating the temperature within a specific range near their transition temperature. When the ambient temperature rises above the PCMs' melting temperature, the chemical bonds in the material break up causing the material to absorb the additional heat, while its state changes from solid to liquid. Later, once the temperature decreases below the PCMs' freezing temperature, the material releases the energy and, consequently, changes back to the solid-state[11].

Unlike conventional sensible storage materials such as masonry or stone, PCMs store heat in a latent form. Latent heat materials are characterized by having a large energy storage density. The thermal energy transfer happens when a material changes from solid to liquid, or liquid to solid. Heat storage and its recovery occur isothermally, preventing temperature variations. During daytime, the PCM absorbs part of the heat through the melting process and at night, the PCM hardens and releases the stored heat. The resulting effect is a noticeable decrease in daytime surface temperature of the coatings and a reduction of the heat flow from outdoor to indoor space [12]. PCMs can considerably increase the thermal mass of buildings in comparison to conventional building material as shown in (Fig.1) below [13].

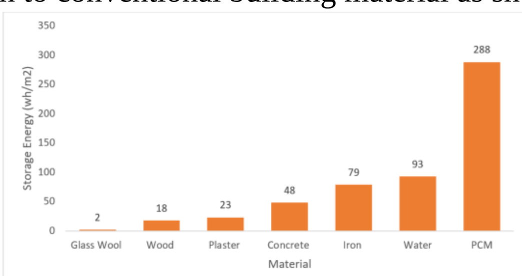


Figure 1. Comparison of the maximum energy storage capacity of 10 mm thickness of different building. Source: [13]

Thermo-physical properties such as melting temperature, latent heat of fusion, thermal conductivity, and density of solid and liquid are the main characteristics of PCMs. When selecting PCMs to be used in buildings, melting temperature must be coordinated with the desired operating temperature like indoor temperature and human comfort temperature range. The heat transfer during fusion or solidification depends on the thermal conductivity of the solid and liquid PCM, thus, high thermal conductivity is beneficial and assists the rate of heat charge and discharge. High specific heat is also needed to provide additional sensible heat, since PCMs change temperature during operation. The density of PCMs is also crucial, the higher the density the less volume the material will occupy. It is also important that the materials melts completely, so that the liquid and solid phases are consistent [14].

2.3.2 COOL MATERIALS

Cool materials stay cool when exposed to solar radiations. Cool materials are known as materials with high solar reflectance value that decrease the solar radiation absorbed compared to conventional building materials and therefore reduces the surface temperature under harsh solar conditions. These materials also have high infrared emittance values that means that they are able to emit the heat gathered to the sky during the night [15]. (Fig. 2) below summarizes the main principles of cool roofing materials.

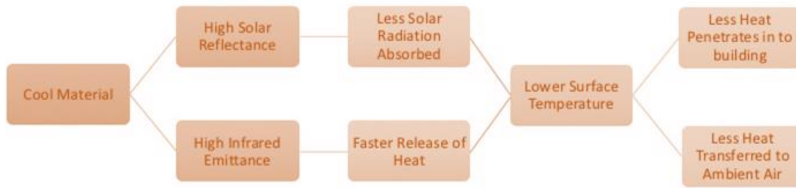


Figure 2. The basic principles of cool materials. Source: Researcher

The application of high albedo surfaces and 'cool' materials -characterized by high solar reflectance and emissivity - are often encouraged as an effective way to mitigate the urban heat island (UHI), to decrease indoor temperatures and therefore reduce cooling loads in warm weather [15].

2.3.3 RETRO-REFLECTIVE MATERIALS

As mentioned previously the solar reflectivity of a building's exterior façade surface is an important factor that affects the UHI intensity within the city. Surfaces covered with diffuse highly reflective (DHR) materials like highly reflective paints such as cool materials can reflect solar radiation to the sky if there are no surrounding higher buildings. However, if there are taller buildings around it, most of the radiation can be reflected to the adjacent buildings and surfaces increasing the UHI phenomenon. In order to overcome this problem when applying DHR materials to building façades, RR materials are a better alternative to DHR materials to mitigate the UHI phenomenon [16].

Unlike DHR coatings of buildings, which produce diffuse reflection, RR can reflect light back along the incident direction shown in (Fig.3) below [17]. Retro reflective materials are made using tiny glass beads which reflect light directly back toward its source, from a much wider angle than reflective material. RR materials haven’t been applied to building envelopes in practice due to their unproven weather resistance. [18]

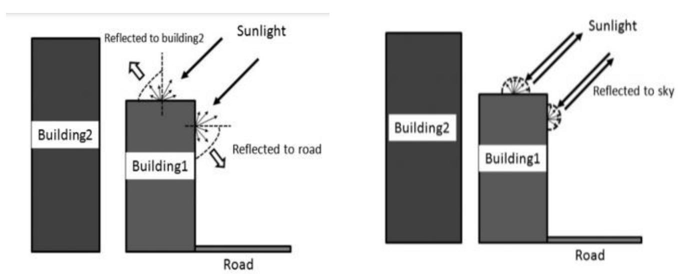


Figure 3. Example of solar radiation reflected by building coatings ; Left: building with diffuse reflection; Right: building with retro reflection. Source:[18]

2.3.4 GREEN FAÇADES

During the summer, wall vegetation can decrease the heat flow entering through the building envelope due to its shading properties and the absorption of radiant energy needed for photosynthesis and thermal energy used in evaporation transpiration processes. At the intersection of surface cooling and vegetation, green façades are a key example of the effectiveness behind integrating multiple mitigation strategies for an optimal solution in certain scenarios. Green façade systems have a large impact in heat reduction when compared to conventional façade materials. Vegetation in the building scale can be applied in two ways either horizontally in the form of green roofs or vertically in the form of green walls or façades [22]. Vegetation on façades protects the wall of direct radiation, this has multiple positive effects including the absorption and reflection of solar radiation, the modification of wind movement and CO2 level adjustment. All mentioned changes create a special climate within the city, which is called Oasis-effect of the urban green spaces. Green façades within the city can also help in creating a better microclimate and mitigating the negative effects of UHI [23].

There are basically two typed of vertical greenery systems from which all others types come under. These are green façades and green walls. A green façade is a system that uses a natural climber plant to run up the side of the building with help from a support function. A green wall, or living wall, is made up of panels which are fixed to a vertical support or the wall structure itself. The panels hold the vegetation from various plants [23]. (Fig.4) shows the difference between green walls and green façades.

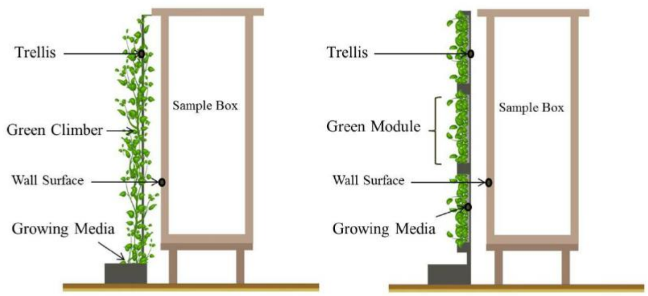


Figure 4. Left: Green façade; Right: Green wall. Source: [23]

Table 1 and Table 2 below show a compilation of an example of the thermal properties of the previously discussed advanced materials. These properties might vary depending on the exact type of material used. These properties were gathered from previous studies that investigated the material's properties.[14] [15] [16] [22]

Table 1. Advanced material Properties. Source: [14] [15] [16]

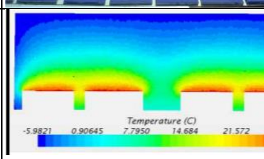
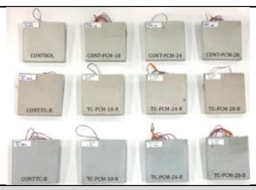
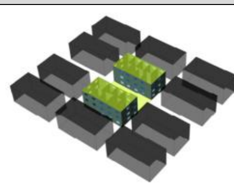
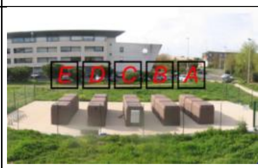
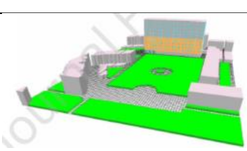
	Thickness (mm)	**Specific heat kJ/(kgK)**	**Conductivity (m2K)/W**	**Density Kg/m3**	**Emissivity**	**Solar Reflectance (Albedo)**
PCM	0.03	2000	0.2	880	0.95	0.9
Cool Materials	0.03	1000	0.001	1050	0.93	0.82
R-R Material	0.03	800	0.002	1000	0.90	0.80

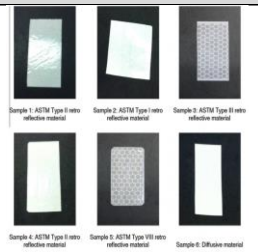
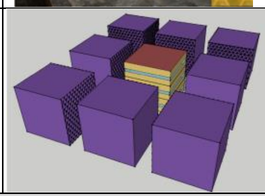
Table2. Green Façade properties. Source [22]

Height of Plant cm	**Substrate Thickness cm**	**Leaf Area Index**	**Leaf Emissivity**	**Leaf Albedo**
0.4	15	1.15	0.3	0.2

In order to better understand the effect of using the four advanced façade finishing materials mentioned previously, and since several researches have discussed their UHI mitigation potentials either by using computer simulation programs or actual experimental setups, A compilation of the UHI mitigation potential of the materials are shown in Table 3 below.

Table 3. Studies showing the four advanced façade materials' UHI mitigation potential. Source: Varies

Reference and Study Location	Study Illustration	Study Brief	Methods		Results of System Performance	
			Experimental	Simulation	Surface Temp Reduction	Outdoor Temp Reduction
		PCM				
[24] Athens, Greece		This study explores the performance of organic PCMs used as latent heat storage materials, for building coatings and urban fabric. The study examined the performance of thirty six different coatings of six different colors of PCMs.	√		Up to 8 ◦C	-
[25] Kang-dong, South Korea		The main aim of this study was to examine the UHI potentials of roofs retrofitted with PCM materials and how compared to conventional roofs they can reduce the UHI phenomenon within a city. The study later used a simulation program to examine the effect of the PCM on reducing the surface temperature of the material as well as the air temperature surrounding it.	√	√	6.8◦C	7.8◦C
[26] Toronto, Canada		The study investigated the effect of using PCM integrated plaster for building façade finishing as a mitigation strategy to control solar and thermal loads over different seasonal conditions.	√		Up to 10◦C	-
		Cool Materials				
[27] Dubai		The research explored the thermal analysis of different façade reflectance values in an urban canyon and their effects on outdoor and indoor comfort conditions. Wall reflectance of 0.43 and 0.95 were tested.		√	-	2.7◦C
[28] France		A scaled model of four street canyons was created in order to give a realistic representation of how cool materials work. The study compared the results of using brown cool paint and conventional brown paint. Later the temperatures of the street canyon with brown cool selective paint façades were compared to the standard brown coating on another street façades, and with an asymmetrical layout.	√		12◦C	-
[29] Greece	________	The study aimed to analyze the impact of large-scale increases in surface albedo on ambient air temperature. A numerical simulations was used for the purpose of the study and two scenarios of modified albedo were studied: a moderate and an extreme increase in albedo.		√	-	2.0◦C
[30] **Italy**		Using a simulation program- Envi-met, this study aimed to investigate the connection between the color used for building façade finishes and its effect on the microclimate and UHI. potential effect on the outdoor microclimate using Envi-met simulations		√	-	1.0°C
[31] Argentina		This study evaluates how reflective materials of the urban envelope modify air temperatures in an urban sector of the metropolitan area of Argentina. The goal is to analyze the effect of this strategy on different locations and urban densities using Envi-met.		√		0.5-0.75 °C

Retro-reflective materials						
[32] Perugia, Italy		UHI mitigation potential of RR materials was evaluated through experimental investigations and analytic evaluations Cool, white, diffusive material compared to white RR materials.	√		3–7 ◦C	-
[33] China		This study experimentally investigates the temperatures of the inner and outer walls of two small-scale building blocks with RR and DR surfaces, respectively. Two blocks stood side by side and were set at an experimental site such that both blocks were sunlit for a half day and were shaded for the other half day.	√		1-3 ◦C	2-4◦C
[34] USA		This study aims to evaluate the thermal and energy performance of urban building networks with applied RR material. Two case studies were modeled and simulated in a dynamic simulation environment for thermal-energy building evaluation.		√	-	0.46◦C
Green Façades						
[35] Sri Lanka		Using a simulation program, Envi-met, the study investigates the outdoor temperature behavior using different green wall ratios in Sri Lanka.		√	-	2.03ºC

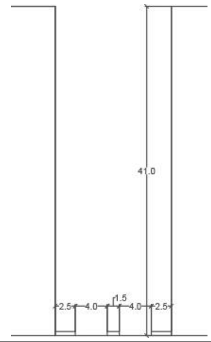
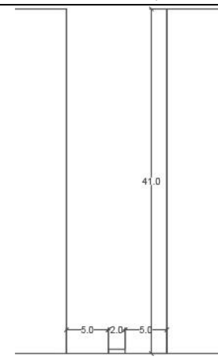
3. METHODOLOGY

3.1 CASE STUDY SELECTION

The case study chosen for the purpose of this research is a new residential complex along the outskirts of Alexandria, Egypt called Bashayer Al Khair. This location was chosen specifically because all residential buildings in this site, unlike most residential areas in Alexandria, have the same construction and finishing materials in addition to all buildings being the same height. This uniformity in materials, geometry and design will help normalize the results taken from the site and it will then be easier to compare to the simulated results. Bashayer Al Khair is located on the outskirt of the city of Alexandria located at Latitude: 31˚09˚42˚N, Longitude 29˚53˚04˚ E.

The selected residential area is considered of medium to high density compared to the other typical residential areas in Alexandria, Egypt. According to the previous literature review, the four main factors that make up the urban canyon are average building height, canyon width, length (from which we can find the W/H ratio of the canyon) and canyon orientation. All these characteristics are gathered in Table 4 above. All buildings in Bashayer AlKhair have the same height with variation in street width depending on whether the building is on a main or secondary street.

Table 4. Case study characteristics. Source: Researcher

	Bldg Height (m)	**Canyon Width (m)**	**W/H Ratio**	**Canyon Orientation**	**Section**	**Real image**
St1	41	14.5	2.8	North		
St2	41	12	3.4	North		

3.2 URBAN SURFACES

As mentioned previously horizontal surfaces can be divided into ground cover and building horizontal surfaces or in this case roofs since the site is free from any shading devices. All streets on site are made from conventional asphalt and the side walks are made from light off white stone paving. one of the three streets has a patch of green are that is in a very poor condition. All streets have no waterbodies. All building roofs are made up of cement tiles. Fig1. below shows the main horizontal surface materials onsite. Vertical surfaces or façades are all identical for all buildings in all streets and are all made up of typical brick and off white and yellow stripped paint finishing material with one meter strip of stone at the bottom. Only buildings with commercial shops have off-white steel doors on the ground level only. (Fig.5) below shows all the materials used in the case study site.

Figure 5. Case study building materials. (A)Commercial building door; (B) Stone; (C) Light colored Plaster; (D) Dark colored plaster. Source: Researcher

3.3 AIR AND SURFACE TEMPERATURE MEASUREMENTS

Air temperatures were taken using a hand held air temperature thermometer. Measurements were taken at the urban canopy layer (UCL) this layer extends from the ground to the building's height since the building façades will have the most effect on this layer. Therefore measurements were taken at 1.5m above ground level in each of the selected measurement points shown in (Fig.6) below. Each measurement took 5 minutes to make sure the measurement was correct therefor each measurement cycle took almost 30 minuets.

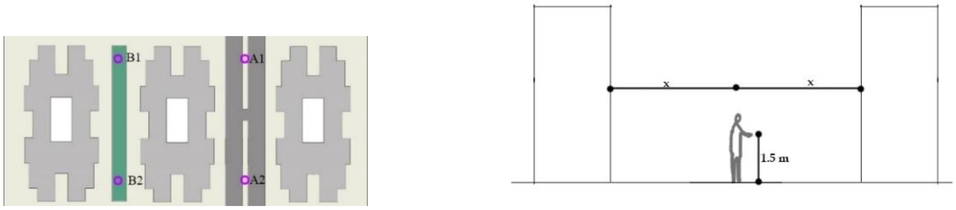


Figure 6. Air temperature measurement points. Source: Researcher

Surface temperature measurements were taken using the hand held infrared thermometer and thermal imaging were taken using the infrared camera. Measurements were taken at two point on the east façade of each street. The east façade was choosen since it's a faced that is not directed to dirrrect solar radiation and thus the surface temperatures will be affected by the abeint air temperature rather than the direct solar radiation. Since each building is made up of three different adjacent façade materials, the surface temperature of each material was taken at each of the points a sample of which is shown in (Fig.7). Measurements were taken approximately 30 cm from each of the building surfaces. Façade surface material measurement points are shown (Fig8) below:

(A) (B) (C) (D)

Figure 7. Sample of the measured Surface temperatures. (A) Façade surface temperature measurement points. (B) Light colored paint; (C) Dark colored paint; (D) Stone. Source: Researcher

A thermal camera was used to provide a visual representation of the difference in temperature between the different façade materials during different times of the day. Thermal images were taken in street 2 on October 16 at three different times of the day to show the heat gain progress of the different façade materials. Thermal images are shown in (Fig.8) below.

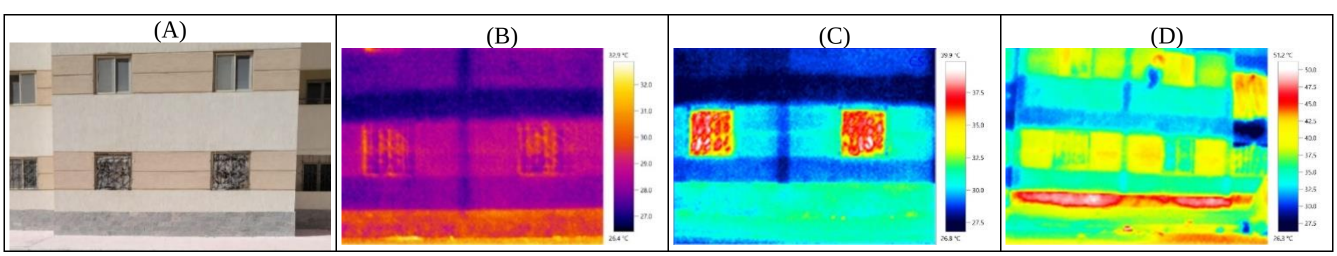


Figure 8. (A) East Façade real image; (B) IR image at 1:25 PM; (C) IR image at 2:25 PM, (D) IR image at 3:31 PM. Reference: Researcher

3.4 RESULTS

Table 5 and (Fig.9) below show how the air temperatures increase as time progresses which is due to the increase insolar radiation. It is clear that measurements taken in street 2 at points B1 and B2 are slightly less than those taken in street 1 at points A1 and A2, this is because street 2 has a lower W-H ratio and thus its surfaces are exposed to less solar radiation compared to street 1.

Table 5. measured air temperature data for the two streets. Source: Researcher

Measurement point	12:30-1:00	1:30-2:00	2:30-3:00
A1	29.9	30.0	32.0
A2	30.3	30.3	32.2
B1	28.9	29.6	31.8
B2	29.6	30.1	31.2

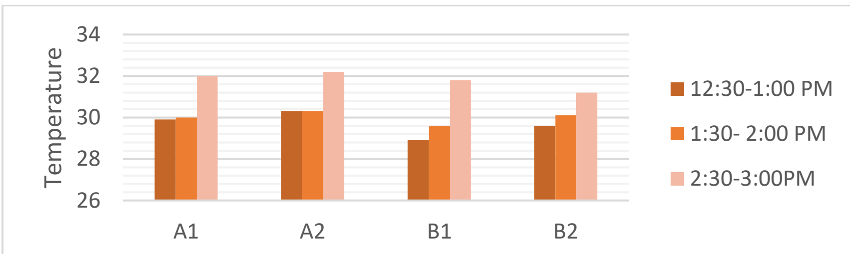


Figure 9. Air temperature comparison graph. Source: Researcher

Both the surface temperature measurements shown in Table 6 and (Fig.10) below and the IR images shown previously clearly show how each of the three different façade materials, light paint, dark paint and basalt stone each gain heat differently over the study period.

Table 6. Surface temperature gathered data. Source: Researcher

	1:00 PM			**2:00 PM**			**3:00 PM**		
Measurement point	**LP Temp**	**DP Temp**	**Stone Temp**	**LP Temp**	**DP Temp**	**Stone Temp**	**LP Temp**	**DP Temp**	**Stone Temp**
A1	29.4	30.5	31.7	34.7	35.6	37.7	44.1	51.0	60.9
A2	30.6	31.5	33.3	35.1	35.8	38.0	44.6	51.2	60.5
B1	28.1	28.7	30.2	31.2	32.2	35.3	45.0	52.5	58.2
B2	29.1	29.5	30.5	33.4	34.3	37.7	43.6	50.2	57.7

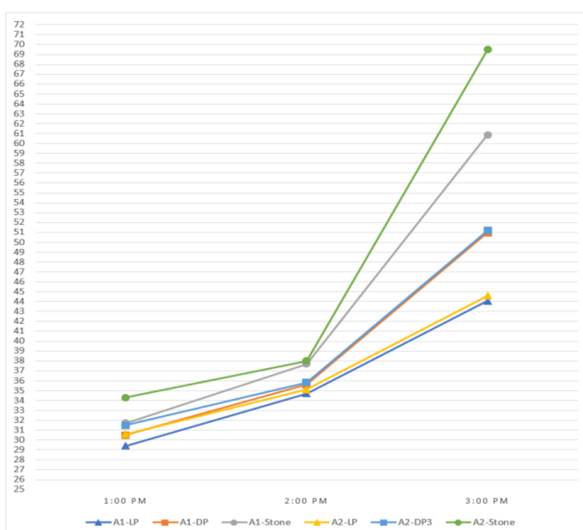


Figure 10. Surface temperature comparison graph. Source: Researcher

During the first measurement cycle at 1 PM the variation in surface temperatures was minimal with a change of 0.5-1 ˚C between the light paint and dark paint and 1-2 ˚C between the dark paint and the stone. As time progresses and thus the solar radiation, the materials start heating up and showing a more diverse change with a difference of up to 7 ˚C between the light paint and dark paint and 9 ˚C between the dark paint and the stone. This difference is due to the different thermal and radiative properties of each material.

3.5 DISCUSSION

This paper reviewed four different advanced façade materials that have UHI mitigation potentials. According to the several gathered studies that tested the effect of using PCM on the UHI phenomenon it was found that PCMs were able to decrease façade surface temperature and the ambient outdoor air temperature by 10◦C and 8◦C respectively which in return will have a tremendouse positive effect on the UHI within a city. Cool materials on the other hand has less impact on the air temperature reduction within a canyon that was up to only 2.7◦C according to the studies gathered. This might be because as mentioned previously the drawback of using cool materials is that when these materials are used in high density areas this can cause surrounding buildings to absorb the reflected radiations and thus cause heat gain within the urban canyon. In order to overcome this drawback the use of retroreflective materials was proposed since according to the gathered data they were able to decrease the air temperature by almost 4 ◦C and the surface temperature by almost 7◦C since RR materials can reflect light back along the incident direction and therefore radiations are not absorbed by surrounding buildings. Finally, green facades were able to decrease air temperatures by up to 4 ◦C according to the gathered studies.
Inorder to better understand the UHI situation in Alexandria, Egypt, this study surveyed a high density residential complex by collecting air temperature and surface temperature data. After reviewing the air temperatures gathered it was clear how the solar radiation has a direct effect on the increase in air temperature since the air temperature in both the study canyons increased as the time progressed. The study also reveals how the different adjacent façade materials showed a great difference in measured surface temperatures, for instance at 3:00 PM there was a temperature difference of up to 7 ˚C between the light paint and dark paint and 9 ˚C between dark paint and stone with the stone temperature reaching a maximum of 60 ˚C. This proves that the change in material thermal and radiative properties can have a tremendous effect on the surface temperature of the material and therefore the UHI within the city.

4. CONCLUSION

The Urban Heat Island (UHI) effect is a common phenomenon caused by increasing urban expansion. UHI happens in the form of increased urban air temperatures compared to adjacent rural areas. Properties of vertical surfaces or building façades have a tremendous effect on the UHI intensity within a dense urban area and thus it was found that using advanced façade materials and systems such as cool materials, retroreflective materials phase change materials and green façades can have a tremendous impact on mitigating the UHI within a city. The research studied four different advanced façade materials in terms of their properties and their UHI mitigation potentials. It was found, according to previous researches, that those materials have a great impact when it comes to both decreasing the surface temperatures of façades and their surrounding air temperatures and thus improve the UHI within a city. In order to assess the extent of the UHI effect in Alexandria, Egypt, air and surface temperature measurements were taken on a specific day. The air temperature measurements showed how the solar radiation has an impact on increasing the outdoor temperatures as time progresses after noon. Studding the different façade materials available on site it was clear how difference in material properties can affect the surface temperatures tremendously and thus affect the surrounding air temperatures. The study concludes that the use of one or more of the discussed advancecd materials will have a positive impact on decreasing the air temperatures within the urban canyons in the city of Alexandria, Egypt and therefore decrease the UHI within the city.

Further Research

This research can further be developed by testing how the discussed advanced materials will act when applied to existing cases in the city of Alexandria, Egypt using either a simulation program and/or actual testing of the materials on scaled models. The study can also be further developed by studying the factors that can affect the selection of these materials to be applied to certain project in an attempt to offer designers and decision makers with all the necessary data and information needed in order to make the optimum decision.

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مراجعه لدور خامات المباني في تقليل الجزر الحرارية

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الملخص:

هدفت هذه الورقة البحثية إلى مراجعة العلاقة بين الجزر الحرارية وخصائص مواد البناء المستخدمة في واجهات المباني. أظهرت العديد من الدراسات تأثير الكثافة الرأسية للمباني على زيادة حدة الجزر الحرارية ، خاصة في فصل الصيف. الخصائص الحرارية والإشعاعية للأسطح الرأسية (أو الواجهات) هي من اهم العوامل الرئيسية المؤثرة في زيادة تاثير الجزر الحرارية خاصة في المناطق المبنية عالية الكثافة. اثبتت الدراسات ان استخدام مواد ذات خصائص معدله يمكن ان يكون لها تاثير ايجابي في تقليل ظاهرة الجزر الحرارية في المدن. يهدف هذا البحث اولا الي تقييم أربع مواد جديدة مختلفة للواجهة ؛ مواد مُتغيّرة الطور (PCM)، والمواد الباردة(Cool materials) ، و المواد عاكسة التبادل (Retro-reflective materials) والواجهات الخضراء (Green Facades) ، من حيث خصائصها ، وأنواعها ,اخيرا قدرتها علي معالجه ظاهرة الجزر الحرارية. ثانيًا ، سيقوم البحث بتقيّم حالة الجزر الحرارية الحالية في مدينة الإسكندرية ، مصر باستخدام قياسات لدرجة حرارة الهواء و الاسطح في الموقع. تهدف هذة هذه الدراسة لزيادة وعي المخططين الحضريين والمصممين وصناع القرار بأهمية اختيار مواد التشطيب ليس فقط من أجل جانبها الجمالي ولكن أيضًا لتأثيرها الضخم على المناخ المحلي للمدينة بأكملها.

الكلمات الداله: الجزر الحرارية, واجهات المباني, مواد التشطيب, خصائص المواد

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