COLORED ROOFS: A SOLUTION TO MITIGATION UHI AND REDUCING URBAN SURFACE HEATING

ZAINAB KHALID

Dept of Architecture, College of Engineering, University of Baghdad/ Baghdad, Iraq

The city is a built-up urban space and multifunctional structures that ensure safety, health and the best shelter for humans. All its built structures had various urban roofs influenced by different climate circumstances. That creates peculiarities and changes within the urban local climate and an increase in the impact of urban heat islands (UHI) with wastage of energy. The research question is less information dealing with the renovation of existing urban roofs using color as a strategy to mitigate the impact of UHI. In order to achieve local urban sustainability; the research focused on solutions using different materials and treatments to reduce urban surface heating emissions. The results showed that the new and old technologies, products, and the materials are complying with the principles of urban sustainability and have the local possibility of reducing urban roof heating, mitigating UHI and creating a sustainable urban environment at a low cost.

Keywords: Urban materials, Reflect radiation, Urban solution, Green roof.

1 INTRODUCTION

The city is an urban built space and multifunctional structures that ensure safety and health; it is the best shelter for humans living (Boukhelkhal and Bourbia 2016, Abaas 2016, Khalid and Abaas 2021a). Urban engineering in cities helps explore thermophysical mechanisms of how urban design modifies heat and thus mitigates heat burdens (Lin et al. 2017, Fathi et al. 2020). We can consider the color of urban roofs as a sustainable feature in contemporary cities; which can be reduced the heat emitted (Premier and Gasparini 2017). The energy emitted from the grey surfaces of concrete roofs increases the air temperature, heat emission and solar energy reflected from surface materials can be addressed during the design process (Lin et al. 2017). The improvement and development of renovation materials and their use in urban areas offer the potential to achieve higher heat reflection while reducing negative climatic impacts (Jandaghian and Berardi 2020). A proportion of the incoming solar radiation is reflected directly into the atmosphere (Lin et al. 2017, Taleghani and Berardi 2018). Solar reflective materials are used to enhance thermal performance, increase radiative properties, and improve the city's ability to mitigate urban heat island effects (Jandaghian and Berardi 2020). New and old technologies, products, and materials are complying with the principles of urban sustainability by providing the cities with the means to adapt to the challenges of contemporary innovation (Abaas 2016, Premier and Gasparini 2017). The adaptions improving the thermal performance include albedo, modifying the roughness and thermal properties of the exciting built surfaces, and changing the surfaces from soft to porous, vegetated, or gravel (Lin et al. 2017, Fathi et al. 2020). To improve urban sustainability and avoid the increase in urban heating and increased temperatures in urban areas, which has a negative impact on people’s well-being, and social and economic consequences (Boukhelkhal and Bourbia 2016, Morris et al. 2016, Jandaghian and Berardi 2020). The research question is less of information that deals with the
renovation of existing urban surfaces using color as a strategy to mitigate the UHI effect on the local climate. And focus on studying the use of color in urban renewal for a range of locally applicable products, technologies, materials, and techniques with the aim of their impact on the UHI to reduce the climate heating, and the possible solutions based on thinking about the color for urban surfaces as a tool to control the heating of surfaces exposed to sunlight and integration with landscapes and environmental quality, thus achieving urban sustainability at the lowest cost.

2 APPLYING DIFFERENT MATERIALS TO MITIGATE THE UHI EFFECT

The properties of roof materials such as convection and radiation with physical variables like shape, texture concentration, surface color, and vegetation have a significant impact on energy use (Lin et al. 2017, Premier and Gasparini 2017, Fong et al. 2019). Today, a wide range of traditional and natural materials has thermal conductors that could be suitable for use on urban surfaces as suitable solutions to mitigate the impact of UHI (Latha et al. 2015, Taleghani and Berardi 2018). In Spain, it was found that the use of light colors is better in warmer climatic areas, while the use of dark colors in colder climate areas is the best option. This coloring of the urban surfaces helped to define the criteria to be considered in the urban surfaces (Fong et al. 2019). According to above, the research identifies some solution that can be applied locally as an urban renewal to improve urban sustainability.

2.1 The Whitening Process

Traditional Mediterranean buildings were white-roofed; they were whitewashed\(^1\) to help disperse heat from the volcanic dark stones. The white roof reduces heat in houses and in cities, and the buildings with white roofs reflect sunlight through the atmosphere into space, and this is why the white roof helps cool the urban climate (Quinn 2016). In Greece, white plastic was used as paint over its concrete roof and found that after applying the cold paint, the indoor air temperature decreased in summer and the effect of cold in winter (Latha et al. 2015). In the United States, the White Roof Project uses fundraising and volunteers for free to cover the roofs of buildings to the residents with low-income. Montanjees' calculations conclude that 100 square meters of flat white roofs offset the greenhouse effect of nearly 10 tons of CO\(_2\) emissions (Quinn 2016).

2.2 High Albedo

In a study of the urban simulation, a significant decrease in the surface temperature of 15.6%, it was observed when the surface albedo was altered, this study provides evidence of the possibility of change the thermal behavior by adding materials which is reducing cooling energy approximately by 10-15%. Increasing the albedo of urban surfaces is one of the verifiable and measurable solutions to mitigate the impact of UHI and urban cooling through simulation programs and mitigation scenarios (Jandaghian and Berardi 2020, Abaas 2020). Recently, high-albedo materials are among the recommended options for urban surfaces (Wang et al. 2016). A study in Montreal showed that the beneficial outcomes of improving albedo were a decrease in daily air temperature by 0.7°C, and an improvement in heat stress indices of 3% (Jandaghian and Berardi 2020). Akbari and Taha (1992) also showed that by increasing the surface albedo by 20%, cooling energy use could be reduced by 30-40% in four Canadian cities, and reduced cooling energy

---

\(^1\) The whitening process was done quite easily and inexpensively using lime produced from burnt limestone (made up of corals and shells that had been compressed over eons to form a solid block of calcium carbonate). The remaining calcium oxide or “quicklime” is then mixed with salt and water before slathering it on.
demand by 10-50% in buildings, this will result in a decrease in heat-related deaths of approximately 4% during heat wave periods (Ramakrishnan et al. 2018, Jandaghian and Berardi 2020).

2.3 Silver Coating
The use of reflective materials is presented as an effective way to reduce temperature, energy consumption and to mitigate the heat island effect in cities (Yang et al. 2015). The reflectivity of roofs in urban areas is usually around 0.2 but can be greatly increased by using highly reflective materials on urban roofs (Wang et al. 2016). The beneficial effects of using reflective coatings for roofs on energy use in buildings have been discussed. And the use of reflective materials is a common choice as an effective method to reduce temperature and lower energy consumption (Yang et al. 2015, Jandaghian and Berardi 2020).

2.4 Greening Roof
Greening refers to cultivating urban surfaces with grass and plants of various types, which are among the most important components of urban design that affect the built environment and contribute to changing the urban microclimate by increasing latent heat flow (Boukhelkhal and Bourbia 2016, Abaas 2016, Lin et al. 2017). In a study of UHI mitigation for New York Street, trees were shown to have a significant cooling potential (Wang et al. 2016). The Toronto Green Development Standard recommends that 30% of urban hard surfaces should be shaded by trees, which reduced building energy demand for cooling by 10% in urban homes and 20% in suburban areas (Ramakrishnan et al. 2018, Jandaghian and Berardi 2020). In the United States, Chicago, Denver, and San Francisco are among the cities that have already issued regulations requiring or incentivizing green roofs. In 2014, there were about 86 million square meters of green roofs in Germany; it is the leader in the technology of modern green roof.

2.5 Photovoltaic Panels
All over the world, photovoltaic solutions are used in a flat or inclined manner, while keeping the surface layers unchanged, as they are considered external installation solutions. It is possible to plan the use of PV panels in an existing building and it is not required to be included in the design, taking into consideration some of the main issues, including the condition of the roof, bearing the additional weights and loads, the installation method and location not affecting the roof water drainage system (Bauder Ltd 2018).

3 DISCUSSION URBAN ROOF SOLUTION LOCALY
According to the studies reviewed by the research, the performance of urban roofs affects the thermal balance of the city (Jandaghian and Berardi 2020). It is clear that products, materials and technologies have a strategic role when shaping urban roofs, and through additions and modifications to the existing urban surfaces we can provide the potential to reduce urban heat in cities and thus reduce UHI effects. Each of the products, materials, and technologies is characterized by a certain color range, and it is possible to consider the building sustainable according to the color of the urban surface (see Table 1).
Locally in Iraq, reflective materials were used as solutions to treat urban surfaces in multiple buildings. Izocam rolls of glass wool, thickness 25-400 mm, density 16 kg/m$^3$; covered with an aluminum layer (IZOCAM 2019), used to insulate external surfaces like the Alwind residential project in Khanaqin (located north east Baghdad) (see Figure 1). Environmental policymakers promote the widespread use of reflective materials to reduce environmental impacts which particularly use in regional aquatic climates (Yang et al. 2015, Jandaghian and Berardi 2020). That matched with the use of IZOCAM which is widely used in middle and northern cities in Iraq at low cost. It is a thermal and humidity insulation. In addition, many studies and experimental models of green roofs made with no application till now (Saleem and Abdulrasoul 2015, Abaas 2020, Khalid and Abaas 2021b).

The complexes that were located at the Tigris River in Baghdad were known as solar energy buildings (Abi Nawas Street) (see Figure 2). In 1998, air conditioners and heating system were installed for all 278 apartments according to the solar energy collection system, and detailed designs were developed by a specialized Japanese company. The system operates through solar collectors that provide (50-60%) of solar energy and devices that convert solar energy into electricity with auxiliary energy saving equipment (energy back up equipment) when needed in the event of unusual weather conditions. The technology that was used in the Abu Nawas buildings was the pioneer in this field at the time and was constantly operating in a closed loop system, and therefore the Abu Nawas buildings were environmentally friendly (Aboud and Shoukor 2016, Abdel Rahman 2023). Now in 2023, new pilot studies for new solar energy systems to reach the highest level of efficiency in use (see Figure 3).

4 CONCLUSIONS

The research concluded to highlight that urban temperature is generated as a result of the absorption of solar radiation in the city by the grey roofs of urban blocks and its storage on these surfaces. Heat emissions and solar energy reflected from roofing materials can be addressed during the design process and can be mitigated for existing buildings, by using Painting, Coating, Greening,
or installation solutions. Color considers a strategic solution from an expressive point of view in controlling the internal and external environmental quality of urban surfaces and their local climate. For centuries, white and light-colored roofs have served to cool buildings in Mediterranean countries and the Middle East. Avoid coloring the surfaces with dark materials, impermeable, heat storage capacity, and high thermal conductivity. The research identified solutions to mitigate the impact of higher urban temperatures locally in Iraq. The use of IZOCAM as a coating solution with ten years of durability is widely used in middle and northern cities; because of the good isolation properties for thermal and humidity at low cost.

Figure 2. Abi Nawas complexes: A Street location (Google map), B solar buildings (Google map), C solar buildings from the river.

Figure 3. Solar system locally: A solar panels, B solar battery, C new solar studies.

References


Abdel Rahman, B., *Solar Energy in Iraq*, Iraqi Forum for Intellectuals and Academics, March 3, 2023. Retrieved from https://iraqi-forum2014.com/%D8%A7%D9%86%D9%84%D9%8A%D8%A7%D9%86%D8%A9-%D8%A7%D9%84%D8%B5%D9%86%D8%A7%D8%B9%D8%A9-%D9%84%D8%B7%D8%A7%D9%82%D8%A9-%D8%B3%D9%8A%D8%A9-%D9%81%D9%8A-%D8%A7%D9%84%D8%B9%8A-%D8%A7%D9 on February 5, 2023.


Boukhelkhal, I., and Bourbia, P. F., *Thermal Comfort Conditions in Outdoor Urban Spaces: Hot Dry