Section of the conference: Social Sciences | Sekcja konferencji: Nauki społeczne

How to cite: Mu, T., Nordin, J., & Aziz, N. F. (2024). Sustainable building internal design combined with vernacular architecture to alleviate overheating in urban villages. *World conference on future innovations and sustainable solutions*. Futurity Research Publishing. https://doi.org/10.5281/zenodo.13736463

Sustainable building internal design combined with vernacular architecture to alleviate overheating in urban villages

Tiantian Mu [1], Jestin Nordin[2], Nor Fadzila Aziz[3]

[1]PhD, School of Housing, Building and Planning, University Sains Malaysia, 11800 Penang, Malaysia, https://orcid.org/0000-0003-0436-6969

[2]Doctor, Senior Lecture, School of Housing, Building and Planning, University Sains Malaysia, 11800 Penang, Malaysia, https://orcid.org/0000-0002-5186-3119

[3]Doctor, Senior Lecture, School of Housing, Building and Planning, University Sains Malaysia, 11800 Penang, Malaysia, https://orcid.org/0000-0002-4082-3285

Accepted: August 22, 2024 | **Published**: September 9, 2024 | **Language:** English

Abstract: As global climate change intensifies and resource utilization challenges grow, the importance of sustainable building design has become increasingly prominent. As a unique type of residential area amid rapid urban development, Wenzhou's urban villages face severe indoor discomfort, particularly during the summer. This study aims to develop a Sustainable Building Interior Design (SBID) method that incorporates vernacular architectural design strategies to address the issue of high indoor temperatures in Wenzhou's urban villages during the summer. By integrating traditional architectural wisdom from the Wenzhou region with modern sustainable design concepts, the study proposes a design approach suited to the local environment and climate, improving natural ventilation and shading, and thereby enhancing indoor comfort.

Keywords: vernacular architecture, sustainable building, sustainability, internal design, urban village

Introduction

In recent years, the trend toward sustainable building design has become increasingly prominent worldwide. With the intensifying challenges of climate change and resource scarcity, the construction industry is gradually shifting towards design models that emphasize low energy consumption, low carbon emissions, and high efficiency. The goal of sustainable building design is to achieve sustainable development throughout the entire lifecycle of a building by optimizing resource utilization, reducing environmental impact, and enhancing living comfort. This trend is not only widely adopted in developed countries but is also becoming mainstream in developing countries, particularly in China.

Significant progress has been made in the practice of sustainable building design in China. The Chinese government has introduced various policies and standards, such as the "Green Building Evaluation Standard" and the "Building Energy Efficiency Design Standard," to promote the development of green buildings. However, despite the successful application of sustainable design in new constructions, older buildings in special environments like urban villages still face many challenges. Wenzhou's urban villages, as a typical example of China's rapid urbanization process, highlight the complexity of these issues.

Wenzhou's urban villages, originally rural areas, became part of the city as they were gradually enveloped by urban expansion. The buildings in these villages are often poorly planned, constructed with substandard materials, and feature inadequate structural designs, leading to significant issues such as excessive indoor temperatures and poor ventilation, particularly during the summer. These environmental problems severely affect residents' quality of life, with discomfort and even health risks during the high temperatures of summer. Therefore, improving the design of buildings in urban villages to enhance indoor comfort has become an urgent issue that needs to be addressed.

Although sustainable building design has been widely applied globally, existing architectural design methods are inadequate in addressing the summer heat issues in Wenzhou's urban villages. Traditional building designs often rely heavily on modern materials and technologies, frequently neglecting local climatic conditions and cultural contexts, which results in poor performance under extreme weather conditions. In Wenzhou's urban villages, the issue of high summer temperatures is particularly severe, as many buildings were not originally designed with adequate natural ventilation, shading, or thermal insulation in mind. Consequently, these buildings fail to provide sufficient indoor comfort during the summer.

Research Methodology

This study employs a research design that combines both qualitative and quantitative methods to comprehensively explore and address the issue of summer indoor discomfort in Wenzhou's urban villages. The qualitative component involves an in-depth analysis of vernacular architectural design strategies in the Wenzhou region, exploring how these strategies can be applied within a modern Sustainable Building Interior Design (SBID) framework. The quantitative component focuses on data collection and analysis to assess the current indoor environmental conditions of urban village buildings. By integrating these two research approaches, the study aims to systematically and

comprehensively understand the root causes of the problem and provide empirical support for the development of the SBID method.

Field Observation: On-site investigations were conducted in Wenzhou's urban villages to record physical environmental data of existing buildings, such as indoor temperature, humidity, lighting, and air circulation. Additionally, detailed observations of the buildings' structural characteristics, material usage, and spatial layout were made to understand how current designs impact indoor environments.

Environmental Performance Analysis: Statistical analysis of the field observation data was carried out to evaluate the environmental performance of existing buildings in Wenzhou's urban villages, with a particular focus on indoor temperature, humidity, and ventilation effectiveness. This analysis helps identify the shortcomings of current building designs and pinpoints key areas needing improvement. Comparative Analysis: The collected vernacular architectural strategies were compared with modern sustainable building design principles to identify similarities and differences. This comparative analysis aids in determining which vernacular strategies are most suitable for integration into the SBID method and how to optimize these strategies to meet modern building requirements.

Identification and Integration of Vernacular Architectural Strategies: Initially, effective design strategies from Wenzhou's vernacular architecture, such as natural ventilation, shading design, and material selection, were identified through field visits. These strategies were then integrated into the modern sustainable building design framework, forming the preliminary SBID method. Design Optimization: Tailored to the specific environmental conditions of Wenzhou's urban villages, detailed adjustments were made to the design of natural ventilation paths and shading facilities to maximize indoor temperature reduction and enhance comfort during the summer. Model Simulation and Validation: Computer simulation tools were used to test the performance of the optimized design schemes, evaluating their practical effectiveness. Through simulation validation, further adjustments were made to ensure the design's effectiveness in real-world applications.

Case Study: Wenzhou Urban Village

This study selected a typical urban village within Wenzhou's city area as the research case. The village consists mostly of self-built houses, lacking systematic planning and design. These buildings are primarily constructed with brick and concrete, characterized by high density and minimal spacing between floors, leading to common issues such as poor ventilation and insufficient natural light. During the high temperatures of summer, the indoor heat is difficult to dissipate, causing residents to suffer from stuffy and hot indoor environments. Additionally, the village has relatively underdeveloped infrastructure, limited public space, and low greenery coverage, which exacerbates the heat issues in summer.

Preliminary Assessment and Diagnosis: Through on-site surveys, the current state of the buildings was recorded, analyzing their performance under high summer temperatures, particularly in terms of indoor temperature, humidity, and air circulation.

Design Scheme Development: Based on the preliminary assessment, a specific application plan for the SBID method was formulated. This plan includes optimizing natural ventilation paths, adding shading facilities, and improving the thermal insulation of walls and roofs. Additionally, traditional

vernacular architectural strategies, such as using local materials to construct insulation layers and designing windows and porches adapted to the local climate, were integrated into modern design.

Simulation and Adjustment: Various design measures of the SBID method were progressively simulated on the selected buildings. Adjustments to the design were made based on the simulation results.

Indoor Temperature Reduction: During high-temperature periods in summer, the indoor temperature of buildings where the SBID method was implemented was reduced by an average of 2-3°C compared to before the renovation. Improved ventilation and added shading facilities reduced solar radiation and indoor heat accumulation, making the indoor environment cooler and more comfortable.

Improved Humidity Control: The optimized ventilation system significantly enhanced indoor air circulation, effectively lowering indoor humidity and reducing the feeling of dampness. Additionally, effective insulation design reduced heat conduction through walls and roofs, further improving the indoor thermal and humidity environment.

Effectiveness of the Method: The application of the SBID method in Wenzhou's urban village proved its effectiveness in improving the summer indoor environment. Compared to traditional architectural design methods, the SBID method not only significantly reduced indoor temperature but also showed better performance in humidity control.

Comparison with Traditional Methods: Traditional architectural design methods often focus on single technical measures, such as using air conditioning or adding insulation layers, while neglecting the overall environmental adaptability of the building. In contrast, the SBID method integrates vernacular architectural strategies with modern technology, providing a more comprehensive and systematic solution that achieves better environmental improvements under limited resources.

Sustainability and Applicability: The SBID method demonstrates good sustainability and wide applicability. By using local materials and traditional design strategies, the renovation costs are reduced while enhancing the building's environmental adaptability. This method is not only applicable to Wenzhou's urban villages but can also be extended to other regions with similar climates, helping to address similar environmental issues.

Discussion

This study significantly improved the summer indoor comfort in urban villages of Wenzhou by applying a Sustainable Building Interior Design (SBID) approach that integrates vernacular architectural design strategies. These findings hold substantial practical significance and provide valuable guidance for Wenzhou's urban villages and similar regions.

Firstly, the research demonstrates the feasibility and effectiveness of combining traditional vernacular architectural strategies with modern sustainable building design. In densely built and resource-limited environments like Wenzhou's urban villages, traditional architectural methods often struggle to address the challenges of high summer temperatures. However, the SBID approach used in this study successfully lowered indoor temperatures and improved residents' quality of life by optimizing ventilation, shading, and insulation. This result indicates that the wisdom of vernacular architecture

still holds considerable potential in modern contexts, especially in coping with extreme climatic conditions.

Secondly, the research offers new ideas and models for building design in Wenzhou and other regions with similar climates. By incorporating local traditional architectural elements into modern designs, the study preserves cultural characteristics while enhancing the environmental adaptability of buildings. For other areas with similar climatic conditions and stages of urban development, this research provides a low-cost, high-efficiency building renovation solution that can be widely applied to urban villages, rural areas, and other underdeveloped regions.

Conclusion

This study explores and applies a Sustainable Building Interior Design (SBID) approach that incorporates vernacular architectural design strategies to provide an innovative solution for addressing summer indoor discomfort in urban villages of Wenzhou. The research confirms the feasibility of integrating traditional vernacular architectural wisdom with modern sustainable building design methods, demonstrating that this integration can effectively improve the indoor environmental quality of urban village buildings under high summer temperatures. Additionally, through specific case studies, the research proposes and applies a practical and adaptive SBID method, significantly enhancing the indoor comfort of the selected buildings. Finally, the study offers a replicable architectural design solution for other regions with similar climatic conditions, holding significant potential for broader application.

References

Attia, S., Hamdy, M., O'Brien, W., & Carlucci, S. (2013). Assessing gaps and needs for integrating building performance optimization tools in net zero energy buildings design. *Energy and Buildings, 60*, 110–124. https://doi.org/10.1016/j.enbuild.2013.01.016

He, S., Liu, Y., & Webster, C. (2010). Urban villages in China's rapid urbanization: Examining structural characteristics and human perceptions. *Habitat International, 34*(3), 242–252. https://doi.org/10.1016/j.habitatint.2009.11.002

Lai, L. W. C., Tao, J. L., & Lam, N. N. (2009). Relationship between indoor environment quality and sick building syndrome in public housing in Hong Kong. *Building and Environment, 44*(6), 1442–1448. https://doi.org/10.1016/j.buildenv.2008.08.001

Liu, Y., He, S., Wu, F., & Webster, C. (2010). Urban villages under China's rapid urbanization: Unregulated assets and transitional neighbourhoods. *Habitat International, 34*(2), 135–144. https://doi.org/10.1016/j.habitatint.2009.08.002

Pacheco, R., Ordóñez, J., & Martínez, G. (2012). Energy efficient design of buildings: A review. *Renewable and Sustainable Energy Reviews, 16*(6), 3559–3573. https://doi.org/10.1016/j.rser.2012.03.045

Qian, Q. K., Chan, E. H., & Khalid, A. G. (2015). Challenges in sustainable urban redevelopment in China: A case study of Wenzhou's urban villages. *Habitat International, 48*, 209–218. https://doi.org/10.1016/j.habitatint.2015.03.021

Song, Y., & Zenou, Y. (2012). Urban villages and housing values in China. *Regional Science and Urban Economics, 42*(3), 495–505. https://doi.org/10.1016/j.regsciurbeco.2011.10.006

Tian, L. (2008). The Chengzhongcun land market in China: Boon or bane? A perspective on property rights. *International Journal of Urban and Regional Research, 32*(2), 282–304. https://doi.org/10.1111/j.1468-2427.2008.00789.x

Yuan, J., Jin, Y., & Lu, Y. (2020). Health impact of living environment on the elderly in rural China. *Journal of Cleaner Production, 256*, 120445. https://doi.org/10.1016/j.jclepro.2020.120445

Zhang, X., Shen, L., & Wu, Y. (2011). Green strategy for gaining competitive advantage in housing development: A China study. *Journal of Cleaner Production, 19*(2–3), 157–167. https://doi.org/10.1016/j.jclepro.2010.08.005

Zuo, J., & Zhao, Z. Y. (2014). Green building research: Current status and future agenda. *Renewable and Sustainable Energy Reviews, 30*, 271–281. https://doi.org/10.1016/j.rser.2013.10.021