

Chapter 18

Building Health: Resilient Building Materials for Global Health and Sustainability

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Abstract

This research explores how locally produced, low-tech building materials can be reimaged as powerful tools for advancing public health and environmental resilience in low-resource settings. Grounded in a multi-national, interdisciplinary collaboration across architecture, civil engineering, entomology, and anthropology, the project investigates novel brick prototypes designed to improve thermal comfort and reduce exposure to mosquito-borne disease in regions facing the compounding challenges of climate change and poor housing infrastructure. Subtle changes to the brick's geometry can enhance its ability to efficiently absorb, store, and release heat. By also leveraging the dynamic properties of air to facilitate convective heat transfer, cool the body, and disrupt the flight of disease-carrying insects, early-stage testing demonstrates that the bricks can increase cross-ventilation, produce a perceptible cooling effect, and interfere with mosquito flight paths, offering potential as a passive vector control strategy while improving indoor comfort. The prototypes are designed to be replicable with regional materials and fabrication methods, supporting scalability in other tropical contexts. Beyond technical innovation, the project also serves as a platform for collaborative pedagogy and applied field research, engaging students in interdisciplinary, cross-cultural inquiry. By elevating the brick from a mere construction unit to a tool for climate resilience and public health, this work contributes to a broader reframing of sustainable infrastructure and material equity in global development, reimagining the relationship between architecture and health.

Keywords: *Low-tech Building Materials, Brick Prototypes, Thermal Comfort, Mosquito-borne Disease, Global Development*

Introduction

Earthen bricks are the most widely used building material in the world, with one-third of the global population living in buildings constructed wholly or partially from earth¹. Their ubiquity reflects low cost, accessibility, and adaptability across diverse climates, alongside properties such as thermal regulation, insect resistance, durability, and ease of maintenance. In rapidly urbanising sub-Saharan Africa, however, demand for 'modern' homes of concrete or steel – materials that symbolise permanence and social mobility – has grown despite their frequent unsuitability to local climates and

¹Mircea Barnaure et al., "Earth Buildings with Local Materials: Assessing the Variability of Properties Measured Using Non-Destructive Methods," *Construction and Building Materials* 281 (April 2021): 122613, <https://doi.org/10.1016/j.conbuildmat.2021.122613>.

high costs of construction and upkeep. These material choices are not merely aesthetic but carry direct implications for health, where poorly suited construction can exacerbate vulnerability to disease.

The case of malaria exemplifies this link between material precarity and public health. Despite decades of intervention, malaria remains one of the most persistent global health challenges, with over 90% of cases and fatalities concentrated in sub-Saharan Africa². Control strategies such as long-lasting insecticide-treated nets (LLINs) and indoor residual sprays (IRS) have saved millions of lives, but their efficacy is undermined by insecticide resistance, mosquito behavioural adaptation, and climate variability³. Bed nets also reduce airflow and create discomfort, discouraging consistent use. Housing quality, therefore, has a direct and underappreciated role in shaping exposure. Yet housing has largely fallen out of the remit of global health⁴, where interventions tend to take the form of scalable commodities, often detached from material and social realities.

Today, climate change, population growth, rapid urbanisation, migration, and most recently, the COVID-19 pandemic, have renewed attention to housing as a critical determinant of health inequalities worldwide. At the same time, sub-Saharan Africa is entering an era of unprecedented growth, with the majority of its 2050 building stock yet to be built. This convergence of urgent health challenges and rapid construction growth presents a unique opportunity to reimagine the humble brick not simply as a structural unit, but as an instrument for climate resilience and disease prevention. This research explores how incremental innovations in brick geometry can enhance ventilation, improve thermal comfort, and reduce mosquito exposure, positioning masonry as an accessible strategy at the intersection of architecture and public health.

Background

Malaria and Housing Quality

Housing improvements, such as closing entry points and enhancing ventilation, offer a neglected but vital avenue for reducing exposure. Windows and eaves, while essential for daylight and ventilation, are also primary entry points for mosquitoes. Surveys in southern Tanzania found that while most households attempted to screen windows, nearly 75% of coverings were compromised, and over half of eaves were left open, as shown in Figure 1, significantly increasing mosquito density indoors^{5,6}. In some cases, households brick up windows entirely until resources are available to install proper screening and safety bars, producing dark, poorly ventilated interiors. These findings highlight the persistent challenge

²Eve Worrall et al., “Is Malaria a Disease of Poverty? A Review of the Literature,” *Tropical Medicine & International Health* 10, no. 10 (2005): 1047–59, <https://doi.org/10.1111/j.1365-3156.2005.01476.x>.

³Christine Giesen et al., “The Impact of Climate Change on Mosquito-Borne Diseases in Africa,” *Pathogens and Global Health* 114, no. 6 (2020): 287–301, <https://doi.org/10.1080/20477724.2020.1783865>.

⁴Philippa Howden-Chapman et al., “Review of the Impact of Housing Quality on Inequalities in Health and Well-Being,” *Annual Review of Public Health* 44, no. 1 (2023): 233–54, <https://doi.org/10.1146/annurev-publhealth-071521-111836>.

⁵Ramadhani M. Bofu et al., “The Needs and Opportunities for Housing Improvement for Malaria Control in Southern Tanzania,” *Malaria Journal* 22, no. 1 (2023): 69, <https://doi.org/10.1186/s12936-023-04499-1>.

⁶Monicah M. Mburu et al., “Impact of Partially and Fully Closed Eaves on House Entry Rates by Mosquitoes,” *Parasites & Vectors* 11, no. 1 (2018): 383, <https://doi.org/10.1186/s13071-018-2977-3>.

of balancing thermal comfort and disease prevention within resource-constrained housing. Against this backdrop, this research turns to the brick itself as a site of intervention.



Figure 1: Collection of window treatments observed in and around Ifakara, Tanzania, 2023.

Ventilated Bricks as an Incremental Innovation

Controlled airflow through the building envelope reframes the wall from a sealed boundary to a responsive membrane capable of regulating heat, air, and moisture under changing environmental conditions. Subtle modifications to brick geometry can integrate thermal performance, ventilation, and vector control into a single building component. Unlike operable windows, ventilated bricks provide continuous airflow while excluding insects, rain, and noise, extending research on permeable envelopes into a familiar and scalable masonry system.

Emerging evidence in building science and fluid dynamics supports this approach. Studies demonstrate that small degrees of wall permeability can enhance turbulence and convective exchange, regulate heat and moisture transfer, and filter airborne particulates^{7,8,9}. In addition to improving thermal comfort

⁷C. Manes et al., “Turbulent Boundary Layers over Permeable Walls: Scaling and near-Wall Structure,” *Journal of Fluid Mechanics* 687 (November 2011): 141–70, <https://doi.org/10.1017/jfm.2011.329>.

⁸Salmaan Craig and Jonathan Grinham, “Breathing Walls: The Design of Porous Materials for Heat Exchange and Decentralized Ventilation,” *Energy and Buildings* 149 (August 2017): 246–59, <https://doi.org/10.1016/j.enbuild.2017.05.036>.

⁹Elisa Di Giuseppe et al., “Thermal and Filtration Performance Assessment of a Dynamic Insulation System,” *Energy Procedia*, 6th International Building Physics Conference, IBPC 2015, vol. 78 (November 2015): 513–18, <https://doi.org/10.1016/j.egypro.2015.11.721>.

and indoor air quality, turbulence generated within permeable systems has the potential to disrupt mosquito flight, while air pockets embedded in masonry assemblies can function as natural insulators, moderating diurnal temperature fluctuations.

Reframing walls as responsive membranes positions the brick not only as a structural unit but as an environmental mediator. Incremental, locally adapted design changes of this kind may provide enduring public health benefits without requiring radical transformations of domestic architecture.

Results: Brick as a Public Health Instrument

Recent design studios at the University of North Carolina, Charlotte, have provided proof-of-concept explorations into how bricks might be reimagined as public health tools. As shown in Figure 2, these prototypes represent early-stage, exploratory design exercises rather than empirical test results. They served to generate hypotheses and inform subsequent research phases focused on measurable thermal and entomological performance. These studios brought together architecture and engineering students with Tanzania-based researchers, including entomologists and social scientists, to co-design a curriculum that examined the ecological, cultural, and thermodynamic dimensions of housing in rural Tanzania. This process underscored the value of design-led, research-driven collaboration as a model adaptable to regions where mosquito-borne disease remains a persistent threat. Building on these foundations, the work is being extended through collaborations with the University of Dar es Salaam (Tanzania) and the University of Oxford (UK), advancing a hypothesis-driven pedagogy that links climate, health, and material performance. The following section highlights two prototypes that illustrate particularly promising directions.



Figure 2: Select student prototypes (2021-2025) illustrating early design explorations.

Prototype 1: The Vortex Brick

Michael Serrano's 'Vortex Brick', shown in Figure 3, draws on the aerodynamic principle of vortex shedding, where alternating low-pressure vortices form downstream of an object. The design explores how localised turbulence could disrupt mosquito flight while sustaining natural ventilation. Internal geometry creates convective pockets of still air, encouraging mosquitoes to exit through the path of least resistance. To stabilise airflow, the brick was intended for staggered installation within a cavity wall system. While preliminary, the prototype demonstrates how redirecting turbulent airflow might simultaneously reduce mosquito penetration and enhance passive cooling.

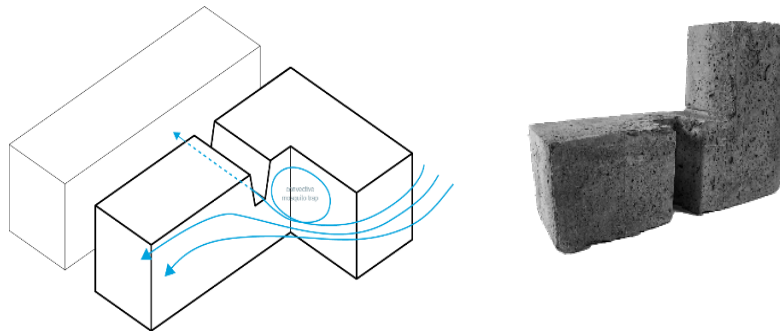


Figure 3: Vortex Brick by Michael Serrano, 2023.

Prototype 2: The Venturi Block

Nathan Smith's 'Venturi Block', shown in Figure 4 and Figure 5, applies the Venturi effect, in which constricted pathways increase air velocity and reduce pressure for a cooling effect. This modular unit promotes convective airflow while generating turbulence disruptive to mosquito flight. Preliminary mock-ups suggested constrictions of about 2.5 cm to balance airflow and constructability. Like the Vortex Brick, the design illustrates how aerodynamic behaviour can be embedded into load-bearing units without major changes to production, yielding potential gains in ventilation and vector control.

Toward Research-Led Innovation

Although still at an early stage and not yet subject to systematic testing, these student-led prototypes point to promising directions for geometry-based modifications in masonry systems. Current research builds on these conceptual explorations by applying empirical methods to assess thermal, airflow, and structural performance under both controlled and field conditions. A critical challenge lies in questions of commercial viability, where the engagement of local brickmakers and builders is indispensable. Centring their expertise opens pathways to interventions that are not only technically effective but also culturally attuned and socially relevant. When brickmakers and masons are equipped with knowledge and tools, they move beyond being implementers to become co-designers of health-promoting housing innovations. This shift reframes global health from top-down, technocratic models toward decentralised practices in which communities actively shape their built environments and, in turn, their health futures.

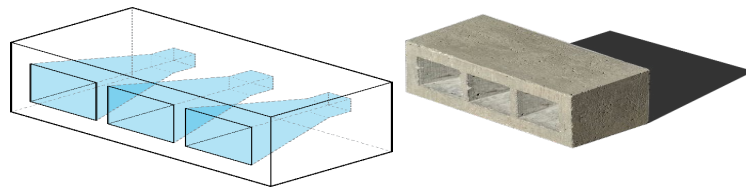


Figure 4: Venturi Block by Nathan Smith, 2021.

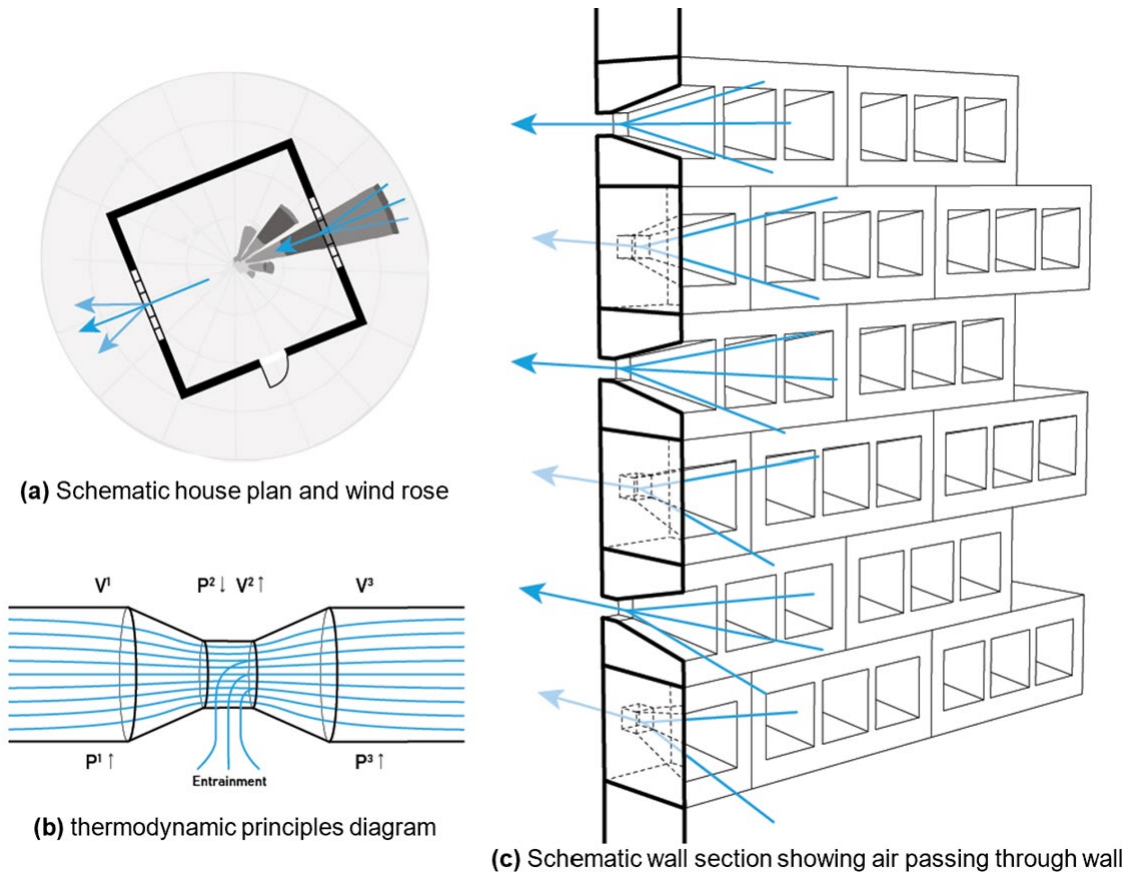


Figure 5: Schematic Details of Venturi Block.

Conclusion: New Foundations for Global Health Markets

These brick prototypes are not proposed as stand-alone solutions to disease control but rather as catalysts for new ways to link public health, urban design, and architecture. Housing must satisfy demands for comfort, convenience, and cultural identity, yet rapidly deployed “modern” typologies, even when subsidised, are often rejected because they fail to align with lived domestic practices. Materials carry cultural significance, defining the visible surfaces of homes and serving as symbols of history, tradition, and aspiration.

Malaria provides both a case study and a gateway, demonstrating an entry point for reconceptualising bricks not merely as building components but as instruments for reducing exposure and improving comfort. By embedding mosquito-resistant design features into masonry units, bricks can evolve from structural elements into health-promoting technologies. Subtle changes to geometry can alter thermal capacity, convective properties, and airflow regulation, with direct implications for comfort and disease prevention.

This approach signals a broader shift in global health. Rather than relying on top-down, technocratic solutions, locally driven interventions grounded in available materials and builder expertise can deliver scalable, culturally attuned, and community-led improvements. Such strategies address immediate risks while laying the foundation for enduring gains in housing quality and resident well-being.

The humble brick thus emerges as a disruptive technology, challenging reliance on chemical or high-tech interventions and redirecting attention to everyday materials that structure domestic life. The central question is whether reimagined bricks can help articulate a new global health vision of the home – one aligned with the incremental nature of house construction and attentive to comfort as a determinant of health. While empirical validation is still needed, the potential is evident. Modest adaptations to brick design could regulate airflow, enhance thermal comfort, deter mosquitoes, and empower communities to be active participants in shaping resilient futures.

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