Biomimetic Ventilation in Sub-Saharan Urban Housing

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ABSTRACT

This article examines how a termite-mound-inspired passive ventilation strategy can address indoor thermal comfort and energy-efficiency challenges in multi-storey residential buildings within Yaoundé's humid equatorial climate. Focusing on the "Climatic Termite Mound" concept developed for a five-storey (R+5) collective housing project in the Olembé district, the study investigates how convective stack-effect principles observed in termite mounds can be translated into architectural chimneys, façade screens, and roof systems suitable for dense urban housing. Adopting a single embedded case-study design, the research analyses a residential building conceived through a combined Generative Artificial Intelligence (GenAI) and Building Information Modelling (BIM) workflow for a real plot in Olembé 2. Site climatic data were processed using Climate Consultant to characterise passive-cooling potential, while four biomorphic design variants generated via GenAI were evaluated against sunlight, ventilation, siting, accessibility, and programme criteria. The selected variant was then modelled in BIM to size two central climatic chimneys using air-change-rate and stack-effect calculations, alongside embodied energy, CO_2, and cost assessments. The resulting paired central chimney system (4.30 m² each), combined with high-level transoms, perforated brick screens, and a multifunctional roof, reproduces the termite mound's convective loop, extracting warm air at approximately three air changes per hour without mechanical assistance. East–west orientation and balcony shading further limit solar gain while exposing long façades to dominant winds, although structural concrete and steel still contribute over 93% of the estimated 1,356 tonnes of incorporated CO_2. Ultimately, this article contributes one of the first documented applications of termite-mound biomimicry to Central African multi-storey housing, extending the Eastgate Centre precedent to Yaoundé's climate, while also demonstrating how GenAI-assisted variant generation—cross-checked against bioclimatic criteria—can operationalise biomimicry early in the design process, offering a transferable framework for climate-responsive densification across Sub-Saharan African cities.

Keywords: Biomimicry; termite mound; passive ventilation; bioclimatic design; Sub-Saharan Africa; Yaoundé; high-density housing; thermal comfort

BACKGROUND

Cameroon's urban population has grown rapidly over the past three decades, and nowhere is this more visible than in Yaoundé, the political and administrative capital, where peripheral districts such as Olembé are being absorbed into the built-up city under the pressure of housing demand (UN-Habitat, 2022). Olembé occupies a strategic position in the city's urban-planning documents: it is classified as a residential-densification zone whose non-planned habitat is expected to be progressively restructured and intensified by 2035, and it already hosts a 60,000-seat stadium, a produce market and a coach station that are drawing commercial activity and new residents to the area (Tene Fosso, 2026). Yet the collective housing being produced to absorb this growth is, in the majority of documented cases, still designed with limited regard for the equatorial climate in which it sits. A recent survey of urban housing in Cameroon found that the dominant typology remains a reinforced-concrete frame with a corrugated-metal roof and little provision for cross-ventilation, a combination that traps solar heat gain and pushes households toward energy-intensive mechanical cooling wherever it is affordable (Mbani Menguissa, 2025). The stakes of this design inertia are rising: recent climate projections for Yaoundé anticipate daytime temperatures reaching 38°C by 2030, driven by the loss of urban vegetation and the proliferation of heat-absorbing hard surfaces (Mbevo Fendoung, 2025).

Passive, climate-responsive design is not a new idea in the region's architectural discourse, but its instruments — orientation, shading, thermal mass, natural ventilation — are usually applied piecemeal, informed by generic bioclimatic guidance rather than by strategies calibrated to a specific plot and building height. Biomimicry offers one route to a more integrated strategy, because it treats an entire physiological system, rather than a single climatic variable, as the design reference. The termite mound is the most widely cited biomimetic precedent in tropical architecture, largely because of the Eastgate Centre in Harare, Zimbabwe, an office and retail building whose rooftop chimneys and exposed thermal mass were explicitly modelled on the convective ventilation of termite mounds and which is reported to use roughly a third less energy than comparable air-conditioned buildings in the same city (Pearce, n.d.). Three decades after Eastgate, however, the termite mound has rarely been re-examined as a model for multi-storey collective housing in a humid equatorial climate, as opposed to the semi-arid highveld climate in which Eastgate was built and in which the temperature swing between day and night is considerably larger. Yaoundé's climate — warm year-round, humid, and ventilated by comparatively gentle winds — poses a different set of constraints on a mound-inspired system, and it is these constraints, rather than the mound's iconic form, that need to be engaged with if biomimicry is to be more than a formal gesture.

This article addresses that gap using a documented case: a five-storey (R+5) residential building designed for a plot in Olembé 2, Yaoundé, through a combined GenAI and BIM design process, in which a Climatic Termite Mound concept was generated, selected ahead of three competing biomorphic variants, and developed into a buildable ventilation system (Tene Fosso, 2026). The article analyses how that system translates termite-mound convection into a central chimney core, a perforated envelope and a multifunctional roof, and asks what the case implies for climate-responsive densification elsewhere in Sub-Saharan Africa's high-density urban housing.

LITERATURE REVIEW

2.1 Biomimicry, Termite-Mound Physics and Passive Ventilation

Biomimicry in construction is generally described across three levels of engagement: mimicking an organism's form, mimicking its behaviour or process, and mimicking the ecosystem it belongs to (French and Ahmed, 2010). Termite-mound biomimicry has mostly operated at the first two levels — copying the mound's silhouette or its apparent chimney effect — while the underlying physiology has been revised substantially since it entered architectural discourse. Lüscher (1961) proposed that some fungus-growing termite species regulate mound temperature and gas exchange through a thermosiphon: metabolic heat from the colony's fungus gardens warms air that rises through a network of vertical flues, drawing fresh air in through basal galleries in a continuous convective loop. This thermosiphon reading is the one most often credited with inspiring Eastgate's chimneys (Pearce, n.d.).

Subsequent research has complicated that account. Turner and Soar (2008) argued that the mound functions less like a static duct system and more like a lung — a porous, actively maintained “exterior physiology” that the colony continuously remodels — and cautioned that buildings modelled only on the mound's outward form, Eastgate included, capture an analogy rather than the underlying mechanism, a critique framed as moving “beyond biomimicry” toward genuinely responsive envelopes. Working with high-resolution scans and computational fluid dynamics, King, Ocko and Mahadevan (2015) showed empirically that the dominant ventilation mechanism in the mounds they studied is not a constant metabolic updraught but a tidal, wind-independent flow driven by the daily oscillation between the mound's exterior and interior temperature: as the mound wall heats and cools faster than the nest core, air is alternately pushed in and drawn out through the porous surface over the diurnal cycle, flushing respiratory CO_2 even on still days. The architectural implication is significant: what should be mimicked is not a single fixed chimney but a distributed porosity that exploits the daily swing between exterior and interior conditions, of which a central chimney is only one component.

Passive-ventilation theory in mainstream bioclimatic design converges with this picture. Olgyay (1963) and Givoni (1998) both treat stack-driven and wind-driven ventilation as complementary, not interchangeable, mechanisms: buoyancy (stack) ventilation depends on height and temperature differential and works even in low or still-wind conditions, while cross-ventilation depends on façade porosity and prevailing wind pressure. Givoni (1998) further shows that well-designed solar shading alone can lower indoor temperatures by 3–5°C without mechanical cooling, and Fathy (1986) documents how vernacular hot-climate architecture combines wind-catching towers with heavy, high-inertia envelopes to the same end. Termite-mound biomimicry, read through King, Ocko and Mahadevan's (2015) findings, essentially formalises the buoyancy half of this classical toolkit and adds a physiological argument for oversizing and distributing stack elements rather than relying on wind pressure alone — a point directly relevant to a site where prevailing winds are only moderate, as discussed below.

2.2 Bioclimatic Design and the Sub-Saharan Urban Housing Challenge

Across Sub-Saharan Africa, the building stock produced to house rapid urban growth is frequently at odds with the bioclimatic literature summarised above. UN-Habitat (2022) frames this as a structural mismatch: cities grow faster than the planning and building-control capacity needed to guide their form, so housing is delivered through informal or semi-formal channels in which construction cost and speed dominate design decisions and climate performance is an afterthought. In Cameroon specifically, Mbani Menguissa (2025) documents a widely replicated urban housing typology — reinforced-concrete frame, corrugated-metal roof, minimal openings — that offers little of the shading, thermal mass or ventilation that Givoni (1998) and Fathy (1986) identify as basic passive levers; the same study reports that bio-based envelope materials combined with east–west orientation, controlled openings and shading can reduce indoor overheating by four to eight degrees Celsius in the Cameroonian context, evidence that the passive toolkit transfers well locally when it is actually applied. Kibert (2016) situates this challenge within the broader sustainable-construction agenda, arguing that climate-responsive envelope and ventilation design is one of the lowest-cost levers available for reducing a building's operational energy and carbon footprint, precisely because it substitutes design decisions for mechanical plant rather than adding cost on top of it.

Termite-mound biomimicry could, in principle, supply a coherent organising idea for this passive toolkit, but the precedent literature is narrow. Eastgate remains the reference case three decades after its completion, and it is a single-volume commercial building in Harare's semi-arid highveld climate, where large diurnal temperature swings are exactly the resource that King, Ocko and Mahadevan's (2015) mechanism exploits. Yaoundé's climate is a different proposition: warm and humid year-round, with a comparatively narrow daily temperature range and moderate prevailing winds rather than the strong, reliable air movement that supports wind-assisted cross-ventilation. High ambient humidity also limits evaporative components of passive cooling, and it means the temperature differential available to drive buoyancy ventilation is smaller and less predictable than in a drier climate. Nor has the mound been tested, in the published literature, as a strategy for a multi-storey, multi-household residential block, where the ventilation core must serve stacked common circulation spaces rather than a single office atrium. These two gaps — climate transfer from semi-arid to humid equatorial conditions, and typological transfer from single-volume commercial space to stacked collective housing — frame the case study analysed in the remainder of this article.

RESEARCH METHODS

3.1 Case-Study Design, Site and Biomimetic Design Process

This article analyses a single embedded case study: a five-storey (R+5) collective residential building designed for a plot in the Olembé 2 sub-district of Yaoundé (approximately 3.9°N, 11.5°E, at an elevation of roughly 750–770 m on a locally elevated, well-drained plateau) as part of an academic design-research project combining BIM and GenAI (Tene Fosso, 2026). The building comprises a ground floor and five upper residential levels, each accommodating four four-room (“T4”) apartments, for a total of twenty dwelling units and a built floor area of 4,381.56 m² extracted from the BIM model.

The design process followed four stages. First, a site and climate diagnostic combined field survey data with hourly weather-file analysis in Climate Consultant 6.0, using the Yaoundé-Nsimalen TMYx station record, to characterise temperature range, rainfall, solar radiation and wind (Milne, 2017). Second, an architectural programme was defined from the apartment mix and the applicable urban-planning constraints for the site's residential zone. Third, GenAI was used to generate several biomorphic massing concepts from a single prompt set encoding the site's orientation, solar path, dominant wind direction, natural-ventilation potential and the requirement to respond to a tropical humid climate; four variants — a canopy-inspired envelope, a termite-mound-inspired ventilating core, a breathing-patio scheme, and a ring-shaped “urban nest” — were produced and screened against sunlight exposure, natural-ventilation performance, siting efficiency, accessibility and programme compatibility (Section 4.2). The Climatic Termite Mound variant was carried forward on this basis. Fourth, the selected variant was developed and coordinated in a BIM environment (Autodesk Revit), used both to resolve the architecture in three dimensions and to extract the quantitative outputs reported in Section 4 — floor areas, material take-offs, embodied-energy and incorporated-CO2 estimates, and a preliminary cost estimate. This use of BIM to test design-stage decisions — orientation, massing and material choice — against quantifiable performance criteria before construction follows an established precedent in the literature, in which a comparable Revit-based workflow was used to quantify the energy implications of building orientation for a case-study dwelling (Abanda and Byers, 2016).

Because the design originates from a single, real, buildable project rather than a hypothetical or parametric study, its findings should be read as an illustrative demonstration of feasibility and design logic rather than a validated performance benchmark; this limitation is returned to in Section 5.

3.2 Sizing and Verification of the Passive-Ventilation System

The chimney core at the centre of the design — the element most directly derived from the termite-mound analogy — was sized using two calculations rather than dynamic simulation. First, the required air-renewal flow rate for the building's common circulation spaces (entrance hall, landings and stairwells) was derived from $Q = V \times N$, where V is the volume of the spaces to be ventilated and N is the target air-change rate, set at three volume-changes per hour, a value considered appropriate for naturally ventilated common areas in collective housing. Second, this flow rate was checked against the stack-effect capacity of the chimney using $Q = Cd \cdot A \cdot \sqrt{2gH\Delta T/T}$, where Cd is the discharge coefficient, A is the chimney's effective cross-sectional area, H is the effective stack height, ΔT is the temperature differential between indoor and outdoor air, and T is the mean absolute temperature. The two climatic chimneys built into the design each measure 1.84 m × 2.34 m in plan, giving a cross-section of 4.30 m² — deliberately larger than the section obtained from the calculation above, in order to stabilise the draught, reduce head losses, and provide a performance margin given Yaoundé's comparatively modest diurnal temperature differential (Section 2.2).

This is a steady-state sizing check rather than an hourly dynamic thermal simulation, and the embodied-energy and CO2 figures reported in Section 4.5 rely on generic material coefficients drawn from international databases — principally the University of Bath's Inventory of Carbon and Energy, ICE v2.0 (Hammond and Jones, 2011), alongside INIES, Ecoinvent and MIPROMALO — rather than locally measured data. Because the ICE coefficients were developed from UK manufacturing and construction processes, and have previously been applied on the same basis to Cameroonian case studies (Abanda et al., 2014), the embodied-energy and incorporated-CO2 values reported here should be read as relative, comparative indicators of the building's material footprint rather than as absolute, locally verified measurements. No post-occupancy thermal or energy monitoring has yet been carried out. These constraints of the underlying design study are discussed further in Section 5.

FINDINGS

4.1 Climatic and Site Ventilation Potential of Olembé, Yaoundé

Yaoundé experiences an equatorial climate moderated by the hills bordering the city to the west and north-west, producing four unevenly distributed seasons: a long dry season from December to February, a short rainy season from March to June, a short dry season in July and August, and a long rainy season from September to November (Tene Fosso, 2026). Mean monthly minimum temperatures vary narrowly between 18°C and 22°C, and mean monthly maxima between 28°C and 32°C, with a recorded extreme high of 33°C in February and a recorded extreme low of 16.5°C in January (Figure 1) — a climate that is warm and remarkably stable across the year, but whose narrow diurnal range limits the temperature differential available for buoyancy-driven ventilation relative to a drier, more thermally variable climate. Annual rainfall averages around 1,700 mm, and relative humidity averages 80%, fluctuating between 35% and 98% over the course of a day; global solar radiation on a horizontal surface reaches 5.0–6.4 kWh/m²/day outside overcast periods.

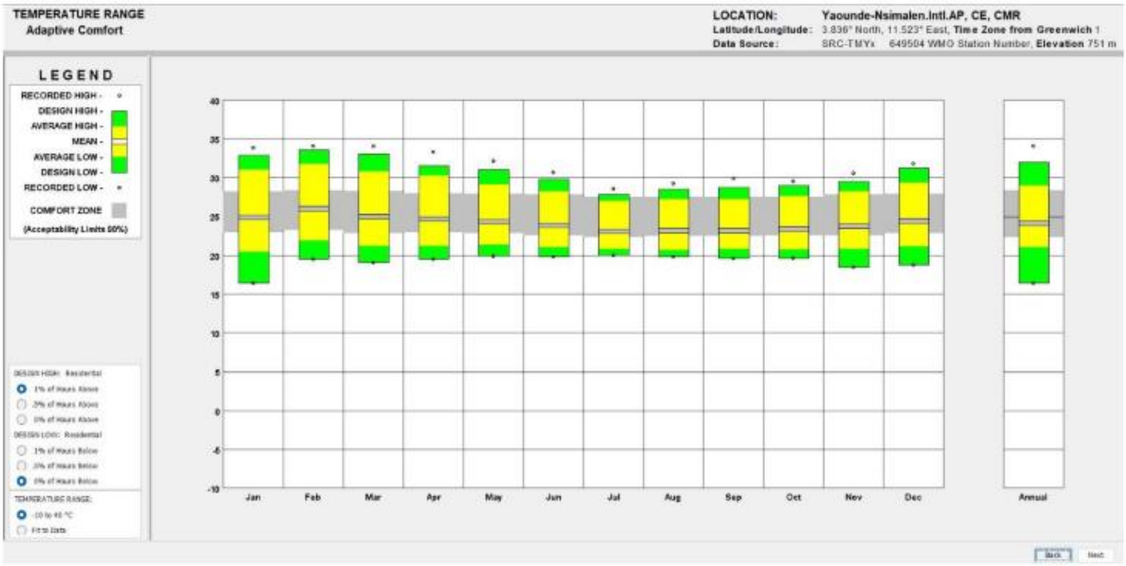

Figure 1. Monthly temperature range for Yaoundé, showing comfort-zone bounds and recorded/design extremes. (Data source: Climate Consultant 6.0, Yaoundé-Nsimalen TMYx station; Milne, 2017; reproduced from Tene Fosso, 2026.)

Wind data extracted for the Yaoundé-Nsimalen weather station show prevailing winds from the west and south-west, at moderate speeds of 2–4 m/s and only occasionally reaching around 6 m/s (Figure 2). This matters directly for the ventilation strategy: moderate, non-dominant wind pressure cannot, on its own, guarantee reliable cross-ventilation throughout a multi-storey block, which is one reason a buoyancy-led system was prioritised over a purely wind-driven one.

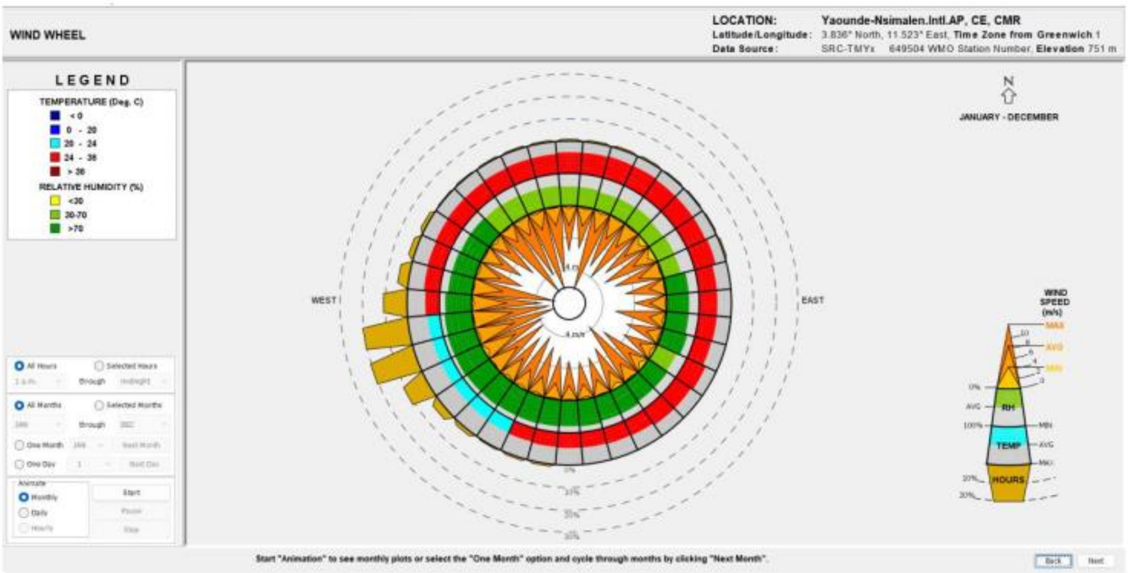

Figure 2. Annual wind wheel for Yaoundé, showing dominant wind directions, speed and associated temperature/humidity bands. (Data source: Climate Consultant 6.0; Milne, 2017; reproduced from Tene Fosso, 2026.)

At the scale of the plot itself, the site occupies a locally elevated, well-drained position on Olembé's undulating plateau (630–770 m across the wider district), found to offer better exposure to the dominant winds than the lower, more enclosed valley areas nearby; the site analysis mapped a favourable ventilation corridor running directly across the building plot from the west and south-west (Figure 3). Together, the climate and site analyses establish the two design constraints the case study had to resolve: a comfortable but thermally narrow climate that limits passive stack performance, and a site with only moderate, if favourably oriented, wind resources —

conditions under which a distributed, buoyancy-oriented strategy modelled on the termite mound is arguably better matched than a purely wind-catching one.

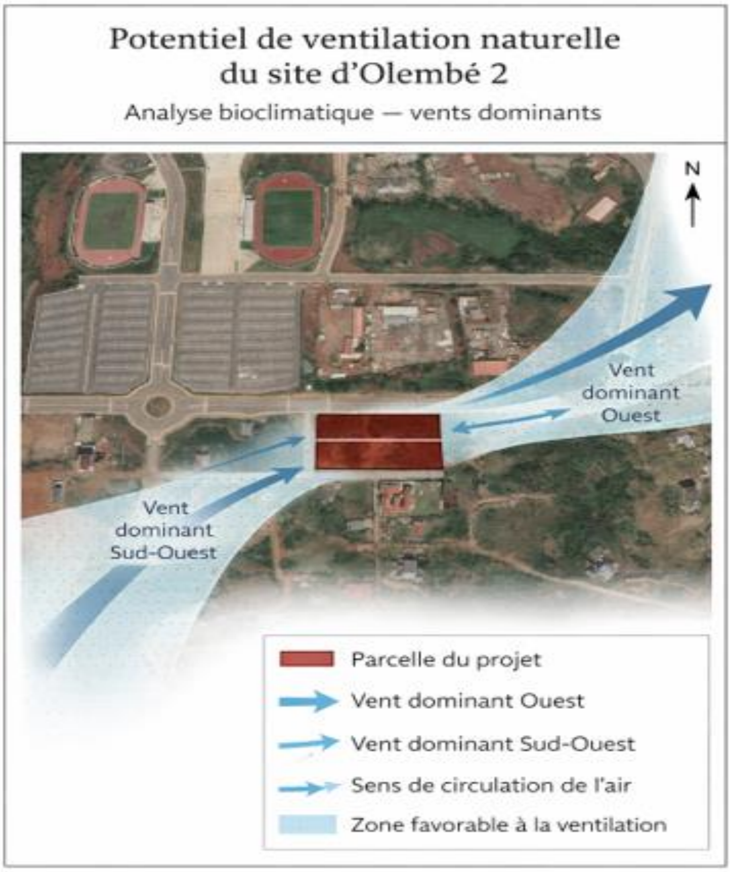

Figure 3. Natural-ventilation potential of the Olembé 2 site, showing the project plot's exposure to the dominant west and south-west winds. (Source: Tene Fosso, 2026.)

4.2 Comparative Appraisal of Biomorphic Design Variants

Four GenAI-generated variants were appraised against the site's sunlight, ventilation, siting, accessibility and programmatic conditions (Table 1). The canopy-inspired variant scored highest on solar control, using balconies, brise-soleil and vegetation as a filtering envelope, but only moderately on natural ventilation. The breathing-patio variant organised the plan around a central void to maximise daylight and cross-ventilation but scored weaker on site fit, since the void reduced usable footprint efficiency. The urban-nest variant arranged dwellings in a protective ring around a shared courtyard, favouring community life and architectural identity, but without a dedicated mechanism for extracting warm air from the building's core. The Climatic Termite Mound variant was appraised as the strongest performer on natural ventilation, siting and programme compatibility, and joint-strongest overall, because its central ventilating core, thermal chimney and porous façade directly exploited the dominant winds identified in Section 4.1 while accommodating the four-apartment-per-floor plan efficiently. This variant was therefore selected for development.

Table 1. Comparative appraisal of four GenAI-generated biomorphic design variants against site-specific bioclimatic and programmatic criteria. (Source: adapted from Tene Fosso, 2026.)

Design variant	Sunlight exposure	Natural ventilation	Site fit	Accessibility	Programme fit	Overall rating
Canopy-inspired residence	Excellent	Good	Good	Good	Good	Excellent

Design variant	Sunlight exposure	Natural ventilation	Site fit	Accessibility	Programme fit	Overall rating
Climatic Termite Mound	Good	Excellent	Excellent	Excellent	Excellent	Excellent
Breathing Patio	Good	Excellent	Fair-to-good	Good	Good	Good
Urban Nest	Good	Good-to-excellent	Good	Good	Good	Good-to-excellent

4.3 The Climatic Chimney: A Termite-Mound-Inspired Ventilation Core

The design's central move borrows directly from the convective ventilation mechanism attributed to termite mounds: warm air rises through vertical flues and is expelled at the top, while cooler air is drawn in near the base through lateral galleries, sustaining a continuous loop without mechanical assistance (Figure 4).

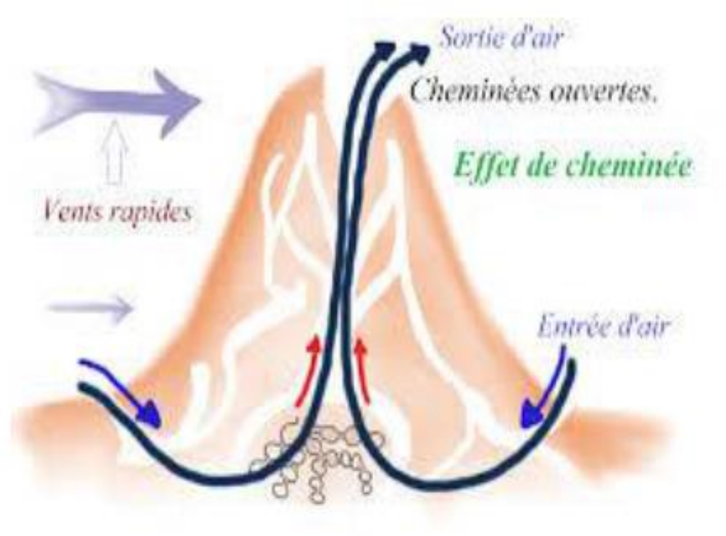

Figure 4. The convective ventilation principle attributed to termite mounds: warm air rises through open flues (chimney effect) while cool air is drawn in through basal galleries. (Source: reproduced in Tene Fosso, 2026.)

In the building, this translates into two central climatic chimneys that run the full height of the block, from the ground-floor entrance hall to a ventilated cap above roof level (Figures 5 and 6). The building's principal axis is oriented close to east–west, which limits direct solar penetration through the two long façades while placing those façades — where most apartment openings sit — in line with the dominant south-westerly and westerly winds identified in Section 4.1. At each floor, high-level ventilation transoms above the landings capture warm air that collects beneath the ceiling and channel it toward the two chimneys before it is expelled at roof level, reproducing at building scale the basal-gallery-to-flue path described for the mound.

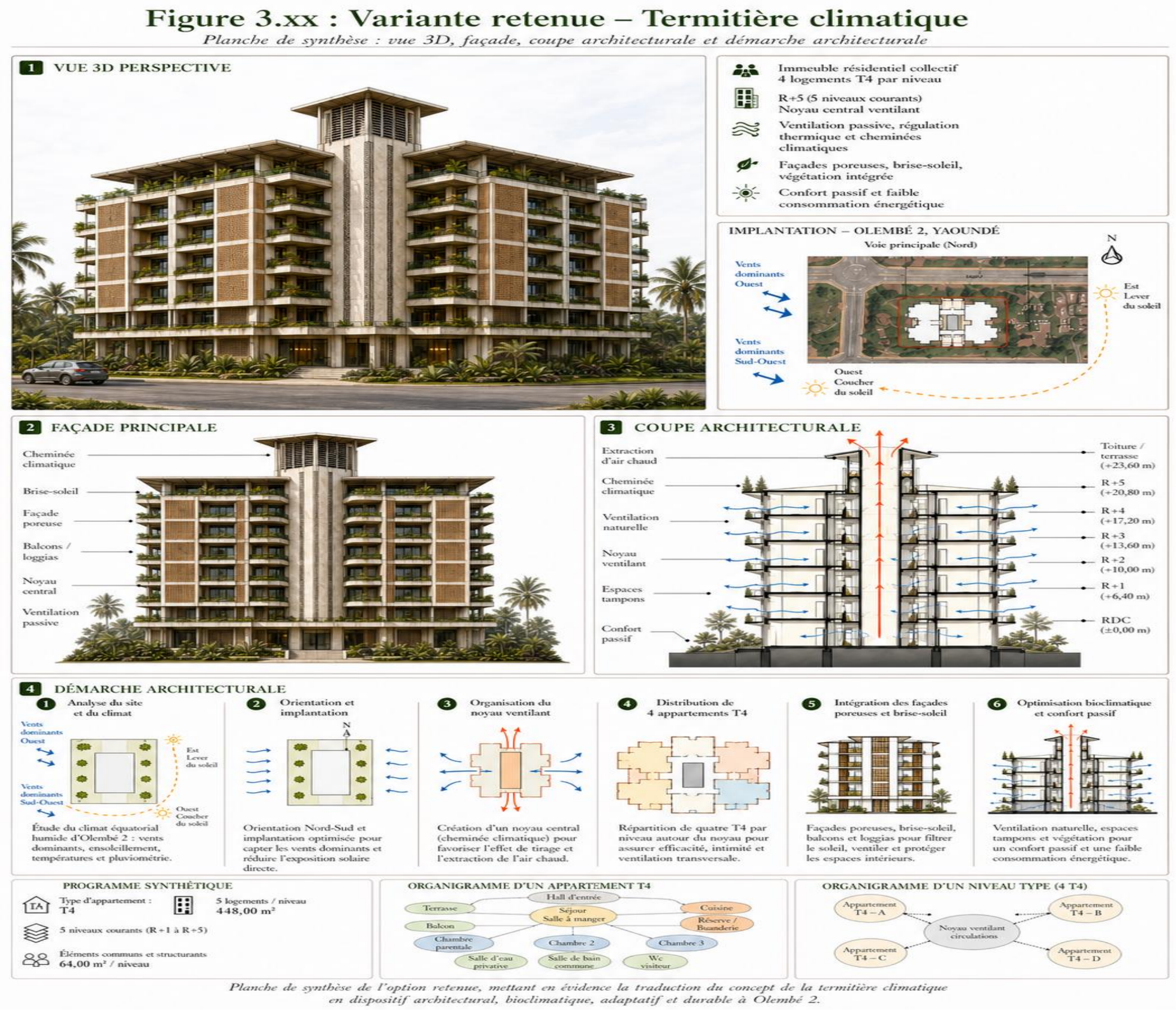

Figure 5. Architectural translation of the Climatic Termite Mound concept: massing, façade and site-plan synthesis of the selected design variant. (Source: Tene Fosso, 2026.)

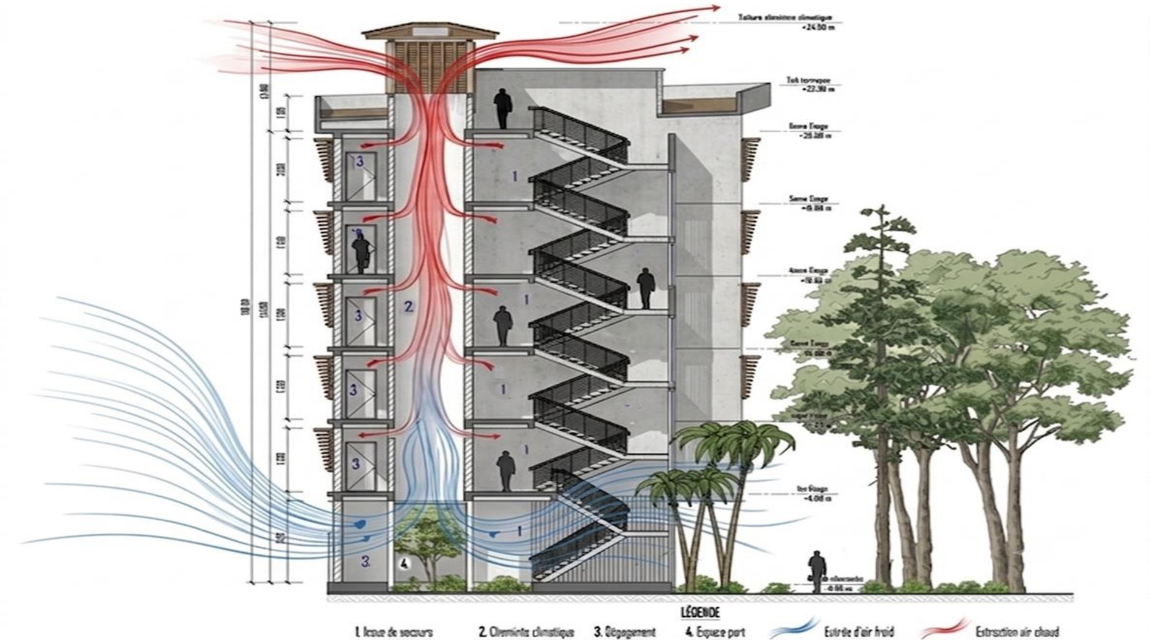

Figure 6. Vertical section showing the path of warm-air extraction (red) and cool-air intake (blue) through the building's central climatic chimneys. (Source: Tene Fosso, 2026.)

The chimneys were deliberately oversized relative to the minimum cross-section implied by the calculation in Section 3.2, a decision that responds directly to the constraint identified in Section 4.1: because Yaoundé's diurnal temperature differential is comparatively narrow, the design compensates by maximising chimney cross-section and stack height rather than relying on a large ΔT, in effect substituting geometry for climate the way the mound substitutes a large, thermally massive structure for the modest day–night swing on the savanna. The material analogy is treated deliberately as well: mounds are built from locally available clay, sand and termite saliva, and the building's non-structural walls use compressed earth blocks, stone, timber and bamboo rather than fired brick or conventional concrete block — materials whose thermal inertia contributes to buffering internal temperature swings and whose local sourcing echoes the mound's reliance on material found on site.

4.4 Envelope Strategies: Perforated Screens, Solar Shading and the Multifunctional Roof

Two further envelope strategies extend the chimney's effect across the façade and roof. First, bands of perforated ("claustra") brickwork are set into the upper portion of the façades immediately below the roofline (Figure 7). The voids between the bricks let warm air that has accumulated under the ceiling escape by the same stack effect that drives the central chimneys, while drawing in cooler replacement air through lower façade openings; the detail also gives the building a distinct architectural identity legible as a direct reference to the termite mound's porous outer wall. Second, balconies attached to the living rooms act as a solar filter, intercepting direct radiation before it reaches the glazed openings and reducing overheating risk in spaces used throughout the day, consistent with the 3–5°C reduction Givoni (1998) attributes to well-designed shading.

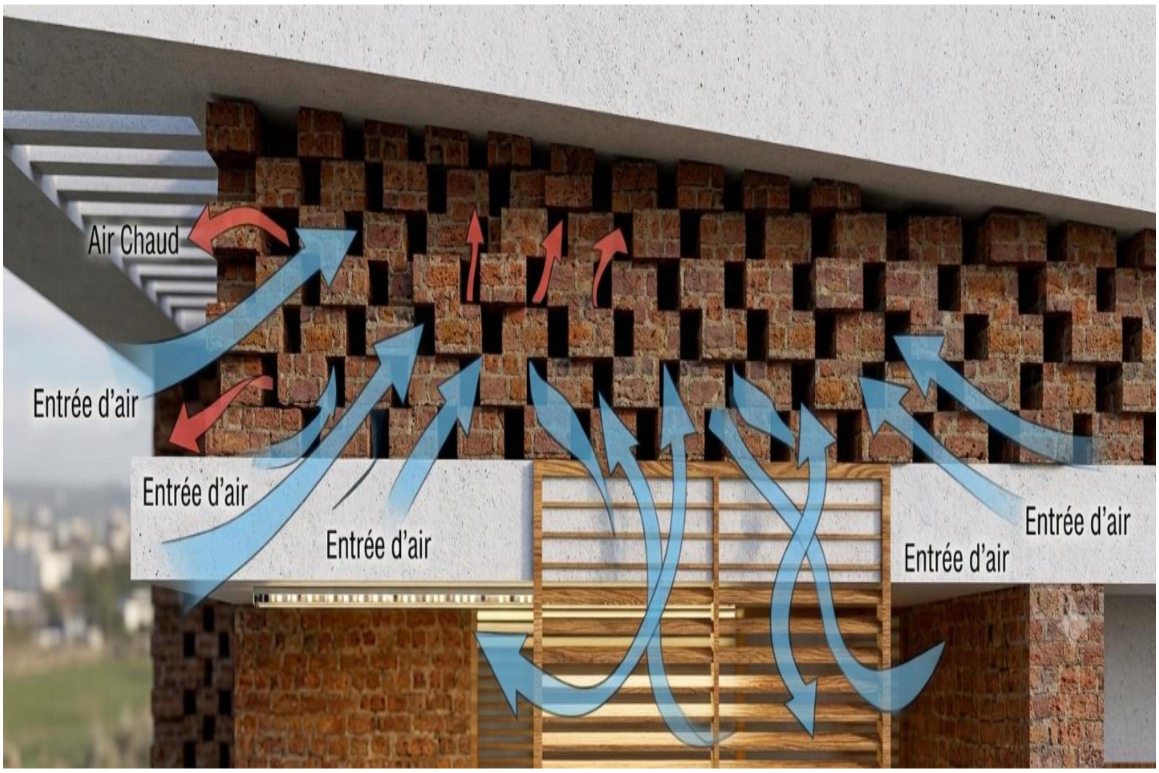

Figure 7. Detail of the perforated ("claustra") brick ventilation screen beneath the roofline, showing warm-air escape and fresh-air intake paths. (Source: Tene Fosso, 2026.)

The roof, rather than being treated as a single surface, is composed of four functionally distinct elements (Figure 8). A translucent roof above the lounges and patios admits daylight into circulation and communal spaces while maintaining airflow, reducing reliance on artificial lighting. A planted (green) roof over other zones moderates solar heat gain, improves acoustic comfort, retains stormwater, and contributes to the building's landscape integration. A conventional concrete roof, used where structural stability and durability are the priority, adds thermal mass and supports technical equipment. Finally, dedicated caps sit above each climatic chimney, shielding the ventilation shafts from driving rain while preserving an unobstructed path for the continuous outward draught — the detail that keeps the building's ventilation "lung" open in all weather, including Yaoundé's long rainy seasons (Section 4.1).

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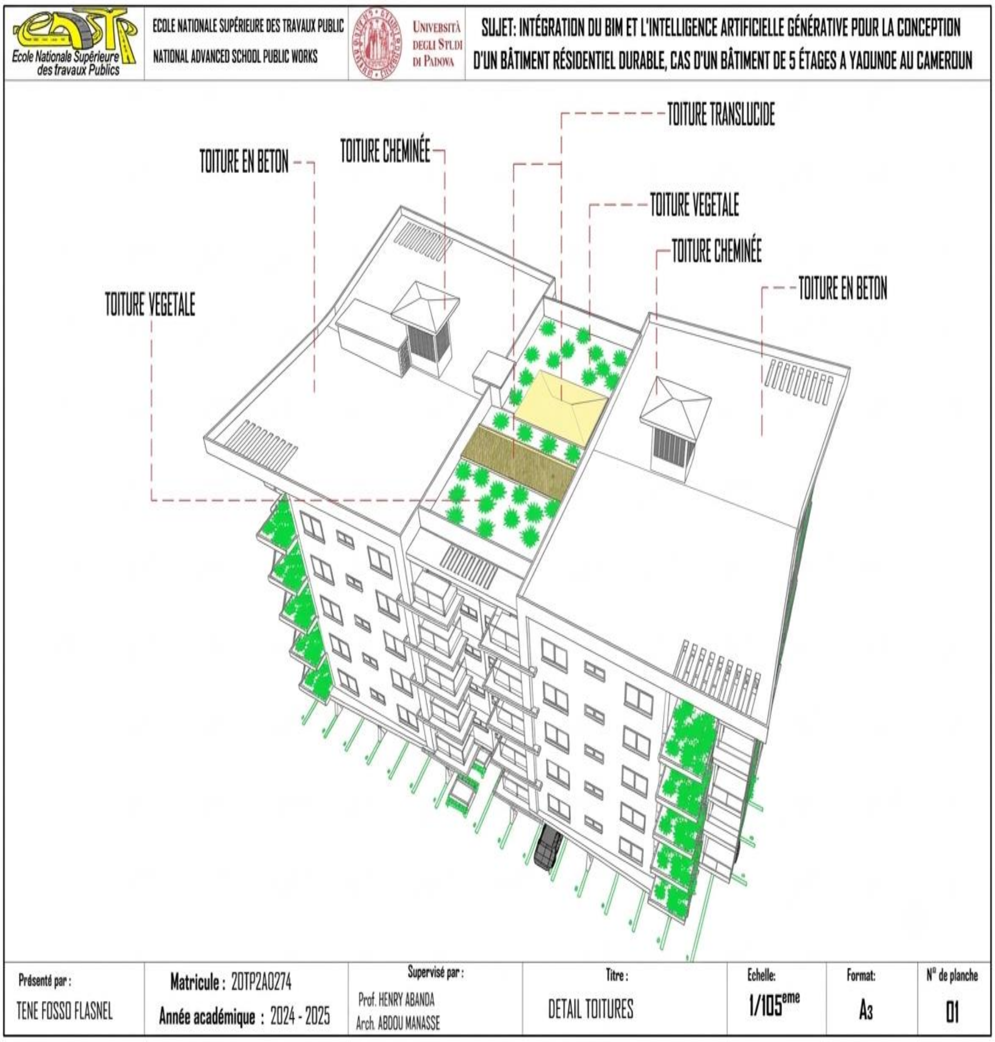

Figure 8. Composition of the building's four-part multifunctional roof system: translucent roof, planted roof, concrete roof and climatic-chimney caps. (Source: Tene Fosso, 2026.)

4.5 Thermal, Material and Cost Implications

A simplified embodied-energy and incorporated-CO2 assessment was carried out on the quantities extracted from the BIM model, converting each material's volumetric or areal take-off into an equivalent mass before applying generic coefficients (Table 2). The assessment estimates a total embodied energy of approximately 13,796 GJ and a total incorporated CO2 of approximately 1,356 tonnes for the building's structure and envelope. Reinforced concrete and steel dominate the result, together accounting for roughly 1,263 of the building's estimated 1,356 tonnes of incorporated CO2 — just over 93% of the total — because these materials carry the highest per-unit carbon intensity and are used, once converted to mass, in the quantities needed to guarantee the structural stability of a five-storey block. By contrast, stabilised compressed earth block, used extensively for the building's non-structural walls and screens, contributes only around 73 tonnes of CO2 despite covering a substantial envelope area — roughly one-seventeenth of the concrete-and-steel contribution for a material that plays a comparable role in the envelope's thermal performance. This makes material substitution at the envelope, rather than the structural frame, the most immediately available lever for reducing the building's upfront carbon footprint, consistent with Kibert's (2016) broader argument that envelope-level decisions are among the lowest-cost routes to a lower-carbon building. As noted in Section 3.2, these figures rest on UK-derived ICE coefficients (Hammond and Jones, 2011) rather than locally measured Cameroonian data, an approach with precedent in Abanda et al.'s (2014) embodied-energy and CO2 analysis of mud-brick and cement-block housing in Cameroon; the totals reported here are therefore best read as a relative comparison between structural and envelope materials rather than as an absolute, verified carbon account for this specific building.

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Table 2. Embodied energy and incorporated CO2 by material, extracted from the BIM model and converted to an equivalent mass before applying generic coefficients (sources: INIES, 2024; ICE v2.0, Hammond and Jones, 2011; Ecoinvent 3.9.1; MIPROMALO, 2022). (Source: adapted from Tene Fosso, 2026.)

Material	**Quantity extracted (BIM model)**	**Unit**	**Density / areal mass**	**Mass equivalent (kg)**	**Embodied-energy intensity (MJ/kg)**	**Total embodied energy (MJ)**	**CO2 intensity (kg CO2/kg)**	**Total incorporated CO2 (kg CO2e)**
Reinforced concrete	2,185	m^3	2,400 kg/m^3	5,244,000	1.20	6,292,800	0.15	786,600
Steel	198,500	kg	–	198,500	32.00	6,352,000	2.40	476,400
Glass (6 mm)	1,245	m^2	15 kg/m^2	18,675	15.00	280,125	1.00	18,675
Stabilised compressed earth block (15 cm)	3,860	m^2	270 kg/m^2	1,042,200	0.80	833,760	0.07	72,954
Construction timber	12,300	kg	–	12,300	3.00	36,900	0.11	1,353
Total	–	–	–	**6,515,675**	–	**13,795,585**	–	**1,355,982**

On cost, a preliminary estimate using Cameroon's national architects' order (ONAC) unit-cost method and the building's extracted floor area of 4,381.56 m² put the construction cost at approximately 1.31 billion FCFA, based on a “Category 2/Standard” unit rate of 300,000 FCFA/m², excluding land, professional fees, taxes and contingencies. Because the passive-ventilation strategy substitutes architectural elements — chimney cores, perforated screens, shading and a differentiated roof — for mechanical cooling plant rather than adding to it, it is reasonable to expect the strategy to be close to cost-neutral relative to a conventionally ventilated equivalent of the same category, though this claim has not yet been tested against a fully costed mechanically-cooled alternative and should be treated as indicative rather than confirmed.

DISCUSSION OF FINDINGS

Read against the literature in Section 2, the case study both confirms and qualifies the termite-mound analogy's value for Sub-Saharan urban housing. It confirms Turner and Soar's (2008) caution that a mound-inspired chimney is only useful if the mechanism it is meant to reproduce is understood: the design responds to Yaoundé's narrow diurnal temperature range by oversizing chimney geometry rather than assuming, as the classic thermosiphon reading might, that heat gain alone will drive a strong draught. In doing so it moves closer to King, Ocko and Mahadevan's (2015) finding that mound ventilation depends on a distributed exchange across a porous envelope over a full day–night cycle, since the design also relies on high-level transoms and perforated façade screens working continuously alongside the two chimneys, not on the chimneys in isolation — though, without dynamic hourly simulation, the extent to which this distributed system actually reproduces a diurnal tidal flow rather than a simpler, wind-assisted stack effect remains an open empirical question that the steady-state sizing calculation in Section 3.2 cannot resolve on its own.

The case also extends the Eastgate precedent along two dimensions the literature had not yet tested together. Typologically, it applies the mound analogy to stacked, multi-household collective housing rather than a single-volume office building, which required the chimney core to serve a vertical sequence of shared circulation spaces rather than one large atrium — a more constrained geometry that the oversized cross-section and the floor-by-floor ventilation transoms were specifically designed to accommodate. Climatically, it applies the analogy to a humid equatorial context whose comparatively small day–night temperature swing and moderate, if favourably oriented, prevailing winds contrast with the semi-arid highveld conditions under which Eastgate was conceived; the design's response — prioritising stack geometry and continuous façade porosity over reliance on a large ΔT or strong wind pressure — suggests that the mound analogy transfers to humid tropical climates only if its sizing logic is adapted to a smaller thermal resource, rather than copied at Eastgate's scale.

The use of GenAI in the design process is a further point of discussion. Screening four biomorphic variants against explicit site criteria (Section 4.2) allowed the termite-mound concept to be selected on the basis of a comparative bioclimatic appraisal rather than because it was the designer's starting assumption, a meaningfully different route into biomimicry than the case-by-case, precedent-driven process typical of most published biomimetic buildings. At the same time, GenAI output is an image of design intention, not a performance-verified proposal, so the subsequent BIM-based sizing and quantity extraction was a necessary, not optional, step before any claim of feasibility could be made; this two-stage process — rapid generative screening followed by quantitative verification — is arguably a more transferable methodological contribution than the specific chimney design itself.

Finally, the findings should be read with the limitations noted in Section 3 firmly in view. The ventilation system has been verified against steady-state calculations and a comparative design appraisal, not against dynamic thermal simulation, wind-tunnel testing, or post-occupancy monitoring of a constructed building; the embodied-carbon and cost figures rely on generic international coefficients and a national unit-cost benchmark rather than site-measured data. The case therefore demonstrates design feasibility and a defensible sizing logic, not a validated in-use performance outcome, and the claims made about comfort and energy savings should be understood as design intentions supported by the wider bioclimatic literature (Givoni, 1998; Mbani Menguissa, 2025) rather than as measured results specific to this building.

5.1 Limitations

Three limitations qualify the findings above. First, the analysis rests on a single embedded case study — one plot, one building configuration and one design team — so the specific chimney, transom and screen proportions reported in Section 4 cannot be assumed to generalise to other building types, heights, plot geometries or climate zones without further testing; the case demonstrates that a mound-inspired strategy is feasible for this particular brief, not that its dimensions transfer unchanged elsewhere. Second, the reported ventilation performance rests on steady-state air-change and stack-effect calculations and a comparative design appraisal (Sections 3.2 and 4.2) rather than on dynamic hourly simulation or long-term monitoring of an occupied building; the airflow rates and comfort claims made in Section 4 are therefore design-stage estimates, not measured outcomes, and should be read accordingly. Third, the embodied-energy and incorporated-CO2 estimates in Section 4.5 draw on the University of Bath's ICE v2.0 coefficients (Hammond and Jones, 2011), which were developed from UK manufacturing and construction data; because Cameroonian material production, transport distances and supply chains differ substantially from the UK context, applying these coefficients — even on the same precedented basis as Abanda et al. (2014) — risks under- or over-stating the building's true embodied-carbon footprint, and the totals reported here should continue to be read as indicative, comparative figures rather than an absolute, locally verified carbon account.

RESEARCH IMPLICATIONS

6.1 Theoretical Contributions

This case study contributes to architectural biomimicry scholarship by repositioning the termite mound from a single, semi-arid, low-rise precedent into a principle that can be tested against a different climate and a different building typology. By explicitly grounding the design in King, Ocko and Mahadevan's (2015) diurnal-oscillation mechanism rather than the older thermosiphon reading commonly associated with Eastgate, the case aligns architectural practice more closely with current biological understanding of mound ventilation, and offers a concrete illustration of what Turner and Soar (2008) meant by moving "beyond" a purely formal biomimicry: sizing decisions are argued from the mound's physiology and the site's specific thermal resource, not from its silhouette. This suggests a general principle for biomimetic design in variable climates — that the element being mimicked should be re-sized, or re-distributed, according to the local magnitude of the physical driver it depends on, rather than reproduced at a fixed scale from a single precedent.

6.2. Practical and Policy Implications

For architects and engineers working in comparable humid equatorial cities, the case suggests a practical rule of thumb: where diurnal temperature differentials are narrow and prevailing winds are moderate, passive-ventilation cores should be oversized relative to a steady-state minimum and paired with continuous, distributed envelope porosity rather than relying on the chimney alone — an approach that is low-tech, largely maintenance-free, and, on the evidence in Section 4.5, unlikely to add material cost once it substitutes for mechanical cooling plant rather than supplementing it. For planning and building-control authorities in Yaoundé and comparable Sub-Saharan cities, the case is a concrete argument for embedding passive-ventilation and embodied-carbon provisions into the building regulations that govern densifying peri-urban zones such as Olembé, particularly given the city's projected warming trajectory (Mbevo Fendoung, 2025). Requiring, or at minimum incentivising, natural-ventilation cores and low-embodied-carbon envelope materials such as compressed earth block in new mid-rise residential permits would extend the logic demonstrated here into a policy lever with city-scale reach.

6.3 Operational Framework for Replicating Biomimetic Ventilation in High-Density Housing

The design process described in Section 3 can be read as a four-stage operational framework that other practitioners and researchers could reuse: (1) a site and climate diagnostic that explicitly quantifies the local diurnal temperature range and prevailing wind resource, since these determine whether a stack-led or wind-led passive strategy is more appropriate; (2) generative screening of multiple biomorphic concepts against that diagnostic, using explicit, comparable criteria rather than a single preferred precedent; (3) BIM-based sizing of the selected ventilation system against both an air-change-rate target and a stack-effect capacity check, with a deliberate safety margin where the local thermal resource is narrow; and (4) quantification of the material and cost consequences of the selected envelope, to confirm that passive strategies are not achieved at a hidden carbon or cost penalty elsewhere in the building. Extending this framework would require the steps flagged as limitations in Section 5 — dynamic hourly simulation, monitored prototypes, and in-use cost data — to move from a feasibility demonstration to a validated performance benchmark that could be referenced with confidence in building-code guidance.

CONCLUSIONS

Yaoundé's equatorial climate — warm throughout the year, humid, and ventilated by only moderate winds — rewards a passive-ventilation strategy built around buoyancy rather than wind pressure alone, because the resource a purely wind-driven strategy would depend on is not reliably available on this site, and the resource a purely thermosiphon-driven strategy would depend on — a large diurnal temperature swing — is narrower here than in the semi-arid climate of the Eastgate Centre precedent. The Climatic Termite Mound variant analysed in this article responds to that specific combination of constraints: two deliberately oversized central chimneys, floor-by-floor ventilation transoms, perforated façade screens and a four-part multifunctional roof reproduce, at the scale of a five-storey residential block, the distributed convective loop increasingly understood to drive ventilation in real termite mounds, while compressed-earth-block infill keeps the envelope's embodied carbon low relative to the concrete-and-steel structural frame that still dominates the building's overall footprint.

Beyond the specific building, the case demonstrates a replicable route into biomimetic design for Sub-Saharan urban housing: a generative screening stage that tests a biological analogy against several alternatives and explicit site criteria, followed by a BIM-based verification stage that turns a promising image into a sized, quantified and costed proposal. This sequencing matters because it treats biomimicry as a hypothesis to be checked against local climate data, not a stylistic reference applied uniformly across contexts, directly addressing the risk — flagged in the literature on Eastgate — that termite-mound biomimicry becomes a formal gesture rather than a functioning system.

The findings should nonetheless be read as a design feasibility study rather than a validated performance record: dynamic thermal simulation, wind-tunnel or field verification, and post-occupancy monitoring of a constructed building are the necessary next steps before the chimney system's comfort and energy claims can be confirmed in use. Extending this work to other plots, other building heights, and other Sub-Saharan African cities with comparable humid equatorial climates would help establish how far the sizing logic identified here — oversizing stack elements to compensate for a narrow thermal resource — generalises beyond the single case examined.

Addressing the limitations in Section 5.1 points to three priorities for further work. First, the proposed biomimetic design should be validated through post-occupancy evaluation of the constructed building, combining indoor-temperature and air-change monitoring, indoor air-quality measurement, metered energy-consumption analysis and structured user-comfort surveys, to test whether the steady-state calculations in Section 3.2 translate into the ventilation and comfort performance claimed in Section 4. Second, the single-case design examined here should be extended to multiple housing projects across a range of African climates — from humid equatorial contexts comparable to Yaoundé to the semi-arid conditions of the Eastgate precedent and drier Sahelian climates — to establish how the oversizing logic identified in Section 4.3 needs to be adapted as the available diurnal temperature differential changes, and to test the adaptability and scalability of termite-inspired cooling strategies more broadly. Third, the embodied-carbon assessment in Section 4.5 would benefit from more locally specific life-cycle assessment data for Cameroonian and wider Central African construction materials — covering local cement, aggregate, timber, compressed-earth-block and steel supply chains — to replace the UK-derived ICE coefficients used here and to produce embodied-carbon and environmental-impact estimates that are directly verifiable against local production conditions rather than indicative by analogy. Together, these three steps would move the Climatic Termite Mound concept from a design-feasibility demonstration toward a validated, regionally calibrated performance benchmark.

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Declaration of Conflicting Interest

The author declares no conflict of interest.

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