

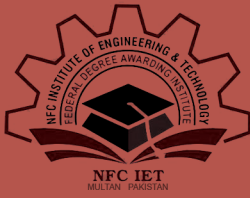
PASSIVE COOLING AND HEATING STRATEGIES FOR ENERGY-EFFICIENT BUILDINGS: A STUDY FOR SUSTAINABLE ENVIRONMENTALLY FRIENDLY GREEN DESIGN PROCESSES

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ABSTRACT

Natural cooling and heating strategies have gained significant attention due to their ability to dissipate heat without electricity, particularly through radiative cooling (RC), especially in tropical climate areas, is essential in achieving sustainable and energy-efficient architecture. However, normal methods are often limited due to some environmental factors such as sunlight, rainfall and also snowfall constrained their effectiveness. To control these factors behavior, we study about the thermal performance of two exterior wall materials—weather paint and red gutka bricks (Multani Tiles) during daytime or under high temperature through an integrated experimental and computational approach. The weather paint reflects almost 60-70% of sunlight depends upon their thickness and texture. Also, the red gutka bricks reduce temperature from 5°C - 10°C on similar properties. Experimental investigations include building-controlled sections of walls with both materials and capturing surface temperature variations using an infrared heat gun under different weather conditions. Simultaneously, four parametric building models have been developed in Revit, two for hot and two for cold climates, incorporating advanced passive design strategies such as optimized orientation, thermal mass integration, and adaptive insulation techniques. A comparative energy performance assessment is performed using Revit's simulation tools to assess the impact of wall material selection on thermal performance and indoor comfort levels. By combining experimental results with synthetic energy modelling data, this study offers a significant understanding of material efficacy in passive climate adaptation for sustainable environmentally friendly green practices aligned with climate-responsive design principles.

INTRODUCTION

Sustainable construction will become very important in future because construction sector uses a lot of energy and causes increase of carbon emissions day by day. In hot climate areas like Multan, people rely on artificial means in summer season. To reduce cost and energy consumption, the use of materials that reduce inner temperature of building is necessary. For this purpose, Gutka tiles (Multani Tiles) and weather paints are compared. This analysis includes experimental testing and Revit models' simulation to compare the resistance and performance of Gutka tiles and Weather paints in different weather conditions. The results will help us to understand green building practices and selection of such materials that are sustainable and eco-friendly for buildings in extreme weather conditions.

METHODOLOGY

Problem Identification
(Need for Passive Cooling and Heating)

Material Selection
(Gutka Tiles and Weather Paint)

Experimental Testing
(IR Heat Gun, Surface Temperature Analysis)

Revit Modeling
(Hot and Cold Climate Models)

Energy Simulation
(Indoor Comfort & Efficiency)

Comparative Analysis
(Performance Evaluation)

Final Result & Evaluation
(Suitable Material Selection)

RESULT & ANALYSIS

PERFORMANCE ANALYSIS SUMMARY

Table 1: Gutka Tile (Multani Bricks)

Key Parameter	Value
Total Carbon	29,141.31 kgCO ₂ e
Embodied Carbon	22,784.75 kgCO ₂ e
Operational Carbon	6,356.56 kgCO ₂ e
Annual EUI	323.83 kWh/m ²
Wall Performance	High thermal mass, delays heat gain 5–10°C

High thermal mass delays heat by 5–10°C, making it effective for passive cooling in hot climates, though with higher embodied carbon.

Table 2: Weather Paint

Key Parameter	Value
Total Carbon	29,036.38 kgCO ₂ e
Embodied Carbon	22,678.43 kgCO ₂ e
Operational Carbon	6,357.94 kgCO ₂ e
Annual EUI	323.91 kWh/m ²
Wall Performance	Reflects 60–70% solar heat

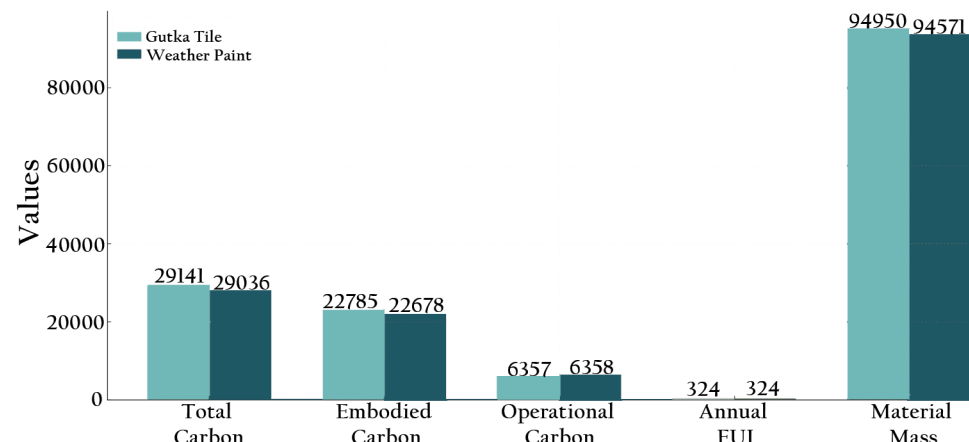
Reflects 60–70% solar heat, lowers footprint and is lighter, but less effective in extreme hot climates.

Table 3: Comparative Summary

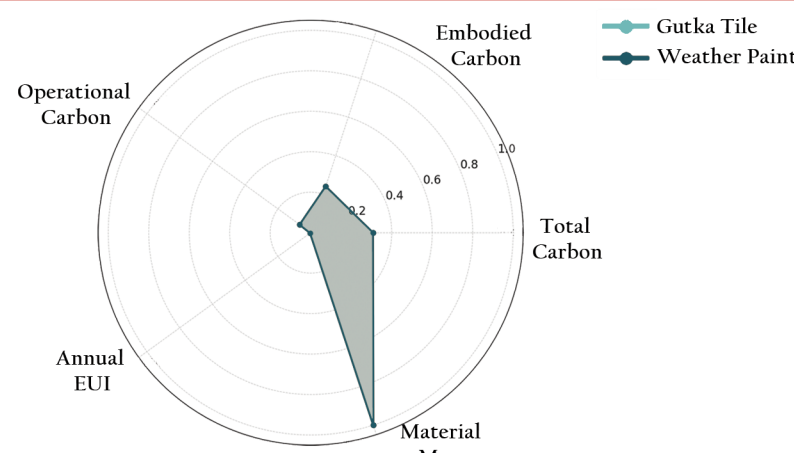
Parameter	Gutka Tile	Weather Paint
Total Carbon	29,141.31	29,036.38 (Better)
Embodied Carbon	22,784.75	22,678.43 (Better)
Operational Carbon	6,356.56 (Better)	6,357.94
Annual EUI	323.83 (Better)	323.91
Wall Performance	Thermal mass (better hot climate)	Reflects heat (better mild climate)

Both useful, but Gutka tiles are more preferable for Multan's hot climate due to stronger passive cooling.

COMPARISON (GUTKA VS PAINT)

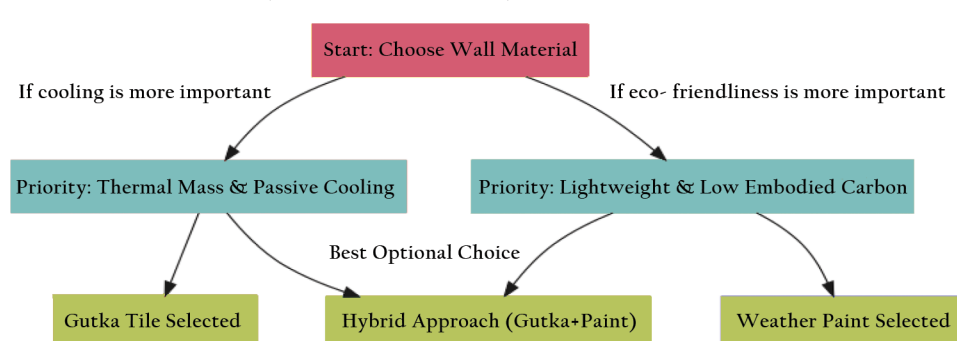


The results show that Weather paint slightly outperforms Gutka tile in terms of lower carbon values, while both options are almost equal in operational performance.



The chart shows that Weather paint has lower carbon impact, while Gutka tiles provide better thermal mass and cooling benefits for hot climates.

DECISION FLOW CHART



THEME

Passive cooling and heating strategies pave the way for greener futures, directly advancing SDG 7 (Affordable and Clean Energy), SDG 11 (Sustainable Cities and Communities), and SDG 13 (Climate Action).



CONCLUSION

This study shows that Gutka tiles (Multani Tiles) and Weather paints help us to make buildings comfortable and eco-friendly but both work in different ways. The simulation model's analysis shows that Gutka tiles reduce energy consumption, whereas the weather paints reduce the carbon emissions rate. Therefore, selection depends upon what is important: For keeping buildings or housing naturally cooled, Gutka tiles are best choice. For cost effective, lighter and eco-friendly buildings, Weather paint is best. Using both strategies together makes the house more comfortable and sustainable in hot climate regions.

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