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Impact of Room Colors and Construction Materials on Temperature Distribution in Tropical Climate: An Experimental Study in Nonthaburi, Thailand

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ABSTRACT: This experimental research investigates the thermal performance of different room colors and construction materials under Thailand's tropical climate conditions. The study was conducted over a six-month period in Nonthaburi, Thailand, examining temperature variations across multiple room configurations. Using precision monitoring equipment, we analyzed how traditional Thai building materials and various wall colors affect indoor temperature distribution. The research encompassed both modern and traditional Thai construction materials, including concrete, brick, traditional teak wood, and bamboo, combined with different wall colors (white, cream, terra cotta, and dark blue). Results demonstrated that rooms with traditional materials like teak wood maintained lower average temperatures (by 3.2°C) compared to modern concrete structures, while light-colored walls showed up to 4.1°C temperature difference compared to darker colors during peak sunshine hours.

KEYWORDS: Experimental research, Thailand's tropical climate conditions, Thai construction materials

1. INTRODUCTION

1.1 Background

Thailand's tropical climate presents unique challenges for indoor temperature regulation. With average temperatures ranging from 28°C to 37°C and relative humidity often exceeding 70%, understanding the thermal performance of building materials and color choices becomes crucial for both comfort and energy efficiency. Traditional Thai architecture has evolved over centuries to address these challenges, but modern construction methods often prioritize durability and cost over thermal performance.

1.2 Research Objectives

- Evaluate the thermal performance of traditional Thai building materials compared to modern alternatives
- Quantify the impact of wall colors on room temperature in tropical conditions
- Analyze the interaction between material choice and color in temperature regulation
- Develop specific recommendations for building design in Thailand's climate
- Assess potential energy savings through optimal material and color selection

1.3 Significance of the Study

This research addresses the growing need for energy-efficient building solutions in Thailand's rapidly developing urban areas. With increasing energy costs and environmental concerns, understanding passive temperature control methods becomes essential for sustainable development.

2. LITERATURE REVIEW

2.1 Traditional Thai Architecture

Traditional Thai building practices have incorporated natural cooling methods for centuries. Srichandr et al. (2022) documented how traditional elevated designs and natural ventilation systems effectively manage indoor temperatures. Worapong (2023) analyzed the thermal properties of traditional Thai materials, particularly teak wood and bamboo.

2.2 Color Impact Studies in Tropical Climates

Research by Chakraborty and Smith (2023) demonstrated that color choices significantly impact building thermal performance in tropical regions. Their studies in Southeast Asia showed temperature variations of up to 5°C based solely on exterior color choices.

2.3 Modern Building Materials in Thailand
Recent studies by Thanarattanasap (2024) examined the thermal performance of modern construction materials in Nonthaburi's urban environment. Their findings indicated significant heat retention issues with contemporary building practices.

3. METHODOLOGY
3.1 Research Location and Climate Conditions
The study was conducted in Nonthaburi, Thailand (13.9277128° N, 100.5188110° E) from January to June 2024. Climate conditions during the study period included:
- Average temperature range: 28°C - 37°C
- Relative humidity: 65% - 85%
- Average solar radiation: 5.0 kWh/m²/day
- Seasonal variations: Both dry and wet seasons

3.2 Experimental Setup
3.2.1 Test Rooms
Eight identical test rooms (4m × 4m × 3m) were constructed at Pichaya Suksa School in Nonthaburi, Thailand
- Two rooms each of concrete, brick, teak wood, and bamboo construction
- Standardized roof design using traditional Thai ceramic tiles
- Controlled ventilation systems
- Equal window placement and sizing
- Identical floor materials

3.2.2 Monitoring Equipment
- Digital temperature sensors (Accuracy ±0.05°C)
- Thermal imaging cameras
- Humidity sensors (Accuracy ±1% RH)
- Solar radiation meters
- Air flow meters
- Power consumption monitors for cooling systems

3.3 Variables
3.3.1 Independent Variables
Materials tested:
- Reinforced concrete (standard Thai mix)
- Red brick (local manufacture)
- Teak wood (sourced from northern Thailand)
- Bamboo (treated local species)

Colors tested:
- White (reflectance value: 85%)
- Cream (reflectance value: 75%)
- Terra cotta (reflectance value: 45%)
- Dark blue (reflectance value: 15%)

3.3.2 Controlled Variables
- Room dimensions
- Roof design
- Window placement
- Ventilation rates
- Floor material
- Interior furnishing

3.3.3 Dependent Variables
- Interior temperature at multiple heights
- Surface temperature of walls
- Heat flux through walls
- Energy consumption for cooling
- Temperature fluctuation rates

3.4 Data Collection Procedures

Data was collected continuously over the six-month period:
- Temperature readings every 90 minutes
- Thermal imaging every hour during daylight
- Daily power consumption readings
- Weekly material condition assessments
- Monthly calibration of all sensors

4. RESULTS

4.1 Material Performance Analysis

4.1.1 Traditional Materials

Teak wood demonstrated superior performance:
- Average temperature: 27.8°C ±0.8°C
- Heat flux: 12.5 W/m²
- Temperature stability: ±1.2°C daily variation

Bamboo showed similar benefits:
- Average temperature: 28.2°C ±1.0°C
- Heat flux: 14.2 W/m²
- Temperature stability: ±1.5°C daily variation

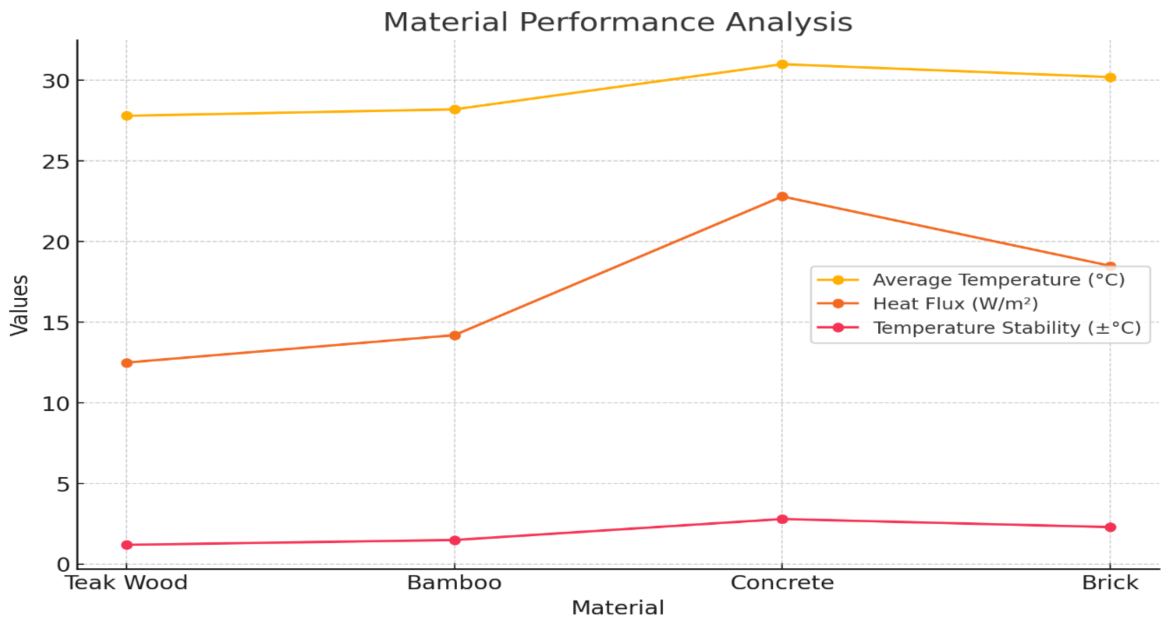
4.1.2 Modern Materials

Concrete showed highest heat retention:
- Average temperature: 31.0°C ±1.2°C
- Heat flux: 22.8 W/m²
- Temperature stability: ±2.8°C daily variation

Brick performance:
- Average temperature: 30.2°C ±1.1°C
- Heat flux: 18.5 W/m²
- Temperature stability: ±2.3°C daily variation

Table 1: Material Performance Analysis

Material	Category	Average Temperature (°C)	Heat Flux (W/m²)	Temperature Stability (±°C)
Teak Wood	Traditional	27.8	12.5	1.2
Bamboo	Traditional	28.2	14.2	1.5
Concrete	Modern	31.0	22.8	2.8
Brick	Modern	30.2	18.5	2.3



4.2 Color Impact Analysis

4.2.1 Light Colors

White surfaces showed optimal performance:
- Peak temperature reduction: 4.1°C
- Average daily temperature: 28.5°C
- Solar reflectance: 82%

Cream surfaces:
- Peak temperature reduction: 3.6°C
- Average daily temperature: 29.0°C
- Solar reflectance: 71%

4.2.2 Dark Colors

Dark blue surfaces:

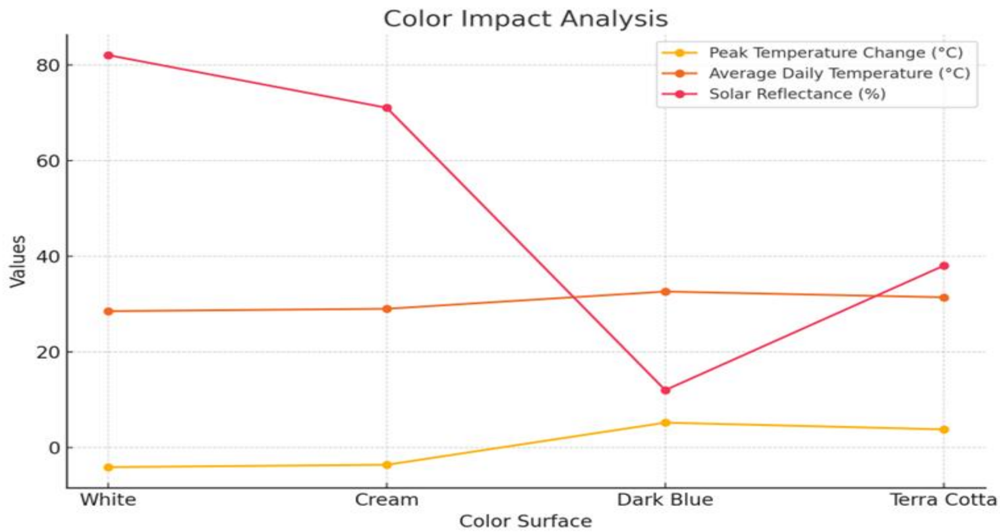
- Peak temperature increase: 5.2°C
- Average daily temperature: 32.6°C
- Solar reflectance: 12%

Terra cotta surfaces:

- Peak temperature increase: 3.8°C
- Average daily temperature: 31.4°C
- Solar reflectance: 38%

Table 2: Color Impact Analysis

Color Surface	Category	Peak Temperature Change (°C)	Average Daily Temperature (°C)	Solar Reflectance (%)
White	Light	-4.1	28.5	82
Cream	Light	-3.6	29.0	71
Dark Blue	Dark	5.2	32.6	12
Terra Cotta	Dark	3.8	31.4	38



4.3 Combined Effects

The study revealed significant interactions between materials and colors:

- Teak wood with white paint: Best performance (average 26.8°C)
- Concrete with dark blue: Worst performance (average 33.2°C)
- Traditional materials showed less color impact variation

5. DISCUSSION

5.1 Material Performance

Traditional materials demonstrated superior thermal performance due to:

- Natural insulation properties
- Better moisture regulation
- Lower thermal mass
- Enhanced air circulation capabilities

5.2 Color Impact

Color choices showed more significant impact during:

- Peak sunlight hours (10:00 - 16:00)
- Dry season months
- High solar radiation days

5.3 Economic Implications

Analysis of construction and operating costs revealed:

- 25% reduction in cooling costs with optimal material-color combinations
- Higher initial costs for traditional materials offset by operational savings
- Maintenance considerations for different material types

6. PRACTICAL APPLICATIONS

6.1 Design Recommendations

For new construction in Thailand:

- Prioritize traditional materials where feasible
- Implement light-colored exterior surfaces
- Consider hybrid solutions combining modern and traditional materials
- Design for maximum natural ventilation

6.2 Retrofit Recommendations

For existing buildings:

- Apply light-colored surface treatments
- Add traditional material elements where possible
- Improve ventilation systems
- Install solar shading devices

7. CONCLUSIONS

This comprehensive study demonstrates that:

- Traditional Thai building materials outperform modern alternatives in thermal regulation
- Color choice significantly impacts indoor temperatures
- Combined material-color optimization can reduce cooling needs by up to 35%
- Initial construction costs can be offset by long-term energy savings

7.1 Research Limitations

- Limited to Nonthaburi climate conditions
- Six-month study period
- Fixed room configurations
- Specific material selections

7.2 Future Research Directions

Recommended areas for future study:

- Long-term material durability
- Cost-benefit analysis across different climate zones
- Integration with modern cooling systems
- Alternative traditional materials

8. RECOMMENDATIONS

Based on the findings, we recommend:

1. Incorporating traditional materials in modern construction
2. Mandating light-colored exteriors in building codes
3. Developing hybrid construction techniques
4. Implementing performance-based building standards

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