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INFLUENCE OF EXTERIOR FINISH COLOR ON BUILDING HEATING IN DRY HOT CLIMATES

(Comparative analysis of light and dark colors)

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Abstract

This article examines the impact of exterior finish color on the thermal performance of buildings in dry hot climates. A comparative analysis of light and dark surfaces is conducted based on their reflectance (albedo). It was found that light-colored facades reduce surface temperatures by 30–40°C compared to dark ones, cutting cooling costs by up to 30%. Analyzes the risks of thermal deformation and the benefits of using "cool pigments" to minimize overheating. The study justifies the priority of light tones to enhance energy efficiency and the durability of urban structures.

Keywords: facade, albedo, thermal regime, solar radiation, energy efficiency, dry climate.

Аннотация

В статье исследуется влияние цвета фасадной отделки на теплотехническое состояние зданий в условиях сухого жаркого климата. Проведен сравнительный анализ светлых и темных поверхностей на основе их коэффициента отражения (альбедо). Установлено, что светлые фасады снижают температуру поверхности на 30–40°C по сравнению с темными, что сокращает расходы на кондиционирование до 30%. Анализируется риски термической деформации материалов и преимущества использования «холодных пигментов» для минимизации перегрева. Работа обосновывает приоритетность светлых тонов для повышения энергоэффективности и долговечности городской застройки.

Ключевые слова: фасад, альбедо, тепловой режим, солнечная радиация, энергоэффективность, сухой климат.

Annotatsiya
Maqolada quruq issiq iqlim sharoitida fasad rangining binolarning issiqlik holatiga ta'siri tadqiq etilgan. Och va to'q sirtlarning aks ettirish koeffitsienti (albedo) asosida qiyosiy tahlil o'tkazildi. Aniqlanishicha, och rangli fasadlar sirt haroratini to'q ranglilarga nisbatan 30–40°C ga pasaytirib, sovutish xarajatlarini 30% gacha tejaydi. Tahlilga ko'ra materiallarning termik deformatsiya xavflarini va qizishni kamaytirish uchun «sovuq pigmentlar»dan foydalanish afzalligi aniqlandi. Natijalar shuni ko'rsatadiki, och rangli fasadlar binoning qizishini sezilarli darajada kamaytiradi va sovitish xarajatlarini qisqartiradi.

Kalit so'zlar: fasad, albedo, issiqlik rejimi, quyosh nurlanishi, energiya samaradorligi, quruq iqlim.

Introduction

The colors that surround us have a profound impact on our emotional state, mood, and even performance. This is a scientifically proven fact – the appearance of a building makes a different impression on people, even if only the color of the facade differs. Research from the Institute of Architectural Psychology [9] shows that the right color solution can increase the attractiveness of commercial real estate by 30%. That is why choosing the ideal facade color for a house is not just an aesthetic issue, but a serious architectural decision with psychological implications.

Fig. 1 Light and dark colored facades

In hot climates, where the intensity of solar radiation reaches its maximum values, the color of the facade finish becomes not just an aesthetic choice but an important engineering parameter determining the energy efficiency and durability of the building. Color accounts for up to 30% of a building's heat energy loss and up to 50% of acoustic energy loss.

The science studying the influence of color on exteriors is complex; several factors affecting energy efficiency should be considered:

First, it is the light transmittance capacity. Some shades transmit more light than others, meaning they cast a denser shadow on the surface they cover. Because of this, the surface becomes darker, and its thermal efficiency decreases by 30%.

The second factor is reflectivity. Different colors reflect different amounts of light, which also affects how warm or cold a building appears from the outside. The higher the reflectivity, the more light will penetrate inside and the more heat will be released. This increases the amount of solar radiation reflected from the facade, leading to heat loss.

The third factor is the emissivity coefficient. Green and blue colors practically do not emit heat in sunlight, unlike other colors such as yellow and red. Homes with an emissivity coefficient close to 1 are less energy efficient than homes with a lower emissivity coefficient (0-50).

A study conducted by scientists at Georgia State University [10] showed that lighter shades tend to be more energy efficient than dark ones. The study also showed that brick or stone facades are more energy efficient than facades made of other materials, and window openings on the south side of a building most effectively reduce energy consumption. [1]

Light shades reflect most of the solar radiation, reducing overheating, while dark ones absorb heat, increasing the temperature of the surface and internal spaces. The main indicator determining the thermal behavior of a surface is the solar radiation reflectance coefficient (albedo). (Fig.2) [11]

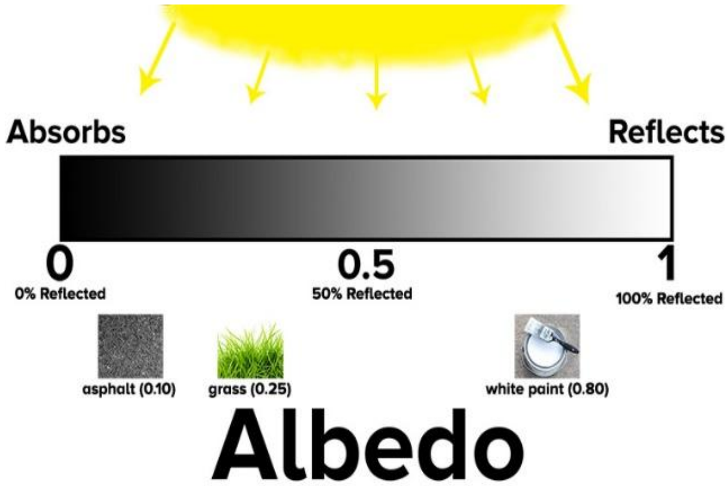

Fig.2. Albedo measurement.

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Albedo is measured on a scale of 0-1. A 0 means that the surface of a material absorbs all of the sunlight that hits it. A 1 means that a material reflects all of the light energy that hits it. In other words, a 1 on the albedo scale means 100 percent reflection. A 0 means no reflection.

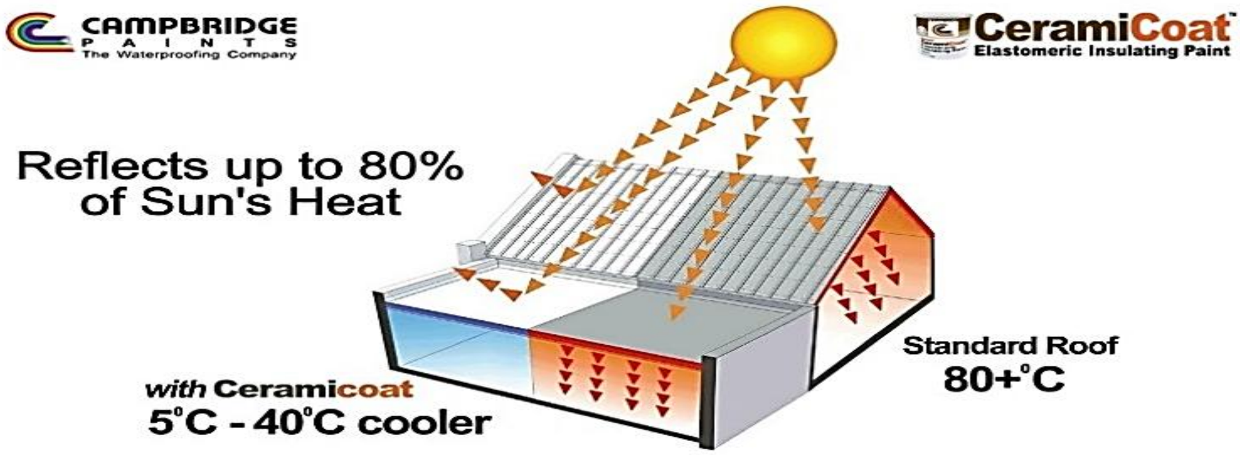

Fig. 3 Elastomeric Insulating paint

Elastomeric Insulating paint Results of using elastomeric thermal insulation paint on the facade and its effect on reducing building heating. [2]

•Light colors (white, light beige, cream): have high albedo (from 0.7 to 0.9). This means that up to 90% of solar energy is reflected back into the atmosphere. (Fig. 4)

• Dark colors (black, dark gray, anthracite): have low albedo (from 0.05 to 0.2). They absorb most of the solar spectrum, converting light energy into thermal energy. (Fig. 3.1) [3].

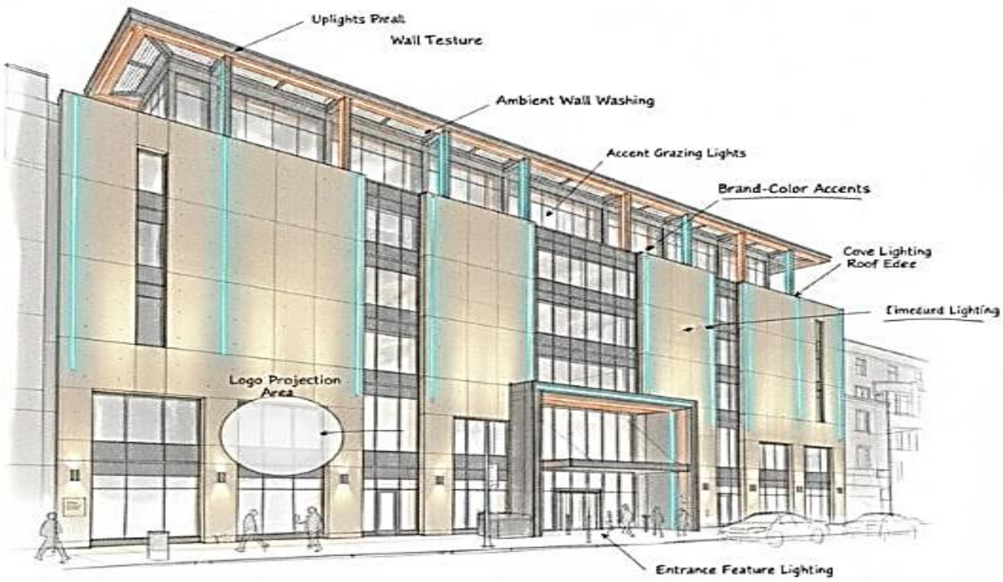

Fig. 4 Light facade

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Light areas of the facade reflect a significant portion of solar radiation, reducing the degree of surface heating; the diagram shows different types of facade lighting.

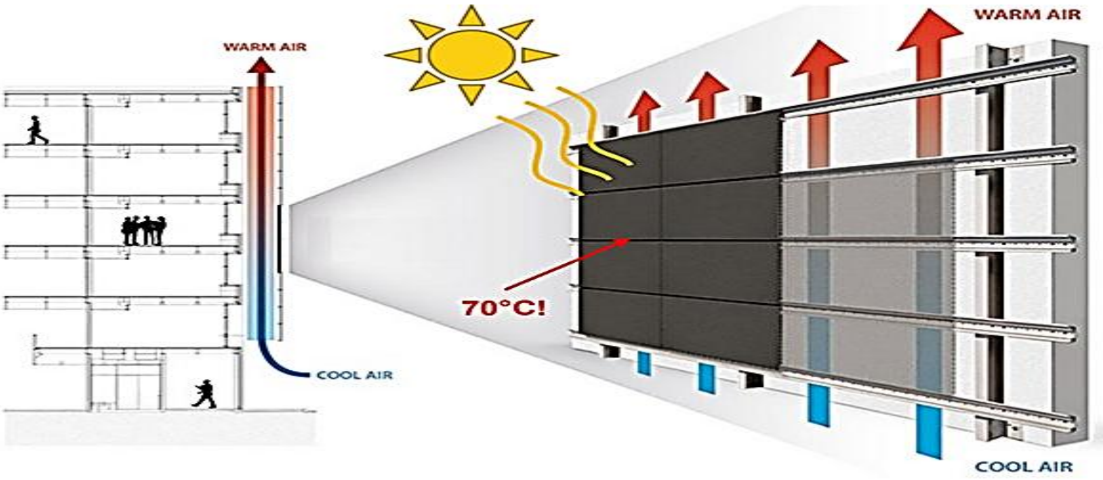

Fig. 5 Dark Facade

Dark cladding panels actively absorb solar energy, converting it into heat, resulting in significant heating of the external surface. Heated air rises along the facade (convection effect). [4]

Comparative Analysis: Light vs Dark Facades. [5]

Characteristic	Light tones (L < 30%)	Dark tones (L > 70%)
Surface Temperature	Exceeds air temperature by only 5-15°C.	Can heat up to 80-90°C at an air temperature of 40°C.
Heat Transfer Inward	Minimal; reduces the load on thermal insulation.	High; requires a significantly thicker layer of insulation.
Cooling Costs	Allows saving 20-40% of electricity on air conditioning.	Increases expenses for split-system operation due to constant heat gain.
Service Life of Materials	Materials are less subject to thermal expansion.	High risk of cracks in plaster and deformation of panels due to cyclic heating/cooling.

Impact on Building Structure

1. Thermal Deformations: Dark facades are subject to sharp temperature changes (daytime heating up to 80°C and nighttime cooling down to 20°C). This creates colossal mechanical stresses in the finishing layers, leading to tile delamination or cracking of decorative plaster.

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2. Overheating of Internal Spaces: In dry climates, nights are often cool, but due to the high thermal inertia of walls heated by the dark color during the day, the building continues to "radiate" heat inside even at night, preventing residents from resting without air conditioning.

3. "Heat Island" Effect: The massive use of dark colors in urban development in dry climates raises the overall temperature of the micro district by several degrees, creating an uncomfortable environment for pedestrians. [4]
When sunlight hits a dark wall, photons are absorbed by the material, causing intense molecular motion, which physically manifests as a sharp rise in surface temperature.

Comparative Analysis: Temperature Regimes. The difference in heating between a white and a black wall at an air temperature of +40°C can reach colossal values.

Finish Color	Surface Temperature (T_surf)	Impact on Structure
White (glossy)	+45°C to +50°C	Stability of linear dimensions.
Light beige	+55°C to +60°C	Moderate thermal expansion.
Dark gray	+75°C to +85°C	High risk of microcracks.
Black (matte)	+90°C to +95°C	Deformation of panels, pigment fading.

Consequences for Building Operation. [6]

- **Load on Air Conditioning Systems**

A dark facade turns the wall into a "heat accumulator." Even after sunset, the heated mass of material continues to release heat into the interior. This forces air conditioners to wear out operating 24/7. Using light tones can reduce cooling costs by 25-40%. [3]

- **Durability of Materials**

Materials expand when heated and contract when cooled.
In dark facades, the amplitude of temperature fluctuations (day/night) can be 70°C. This leads to material fatigue: plaster cracks, adhesive compounds lose adhesion, and polymer panels deform ("buckle").

- **"Heat Island" Effect.**

A city with a predominance of dark roofs and facades heats up more than the surrounding rural area. Light facades help reduce the overall temperature of the urban environment. Also, for additional management of heat loss in buildings, especially depending on climatic conditions, the installation of a radiant barrier is necessary.

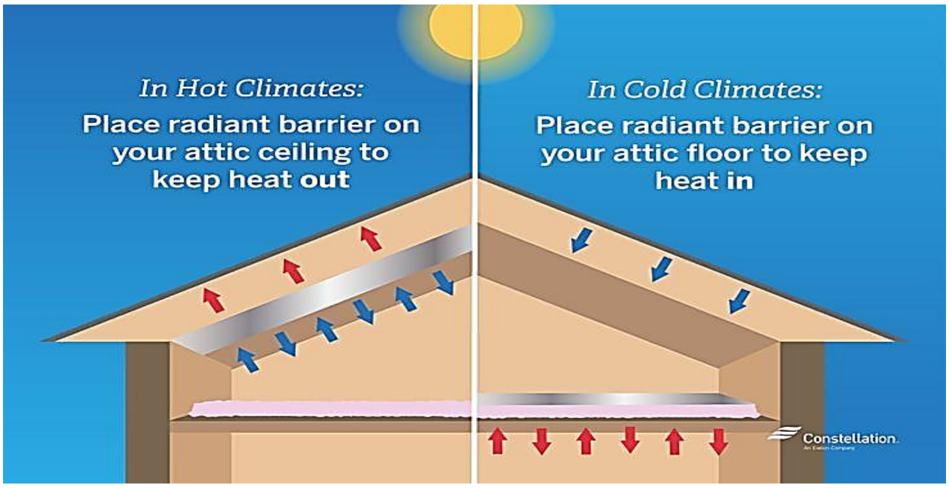

Fig. 6 Radiant barrier for the attic

In hot climates, it is recommended to install a radiant barrier on the attic ceiling. This allows reflecting solar heat penetrating through the roof back into the atmosphere. Thus, the barrier prevents overheating of interior spaces, creating more comfortable living conditions. Installing a barrier on the attic ceiling helps reduce the load on air conditioning systems, which in turn saves energy and reduces cooling costs [1].

In cold climates, installing a radiant barrier on the attic floor becomes a key element for retaining heat inside the building. The barrier reflects heat emanating from heating systems back into the living spaces, minimizing heat loss through the roof. This is especially important in winter when maintaining a comfortable temperature is a priority. Installing a barrier on the attic floor helps create more effective thermal insulation, reducing heating costs and increasing the overall energy efficiency of the building. Thus, proper installation of a radiant barrier depending on climatic conditions can significantly improve comfort and reduce energy costs in buildings.

Conclusion

Facade color is one of the key factors influencing thermal comfort. Its correct choice helps regulate the amount of solar energy that penetrates the surface and affects the internal microclimate. This approach is important not only from an aesthetic point of view but also from an energy-saving perspective. The optimal facade color can reduce the need for air conditioning or heating systems, making the building more adapted to environmental conditions. This directly affects operating costs and the level of comfort for residents. Furthermore, the influence of color on the thermal regime of a building is closely related to material characteristics and structural features, requiring a comprehensive consideration during design and construction. The influence of facade color can vary depending on the intensity of solar radiation, so a correct assessment of these factors contributes to the creation of more efficient and sustainable buildings. It should also be considered that the choice of facade color can have long-term consequences for the condition of building structures, as excessive heating or cooling can lead to deformations or a reduction in the service life of materials. Thus, facade color actively participates in shaping the microclimate, making it an important element when choosing exterior finishes. Consideration of all these aspects allows achieving a harmonious combination of functionality and external attractiveness of the building. It should be noted that thermal comfort depends not only on color but also on the complex interaction with other factors; however, the influence of color remains one of the most accessible and noticeable ways to regulate the temperature inside a home. Using the correct facade color helps create favorable living conditions regardless of seasonal temperature changes and climate features, thereby ensuring a high level of comfort throughout the year.

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