Climate Responsive Uses of Vernacular Terracotta: Integrating Regional Clay Techniques into Structural Envelopes, Passive Cooling Systems and Interiors

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Abstract*—The primary focus of this research is to establish a collaborative design methodology between architects and local clay artisans (Kumbhars) in Vidarbha, transitioning regional terracotta from a decorative accessory into load-bearing, functional, and climate-regulating architectural assemblies. In the hot-arid climate of Vidarbha, contemporary construction relies heavily on high-embodied-energy materials like concrete and steel, resulting in extreme indoor thermal discomfort, high mechanical cooling loads, and the economic marginalization of traditional craft communities. Concurrently, regional pottery and clay crafts are increasingly relegated to small-scale decorative souvenirs, threatening the extinction of local material knowledge. Rather than treating terracotta as an aesthetic overlay, this study investigates how architect-artisan partnerships can upscale local clay construction using modern passive engineering and spatial design principles. The research focuses exclusively on evaluating, adapting, and organizing established regional terracotta techniques—specifically parametric breeze screens (jaalis), thermal-mass filler slab roofs, double-skin ventilated facades, and interior exposed brickwork—into a cohesive building strategy. By standardizing local clay unit geometries and dry-assembly systems, this paper demonstrates how traditional terracotta can be applied directly as primary building envelopes, passive cooling devices, and high-performance interior partitions tailored to Vidarbha's extreme environmental conditions.

I. INTRODUCTION

In the rapidly modernizing built environment of Vidarbha, contemporary architectural practices have increasingly decoupled from indigenous traditions, relegating rich vernacular clay crafts—specifically traditional terracotta pottery and tile making—to mere decorative superficialities or altogether ignoring them in favour of standardized, industrial materials like concrete and steel. This systematically marginalizes local artisan communities (Kumbhars), severing their access to the formal construction economy, accelerating the loss of ancestral material knowledge, and forcing new buildings to rely on high-energy, thermally inefficient envelopes ill-suited for Central India's hot-arid climate.

Re-integrating terracotta as a core structural, spatial, and micro-climate regulating system offers a transformative path forward; by elevating artisans to co-builders and utilizing indigenous, low-carbon clay, architects can produce structurally sound, environmentally adaptive, and culturally rooted spaces. To address this gap, this research aims to explore and document the innovative, practical techniques contemporary architects use to transform simple terracotta from a decorative craft into functional building envelopes, passive cooling screens, and high-performance interior systems.

II. AIM

The aim of this research paper is to gather, document, and organize existing terracotta techniques—specifically porous breeze screens (jaalis), thermal-mass filler slabs, double-skin facades, and exposed clay masonry—into a practical architectural and interior framework for hot-arid climates. By compiling these proven methods into standardized construction details and spatial guidelines, this study provides a clear blueprint for transforming local clay craft from a superficial decoration into a functional building envelope, high-performance interior system, and passive cooling engine.

III. LITERATURE REVIEW

Passive Micro-Climate Regulation & Energy Reduction

Terracotta jaalis and hollow filler slabs leverage the Venturi effect and thermal air pockets, cutting indoor temperatures and reducing mechanical cooling loads by 20% to 35%.

Transition from Decorative Craft to Engineered Tectonics

Modern projects use tension cables, dry-stacking, and custom molds to transform traditional raw clay from small decorative items into structural screens, rainscreens, and high-performance interior walls.

Artisan Economic Empowerment

Standardizing local clay block geometries integrates potter communities (Kumbhars) directly into the construction supply chain, turning low-margin craft makers into primary site specialists.

IV. OBJECTIVES

1. To document the physical limits, firing methods, moisture absorption rates, and load-handling properties of local Vidarbha terracotta (e.g., compressive strength, efflorescence prevention, and dimensional tolerances for dry-stacking).
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V. SCOPE

The shift toward industrial building materials stems from rapid urbanization and the common assumption that vernacular crafts are purely decorative rather than structurally functional. Consequently, modern buildings in Vidarbha suffer from high solar heat gain and heavy reliance on mechanical air conditioning, while local artisan communities (Kumbhars) remain economically disconnected from the formal construction sector. Applying established terracotta techniques directly to the building envelope and interior spaces addresses both environmental and socio-economic issues. Porous terracotta screens (jaalis) compress wind and filter glare, hollow filler slabs insulate roofs against overhead radiation, and high-mass clay masonry stabilizes interior humidity—all while reducing a building's embodied carbon. This research paper aims to gather, organize, and document these proven contemporary terracotta techniques into a clear architectural and interior design framework tailored to Vidarbha's hot-arid climate.

VI. METHODOLOGY

The research adopts a qualitative approach combining:

- Selection of relevant craft-integrated & public architectural projects.
- Classify selected case studies based on their spatial planning, structural systems, material usage, and degree of artisan involvement.
- Develop a comparative matrix to systematically evaluate the performance, strengths, and physical execution of each precedent against hot-arid climate requirements.
- Identify where existing precedents fail to integrate traditional crafts as load-bearing structural elements, relying instead on craft as non-functional surface decoration over concrete frames.
- Translate the lessons learned and gaps identified into a set of architectural design guidelines, structural modules, and material specifications.

VII. CASE STUDIES AND ANALYSIS

LITRTURE CASE STUDIES

1] AVADH SHILPGRAM





Uttar Pradesh, India.

Location: Sector 9, Amar Shaheed Path, Vrindavan Yojana, Lucknow, Uttar Pradesh, India.

Establishment year: 2016 (designed by Archohm Architects).

Facility type: A integrated craft hub and urban bazaar hosting craft exhibitions, live artisan workshops, cultural performances, retail space for regional handicrafts, and regional food courts.

Area covered: ~20 Acres / 8.1 Hectares (~29,784 sq. m built-up area).

Administered by: Uttar Pradesh Tourism Department (Government of Uttar Pradesh

Capacity: Accommodates around 200 craft shops, a 300–500 seat auditorium, a dormitory hostel, and open lawns/courtyards that hold up to 2,000+ visitors for large events.

[A] POSITIVE ASPECTS

- The continuous elliptical/spiral plan avoids dead ends and naturally guides visitors through the entire artisan complex, drawing foot traffic toward a central open-air Amphitheatre.
- The building envelope incorporates steel-and-sandstone jails (breeze screens), turf-covered green roofs over workshop blocks, and shaded corridors. These design choices reduce direct solar heat gain while promoting cross-ventilation in hot summer months.
- Instead of copying historical Mughal or Awadhi structures directly, the project abstracts local motifs—such as the double-height grand arches (inspired by the Roomi Darwaja and Buland Darwaja) and Chikan Kari embroidery patterns cut into Red Agra sandstone.
- The complex balances economic, residential, and cultural needs by integrating ~200 craft shops, open-air workshop courts, dormitories for visiting artisans, exhibition halls, a food court, and an Amphitheatre within a single site.
- The extensive use of Red Agra Sandstone unifies the sprawling 20-acre layout under a consistent visual identity while linking the structure to regional.

[B] NEGATIVE ASPECTS

- Despite the extensive open plazas and pedestrian pathways, there is a noted lack of shaded, comfortable resting zones along the main walking loops during high-temperature days.
- The high-budget construction (using heavy steel frames, pre-fabricated sandstone jaalis, and structural concrete) reflects an urban government project rather than a craft village built by artisans using low-cost, local techniques.
- The vast, repetitive spiral corridors and similar-looking arch facades can disorient visitors, as the complex lacks clear, intuitive directional signage.
- Open access to upper levels and roof terraces via steep ramps poses safety risks if left unmonitored. Additionally, maintaining turf roofs and extensive sandstone jaalis against weathering requires ongoing government funding.

2] DELHI HAAT





New Delhi, Delhi.
Location: Sri Aurobindo Marg, Opposite INA Market, Kidwai Nagar, New Delhi, Delhi 110023.
Establishment year: 1994 (Inaugurated in March 1994; designed by Pradeep Sachdeva).
Facility type: An open-air rural craft bazaar, food plaza, and cultural center. It features rotating artisan craft stalls (allotted on a 15-day rotational basis), regional food stalls representing various Indian states, live cultural performance areas, and exhibition grounds.
Area covered: ~6 Acres (Built-up area: ~3,190 sq. m).
Administered by: Delhi Tourism and Transportation Development Corporation (DTTDC), New Delhi Municipal Council (NDMC), and the Ministry of Textiles / Ministry of Tourism (Govt. of India).
Capacity:
Stalls: ~62 to 200+ craft stalls and 25 regional food stalls.
Amphitheatre: Open-air performance space accommodating ~300 to 450 people.
Daily Footfall: Handles an average of 3,000 to 5,000 visitors per day (scaling up to 10,000+ during peak festival seasons).

[A] POSITIVE ASPECTS

- The layout uses open-air, brick-paved pathways that meander between low-rise stalls, mimicking a traditional village street. This prevents a rigid corridor feel and allows visitors to explore at an unhurried pace.
- The architecture prioritizes low-rise exposed brickwork, stone masonry, bamboo roofing, and thatch structures. This keeps construction human-scaled and approachable without overwhelming the crafts on display.
- The small 3m x 3m modular stalls are basic by design. They allow different artisans to move in every 15 days, set up their wares quickly, and operate without needing specialized infrastructure.
- The design was built around the site's existing mature trees, using them to create natural shade, pockets of courtyards, and informal gathering spaces throughout the complex.
- Dilli Haat was one of the earliest public projects in Delhi to incorporate continuous ramps, gentle slopes, and paved pathways across the site, making it largely wheelchair and stroller accessible.

[B] NEGATIVE ASPECTS

- Because most circulation pathways and dining plazas are completely open-air, visitor comfort drops significantly during extreme summer heat (40°C+) and heavy monsoon downpours.
- Stalls lack secure, weather-proof back-of-house storage. Artisans often have to stack inventory inside their small display areas or cover items with tarpaulins during rain.
- The narrow 2m TO 3m brick pathways get severely congested during peak weekends and festival seasons, creating bottlenecks near popular food stalls and central plazas.
- While crafts are sold extensively, there are limited designated spaces equipped with heavy tools, kilns, or water connections for artisans to demonstrate live production (like pottery or metal casting) safely.
- The high daily footfall (~5,000+ visitors) has led to the degradation of brick paving, public restrooms, and drainage channels, requiring frequent maintenance by municipal authorities.

VIII. COMPARATIVE ANALYSIS

Parameter / Aspect	Avadh Shilpagram (Lucknow)	Dilli Haat (INA, New Delhi)
Architect / Firm	Archohm (Nitin Suresh)	Pradeep Sachdeva Design Associates
Primary Material	Terracotta Jaalis & Red Brick	Exposed Red Brick & Slate/Stone
Spatial Layout	Elliptical, Arched Arcades, Central OAT	Linear Pedestrian Spine, Village Haat Grid
Facade Technique	Parametric Terracotta Screen (Jaali)	Low-Rise Brick Walls & Slate Roofing
Climate Adaptation	Micro-climate Cooling, Shade, Venturi Airflow	Shaded Verandahs, Tree Canopies, Permeable Paving
Interior Treatment	Exposed Brickwork, High Acoustic Vaults	Rustic Brick Paving, Open Brick Partitions
Artisan Integration	Permanent Craft Workshops & Bazaars	Rotational Stall System (15-day cycle)
Structural Scale	Large-span Arches, Contemporary Monolithic	Low-rise, Human Scale, Modular Stalls

IX. HISTORY OF TERRACOTTA

- Historically, terracotta (burnt clay) was Central India's default building envelope due to its abundant raw clay, low cost, and thermal performance in hot climates.
- Semi-cylindrical, hand-rolled clay tiles laid in overlapping channels over bamboo or timber rafters. They created air gaps that trapped heat before it reached living spaces.
- Sun-dried or low-fired mud bricks and unglazed floor tiles provided high thermal mass, absorbing summer heat during the day and releasing it slowly at night.
- Hand-carved or molded clay screens and decorative friezes allowed light and air movement into interior courtyards while maintaining privacy.

X. CHALLENGES OF INCORPORATING TERRACOTTA IN ARCHITECTURE

- This cost factor can be a significant challenge, especially for large-scale construction projects. b) Installation complexity - Installing terracotta products may require specialized skills and expertise.
- The complexity of installation can contribute to higher labour costs and potential delays in construction projects. c) Durability concern - While terracotta is generally durable, its long-term performance can be affected by exposure to harsh weather conditions, particularly freeze-thaw cycles.
- Proper maintenance and protection measures may be necessary to ensure durability.

XI. ARCHITECTURAL UTILIZATION OF TERRACOTTA IN CURRENT TIME

1. PARAMETRIC & SUSPENDED BREEZE SCREENS (JAALIS)ARCHITECTURAL UTILIZATION:

Using hollow or custom-molded terracotta blocks strung on stainless steel rods or dry-stacked to form breathable, light-filtering secondary envelopes. The clay apertures compress incoming air via the Venturi effect, lowering internal ambient temperatures through natural cross-ventilation.



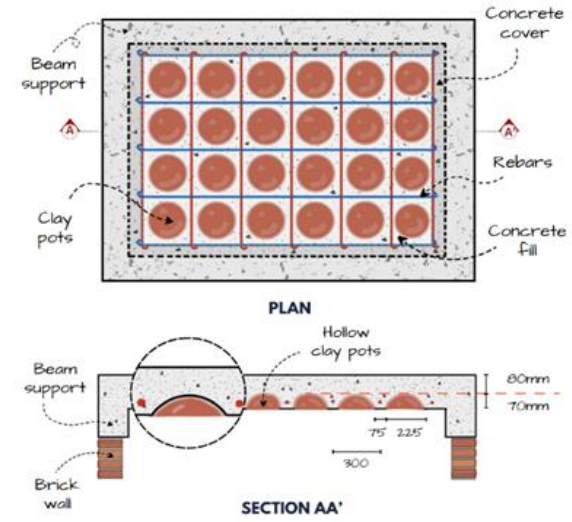
Avadh Shilpagram Terracotta Breath House / live out studio

1) Define the facade grid digitally using parametric software (e.g., Grasshopper/Rhino) to adjust each unit's rotation angle and aperture size based on local solar paths and wind data.
2) Extrude or mold high-density terracotta blocks with pre-engineered hollow central cores or side slots to receive structural
3) Install heavy-gauge steel or aluminum sub-frames directly onto the building's RCC floor slabs or edge beams to bear structural loads.
4) Thread vertical stainless-steel rods or high-tensile cables through the central cores of the terracotta units, locking them in place with dampening rubber gaskets.
5) Stack and rotate the blocks unit-by-unit along the rods according to the parametric script, securing the assembly at top and bottom tensioners without wet mortar.

2. POROUS TERRACOTTA ROOF VAULTS & FILLER SLABS:

Replacing heat-trapping structural concrete in roof and floor slabs with hollow terracotta units (Hourdis tiles, clay pots, or Tavellas). The trapped air pockets inside the clay blocks act as continuous thermal insulation

against direct overhead sun exposure while reducing total concrete usage by 20–30%.







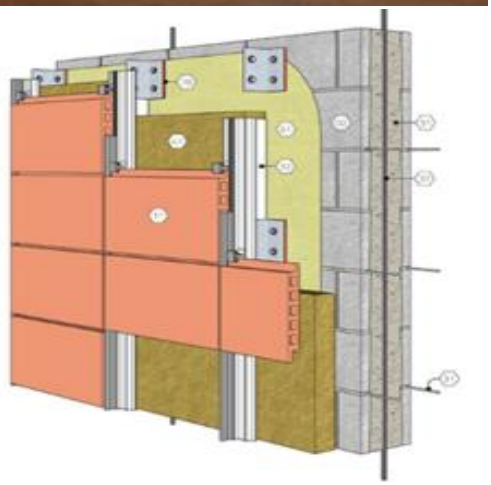
LAKE HOUSE, SURAT by blurring boundaries

1) A filler slab follows the same basic structural principles as a conventional RCC slab but optimizes material usage. It is constructed by placing filler units between the bottom reinforcement bars within the slab formwork, ensuring these units do not interfere with the concrete cover or reinforcement spacing. The key components include:
2) Compression Zone: The upper part of the slab that resists compressive forces, cast in solid concrete.
3) Tension Zone: The lower part where tensile reinforcement is placed; here, concrete is replaced with lightweight filler material.
4) Reinforcement Bars: Steel rods placed in both directions to resist tensile stresses.
5) Filler Materials: Hollow or lightweight objects such as clay pots, tiles, bottles, or shells that displace concrete without affecting load-bearing capacity.
6) Formwork: Supports and shapes the slab during casting, ensuring correct placement of fillers and steel.

3. DOUBLE-SKIN VENTILATED FAÇADES & RAINSCREENS

Hanging extruded terracotta panels or terra-cotta baguettes on metal sub-frames outside the primary structure, leaving a ventilated cavity (20–50mm) between the cladding and the wall.





The University of Queensland

- Terracotta Baguette/Louver.

1) Terracotta baguettes are made from natural clay. They are extruded by the high-pressure vacuum extrusion machine. After being fired with high

temperature in firing kiln, terracotta baguettes are given with high strength against the external forces and foul weather. Terracotta baguette is light, moldable, fire resistant, and environmental-friendly.

- Application of Terracotta Baguette & Louvers t50 terracotta louver

1) When designed together with terracotta panels, it works well in corners, parapets, roofs, balcony, parking buildings and etc., achieving a harmonious and integral facade effect. It's also a very special architectural design element when used alone.
2) Terracotta baguettes of different shapes, dimensions, colors and finishing for architect's selection. It can be customized to other irregular shapes.

4. DOUBLE-SKIN VENTILATED FAÇADES & RAINSCREENS

Utilizing low-fired or sun-dried terracotta bricks for interior load-bearing partitions and unglazed terracotta floor tiling. The clay material acts as a thermal sponge, absorbing radiant heat during high daytime temperatures and releasing it slowly at night to stabilize interior humidity and microclimates.



Alloa Hills Weekend House.

1. Lay a high-density damp-proof course (DPC) over the slab base to prevent capillary moisture and ground dampness from seeping up into porous clay units.
2. Lay bricks using a rich 1:1:6 (Cement:Lime:Sand) or pure lime mortar. Lime preserves breathability, cushions differential expansion, and prevents salt staining.
3. Stack bricks in a Rat-Trap bond (edges facing out with hollow interior cores) or half-brick thick partitions. This creates internal air pockets for room-to-room acoustic isolation and thermal buffering.
4. Rake back wet mortar joints by 10mm before curing, then flush or concave-point with contrasting lime mortar to highlight the terracotta geometry.
5. Scrub dried efflorescence off the brick face with a soft wire brush and apply a breathable, clear silane/siloxane sealer to block dust, oils, and moisture without altering the natural matte clay finish.

XII. CONCLUSION

Contemporary projects often treat craft as superficial facade ornament over concrete. True vernacular sustainability requires integrating crafts into load-bearing assemblies—such as using Dhokra brass as joinery hardware, bamboo as primary trusses, and terracotta as breeze-cooling envelopes.

Relying on regional passive techniques—such as terracotta jaalis for evaporative breeze cooling and high-overhang bamboo roofs for sun shading—provides better microclimate regulation for hot-arid heat than energy-intensive mechanical air conditioning.

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