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THEME :

MATERIA-VERSE :

Material transformations: skillful renditions of strength, form and texture

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ABOUT THE COVER PAGE

Shashank Manohar | 8th sem

The cover page, a grid-like mosaic, intricately represents the vast diversity of materials shaping today's architectural landscape. Each grid compartment serves as a symbolic ode to the array of materials employed by architects, engineers, and designers in construction—ranging from traditional bricks to cutting-edge composites. This meticulous arrangement reflects the organized complexity found in contemporary structures. As readers embark on a journey through the 'Materia-verse,' the grid transcends mere aesthetics, becoming a metaphor for the interconnected elements within our expansive multiverse of construction, inviting contemplation on materials as integral facets, harmoniously coexisting to sustain the evolving dynamics of our built environment. The grid, mirroring the cosmic perspective, becomes a visual celebration and exploration of the materials that define architecture.

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- To share the benefit of intellectual and professional capabilities with society by establishing institutional consultancy.
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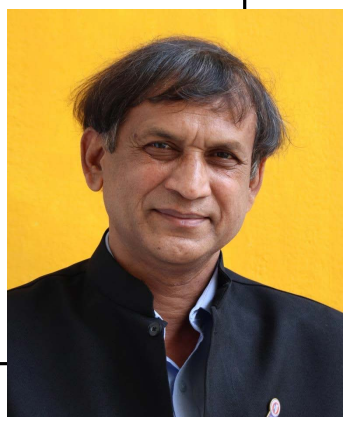

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FOREWORD

- from the editor in chief

Material has been one of the most fundamental factors that has shaped the style of Architecture across the globe over the ages. Ease of availability, climatic factors and prevailing technologies have dictated the manner in which materials have been exploited by the builders of the era and the architects of the current age. Architects have capitalized highly on the inherent strength, durability, accessibility and aesthetic qualities of every material. As technology advanced there have been changes in the evaluation criteria for a material's applicability considering their usage in buildings, keeping functionality as the core criterion. Factors such as sustainability, climate change etc. emerged as overriding considerations for material choice. Energy intensive materials became a comparatively less preferred choice since their adverse impacts on climate and environment have been scientifically established. Off late, smart materials have also made their way in the construction sector. These materials are capable of showing quick response mechanisms to changes in the prevalent conditions and environment.

The works of Architects like P.L. Nervi, Le Corbusier, Zaha Hadid ,etc demonstrate how architects have used materials to manifest their creative ideas. Design studios in the campus of RVCA are inspired by the works of these legends and many a time the concepts are driven by the ideas of material in architecture. In line with these thoughts, I find it highly relevant and appreciable that the learned editorial team of "Kalpa" has dedicated this issue to the theme "Materia-verse" that provides a platform for Architects, researchers and academia to express their views on various facets of material.

I wholeheartedly compliment the contributors for providing their valuable papers and articles for consideration of publication. The constraint of pages & volume allows us to publish only a selected few.

I am sure that this special issue of "Kalpa" will be well received by the architecture community.

Prof. Dr. Om Prakash Bawane

Editor-in-Chief &
Principal, RVCA

EDITORIAL NOTE

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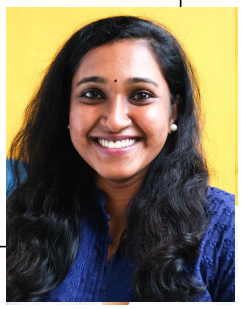

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KALPA, a brainchild of RVCA academicians, engulfs itself on the culture of research to inculcate its ideologies in architecture and related fields. Architecture being a very subjective programme, gives rise to an investigative feature that lets us explore the complex peripheral streams informing design. This necessitates a foundation in research to infuse the philosophy of systematic study, often driven by context.

The inspiration for the word 'Kalpa' lies in its ritualistic approach that endures significant cycles of learning, revolving around the processes of creation, dissolution and recreation. Kalpa evolves with five definitive wings that guide through Chandas (patterns), Shiksha (learning), Vyakarana (grammar of assembly), Nirukta (etymology) and Jyotisha (timeline). When looked closely, these concepts constitute the essence of research.

The first volume of the magazine (2020) explored the 'Idea of Research in Architecture' through dialogues with the institution's faculty, framing informal yet in-depth perceptions and the complexity it (research) endures. The second volume (2021) dissected the concept of 'Human Migration: its sociocultural, ecological and economical impacts'. Both the issues were enriched with the contributions of students attempting a structured take on the themes.
The third volume of Kalpa (2022), through the works of students of Architecture and planning (Undergraduate and Postgraduate) dealt with the overarching theme of 'Urban Future or (Fantasy?)' as a critical elucidation to the United Nations (UN) Sustainable Development Goal 11 (SDG 11) and as a response to their agenda of Inclusive, Safe, Resilient and Sustainable urban environments. The contributions explored connotations in defining an ideal city in the milieu of complex political, sociocultural, environmental and economic transactions. Following the success of three volumes Kalpa now bears its own International Standard Serial Number (ISSN) as 2583-696X (Online).

Kalpa's current and fourth volume is an expedition into the Universe of Materials or as we call it, the Materia-verse: Material transformations through skillful renditions of strength, form and texture. Here, we conceptualise material science to be synonymous with its sustainable applications. The theme was explored along two threads i.e., a) Material Transformation through Time: an attempt to map evolution and transformations in a material's applicability, form, tactility and strength; and b) Material explorations through Disciplines: an exploration of the material world beyond the construction or building industry that highlight material adaptations across disciplines as well as pedagogical experiments that ameliorate cognizance of material morphology. The volume covers expert articles, student articles, student illustrations and expert interviews.

We hope to enrich the objectives of Kalpa further along thematic scales that question the nuances of the field and its peripherals. We acknowledge the immense support and encouragement of our Principal Dr. Om Prakash Bawane, our Dean Professor Suresh K Murthy and the faculty at RVCA. We also applaud the consistent efforts of the student teams in the success of this edition.

Hope you have a good read. Cheers!

Prof. Hiranmayi Shankavaram and Prof. Ramya Krishna

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Navigating the materia-verse.

In this issue of Kalpa, as we embark on an exploration of the 'materia-verse,' I urge readers to transcend a reductionist perspective on materials and conceive of them as integral components of a holistic entity. Moving away from 'sustainability' as a noun invites critical thinking on the multi-faceted connotations inherent in the notion of what it means to 'sustain.' To do so, one must shift from the 'container' idea of space and recognize space outside of it. Essentially, by thinking of 'space as a continuum,' where space encompasses everything—matter, emptiness, and energy—an idea similar to the way Ar. Dilip Da Cunha conceptualized the world as different degrees of wetness.

The inaugural section addresses questions of scale, community, and adaptability. The example of Kumbh Mela underscores its cyclical nature, its deference to topography, and judicious use of resources. Against the backdrop of contemporary climatic exigencies, Kumbh Mela provides a pivotal context for comprehending the insights presented by Ar. Anushree Parkhi on deployable structures, delineating their adaptiveness and transportability, along with Ar. Nishant's article that scrutinizes valuation methodologies for tangible and intangible heritage resources. In a complementary vein, Nipun Prabhakar's interview emphasizes the need for design practices to operate or be part of 'collectives' with shared values in the built/unbuilt environment, leading to rigorous questioning of the architect's role and what it means to 'build' today. Rooted in grassroots engagement, their practice attempts to look at sustainability holistically, respecting the agency of the communities they design for.

The subsequent section explores collaborations between students and faculty and their varied engagements to understand materials tangibly—their properties, lifecycles, efficiency, embodied carbon, among others—and use them to design community spaces. Mr. Harish Borah highlights the significant ramifications of the construction industry on the global economy and the environment. While he acknowledges progress in the development of energy-efficient and carbon-free buildings, he calls for a comprehensive and accelerated approach to solving the climate crisis.

The third section engages in meticulous examinations of specific materials by individual contributors, underscoring the necessity of a change in the construction sector towards the selection of ecologically sound materials and methodologies. All the articles emphasize how crucial it is to study the physiographical setting of a place when determining the optimal building materials. Nuanced discussions ensue regarding the intricacies and constraints inherent in working with local materials and artisans, acknowledging challenges in standardization, and expressing aspirations to harness latent material potential through technological advancements.

The concluding section deals with the realities and challenges of working within the construction sector, the ways in which material properties influence design and the connotation of luxury through material expressions. An analysis by Dr. Shikha Verma leads to a conceptual framework advocating a shared GIS database, facilitating collaboration between C & D waste processors and users of processed C & D waste. Simultaneously, Senthil Doss and Edifice consultants elucidate how the selection of a material as a starting point of a project influences its design, construction, and decision-making processes. They demonstrate that understanding a material in its local context holistically begets a distinctive design language, thereby resulting in specific manifestations in the built form.

We hope these diverse perspectives offer new avenues to students and professionals to embrace a more holistic and conscientious approach to the ever-evolving 'materia-verse', articulate what it means to sustain and contemplate the intricate relationship between materials, design, space, and time.

Happy Reading!

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Within the pages of KALPA, The Materia-Verse: Material Transformation, skillful renditions of strength, form and texture, I take immense pride in its role as a beacon of excellence in the realm of architecture. Kalpa not only fosters academic growth but also instills a profound dedication to the profession and groundbreaking research. It intricately weaves together diverse elements that contribute to the tapestry of original and authentic research.

Functioning as a hub of excellence, the magazine serves as a platform for researchers engaged in both qualitative and quantitative studies. Utilizing appropriate tools such as simulations and innovative teaching techniques, it establishes indicators and parameters for the overall enhancement of the field. Tailored for individuals seeking to cultivate a mindset embracing creativity and challenging architectural norms, it opens avenues for further exploration and patent development.

Going beyond the confines of academia, Kalpa inspires us to view ourselves as vital contributors to research in crucial areas of architecture and related disciplines. This active participation contributes significantly to the progress of the field. As you embark on the exploration of the magazine's pages, envision the profound impact it aims to make—a legacy characterized by creative thinkers, transformative designs, and an unwavering commitment to welfare. Welcome to a journey where architecture transcends the ordinary, and education serves as a catalyst for future discoveries and inventions in the field. Kalpa invites readers to immerse themselves in a world where architectural exploration knows no bounds, fostering an environment where innovation flourishes and contributes to the evolution of the discipline.

STUDENT EDITORIAL

As we navigate the dynamic landscape of the 21st century, we find ourselves at the intersection of innovation, design, and sustainability. The evolution of our era, marked by technological leaps and cultural shifts, is intricately woven into the very fabric of our surroundings – the materials that shape our built environment. In this fourth volume of Kalpa, our annual research magazine at RV College of Architecture, we embark on a captivating exploration of the 'materia-verse,' delving deep into the realms of material science and its profound impact on diverse fields.

In our pursuit of knowledge and exploration, we recognize the pivotal role of materials in shaping sustainable futures. The choices we make resonate with socio-cultural complexities, scientific advances, and an unwavering commitment to environmental standards. The very essence of material science is synonymous with sustainability, and the pages of Kalpa Volume IV unfold a narrative that underscores the importance of sustainable applications. We believe that the innovative use of 'sustainable materials' is not just a choice but a responsibility, offering long-term benefits to both the environment and the communities where they find purpose.

As students of architecture, we invite you to join us on this captivating journey through the materia-verse. Our magazine is a testament to the limitless possibilities that arise when creativity converges with science, aspiring to spark inspiration for future explorations and innovations beyond the 'built' world. Kalpa Volume IV – sparks dialogue, urging reflection on our built environment's impact and the profound influence of materials. We hope this edition inspires contemplation on the spaces we craft and their resonance in the lives we shelter, after all the future is shaped by the materials we choose today.

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Neha Ajit
Shruti Gopalan
Rohan Chaturvedi
Ganganagunta Harikiran
Anish Perumal

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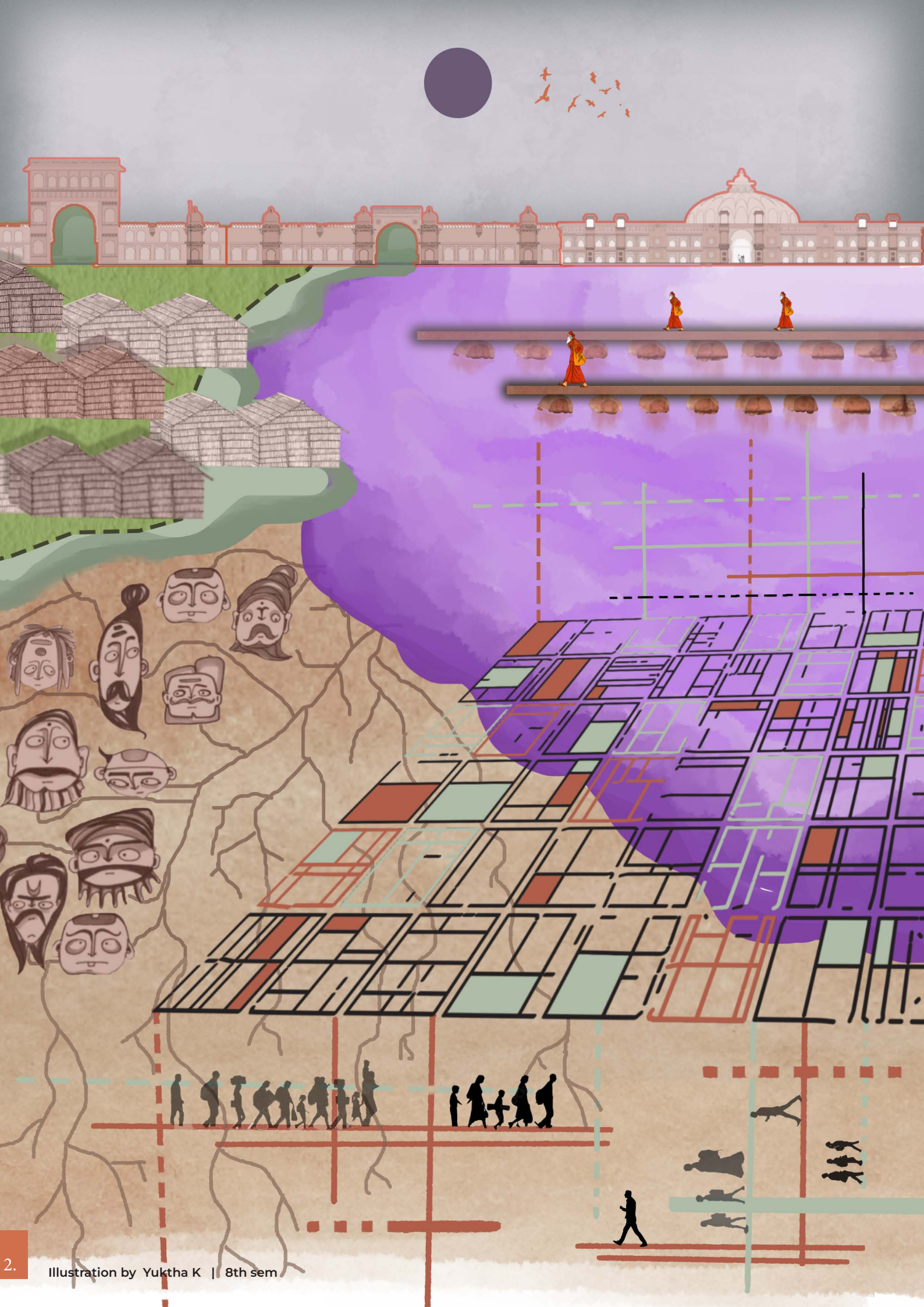
SECTION 1 :

Worlding, Adapting and Transforming : Blurring the Boundaries.

Illustration by Haashim Aslam Maricar | 8th sem



2. Illustration by Yuktha K | 8th sem

01. The Kumbh Mela, the World's Largest Public Congregation: A Paradigm for the Sustainable Use of Land.

Authors : Ar.Sama Arekal and Ar.Subhay Baberwal

Kalpa, Vol.04, 2023, pp. 03-08

Abstract :
Architect Subhay and Sama emphasizes the imperative of enhanced biopsychosocial considerations and policy implementations to safeguard the urban environment. Using India's diverse cultural landscape as a model for intercultural harmony and sustainable practices, the article highlights the Kumbh Mela[1] as a significant example of sustainable land usage. Proposing a shift towards ecological sustainability, the paper advocates for recognizing and regulating ecosystem services to benefit both people and the environment. Drawing inspiration from the Kumbh Mela, the paper encourages large-scale events to prioritize resource reduction, reuse, and recycling along with a redesign of contemporary public spaces, transforming them into multipurpose settings that foster healthy urban living. The article concludes by urging readers to assess the ecological impact of their decisions, promoting a conscious approach to land use and fostering a harmonious relationship between humans and the environment

Keywords:
Land, Alternate scenarios, Management Perspective, Revitalization, Redevelopment.

Across the globe, land is treated as a secure commodity and rarely viewed as an ecological asset with veritable environmental impacts. Likewise, in India, we seldom account for the impact of raw materials before they manifest into their utilitarian forms, posing a looming threat to the environment. This implies the need for better biopsychosocial considerations and policy implementations to safeguard urban ecology in the emergence of climate change in the global South today.
India is a land that nurtures a vast ecosystem of culture, language, and religion that encompasses a range of festivities to celebrate its secularity. Therefore, it sets a template for environmental communication, intercultural and social cohesion, and sustainability strategies to boost eco-friendly practices in a framework that is currently out of practice or lost in translation. Here, land transcends the idea of a commodity and margins of governance that anchor its life force. We are continuously inundated with stories of the rising water crisis in the global South and yet fail to address some of its roots that are embedded in the mistreatment of land. For instance, sand is the second most extracted natural resource on earth, harvested by strip mining our rivers and beaches, often illegally and unsustainably. This sets off a chain reaction that feeds back into systemic urban problems.

There is a pervasive influence of the industrial global North in how we manage our connections to culture and life in public realms through the land on which it thrives. Furthermore, our society is structured with the need for security. Communities are often synonymous with the idea of permanence that bleeds into urban planning facets of inhabited spaces. The Kumbh Mela[1] sets an important precedent in dealing with similar quandaries through lessons gleaned from Indian traditions and social cohesion that demonstrate how we can formulate new interventions today to address climate change. Land is often regarded with a sense of stability and inanimation that is not in its nature where even on fallow land, the soil is alive and brimming with purpose.

The Kumbh Mela, a precedent for sustainable land use:

We revisit the century-long tradition of the Kumbh Mela, to reflect on its planning process, as it sets to present key ideas for the sustainable use of land in our public spaces. The Mela is situated at the confluence of the Ganges, Yamuna, and Saraswati Rivers in Allahabad, Uttar Pradesh, India. As the Monsoon arrives, the river morphs into its monthly phases from September to December and culminates in housing festivities from January through March.
The river bed and its banks are brought to the forefront by the receding water levels to serve as the foundation on which a boundless cultural centre is concocted– for a congregation that has taken place since the Gupta[2] dynasty. The Mela goes through morphogenesis on land that includes stages of planning, construction, assembly, operation & disassembly, deconstruction & reabsorption that are reminiscent of the Hindu belief in the cycle of Samsara[3].

[1]Kumbh Mela: a Hindu festival and assembly, held once every twelve years at four locations in India, at which pilgrims bathe in the waters of the Ganges and Jumna Rivers.
[2]Gupta: The Gupta Empire was an ancient Indian empire which existed from the early 4th century CE to early 6th century CE.
[3]Samsara: the cycle of death and rebirth to which life in the material world is bound.

Image 1: Aerial View of the Kumbh Mela. Source: Lars Hanf (picture)

The first monsoon phase (September to December) is one of preparation, where the receding water proffers agricultural land to be leveled; and roadways to be marked. Materials for the pontoon bridges are transported to vacant spaces near the floodplain. The transforming land is now referred to as Nagri and will anchor the largest public gathering on Earth. The Nagri is 23.4 Square kilometers of kaleidoscopic imagery of tents that nurture a rich heritage celebrating the pilgrims' religious and spiritual life. The festival is regarded as the only place on the planet where ascetics and lay people from theologically disparate traditions co-exist and work together to manifest this massive economic event of commerce and entertainment. For its visitors, that includes musicals, theatre performances, and demonstrations of spiritual accomplishments by yoga practitioners.

In the following months, the infrastructure is set up in a planned grid to ensure easy navigation for circulation and population distribution from densely to sparse areas allowing a comprehensive mobility plan to be established. Gradually, it reveals streetlights and electric poles, bridges, and enclosure systems for a wide range of congregational spaces to crop up. Other aspects include civic amenities like water supply, sewage system, and CCTV cameras for security. The grid pattern consists of uniform distribution of public and social infrastructure of clinics, hospitals, and other emergency services, based on Corbusier's idea of sectors which makes for easy navigation and implementation of technical systems (sanitation, electricity, etc) and most importantly, the ecological restoration and treatment of land. The perimeters of the Nagri are the only areas that house permanent structures. This fugacious compact grid city is planned to facilitate the Hindu community's long-standing religious celebrations and bathing fair that occurs every twelve years with smaller editions every four years.

Furthermore, the Mela is a public space that is pre-programmed from its planning stage to house specific activities in the zones they are classified into that are at times activated simultaneously to dictate certain experiences and human behaviour; it also controls the movement of the gathering based on their interests, something is offered to everyone apart from the tradition of bathing ritual.

Post the Mela, all the soft infrastructure systems are dismantled either entirely or reused for other construction works. Of the remainder, some (like the reed roads) are reabsorbed by the returning water, and the rest are recycled for the next Kumbh Mela. A structured deployment and deconstruction employing sustainable practices ensures that time does not propagate fear, but a gradual acceptance that public space must be transitory where the framework of design aligns with the sustainable use of land. This idea is best reiterated by Andrea Branzi, a famous Italian urban planner, who suggests that good urban design implements reversibility with adaptable solutions subject to change where permanent solutions are reimagined as new protocols that can be "constantly

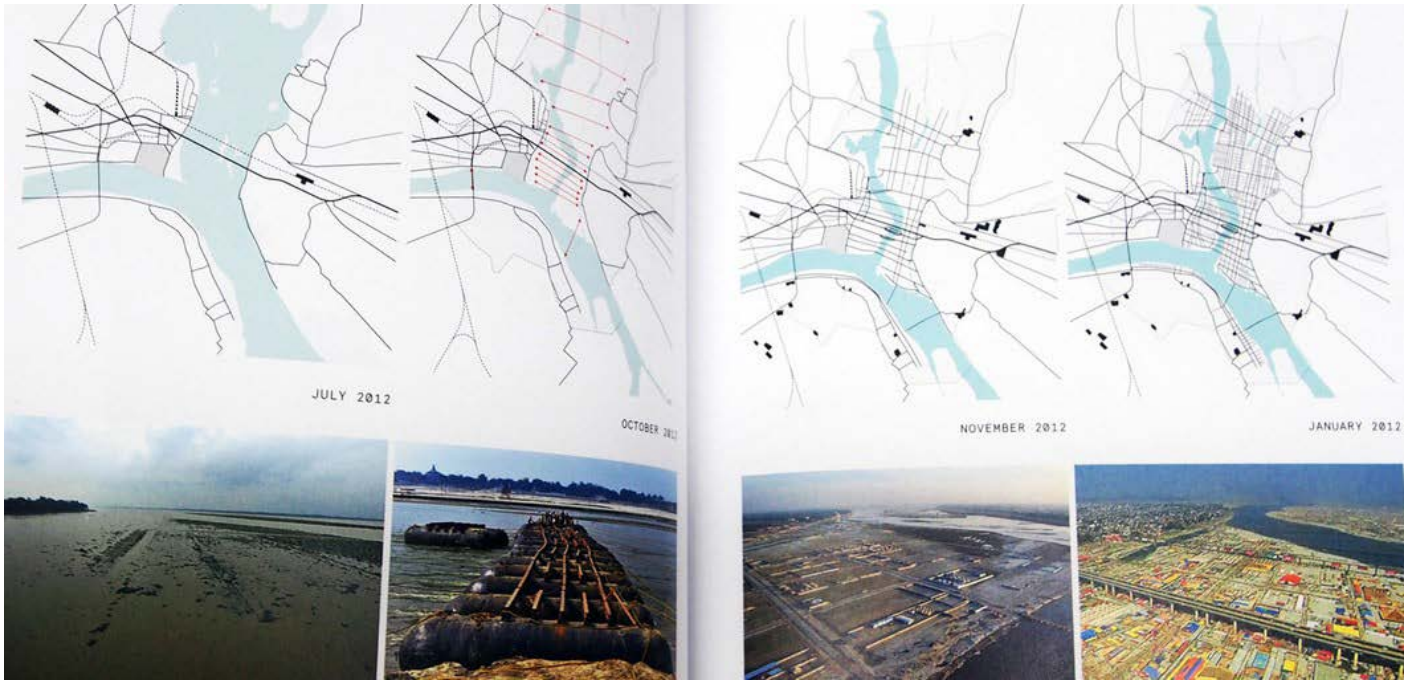


Image 2 : Land Morphology Maps to Visual at the site of Kumbh Mela. Source: Archdaily, Pages 108 and 109 from Kumbh Mela: Mapping the Ephemeral Megacity by Rahul Mehrotra and Felipe Vera; Image courtesy: Felipe Vera. (picture)

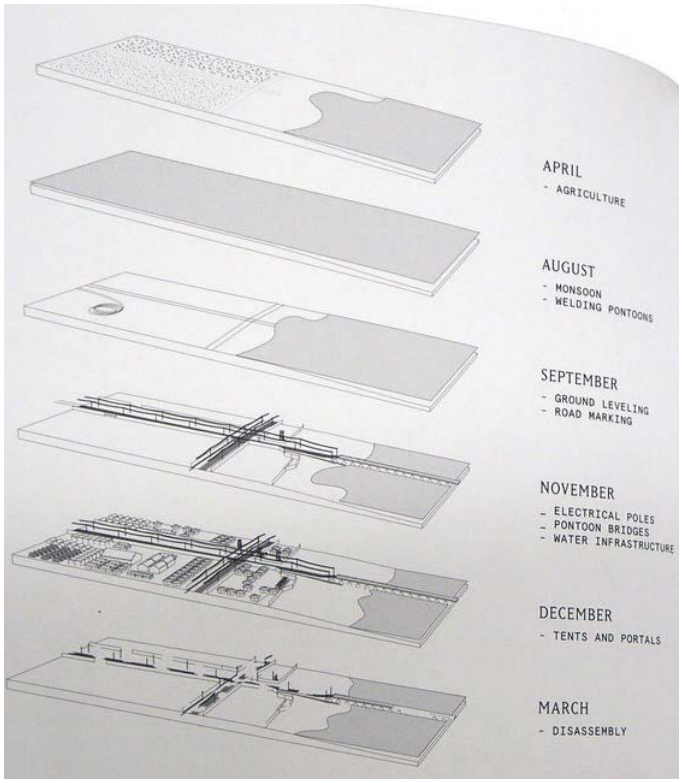


Image 3 : Land Morphology illustration at the site of Kumbh Mela. Source: Archdaily, Page 270 from Kumbh Mela: Mapping the Ephemeral Megacity by Rahul Mehrotra and Felipe Vera; Image courtesy: Felipe Vera. (illustration)

reformulated, readapted, and re-projected in an iterative search for a temporary equilibrium that reacts to a permanent state of crises." (Mehrotra, R. 2021)

The major drawbacks of such a transitioning cityscape, as the Mela, are tedious as they require colossal work and financial aid for its construction and deconstruction (about INR 155 crores). The planning of the Mela also limits the imagination of how spaces can be utilised apart from their predetermined function, for example, one cannot rest in the market space as they are intended to be spaces for commerce and movement which houses functions such as shops, games etc.

The entire process also employs trained staff and volunteers to operationalize different phases of this public event until the land is returned to its original state- including crowd management and displacement- which is a herculean administrative task. Similarly, so is the sourcing of materials for various phases of this event, especially temporary infrastructure for enclosures that are assembled by using bamboo, corrugated metal sheets, tent fabric, metal anchors, and ropes.
However, The Kumbh Mela tackles all the technical as well as the socio-cultural aspects of a festival at this scale while respecting the ecosystems of the region to avoid land pollution- which no other festival across the globe is in a position to deliver. In the end, the land is left to transform into a place that nurtures food sources through seasonal farming practices until it is time for monsoon where water submerges the land allowing it to replenish its soil with nutrition.

An example of Human Flourishing through Ecological Sustainability:

Seetha Low reiterates environmental sustainability as defined by the United Nations World Commission, saying it "presupposes the goal of improving the quality of human life while remaining within the carrying capacity of current ecosystems and stabilising the disruptive relationship between human culture and the biophysical world". (Low, S. 2022, pg.126).
Ethnographic fieldwork on numerous public space typologies indicates that ecological and environmental sustainability is a factor of human flourishing. We need a paradigm shift from the fallacy that afforestation is a panacea for the global climate crisis to focusing on the coherent management of our ecosystem services. In what ways can we evolve from environmentally sustainable practices to devising ways for ecological sustainability to ensure healthy ecosystems for future generations? Seetha Low further explains in her book, that the Earth's ecosystems are interconnected to allow certain groups of species to thrive and their existence is essential for certain "micro-processing" to take place which determines the quality of basic elements of life like air, water, soil, and climate systems. Thus, the argument considered allows us to establish a thought on the ephemeral state of an ecosystem to include a diverse set of species and not limit to a single group; an extension that permeates beyond the human-centric approach.

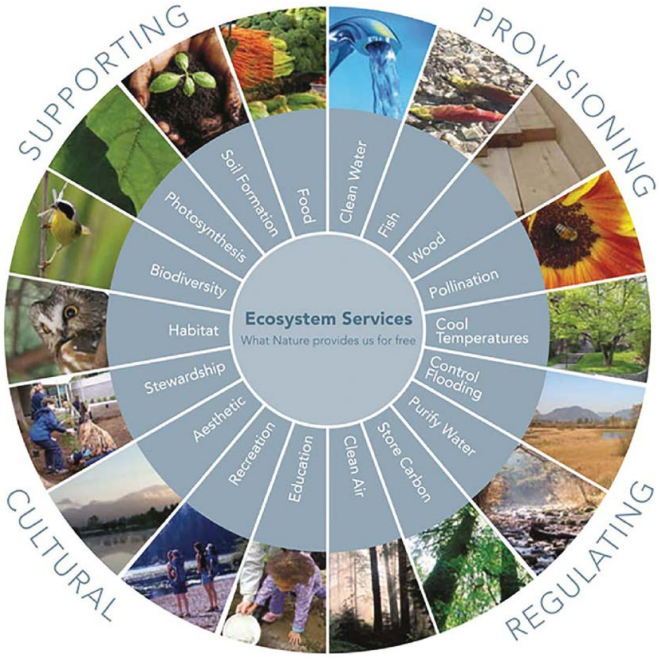


Image 4 : The Millennium Ecosystem Assessment (MEA) organises 'ecosystem services' into four broad categories. Source: Metro Vancouver (illustration)

The Kumbh Mela's inadvertent adherence to ecologically sustainable factors could proffer a template for modern public space gatherings. It successfully satisfies at least two types of ecosystem services as stipulated by the MEA (Millenium Ecosystem Assessment), namely, the Cultural and Supporting services. By this, we mean that the Mela nurtures the human-ecosystem relationship by providing

for social development through the congregation and supports ecological life by allowing for the cycling of nutrients in the soil through the use of biodegradable materials and honouring seasonal conditions.
"Land is emotive, social and intensely political but it is also very concrete and material." - (Nikita Sud, The Making of Land and The Making of India, Oxford Press.)

The honourable treatment of land:

A biopsychosocial approach to the problems of land use is that land and honour are not synonymous in the current industrial zeitgeist. If there is a modicum of honour, it is reserved for that which is owned. Therefore, the land is highly commodified and politicised often subjecting it to ill-treatment and misuse leading to inevitable abandonment and spoiling. Riverside developments, agricultural land, manicured parks: are these paradigms for the honourable treatment of Land?

The indigenous American botanist Robin Kimmer in her book Braiding Sweetgrass, talks about a restoration plan that sprouts from understanding multiple meanings of land: "Land as a sustainer, land as identity, land as a grocery store, land as a pharmacy, land as a connection to our ancestors, land as a moral obligation, land as sacred and land as self." Moving from the divisive sustainable strategies that are mostly siloed to phytoremediation, we as urban planners/architects must consider nurturing a biocultural strategy. This means that we need to reconsider the relationship between the people and the land, just as much as efficient hydrology or decontamination. Thus, public spaces when frequently used provide meaningful social engagements like shared ideologies, traditions, and cultural interests that establish a deeper connection with the land itself. Here, The Kumbh Mela (space) is situated on the delta land of the rivers (place) that holds a deep and significant space-to-place connection channelled through shared memories via recurrent spatial experiences that transcend commodification through 'spirituality'.

What the Kumbh Mela can teach the world is to effectively use its materials and resources, whether it be land or the soft infrastructure on it. The Mela also reinforces the popular idea of recyclability, reducibility, and reusability, by challenging the notion of large-scale sustainability paradigms while serving as a template for navigating one of the biggest challenges in public spaces/gatherings: catering to a diverse culture and accompanying needs

Urban Lessons from the Kumbh Mela:

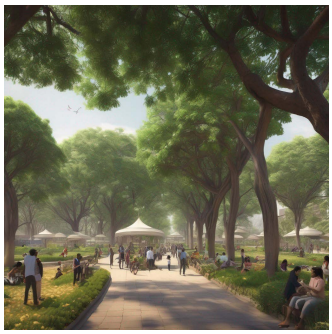
Large-scale events like Music festivals can espouse a universal system where governments can build a repository of materials to be repaired and reused. Re-envision what development means in a sustainable city by modelling some of the practices from the Kumbh Mela. Primarily, that of working with an ecological quotient of the land. The only con of this idea is that it would be environmentally deterministic.
Could we reimagine our current public gathering space?

To take a current example of one of the largest congregational spaces in the City of Bengaluru, India: Palace Grounds, situated on about 400 acres of land. It is a prime location for eco humanistic intervention in the urban planning of the city. The Palace Grounds currently distributes its activities seasonally and leaves large acres of land barren in the heart of the city.

Image 5: Bangalore Palace Aerial view. Source: Times of India; Image Courtesy: OYO Hotels.(image)

In the early aughts, the Supreme Court of India decreed that no permanent structures be built on the grounds and allowed temporary structures to remain for a few days. In an article by Citizen Matters, Bengaluru, Naresh Narasimhan, Principal Architect, Venkataramanan Associates, says about the events in Palace Grounds, "Why should it be treated like a private property? The government should convert it into a big botanical park with the biodiversity of Karnataka."
In line with this, the hope is to espouse the approach of an "adaptive reuse project". By that, we mean envisioning different uses of land off-season contrary to on-season (as per auspicious times for weddings and religious festivals). Like the Kumbh Nagri, temporary structures are erected to hold gatherings as needed and with a similar deployment and deconstruction concept. Guerilla urbanism, as it is termed, could revive Palace Grounds as a lung for the city while also emphasising the self-organised reuse of vacant land and buildings to give way to ecological housing, alternative cultural centres, nutrient cycling agriculture that can function as community gardening or urban farming projects.
The city of Bengaluru continues to see rapid urban expansion, but what happens to the city when it has reached its limit? The general consensus is to try to find answers in suburban sprawls. However, Charles Correa, an eminent architect, believed that there was a limitation to sub-urbanisation and solutions had to come from solving urban crowding and sprawl. Palace grounds provide an opportunity to be the perfect case study for insurgent space interventions that revamp the quality of public life contributing to healthy living conditions in the city.

Image 6: Imagination of insurgent public space in Palace Grounds by the citizens. Source: AI-generated image- stable diffusion/Sama's stable-diffusion.(image)



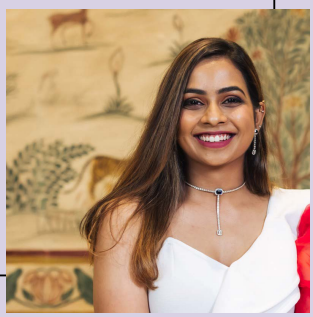
Public space occupancy must be viewed as transient and therefore, must employ alchemical design interventions. Creative sustainability is understood as a means to develop places and communities in ways that do not lead to rapid gentrification but gentle transitions between urban modalities.

Are we, as a conscious species, actively making deliberate choices to influence the relationships between ecosystems and reevaluating our approach to land?

References :

- Grover, T. B. (2015). What Conservation Can Do For Community: Maximizing the Contributions of Adaptive Reuse Interventions to Community Development . Animating Public Space , 1-201.
- Hou, J. (2010). Insurgent Public Space: Guerrilla Urbanism and the Remaking of Contemporary Cities. Insurgent Public Space, 1-267.
- Low, S. (2022). Why Public Space Matters. In S. Low, Why Public Space Matters 1- 272 New York : Oxford University Press.
- Macomber, T. K. (2015, July). Kumbh Mela: Mapping the Ephemeral Mega City. Retrieved from Harvard University : https://www.gsd.harvard.edu/publication/kumbh-mela-mapping-the-ephemeral-mega-city/
- Mehrotra, R. (2021, November 4). gsd.harvard.edu. Retrieved from Excerpt from The Kinetic City & Other Essays: The Permanent and Ephemeral : https://www.gsd.harvard.edu/2021/11/excerpt-from-the-kinetic-city-other-essays-the-permanent-and-ephemeral-by-rahul-mehrotra/
- Mehta, V. (2022). Public Space notes on why it matters, what we should know, and how to realize its potential. In V. Mehta, Public Space notes on why it matters, what we should know, and how to realize its potential 1-268 Routledge.
- Mittal, L. (2015). Mapping the Ephemeral Mega-City. Kumbh Mela, 1-53.
- Nair, A. (2012, September 24). Citizen Matters. Retrieved from Citizen Matters Bengaluru: https://bengaluru.citizenmatters.in/4540-palace-grounds-tiff-ban-on-events-4540

Authors' profiles :



Ar. Sama Arekal

Sama Arekal describes herself as an architect by degree and a transdisciplinarian at heart; a writer and philosopher who resides at the nexus of science, art, and culture. She hopes to raze professional ramparts to provide interdisciplinary mitigations to existing social concerns. Her current passions align with the climate-conscious culture of urban mobility and public spaces, climate change through art, and enriching human health through ecological sustainability.

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Ar. Subhay Baberwal

Subhay Baberwal is a practicing architect who has worked on over 35+ architectural and interior projects in the past five years with firms like taller-S Design and Abhikalp Shristi Karyashalla. His experience also includes handling internship administration, external communication and website content for the firm. Furthermore, he is an external consultant, Academic Office at Indian Institute for Human Settlements. He curates the Urban Fellows Programme (UFP) multi-sectoral internship placement process, IIHS Alumni engagement and coordinates on the academic outreach, collaterals and strategies. He co-teaches Contestation and Negotiations in Public Spacemaking/ Placemaking elective and was the curator of the 30th IIHS Library Exhibition - (Un)restricted: Confronting expression of cultures and connections in public spaces between January- March 2023.

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Illustration by Shruthi B K | 8th sem

02. Community Creations.

Conversation with **Ar.Nipun Prabhakar,** Community Architect and Designer, Founder of Dhammada Collective.

Kalpa, Vol.04, 2023, pp. 10-13

Intent :
Architect Nipun Prabhakar, the mind behind Dhammada, is acclaimed for his transformative vision in sustainable architecture and community engagement. His commitment to duty and sustainability, showcased through the Dhammada collective, aligns with Kalpa's focus on eco-conscious endeavours. Ar. Prabhakar's innovative use of natural and reclaimed materials, collaborative initiatives with tourism boards, and advocacy for community-centric decision-making make his insights invaluable. His holistic approach to architecture, blending environmental consciousness with community welfare, aligns with Kalpa's mission to explore and promote responsible design practices, making his interview a compelling feature for readers who are passionate about sustainable living and thoughtful architectural solutions.
A series of written inquiries were addressed by the Dhammada team, focusing on community well-being and their perspectives regarding eco-conscious architecture on a collective level.

What does the term Dhammada mean? Could you give us a deeper understanding of the phrase "participatory design collective."

Dhammada Collective derives its essence from the word Dhamm-ada, which embodies the idea of performing one's 'Dhamma' or duties. My introduction to the term "Dharmada" occurred while collaborating with Designer Rajeev Sethi on a project in Jharkhand. At that juncture, I substituted 'Dharma' with Buddhist Dhamma to emphasise our duty to work sustainably, benefiting the earth, local communities, craftsmen, and artisans. Sustainability is no longer a choice; it's our obligation, thus the name - Dhammada.
We constitute a collective of architects, town planners and artists situated in Bhopal, Indore, and Delhi. Our practice is dedicated to socially relevant and environmentally conscious projects rooted in grassroots engagement. We specialise in community-based architecture, exhibition design, natural building, and craft-based product designs. Furthermore, we have formed a broader collective, comprising of like-minded individuals and experts from around the world, all committed to grassroots work.

What led you to specialise in community architecture? What inspired you to work with local materials and artisans?

My journey into community architecture was shaped by a desire to avoid conventional commercial architecture firms, even during my education. In 2015, I embarked on an internship with Hunnarshala, an organisation based in Bhuj. This group emerged after the 2001 Gujarat earthquake, focusing on community and artisan empowerment. During my tenure there, I spent four to five months in Muzaffarnagar, rebuilding houses for those affected and displaced by the 2013 riots.
Conventional architectural education often instills the notion that architects possess god-like design authority. We tend to dictate even the minutiae, such as anchoring furniture to building surfaces. However, my time at Hunnarshala taught me a different approach, where communities take centre stage in decision-making. We architects support them in designing their homes and provide technical guidance, but the ultimate power to build and shape their environment rests with them.

Image 1: Dhammada's Studio space in Bhopal. (Photo: Nipun Prabhakar)

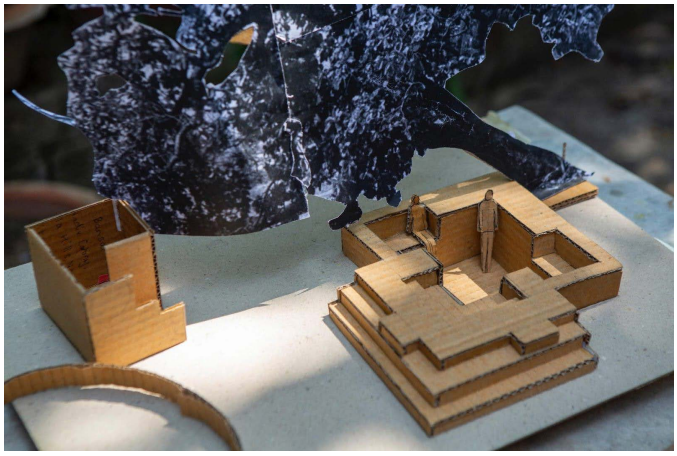

Image 2: Model of a stepwell like plunge pool near Bhopal. Design team - Nipun Prabhakar, Simran Channa, Nilesh Suman, Sanika Kedar. (Photo: Nipun Prabhakar)

An influential chapter in my life was living in Hardoi, a small Uttar Pradesh town where my parents were transferred. This experience, spanning nine years, provided insight into small-town life, contrasting with the upbringing of my friends in larger cities like Delhi.

My innate shyness and reluctance to engage with people pushed me towards community engagement. I aspired to be in the field, conversing with people rather than being confined to an office, drafting plans. My aversion to "othering" individuals and my curiosity about people enhanced my ability to work effectively with diverse communities.

What properties of these materials inspire you to work with them, and how do these compare to more modern materials?

Working with natural and reclaimed materials brings a unique sense of connection with the earth.
These materials have a lower environmental impact than their modern counterparts due to reduced energy requirements for extraction and manufacturing. Additionally, they echo the local character, preserving a region's culture, traditions, and craftsmanship, infusing a deeper sense of meaning into the built environment.
Their aesthetic appeal lies in their timeless beauty, the irregularities, and the unique textures they offer, creating visually captivating spaces. They are also impermanent. Impermanence is an innate natural character. I remember a nice line from Christopher Alaxender's 'Timeless Way of building'. It said something like, 'if you want a building to be timeless, build it with materials that eventually die.' Modern materials work on the idea of permanence.

What challenges do you typically encounter when working with materials like kulhads[1] and earthen pots, especially on a large-scale project?

While we haven't employed kulhads extensively in large-scale projects, working with local and natural materials presents specific challenges. One recurring issue is the disruption of supply chains by industrial materials, like cement and steel. People often find it more convenient to purchase these industrial materials from a nearby shop rather than seeking quality mud from their neighbour's land or farm.

Image 4 : During the construction of Kulhad Cat house. (Photo : Nipun Prabhakar)

Image 3: From Kesh Kala - The Art of Hair in India. An exhibition we recently designed for Bihar Museum, in collaboration with Ghent University, Belgium. We tried to collaborate with local craftsmen in the region to prepare installations. Photo: Nipun Prabhakar

[1]Kulhad : traditional earthern handleless pottery cup from South Asia that is typically undecorated and unglazed

Could you provide us with an overview of the Homestays built in Madhya Pradesh and run us through your process of design and construction.

We are collaborating with approximately ten villages in three districts of Madhya Pradesh to develop homestays in partnership with the local communities. This initiative, conducted in conjunction with the Madhya Pradesh Tourism Board and in collaboration with Hunnarshala Foundation, embodies a profoundly community-centric approach. Together with the locals, we craft designs based on regional traditions, utilising locally sourced materials.

These homestays serve the dual purpose of providing comfortable lodging for travellers in Madhya Pradesh's villages, while generating additional income for the property owners. They are strategically located around tourism hotspots in the state, promoting both tourism and community participation.

Image 5 :Nilesh Suman during community discussions about design

Image 6: Nipun Prabhakar in discussion about homestay designs with the village community. Photo by Sejal Selwadiya.

How did the project's locale and climatic nuances influence the selection of the chosen materials?

Our design process unfolds in three stages. Initially, we immerse ourselves in the villages, comprehending the local climate, spatial utilisation, native materials, and artisanal expertise. We document traditional structures, engage with local craftsmen, and gain a holistic understanding of building practices. We identify challenges in traditional architecture and brainstorm solutions.

Returning to our studio, we synthesise our insights into designs that consider both tourists' needs and homeowners' concerns. Subsequently, we return to the villages with design proposals, involving the community in a selection process.

Materials are chosen based on local wisdom and suitability. We place a high level of trust in locally sourced materials, which have evolved through centuries of trial and error.

Image 7: A resident enjoying his newly built homestay. Photo: Nipun Prabhakar.

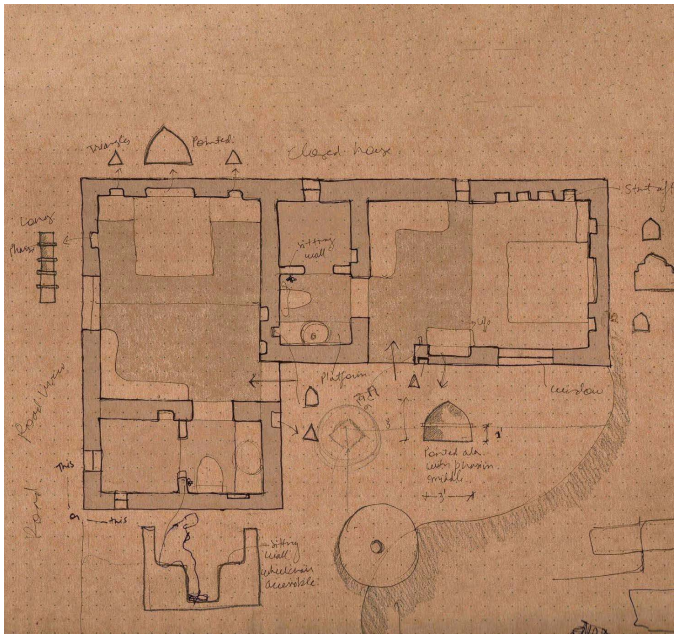

Image 8: Sketch of Homestay design by Nipun Prabhakar.

What role did the owner's comfort, vision, and finances play in the selection of materials for interior spaces?

In most cases, the villagers we work with are comfortable with earth-based materials for interiors, such as mud plaster and exposed wood. These choices also align with the project's objectives and demands.

What engineering methods did you utilize to ensure the structural stability of the Homestays, given that the bricks used were almost 50 years old?

We didn't employ complex engineering methods. Instead, we relied on the wisdom of local artisans. The bricks, even though nearly half a century old, had previously been part of a standing structure. We conducted on-site testing to confirm their strength. Additionally, the new structures were single-story, reducing structural demands.

Today, sustainability is an indisputable precept of any discipline. How would you define sustainability and its applicability?

Sustainability has become a buzzword, often losing its core meaning. It's a concept that varies for each person, rooted in their morality and boundaries. At its extreme, I question whether constructing anything on the ground is sustainable, as it displaces countless living beings and disrupts ecosystems, even when merely digging foundations. Therefore, our initial step in any design project is to question the necessity of construction.
True, sustainability, in my view, involves using local materials, trusting local wisdom, and considering the well-being of the earth at every design and construction stage. It's about making choices that benefit both the environment and our clients.

Lastly, what would be your advice to young architects in creating and energizing one's design through material choices and resource management?

Architectural education often neglects materials, focusing primarily on design. My advice to young architects is to observe, touch, and feel materials in their surroundings. Sometimes, materials' limitations and qualities guide the design. Stay curious and stay informed about material innovations to become better designers.

In today's rapidly evolving construction industry, new material innovations emerge constantly. Despite this influx of new options, some vernacular materials still persist as relevant construction materials. Why do you think these materials continue to find their place, despite the constant emergence of new materials and technological advancements in the building industry?

Embracing technology is crucial, and we shouldn't shy away from it. We should leverage technology to create advanced eco-friendly materials and develop innovative sustainable practices. This shift should reorient technology from being solely economically driven to being sustainability-centric.

Interviewee's profile :

Ar. Nipun Prabhakar
Nipun Prabhakar is an Architect, designer and photojournalist based in Bhopal and Delhi. He works closely with communities in South Asia where he designs built structures and documents stories at the intersections of ideas, artefacts, culture, transformation, and the built environment. He is the Founder of Dhammada, a community architecture collective.

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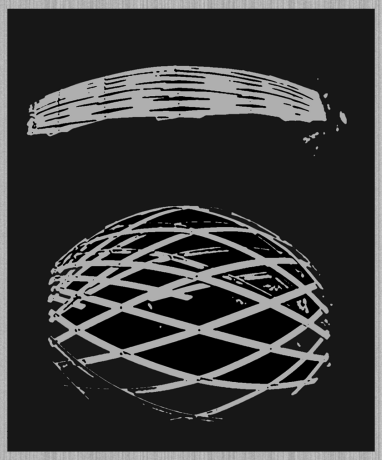

DEVELOPMENT

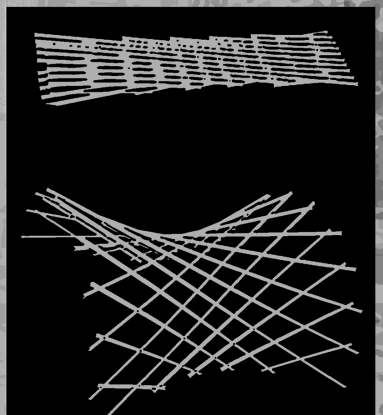

Illustration by Eashwar Minimudi Suresh | 8th sem

03. A Brief Overview of Deployable Structures.

Author : Ar.Anushree Parkhi , RVCA Alumnus, currently pursuing M.Arch at University of Illinois Urbana- Champaign.

Kalpa, Vol.04, 2023, pp. 15-19

Abstract :
Deployable-Collapsible structures are unique types of structural systems capable of transforming from a closed configuration to large-span (and vice-versa) enclosing structure. Due to their compact nature, ease of transportation and expansion ratio, these often find use in semi-permanent structures, bridges, emergency shelters and facilities, and also outer space structures. The use of any deployable structure is majorly governed by the needs and the type of deployment required. The types of deployable structures can further be classified depending on the nature of elements that make them up. The article gives an overview of the types and characteristics of deployable structures and provides an insight into the morphology and applications of deployable structures.

Keywords :
Deployable structures, Transformative, Tensegrity

INTRODUCTION

'Adaptable', 'Kinetic', 'Evolving', are some keywords that are critical considerations for contemporary buildings. New techniques and technologies are implemented in facades, building roofs, etc, which allow for the transformation of the building form as a whole or portions of it, thereby creating a dynamic user experience. Deployable-Collapsible structures are unique types of structural systems capable of transforming from a closed configuration to large-span (and vice-versa) enclosing structure. These are exceptional in the sense that they can be rapidly deployed, can be stowed and transported from place to place.
Moreover, these are geometrically designed to be self-stable structures in their closed and open configurations. Some types of deployable structures may exhibit non-linear behaviour, which means that for any small load applied, they have large displacements. This makes them a highly specialised class of structural systems. The article gives an overview of the types and characteristics of deployable structures and provides an insight into the morphology and applications of deployable structures.

USES/ APPLICATIONS

The transformable nature of deployable structures opens up a wide range of possible uses. Due to their compact nature, ease of transportation and expansion ratio, these often find use in semi-permanent structures, bridges, emergency shelters and facilities, and also outer space structures. Depending on the category and type of geometry these structures can be retractable domes, expandable walls, collapsible vaults, etc. Current ongoing research in this field opens up possibilities of many new geometric configurations, which would increase further prospects for the use of deployable structures.

TYPES

In general, the use of any deployable structure is majorly governed by the needs and the type of deployment required. The type of deployment is primarily dependent on the geometric linkage which defines the behaviour of the structure.
(Zhang 2021) classified deployable structures into three types:
Rigid Deployable, Flexible Deployable and Hybrid Deployable structures.
Rigid Deployable structures provide high stiffness ratio and consist of stiff linkages. Image-1 shows an example of a rigid deployable structure.

A flexible deployable structure on the other hand consists of flexible rods, shells and thin cables and is suitable only for one time deployment. The flexible cables are folded to a small volume by external force and these store potential energy within themselves. When this energy is released, the structure expands. This technology is frequently used in solar arrays, solar booms and sails.

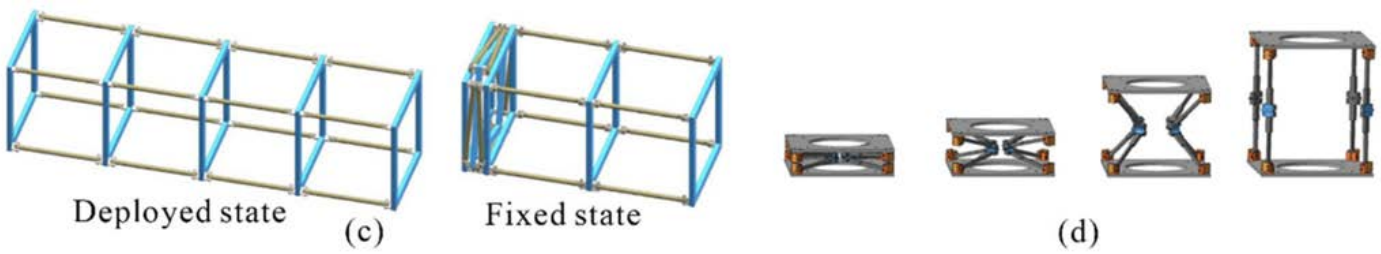

Image 1: Rigid Deployable Structures ; (Source: Xiao Zhang, 2021)

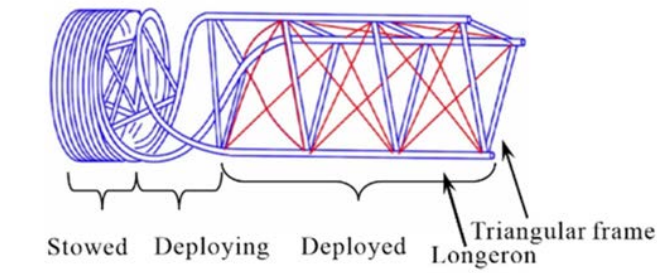

Image 2: Image of a flexible deployable structure ;
(Source: Xiao Zhang, 2021)

The third category is that of hybrid deployable structures. These types of structures consist of rigid linkages with intermediate flexible elements. The rigid linkages provide stiffness and stability to the structure, while the flexible cables allow for folding and add to the lightness.

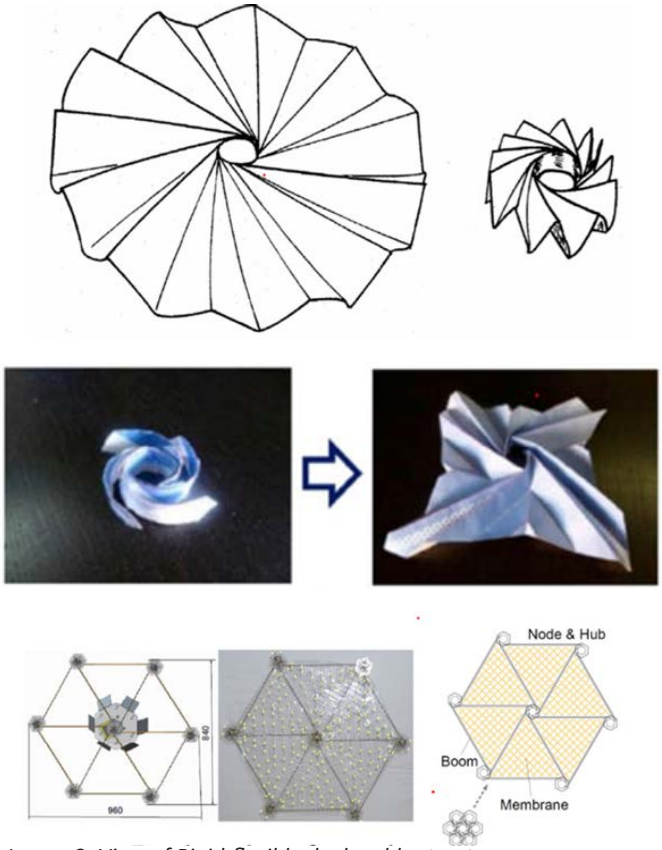

Image 3: View of Rigid-flexible deployable structures
(Source: Xiao Zhang, 2021)

The three types of deployable structures can further be classified depending on the nature of elements that make them up. As mentioned by (Amela Šljivić et al., 2021), they can be further classified into structures composed of bar elements, plate elements, spatial elements such as, pneumatic structures, and combined elements which include bar and membrane or plate elements. The façade of the Al Bahar tower in Dubai is an example that uses combined elements of bar and plate elements, to create an adaptable façade. Deployable structures with plate-like elements often use origami principles to determine the method of folding. Different types of folds can guide different movements. Some common fold types include the Miura fold, the Resch fold, and Yoshimura fold

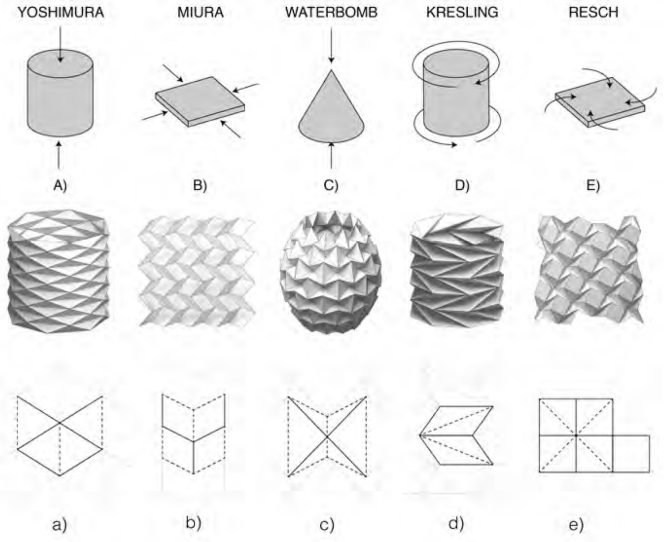

Image 4: Different fold types
(Source :Matthew Gardiner, 2018)

The deployable structures that use the bar elements can be further classified as those using a tensegrity mechanism or structures with scissor linkages. Deployable tensegrity structures contain cables that are in tension and bar elements that are in compression. Folding of the tensegrity structures is primarily dependent on the cables.

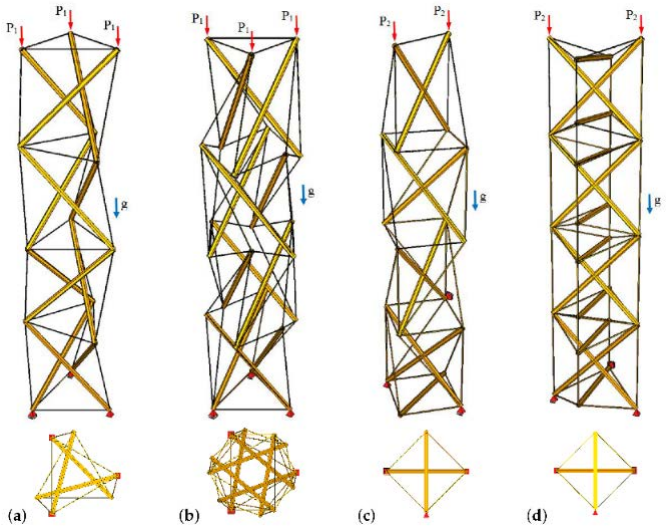

Image 5: Tensegrity deployable structures
(Source: https://www.mdpi.com/2076-3417/10/23/8676)

The deployable structures with scissor linkages are a very interesting classification in the domain of deployable structures. Some of the scissor based deployable structures were developed early on by Pinero and Hoberman. The following image shows a deployable dome made with scissor-based elements by Hoberman. Depending upon the geometry of the linkages, the scissor type deployable structures can fold and move linearly, radially or in a polar configuration.
Different scissor configurations can generate various movement patterns. The section below highlights some examples of buildings, which implement deployable structures in their roof, facades, etc.

Image 6: Deployable dome by Hoberman
(Source: https://www.designersandbooks.com/blog/greg-lynn-book-list-digital-dialogue)

EXAMPLES

The following two examples highlight buildings which use deployable structures, mainly rigid elements, in different parts of the overall structure. An example of a building which uses the scissor bar type of deployable structures is the Olympic Arch at Utah. Also known as the Hoberman Arch, the structure is a massive 72 ft span x 36 ft tall transforming curtain, installed for the 2002 Winter Olympics. The curtain was controlled by two motors of 30 HP each which allowed it to open in 20 seconds. The Olympic arch at Utah, was a key example of a scissor type deployable structure, with eccentric connections, which allowed for the polar movement of the arch. This mechanism is also known as the Iris mechanism

Another interesting example is that of the Rolling Bridge in London by Heatherwick studio. Spanning across the Paddington Basin in London, the concept was to create a bridge that breaks apart or moves out of the way to let boats pass through. The idea was to develop a mechanism for mutating the form of the bridge, rather than fracturing it. Built in 2004, the 40 ft long steel truss bridge can curl up to form a circle, and open to form a full-length bridge in a time span of two minutes. Fixed to only one end of the coast, the bridge consists of eight triangular sections, each with hydraulic pistons, that help open and retract the bridge. The steel trusses form the structural component of the bridge, while the base path is created by timber sections mounted within each triangular section. The deployment of the bridge follows

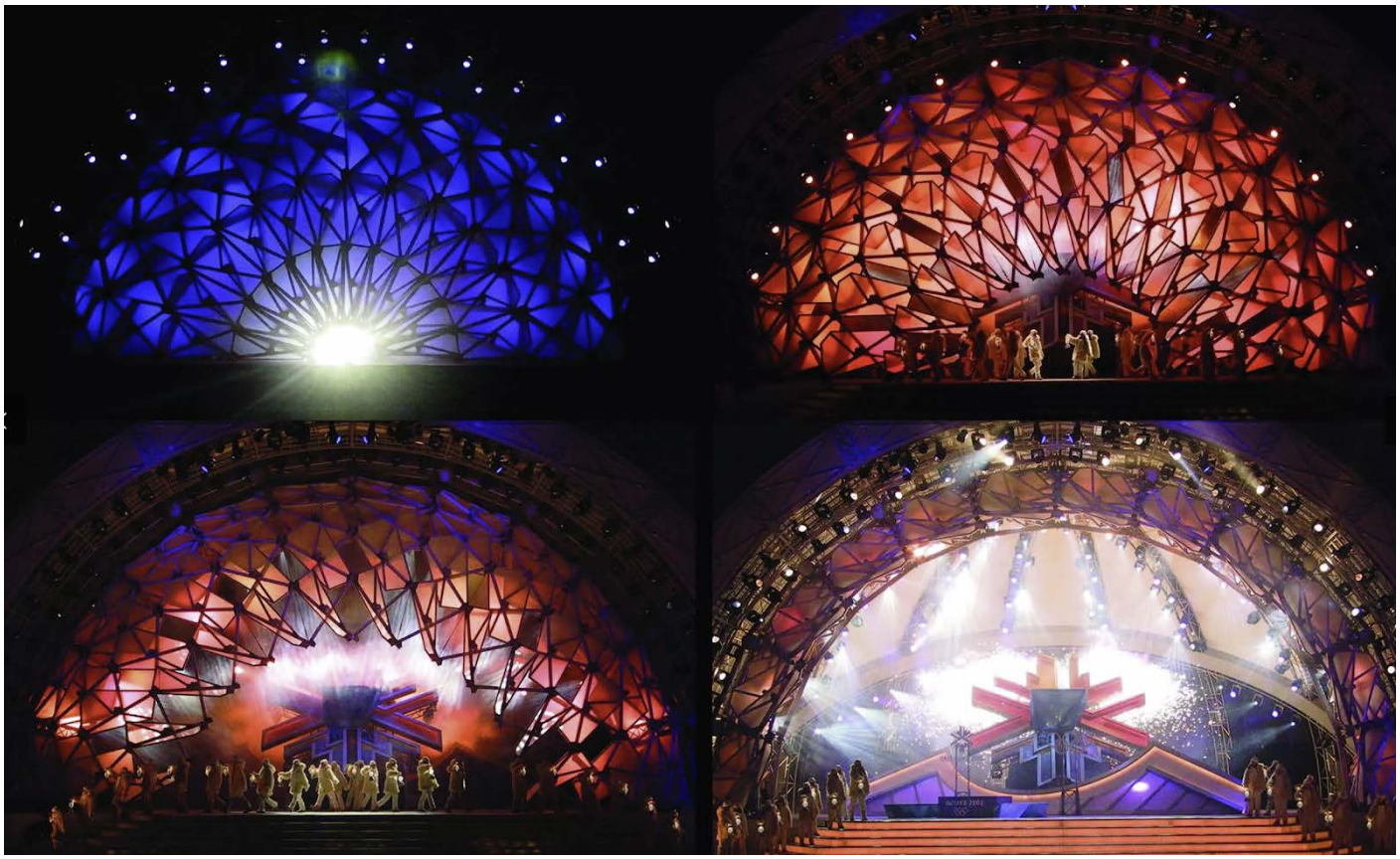

Image 7: View of the Olympic arch at Utah, closed to open configurations
(Source: https://www.hoberman.com/portfolio/olympic-arch/)

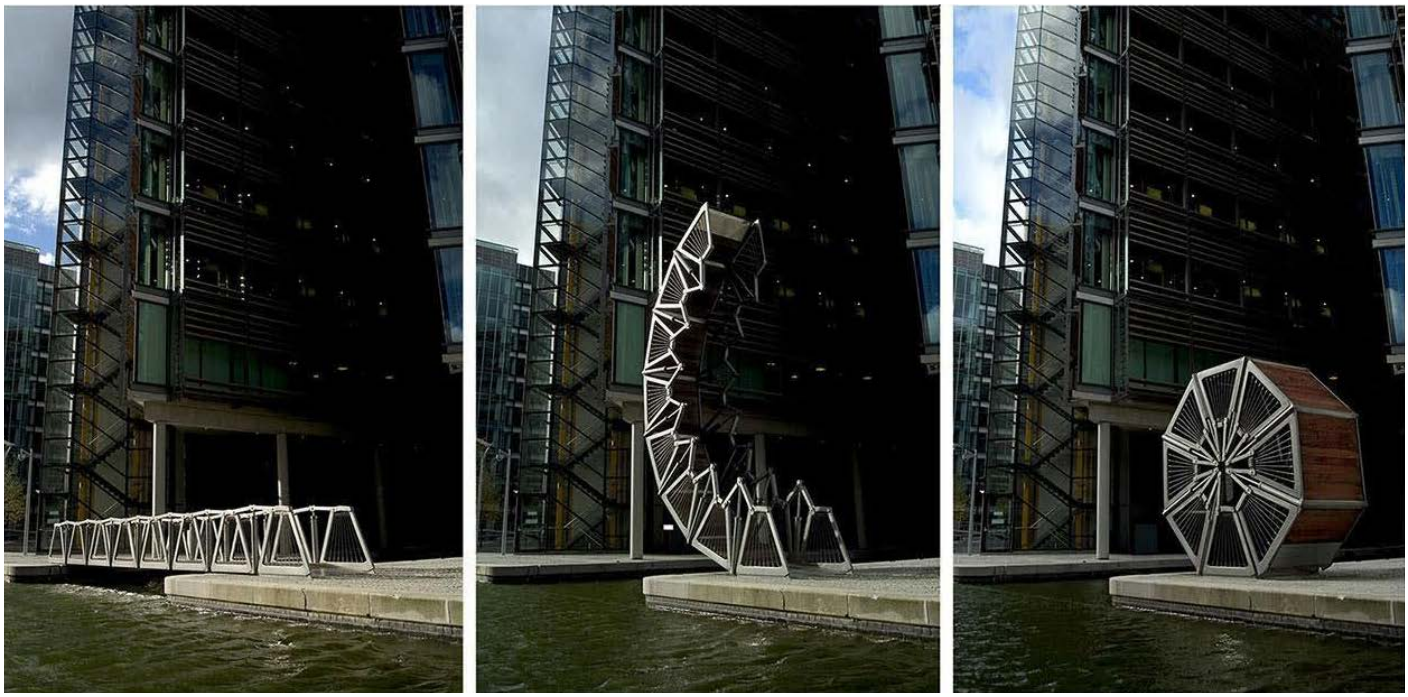

Image 8: View of the Rolling Bridge London in different deployment stages (Source: https://www.heatherwick.com/project/rolling-bridge/)

a polar movement due to eccentric connections between the steel members of the bridge. Each of the trusses is pin-jointed with pistons as a vertical post in the centre of the triangle. This allows for free movement of the steel members, and also creates a lightweight structure. The bridge is an interesting example of an engineering feat in architecture. Image-8 and Image-9, below show the 'Rolling Bridge', London, in its closed, intermediate, and deployed states, and its details.

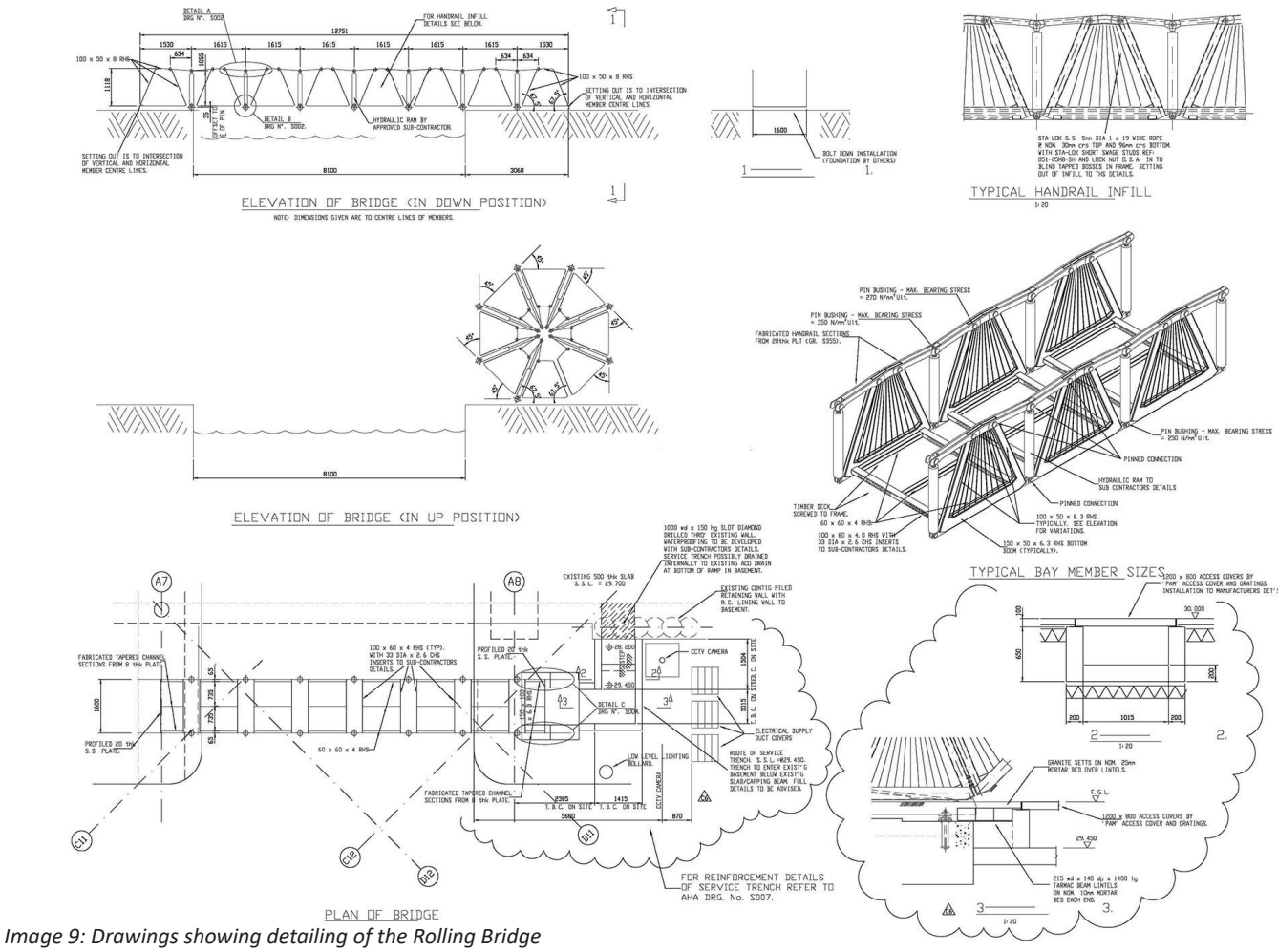

Image 9: Drawings showing detailing of the Rolling Bridge (Source: https://www.heatherwick.com/project/rolling-bridge/)

CONCLUSION

The above examples clearly illustrate how deployable mechanisms can help create adaptable buildings, which generate interesting experiences. The use of deployable mechanisms in buildings and building elements such as facades, roofs, walls, etc. is definitely on the rise due to the multiple possibilities offered by these structures. These structures however do require careful geometric design and advanced structural analysis, as they are susceptible to large deformations under small loads. Their minimum volume, adaptiveness, transportability, and reuse, make them a favourable choice in many fields. Possible parametric variationas in geometries open up a myriad of new possibilities of forms and movement. Overall, deployable structures is an interesting field of special structures that offer a plethora of design opportunities for architects and engineers.

References

- Sljivic, Amela & Miljanović, Slađana & Zlatar, Muhamed. (2021). A new classification of deployable structures. E3S Web of Conferences. 244. 05016. 10.1051/e3sconf/202124405016.
- Gardiner, Matthew & Aigner, Roland & Ogawa, Hideaki & Hanlon, Rachel. (2018). Fold Mapping: Parametric Design of Origami Surfaces with Periodic Tessellations.
- Zhang, Xiao & Chen, Yan & He, Baiyan. (2021). Deployable Structures: Structural Design and Static/Dynamic Analysis. Journal of Elasticity. 146. 10.1007/s10659-021-09860-6.

Author's profile :

Ar. Anushree Parkhi

Anushree is a first-year graduate student at UIUC with a profound passion for architecture. She is particularly interested in the integration of architecture, services, structures, computation, and other related disciplines. Anushree firmly believes that architecture revolves around creative problem-solving, and this aspect excites her the most about her field. The prospect of innovation, exploration, and facing challenges keeps her motivated and eager to tackle new problems every day.

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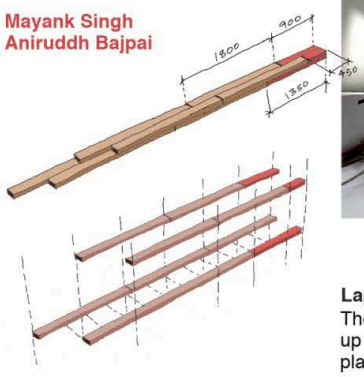
04.

Bending-active Timber Gridshell

Mayank Singh
Aniruddh Bajpai

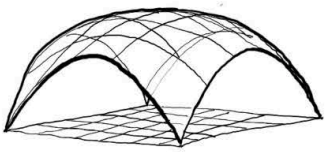
Timber bending active gridshells represent an innovative and cutting-edge approach in architectural design and construction. Combining the strength and versatility of timber with advanced computational techniques, these structures push the boundaries of traditional construction methods.

They are constructed using the "bending-active" principle, harnessing the inherent flexibility of timber. Thin timber beams are assembled in a flat grid pattern on ground. They are then pushed and bent physically deforming under external loads, redistributing forces and achieving self-stabilization. This results in efficient load-bearing and elegant curved forms without the need for additional rigid elements. The method blends architecture and engineering to create visually stunning, resilient structures.

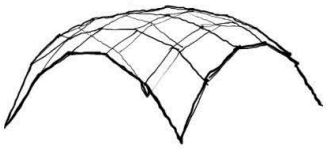


Skewer model

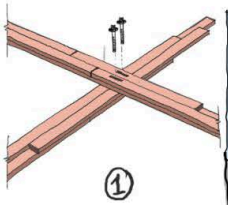
Lapping detail
The individual members are made up of four 150 x 50 mm timber planks with a staggered lapping arrangement of 450, 900, 1350 and 1800 mm lengths.

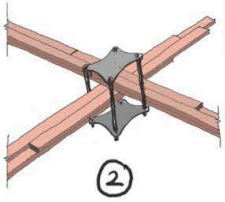


Bending-active gridshell

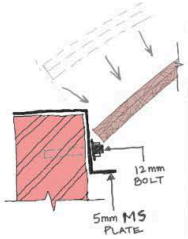


Discrete gridshell

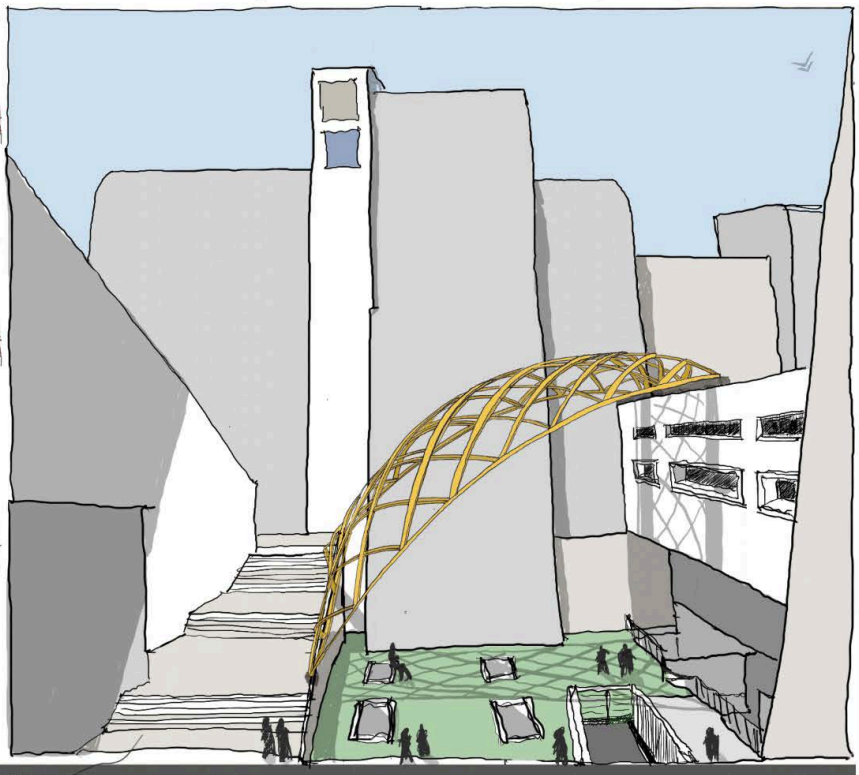




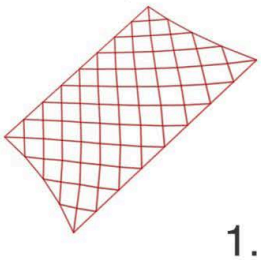
Nodal connection



Socket Detail

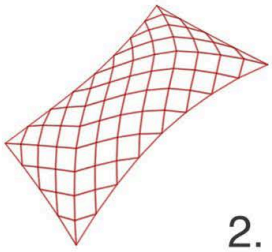


FORM FINDING



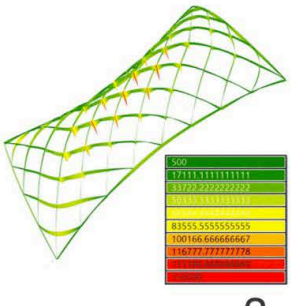
1.

A flat CAD mesh is drawn with disjointed lines and nodes as afirst step. This source mesh shall be used for the dynamic relaxation and structural analysis.



2.

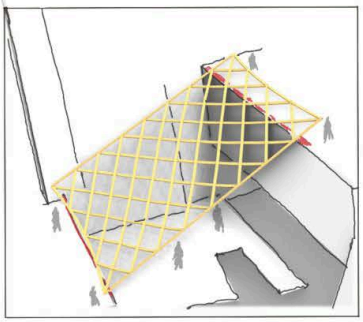
In this step, very mild dynamic relaxation is applied using *Kangaroo* plugin within *Grasshopper3D* to introduce minor eccentricities which would kickstart the bending simulation.



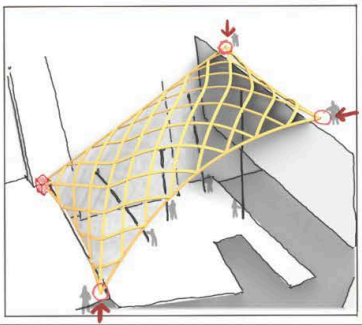
3.

Bending simulation is carried out in *Kiwi3D*, by applying a compressive prestress of about 400 N at the peripheral nodes. The legend shows the range of Von Mises stress induced (N/m^2) in the beams, which is way under the maximum limit of any timber member.

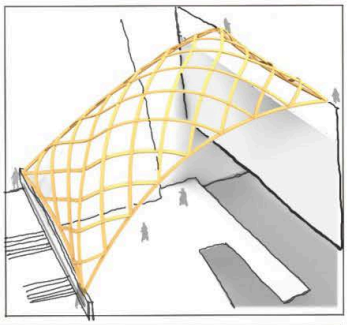
CONSTRUCTION



1. The timber members are laid flat or inclined on the site and interconnected via bolts and screws. Only the two opposing peripheral edge members are slightly bent.



2. As per the arrows shown, manual force is applied inward keeping one corner node's position stationary. Little nudging may be required from the bottom with the use the posts to avoid reverse bending.



3. One the deseirable form is achieved, the corners are locked into the anchor plate which is bolted and grouted with the peripheral walls.

Illustration by Tummala Pranesh | 8th sem

05. Tangibility and/or Materiality of Heritage Resources.

Author : Ar.Nishant, Assistant Professor , RV College of Architecture.

Kalpa, Vol.04, 2023, pp. 22-25

Abstract :
This paper aims to explore the tangible/physical aspects of heritage resources. Heritage resource is a combination of numerous tangible and intangible values, these values have been delineated by heritage scholars and practitioners. Institutions such as UNESCO[1], ICOMOS[2] and ICCROM[3] are continuously involved in broadening the scope of values associated with heritage properties.
When it comes to tangible/physical aspects of the values associated with heritage resources, the economic values take the central stage. Based upon existing economic theories, several scholars have developed valuation frameworks for historical properties. The Applicability of these frameworks depends upon the nature and context of the heritage resources. This article reviews existing literature and compiles a list of the most common economic valuation methods. The basic introduction, methodology and application process of these valuation methods are demonstrated. By highlighting the strength and weakness of these valuation methods, the article proposes a list of conditions for the selection of appropriate methods.
The extension of this paper would involve various case studies based upon different methodologies and testing through selection of a heritage site and application of appropriate methods. The future significance of this study is to develop a holistic understanding of these quantitative methods for evaluation of both, intangible as well as tangible aspects of heritage resources.

Keywords:
Heritage Resource, Tangible, Valuation method, Intangible, Institutions.

Introduction

Heritage resources serve as a connecting thread between the past, present and the future; it contains the tangible as well as intangible aspects of human development.

Over the past thirty years, the concept of cultural heritage has been continually broadened. The Venice Charter (1964) made reference to "monuments and sites" and dealt with architectural heritage. The question rapidly expanded to cover groups of buildings, vernacular architecture, and industrial and 20th century built heritage. Over and above the study of historic gardens, the concept of "cultural landscape" highlighted the interpenetration of culture and nature (Bouchenaki, 2003).

Cultural heritage is a complex relationship between person, society (a group of people exchanging ideas), norms and values (faith, belief systems, rituals). The cultural products frame the tangible/material evidences of social values. These products establish a relationship between tangible and intangible,where, intangible aspects are the main driving force behind tangible manifestation and this should be regarded as having high value. The tangible/physical heritage resources take shape within these undefined boundaries of intangibility. The Istanbul Declaration, adopted at a round table of 71 Ministers of Culture, organized by UNESCO in Istanbul in September 2002, stresses that "an all-encompassing approach to cultural heritage should prevail, taking into account the dynamic link between the tangible and intangible heritage and their close interaction." This dialectic may prove particularly fruitful in providing greater representation for those cultures of the world that attach more importance to the oral tradition than to the written one (Bouchenaki, 2003).

The conflict between tangible and intangible aspects of the heritage resources arrives at an interesting junction, when it pertains to the practical aspects of heritage conservation. The physicality of heritage resources participates in the process; hence the projection of tangible aspects takes the central stage. In the real world the physicality of heritage resources needs to be evaluated, its association with the context also needs to be measured within the subjective framework.

It is probably apt to presume here that, a world in which that which is visible, and concrete takes precedence over that which is immaterial. Central to all is the issue of values and valorisation: what qualified as cultural heritage was deemed to be stable and static and having 'intrinsic values' as well as qualities of 'authenticity'. In the real world, ceteris paribus the cart does not pull the horse. Cultural heritage should speak through the values that people give it and not the other way round. Objects, collections, buildings, etc. become recognized as heritage when they express the value of society and so the tangible can only be understood and interpreted

[1]UNESCO: United Nations Educational, Scientific and Cultural Organization
[2]ICOMOS: The International Council on Monuments and Sites
[3]ICCROM: International Centre for the Study of the Preservation and Restoration of Cultural Property

through the intangible. Society and values are thus intrinsically linked (Munjeri, 2004).

The concept of tangibility in heritage resources refers to its physical nature, which allows us to experience the past at a non-instinctive level. This also enhances our understanding of cultural evolution, societal development and the intricate manifestation of human skill. The tangibility of heritage resources is a material evidence of craftsmanship, creativity, and innovation of the past generation. It covers a wide range of artifacts, objects, structures and architectural marvels, which has travelled through the test of time and reflects the associated values and aspirations of the society that created them. This physical manifestation holds the same frequencies that resonate with a contemporary observer. The materiality of heritage resources has the ability to evoke emotional responses, which ultimately bridges the gap between generations. It allows people to touch, see, and sometimes even smell and hear the elements from the past. This multidimensional relationship creates a deeper understanding of the past.

The road to that truth was opened up by those involved in the conservation of the tangible heritage. How tangible was the tangible heritage? This is a question that constantly confronts conservators when dealing with material heritage. If cultural heritage was to be passed on to posterity (as indeed the World Heritage Convention stipulated), what values were to be transmitted to future generations? If values were in the physical property per se, what message was being passed on and why? The dilemma raised by the definition of 'authenticity' was to open a Pandora's Box. This ultimately led to a conference on authenticity held in Nara, Japan in 1994. Conservation policies were supposed to be based on a critical process starting with 'intrinsic cultural resources and values' related to it. What were these intrinsic values? All along they were considered to be four i.e.: 'material', 'workmanship', 'design' and 'setting'. The primary aim of conservation was to 'safeguard the quality and values of the resource, protect material substance and ensure integrity for posterity'. But could that be all? (Munjeri, 2004).

Methods

This paper will try to explore all the used frameworks to convert both tangible and intangible assets into other forms of negotiable values, which is ultimately the primary objective of the current integrated approach towards heritage resources. In future one may explore for a hands-on case study for the valuation of heritage resources.

Exploration of the dynamic and complex nature of value conversion requires a paradigm shift in the current traditional approach towards heritage resources. In this process we try to explore the heritage resources from asset view to negotiable goods and in the form of deliverables. The most common way a heritage resource comes into the market is when it gets converted to goods and services having some kind of financial value.

Value conversion is the act of converting or transforming financial to non-financial value or transforming an intangible input or asset into a financial value or asset. The theme of value conversion runs through social exchange theory and is a key question in the field of socio-economics (Allee, 2008). When heritage comes into business and economic activities, the premise becomes much more complex. Business and economic activities often entail a sophisticated barter system involving heritage resources that plays a vital economic activity in terms of business transactions, in terms of business relationships, creating value and making sure that the transactions run smoothly. The heritage resources must be taken as multiplication of tangible and intangibles and how they are converted into other negotiable forms of value.

Historic properties contain a wide range of values which are almost impossible to measure in monetary terms. In particular, social and cultural values have an important effect on society's well-being and quality of life (Throsby, 2001). Like environmental goods, cultural heritage can be seen as non-tradable goods which contain non-market values (Mazzanti, 2002). Cultural heritage consists of both tangible goods such as historic buildings or archaeological sites, art works and intangible goods such as local traditions, customs and cultural landscape (Yung et al., 2013). In terms of the heritage resource valuation framework, there are many different economic methods which have been used. The entire process entails two categories – Monetary and Non-Monetary Methods. Below is the list of economic models which have been used for the valuation of heritage resources around the world.

Monetary Method:

Revealed Preference Method

- Market Price Method.
- Travel Cost Method.
- Hedonic Pricing Method

Stated Preference Method

- Deliberative Valuation Method
- Contingent Valuation Methods
- Choice Experiment Method.
-

Non- Monetary Method:

Revealed Preference Method

- Observation method
- Document method
- Social media-based method

Stated Preference Method

- Interview method
- Questionnaire method
- Narrative method
- Focus group method
- Expert based method
- Q-method
- Participatory mapping method
- Participatory GIS method
- Public participation GIS method

S No	Empirical studies applying stated preference and revealed preference techniques in case of heritage resource						
	Studies	**Countries**	**Type of Heritage Resource**	**No of Heritage Resources**	**No of subject Variables**	**Statistical Model Used**	**Sample Size**
	Travel Cost Method 2002						
	Boxal	Canada	Cultural Heritage (Park)	1	6	Quantity Demand	661
1	Poor & Smith	UK	Heritage Site	1	4	Quantity Demand Zonal Model	328
	Contigent Valuation 1994						
	Wills	UK	Historic Site	1	5	open ended	92
1	Grosclaude & Soguel	Switzerland	Historic Site	1	5	open ended	200
2	Powe & Wills 1996	UK	Historic Site	1	6	open ended	201
3	Lockwood 1996	Australia	Natural Heritage	1	5	Dichotomous Choice	702
4	Garrod 1996	UK	Historic Site	1	7	Dichotomous Choice	217
5	Beltran & Marino 1996	Mexico	Archeological Sites	3 zones 7 cities	9	open ended WTP	6503
6	Hansen 1997	Denmark	Theatre	1	5	open ended WTP	1843
7	Morey 1997	USA	Marble Monuments	3	4	Dichotomous Choice	272
8	Riganti & Scrap 1998	Italy	Archeological Sites	1	1	Dichotomous Choice	448
9	Scrap	Italy	Heritage Site	1	1	Dichotomous Choice	1323
10	Chambers 1998	USA	Historic Site	1	9	Payment Card	306
11	Santagata & Signorello	Italy	Museum	1	8	Single Bounded Dichotomous Choice	468
12	Maddisson & Mourato	England	Archeological Sites	2	24 WTP level		357
13	Bravi 2002	Italy	cultural service	2		Dichotomous Choice	1323, 854
14	Tohmo 2004	Finland	Museum	1	8	open ended	800
	Conjoint Analysis						
1	Colombino 2005	Italy	Archeological Sites	3	10	open ended	552
2	Laplante 2005	USA	Natural Heritage	1	27	Dichotomous Choice	6900
3	Dutta M 2007	India	Historic Site	1	12	Iterative Bidding	203
4	Multinominal Logit						
5	Alberini 2003	Ireland	Historic Site	2	4	Iterative Bidding	705
	Discrete Choice Analysis						
1	Louviere & Hensher 1983	Australia	cultural event	8	16	Dichotomous Choice	550
	Combined Model						
1	Boxall 2003	Canada	cultural Artefacts	8	na	travel cost	386
	Analytical Network Process						

Source : Author

Results

The next step was to prepare a matrix of Empirical studies applying stated preference and revealed preference techniques. The matrix is combination of several parameters such as – studies, country of performance, type of heritage resource, no of heritage resources used, number of subject variables, statistical model used for analysis and the sample size used for analysis.

Here we can see various case studies where different economic models have been used with different statistical analysis tools. Few cases adopt mixed models. The striking part here is that there is only one case study in the Indian context, but when we see the amount of heritage resources available in India , we can simply conclude that there is huge scope and potential for similar case studies which can guide the decision making process and transform the heritage sector for sustainable development.

Discussion

Valuation of heritage properties and resources is a multidimensional process which combines the tangible (economic) and intangible (cultural) dimensions. This process reveals the quantitative aspects of heritage resources. However it is acknowledged by all economic experts and scholars that heritage resources are not simply commodities but they embrace a synthesised manifestation of our historical, cultural, social and technological significance.

Here we can see that there is no single economic model which can fully translate all the values associated with a heritage resource. Instead these models should be taken as a tool to analyse the one aspect of the multidimensional framework of heritage conservation. Following are the observations drawn from the findings/results on the use of economic models in heritage valuation.

Dynamic nature of heritage: Heritage resources are the repository of time, place and people. Hence any economic model to analyse such resources must accommodate all three dynamic/changing parameters ie., time, place and people into its account. Recognising heritage value as a non-static entity and having flexibility in its valuation method is the most crucial observation.

Balancing economic and cultural properties: We must accept the fact that economic valuation is an important factor for any decision making process, however, it is not the holistic reflection of all the values associated with heritage resources. The cultural values associated within a heritage resource are its soul, hence a fine balance between economic development and heritage conservation is required.

Interdisciplinary approach: As we have seen, heritage resources are dynamic in nature, therefore its historical, cultural, social and technological significance should also be considered. Collaboration of experts of different disciplines such as economists, conservationists, historians, engineers, and community stakeholders must be ensured before taking decisions of the valuation process. We must accept the valuation process as a multidisciplinary subject.

Community engagement: When we look at any heritage precinct, it is the immediate community which is having the strongest association with it; hence ignoring such profound stakeholders would lead to a truncated approach towards the valuation process.

Sustainability: Conservation and preservation of heritage resources should not aim only for economic/monetary benefit but also for long-term sustainable development. Recognition and harvesting the economic potential of a heritage resource gives us an edge for self-management and self-reliance.

In conclusion, economic models are valuable tools for the analysis and valuation of heritage properties, providing important quantitative data that can help the decision-making process. However, they should always be used hand in hand with a deep appreciation for the cultural and social significance of these resources. Heritage is a non-renewable asset that connects deeply with our identity/memory; hence its value extends beyond money. Thus a thoughtful, inclusive, participatory and dynamic approach is required for the conservation of heritage resources.

References

- Allee, V. (2008). Value network analysis and value conversion of tangible and intangible assets. Journal of Intellectual Capital, 9(1), 5–24. https://doi.org/10.1108/14691930810845777
- Bouchenaki, M. (2003). The interdependency of the tangible and intangible cultural heritage. ICOMOS 14th General Assembly and Scientific Symposium (October 27-31, 2003), 1–5.
- Fairchild Ruggles, D., & Silverman, H. (2009). Intangible heritage embodied. Intangible Heritage Embodied, 1–214. https://doi.org/10.1007/978-1-4419-0072-2
- Fredheim, L. H., & Khalaf, M. (2016). The significance of values: heritage value typologies re-examined. International Journal of Heritage Studies, 22(6), 466–481. https://doi.org/10.1080/13527258.2016.1171247
- Jiang, W., & Marggraf, R. (2022). Making intangibles tangible: Identifying manifestations of cultural ecosystem services in a cultural landscape. Land, 11(1). https://doi.org/10.3390/land11010026
- Munjeri, D. (2004). Tangible and intangible heritage: From difference to convergence. Museum International, 56(1–2), 12–20. https://doi.org/10.1111/j.1350- 0775.2004.00453.x
- Murzyn-Kupisz, M., & Działek, J. (2013). Cultural heritage in building and enhancing social capital. Journal of Cultural Heritage Management and Sustainable Development, 3(1), 35–54. https://doi.org/10.1108/20441261311317392
- Taylor, K. (2004). Cultural heritage management: A possible role for charters and principles in Asia. International Journal of Heritage Studies, 10(5), 417–433. https://doi.org/10.1080/1352725042000299045
- Yung, E. H. K., Yu, P. L. H., & Chan, E. H. W. (2013). Economic valuation of historic properties: Review and recent developments. Property Management, 31(4), 335–358. https://doi.org/10.1108/PM-01-2013-0005

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Nishant, a conservation architect, earned his B. Arch. from SPA Delhi in 2012 and M. Arch (Architectural Conservation) in 2015. As Deputy Architect at CPWD, New Delhi, he played a vital role in executing the "Proposed extension to Parliament House Annexe." His contributions extend to renovating the Parliament Library, Parliament House, and the Old Parliament Annexe. Nishant is passionate about traditional and vernacular architecture, focusing on indigenous knowledge systems for innovative solutions. He has presented multiple research papers at national architecture conferences.

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SECTION 2 :
Crafting Curriculum : A Guide to Material Excellence.

Illustration by Shruthi BK | 8th sem

06. Solar Decathlon India.

Authors : Team Encircle, Team Engriha and Team Green Collars.

Teams representing RV College of Architecture at the Solar Dectahlon India (SDI) competition.

Kalpa, Vol.04, 2023, pp. 27-37

Abstract :

Rapid urbanisation and globalisation has, today, put cities on an investigative as well as an empathetic trail of overcoming complex issues incorporating sustainable and resilient practices. Needless to say, the built environment plays a crucial role in the management of such urban complexities and transformations. Solar Decathlon, organized by The Indo-U.S. Science and Technology Forum (IUSSTF), the Alliance for an Energy Efficient Economy (AEEE), and The Indian Institute for Human Settlements (IIHS) is a challenge put forth to undergraduate and postgraduate students of India to explore net zero building concepts and propose design solutions incorporating energy efficient, affordable and resilient. The participants are encouraged to propose real time projects of the building sector with an overarching aim of combating climate change. This year-long challenge exposes the participant teams to self learning modules and mentorship programs to develop the necessary skills and tools to develop affordable and industry ready net zero solutions.

The report presented below entails the project works of three teams representing RV College of Architecture.

1. Team EnCircle:

Team EnCircle's project titled Aikyam provides insights into a net-zero energy community resilience shelter for PWD (Public Works Department.) Arunachal Pradesh. The project's intent is to enhance the microclimate of the site and provide shelter, aid, and comfort during disasters. Strategies such as using locally sourced, recycled, and rapidly renewable materials, along with life cycle assessments, showcase the project's dedication to sustainability.

2. Team Engriha:

Team Engriha highlights their project focusing on designing a net-zero construction worker housing colony. The team prioritises modularity, economic viability, structural stability, and reducing embodied carbon. The material selection process involves an in-depth analysis of various options, and they opt for innovative solutions like Ricron panels with corrugated jute cores.

3. Team Green Collars:

Team Green Collars Discuss their project, EKĀGRA, a net-zero-energy-water school in Nagaon. Their approach involves a holistic consideration of factors such as energy efficiency, water conservation, and circular economy principles.

Overall, each team addressed environmental issues, with a clear objective of achieving lower carbon footprints, and establishing a standard for sustainable practices in the building sector.

Keywords:

Sustainability, Net Zero, Carbon footprint, Materiality, innovation

Team EnCircle

Division : On Site Construction Workers Housing

Team EnCircle, as part of the Solar Decathlon (India), seized the opportunity to design a net-zero energy community resilience shelter for the PWD[1] Arunachal Pradesh in Itanagar. The team's mission was to enhance the microclimate of the space (using GRIHA[2] strategies) and providing shelter, aid, comfort, social resilience, water, and food resilience to people during disasters. The proposed project, Aikyam, is a G+2-story office building situated in the Civil Secretariat complex at Itanagar, with a site area of 3,640 sqm adjacent to NH415. This report delves into the comprehensive process followed by Team EnCircle in choosing the right materials, the initial choices, the reasons for rejection, and the final materials that were incorporated into the construction of the project to create a sustainable and environmentally friendly structure. The goal for the total embodied carbon emissions of the project to be achieved was at least 50% lesser than the base case (68% achieved).

Process of material selection for team encircle's Aikyam involved several key steps:

Identifying Contest Criteria and Material Criteria:

Team EnCircle began by analysing the ten contests in the Solar Decathlon competition. These contests likely covered various aspects of the building criteria and then defined essential material criteria, including U-value, earthquake resilience, environmental impact, sustainability, availability, moisture resistance, availability of skills, and cultural and aesthetic relevance.

[1]PWD: Public Works Department | District East Siang, Government of Arunachal Pradesh | India.

[2]GRIHA: Green Rating for Integrated Habitat Assessment. GRIHA is a rating tool that helps people assess the performance of their building against certain nationally acceptable benchmarks. It evaluates the environmental performance of a building holistically over its entire life cycle, thereby providing a definitive standard for what constitutes a 'green building'.

Understanding Materials with Low-Embodied Carbon:
Embodied carbon refers to all the greenhouse gas emissions generated throughout the materials' lifecycle from extraction to disposal , which includes , manufacturing, transportation, and disposal phases of a material. Reducing embodied carbon has emerged as a crucial objective in the battle against climate change since the building sector contributes significantly to global greenhouse gas emissions.

Design Strategies:
The team worked on the following predeterminants for material selection

1. **The use of locally sourced materials**: All materials apart from recycled steel, are available within a 300-kilometre radius. Recycled steel is bought from Jindal Steel and Power, Chhattisgarh, located 1850 km away from the site. Material suppliers are located within a 30 kilometre radius of the site, reducing the embodied carbon emissions due to reduction in transportation time.

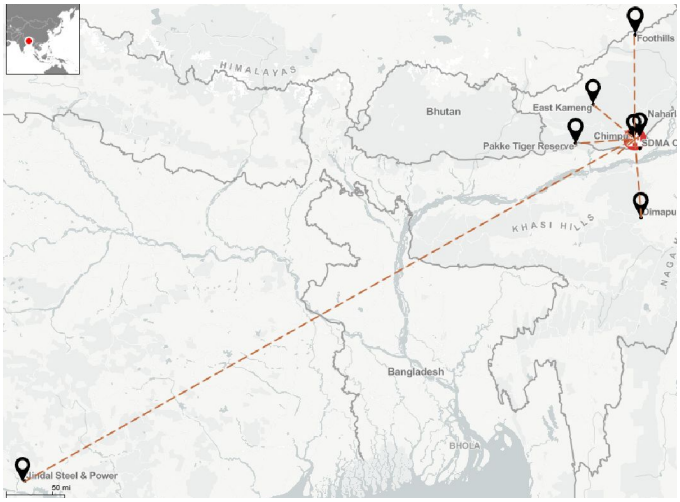

Fig. 1. Sourcing of materials (Source : Page 18, Team EnCircle design report)

2. **Recycled and Recyclable Materials**: Reduces the need for production procedures that are energy intensive and also helps in preventing trash from ending up in landfills.

3. **Rapidly Renewable and Natural Materials:** Since bamboo and wood are naturally replenishable materials, the embodied carbon footprint can be reduced by substituting these materials for more carbon-intensive ones.

4. **Fly Ash-Based Products:** Traditional cement produces a significant amount of carbon dioxide during production, which was reduced through the utilisation of fly ash-based products. Using earth blocks and fly ash-based building materials can result in usage of less water during the process of construction and also reducing water-related emissions.

5. **Minimising Cut and Fill:** To lower the emissions caused by soil extraction and transportation.

6. **Construction Waste Management:** To cut down on methane generation and emissions from decomposition.

7. **Afforestation and Social Forestry**

Exploring Material Options
Each material underwent rigorous assessment against the defined criteria. Factors like embodied carbon, seismic performance, thermal properties, environmental impact, and local availability were carefully considered. Prospective materials were also compared to conventional alternatives to determine their relative sustainability.

MATERIAL	AAC BLOCKS	GLASS		RAMMED EARTH	VINYL FLOORING	BAMBOO REINFORCED CONCRETE	SHEEP WOOL INSULATION
U-VALUE							
EARTHQUAKE RESILIENCE							
ENVIRONMENTAL IMPACT							
SUSTAINABILITY							
AVAILABILITY							
AFFORDABILITY							
MOISTURE RESISTANCE							
AVAILABILITY OF SKILLS							
CULTURAL AND AESTHETIC RELEVANCE							

Table showing the properties of the different materials considered. (Source : Page 17, Team Encircle design report)

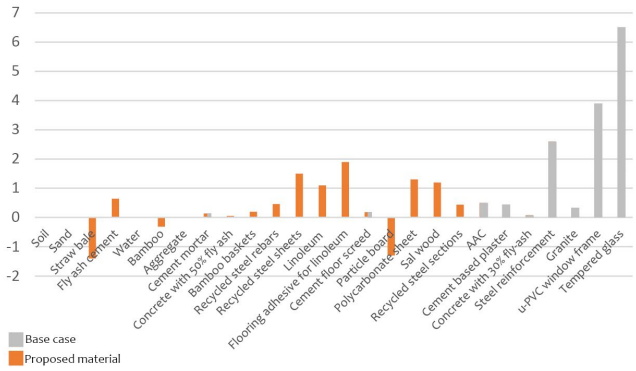

Fig. 2. Embodied Carbon values (Source : Page 17, Team Encircle design report)

Conducting Life Cycle Assessments

Life cycle assessments (LCAs) were conducted for shortlisted materials to analyse their environmental impact from cradle to grave. LCAs helped in quantifying the embodied carbon emissions and overall environmental footprint of each material, aiding in making informed decisions.

Prioritising Low-Embodied Carbon Materials

Reducing embodied carbon was a primary objective for Aikyam. Hence, materials with the lowest embodied carbon emissions were given precedence, provided they met other essential criteria.

Low-embodied carbon materials used by Team EnCircle

1. Walls Made of Earthen Blocks: Compressed earth blocks (CEBs), 600 x 200 x 155 mm, commonly referred to as earth blocks or compressed sand, are made by compressing a mixture of soil (55%), sand (22%), straw fibres (8%), water (3%), and cement (7%) with 30% fly ash. Sand and cement help in increasing the block's strength and make it more seismically resistant. Straw fibres serve as a binder to connect the various components together. All of these materials are readily available nearby, which reduces the transportation-related embodied carbon emissions. In order to hold the blocks together in the event of shear and lateral thrust, each block will include two 40 diameter voids for the insertion of bamboo. The bamboo can be fastened in place using 10mm aggregate and cement mortar. This method not only includes structural stability but also helps with sustainability and carbon sequestration.

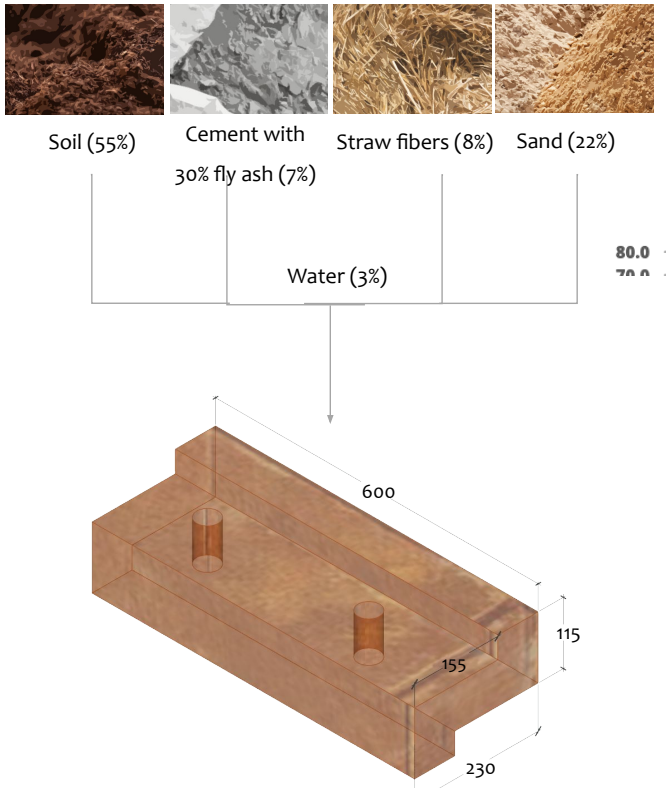

Fig.3. Compressed earth blocks (Source : Page 20, Team EnCircle design report)

2. Linoleum Sheets: It is an excellent alternative for flooring in locations that are susceptible to earthquakes due to its flexibility and endurance. It has low embodied carbon because it is made up of natural, renewable resources like linseed oil, wood flour, and jute, which are non-toxic and biodegradable. Additionally, it requires less maintenance, which means there is less need for harsh cleaning products or chemicals that could harm the environment.

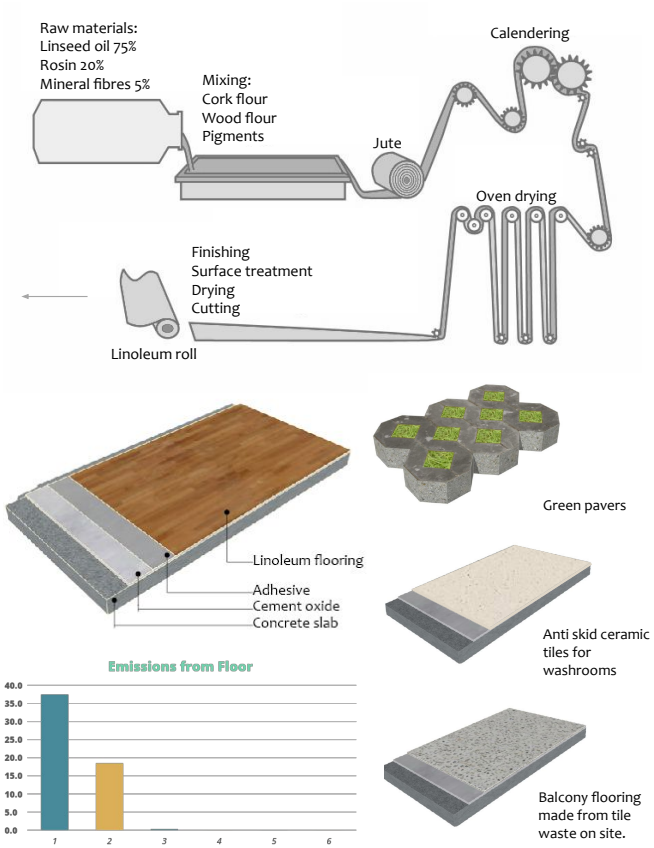

Fig.4. Linoleum flooring (Source : Page 18, Team EnCircle design report)

3. Fly Ash Concrete and Recycled Steel Columns and Beams: The World Steel Association published a report in 2018 stating that the average embodied carbon value of recycled steel is 0.46 kg CO2 eq per kg of steel, which is significantly lower than that of virgin steel because the recycling process uses significantly less energy and emits significantly lesser emissions than the production of virgin steel. A 2018 report by the World Business Council for Sustainable Development estimates that the embodied carbon value of concrete with 30% fly ash replacement is roughly 295 kg CO2 eq per cubic metre,

while that with 50% fly ash replacement is estimated to be around 200 kg CO2 eq per cubic metre, which is half the value of conventional concrete, or 400 kg CO2 eq per cubic metre. Construction projects can maintain structural integrity while reducing their environmental impact by integrating these low embodied carbon materials.

4. Slabs, Including Waffle and One-Way Slabs: Compared to PVC (Polyvinyl Chloride) waffle pods, bamboo baskets often have a lower embodied carbon value. Bamboo is estimated to have an embodied carbon value of between 0.1 and 0.3 kilogrammes CO2 eq per kg of bamboo, compared to 1.5 to 2.5 kg CO2 eq per kg of PVC in waffle pods. Exposed bamboo basket pods not only reduce the carbon value but also add an additional touch of vernacularity and aesthetic when exposed . The carbon content and dead load of one-way slabs that alternate recycled steel reinforcement with bamboo reinforcement are significantly reduced.

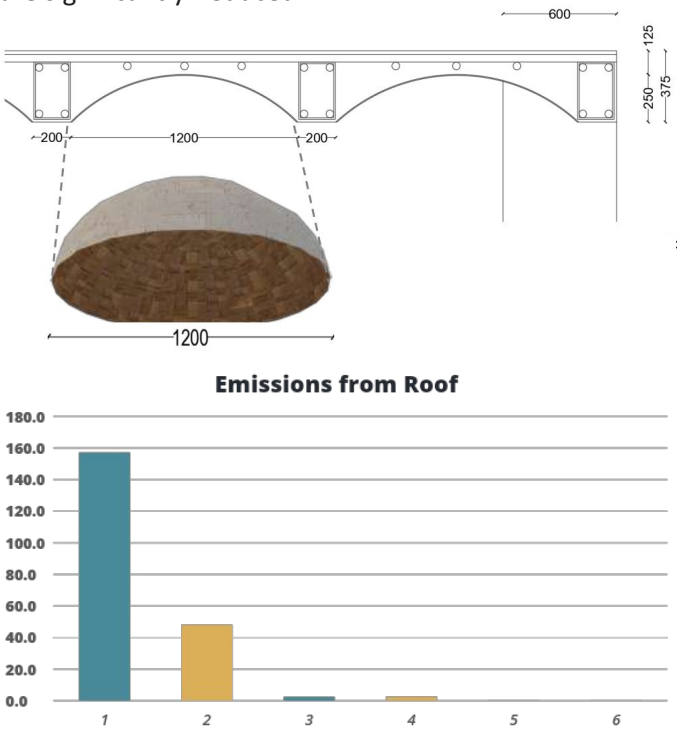

Fig.5. Structure - Waffle slab system (Source : Page 22, Team Encircle Design Report)

5. Fenestrations: Polycarbonate with Sal Wood Frames:

i. Sal wood: wood has a lower CO2 equivalent per kilogramme compared to other building materials, such as steel or aluminium, at 1.1 to 1.3 kg. As a result, the property will receive twice as many trees as were cut down.

ii. Particle board light shelves with reflective coating: Particle board has a lower embodied carbon value than solid wood, because it is typically made from smaller pieces of wood that would otherwise go to waste, it is created by compressing and bonding wood particles together with adhesives. This approach can use less energy and generate less waste compared to solid wood

iii. Polycarbonate: According to life cycle assessment research carried out by the University of Bath and the European Union, polycarbonate sheets have an embodied carbon value that ranges from 1.1 to 1.5 kg CO2 eq per kg of material.They can be used in earthquake prone areas due to their lightweight and flexible nature which allows them to absorb the seismic forces.

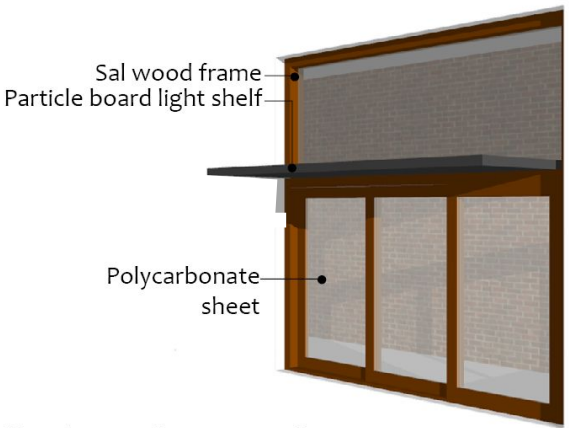

Fig.6. Fenestrations (Source : Page 19, Team EnCircle Design Report)

6. Fins: Wooden Frame with Bamboo Panel: Bamboo is a carbon-sequestering material, according to studies from the Delft University of Technology, with an embodied carbon value of -0.313 kg CO2 eq. Additionally it is conveniently located nearby, decreasing embodied carbon emissions from transportation. Bambusa Tulda,a fast-growing bamboo species that is known for its strength, durability, resistance to pests and diseases, sourced from Chimpu village . This sourcing method helps generate income for the locals through the sale of bamboo. Bamboo harvesting and trade are regulated by the local Forest Department.

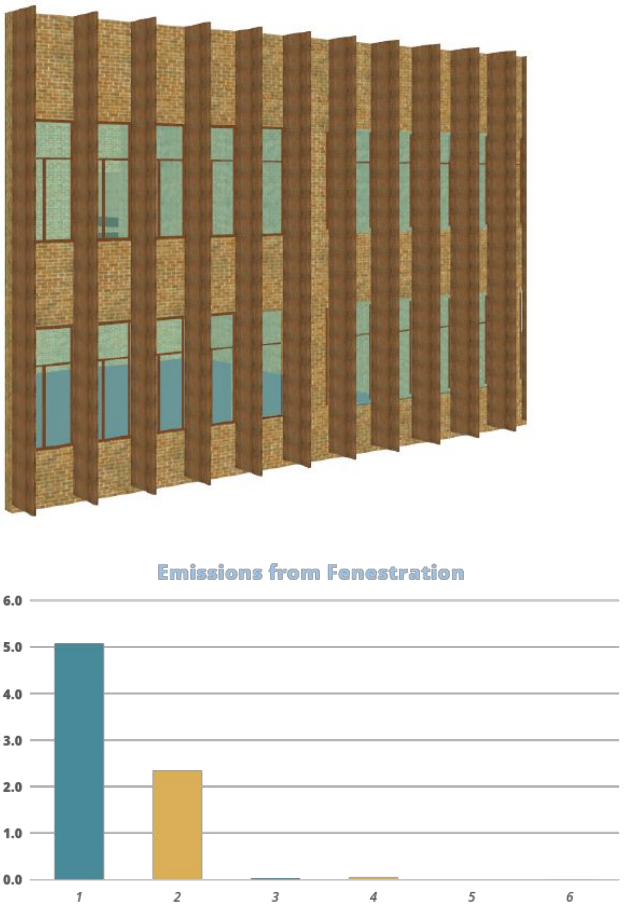

Fig.7. Bamboo fins (Source : Page 19, Team EnCircle design report)

7. Moss Concrete: By absorbing carbon dioxide during photosynthesis, moss minimises emissions from making cement. This cutting-edge application helps in creating a more aesthetically pleasing and environmentally friendly design.

8. Short pile foundation: Commitment to reducing embodied carbon emissions and enhancing seismic resilience, short piles not only offered a stable foundation but also minimised the use of virgin steel, leading to a lower environmental impact. By incorporating fly ash concrete, a byproduct of coal-fired power plants, the team reduced the need for traditional cement, which contributes significantly to carbon emissions during production.

CONCLUSION

Project Aikyam exemplifies the importance of low embodied carbon materials in creating a sustainable future for construction. Through a thoughtful and comprehensive selection process, the project prioritised materials that align with environmental responsibility, cultural relevance, and seismic resilience. Aikyam's harmonious blend of tradition and innovation serves as an inspiring example of how sustainable architecture can lead us towards a brighter, greener, and more resilient future for generations to come.

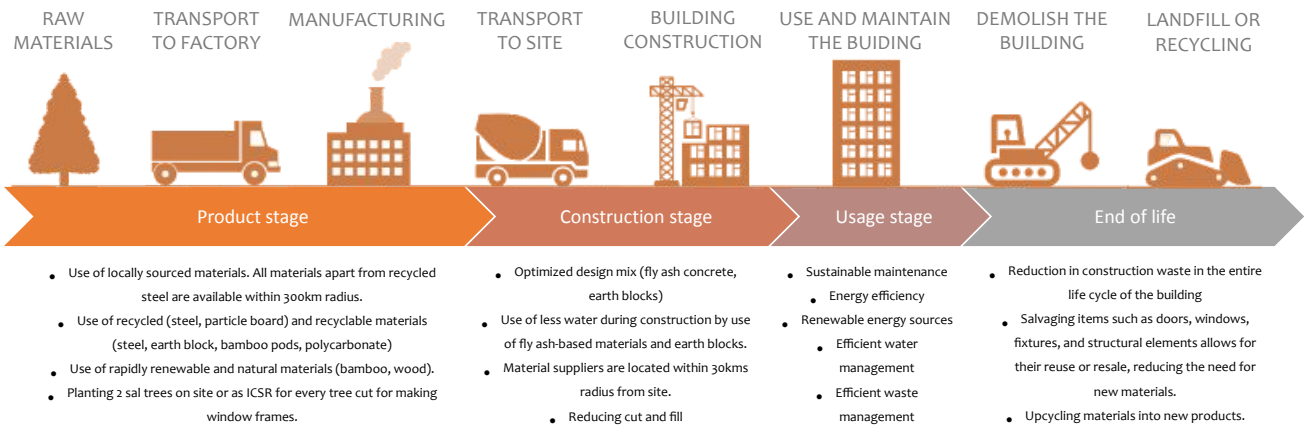

Fig.8. Cradle to grave: Embodied carbon reduction strategies (Source : Page 17, Team EnCircle design report)

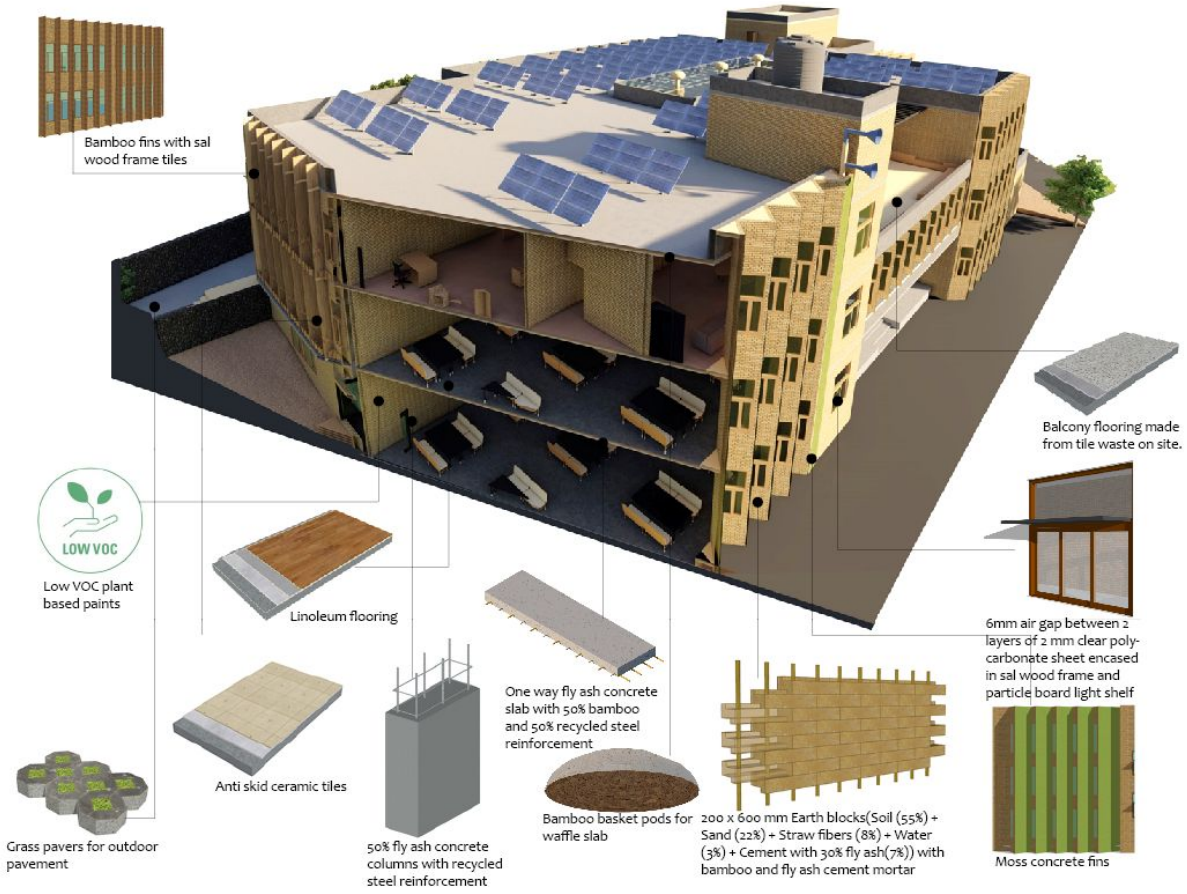

Fig.9. Materials : Embodied carbon reduction strategies (Source : Page 17, Team EnCircle Design Report)

Team EnGriha:

Division : On Site Construction Workers Housing

Introduction and Context :

EnGriha, embarked on a journey with the fundamental query: “Is it fair to assume that construction workers, as transient occupants, should be deprived of fundamental amenities and suitable living conditions?” EnGriha placed its primary focus on the development of a net-zero construction worker housing colony designed to cater to the unique requirements of this housing sector within India. Employing a data-driven methodology, they brought together students specialising in architecture and engineering to guarantee sustainability, comfort, and a high standard of living for the workers. The intervention site was in Vizag, under a project by KEC International, but the project works as an infill irrespective of the context making it a modular solution to urban housing problems.

Fig.2 : Render of the overall cluster with the panel installed (Source : Page 12, Team EnGriha design report)

Design and Optimization

The team had a clear set of major factors in mind that they aimed to achieve. Firstly, they prioritised modularity in their design, recognizing the need for easy relocation within a construction site for construction workers while minimising waste generation (less than 5%) at the current site.

Secondly, the team considered the economic aspect of the project. They acknowledged that construction worker housing represents a temporary and uncertain investment, which often discourages substantial investments in robust designs and long-term plans. Addressing this, they proposed a rental model, allowing excess housing units to be rented out for income generation, achieving an impressive return on investment of 62.19% per year. The modularity of the structure played a pivotal role in enabling this rentability.

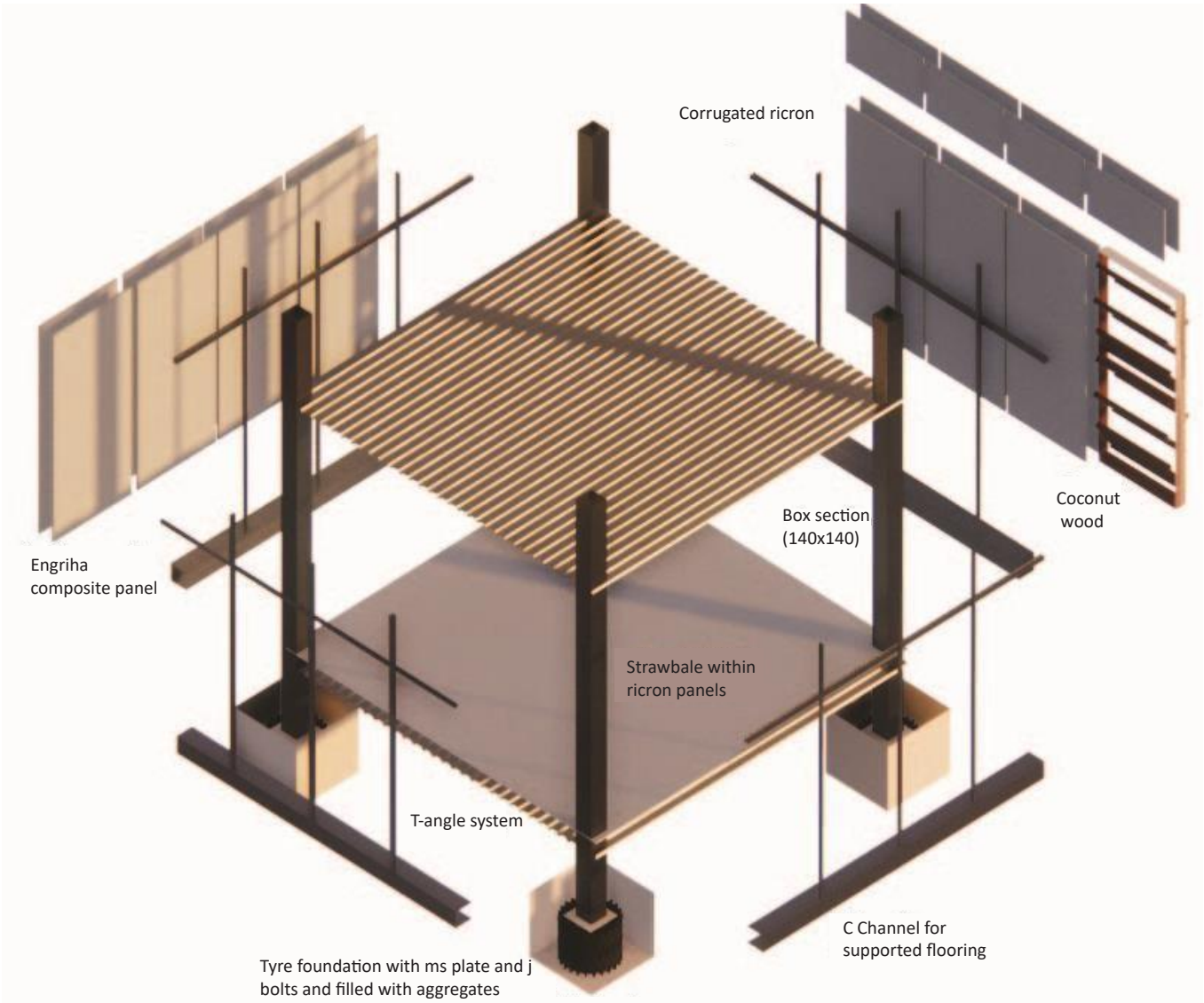

Fig.1 : Exploded view of one unit showing the location of the panel (Source : Page 11, Team EnGriha design report)

The third crucial factor was to ensure structural stability. To meet this requirement, the team adopted a panel and structure system, consisting of primary and secondary members constructed using steel, while the walls were composed of a composite panel.

Lastly, the team placed great emphasis on addressing Embodied Carbon. Given their choice to use steel for structural components due to its ease of construction, strength, and stability, they innovated by incorporating natural and recycled materials to balance the high embodied carbon associated with steel. This forward-thinking approach aimed to minimise the environmental impact of the construction worker housing colony

With the structure and foundation firmly established, the team turned its attention to the crucial aspect of panel selection. A wide array of market-available panelling materials presented themselves as potential options, including familiar choices such as tin corrugated sheets, Polyurethane Foam panels, Aluminium Composite Panels panels, cement boards, and even treated bamboo panels. The team then embarked on the process of narrowing down these choices, considering various factors. Their first and foremost consideration was to reduce Embodied Carbon, which quickly narrowed the options down for panelling materials. They were astonished by the significant carbon emissions associated with the production of these widely used panels. Next, they scrutinised the options based on cost, leading them to focus on three remaining choices: cement boards, Vaspar Concepts, the company (corrugated plastic panels), and bamboo panels. In addition to these market-available options, the team also contemplated the possibility of developing a custom solution which is currently not available in the market. This comprehensive evaluation ensured that the final panel selection would align with their project's environmental goals and budgetary constraints.

Corrugation density can be changed based on the U value required Corrugated Jute Ricron Panel Grasshopper code Prototyping.

Initially, the team explored the possibility of using Vaspar Concepts' panels due to their recycled and lightweight nature. However, upon closer examination, it became evident that these panels would significantly strain the project's budget. To put it into perspective, using these panels for the walls alone would have consumed nearly 50% of the budget.

While bamboo was considered a viable option, it didn't quite offer the structural resilience needed for continuous assembly and disassembly. Consequently, bamboo was reserved for the use in common areas, leaving the team with no viable choice for the living units themselves. At this juncture, the team discovered Ricron, a panel material crafted from recycled MLP (Multilayer Plastic).

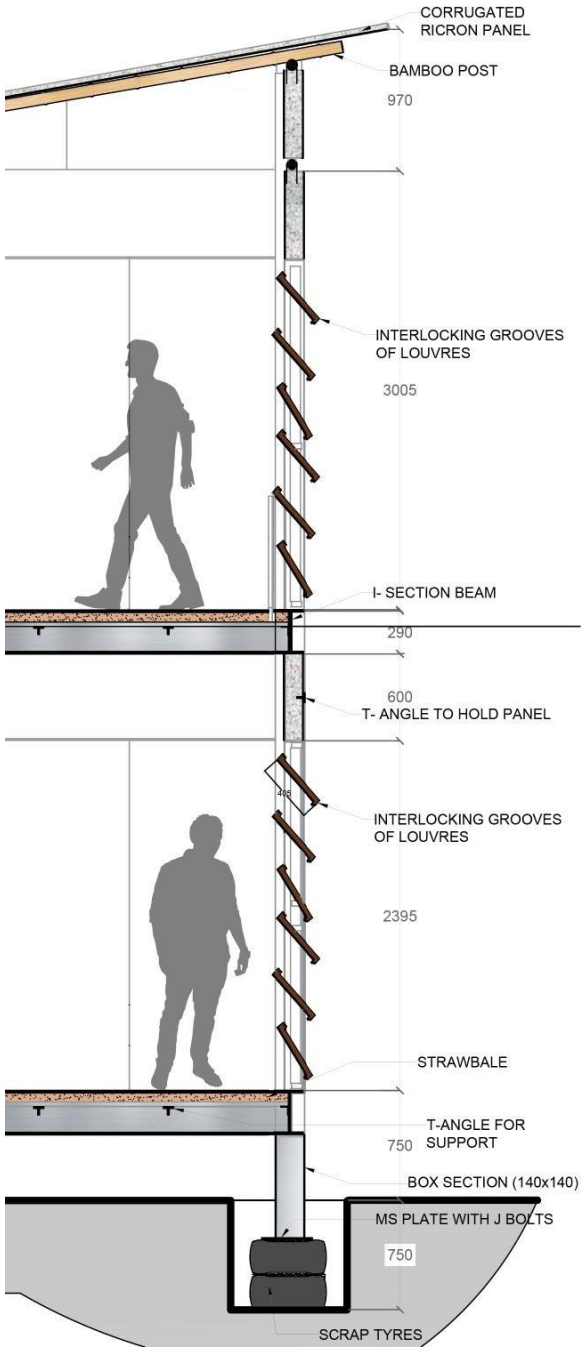

Fig.3 : Section through louvred panel (Source : Page 12, Team EnGriha design report)

Fig.4 : View of a unit with the panel installed (Source : Page 36, Team EnGriha design report)

Ricron was not only cost-effective, but it also addressed environmental concerns by repurposing MLP waste. Encouraged by discussions with their industry partner, RICRON India Pvt. Ltd., examination of Central Institute of Plastics Engineering And Technology (CIPET) test results, and conducting their own series of tests, the team went ahead in selecting RICRON as their exterior cladding material. However, the challenge still remained with the core material. Given the advantages of corrugation and the alternating layers of air and insulation seen in the Vaspar Concepts panel, the team decided to utilise corrugated jute as the core material. This innovative approach aimed to strike a balance between structural integrity, environmental sustainability, and cost-effectiveness in the panel design.

Testing

To validate the simulated U-value obtained through Grasshopper, the team conducted physical testing on the constructed panel. This testing took place over a 6-hour period, starting from 11 am to 5 pm. To facilitate the testing process, they built a plywood chamber to enclose one side of the EnGriha panel. During the testing, the panel was positioned so that one side remained shaded within the chamber, while the other side was exposed to direct sunlight. To monitor the panel's performance, thermometers were affixed to both the inner and outer surfaces of the panel. Hourly readings were diligently recorded throughout the 6-hour testing period. Upon completing the testing and collecting the necessary data, the team calculated the composite U-value for each panel, which was determined to be 0.253 W/m² K. Remarkably, this experimental value closely aligned with the previously simulated U-value obtained through Grasshopper, which had been calculated to be 0.258 W/m² K. This congruence between the simulated and experimental results affirmed the accuracy and reliability of their simulation methodology

Thermal comfort comparison of the unit

In order to analyse the impact of corrugation value, density, volume, and the resulting U-value of jute, the team created a Grasshopper code. This code enabled them to determine the equivalent volume of jute when it was in corrugated form and calculate the final U-value of the panel. Initially, they conducted simulations to assess the panel's performance, focusing on obtaining the composite U-value. Key parameters such as the thickness of the Ricron panel, the equivalent thickness of the corrugated jute, and air were used as input variables. These parameters were input into the Grasshopper simulation, which was then executed to calculate the composite U-value. The outcome of this simulation revealed a composite U-value of 0.258.

Results

TIME OF DAY	INSIDE (K)	OUTSIDE (K)	DIFFERENCE IN TEMPERATURE (ΔT)
11:00 AM	306.65	306.85	0.2
12:00 AM	311.18	311.21	0.03
1:00 PM	311.75	312.04	0.29
2:00 PM	310.15	310.35	0.2
3:00 PM	309.15	310.35	1.2
4:00 PM	308.15	308.32	0.17
5:00 PM	307.25	307.45	0.2

(Source : Page 35, Team EnGriha design report)

Reading

Q VALUE		K VALUE	R VALUE	U VALUE
Q1	0.105269507	0.035528458	3.949770826	0.253179246
Q2	0.015790426	0.035528458	3.949770826	0.253179246
Q3	0.152640785	0.035528458	3.949770826	0.253179246
Q4	0.105269507	0.035528458	3.949770826	0.253179246
Q5	0.63161704	0.035528458	3.949770826	0.253179246
Q6	0.089479081	0.035528458	3.949770826	0.253179246
Q7	0.105269507	0.035528458	3.949770826	0.253179246

(Source : Page 35, Team EnGriha design report)

Team Green Collars
DPS EKAGRA – You Run the School
Solar Decathlon India: Winners – Educational Division

Solar Decathlon India's challenge to combat Climate Change defined the main aim of the team Green Collars to design a net-zero-energy-water building while partnering with leaders in real estate development enabling the team to explore innovative and affordable market-ready solutions. The team worked on innovative and regional solutions in order to design an educational building and addressed unique building problems faced in India.

With the global GHG (Green House Gas) emissions raising the global temperature and making climate change a real threat, the future of life, as we know it, on our planet earth stands questionable. The AEC (Architecture, Engineering, and Construction) sector is responsible for 30% of total global final energy consumption (Source: International Energy Agency). One of the few ways we can attempt to ensure a safe and satisfactory future for the generations to come is by curating current systems to align with sustainable practices while establishing the importance of the same among the youth.

The school, EKĀGRA, DPS (Delhi Public School) in Nagaon aimed to accomplish this goal. The total site area is 77,054 sqm of which phase 1 of the project was proposed with a site area of 43,820 sqm. Located in the warm and humid suburbs of Nagaon, Assam, the school with an area of 8,072 sqm hosts 1,800 students and 200 teachers and staff, with the possibility of future expansion. The campus, owned by GYANDEEP FOUNDATIONS works on a Build-Own-Operate (BOO) model and targets to serve students in Nagaon and its neighbouring villages.

Design:

While designing the school, the team focused on two primary aspects - one, to design a facility that enhances the sharing of knowledge while ensuring productive learning in schools, and two, making the building a net zero energy, water, and carbon built environment.

In order to achieve this, the team began their material exploration alongside the design process, team members who were in-charge of materials and innovation proposed multiple combinations to the rest of the team, after which the team decided on the most optimal solution based on various aspects of sustainability. For instance, the energy division preferred materials with low thermal transmittance values; the water division wanted materials with appropriate run-off coefficients which also reduce water consumption while construction; choosing materials with low carbon emissions was the first priority for the embodied carbon division, while the engineering and resilience team favoured strong and earthquake resistant materials. The health and well-being division focused on low VOC (Volatile organic compounds) materials while the costing division demanded materials within the budget.

The team focused on the concept of circular economy which ensured that the materials are kept in circulation for as long as possible through reuse, remanufacturing and recycling at the same time making products as durable as possible. The team also developed material passports (Fig 1) for every material used in the building construction hence making it vastly easier at the end of the building's life to recover the value, preventing these

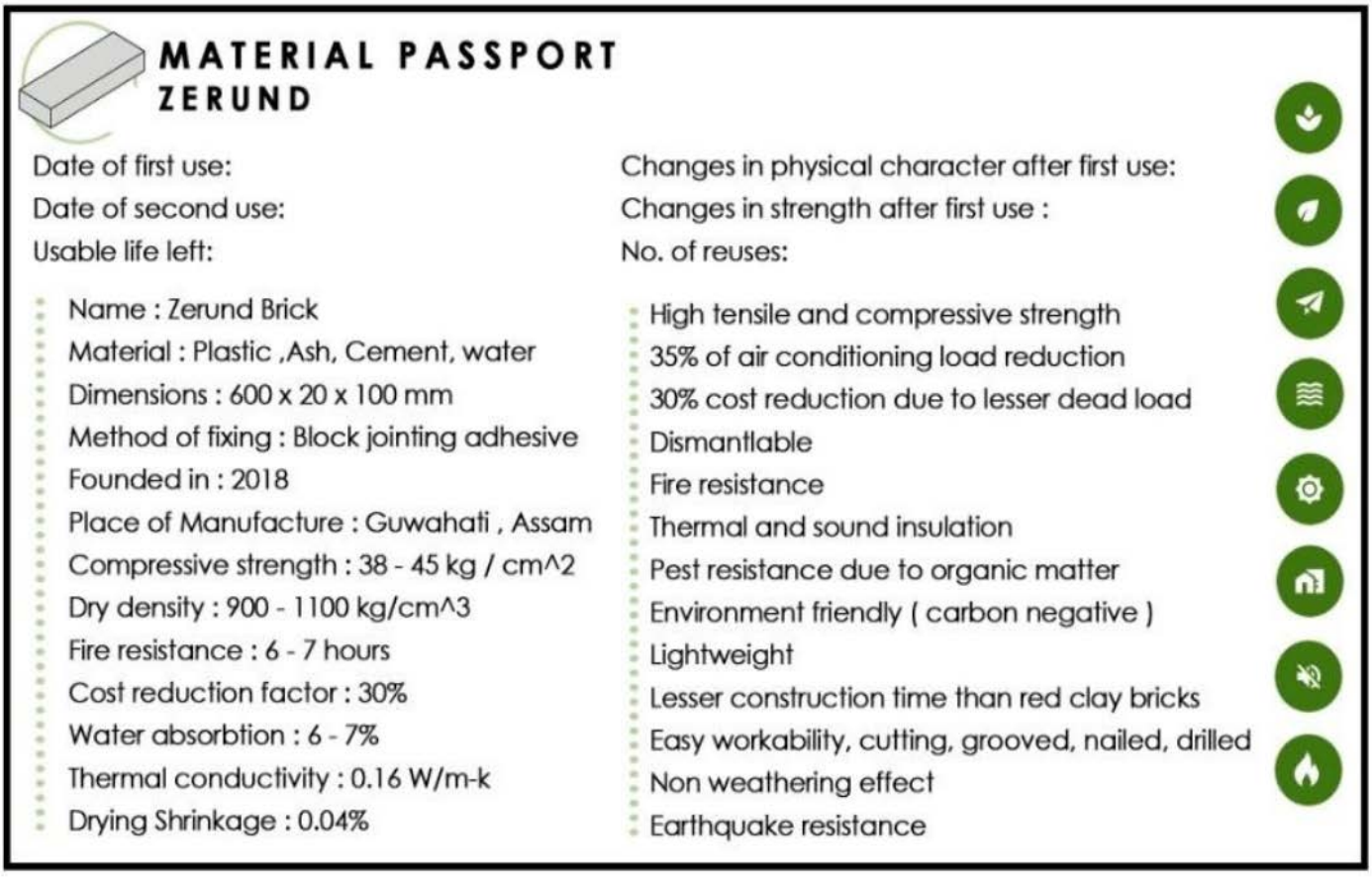

Fig.1 : Zerund brick material passport (Source : Page 23, Team EKAGRA design report)

materials from being dumped or incinerated during demolition or renovation.
Based on the above mentioned criteria, the team chose the best option for different building elements, such as :

Walls:
Agrocrete blocks were considered initially for their low embodied carbon and the availability of agricultural raw materials on site. However, because of the distance of the manufacturing unit from the site, the transportation costs and emissions were high, due to which it was eliminated. Finally, for the external walls, Zerund bricks with circular voids for bamboo poles were used, while bamboo mat boards and reclaimed mosaic enhanced the interior and south façade respectively. Lime plaster was applied externally, and labour ensured smooth implementation. The building prioritised sustainability with moulds over kilns to reduce its carbon footprint. Block jointing adhesive replaced cement mortar, which further helped in cutting down the emissions. The walls are easily dismantlable, promoting reusability and waste reduction. The construction resulted in a carbon-negative walling system (Fig 3) with embodied emissions of -17.3 kg-CO2 e per unit.

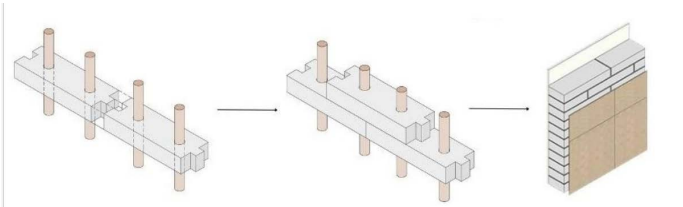

Fig.2 :Walling system : Zerund bricks (Source : Page 24, Team EKAGRA design report)

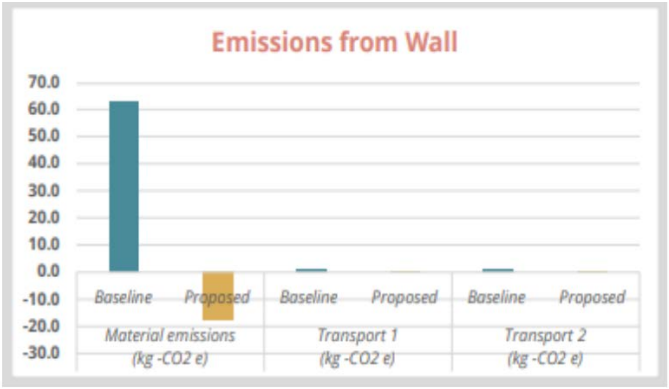

Fig.3 :Emission from wall (Source : Page 24, Team EKAGRA design report)

Floor slabs:
At first, clay tiles embedded with rice husk were considered to incorporate locally available materials. Due to insufficient data regarding their embodied carbon values and load bearing capacities, it was not carried forward.
The final design featured sustainable construction elements, such as filler slabs using local terracotta pots, ACC Ecomaxx[3] concrete, and steel reinforcement. This reduced usage of concrete in slab by 30% while supporting the local industry and enhancing aesthetics. The flooring consisted of 40mm IPS(Indian Patent stone) flooring mixed with 10mm red oxide, skillfully coloured with natural oxide pigments. It is durable, cost-efficient, and easy to maintain, with embodied carbon emissions of 35.4kg - CO2 e per functional unit.

Fig.4 :Flooring composition (Source : Page 24, Team EKAGRA design report)

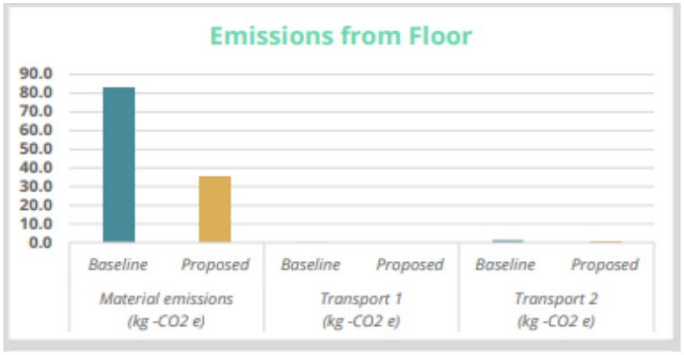

Fig.5 :Reduction of Ec from base case (Source : Page 24, Team EKAGRA design report)

Roofs:
A bamboo truss system was the basis of the roof design from the start. However, as the design progressed, the system was layered with other materials to achieve the final result.
The building's North Light truss system was made from carbon-sequestering bamboo. Onsite bamboo treatment reduced transport related emissions, while fish mouth joints eliminated the need for gusset plates. Bamboo corrugated sheets with glass wool insulation were used for sheeting. Manual labour for truss fabrication increased energy efficiency, resulting in an embodied carbon of 13.8 kg - CO2 e per unit.

Fenestrations:
Bamboo Wood was one of the materials that was considered for fenestrations, however, this was replaced with Bamboo ply based on the advice of the team's industry partner, owing to the higher embodied carbon value and cost of Bamboo Wood.
Louvres made of beaten bamboo, chajjas[4] constructed with stabilised clay, rice husk, bamboo fibres, and lime and skilfully crafted bamboo ply doors were used throughout the building. These components act as carbon sequestering elements, resulting in remarkable embodied carbon emissions of -1.1 kg CO2e per functional unit. The extensive use of locally available bamboo led to incorporating a bamboo plantation as part of the design.

[3]ACC Ecomaxx: ACC(Autoclaved cellular concrete) ECOMaxX is a green concrete block with minimum 30% reduction in embodied carbon designed to meet sustainable construction needs.
[4]Chajjas: A chajja is an overhanging eave of roof covering found in Indian architecture. It is characterised with large support brackets with different artistic designs. It is used to protect fenestrations from the harsh weather conditions

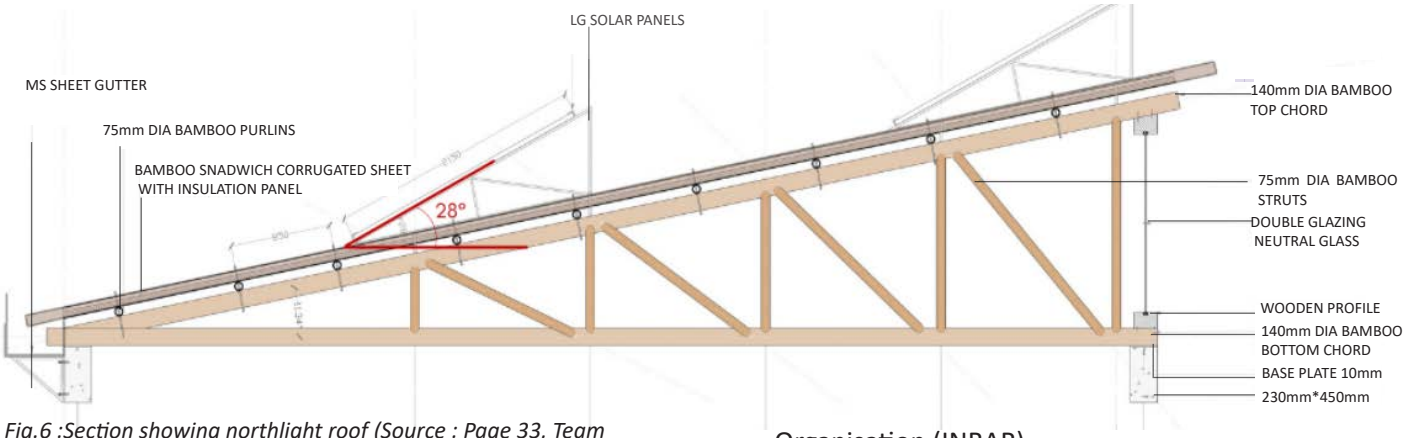

Fig.6 :Section showing northlight roof (Source : Page 33, Team EKAGRA design report)

Structural system:

Bamboocrete was an initial consideration due to the extensive availability of bamboo in Assam, but this was quickly disregarded since various studies showed that for a building of this scale, in earthquake Zone V, bamboo crete would not be suitable.

Finally, the main structure of the building, including columns, beams and foundation, was made using RCC. To reduce carbon emissions, ACC Ecomaxx green concrete was chosen, which has 45% lower embodied carbon than ready-mix concrete. It incorporates fly ash, recycled concrete aggregates, and aluminium can fibres, along with steel reinforcement. Despite higher transport emissions, ACC Ecomaxx concrete was preferred because of its eco-friendliness.

Due to the site being in earthquake zone V, the structure is built without compromising on strength. The embodied carbon per functional unit of the building is 39.8 kg-CO2e.

Conclusion:

EKĀGRA, the net zero school designed by Team Green Collars, sets a remarkable precedent for sustainable architecture in educational institutions. The innovative approaches, smart material choices, and carbon-reducing strategies have not only created an environmentally friendly campus but also offered an inspiring model for future projects. With EKĀGRA, Team Green Collars has proven that combining sustainability with creativity and determination can lead to a brighter, greener future for all.

References:

- (29 May 2018). World Steel in Figures . Brussels, Belgium: The World Steel Association. WORLD STEEL IN FIGURES 2018. (2018).
- Roberts, M., Cascione, V., Allen, S., Dams, B., Maskell, D., & Coley, D. (2022). Applying life cycle assessment with minimal information to support early-stage material selection. Paper presented at Central Europe towards Sustainable Building 2022, Prague, Czech Republic. https://doi.org/10.14311/APP.2022.38.0044
- van der Lugt, P., & King, C. (2019). Bamboo in the Circular Economy: The potential of bamboo in a zerowaste, low-carbon future. (Policy Synthesis Report; Vol. 6). International Bamboo and Rattan Organisation (INBAR).
- IEA (2019), Global Status Report for Buildings and Construction 2019, IEA, Paris https://www.iea.org/reports/global-status-report-for-buildings-and-construction-2019, License: CC BY 4.0

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RVU

Rakesh Shankar, Dhatri NK

Illustration by Jennis John Varghese | 8th sem

07. Educating Architecture Students about Green Buildings - A Case Study of Green Building Project in Undergraduate Courses.

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Abstract :
This article delves into the imperatives of addressing global warming through the design of a green buildings, reflecting a proactive response to the escalating environmental concern. Supported by compelling statistics, it underscores the potential catastrophic consequences if current trends persist. The article addresses the interconnected systems on Earth's surface and emphasizes humanity's impact on these systems, the learnings of which serve as an important educational tool for architects. The green building design, undertaken within the University Curriculum of eighth semester, employs case studies and site studies, with students employing the checklists of National green building codes such as GRIHA. The semester culminates with heightened student interest in comprehending green building concepts, design processes, and construction methods—forming an effective strategy to mitigate global warming effects.

Keywords:
Global warming, Green building design, Sustainability, Pedagogy, GRIHA.

Global warming is the result of an increase in the temperatures of the Earth's surface. This is not a new phenomenon but has been witnessed for billions of years. The reason for this being a subject of discussion is that the temperature has increased rapidly in the last few years. Specifically since 1760, the beginning of the Industrial Revolution, the burning of fossil fuels has increased. Other activities of mankind are causing a steady increase in the surface temperature of the Earth. The mean temperature on the surface of the Earth is about 14°C (highest temperature has reached 70.7°C (159°F), which was taken in the Lut Desert of Iran, and the lowest temperature recorded is -89.2°C (-129°F) on July 21st, 1983, at the Soviet Vostok Station on the Antarctic Plateau) (Lindsey R. 2009).

This temperature has gone up by about 1.1°C since the pre-industrial era, which is an unprecedented rise in comparison to the previous ten thousand years.

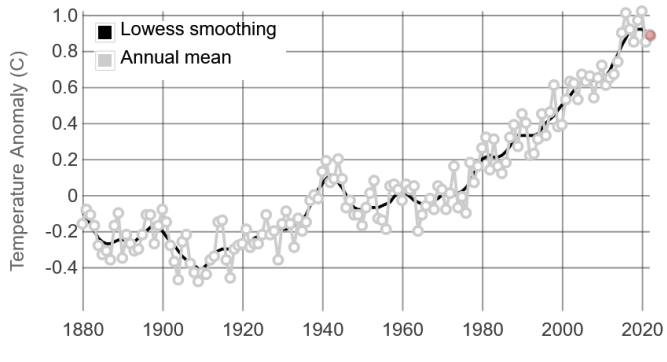


Fig.1 : Earth's global average surface temperature in 2020 statistically tied with 2016 as the hottest year on record, continuing a long-term warming trend due to human activities.
Source: https://climate.nasa.gov/vital-signs/global-temperature/

When radiation from the sun reaches Earth's surface, four things happen, one, part of the radiation is re-radiated back into space, two, part of it is absorbed in the upper atmosphere, three, part of it is absorbed by the Earth's surface (also called Insolation), and lastly, there is some outbound re-radiation from the Earth's surface into outer atmosphere. This outbound radiation (the long-wave IR waves), keeps the Earth's temperature in balance. However, with the increase in Greenhouse Gases (GHG), namely, carbon dioxide, methane, chlorofluorocarbons, nitrous oxide and water vapour, resulting from human activity, also known as anthropogenic activities, this outbound radiation and re-radiating have increasingly been trapped and absorbed back by the surface hence causing global warming.

Rapid industrialization is the major cause of this global warming, which in turn is causing climate change. Climate change is causing severe impacts on the weather, agriculture, livestock, rains, hurricanes, droughts, melting of the ice caps, and thus, human beings (Lindsey R., 2009). It is important to understand that there are two systems in play, one is the survival of the Earth's System and two, the survival of mankind as we know it.

Earth's System: The atmosphere is influenced by and linked to various features of Earth, like oceans, ice masses, land surfaces, and vegetation. Together, they make up an integrated Earth system, in which all components interact with one another in complex ways. Apart from these features, the atmosphere is impacted by solar radiation, volcanic activities, tectonic activities, Earth's orbital variations, human activities, and feedback

of components on the Earth's system.(Heavens, N. G., Ward, D. S. & Natalie, M. M, 2013) Climate is constantly changing and the gradual change leads to an abrupt tipping point. The record shows that there have been abrupt changes in the climate system before, that indicate many ancient tipping points.

Mankind: Anthropogenic activities in the last few decades have been aggressive in exploiting natural resources and as a result causing irreparable damage to the Earth System. Consequent to these damages, the changes to the climate are rapid and detrimental. It is possible that the Earth System is rapidly changing to the tipping point. Comprehending the climate changes to slow the rapidity of changes, and to improve the quality of life is a priority. The Point of No Return (PNR) with a 2°C target in climate change, that reaches in 2035 according to present trends, can be pushed by about 07 years if negative emissions and, an increase in renewable energy share, strategies are adopted rigorously. (Aengenheyster, Matthias & Feng, Qingyi & Ploeg, Frederick & Dijkstra, Henk, 2018).

Educating the Architecture student:

95% of urban population growth is expected in the cities in emerging markets. 2.5 billion more people will join cities by 2050. 1.2 million Sq. Km. of new urban built-up area is expected to be added in the next three decades. Cities consume 2/3rd of global energy consumption and are responsible for 70% of GHG emissions. A 50% increase in urban water demand is expected by 2050. (United Nations, Department of Economic and Social Affairs, Population Division, 2019) 90% of waste is unmanaged in low-income countries, like ours, while construction consumes about 40% of natural resources. (Shitaw T, Girma Y E, Dessalegn E, 2022)
Thus, the contribution of architects in adopting sustainability practices could be enormous in mitigating global warming and climate change. Sustainability concepts must be taught & learnt in undergraduate schools of architecture so that they are a part of the professional services provided by every architect. Educating the architect is of paramount importance. Although the mitigation of global warming in the immediate future is difficult to achieve, environmentally friendly practices will pay dividends in the long run.
This article discusses the pedagogical approach adopted since 2018 in educating the higher semester students of the undergraduate architecture programme to equip them with the theoretical concepts and practical knowledge in understanding and designing green and sustainable buildings.
The topic 'Green Building concepts' is part of the syllabus of 'Materials and Methods of Building Construction (MMBC) VIII' subject in the Visvesvaraya Technological University (VTU) B. Arch curriculum from the year 2018. At RV College of Architecture, Bangalore, this topic is taught with gravity and rigor through a three-fold methodology of - Lectures, Case-Studies, and Design Project.

Lecture Method:

The studio faculty, which included an independent sustainability consultant Ar. Mini Shastry commenced the lecture sessions by introducing the definition of sustainability, its importance in architecture and the various terms and matrices used for measuring sustainability in the current Indian built environment practices. Green Rating for Integrated Habitat Assessment (GRIHA) methodology was introduced in these lectures.
The lectures by Ar. Minni covered topics related to Sustainable Site Planning, Construction Management, Energy Optimization, Occupant Comfort, Water Management, Solid Waste Management, Sustainable Building Materials, Life Cycle Costing (LCC), Socio-Economic Strategies, Performance Metering and Monitoring and Innovation. Thus, the basic concepts of proper site analysis, efficient construction planning, building massing, orientation and envelope optimization, Building Systems optimization, Indoor Air Quality and user well-being, water efficiencies, selection of building material based on carbon footprint and LCC etc. were dealt with in great detail. Mr. Harish Borah (expert in cost and carbon studies, was invited to deliver lectures on LCC and Life Cycle Assessment (LCA) etc.)

The Case Study:

Case studies of projects like TERI[1] Retreat, Gurgaon, and Govardhan ECO Village retreat Center, Galtare, Maharashtra, were discussed to enhance their comprehension.

The Design Project:

A Sustainable Design Project was introduced to the students along with the site and context. Students were then taken for a site visit where they were introduced to the site. The site was used for five consecutive years, and has helped to evolve a plethora of ideas for different design ideas from students.

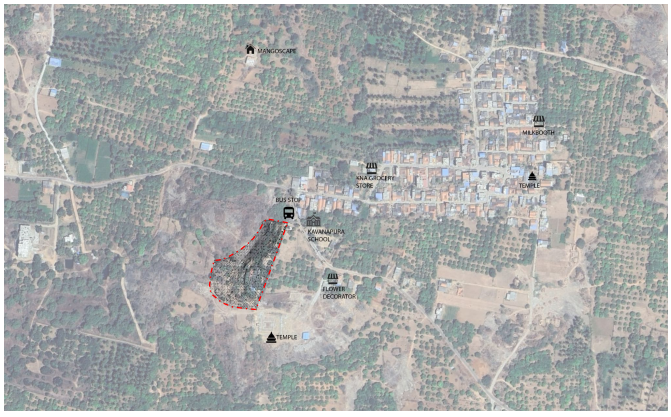


Fig 02. shows the location context and site surroundings.
Source: Page 6, student report 'Kshema'

[1]TERI : The Energy and Resources Institute

This site of about 11000 Sq.M. is located in the Ramanagara district of Karnataka, about 50 km away from Bengaluru, latitude of 12°38'33"N and a longitude 77°17'56"E with a moderate climate. The hilly terrain has a mango grove and is situated outside Kavanapura village.

After the site visit students presented their individual findings and observations.

Design of a green building is an onerous task, especially if concepts and applications are to be accomplished during one semester. Therefore, 5-6 students were teamed to take up the design project. The teams were then entrusted with the work of developing a "PROJECT BRIEF" with a built-up area ranging between 400 to 500 sq.m.

Students conceived projects like "Kalakriya"- an art centre (Fig, 02), "Kshema"- nature's healing centre (Fig. 03), "Sattva"- an embodied way of living, etc.; all focused on sustainable building proposals. The brief was to include the purpose of the project on the site This encouraged them to explore materiality and the availability within about a 50km radius.

The teams submitted their programme proposals with occupancies, areas and themes, and obtained approval from the faculty. The next step was to analyse the site and the surroundings and devise passive strategies to reduce energy consumption. Case studies of climate analysis outputs were discussed and students were encouraged to apply the inferences in their projects.

The students used manual analysis methods like, psychrometric chart, Mahoney's Table, and shading masks and also state-of-the-art tools and software like GeoSlope, ClimateStudio and Climate Consultant 6.0, etc. (Fig.3) to analyze the Slope, Wind (intensity and direction) patterns, monthly Air Temperature patterns, monthly Relative Humidity (RH) patterns, annual Rainfall analysis, and Solar Radiation analysis, etc. to identify the optimum passive strategies.

The green building studio attempts to innovate alternative solutions to step away from the mundane, energy-consuming building designs. Students explored various green building principles like orientation, siting, massing, solar radiation, etc. Design reviews were held regularly, and progress of work was monitored.

The final step was to validate their designs and strategies by applying metrics for calculating energy, water, waste, etc. consumptions in their projects. A template for the final project submission was provided. The final submission included a checklist that audits their design against the GRIHA[2] assessment method.

Most of the groups achieved a 3 to 4 star GRIHA rating for their project. The teams were able to achieve a 75% to 85% reduction in Water Performance Index (WPI) as compared to the GRIHA base-case. Teams validated a reduction of about 60%-80% in the Energy Performance Index (EPI) from the GRIHA base case. Out of this about 50% of reduction was demonstrated by optimising the building envelope and use of other passive strategies, thus providing the proof of concept for sustainability through proper selection of building materials

The semester culminated with an expert review by the faculty of all the proposals submitted by the teams and a final discussion on the outcomes of the studio.

Two of the hundred projects that came out of this

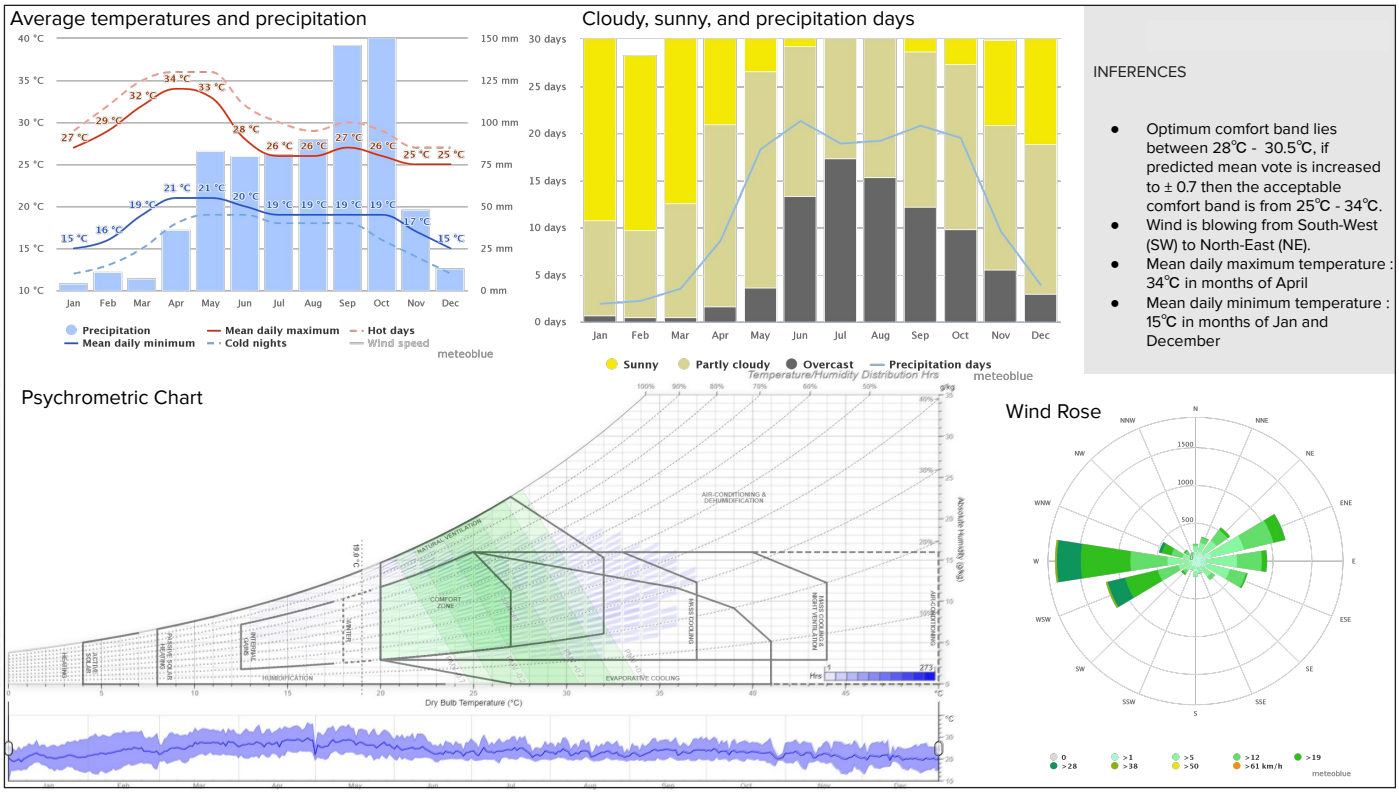


Fig 03. : shows some inferences achieved on climate, wind and temperature
Source: Page 4, student report 'Kalakriya'

[2]GRIHA : The Energy and Resources Institute

pedagogical approach are described below to elaborate on the innovative strategies that the student groups were able to achieve through their projects.

The project “Kalakriya”, designed by one of the teams in the Academic Year(AY) 2021, focused on a low environmental impact design by retaining the natural characteristics of the site as much as possible.

The project aimed to envision a thriving and diverse community that would sustain on a net positive (or zero) systems of water, financial, societal and ecological balance. The objectives were to use minimal natural resources, to promote the three R’s - Reduce, Reuse and Recycle, to encourage efficient construction practices, energy and water efficiency.

The concept revolved around the idea of a courtyard structure. This would provide an open plan with maximum natural lighting, ventilation and interaction between two or more spaces as elaborated in (Fig. 04)

Students optimized the envelope by optimizing the U-value of the materials, proper use of shading devices for openings and ensuring daylight utilisation within the built structure (Fig. 05). They calculated the overheated periods and experimented with shading mask solutions for different heated orientations. Thus decided on the Vertical Shading Angles (VSA) and Horizontal Shading Angles (HSA) required for designing horizontal and vertical shading devices respectively. (Fig. 06)

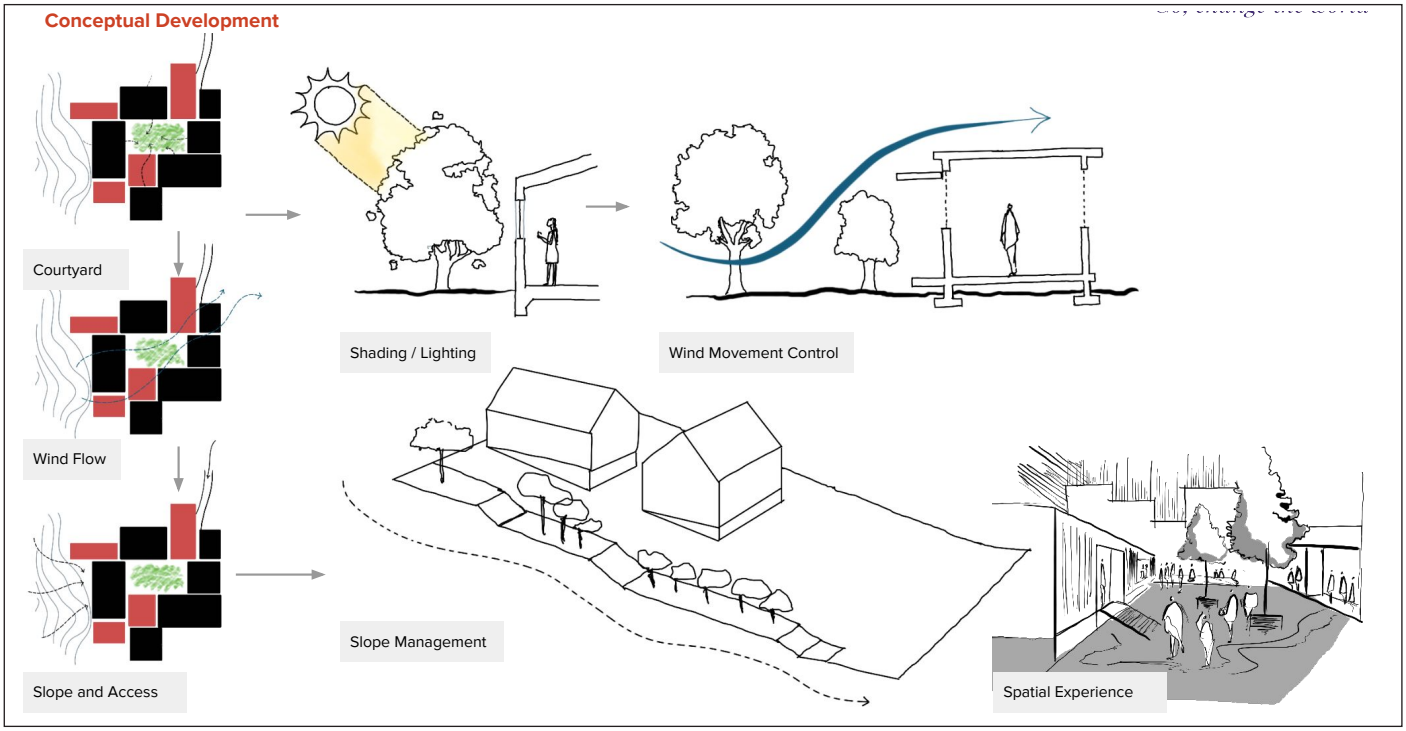
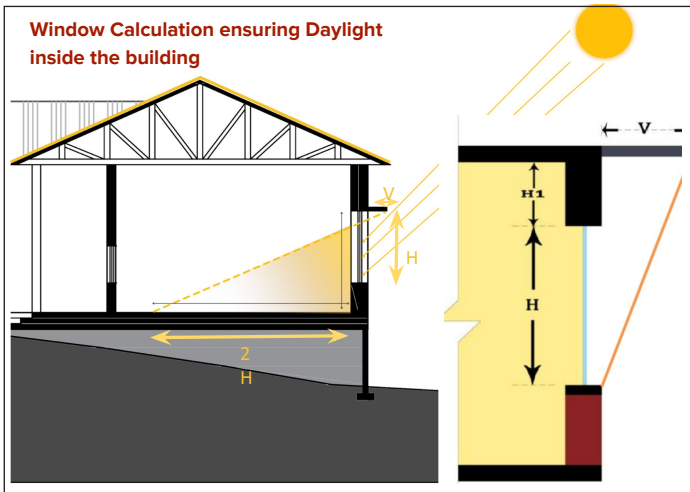


Figure 04: Shows the building footprint consideration and courtyard concept; Source: Page 08, student report ‘Kalakriya’

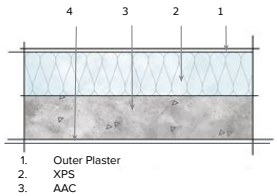


Daylight Alternative 1 - GRIHA	
The WWR and SRR to not exceed 60% and 5% respectively &; All the fenestrations meet the SHGC requirement of ECBC-2007/Weighted Façade average SHGC meets SHGC requirements of ECBC-2007 OR Any combination of the above strategies on 100% of the fenestrations	0
Minimum of 25% of the living area should meet adequate level of daylight (daylight factors) as prescribed in SP 41	0
Adequate daylight factors are achieved in more than 50% of total living area	2
Adequate daylight factors are achieved in more than 75% of total living area	4

Envelope Optimisation

Building massing and orientation, as well as insulated walls, control heat gain. The building's windows face south and north to improve daylighting and solar control. Several simulations and analyses were done to get the final proposed design.

Façade Direction	WWR
North	40%
South	25%
East	10%
West	4.5%



Roof details

	ROOF	WINDOW
STANDARD DESIGN	Cement plaster 0.01m +XPS 0.00m+ RCC slab 0.15m + inner cement 0.01m **U VALUE - 0.33**	6mm (solar control glass) - 12mm air gap - 6mm clear glass **U VALUE - 3**
PROPOSED DESIGN	Outer cement plaster 0.01m +XPS 0.015m+ RCC slab 0.15m + inner cement 0.012m **U VALUE - 0.21**	Vertical sealed double glazed window - 20mm air gap - ordinary glass of medium coloured having SHGC 0.18 **U VALUE - 1.95**

Figure 05: Envelope Optimization ; Source: Page 15, student report ‘Kalakriya’

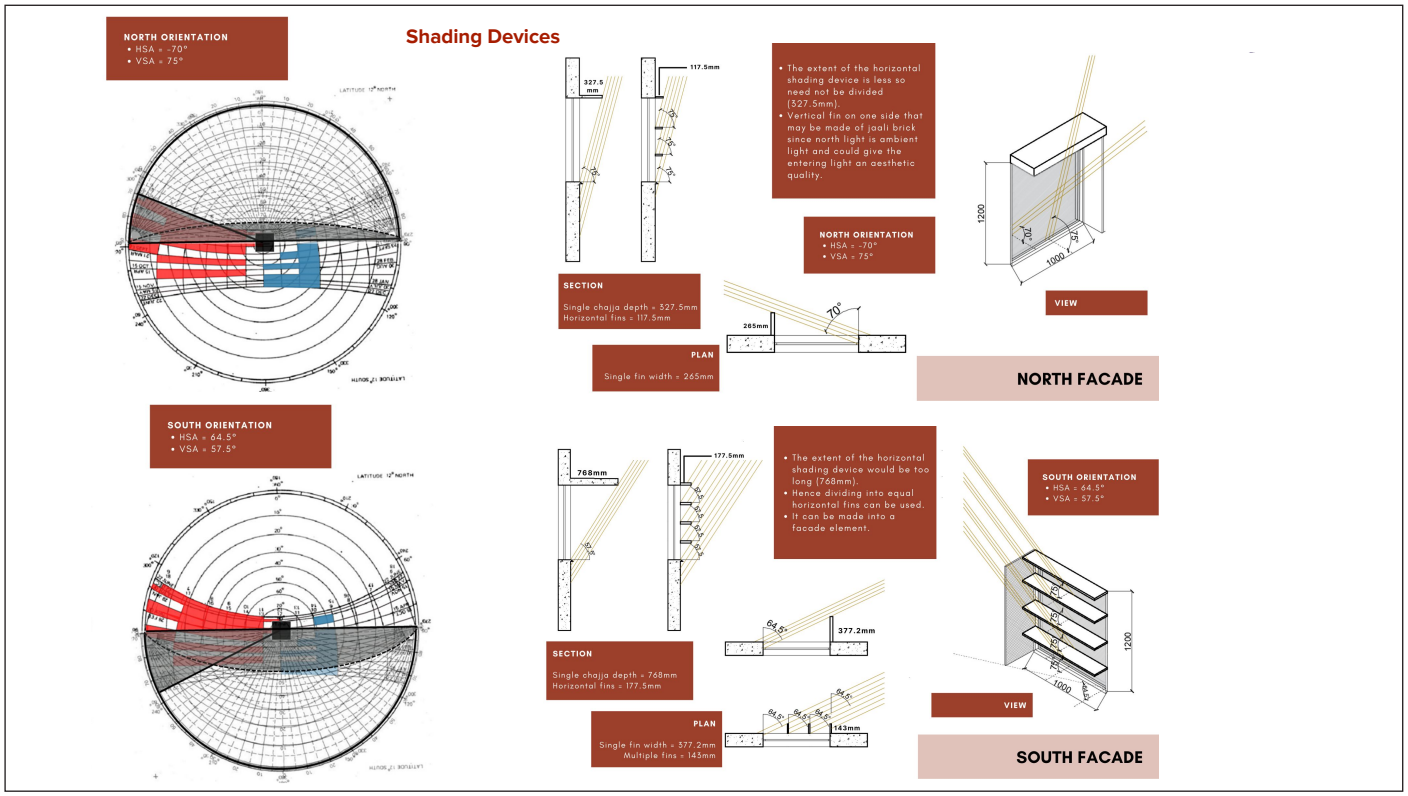
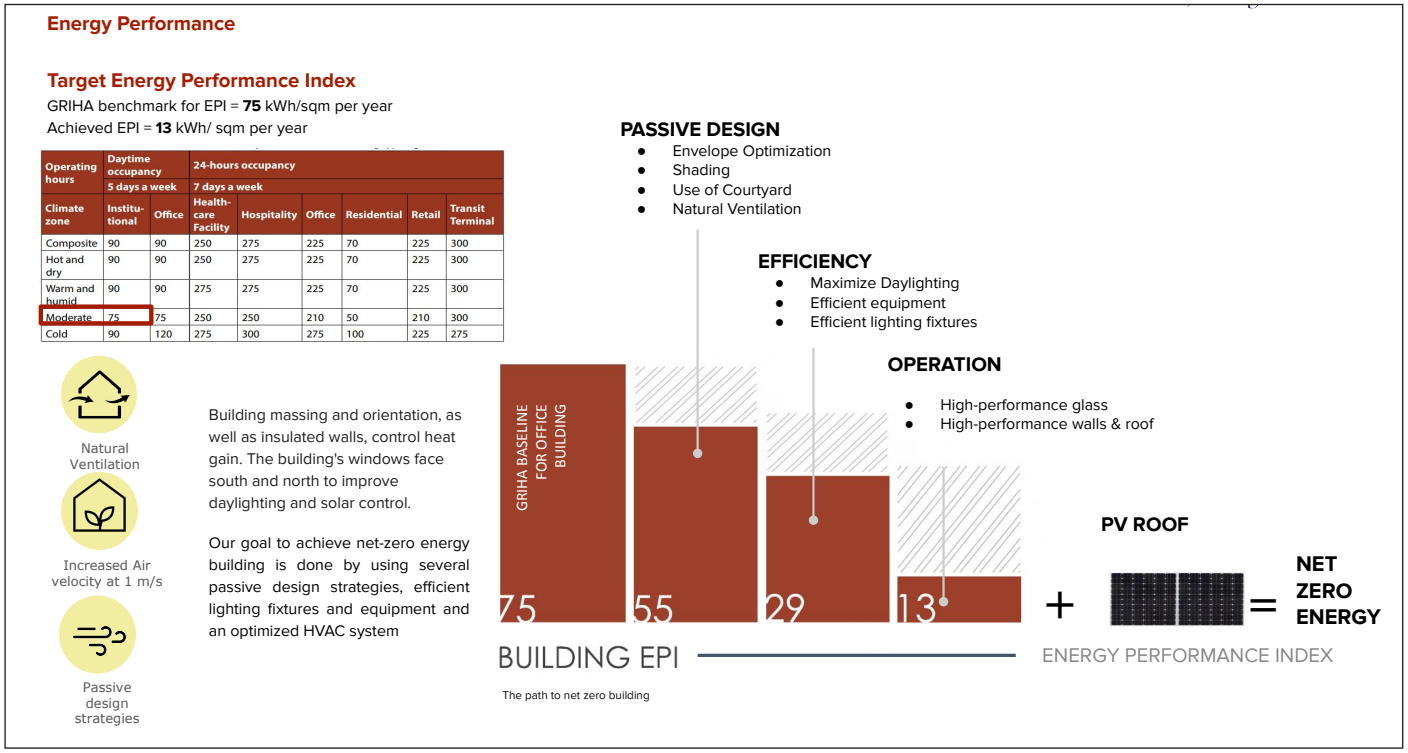


Figure 06: overheated periods, shading mask, Vertical Shading Angles (VSA) and Horizontal Shading Angles (HSA)
Source: Page 14, student report 'Kalakriya'



Operating hours	Daytime occupancy		24-hours occupancy					
	5 days a week		7 days a week					
Climate zone	Institutional	Office	Health-care Facility	Hospitality	Office	Residential	Retail	Transit Terminal
Composite	90	90	250	275	225	70	225	300
Hot and dry	90	90	250	275	225	70	225	300
Warm and humid	90	90	275	275	225	70	225	300
Moderate	75	75	250	250	210	50	210	300
Cold	90	120	275	300	275	100	225	275

Fig 07: elaborates on the required criteria to achieve net zero energy building and the practical calculation to achieve an EPI that is less than a benchmark as given by GRIHA ; Source: Page 12, student report 'Kalakriya'

Students optimized the envelope by optimizing the U-value of the materials, proper use of shading devices for openings and ensuring daylight utilisation within the built structure (Fig. 05). They calculated the overheated periods and experimented with shading mask solutions for different heated orientations. Thus decided on the Vertical Shading Angles (VSA) and Horizontal Shading Angles (HSA) required for designing horizontal and vertical shading devices respectively. (Fig. 06)

The annual water consumption was calculated to be 175475 litre as against GRIHA's base case of 522315 litre annual consumption. This demonstrates the reduction of water usage by 66.40%. This was achieved by using efficient plumbing fixtures reducing the per day consumption. Freshwater requirement was reduced by using recycled water from STP[3] for non-domestic usage and filtered rainwater for domestic usage. (Fig 08)

[3]STP – Sewage Treatment Plant

Water Performance Index (WPI)

WPI benchmark as per various building typologies

WPI benchmark as per various building typologies (liter/person/day)				
Typology	Base case	25%	50%	75%
Healthcare Facility	572	429	286	143
Hospitality	320	240	160	80
Institutional	80	60	40	20
Offices	52	39	26	13
Residential	120	90	60	30
Retail	48	36	24	12
Banquet/Wedding Hall	80	60	40	20
Multiplex	24	18	12	6
Transit and Terminal Station	60	45	30	15

$$\text{WPI (liter/person/day)} = \frac{(\text{Domestic water} + \text{Flushing water} + \text{Irrigation water} + \text{Cooling tower water}) - (\text{Stored rainwater} + \text{Treated wastewater})}{\text{Occupancy}}$$

Domestic water	191.25L
Flushing water	289.5L
Irrigation water	26.19L
Treated waste-water+ Stored rainwater	142.5L
Occupancy	30

WPI (Liter/person/day) = (191.25+289.5+26.19)- (142.5)/30

= (506.94)- (142.5)/30

= 364.44/30

= **12.148 Litre/ person/ day**

Water Quality & Self Sufficency (WPI)- GRIHA points		
Ensure that the project meets water quality norms for drinking/domestic use as per BIS 10 500 : 2012 and treated water for irrigation and discharge should be as per the CPCB	0	0
Ensure that the project demonstrates reduction from GRIHA benchmark WPI		
Percentage reduction from GRIHA benchmark - < 75%	5	5
Criterion total	5	5

WPI Reduction = $\frac{(\text{Base case WPI as per GRIHA benchmark} - \text{Design case WPI}) \times 100}{\text{Base case WPI as per GRIHA benchmark}}$

= (80-12.148)X100/ 80

= **84.815%**

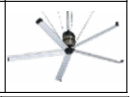
Fig 08: showcases the Water Performance Index(WPI) reduction calculation ; Source: Page 29, student report 'Kalakriya'

Low-wattage and high-luminescence lighting fixtures were chosen and lighting loads were calculated. An EPI[4] of 7.61 kWh/sqm/year was achieved which was much less than the GRIHA benchmark case of 13 kWh/Sq. m/ year. This was achieved by using fewer electrical lighting equipment by proposing solar-operated lighting devices and utilizing maximum solar energy during day and night. (Fig. 09, 09a) "Kshema", designed by one of the teams in AY 2023, experimented with more naturally available sustainable materials. During this AY[5], green building approach was narrowed down and a comprehensive GRIHA checklist format was provided to the batch for a better presentation of analysis and design at the end.

To reduce vehicular movement on site and reduce the carbon footprint produced by fuelled transportation, provision for electric vehicle shuttle services, bike paths was made.

Water conservation during construction was proposed using gunny bags for watering and compacting rammed earth walls. This method ensures that water is used efficiently by minimizing losses through evaporation and the amount of water used can be carefully measured and monitored. Furthermore, stormwater and treated wastewater are proposed to be utilized for purposes like cleaning, flushing and irrigation for water efficiency during operation.

Equipment Load Calculation

Appliances	Cost in rupees	Power	
Farberware Classic FMO07ABTWHA Microwave oven	15,299	700	
Godrej 190 L 5 Star Inverter Direct-Cool Single Door Refrigerator	16,990	285	
High Volume low Speed (HVLS) Fan HF-12 B5	20,000.00	750	

Appliances	Cost in rupees	Power	
Dell Latitude series laptop	59,828	137	
Havells Exhaust fan (Ventil air) @200mm	1290	32	
HP SMART TANK 750 WI FI DUPLEXER PRINTER	23,020	0.1 watts (off); 1.10 watts (sleep)	

Rate of equipments used

Appliances	Nos.	Wattage	No. of hours per day	No. of days	Energy consumed annually (kwh)
Printer (commercial)- Standby	1	30	0.5	240	3600
Printer (commercial)	1	400	1	240	96000
Microwave	1	700	0.5	240	84000
Refrigerator	1	285	24	240	1641600
Water purifier	1	25	0.5	240	3000
Projector	1	300	1	240	72000
Pump	1	60	8	240	115200
Fan	22	750	7	240	1260000
Laptops	7	50	7	240	84000
16A power socket	2	1000	1	240	240000
6A power socket	25	100	2	240	48000
CCTV	2	20	24	365	175200
Electric Stove	1	1500	0.5	240	180000
Exhaust Unit	3	60	1	240	14400
Generators	1	800	1	240	192000

Total (Wh)	**4209000.00**
Total (kWh)	**4209.00**
Built up area	**553.30**
EPI	**7.61**

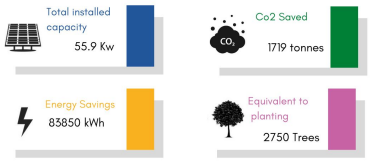
Fig 09: lighting load calculation ; Source: Page 18, student report 'Kalakriya'

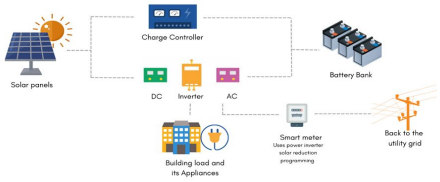
[4]EPI - Environmental Performance Index
[5]AY - Annual Year

Solar Potential

The site receives an average solar irradiance of 1266.52 W/sqm.1 kWp solar rooftop plant will generate an average over the year 5.0 kWh of electricity per day(considering 5.5 sunshine hours) Total roof area of the project is 699 sqm and the rooftop available for the solar panels after eliminating the joineries and connection is 80%. Hence total electricity generation from solar plant annually is 83850 kWh.

MODULE SPECIFICATIONS
Loom Solar Panel - Shark 440
Size : 6.9 ft * 3.4 ft
Monocrystalline solar panel
Series : (12*6)*2 of 144 cells





Schematic working diagram of PV Panels

1. Size of Power Plant	
Feasible Plant size as per your Roof Top Area :	55.9kW
2. Cost of the Plant :	
MNRE current Benchmark Cost (without GST) :	Rs. 38236 Rs. / kW
View Benchmark Cost List	
Without subsidy (Based on current MNRE benchmark without GST) :	Rs. 2137392
With subsidy 0 (Based on current MNRE benchmark without GST) :	Rs. 2137392
3. Total Electricity Generation from Solar Plant :	
Annual :	83850kWh
Life-Time (25 years):	2096250kWh
4) Financial Savings :	
a) Tariff @ Rs.8/ kWh (for top slab of traffic) - No increase assumed over 25 years :	
Monthly :	Rs. 55900
Annually :	Rs. 670800
Life-Time (25 years) :	Rs. 16770000

Renewable energy utilization		
Would you select Alternative 1 or Alternative 2?	Alternative 1	
Alternative 1: On-site/Off-site renewable energy system installation to offset a part of the annual energy consumption of internal artificial lighting and HVAC systems (Mandatory requirements must be met through On-site renewable energy system)	7	7
Alternative 2: Off-site renewable energy system to offset 100% building energy demand	0	
Criterion Total	7	7
Low ODP materials		
All the insulation used in building should be CFCs and HCFCs free	1	
All the refrigerant in the HVAC and refrigeration equipment should be CFCs free		
The fire suppression systems and fire extinguishers installed in the building are free of halon		
Criterion Total	0	

Fig 09a: equipment load calculations ; Source: Page 20, student report 'Kalakriya'

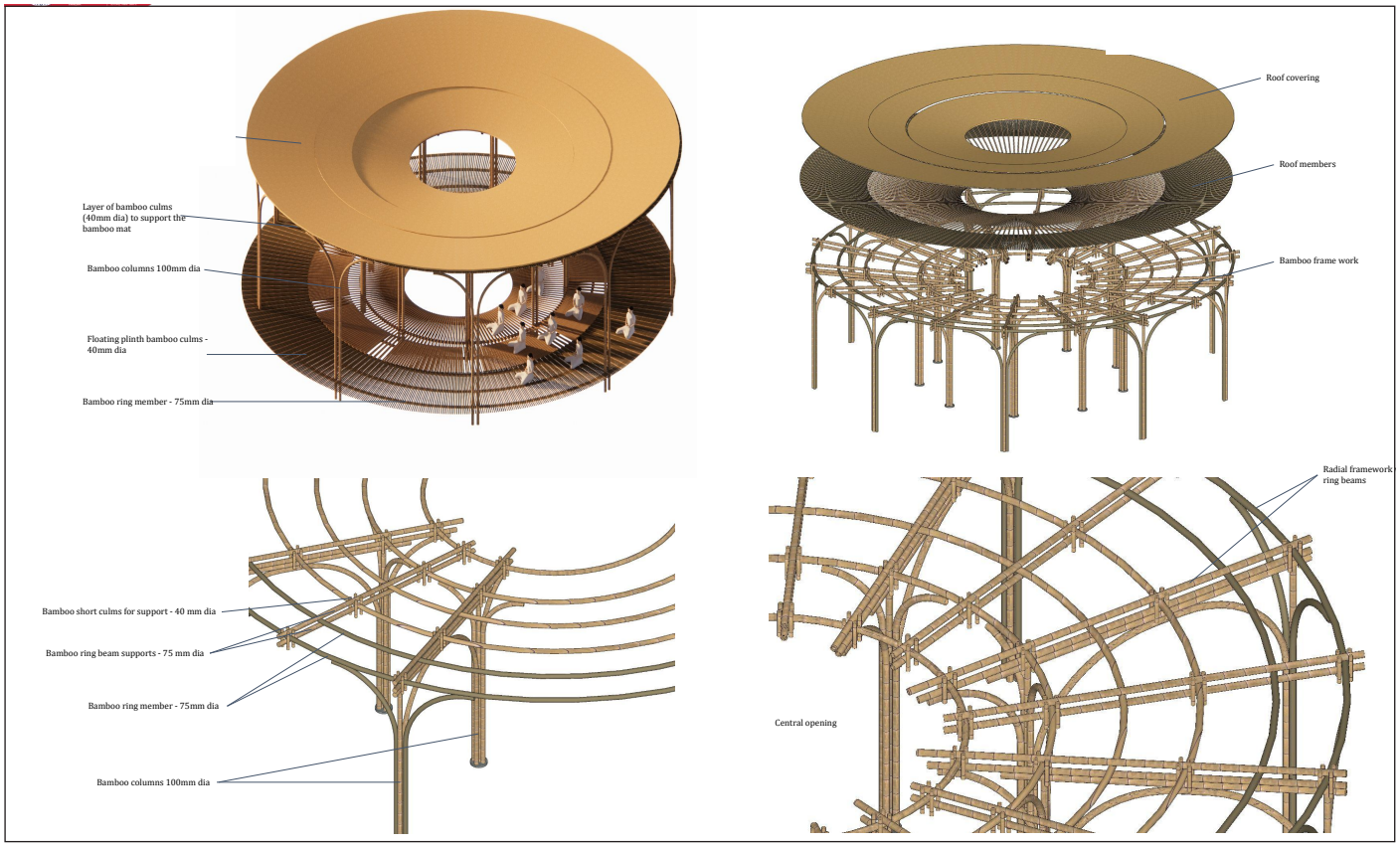


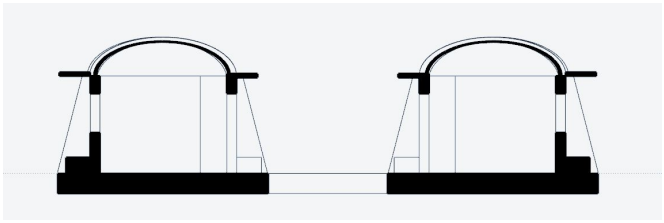
Fig 10: Elaborating on use of bamboo in the design. ; Source: Page 12, student report 'Kshema'

Hybrid recycling techniques were proposed, which combine both on-site and off-site recycling methods. This involves segregating waste directly at the source, such as having designated containers for wood, earth, and non-recyclables like plastics. This includes multi-colored waste bins for e-waste, biomedical waste, organic waste, plastics, paper, and other non-organic solid waste. Additionally, it lessens the workload for waste handlers, leading to cost savings.

To further minimize waste, excavated earth from the site was repurposed as a building material in the form of rammed earth walls and mud bricks for vault construction.

Bamboo has been one of the major construction materials proposed in this project. Bamboo is known for its low carbon emission in addition to its vast availability, its flexible feature and for its biodegradable nature. (Fig. 10)

The material composition of the various building components was used to reduce their Thermal Transmittance(U – Value). For wall construction, the use of 2 lines of bamboo with mud plaster gave a U-value of



Dorms section

Dorms view

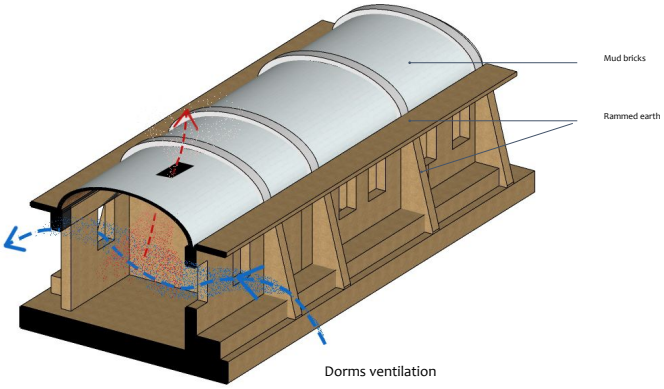


Fig 11: Elaborating on use of materials ;
Source: Page 10, student report 'Kshema'

1.4W/m² and for a wall constructed with rammed earth, the U -value achieved was 1.9W/m² which is lesser than that of a standard brick masonry wall (2.0 W/m²).
For roofing, earth vaults with bamboo reinforcement were used giving a U-value of 0.31 as compared to a concrete 6" thick roof slab with a thermal transmittance range of 1.67 - 0.83 (Fig 11)
A Double Glazed Unit (DGU) with an air gap of 6mm of U -value - 3.6W/m² was used for the windows, this value is lesser than that of single glazed window of a U value - 5W/m² Window Wall Ratio (WWR) of 25% was designed to increase daylight and natural ventilation.
As a result of reduction in energy consumption, an Energy Performance Index (EPI) of 29.642Wh/m²/annum was achieved which is 57.65% less as compared to GRIHA base case of 70Wh/m²/annum.

Parameter	Data
Site Area (m2)	11000
Total Built up Area (m2)	400
Occupancy	40
Occupancy Schedule Weekdays// Weekends Usage Hours per day	7 days a week 24 hr/day
Number of days building used (Annually)	360
Annual Electricity Consumption in Lighting (kWh)	1917.12
Annual Electricity Consumption in Ventilation (kWh)	1050
Total Annual Electricity Consumption (kWh)	12424.5
Energy Performance Index (EPI) (kWh/m2/annum)	29.642
GRIHA EPI and Percentage Reduction	57.65
EPI Considering only lighting and ventilation	7.4175
Percentage reduction from GRIHA	89.23

Fig 12(a): EPI reduction calculation ;
Source: Page 19, student report 'Kshema'

The project proposed use of water efficient plumbing fixtures, reduction of fixtures by designing common wet areas, and shorter distance to STP to reduce material cost. Use of filtered rain water collected through catchment areas and sewage treated water that would not compromise on the hygiene of the user. was used for landscape, planting native shrubs and trees. In addition, a drip irrigation system was used to reduce use of water intensity. All these adaptations resulted in reducing the water consumption by 77%.

Lighting load =	1917.12	EPI =	Total energy consumed
Power demand =	9939.68		Total built area
	11856.8		Lighting Load + Electrical Load
			Total Built Area
	29.642		
			6121.5+12484.6
			400
			11856.8
			400
			29.642
		GRIHA Base Case EPI = 70 (Residential)	

Fig 12(b): EPI reduction calculation ;
Source: Page 19, student report 'Kshema'

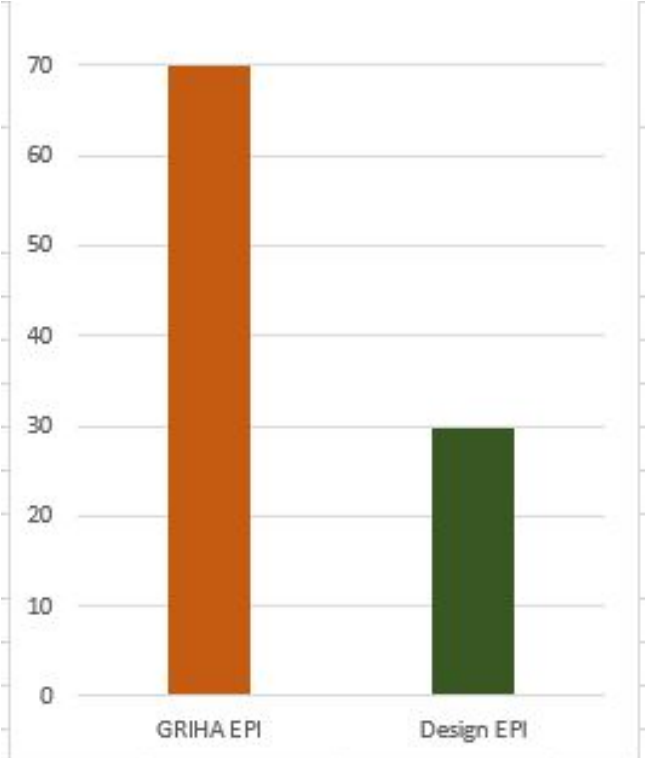


Fig 12(c): EPI reduction calculation ;
Source: Page 19, student report 'Kshema'

Conclusion:

The students have evinced interest in the project from the outset as the idea of design audit based on the GRIHA checklist fascinated them. It was in-turn fascinating to witness the teams to be innovative and resolve the given predicament.

The following points may be deduced from the feedback from the students:

1. Most of the students felt that they were introduced to the concept of green buildings well and they could retain the principles involved. (Weighted average of 7.6 was achieved on a 10-point scale)

2. Most of the students felt that they could relate to the latest construction trends. (Weighted average of 7.6 was achieved on a 10-point scale)

3. There was a mixed response about the Green Building lecture material's utilization thus indicating a scope for improvement. Although a lot of students understood and could use the information well, a small section of the students felt it could have been elaborated better. (Weighted average of 6.8 was achieved on 10-point scale)

4. There was a mixed response about the Project Checklist/ Self-Assessment tool's utilization indicating a scope for improvement. Although a lot of students could use it well, a small section of the students felt some difficulty in using the same. (Weighted average of 6.8 was achieved on a 10-point scale)

5. There was a mixed response about the insights about the Greenabout Green Building Project Design process indicating a scope for improvement. Although a lot of students felt that they were useful, a small section of the students felt some difficulty in relating to the same. (Weighted average of 7.3 was achieved on a 10-point scale)

6. Some students indicated that they needed more practical exposure with case studies, to understand the entire design and assessment process.

This pedagogical process experiment stands as a good example of cross-sectional integration of design and construction towards a greener and more sustainable architectural profession. Going forward, more relevant case studies may be introduced to reinforce the connection between concept and reality.

References:

- (Lindsey, R. (2009, January 14). Climate and Earth's Energy Budget. earthobservatory.nasa.gov. https://earthobservatory.nasa.gov/features/EnergyBalance. Accessed December 20, 2023.)
- (Heavens, N. G., Ward, D. S. & Natalie, M. M. (2013) Studying and Projecting Climate Change with Earth System Models. Nature Education Knowledge 4(5):4)
- (Aengenheyster, Matthias & Feng, Qingyi & Ploeg, Frederick & Dijkstra, Henk. (2018). The point of no return for climate action: Effects of climate uncertainty and risk tolerance. Earth System Dynamics. 9. 1085-1095. 10.5194/esd-9-1085-2018.)
- (United Nations, Department of Economic and Social Affairs, Population Division (2019). World Urbanization Prospects: The 2018 Revision (ST/ESA/SER.A/420). New York: United Nations.)
- (Shitaw Tafesse, Yidnekachew Esayas Girma, Eliyas Dessalegn, Analysis of the socio-economic and environmental impacts of construction waste and management practices, Heliyon,Volume 8, Issue 3, 2022, e09169, ISSN 2405-8440, https://doi.org/10.1016/j.heliyon.2022.e09169.)

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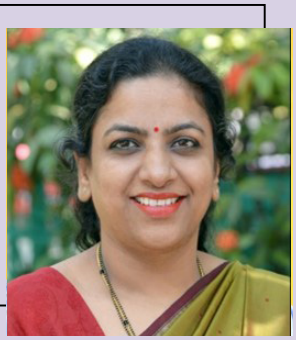

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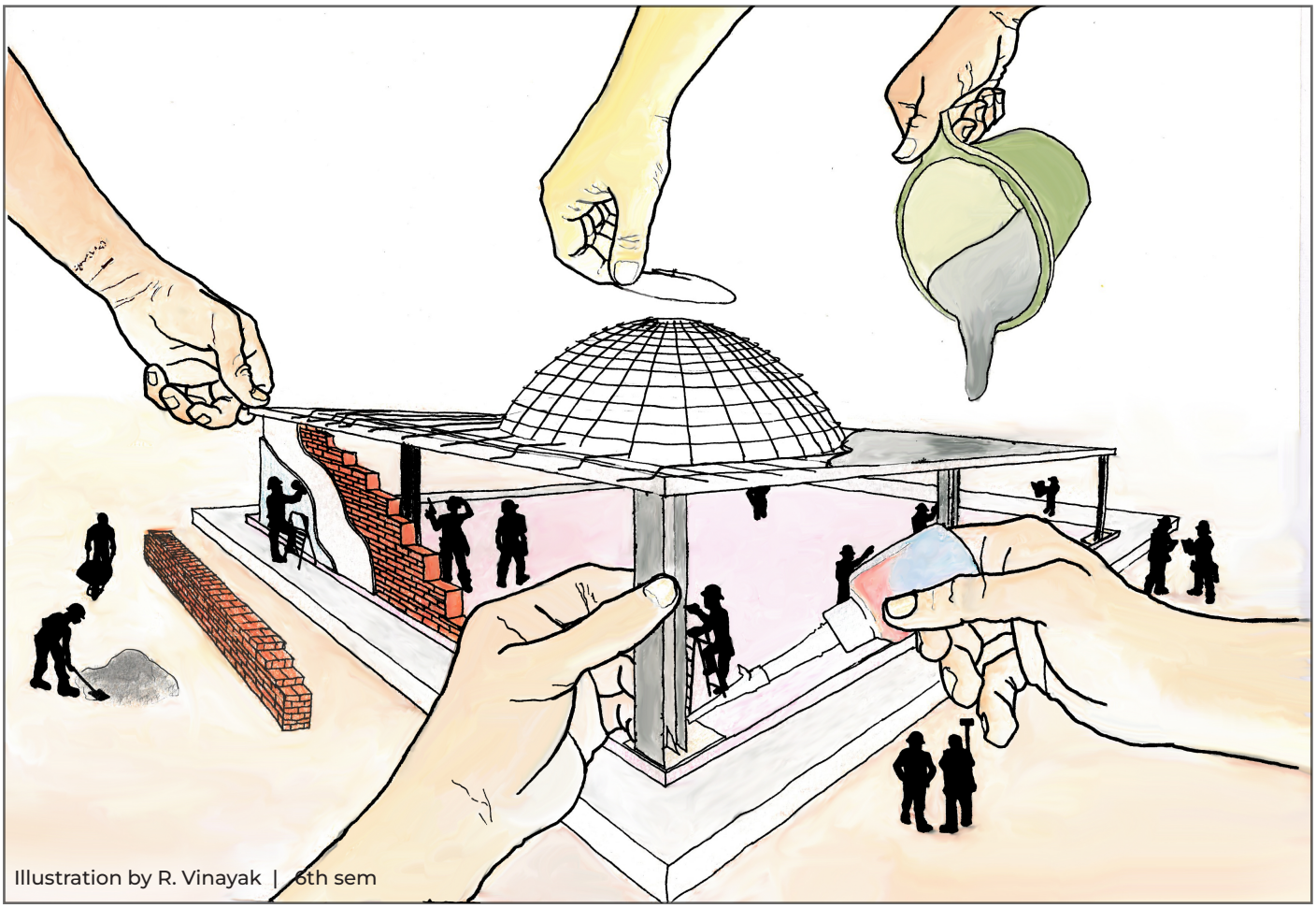

Illustration by R. Vinayak | 6th sem

08. Enhancing Material Understanding through Hands-On Experiences.

Authors :
Ar. Pedaparthi Shweta, Assistant Professor, RV College of Architecture.
Ar. Akanksha Singh, Assistant Professor, RV College of Architecture.

Kalpa, Vol.04, 2023, pp. 49-53

Abstract :
The article examines the innovative approaches in pedagogy adopted by the faculty of the course "Materials and Methods of Building Construction" highlighting the benefits of hands-on workshops. The article demonstrates the effects of innovative on-site demonstrations and model-making methods that led to an improved cognition of construction techniques related to RCC, Bamboo, and other alternatives. Group activities, such as creating scaled models, mixing and application of composites, stress tests etc., provided a tangible understanding of construction processes. This departure from traditional lectures to experiential learning represents a noteworthy change, fostering practical thinking and problem-solving in students.

Keywords:
Pedagogy, Hands-on techniques, Experiential learning, Innovative education.

Architecture as a course of study has always been closely related to its practice & profession. Since the birth of the profession and structuring of its curriculum, there has always been a very close association and influence of the practice on the curriculum. Architecture, as an art and science, stands at the intersection of creativity and functionality. It involves designing spaces that not only inspire and uplift, but also serve the needs of individuals and communities. In the realm of architecture, hands-on workshops hold a pivotal role in shaping the education and development of future architects. In addition to architectural design being a core course, "Materials and Methods in Building Construction" hereafter mentioned as MMBC, has consistently been recognized as an essential component for the comprehensive development of an architect.

On the contrary, this hands-on building construction course has gradually started taking a didactic approach

of pedagogy and this may affect the objectives of the course being limited to a lecture-based course with the outcomes being condensed to merely drafting of sheets. Unfortunately, in today's extremely fast paced digital world, the importance of hands-on experiences in education is often overlooked. Actively engaging with materials firsthand nurtures, a more profound grasp of their characteristics and potential uses. Dr. Niloufar Emami, Assistant Professor, University of Illinois Urbana-Champaign in her article "Teaching structures to architecture students through hands-on activities" emphasised on the visual and tactile understanding of building materials and stated how the inability to directly interact with real materials hinders learners' progress in this regard. This article explores the transformative power of workshops and gives an in- depth understanding of various pedagogical techniques that some of the hands-on workshops can bring forth in the overall development of a student in the architectural curriculum.

This study has a deep exploration of the third semester course of (MMBC) syllabus prescribed under Visvesvaraya Technological University hereafter referred to as (VTU). This course work includes understanding of Reinforced Cement Concrete hereafter referred as (RCC). RCC slabs like one-way slab, two-way slab, continuous slab, cantilever slab & RCC domes & vaults, alternate roofing materials and techniques, understanding paints and finishes, masonry domes, vaults and funicular domes. The academic plan for this studio was curated by the faculty team in order to enlighten the students by immersing them in practical activities, with the workshops not only imparting technical knowledge but also sparking creativity and innovation in material explorations .

Demonstrations:

1) Reinforced Cement Concrete

Reinforced Cement Concrete (RCC) slabs represent a ubiquitous construction technique employed throughout the country for building floors. They find application in structures of all sizes and types. A crucial aspect of working with RCC involves a comprehensive understanding of the intricate process of laying steel reinforcement bars, their bending, correct placement, and the utilisation of support elements like chair bars[1].To effectively convey these complex concepts to students, educators have found that model making emerges as an exceptionally efficient teaching method. The teaching approach involves dividing students into groups, each tasked with crafting a scaled-down 1:10 model, illustrating the reinforcement details of various slab types. Additionally, students attempted to replicate reinforcement details for more complex structures, such as RCC domes and vaults. Materials used for making the model were foam sheet, GI wire, Aluminium wire, Wire mesh etc.

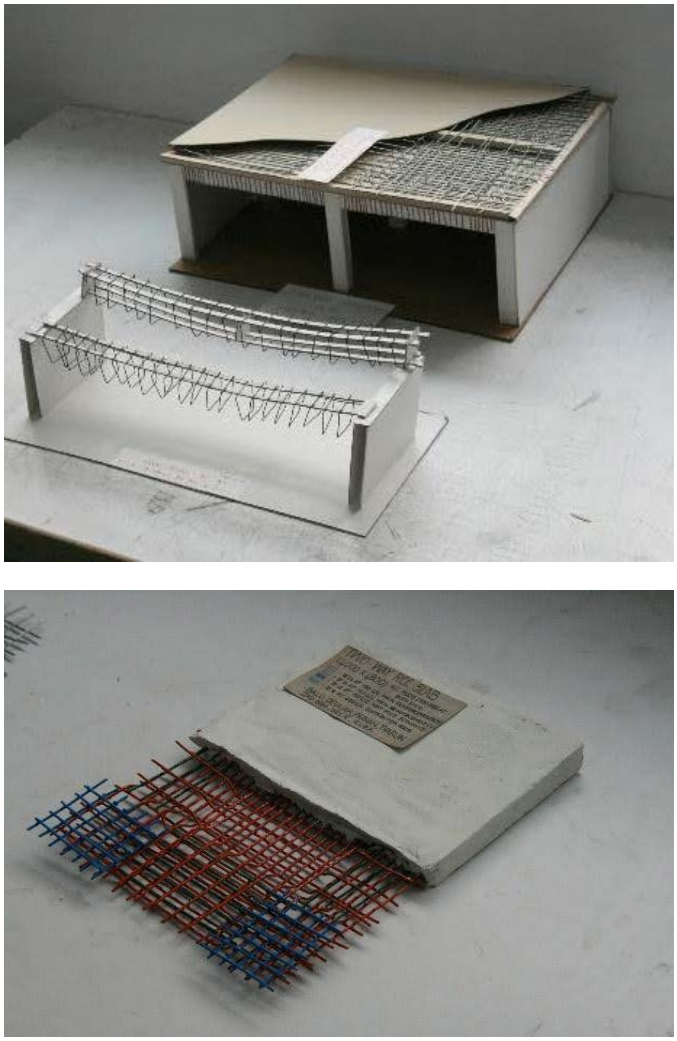

Fig 1: Showcasing final models made by the students (Batch 2016-2020 in groups of 8)-(Source : Author)

2) Bamboo,a material exploration through 1:1 scale models

The basics of bamboo workshop was a three-day workshop for students to construct five bamboo pavilions on the campus as an attempt to gain insight into alternate roofing materials and techniques. The intent of the workshop also included to test and understand the flexibility of bamboo as a structural material, working hands-on with it and having a basic knowledge of the joinery details. Bamboo's versatility, strength, and sustainability make it an ideal material for various uses in

Fig 2: Final outcome of the bamboo workshop. (Made my students of 2018- 2023 under the guidance of Ar. Vinutha S N & Ar. Amit K)

[1]chair bars-chair bars are supports places at predetermined heights to ensure proper spacing and holding up of main reinforcement bars.

the construction industry. The workshop began with an introduction to bamboo's anatomy and growth patterns, followed by a lecture discourse on harvesting, treating and procurement of bamboo poles. The students then set foot on making bamboo vaults - from bending, shaping, cutting and joining they were deeply involved with the material and its behaviour. Participants learnt about construction techniques by constructing a simple structure in the days' time.

3) Exploring Vault and domes as masonry roofs

The objective of the workshop was to provide participatory sessions on two masonry roofing types as alternative construction techniques. The materials used for the masonry vault and funicular dome were hollow clay blocks and custom-sized clay bricks respectively. The exercise was done with the partnership of Ar. Gouthama D M (Mud Hands) for the batch of 2017- 2022(fig 3,4). The workshop introduced the participants to the innovative world of lightweight structures. Funicular domes, inspired by nature's efficiency, emphasise tension and compression forces for stability. This workshop combines engineering principles with hands-on activities to build small-scale models of funicular domes using materials like bamboo, timber, or lightweight metals. Participants learn about geometry, structural analysis, and the delicate equilibrium that makes these structures possible. Through practical experience, participants comprehend the complex interplay of forces that dictate the stability of funicular domes. They explore the concept of form-finding, where the shape of the structure arises from the balance of internal and external forces. By physically assembling these models, participants grasp the engineering challenges and aesthetic potential of lightweight, efficient structures. A similar exercise was done for the students of batch 2022- 2027 in collaboration with Eco Home Solutions where they attempted a masonry vault in the construction yard in the RVCA campus.

Fig 3 : Students attempting scaled prototypes of funicular domes before the construction of the dome (Source: Author)

Fig 4: Process of construction of Masonry vault (Source : Author)

4) Natural plasters

Sustainable practices in building construction are becoming the need of the hour. The next interactive workshop was done to enhance the understanding of natural plasters. The students were introduced to various vernacular plastering materials like clay, lime, and earth. They were taught the art of mixing, applying, and finishing natural plasters, The workshop aimed to highlight the historical and cultural significance of natural plaster techniques, encouraging the preservation of traditional building methods and demonstrating that natural plastering can be a cost-effective and sustainable choice for both new construction and renovation projects. Unlike processed building materials like cement, earth requires higher-order thinking skills (from Bloom's Taxonomy- Cognitive Domain) and several rounds of tests that make plaster workable. The workshop also emphasised on the importance of locally sourced materials and the low environmental impact of non-toxic finishes. The students experimented with the ratio of water to be added to various mixes for perfect workability and the role of pigments in the overall aesthetics of the plaster. Engaging with natural plasters also offers a tactile understanding of its properties like breathability & thermal performance which is difficult to

Fig 5 : Showcasing the display of different types natural plastering materials (Source : Author)

Fig 6– Students preparing batches of natural plaster (Source : Author)

understand through verbal communication. The balance between material composition and artistic expression is a valuable takeaway from the workshop. This was supported by the architectural firm Made in Earth for the batch 2016- 2021 (fig 5,6) and a similar exercise was repeated with the batch 2021- 2026 under the guidance of Ar. Ajinkya Unhale (Unearth) (fig 7).

Paints and finishes make a small part of a module in this curriculum. Previously, various interactive theory sessions on paints were conducted to make students understand its application. It was observed that during assessments the students would often have severe confusion between the painting materials, surface compatibility, constituent of paints and various other details. In order to counter this challenge the students were divided in groups of 4-5 where each one of them were given a particular type of paint. Paint samples were bought from the market and tried on different surfaces like wood, metal, concrete, paper, stone etc. They had interesting observations and tabulated their entire study. (fig 8, 9)This was discussed in length in class. During a verbal feedback session students expressed that they had a deeper and easier understanding of the topic which was initially difficult to correlate and recollect when it was limited to lecture-based teaching. This was one of the simplest yet effective approaches that helped cut down long theory hours of classes.

Hands-on experiences offer an unparalleled pathway to material understanding. Workshops such as basics of bamboo, natural plasters, and funicular domes go beyond theoretical knowledge, allowing the students to forge intimate connections with the materials they work with. These immersive experiences empower individuals to create, innovate, and think critically about material applications. As we continue to advance technologically, the timeless value of tactile engagement remains a cornerstone of meaningful education and sustainable creativity. Overall, the pedagogical approach presented in this article promotes a shift from passive learning to active exploration, enabling students to become more independent and resourceful learners. It aligns with the idea that true understanding emerges from direct experience, and it can be particularly effective in disciplines where tangible, hands-on interactions with materials are integral to the subject matter.

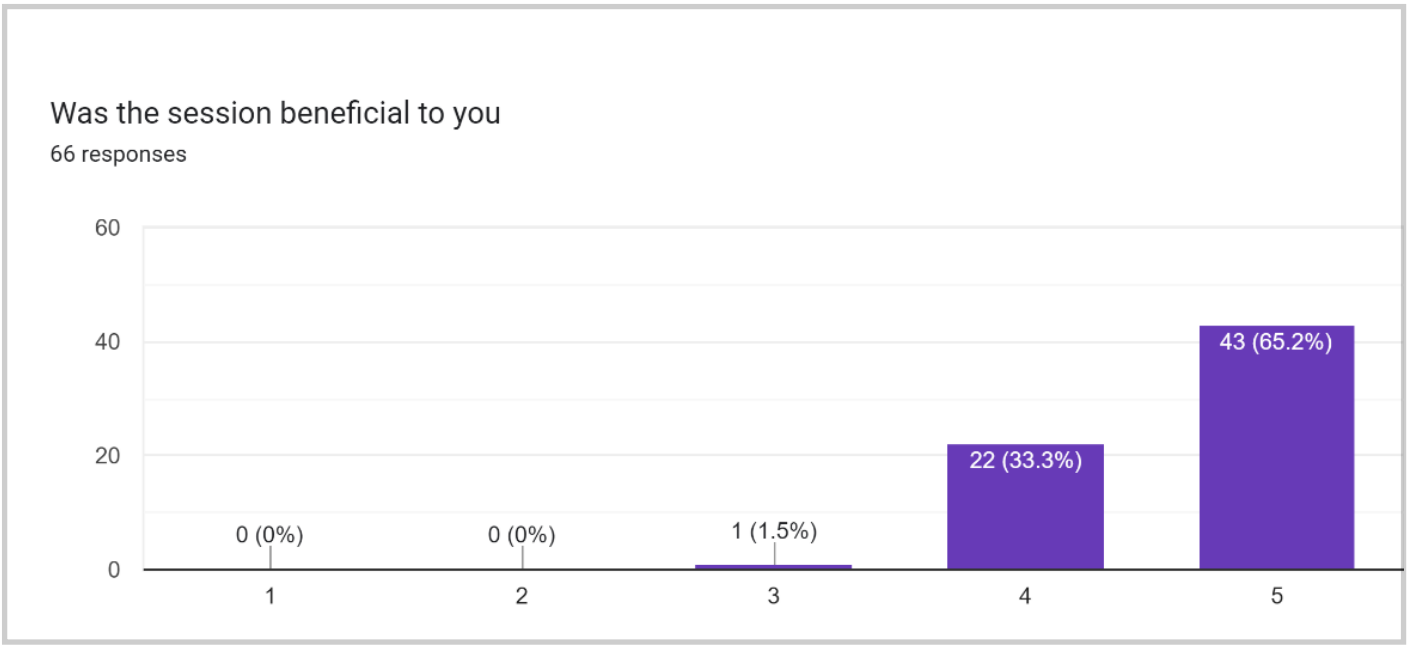

Fig 7. Feedback from students of batch 2021- 2023 (Source : Author)

Fig 8. Showing the table filled post market study done by the students of batch 2021- 2023. (Source : Author)

References:

- VTU Syllabus for MMBC- 2018 Scheme- https://www.bmsca.org/pdfs/B.Arch/VTU/SYLLABUS/3rd-Sem-2018-Syllabus.pdf
- VTU Syllabus for MMBC- 2021 Scheme- https://vtu.ac.in/pdf/2021syll/barchsyll.pdf
- Emami, Niloufar & Von Buelow, Peter. (2016). Teaching Structures to Architecture Students through Hands-On Activities.

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Illustration by Tummala Pranesh | 8th sem

09. Buildings in Climate Action.

Author : Harish Borah, LCA Practitioner/Educator & Founder, OnePointFiveTribe.

Kalpa, Vol.04, 2023, pp. 55-57

Abstract :
The primary intent of this article highlights the construction industry's dual impact on the global economy and environment, emphasizing economic growth alongside environmental concerns, especially regarding climate change. Urging rapid adoption of sustainable practices and reduced reliance on fossil fuels, the article stresses the need for collaborative efforts within the industry to prioritize climate measures. Systemic changes and innovation are advocated for achieving a lower carbon footprint, whilst recognizing progress in energy-efficient buildings and demanding a more comprehensive approach to address the climate crisis. The article suggests the need for coordinated action amid internal challenges, external demands, and market growth, promoting a shift towards sustainable practices and active participation in global climate action.

Keywords:
Climatic Influence, Market Equity, Global collaboration, Construction industry, Climate change.

Buildings are everywhere. They make our homes, schools, medical centres, offices, retail spaces, restaurants, gyms, warehouses, factories and so much more.
Enter the collective: the building industry sector
And the significant influence it has on our society – cannot be underplayed. It offers housing needs to the society's individual; while creating economic value for businesses in the form of tailor-made workspaces, plants, and infrastructure.

The Global Economic Context

The building sector, despite its many internal challenges, plays an important role in the global economy and prosperity. Let's take a moment on the projection of the sector in the coming decades.

Numerous economic forecasts suggest that the building industry is likely to remain on a path of growth, going forward into the current decade 2020-2030, as well. (Statista, 2023)
Among other many reasons, this growth is particularly expected to occur on account of 3 prominent factors -
(i) the growing human population,
(ii) the increasing migration from rural to urban areas, and
(iii) the prosperity of individuals themselves: as the global economy grows, particularly in the emerging countries.

The influence of these factors is confirmed when we look at the largest global construction markets of today.

As I put this piece together in August 2023, the Asia-Pacific region remains the largest global construction market, followed by MENA (Middle East and Africa),where all these factors co-exist.
All things said, the building sector is likely to keep growing in this decade. This sector growth will demand not only more manufacturing of construction materials; but also, generation of electricity to power the new building stock along its life.

The Climate Backdrop

To produce this stock of construction materials and electricity, we will inevitably fall back on our traditional form of energy – burning of fossil fuels (coal, oil and gas). Since the industrial revolution, fossil fuels have provided the primary means of energy to run machines and technologies for manufacturing among other things; and produce electricity.

Enter Climate Change.
The chemical reaction involving the burning of fossil fuels for energy is also complemented with the release of a large amount of carbon dioxide and other greenhouse gases. (note: fossils are nothing but highly concentrated carbon matter. So, when they are burned, the locked carbon in them is released into the atmosphere)
Our prolonged dependency on fossil fuels over the years has resulted in continuous emission of large quantities of greenhouse gases – which have accumulated within the earth's atmosphere. They have formed an atmospheric blanket, trapping more of the solar energy reaching the earth – causing global warming and thereby climate change.
To slow down climate change, we not only have to limit any further greenhouse gas emission into the atmosphere; but find ways to suck back out those that have accumulated in our atmosphere over the years. This is the climate action agenda the world is on path today.

Building's Emission Burden

The building industry sector relies on the combustion of fossil fuels primarily for construction material manufacturing and generation of electricity to power it up. But that is not all.
The dependency of fossil fuels is well intertwined across

the other stages of building life as well – as petrol-diesel in transportation of construction materials, as petrol-diesel & electricity from fossil fuels in the construction process itself, maintenance of the building stock and its final demolition.

In fact, the building sector's burning of fossil fuels is so significant, that the industry is alone responsible for about 37% of all greenhouse gas emissions that take place across the globe each year. (United Nations Environment Programme, 2022).

This is approximately 10,000,000,000 tonnes of CO2, every year, changing the climate with each tonnes of CO2 released into the atmosphere. (United Nations Environment Programme, 2022).

To break it down further,
(1) about 9% of this emission comes from the burning of fossil fuels to extract, manufacture and transport building materials and products, while,
(2) The remaining 28% comes from the burning of fossil fuels to meet building's energy demand – particularly in the form of electricity.
The building sector is hence a major contributor to the ongoing climate crisis.
It must hold the responsibility to limit any further greenhouse gas emission into the atmosphere. Or putting it another way, the climate action movement would fail if buildings were not a part of the fix. It is without doubt that how the building sector shapes its emission pathway will largely determine the extent of success in our efforts towards a global low-emission-economic-future.

It is this mammoth share of the building industry's emissions that builds the case for a meaningful climate action aimed at significantly reducing the emission footprint of the sector.

Challenges Ahead

The biggest hurdle to the transitioning of the building sector to a low-carbon-emitting entity will come from the industry itself.
One, the Internal Challenge: The main challenge particularly lies in the colossal task of aligning the various stakeholders within the building industry on climate action. These stakeholders include, but are not limited to construction product manufacturers, architects, structural engineers, services engineers, facility managers, and most importantly the investors.
Each stakeholder group is a mini sector in their own right with their own priorities and challenges. Aligning these stakeholders for the building sector's climate action will require them to channel their priorities to lower the building sector's overall carbon emission footprint.
This is no easy task. Furthermore, it raises questions than one might think: Who will lead this effort? Architects? Investors? What common platforms are available to do such sector-level conversations? What should be the role of the Government in moderating this change?

Two, the External Challenge: By virtue of the fact that the building sector offers economic value (via workspaces, plants, and infrastructure) to other sectors; it will likely also be the first in line when "other sectors" begin to solve their emission problems. "Other sectors" are likely to demand their building assets to be low-carbon emitting.
A primary example of this can be seen in the changing building asset portfolio of India's IT Giants. Most IT companies in recent years have now invested new money into ensuring that their building stock is made up of not only materials with low embodied carbon, but that their building stock is energy efficient (and where possible, almost independent of the electricity grid).

Three, the Market Challenge: If the above wasn't challenging enough, the situation is further stretched by the fast-growing demand for new buildings with every passing year. We have explored this earlier in this article. Especially in the fast-developing countries of Asia, Middle East and Africa.
To sum it up, the building industry will not only have to develop solutions to reduce its emissions to near zero in alignment with global climate action; but do it while continuing to move faster to meet growing demand. In all fairness, the challenge to the building industry is enormous and will require system-level changes. Business as usual is not much of an option – going ahead.

The Quintessential Future

Clearly, the building and construction industry is a crucial component of the Global Climate Action Plan. With over half of the buildings that will be standing in the year 2050 yet to be built – the building industry stands on a very interesting junction of growth. And most of us in the industry today, will be witnesses and participants of how the industry's progress beyond this junction to a low emission pathway.

What we build today will be our emissions legacy.
While much needs to be done, a sensible place to start participating in solutions would be to acknowledge the work that is already underway within the building sector to this means.
Numerous debates and dialogues have taken place over the past few years and 'frameworks/call to action' such as those for energy-efficient buildings and net-zero carbon buildings have been developed to prevent the devastating impact of a rapidly changing environment.

Leaders in the building sectors acknowledge that a tried and tested 'business-as-usual approach' to constructing and operating buildings will not work, going into the future.

This has encouraged experimenting with new solutions, concerned with systemic changes within the industry and innovative thinking on manufacturing processes and building design.

The 'energy efficient' and 'net-zero' carbon building frameworks that have emerged over the past few years are an example of this. They are offering a critical opportunity to address climate change, within the building industry.

However, the speed and scale of this transition are not near sufficient, we will need all of us.

References

- Group, S. (2023, August 31). Statista. Retrieved from Statista Research Department: https://www.statista.com/statistics/1290105/global-construction-market-size-with-forecasts/
- Martín Alurralde,Margarita Velasco, Eduardo Oliver. (July 2023). GPoC 2022 Global Powers of Construction. Madrid: Marketing & Brand Department.
- United Nations Environment Programme (2022). 2022 Global Status Report for Buildings and Construction: Towards a Zero-emission, Efficient and Resilient Buildings and Construction Sector. Nairobi.

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PYRAMID

BY VERTEX FURNITURE

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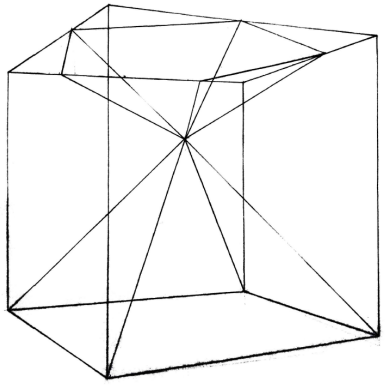

The transformation of one shape to another is a fascinating exercise. It explores the various hidden geometries of the shape and with each iteration a new discovery Is made. The Pyramid Series explores just that.

It takes a regular pentagon and transforms it into a regular square. The five vertices at the pentagon is brought to one point; creating a pyramid with a pentagonal base. This is then extended further to make a pyramid with a square base.

Pure geometry is without material. Points and lines are ideas that follow a certain natural language. Materializing this idea i.e., adding material to the geometric system is what elevates the idea into the realm of an object. This exercise of materializing the idea stems from the functional requirement of the object. The ability to withstand the weight of a person on it requires a utilization of structural principles. This is where the geometry and material work hand in hand to make it possible. The geometry is playing at two levels; the overall form of the furniture and the structurally sound utilization of the materials when converting the geometric exercise into an object. The material is oriented perpendicular to the weight of the person sitting on the chair; an orientation that makes it quite capable of taking that load. Adding to that, the material is also bent, thereby furthering the load bearing capabilities of the structure.

The material is also working at two different levels; complementing the purity of the geometry and adding a function to the resulting object. The sound structure is brought forth by the material in the geometric system. The utilization of metal sheets, with its thin nature works very well in enhancing the geometric form of the piece and showcases it by going along with the lines while not coming in its way. The sheet, also being strong in its compressive capabilities (when used in the appropriate manner), withstands the load that is applied on it, thereby allowing the forms to be used well as furniture. Creating an object exercises efficiency. In that respect, materials and geometry go hand in hand. Understanding geometry and understanding materials are crucial as some of the most efficient exercises in object making utilizes this very notion and explores the extent of one complementing the other

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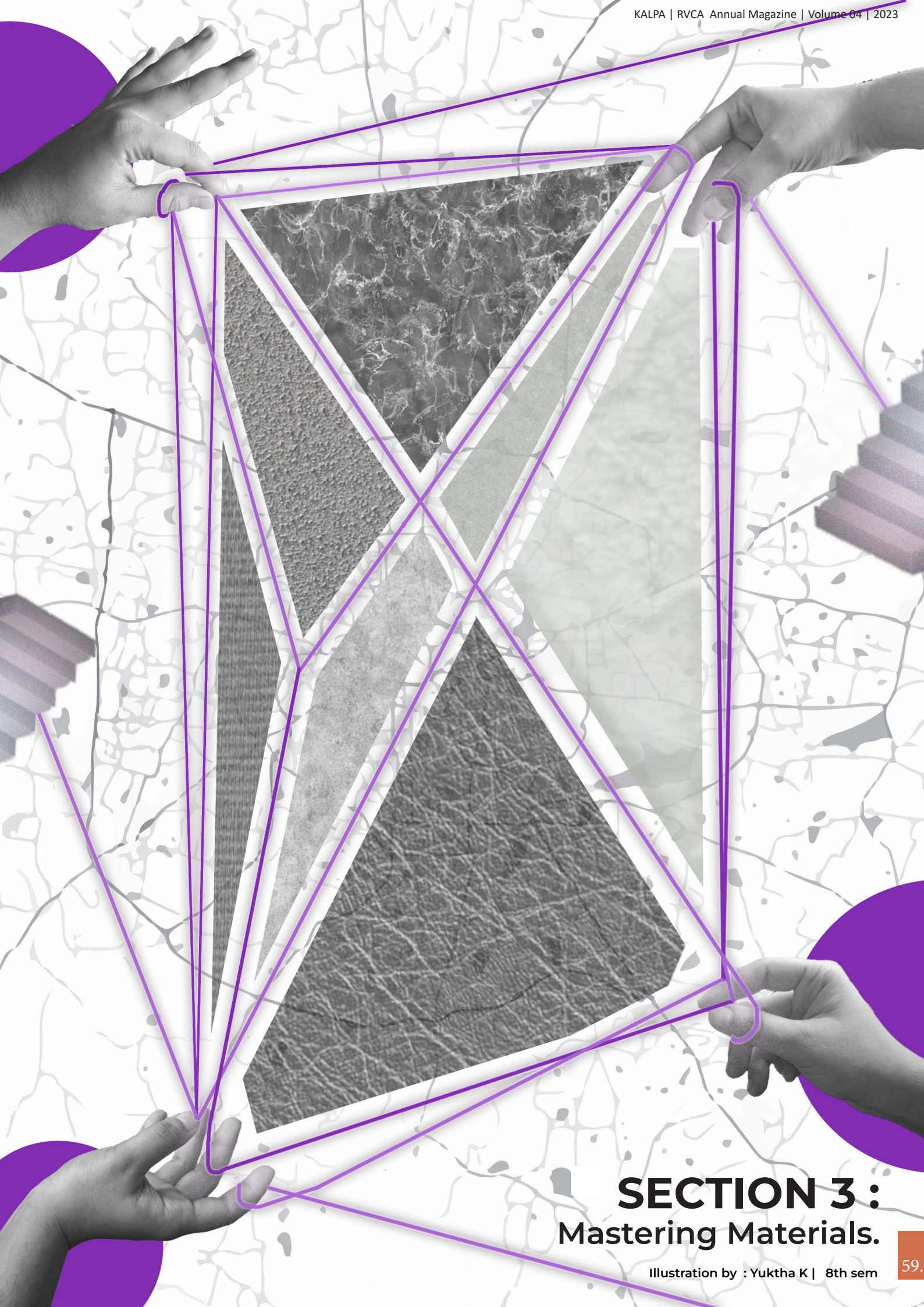
Furniture Designer,
Vertex Furniture.



SECTION 3 :
Mastering Materials.

Illustration by : Yuktha K | 8th sem

Illustration by Haashim Aslam Maricar | 8th sem

10. Bamboo's Role in Eco-Friendly Architecture.

Conversation with **Ar.Udit Mittal,** Founder of QX Designs.

Kalpa, Vol.04, 2023, pp. 61-64

Intent :
In this conversation, Architect Udit Mittal emphasizes his commitment to environmentally friendly architecture, focusing on bamboo as a sustainable alternative to traditional building materials. He advocates for a shift in the construction sector towards ecologically friendly practices and a comprehensive approach to material selection. Team Kalpa had the esteemed opportunity to engage in an insightful interview with Udit Mittal, to facilitate a thorough and meaningful discussion. Aligned with Kalpa's commitment to sustainability, the discussion explores Mittal's forward-thinking insights significantly contributing to a transformative narrative in architecture.

What led you to specialise in bamboo architecture, and what inspired you to work with this material, considering that no one thinks of bamboo as a material that can be used primarily in architecture and is normally thought of as a supporting element?

We are all ingrained with this conventional view of the construction industry. At some point during our education, we learned about global warming and realised that the construction industry contributes to more than 50% of it. So, naturally, we start thinking about other ways of construction, right? In fact, sometimes it's not a very conscious decision; it's just a desire to do things differently. When you start thinking about the options available to you in terms of materials, you begin to explore structural options as well. It's not about disliking concrete, but once you understand the consequences and implications that come with the cement industry, you start to think differently. Even though concrete is one of the largest contributors to Global Warming, there is also a great respect for concrete. There are things that RCC, PCC, or a certain mix of concrete can do that very few materials can compete with in that regard. And, of course, there is a history of construction using bamboo. However, it was mostly used as a temporary material. But, at least, you are drawn towards the understanding of what it is.It wouldn't be surprising to see any young architect explore these alternatives. I personally do not want to be labelled as someone focused on alternative construction methods. It's more about being sensitive and understanding what makes sense. What does it mean to use natural materials - those with low carbon emissions and low embodied energy? I remember in 2015 when I graduated, I applied for an internship in Nagaland under Richard Belho (which I couldn't get). I got a chance to create an installation for an art festival in 2017, and attend a workshop under Ravi Mukhopadhyay in Calcutta . They had a building centre with many engineers and technologists who had conducted extensive research over the last 25-30 years on the mechanical properties and understanding of bamboo as a material. So, many of my misconceptions about bamboo were clarified. It has amazing strength and incredible structural versatility, and there are ways to treat it. So, starting from that workshop, all the apprehensions that people have in general about bamboo started to fade away. I learned what it actually is, where the concerns lie, and how they are perceived. That's how I realised that it is an excellent material for becoming a carbon sink. When you look at bamboo at a holistic level, you never realise how much you can get into - the social impact, for instance. It's not limited to architecture; we start appreciating it right from the plantation, from farming, and how it can create a positive impact. To sum it up in two facts: If you talk about the material for its green value, bamboo is a plant (of course, there are multiple species), but in general, it's a kind of plant that can absorb 35% more carbon compared to any other plant. While other plants might take 25-30 years for such absorption, bamboo accomplishes it in just 4-5 years. Secondly, a few species have a higher tensile strength compared to metal. You see many values, and you become committed to exploring and applying them to see how you can address the drawbacks. We don't only work with bamboo; we don't want that as a label. Everything has its own relevance and is relative to the context. We have great respect for concrete, and we use it judiciously. All other materials are used contextually.

As you mentioned, bamboo is almost like a natural alternative to metal, so are there some unique properties which bamboo has as a construction material that can compare to any conventional materials that we use, such as steel, concrete, etc.?

In terms of comparing bamboo to conventional materials, if you look at bamboo, there are many species that have higher compressive strength compared to concrete. Let's say you have a pole of PCC and a similar pole of bamboo; the bamboo pole would have higher compressive strength, considering only a select species of bamboo. When it comes to tensile strength, a few species have higher tensile strength compared to steel. When we talk about bamboo in the construction industry, there are specific species that we focus on, like bambusa, asper and guadua which is one of the best species for construction. To understand this material in-depth, bamboo is made of fibres that run continuously from the root to the tip of the culm at the other end, giving it its strength, especially tensile strength. Understanding the properties of different species involves looking at the internodal distance, wall thickness, density, and diameters.

Bamboo does not only compare to architectural materials like concrete and steel but also plastics. We even see it being used for cups and mugs as alternatives to bakelite. But why haven't we seen this becoming mainstream? What do you think are the challenges that we are encountering while working with bamboo, and how would you try to overcome them?

From my understanding and exposure, there are many other factors connected to understanding this that go beyond architecture. It's about industrialization, market economics, and the significant role played by consumers and their purchasing choices. It also involves understanding where the craft of bamboo begins and ends and what it's precisely competing with. If we were to compare the use of plastic mugs and cups to bamboo, we need to consider the production of these materials. Plastic products are mass-produced thanks to industrialization, while bamboo hasn't seen much, that sort of a standardised method of reproducing products of the same quality in a mechanised way. So, we're comparing more than just the possibilities and properties of the material; we're comparing handcrafts to industrialised products, including factors like durability and cultural lifestyle.

The first big challenge arises because you can go to a market and purchase a steel section of a particular specification from a specific source, and you're very sure about getting exactly what you asked for. However, that's not the case with bamboo, which becomes the single most significant reason why it's not easy to start working with this material. For us, it was crucial to understand our sources and how we can treat bamboo to increase its longevity. Knowing the right species and the right source is a 50% game-changer; the rest lies in how we use it on-site. It depends on the approaches of the marketing cooperative. We allow for some intuitive changes, a different process of reading our buildings compared to standard drawings. There is room left for improvisation on-site based on the behaviour of the material. This process makes us feel more connected to the construction activity.

When we look at your projects, what really impacted the team was the disaster-resilient community shelter in the Sundarbans that you designed. Firstly, could you give us a brief overview of the process of designing the shelter?

Certainly. First, it's crucial to understand the unique geographical context and the issues faced by the Sundarbans. The main issues were annual flooding, which was increasing in severity and frequency. For over a century, people had been building their homes on the ground. So they need to elevate their houses, essentially building on stilts. When we talk about disaster resilience in architecture, we're looking for an affordable solution that provides shelter above the flood level, with a strong roof that can withstand strong winds. The solution not only had to be affordable but also adoptable, so that people could easily use it, learning new techniques. This complexity makes it a challenging design problem. So, the outcome involved a two-stage intervention in this village for disaster resilience. The second stage was the guest house, while the first phase involved smaller huts. In this phase, collaboration with the local community was crucial. We needed to respect their feedback and determine what would work and what wouldn't. Our design process was a collaborative effort, not just my own work. We collaborated with a team led by a non-profit organisation called Blue Planet, headed by Sangeetha Kapoor. She connected with various technologists and engineers in the country and gathered their input. We formed a team in Calcutta, including a highly seasoned architect and engineer Laurent Fournier familiar with the Sundarbans, having worked there for a long time. The third member was myself. Together, we developed three technologies and three different prototypes and solutions. Our goal was to provide the

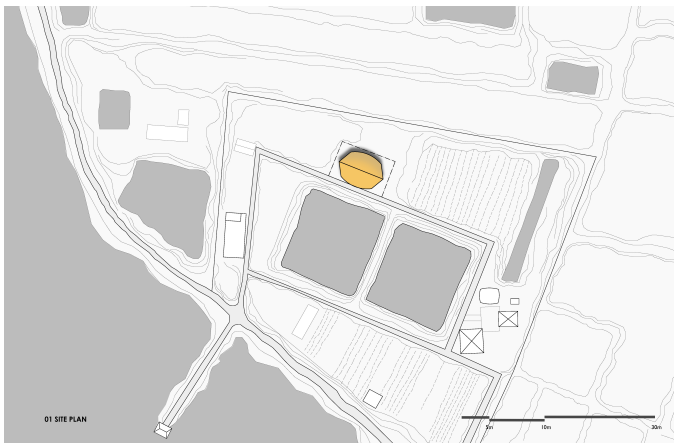


Fig 1. Site plan of Mukti Guest house,Sunderbans (Source : QX Designs)

Fig 2. Concept behind Mukti Guest house,Sunderbans intended to be a cyclone resilient shelter (Source : QX Designs)

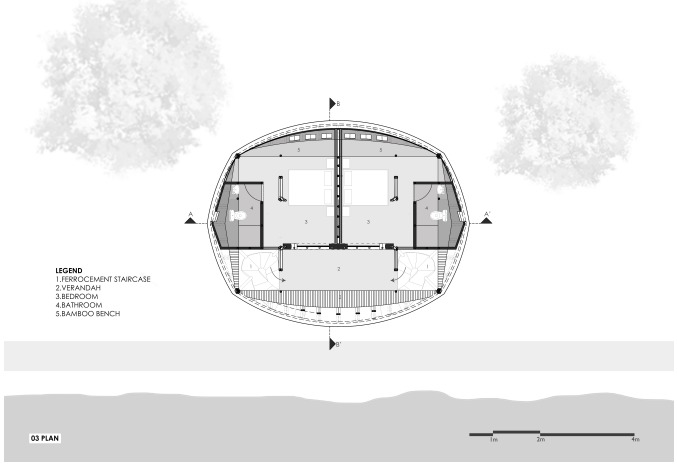


Fig 3. Plan of Mukti Guest house,Sunderbans (Source : QX Designs)

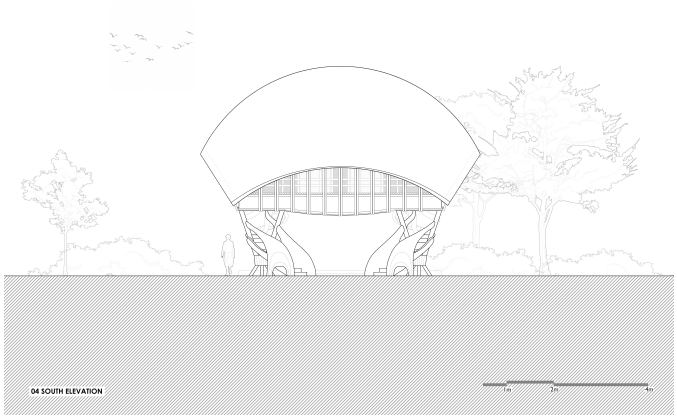


Fig 4. South elevation of Mukti Guest house,Sunderbans (Source : QX Designs)

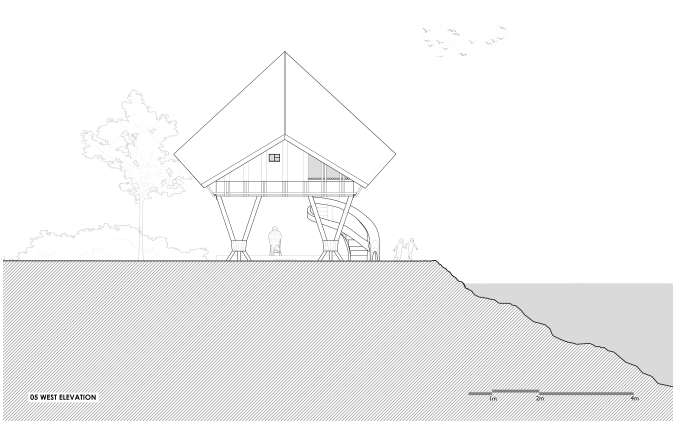


Fig 5. West elevation of Mukti Guest house,Sunderbans (Source : QX Designs)

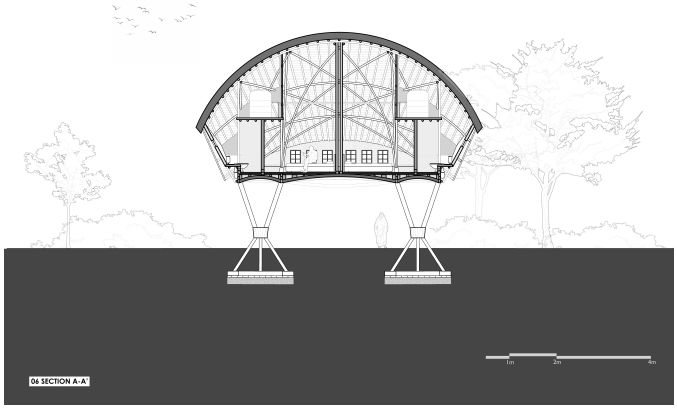


Fig 6. Section AA of Mukti Guest house,Sunderbans (Source : QX Designs)

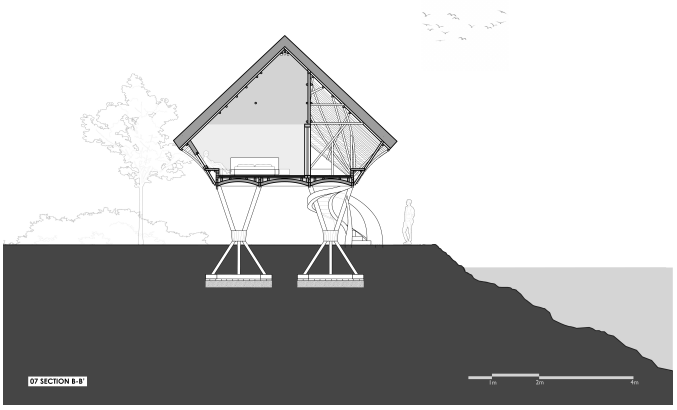


Fig 7. Section BB of Mukti Guest house,Sunderbans (Source : QX Designs)

villages with different options, covering everything from the foundation and stilts to the plinth, flooring, finishes, upper floors, slabs, and the roof. We maintained the same spatial configuration - a room above and a room below, a small balcony in the front and rear - while applying three different construction techniques. In the first phase, some construction techniques became popular, such as ferrocement for the floor slab and shallow domes. We introduced bamboo as a roofing material in this phase, with a conscious effort to abandon the use of mangrove wood. The third option featured thatch roofing. The second phase was easier since we had tried and tested techniques from the first phase on a smaller scale. The guest house used shallow domes in a playful manner, eliminating two shallow domes to create a staircase space. We also modified the stilt system, using in situ columns with different foundations, creating a pyramidal design. The guest house's design was intended to blend space and structure seamlessly, making it challenging to discern which came first.

Looping back to the idea of material itself: The project is very grounded in the context of Sunderbans, so in that purview, how do you think the project's location and climatic nuances of the location helped you select the material?

There is already a certain palette that we introduced, a few material technologies, which we wanted to use a comparatively layered feel now with the guest house. So right from the foundation, we use things that we've

Fig 8. Interior views of Mukti Guest house,Sunderbans (Source : QX Designs)

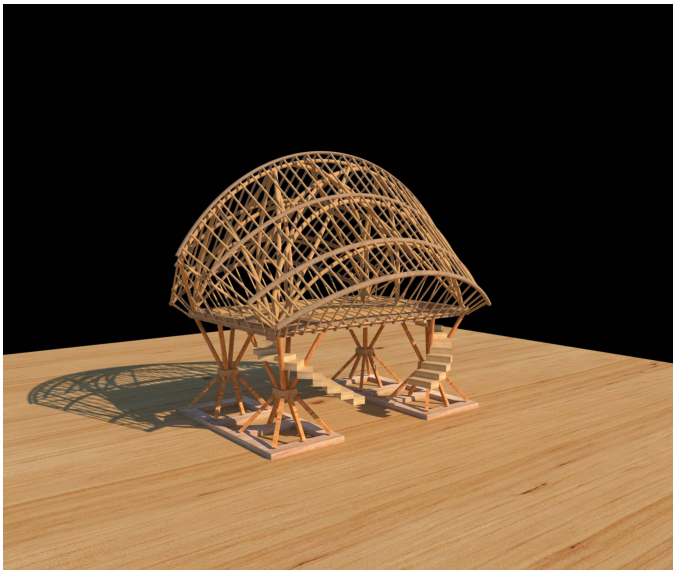


Fig 9. Model of Mukti Guest house,Sunderbans (Source : QX Designs)

already worked with. After the base, the foundation is like a pyramid. Four pyramids were made by prefab RCC posts, which is already done in villages, where you have 4x4 or 5x5-inch cross-sections that people purchase to make columns for the building. We changed the configuration of the steel required and even kept a hole in the column to place a tender right from the base of the foundation till the upper beam, which was for earthquake considerations. We deliberately decided not to build anything on the ground, although there had been earlier discussions with our clients of making a hall, or a storage, some place for caretakers. Raising the building allows for a visual flow and venturi effect. All these systems created the skeleton of our structure. To create spaces in this, we used wattle and daub walls with proper mud finishes, and something that came up in the process, bamboo with ferrocement, which are present on the walls of the gable side .

When we were looking at the design, there were many materials interfacing. You have ferrocement in the staircase and your foundations of concrete, shallow domes of bricks, bamboo on top. We were curious about the interface of these materials and how they work together. What are the considerations of these interfaces?

Some people perceive this combination of materials as a blend of high-tech and low-tech. Typically, when we see the use of RCC or concrete, we label it as somewhat high-tech, giving a sense of solidity. However, as an architect, I didn't see it that way. I was aware that we had a raised base on stilts with a bamboo thatch, which is often seen as less solid or 'pakka,' in common terms. Additionally, the flooring was seamless. Even in our previous cottage projects, we utilised bamboo for the roofs and had different stilt systems. In one case, it was simply a load-bearing wall with ferrocement shell, while in another, we used prefabricated posts for stilts and shallow domes, both covered by bamboo roofs. There was also an initial concept involving bamboo stilts, similar to a project we'd seen by Laurent Fournier done by the Seeds Organization. In that project, we observed the same shape and stilt system, but it was entirely constructed using bamboo. In our case, we understood the system where anchor points would connect with bamboo, with steel embedded into the bamboo. We were conscious of these connections, following the flow of forces from top to bottom. Laurent Fournier acted as a mentor, helped me grasp the entire structural concept, which was present from the project's inception. This concept was originally developed for a cyclone shelter by Fournier, featuring a stilt system and shallow dome. It was based on a "dochalla" roof style, which connected with the traditional Bengali roof, offering exceptional aerodynamics. We discussed how we could adapt this concept for the guest house. We aimed to create a similarly spacious interior, and we made improvements by tailoring it to our specific requirements and changes. This represents our design process—a comprehensive understanding of structural elements and how they interact. We viewed it as a composite structural system, always considering where the loads are being transferred. Our goal was to ensure they were directed to the corners, which held the weight.We incorporated partition walls and anchor points to create an internal column-based structural framework, all designed to support the positions of the columns. Initially, we established a 4-column system with 4 inverted pyramids, and we had to make sure that these 16 points supported the bamboo structure on top.

Interviewee's profile :

Ar. Udit Mittal

WHY, WHAT, HOW, and WOW are the four words that summarize the design process of QX Designs founded by Udit Mittal. They signify an inquiry into EMOTIONS, PROGRAM, and TECHNOLOGY in each project with an intent to PROVOKE. Based out of Kolkata and Bhubaneswar, Udit runs his practice along with his wife Kirti Jalan and a team of talented creatives from different parts of the country.

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Illustration by : Haashim Aslam Maricar | 8th sem

11. Soldering Through Stone.

Conversation with **Sreeram Rohith.**

Kalpa, Vol.04, 2023, pp. 66-68

Intent :
Sreeram Rohith, explores the use of stone in architecture, delving into its properties and aesthetic contributions. Advocating for tactile and expressive experiences, he emphasises the importance of selecting the appropriate type of stone based on its unique properties. As a stone ambassador, Mr. Rohith aims to raise awareness about the material's historical sustainability and its potential in art, architecture, and construction. With an engineer's insight and perspective, Rohith believes that he can be a catalyst to revolutionise the use of stone and its applications, through innovative technologies. The questionnaire inquired into the works of the acclaimed artist and stone as a timeless material in architecture.

How would you describe your understanding of stone as a unique artistic medium, and what attributes of stone do you find particularly captivating?

From my understanding and exposure, there are many other factors connected to understanding this that go beyond architecture. It's about industrialization, market economics, and the significant role played by consumers and their purchasing choices. It also involves understanding where the craft of bamboo begins and ends and what it's precisely competing with. If we were to compare the use of plastic mugs and cups to bamboo, we need to consider the production of these materials. Plastic products are mass-produced thanks to industrialization, while bamboo hasn't seen a standardised method of reproducing products of the same quality in a mechanised way. So, we're comparing more than just the possibilities and properties of the material; we're comparing handcrafts to industrialised products, including factors like durability and cultural lifestyle.

The first big challenge arises because you can go to a market and purchase a steel section of a particular specification from a specific source, and you're very sure about getting exactly what you asked for. However, that's not the case with bamboo, which becomes the single most significant reason why it's not easy to start working with this material. For us, it was crucial to understand our sources and how we can treat bamboo to increase its longevity. Knowing the right species and the right source is a 50% game-changer; the rest lies in how we use it on-site. It depends on the approaches of the marketing cooperative. We allow for some intuitive changes, a different process of reading our buildings compared to standard drawings. There is room left for improvisation on-site based on the behaviour of the material. This process makes us feel more connected to the construction activity.

How would you describe your understanding of stone as a unique artistic medium, and what attributes of stone do you find particularly captivating?

Stones are known for their variety and inherent ability to tell a story. They present a comprehensive image that is not only visually appealing but can also be experienced through the sense of touch., which makes it more unique than other forms of art expression. Stone designing involves a lot of creativity at minute levels across different textures; I particularly find the colours, formations, and textures more captivating about stones and believe they contribute together to create a great design for any space.

From your perspective, how does the use of stone in architectural design contribute to the artistic expression and aesthetics of a space?

Stone designing has been an active interest of modern designing techniques for quite some time now; people prefer having stone flooring or accent walls to make certain spaces stand out, and in terms of longevity, stones have to offer. Also, since stones are natural material, they age very well, and it becomes a lot easier to wither, carve, or work upon them in different styles.

You can often find accent walls made up of stones in office areas, lobbies, or living rooms, giving a more aesthetic look to the space due to the colours and formations on it. Stones quarried across various geography differ, and their texture and colour properties make them more aesthetic in terms of the architectural design for a space.

Could you explain the different types of stone you work with and what distinguishes one type from another in terms of composition and characteristics?

Stone designing has been an active interest of modern designing techniques for quite some time now; people prefer having stone flooring or accent walls to make certain spaces stand out, and in terms of longevity, stones have to offer. Also, since stones are natural material, they age very well, and it becomes a lot easier to wither, carve, or work upon them in different styles. You can often find accent walls made up of stones in office areas, lobbies, or living rooms, giving a more aesthetic look to the space due to the colours and formations on it. Stones quarried across various geography differ, and their texture and colour properties make them more aesthetic in terms of the architectural design for a space.

How do modern designers perceive the revitalization of stone in today's world, considering its historical significance and the increasing recognition it's gaining, leading to mass production?

Using stones in architectural space is not a new concept and dates long back with a historical significance. Ages ago, people used stones to create sustainable homes, temples, forts, and other structural arrangements that have withstood the test of time. To give the same artistry feel and appeal, modern designers have recalled the concept in a contemporary way to create aesthetic environments. In fact, even if you set apart stone designing, stones are widely used in kitchen platforms and stair flooring due to their durability and nature, which make them of wide use.

With more artistic opportunities in stones, the concepts of accent walls and the use of stones in architectural space have boomed with the acceptance of aesthetic trends, and people are more interested in giving a stand-out look to their space.

In the context of stones' resurgence, how do designers balance preserving traditional techniques with embracing contemporary innovations to create unique and relevant art pieces?

Using stone designing in architectural spaces is a clever idea, giving a more natural look through accent walls,whether interiors or exteriors, or around subjective spaces like pool areas, lobbies, and more.

Designers can constantly innovate traditional techniques by creating different structural formations and crafting at various levels. Recent designs include creating formations that make the subjective space directly or indirectly contrastingly, differing in appeal and appearance, while traditional usage of stone designing was to convey messages through art.

How would you establish sustainable tenets of stone?

Stones are largely overlooked when it comes to sustainability and eco-friendliness. We often come across videos that show green labelling of recycled plastic, wooden structures, and a palette of sustainable and eco-friendly materials, while stones qualify equally or more in terms of longevity and life. Take our heritage structures that are carved out of huge mountains or use certain stone materials quarried from the earth that still stand strong.

Stones also have a wide application in architectural design, ranging from beautiful interior walls to exterior cladding that leaves a statement in your space. The recent modern design trends also show the use of stones in designing interior items like furniture or more authentic-looking art pieces

In light of changing consumer preferences and sustainable practices, have these challenges led to a re-evaluation of vernacular materials' position in contemporary design?

Of course, the industry is changing rapidly, and there are challenges to vernacular architecture and techniques, considering the changing landscapes of Mother Nature. But if we are thinking of long-term sustenance, contemporary vernacular design is still one of the better options, where the consumer's preferences are dynamic and slightly leaning towards structures that give an aesthetic look and feel to their space while also closer to the natural elements of the earth over plasticity and toxins that certain ready material holds.

How has stone managed to retain its relevance, and have there been any distinctive strategies employed to re-establish its significance?

Stones have been used for a long period to create an architectural history that stands in front of us. But years before, consumers started using other building materials such as concrete and iron casting to give their homes a softer texture and easy-to-build application. While only the exteriors have been widely affected, consumers still prefer using stones in their kitchens, flooring, walls, and other areas where they need more durability and strength along with an appeal, which is also why it has managed to retain its relevance.

The more modern use of stone to create art pieces in interior and exterior cladding and other significant areas has increased its popularity and given a new perspective on using stones.

Could you provide examples of instances where stone as a material has reasserted its dominance as a favoured medium, whether in art, design, or architecture, and how has this influenced perceptions of its value?

More generically, stones have reasserted the dominance in certain architectural spaces where consumers want to relate to nature or create such an environment. Of course, there are stone-designed artefacts that are usually placed in libraries or reception areas, living rooms, or other areas where you want the space to feel more natural. One of the most popular instances of stones is on the wall, be it limestone, slate, or even carved granite or marble for both exterior and interior walls.

Practically speaking, using stone designing, stone art, or walls can leave a long-lasting visual impact on the one viewing it. In modern architecture it can be viewed as people considering a part of vernacular architecture as a part of their design rather than the whole due to bigger buildings and apartment-style systems. Consumers are relating back to nature by adding such small fragments in their modern design, be it in the form of art or a part of the design itself.

In your opinion, what has been the role of technology as a discipline as well as an application in moulding better designs/products?

Of course, with modernity, the use of technology has impacted the entire process of designing and moulding better products. With high-end software, designers can create guided 2D and 3D artwork and reduce the complexity. Also, such software provides you with simulations and helps in making the precise edges and knowing if such a design is possible with the designer's perception. For me, it becomes relatively easier to use the software to create such designs as I come from the same background as an engineer, and it gives an added advantage over most of the others who are new to the interface. Of course, there is a scope for changes, and others can adapt to the technology, but I can save that time through my given expertise, and the process becomes a lot easier.

In addition, not just the software but also technological advances in the manual inspection of the stones make it easier to decide the quality of the stone and its other characteristics before considering it in use. With the right pace and growing technology, the industry is rapidly changing, and experts like us are truthfully being catalysts.

Lastly, how would you consider yourself an ambassador of change in the growing, ever-evolving field of stone in design?

As one of the ambassadors for stone design, I believe I can be a catalyst for change and innovation in this field. My expertise can help in setting the right use of stones, not just for the appeal but also in more sustainable design frameworks. Every day, we spend hours together to bring more life out of the stones by working on new finishes, designs, and details over the medium. Our workshop is equipped with the right kind of machinery where the team works to achieve the best out of the stones.

For the past 12 years, we have been functioning on mastering multiple textures and finishes such as Riverbed, Leather, Blast 57, Rupture, Satin Leather, among other prominent finishes that we can now commonly find in the industry standards. Some of the other notable textures that we have worked on are Cypress, Stencil, Denim, Concave and Convex, and Flute with a grove.

I believe what is more important is to serve the right education and awareness of why one should be using such vernacular material in their everyday life and how consumers and designers can get innovative with its use, which requires a team like ours. It is also important to stick with the changing consumer trends with how the stones are put to use, and if there are more sustainable and appealing uses of stones, they should be made more adaptable to the global audience with the right kind of expertise promoting them.

Interviewee's profile :

Sreeram Rohith

Sreeram Rohith is a skilled professional whose passion lies in crafting unique textures on various stones, turning them into works of art for homes, office and other spaces involving facade walls and landscaping projects, with a primary focus on outdoor stone finishes that exude luxury in design. Notable projects that showcase his mastership include Hospet Mane, an award-winningproject known for its captivating design with intricate stonework and Amita Rasa, a breathtaking destination wedding venue nestled in the foothills of Nandi. With a unique blend of technical understanding and artistic sense derived from his passion and technical education, he aims to redefine the possibilities of stone design, one texture at a time.

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Illustration by Jennis John Vargese | 8th sem

12. Clay Craft Chronicles.

Conversation with **Rajeev.B.R.**

Kalpa, Vol.04, 2023, pp. 70-73

Intent :
Artist Rajeev BR's works embody the blend of art, culture, and sustainability. As a skilled potter adept in wheel throwing and hand-building, Rajeev expresses his artistic vision influenced by cultural elements. Rajeev's role in the local art scene and adept navigation of market trends, balancing tradition and innovation, enriches the narrative in a straightforward exploration of artistry and eco-conscious craftsmanship.
In a recent exchange, a tailored questionnaire was devised probing into his artistic process and commitment to sustainable pottery practices. Rajeev graciously provided valuable insights into his techniques, cultural influences, and the choice of materials in his work.

What is your take on materiality and its importance in the field of art?

Clay is one of the most abundant and versatile resources on earth. My work is inspired by Indian Philosophy. The analogy of the potter, clay, and the pot, indicates a metamorphosis from formless into form. A potter transforms a lump of clay into a pot, hence giving it a shape and a pot can disintegrate back into being clay. This material aspect of clay has intrigued me. Clay is a forgiving medium and can be moulded into any form with the right skills. Working with clay has helped me improve my attention span and to be mindful and present. I think clay has an incredible impact on the mind due to its material nature

In the intricate world of pottery and ceramics, the foundation lies in selecting materials that form the core of artistic creation. What are the fundamental materials used in pottery and ceramics? Do you source your materials locally? How does using locally sourced materials affect the quality and character of your pottery?

Pottery has been one of India's traditional art forms. Pottery has existed for thousands of years. One of the earliest pottery artefacts discovered dates back to 20,000 years implying toughness and withstanding the test of time. Clay when fired to a high temperature of around 1200. C gives it a characteristic rock-like substance. This unique property gives its long shelf life when properly taken care of. Studio pottery and industrial production uses glazes which are a mixture of silica, aluminium, fluxes, and oxides which add character to the pots. Glazes are very important in my practice. One remembers a piece of pottery by its colour and texture rather than form, therefore the characteristics that meet the eye are vital.
Tools are highly indispensable in pottery. Carpentry and blacksmithery are interdependent with pottery as wooden and metal tools are used to craft a pot. A lot of the materials in our studio are sourced locally as much as possible. Clay is sourced from different parts of India. At our studio, we prepare our glazes. I have also ordered glazes from abroad. However, the cost is high. It is much more viable to use locally available resources.

In the last decade, India has seen a tremendous increase in studio pottery. The number of people pursuing pottery is increasing. In India, traditional pottery has been limited to earthenware and not much stoneware or porcelain types of clay. The locally available materials have their attributes. Pure porcelain is available only in China and hence importing it is expensive. Its impact on climate change considering its carbon footprint poses a challenge. I also use dental tools in my practice, thus relying on what is already there. Twenty years ago, the Indian ceramic market did not even have the variety of materials we have. I can see an upward trend in the market. In my work, I have so far relied on locally available materials. However, I would like to see the decentralisation of technology and an increase in local production of ceramic materials that would help expand artistic expression.

Rajeev BR in his clay studio. (Photo : Yashas P S (@yashas_ps))

Following the previous question, could you explain the different types of clay you work with, and what distinguishes one type from another in terms of composition and characteristics?

Ceramics is a broad term and consists of three types of clay, the first being earthenware also commonly known as terracotta which is porous and can hold up to 25% of water. Hence water when stored in earthen pots tends to be cool.

The second type of clay is called stoneware which is less porous compared to earthenware which can hold up to 10% of water. Most commercially available crockery such as mugs and plates are made up of stoneware.

Porcelain represents the third major type of ceramics. When fired, porcelain will achieve translucency, which imparts it with a glass-like quality. Porcelain was a priced commodity in 16th-century Europe. Chinese porcelain cutlery was highly sought after by the aristocracy and royalty in Europe.

In my practice, I predominantly work with stoneware clay but I also have a fair bit of experience with terracotta and porcelain.

The art of ceramics, a timeless craft, is experiencing a resurgence in recognition and popularity in today's world. As this ancient practice gains modern attention, it's intriguing to explore how contemporary potters perceive this evolution.

a) How do modern potters perceive the revitalization of ceramics in today's world, considering its historical significance, and the increasing recognition it's gaining leading to mass production?

Studio pottery is still in its infancy in India. Access to essential information about sourcing raw materials, tools, and different techniques is a challenge, highlighting the burgeoning nature of this field and the potential for significant growth.

Even within university settings, the absence of open academic or research centres dedicated to comprehensively studying India's diverse clay types and their potential application in response to supply

Works of Rajeev BR. (Photo : Yashas P S (@yashas_ps))

Intricately detailed clay pots by Rajeev BR. (Photo : Yashas P S (@ yashas_ps))

and demand is evident. In my experience, there is a noticeable lack of accessible information on this subject. The revitalization of ceramics in India can be more aptly described as a process of reinvention, rather than a discovery, as pottery has remained an integral part of Indian material culture. Furthermore, pottery studios have sprouted across India both in rural and urban areas. contributing to the resurgence of ceramics in India.

b. In the context of ceramics' resurgence, how do potters balance preserving traditional techniques with embracing contemporary innovations to create unique and relevant art pieces?

In my case, clay serves as the cornerstone of my artistic expression. My work predominantly draws inspiration from the intricate motifs adorning temple walls, with a significant focus on the captivating Hoysala architecture. I transform these motifs into my designs by crafting moulds and replicating them on pottery. While traditional architecture predominantly employs wood and stone, my work underscores the unique significance of clay as a medium. The essence of my artistic practice lies in faithfully representing temple architecture through the medium of clay. I view clay as a powerful medium for narrating the rich tapestry of Indian history and mythological tales. Depicting temple architecture through clay has garnered recognition due to its innovative approach. While individuals can't possess entire temples, they can take home a tangible piece of history through these creations, offering personal fulfilment and a sense of ownership. It is the innate human curiosity and drive for innovation that have guided me on this unique journey, driven by a commitment to thinking beyond conventional boundaries and pursuing distinctive endeavours.

I've had the privilege of discovering the work of Japanese artist Hitomi Hosono, whose art is deeply rooted in nature and brings the natural world into people's living spaces. Based in the UK, her intricate creations delve into Japanese flora, exploring the philosophical dimensions of these elements. Her approach not only preserves traditional pottery craftsmanship but also infuses it with contemporary relevance, igniting curiosity about biodiversity conservation and fostering a deeper connection to nature. Inspired by Hosono's work, I've recently embarked on exploring the Japanese technique of Nerikomi. This stained clay technique involves creating intricate patterns that seamlessly extend from the interior to the exterior of a pot. My early experiences working with the indigenous communities in Gudalur, nestled in Tamil Nadu's Nilgiri district, were pivotal. Engaged in a botanical documentation project, I gained profound insights into the region's natural world. This encounter served as the foundation for my series "Floral Stories," comprising functional and decorative pieces, where clay became the medium to narrate these tales. In December 2023, I exhibited "Floral Stories'' garnered significant appreciation, reflecting my endeavour to reinvent storytelling through the medium of pottery.

It is intriguing to notice the challenges some of the vernacular materials such as clay, stone etc compete for dominance as a preferred medium not just for artistry and aesthetics but even more as the core of the built component stressing today's need for "sustainability".
a) Let me begin by asking, How would you define sustainability and its applicability?

Ceramics production is energy-intensive, involving double firings at temperatures of up to 1200 degrees. In today's climate-conscious era, material usage demands heightened mindfulness. At Trayah Pottery Studio, we continuously explore avenues to minimise energy-intensive processes. We are continuously engaged in the process of developing clay and glaze recipes and techniques.
While fired pieces can't be reused as clay, we are finding innovative solutions. Collaborating with an architect, we repurposed broken ceramics into striking mosaics. Similarly, Tatva Ceramics, led by an NID alumnus, is pioneering sustainability in ceramics. They have experimented with powdered fired clay to develop new clay recipes. Certain tile industries in India also accept fired pots to create coloured pigments. However, these practices remain sporadic and lack the scale needed to address the climate crisis effectively.
Looking ahead, sustainability is imperative. I have thought of exploring solar power as an eco-friendly alternative to our current coal-dependent electricity supply for firing. While the US offers successful examples of solar grid implementation, such initiatives require resources, time, and research commitment. Studio pottery, though relatively small, presents an opportunity for innovation. Universities spaces should spearhead such research, benefiting both entrepreneurs and the larger ceramics industry in India, given its significant tile and ceramics manufacturing sector.

b) In light of changing consumer preferences and sustainable practices, have these challenges led to a reevaluation of vernacular materials' position in contemporary design?

I've delved into terracotta as a cost-effective and locally abundant alternative in ceramics. Its lower firing temperature requirements have yielded promising results. We're actively experimenting with new recipes, albeit within the constraints of our small establishment and limited resources.
Additionally, some of our colleagues are devising innovative climate change solutions. My artistic pursuit, centred on redefining temple architecture through clay, is deeply rooted in vernacular aesthetics. While European pottery leans towards Greco-Roman designs, my focus is on incorporating Indian aesthetics into ceramic art. This entails exploring the distinctive shapes and forms found in India. I view this approach as a celebration of the vernacular, infusing it with new life and meaning within the realm of ceramics.

c) How has this sector managed to retain its relevance, and have there been any distinctive strategies employed to re-establish its significance?

The rapidly increasing number of studio potteries in India stands as a testament to the growing relevance of ceramics to the public. People are increasingly drawn to pottery not only as a creative hobby but also for its therapeutic benefits, providing a means to explore their creative boundaries. This surge in interest shows the promising potential of this field.
Considering the economic landscape, as India's economy continues to thrive, there's a rising demand for luxury items like ceramic home decor. People are eager to enhance their homes with ceramic pieces. This expanding market further emphasizes the relevance of ceramics.
Affordability and a growing consumer base have bolstered ceramics' significance. Within India's art community, numerous artists utilize social media platforms such as Instagram to showcase their work. Events like the India Art Fair in Delhi have featured ceramic artists. Numerous cities are hosting potters' markets where studio potters display their work. The Indian Ceramics Triennale is another event to watch out for.

Works of Rajeev BR. (Photo : Yashas P S (@yashas_ps)

d) Could you provide examples of instances where pottery has reasserted its dominance as a favoured medium, whether in art, design, or architecture and how has this influenced perceptions of its value?

While pottery has its drawbacks, including fragility and brittleness, it cannot be claimed as the dominant choice. Metals, given their durability, lightweight nature, and sturdiness, are often preferred over pottery. However, the renewed interest in ceramic cutlery can also be attributed to the increased affordability. This resurgence indicates that pottery holds a significant presence and appeal in the market.

e) How do you consider yourself as an ambassador of change in the growing ever-evolving field of pottery in arts and crafts?

To my knowledge, few have melded history, architecture, and clay into tangible art forms. This unique approach positions me as a bridge between the past and contemporary expressions, harmonizing traditional art forms with modern applications. During a recent encounter with a faculty member at the National Institute of Design, Ahmedabad (NID-A), it became apparent that my work using the sprig technique is a rarity. The reactions and responses my work has evoked in people affirm its ability to instigate change and create ripples of impact, serving as a source of reassurance for my artistic journey.

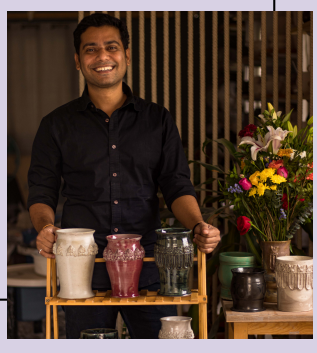
As pottery evolves in step with modernity, so do the materials and techniques that shape it. In your opinion, what has been the role of technology as a discipline as well as an application in moulding better designs/products?

I share a mix of awe and concern surrounding the advent of artificial intelligence, much like many others today. The presence of 3D printers, which can conjure intricate and detailed designs is impressive. However, I firmly hold the belief that human creativity and intelligence are irreplaceable, and AI is a product of the human mind. While there are certain designs that AI can mimic, it cannot replicate the unique touch of the human hand. Undoubtedly, AI offers cost-effective ways to produce art, and emerging technologies like 3D scanners hold promise for the future. Yet, there is much that remains unknown, with ongoing technological advancements in ceramics, not only in their application but also in the production processes.

Lastly, how would you encourage and inspire young minds to actively participate in and contribute to your captivating world of artistry, ensuring that this cherished art form continues to thrive in the hands of the next generation?

I am relatively young in my journey, having started just five years ago. Surprisingly, my background as a dentist, coupled with my engagement in public health practice alongside pottery, often catches people off guard. I believe that the ability to multitask is inherent in all of us, and perhaps that's why I've been able to manage both roles effectively, garnering some visibility along the way. I believe the work should speak for itself, and recognition should be given where it's due. I draw inspiration from numerous artists and the world around me, which fuels my creative drive. If my work manages to ignite inspiration in someone else, it brings me immense satisfaction and a profound sense of accomplishment.

Interviewee's profile :



Rajeev B R

Rajeev B R is a dedicated ceramic enthusiast and an accomplished potter. With hands deftly skilled in the art of clay manipulation and a profound passion for the craft, he adeptly transforms raw clay into exquisite, finely crafted ceramics. His journey in the realm of pottery serves as a remarkable testament to the transformative power of human creativity upon humble earth substances. The journey into ceramics began serendipitously in 2018 when he embarked on a pottery course. Drawing from past experiences in high school and a career in dentistry, he swiftly decided to pursue an intermediate-level course at Trayah Pottery Studio in 2020, merging dental dexterity with artistic inspiration to forge a unique artistic identity.

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Illustration by Shashank Manohar | 8th sem

13. Thermal Performance of Mud in Composite Climate: An Overview.

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Abstract :

Indoor thermal comfort can be increased through the careful selection of building materials, among other things. India has a wide range of weather extremes, from warm and humid to cold and dry. Across a sizable portion of the country, the composite climate predominates among several climatic conditions. Twenty-percent of the world resides in earthen dwellings, and many rural people have lived in mud huts for generations as an integral part of their culture. This research examines rural indigenous mud-based construction, the characteristics of mud and how well it performs thermally in the diverse climatic conditions of India. The fundamental thermal properties of mud have been researched to establish its suitability and successful use in the seasonal fluctuating traits of a composite climate. Ranchi, the capital city of Jharkhand has been taken into consideration as an example to demonstrate the performance in a typical composite climatic zone.

Keywords:

Building Construction Material, Composite Climate, Thermal Mass, Thermal Performance.

Introduction:

Gernot Minke (2005) suggests that clay block construction was a popular practice in dry, hot, subtropical and moderate climatic zones and it is still a convenient, affordable, straightforward, and environmentally beneficial building material for several native rural buildings. According to the 2011 Census (Census, 2011)[1], mud walls are still present in over half of all Indian houses. Over 1/3 of the population in the world, according to Dr. B B Puri (2003), lives in mud huts. The following traits, which are most prevalent in rural areas, have a major impact on the indigenous architecture of that area.

- Climatic Conditions
- Locally available building material
- Local construction techniques
- Social customs and traditions (Susilo, 2007)

From the above, it is clear that in areas where clayey soil/earth is available in abundance, mud is the most accessible, cost-effective, and practical building material for rural housing. This study investigates how mud performs as a building material in the diverse environment of rural India, focusing on its thermal characteristics. Many tribes in eastern, northeastern, and central India have mud huts as a part of their cultural history. For India's rural population, it is crucial to improve them by enabling improved thermal comfort indoors. As they are readily available, affordable, and relatively simple to work and construct with, mud and straw are the oldest construction materials in human history. Mud's plasticity and versatility has enabled its use in constructing various structures, from desert huts to multi-story homes, across diverse terrains. Using both ancient architecture and contemporary technologies, mud construction is necessary for a sustainable future society (Hassan, 1973)

According to Dr. B B Puri (2003), there are two general groups of mud buildings: those made using traditional methods and those made using modern methods. The majority of traditional rural homes are built using the following traditional techniques:

1. Sun-dried brick or adobe
2. Rammed earth buildings
3. Wattle and daub[2] building

The modern methods consist of:

1. Blocks of compacted mud
2. Blocks of stabilised, compacted mud
3. Stone facia and compacted mud blocks
4. Mud blocks with chemical stabilisation
5. Pneumatic ramming of the earth

Of all the techniques and methods mentioned above, rammed earth technique is effective in both conventional and modern approaches. Rammed earth building was first used in India in 1948 when 4000 homes were built in Karnal (Haryana). These homes have now been occupied for more than 50 years. With an extensive analysis through trial and error, vernacular architecture often expresses an ideal form, which is extremely responsive to the environment and the materials at hand (Cooper, 1998). With an extensive analysis through trial and error, vernacular architecture often expresses an ideal form, which is extremely responsive to the environment and the materials at hand (Cooper, 1998).

The ensuing paragraphs present some facts about the

[1] https://censusindia.gov.in/census.website/

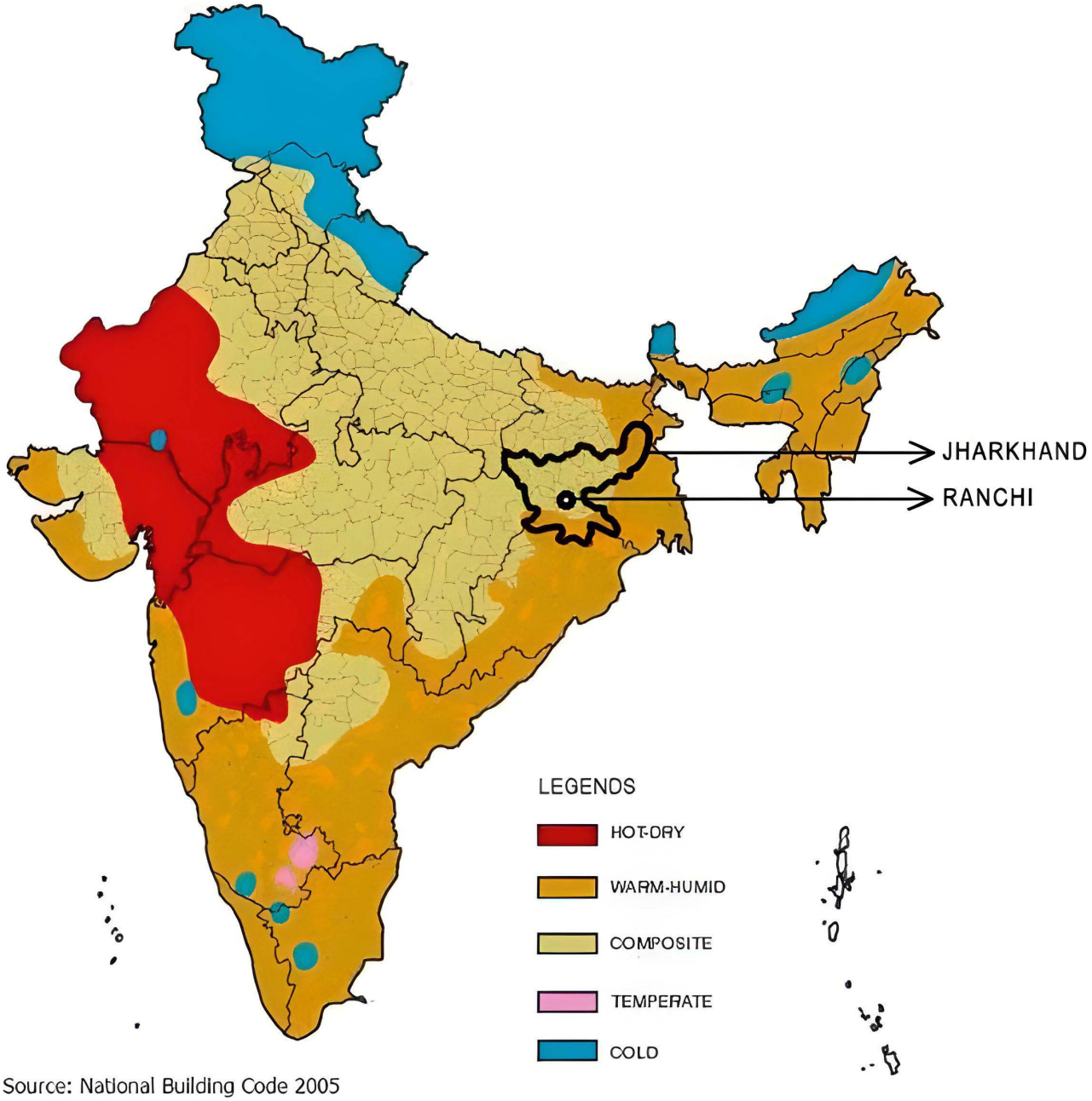
[2] Wattle and daub : Mud mixed with the framework of Bamboo

thermal performance of mud walls, frequently used in the construction of rural mud-dwellings in Ranchi, Jharkhand, situated in the Indian subcontinent's composite climatic area.

Key Features of Composite Climate

There are 5 different climatic zones in India, as per NBC (National Building Code, 2005) which are Hot-Dry, Warm-Humid, Temperate, Composite and Cold (Refer to Fig. 1). The Composite typology combines the effect of hot and humid and hot and dry. Composite climates exhibit varying characteristics throughout the year, cycling between short periods of heavy rainfall and high humidity, and extended periods of intense heat and dryness. There is a third season, winter, which features chilly nights and dry, sunny days. The central region of India is covered under the composite zone. New Delhi, Kanpur, Ranchi, and Allahabad are a few cities that have this kind of climate. In the summers, these contexts receive direct sunlight and during the rainy season, the sunlight is not too bright, and they receive mostly scattered light. In the summer, it can get really hot during the day, between 32 to 43 degrees Celsius, and at night, it's warm, around 26 to 32 degrees Celsius. In winter, it gets cooler, with nights being cold, between 3 to 10 degrees Celsius, and daytime temperatures range from 10 to 25 degrees Celsius.

In dry and wet times, the relative humidity ranges from 20 to 25% and 55 to 95%, respectively. In this region, annual precipitation ranges from 500 to 1300 mm. During the monsoon, this area is subjected to strong winds from the southeast and dry, chilly breezes from the northeast. The state of Jharkhand, which is situated in the eastern region of India, has Ranchi as its capital. The research location, Ranchi District, is located along the Tropic of Cancer. The latitude and longitudes of Ranchi are 23.3* N and 85.3* E. Ranchi Plateau is situated at an average altitude of 900 metres above sea level, which is



Source: National Building Code 2005

Fig. 1: (National Building Code, 2005) Classification of Climatic zones and the location of the Site.

a reasonably high altitude. According to the 2011 census (Census, 2011), Jharkhand has a sizable tribal population and 75.9% of its residents live in rural areas. As per the census 2011 (Census, 2011), 58.5 percent of dwelling units in Jharkhand have mud walls and 53.4 percent have clay-tiled roofs. All year round, the city receives high solar radiation and with moderately directed winds.

Literature Study

Traditional mud-based materials for constructing walls. Mud is frequently used to build mud walls all across India because it can be used in a variety of ways and in conjunction with other materials. Table 1 lists some of the possible combinations that could be employed with other materials. The construction methods found in central India i e., Madhya Pradesh, Chhattisgarh and Odisha in the East, and in some Northeastern states as well include Daub (mud mixed with bamboo framework), Rammed earth mud walls and cob walls (built layer by layer). The majority of rural homes in these areas are made with mud walls and thatched roofs. The seven sisters, or the northeastern states of India, use mud, timber, and bamboo. Some northern and centrally located states' rural areas employ mud bricks and tiles for construction. In the southern part of India, clay bricks are used in many parts of Kerala and Mud bricks are commonly used in Pondicherry. The following table demonstrates different methods used to construct mud based walls mostly found in rural dwellings:

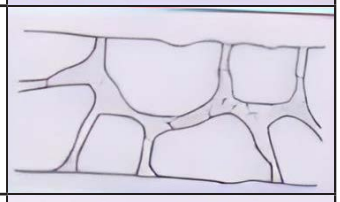
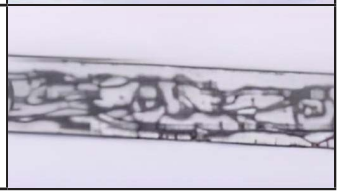
Combinations of Materials Used	Graphical representation
Cow dung Slurry with Compacted earth.	
Stone Masonry made with mortar of Mud	
Mud Mortar Coating on Poles and Twigs	

Table 1: Overview of Wall Building Materials Found in Composite Climate Zone of India (Bansal, 1988)

Knowing Mud as a building material and its Thermal Properties in detail.

Understanding material under various environmental circumstances is crucial to comprehend its thermal performance . This section examines the work that has already been done to describe the specific thermal characteristics of mud and their anticipated effects on the thermal performance that has been manifested so far. A study looked into people who live in traditional mud huts and their perspectives toward thermal comfort. According to their survey, 90.6% of people who live in mud homes say they are comfortable without artificial cooling or ventilation(Cooper,1998). According to Matthew Hall and David Allinson (2008) rammed earth typically has low thermal conductivity, measuring between 0.6 and 1.0 watts/mK. The following table (Table 2) lists some commonly used construction materials' thermal conductivity (K values) at moderate temperatures.

S.N.	Building Material	Thermal-Conductivity(k) (Watt/Metre Kelvin)
I	Brick	0.811
II	RCC (Mix 1:2:4 by weight)	1.582
III	Cement Mortar	0.951
IV	**Mud**	**0.6**
V	Brick Tile	0.681
VI	Cement Plaster	0.721
VII	Window Glass	0.815
VIII	G.I. sheet	60.47
IX	Thatch	0.35
X	Cellular Concrete	0.188

Table 2: Thermal Conductivity (K Values) of Common Building Materials at Moderate Temperature (Verma, 2004)

As per Gernot Minke (2005) the U value (Thermal transmittance) of the rammed earth wall which is 300mm thick reaches up to 2 Watt/Sq. Metre Kelvin, which is also known as its "Thermal Mass". It has a large thermal mass and great potential to store heat energy (Madhumathi, Vishnupriya and Vignesh, 2014). This means that they naturally control a building's interior temperature. Although they cannot easily stop the passage of heat energy, they can absorb and store it because of their high density. On the other hand, due to its density, rammed earth performs as a poor insulator. The interior relative humidity of the home is automatically regulated by rammed earth, leading to better air quality. During summers, the increased thermal mass prevents the heat from entering and shifts the thermal lag (Narayan, 2009). Insulated rammed earth walls offer excellent thermal resistance and surpass solid rammed earth buildings in terms of thermal mass. High thermal mass and low thermal conductivity can be achieved using rammed earth and rigid insulation.

By combining low thermal conductivity with high thermal

mass, a composite envelope can be created using rammed earth and rigid insulation (S, 2009).Comfortable dwellings have always been built with earthen resources. Buildings' fluctuating humidity and temperature are reduced to a minimum when the earth is incorporated (White, 2009).

Enhancing Mud's Insulation.

To boost the thermal insulation of mud-based materials, consider incorporating porous elements which include seaweed straw and light plant-based material. Insulation can be improved by adding material such as from plants, naturally and chemically formed mineral particles like lava, expanded clay, pumice and formed glass. Also, some of the waste products like wood shavings, grain husks, and sawdust, given their higher density makes them less effective as an insulator. Increasing the material's porosity enhances both its lightweight properties and thermal insulation. Notably, insulated rammed earth walls outperform solid rammed earth buildings in terms of both thermal resistance and thermal mass (Fix 2009). By combining high thermal mass and low thermal conductivity constructed from rammed earth and rigid insulation within a composite envelope, the U Values5 of these walls can be reduced to 0.33 Watt/Square metre Kelvin and 0.24 Watt/Square metre Kelvin, respectively only by utilising insulation that is either 50 mm thick or 75 mm thick (Stone, 2013).

Combining Mud and Bamboo.

Among the several methods for building mud-integrated bamboo walls, wattle and daub involve covering the bamboo structure with more mud than necessary, boosting the mud's insulation capabilities and promoting thermal comfort within. (See Fig.2)

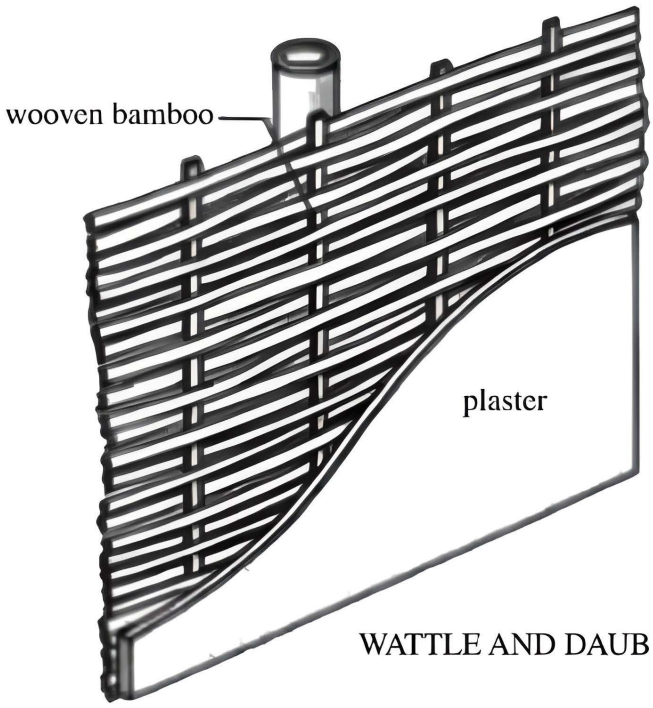


Figure 2: Wattle and Daub (Socrates, 2012).

Mud walls strengthened with bamboo provide insulation from heat and cold. Traditional buildings had walls > 50 cm thick, but mud walls these days are thinner because they are reinforced with bamboo culms that have been appropriately split in quarters and heated to bitumen. The horizontal and vertical strips of the reinforcing mesh are properly secured at the crossings using wires. A mixture is made by kneading rice husk, mud, cinder, little lime and water. This mixture is applied layer by layer while the bamboo grid remains in the centre.

Discussion:

Thermal Performances in Studied Mud-Dwelling.

Typical mud homes in Jharkhand feature walls that are 450 mm thick, constructed using the cob technique. This method entails applying layers of mud one over the other, gradually building up the wall's thickness (Fig. 3, 4, and 5). The following images show contextual examples and schematic sections:

Figure 3: Square Dwelling Unit 1. (Plan and Photograph).

Figure 4: Mud wall 450mm thick. (Source: Clicked by author).

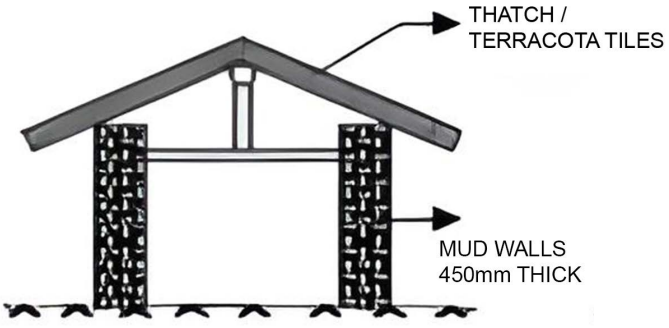


Figure 5(a): Typical mud huts in the studied area. (Sketched by author).

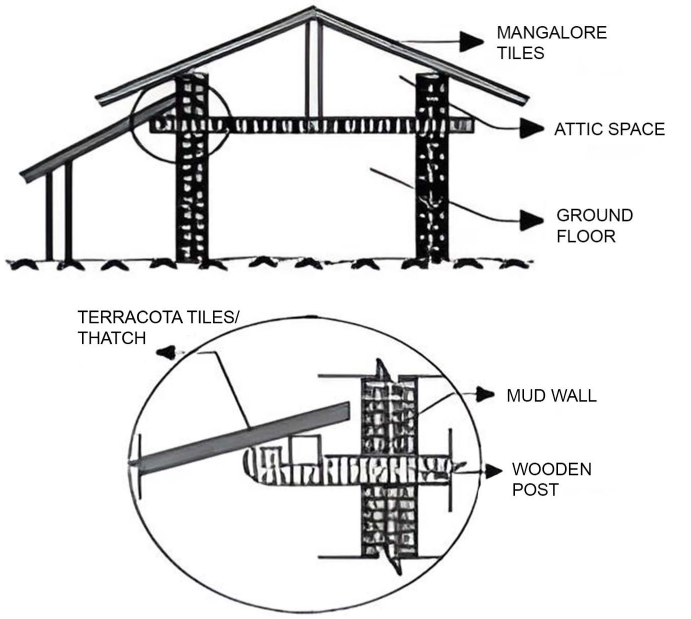


Figure 5(b): Typical mud huts in the studied area. (Sketched by author).

Observation: Fluctuations in temperature when studied for over 24 hours.

The authors conducted temperature measurements year-round, encompassing the hottest and coldest seasons determined from historical climatic data. These measurements were taken inside sample mud huts to gain a comprehensive understanding of how mud walls interact thermally throughout the year. The conventional mud home prototype's interior and exterior temperatures were measured and following were the observations:

1. In the summer and during daytime the thermal behaviour of the mud wall proved to be an advantage. But as night falls and temperatures drop, the temperatures within the hut continue to be high. When the outdoor temperature reaches 42 degrees Celsius during the height of summer, the temperatures inside all the buildings average around 35 degrees Celsius. Even though the outside temperature has dropped to 27 degrees Celsius, nighttime temperatures inside the hut are still high at roughly 35 degrees. The mentioned fact underscores the necessity of reducing thermal mass in mud walls during the warmer months to enhance cooling through night time ventilation.

2. The intrinsic thermal characteristics of mud, which permit thermal lag inside the mud dwelling, are useful in winter since they maintain nighttime temperatures above the cold temperatures outdoors. Due to the thermal time-lag factor, the interior temperatures do not decrease to that level. When the temperature of the outside drops to 3 to 4 degrees Celsius during the winter, the inside temperatures remain about 13 degrees Celsius.

Overall, it can be inferred that a thorough investigation of the thermal characteristics of Non- Stabilized Compressed earth blocks should be conducted and reported in ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) and the Indian building codes. IS: 2110-1980 Bureau of Indian Standards (BIS) talks about building cement soil walls in rural areas. Therefore under the BIS, in order to establish uniformity in mud construction procedures across the nation and make traditional mud architecture functional and modern, further rules for rural homes need to be introduced for the usage of compressed earth blocks and rammed earth walls.

References:

- Bansal, N. K. (1988) Climatic zones and rural housing in India. Zentralbibliothek Publishers.
- 'Bureau of Indian Standards' (1987).
- Cooper, I. (1998) Traditional buildings of India. Thames and Hudson.
- Hall, M. and Allinson, D. (2008) 'Assessing the moisture-content-dependent parameters of stabilised earth materials using the cyclic-response admittance method', Energy and Buildings, 40(11), pp. 2044–2051. doi: 10.1016/j.enbuild.2008.05.009.
- Hassan, F. (1973) Architecture for the Poor: An Experiment in Rural Egypt.
- Madhumathi, A., Vishnupriya, J. and Vignesh, S. (2014) 'Sustainability of traditional rural mud houses in Tamilnadu, India: An analysis related to thermal comfort', Journal of Multidisciplinary Engineering Science and Technology (JMEST), 1(5), pp. 3159–3199. Available at: www.jmest.org.
- Minke, G. (2005) Building with Earth: Design and Technology of a Sustainable Architecture.
- National Building Code (2005).
- Puri, B. (2003) Mass Scale Housing for Hot Climate, Auroville Earth Institute. Oxford & IBH Publishing Co. Pvt. Ltd.
- S, F. (2009) Viability of Rammed Earth Building Construction in Cold Climates.
- Susilo, I. W. (2007) 'The {Living} {Culture} and {Typo}-{Morphology} of {Vernacular}-{Traditional} {Houses} in {Kerala}', EJournal of Asian Scholarship Foundation, diunduh pada, 22(Papanek 1995), pp. 1–25. Available at: https://www.researchgate.net/profile/Indah_Widiastuti6/publication/237707567_The_Living_Culture_and_Typo-Morphology_of_Vernacular-Traditional_Houses_in_Kerala/links/02e7e52c440cc2b7ec000000.pdf.
- Verma, V. a. (2004) 'Thermal Performance of wall and roof sections, Building Research', Central Building Research Institute, Roorkee., p. 88.
- Narayan, T. A. (2009). Passive courtyard home in Jaipur, India: Design analysis for thermal comfort in a hot desert climate. unpublished manuscript.
- White, T. (2009). The effect earthen plasters and exterior lime stuccos have on controlling humidity and temperature in building envelopes. Sixth Annual Conference. Adobe Association of the Southwest, Northern New Mexico Community College, (pp. 15-20). El Rito, New Mexico.
- Stone, C. e. (2013). Embodied Energy of Stabilized Rammed Earth. Technical Transactions. Civil Engineering, Volume 9.
- Socrates,N. (2012).Retrieved from slideshare.com

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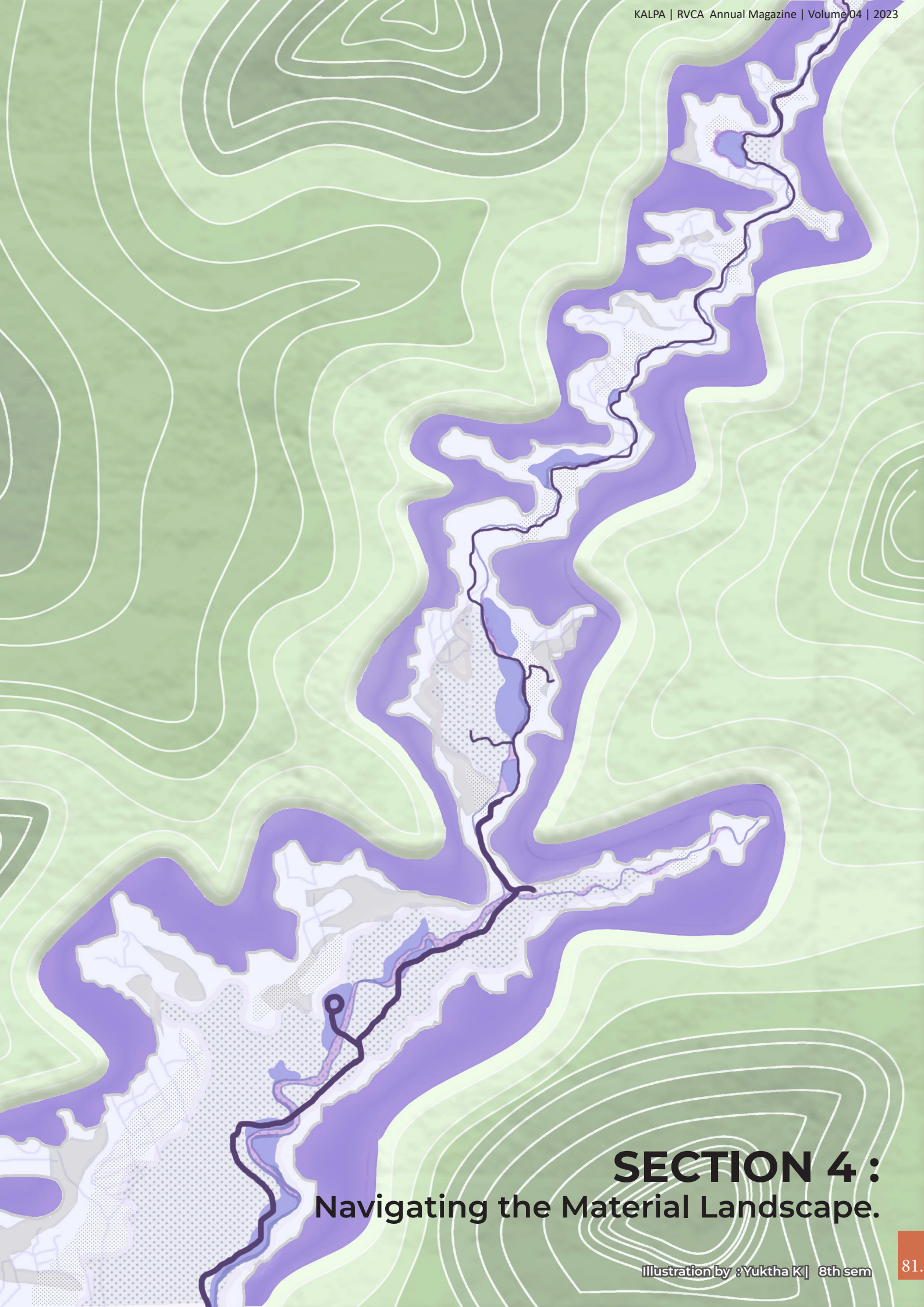

SECTION 4 :
Navigating the Material Landscape.

Illustration by : Yuktha K | 8th sem

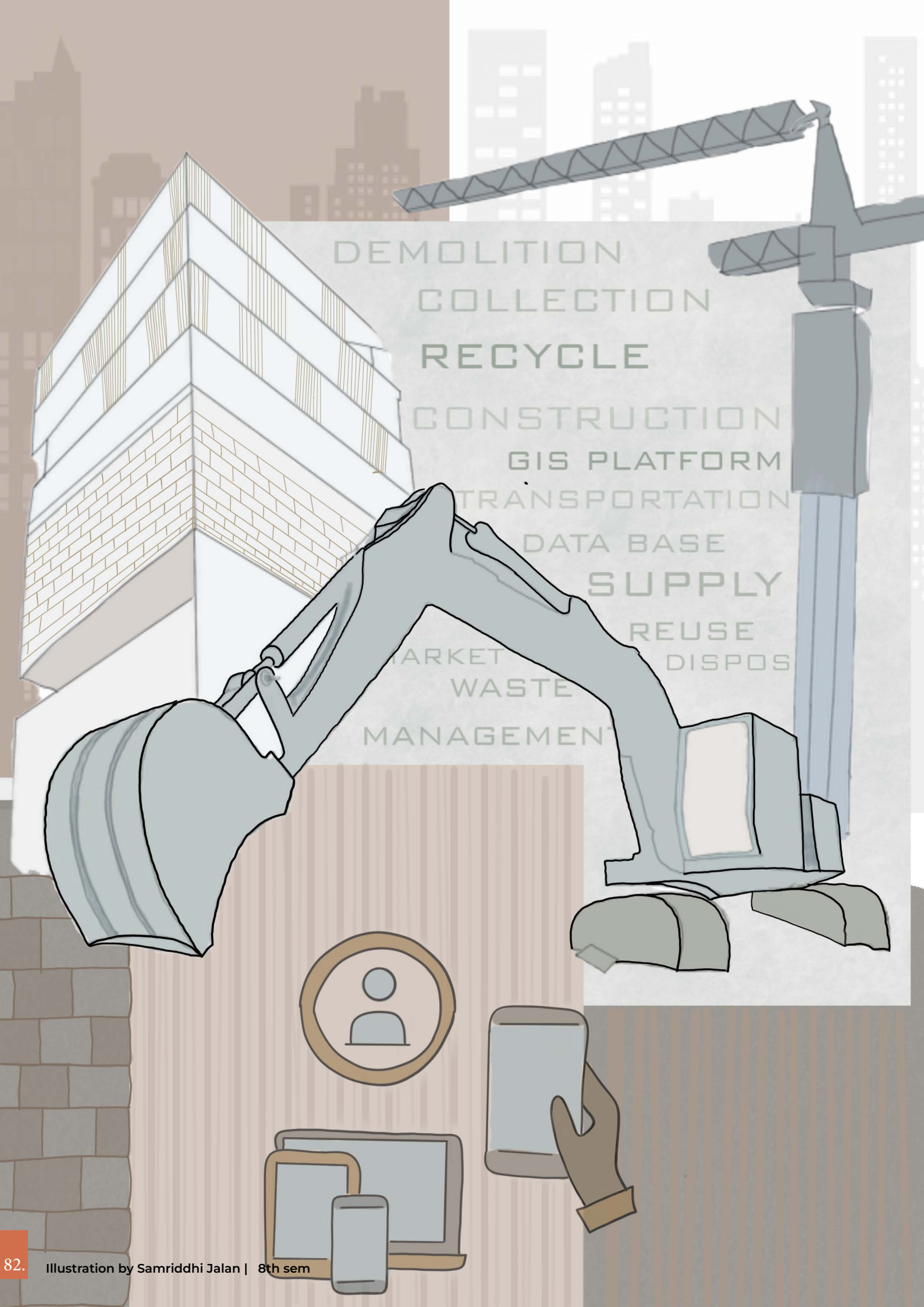

Illustration by Samriddhi Jalan | 8th sem

14. Sustainable System for Recycling C & D Waste - A Conceptual Framework.

Author : Dr. Shikha Verma , Assistant Professor, RV College of Architecture.

Kalpa, Vol.04, 2023, pp. 83-88

Abstract :
The need for recycling Construction & Demolition (C&D) waste is increasing day by day as various government projects and the real estate sector are continuously demolishing buildings to accommodate new infrastructural development. Though the government has come up with the C & D waste management rules in 2016 and Delhi has successfully implemented the country's first recycling plant running on PPP model, there exists a vast gap in the material supply and the market for C & D waste. The recycling plant is capable of segregating and processing C & D waste but there is no market. Surveys with the manufacturers of construction products reveals that they are not getting supply of processed C & D waste and thus they opt for natural building material like natural sand and natural aggregate. There is a decline in the natural resources on one side and a dumping problem of C & D waste on the other. The problem needs to be addressed with sustainable solutions. The gap between the market supply and the demand can be bridged if the information about waste processed and recycled C & D waste end users are shared using the GIS platform.
The proposed conceptual framework will provide a sharing database in GIS where C & D waste processors and processed C & D waste users can find their solutions. The study will thus provide a GIS based viable solution in the form of conceptual framework for C & D waste management

Key words:
Recycling plant, Waste processing, Open dumps, waste management, GIS.

Introduction

An increasing amount of construction & demolition waste (C&DW) has become a major concern of governments and various governing bodies and stakeholders[Jin et. al.,2019, Ferronato et. Al.,2019]. The construction industry is estimated to be accountable for using around two-fifths of the world's energy and materials flow, one-sixth of freshwater reserves and one-quarter of global wood harvest [Horvath,2004] while contributing to 13–30% to total waste generated worldwide.The exact figures regarding the share of C&D waste in the total Solid Waste stream can be very high and also vary significantly. Referring to waste generated in the process of dismantling, repair, and/or construction of buildings, the conventional preferred way of C&D waste management—in most countries—is disposal to designated landfills. It should be noted that the disposal to landfill is associated with costs, the largest and the most visible ones being transportation costs and landfill tipping fees. Various concerns on environmental pollution and rapid depletion of natural resources as well as sustainability programs being implemented have urged many other countries to find alternative ways for a more efficient waste management. On the contrary, companies are seeking for more efficient ways of waste management most often in terms of economical sustainability than in terms of environmentally and socially sustainable development, leading mainly to cost-cutting strategies.

According to the Technology Information, Forecasting and Assessment Council (TIFAC) (2013), India produced new construction waste of 40- 60kg/sqm. of C & D. Based on this, India produced almost 50 MT of C & D wastes in 2013. The waste generated 300-500 kg per sqm of destruction is ten times that produced during the construction phase as per TIFAC. It is assumed that annually 5% of the current building assets gets dismantled and reconstructed entirely and therefore, nearly 288 MT more of C & D waste had been produced in the year 2013 itself due to demolition activities.

India requires a paradigm shift from a dumping-based approach to utilizing C&DW efficiently. C&D can be recycled to replace natural building material; this is not only beneficial for the environment, but also results in substantial cost and resource savings (Ministry of Urban Development, Government of India).The study area considered includes the urban precincts of Bengaluru, India. As per survey done by personal communication, the manufacturers are willing to utilize the recycled product as the material availability is economical to them but they are reluctant to use them because there is no continuous supply of utilizable C & D waste to them. The present study sensitizes this problem and addresses the same by providing a conceptual framework that can utilize the GIS capabilities of storing, managing and analyzing huge amounts of data.

Relevance of GIS Based C & D Waste Management System

GIS can be used for C & D waste management as is evident in various studies. (Zainun et. al, 2016) presented a mapping of construction waste illegal dumping in Kluang district, Johor using Geographic Information System (GIS) software. Information of the dumped waste such as coordinate, photos, types of material and quantity of waste were gathered manually through site observation. All information regarding the waste was assigned to the GIS for the mapping process.

The C&D waste recycling industry in India is still to gain impetus in spite of several possible solutions and the ready reckoner for utilization of C & D waste provided by the Building Materials & Technology Promotion Council, Ministry of Housing & Urban Affairs Government of India (Table 1). The current study is an attempt to provide for this need of the Building Materials & Technology Promotion Council by putting forth a conceptual framework of GIS based C & D waste management system.

Literature Review : C & D waste management -National and International Scenario

C & D waste management and processing is now proposed in many cities in India. Various municipal corporations are proposing recycling facilities. Recently a recycling facility in Delhi is operational and utilizing C & D waste for various construction products. Some cities in India have already proposed C & D waste processing facilities as shown in Table 2.

Considerable research has been carried out in the U.S.A, Japan, U.K, France, Germany, Denmark etc. for recycling concrete, masonry & bricks, bituminous and other constituents of waste from the construction industry. These studies have demonstrated the possibility of using construction waste to substitute new materials for recycling. Even in the USA which is known for its proliferation of landfills, California, the most progressive state, has promulgated an ordinance which requires 50 per cent recycling of C&D waste and 75 per cent diversion of inserts away from landfills. Singapore was recycling 98 per cent of its construction waste by 2007. Hong Kong has been recycling its waste to produce

S.No	Type C & D Waste	Potential use of C & D Waste
1	Concrete	Demolished concrete can easily be recycled as aggregate and used in concrete (As per research carried by Central Building Research Institute - CBRI)
2	Bricks	If deconstructed properly, it can be reused after removal of mortar for refilling or for manufacturing debris paver blocks or debris blocks
3	Stone	Stone can be reused for plinth formation, masonry construction, landscape purpose, ledges, platforms, window sills, coping etc. depending upon the form of available stones
4	Timber	Whole timber arising from construction and demolition works can be utilized easily and directly for reused in other construction projects after cleaning,de-nailing and sizing. Plywood and other timber based boards can be either reused for interior works in new construction or it can be recycled for manufacturing of timber based boards.
5	Gypsum	Phosphor-gypsum and lime sludge can be recycled for manufacture of Portland cement, masonry cement, sand lime bricks, partition walls, flooring tiles, blocks, gypsum plaster, fibrous gypsum boards and super sulphate cement.
6	Steel	Scrap steel is almost totally recyclable and can be reused
7	Debris	Can be recycled to be used in paver blocks

Table1: Potential use of C & D Waste. (Source : Author)

S.No	Name of City	Status of C & D waste recycling facility
1	Nasik	Nasik Municipal Corporation has identified sites for dumping C & D debris. The responsibility for disposing the construction debris is with the waste generators and not with the Corporation. Inert processing unit is of capacity 50 TPD.
2	Ahmedabad	Ahmedabad Municipal Corporation (AMC): m/s DNP Infrastructure Pvt. Ltd. has been awarded operations of a 300 TPD C & D waste processing plant on 5 acres of land on PPP mode for 30 years. It is operational from October, 2013, involved in collection & transportation of such waste from 24 designated locations
3	Indore	Indore Municipal Corporation (IMC) proposes to award 75 TPD C& D waste processing facilities on four acres of land in Devguradia region for a period of 15 years.
4	Bengaluru	Bruhat Bengaluru Mahanagara Palike (BBMP) - proposes to put up the C & D waste processing facilities in PPP mode in three abandoned quarry areas in Kannur, Mallasandra and Anjanapura, each with capacity to process 750 TPD he facility to BBMP
5	Pune	District administration has allocated 2 acres of land at Wagholi for C & D waste processing.
6	Hyderabad	Decentralised C & D waste plants at four identified locations, Fathullaguda, Jeedimetla, Kothwalguda and Mallapur have been identified
7	Mumbai	The Youth for Unity and Voluntary Action (YUVA) and City Industrial Development Corporation (CIDCO)have come up with a decentralized solution for recycling debris into construction material such as bricks and interlocking pavers.
8	Faridabad	The Municipal Corporation has proposed to set up a C & D waste recycling facility near Kachra Chowk on the Gurgaon Faridabad Road.
9	Greater Vishakhapatnam	The state government has accorded permission to the Swachha Andhra Corporation to float request for Proposal for 80 TPD capacity recycling plant near Kapuluppada.

Table 2: Status of recycling facility for C & D waste in some Indian cities (Source : Source: https://kspcb.gov.in/Guidelines_C_and_D_waste.pdf)

Recycled Aggregates (RA) for use in government projects and R&D work. In Taiwan, a comprehensive plan for the management of C&D waste was put in place in 1999 as a response to the challenge posed by the severe earthquake that year, which damaged about 100,000 dwellings (Earth5R, Sustainable Development Goals, 2007) .Figure 1 provides the international scenario of C & D waste generation and Table 3 shows the recycling plants' performance in various countries.

C & D waste generation scenario in the Study area and proposed Conceptual Framework.

The study area of the paper is Bengaluru city, India. Estimates of construction & Demolition Waste(CDW) in the Bengaluru city vary from 2,500 TPD to 3,600 TPD (Vunnam et.al.,2016).The study showed that it has grown from 2,981 TPD in 2012 to 3,540 TPD in 2016, and is likely to reach 4,118 TPD by 2022. Bengaluru, the city generates

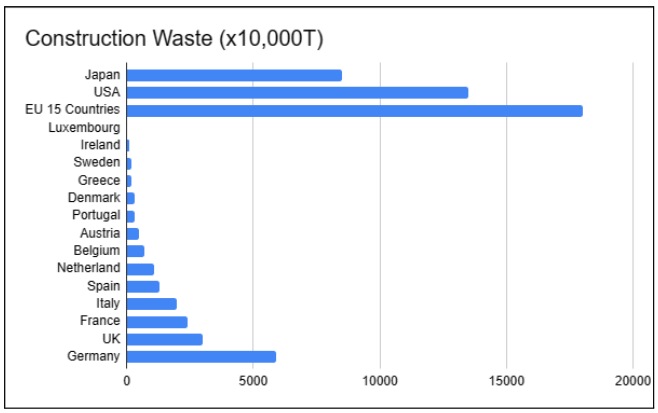

Figure 1:International Scenario of C & D waste generation

S.No	Country	No. of recycling plants
1.	Belgium	60
2.	France	50
3.	Neitherland	70
4.	UK	120
5.	Germany	220
6.	Denmark	20
7.	Italy	43

Table3: Global practice of recycling plants for C & D waste utilization. Source: (Source: Building Materials & Technology Promotion Council, Ministry of Housing & Urban Affairs, Government of India. Utilization of Recycled Produce of Construction & Demolition Waste A Ready Reckoner (http://164.100.228.143:8080/sbm/content/writereaddata/C&D%20Waste_Ready_Reckoner_BMTPCSBM.pdf)

2500-3000 tonnes per day of C & D waste (Construction waste chokes Bengaluru lakebeds, roadsides, 2020). As per study done by Center for Study of Science, Technology & Policy, Bengaluru, (Construction and Demolition Waste Utilisation for Recycled Products in Bengaluru: Challenges and Prospects, 2016) 60-80% of C & D waste is fit to be recycled back into new construction with some pre-processing. However currently a major fraction of the CDW is dumped along roads, highways and next to water-bodies, and most of BBMP's designated CDW disposal sites are either inactive or under-utilized. The monitoring mechanism for CDW disposal is weak and most Demolition and Transportation Contractors (DTCs) are unregulated. The only Stone Crushing Unit (SCU) utilizing CDW currently is operating at unviable Capacity Utilization (CU) due to lack of demand for its products. Other SCUs have also cited the absence of proper market mechanisms, regulations and standards for CDW-based products. There is a lack of awareness among potential market players regarding CDW utilization. Recently installed processing plant at Kannur named 'Rock Crystal' is being utilized by 10% only as per Construction waste chokes Bengaluru lakebeds, roadsides, (2020) due to lack of continuous supply of C & D waste and meager market of waste products.

The survey in the study area concluded that there are many paver block manufacturing clusters in Bengaluru which can use aggregates processed from C&D waste if there is regular supply at rates lower than natural aggregates. It was also found that price of natural aggregates is directly proportional to distance of stone quarry from paver block manufacturers. Paver block manufacturers situated close to the stone quarry are paying less per unit of aggregate than those situated far from them. The opportunity thus lies for a C&D waste mobile processing unit or standalone processing unit of small capacity in dump sites near to the paver block manufacturers. Designated sites for collection points can be identified for installing decentralized units for processing.

Figure2 below depicts the conceptual Framework for managing C & D waste by preparing a common GIS database after mapping C & D waste generation potential sites, illegal C & D waste dumping sites, encroachment sites (by C & D waste), identified Collection Points (for C & D waste for Recyclers) and manufacturers of Construction Products (which can utilize C & D waste). GIS based information shall help in retrieving waste generation and waste collection information to various C & D waste players which need this data for their required purpose. Table 4 provides some sample data that can be collected and mapped for the C & D waste management system created in the GIS Platform. The Common database can prove to be a common platform where any players who are interested in either C & D waste collection or waste recycling or waste utilization can be benefited in context to their associated data utilization

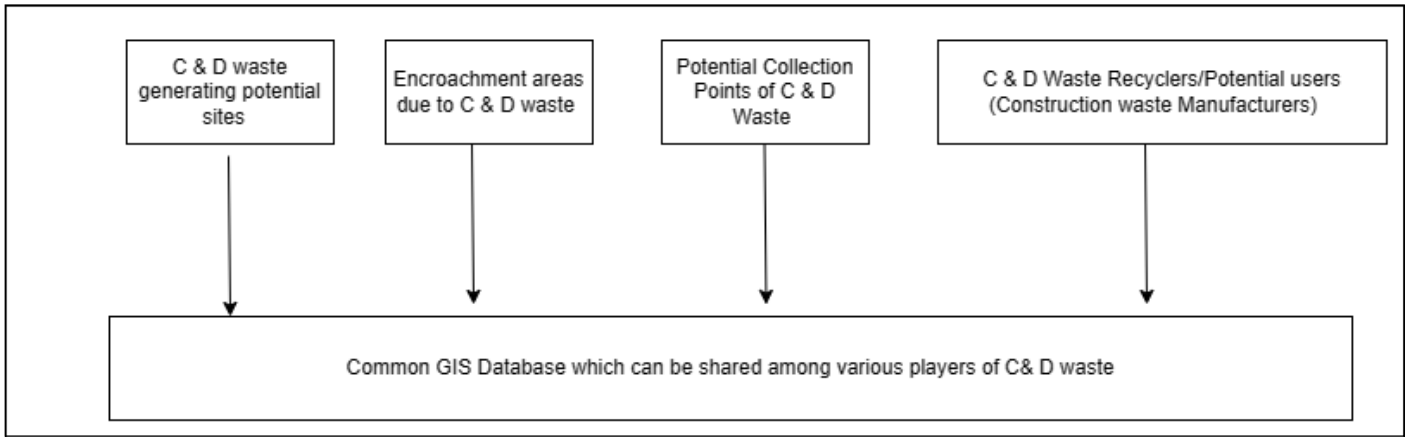

Figure2: Conceptual Framework for GIS based data sharing of C&D waste among various players (Source : Author)

C & D Waste Players	Type of data to be collected and mapped
Location of waste generators in construction or demolition works	1. Amount of waste generated by them
	2. Waste management plan of the waste generator in brief
	3. Whether keeping a record or track of the generation of construction and demolition waste within its jurisdiction and establishing a database and updating once in a year.
	4. Name of service provider or institution consulted for waste management
	5. Image for milestones achieved in waste management
	6. Time frame for various works
	7. Whether incentive received for waste salvation, processing and recycling as given under Construction and Demolition Waste Management Rules, 2016
	8. Whether incentive provided by municipal authority for use of material made out of construction and demolition waste in the construction activity including in non-structural concrete, paving blocks, lower layers of road pavements, colony and rural roads as required under Construction and Demolition Waste Management Rules, 2016
Location of various various construction industries which are potential utilizers of C & D waste	1. Names of product produced by them Amount of various material required by them including amount of cement, concrete, sand etc. 2. Willing to use recycled c & D waste Amount of C & D waste used by them 3. Name of supplier from where they receive C & D waste 4. Difficulties in getting C & D waste in terms of amount and time 5. Cost comparison of product made from recycled C & D waste and natural building material
Mapping of various sites of C & D dumping	1. Site with encroachment on river bank 2. Site with encroachment on wet bodies 3. Site with unauthorized filling of low line areas Mixing with solid waste 4. Sites with encroachment in Parks 5. Sites with encroachment in Footpaths etc.

Table 4: C and D waste Players and information required for Common GIS database (Source : Author)

Conclusions

The study depicts the National and International Scenario of C & D waste management along with C & D waste management scenario in Bengaluru city. The problem of C & D waste management has been addressed by identifying the information gap between C & D waste generators, waste utilizers and waste recyclers and other C & D waste players. The solution has been provided in the form of a GIS based conceptual framework for data sharing so that the information about demand of C & D waste can be provided to its suppliers. The current study also fulfills the technological intervention through GIS as per requirement of Building Materials & Technology Promotion Council Ministry of Housing & Urban Affairs Government of India .

References:

- Agency, T. (2023). Corporation to set up 2 units to process construction waste. Chennai: The Times of India.
- Asundi, J. V. (2016, July Friday). Construction and Demolition Waste Utilisation for Recycled Products in Bengaluru: Challenges and Prospects. Retrieved

from Research gate: https://www.researchgate.net/publication/317715058_Construction_and_Demolition_Waste_Utilisation_for_Recycled_Products_in_Bengaluru_Challenges_and_Prospects
- Blessen Skariah Thomas, J. Y. (2022, March Thursday). Cleaner Materials,Volume 3. Retrieved from Science Direct: https://www.sciencedirect.com/science/article/pii/S2772397622000168
- Earth5r. (2020, July wednesday). Sustainable Construction Waste Management In India. Retrieved from Earth5R: https://earth5r.org/sustainable-construction-waste-management-india/
- Ferronato N, R. E. (2019, January Thursday). Introduction of the circular economy within developing regions: A comparative analysis of advantages and opportunities for waste valorization. Retrieved from Pubmed: https://pubmed.ncbi.nlm.nih.gov/30293021/
- Franco Muleya, H. K. (2017, October friday). An Investigation of Waste Management Practices in the Zambian Construction Industry. Retrieved from Scientific Research: https://scirp.org/journal/paperinformation?paperid=74006
- Horvath, A. (2004, November Sunday). CONSTRUCTION MATERIALS AND THE ENVIRONMENT. Retrieved from Annual Reviews: https://www.annualreviews.org/doi/abs/10.1146/annurev.energy.29.062403.102215
- Horvath, A. (2004, October Thursday). CONSTRUCTION MATERIALS AND THE ENVIRONMENT. Retrieved from Annual Reviews: https://www.annualreviews.org/action/showCitFormats?doi=10.1146%2Fannurev.energy.29.062403.102215
- Ibrahim, K. M., Hosni, H. A., & Peterson, P. (2016, January Sunday). Animal feed resources information system. Retrieved from Feedipedia: https://www.feedipedia.org/node/24001
- Jin, R. H. (2019, January Tuesday). Science Mapping Approach to Assisting the Review of Construction and Demolition Waste Management Research Published between 2009 and 2018. Retrieved from Research Gate: https://www.researchgate.net/publication/327883680_Science_Mapping_Approach_to_Assisting_the_Review_of_Construction_and_Demolition_Waste_Management_Research_Published_between_2009_and_2018
- Lai, P. C. (2017, April wednesday). The literature review of technology adoption models and theories for the novelty technology. Retrieved from Research gate: https://www.researchgate.net/publication/317412296_THE_LITERATURE_REVIEW_OF_TECHNOLOGY_ADOPTION_MODELS_AND_THEORIES_FOR_THE_NOVELTY_TECHNOLOGY
- Nirmal Prashanth Maria Joseph Raj, N. R. (2020, August Monday). Adoption of artificial intelligence (AI) for talent acquisition in IT/ITeS organizations. Retrieved from Emerald Insight: https://www.emerald.com/insight/content/doi/10.1108/BIJ-04-2020-0186/full/html
- R, R. B. (2020). Construction wastes chokes bengaluru lakebeds. Bengaluru: The Times of India.
- Rogério Bonette Klepa, M. F. (2019, February Friday). Journal of Cleaner Production Volume 209. Retrieved from Science Redirect: (https://www.sciencedirect.com/science/article/pii/S0959652618332517)
- Technology think tank for government of India. (2023, - -). Retrieved from Technology Information. forecasting and assessment council: https://tifac.org.in/index.php/8-publication/184-utilisation-of-waste-from-construction-industry
- Thongkamsuk, P. K. (2017, October Not available). Waste generated in high-rise buildings construction: A current situation in Thailand. Retrieved from Research Gate: https://www.researchgate.net/publication/321111755_Waste_generated_in_high-rise_buildings_construction_A_current_situation_in_Thailand
- TIFAC. (2001, - -). Utilization of waste from construction industry. Retrieved from TIFAC: https://tifac.org.in/index.php/8-publication/184-utilisation-of-waste-from-cnstruction-industry
- Zainun, N. Y. (2016, November Tuesday). Mapping Of Construction Waste Illegal Dumping Using Geographical Information System (GIS). Retrieved from Research gate: https://www.researchgate.net/publication/311484257_Mapping_Of_Construction_Waste_Illegal_Dumping_Using_Geographical_Information_System_GIS

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15. Rooted in tradition.

Conversation with **Ar.Senthil Doss,** Principal Architect and Founder at Play Architecture.

Kalpa, Vol.04, 2023, pp. 89-92

Intent :
Architect Senthil Doss offers a unique perspective on Architecture by integrating historical influences and emphasizing sustainability. His work on the Devadhare Project, with the innovative use of brick tiles exemplifies the practical ramifications of his design principles. With a coherent understanding of materials, their properties and limitations, Ar. Doss develops an exclusive design language, which is reflected in most of his built forms. Doss's insights align seamlessly with Kalpa's focus on eco-friendly and culturally rooted practices, making him a compelling and inspiring figure for readership. The interview was conducted online where Architect Senthil Doss provided insight on his award-winning project, Devadhare and his belief in architecture as a practice and profession.

What were the primary determinants considered while curating the material palette for the project? Kindly elaborate:
How did the project's locale and climatic nuances influence the selection of the chosen materials? Were there any avant-garde or pioneering materials employed in this endeavour? If so, what led to their selection? What role did the occupant's comfort, finance and health play in the selection of such materials?

The timbrel vault is inspired by a traditional African technique, which existed 800 years ago. Later seen in Spain, after which it disappeared, because of the lack of skilled labour and the expensiveness of the technique. The trigger was a masonry structure with negative brachian curvature that is ideally not possible in any traditional structure. It is conclusive of the fact that the geometry in any structure plays an important role. Prior to this, research work was being done on catenary based structures, which showed that the material that is used plays an important role. Conventional materials like concrete and brick were not suitable. Instead, thin brick tiles were used to give the vault a form. It was used in multiple layers, in different directions, which adds to the tensile properties of the vault. Took five years of research, using bricks and plaster of paris. Initial formwork was complicated and failure was met multiple times.

Timbrel vault in the "Devadhare " project (Image : Senthil Doss)

Timbrel vault can be used for long spans with negligible thickness, and its geometry plays an important role in understanding the resolution of forces with respect to the ground. A Catenary curve saves on a lot of material and reduces redundancy. Form becomes more meaningful, and less whimsical, when it is derived closer to nature, because straight lines do not exist in nature.
The Devadhare project started off by understanding nature with a stay in a tropical forest, a valley, with a lake and streams feeding into it. A structure like the one envisioned, would have problems of leakage due to the heavy rainfall that occurs in that region, if it is not dealt with properly, especially since it is a masonry structure. Recycled GI pipes were previously planted on site in the hopes that a platform could be mounted, that can be used for meditation etc. a spontaneous call, which was later embraced and allowed a program to conform around it. These pipes blended with the ecosystem and removing them would cause a disturbance to the existing balance. Hence, the columns were connected, and a thin stone flooring was built. The vault was built by people who did not know what it was. A system was developed out of steel as the formwork, which can be repurposed.
We made sure the scale does not dominate the landscape. The scale and proportion was extremely important in that sense. It had to work practically for a dining space, which was to accommodate 40-50 people to dine, devoid of any decoration. So the architecture becomes the interior, the landscape or vice versa. Simple glass tables because it reflected the surrounding back into the space, like an oasis.

Did the cultural or historical milieu of the project area imbue the material selection with a sense of contextual resonance? If so, which materials were specifically chosen for their culturally significant symbolism?

If you look at the tile vault, it was initially not historical. But the roots of the idea goes to history, but not Indian history, and the relevance in terms of why the technique can be adapted in India is because we are used to bricks and we have been living with bricks for hundreds of years. If you go to Tamil Nadu, it was even more appropriate

when we started the research because you get something known as “Achakal,” which means thin bricks in Tamil. It is a traditional way of constructing in Tamil Nadu, like all the mantapas and temples, the vaults,arches and foundations were built using this. This is very popular in Auroville too. The material belongs to the region and we did not know the technique. So it was very appropriate to talk about the scientific component, the global idea and use of sophisticated softwares to design and build, and a material which is very local. There is a nice marriage between this very parametric process, plus the regional idea coming through.

I happened to have a conversation with Prof. Philip Block from Zurich, when IIT Chennai invited us. I felt like the mason in this case and the professor was a mathematician. So why do you want to drag us both into this conversation? They said that both forms of knowledge hold equal value. So, I had a chance to ask if so much analysis is required. He was the one who developed the rhino vault, a software for analysing shell structures like this.

He just smiled and said that your project has proved that you do not need analysis, but when there is a need to probably submit a document to the government or when you really need an analysis, this is where the support systems come into play. It’s a nice marriage in terms of the global versus the local ideas. In the case of the timbrel vault, the trigger was more modern but it goes back to the roots of history. In the case of the stone house, the trigger was a very insignificant temple in Tamil Nadu, my hometown- Thanjavur and Kumbakonam. These are known for temples. In 2000, I had done 3-4 proposals for the same site, but I was not happy for some reason, because they were all known; the material was known,

Interior of the dining space (Image : Senthil Doss)

the way you wanted to build was known, and I think when you are doing something for yourself, that’s when you get the complete freedom of doing something new. So I wanted to come out of this comfort zone, and touch something which is new. I was with my wife and there was a lot of spiritual connection, and we were in this temple and it’s very common to see stone columns, and I think it was an appropriate time in the evening, with the evening sun kissing the stone columns and floor and it just left a femoral quality.

It’s just there and it disappears; the feeling. But it leaves an impact that is always in your heart. You come back and you think that it should work with stone; I think it’s a beautiful material and it’s got purity. You become mad and say, I just want to work with stone.

You come back from there and the context shifts from Tamil Nadu to Bangalore, specifically where our chappadis are our unsung heroes, so you see them as drains, slabs and compound walls. There was a question

Playful engagement with the roof (Image : Senthil Doss)

as to whether I can use this stone as the structural system. Alone, you know that it is weak in tension, so it cannot perform. So we did research for one and a half years in terms of how you can interlock, how you can join them and see how it could work; and I realised that I needed a structural engineer. With the vault, there was no structural engineer and I was also touching stone for the first time, so we felt that there is a need for somebody who would be able to make more sense. So I spoke to B.L Manjunath, our favourite structural engineer, and he was laughing. He said that, in spite of whatever you do, you are still an architect, you do not understand structural order. To the extent of what we were trying to do there, it's critical, because you need to really understand the material and its properties. As an engineer, he is able to see the pitfalls of the material, so he asked me if I wanted to goof up a couple of times and find a way to build, like the vault process, then well and good. He asked me if I had so much money, but I declined. It's my own project and I will have to fund it myself. He said that he will have to rearrange the way I am looking at it. He said that it's a great idea to work with stones and to combine them to form a structure, but the way in which we are combining will have to be revisited and look at the order in a different way. So he asked me if I am open to it. He said that I cannot be only an architect and I cannot be only a structural engineer. We will have to step into different shoes at different points of time. That's the reason I asked him to help me out. So it was a very beautiful journey in terms of sharing our thoughts and he came with whatever was finally constructed.

When it came to the roof, work was stopped for 3-4 months. He said that a beam and stone is not engineering-wise appropriate. So I asked how these ancient temples work, because that's what I have seen from my childhood. I was told that I only saw the beam but not the thickness of the wall supporting the beam. Which means he was talking about how it was density-based, traditionally, and in this case we are working with stone almost as a surface. So that's primarily the difference. But since the span was only 12ft, I asked him if we should really be worried about it. As it is we should be worried about it as it is not correct, engineering-wise. One fine day, we had waste cut pieces of stone, and pasted it, and loaded 2 tons over it. The stone looked like it could probably withstand 10 tons more. As long as the load is distributed evenly throughout the surface, it will not have any issues.

Aerial view of the timbrel vault in the Devadere project (Image : Senthil Doss)

So the plan is a typical, traditional grid, with the centre open. The material is traditional and if you just change the order, the experience achieved is completely different. Traditional plan, traditional material, but the order is different. One of my inspirations was Bruce Lee, and he found a lot of redundancy in the process of martial arts. That's something that we have been trying to do, consistently as well. Either with the Sakleshpur project with the form, and a stone project which is the opposite of the Sakleshpur project. A very simple thought, but very challenging in terms of execution, and hence, we made sure to be close to the site at all times. No concrete or steel was involved in the project, other than the compound wall which is a gabion wall.

With an atypical/uncommon fusion of materials comes extensive research and added complexities. What were the challenges encountered in harmonising the chosen materials, and keeping it in tune with the conceptual framework? How were these intricacies adroitly addressed?

With 23 years of experience working as an architect, you learn to digest the whole process in layers. It is simultaneous, and never an isolated process. You have to look at the essence of the project, and the material has to be appropriate. It cannot be forced. It has to be deep-rooted and holistic. So all these layers keep adding in your head, and I always see it as a continuous process. So you choose a material, which leads you to a certain understanding, that leads to a certain form. On the contrary, like the Devadhare project, you have to have a roof that lets the water flow back into the stream and it was supposed to show this dialogue between impermanence and permanence. Concrete is more permanent and a thatch is temporary; so the in between is explored.

Today, sustainability is an indisputable precept of any discipline. How would you define sustainability and its applicability? What were some of the decisions made that animate resource management as a sustainable system?

Sustainability is not a new concept; it has been forgotten in the last 20 years. When I was a student doing my thesis, I think this concept resurfaced. Nowadays with social media, the visibility is more. Somehow, sustainability is seen as very research-based, and only few people would adopt it, like Auroville.

So if we talk about sustainability, it means being closer to nature and being sensitive to the local context. Some construction techniques cannot be framed as a sustainable practice. A rammed earth construction in a place where you do not get red earth is not sustainable; or if you imagine all of us building with earth as a

material, we might run out of earth. But on the other hand, once the purpose of the building is over, it can just disappear into the landscape. So when you do something like this, you have to know how long a building can perform, and once its purpose is served, how easily it can disintegrate into the landscape. That's one way to look at sustainability.

With respect to larger sustainable systems, if you look at the Devadhare project, the whole structure was built around the existing landscape. Only a few branches on the trees were trimmed so that they do not fall during the construction process. If you look at water systems, the entire form of the structure is to accommodate for the flow of water, which reflects in the geometry. So the water goes back to the landscape, through the streams. It does not require any specific harvesting system; we just have to make sure that the water does not stagnate elsewhere, and that it is allowed to flow back into the source. In fact, neither of the two projects had any need for a separate water harvesting system, because of the presence of an existing water body near the site.

With respect to recycling, it happens at a very small scale, in terms of the formwork and the interior dining elements, which could be very poetic, or it could be the aspiration to recycle. But to be honest, I do not consciously work with these harvesting systems, but maybe in the future.

Technology has its implications on the quality of material, its utility and the innumerable choices we have as designers. What are some of the advanced systems that have been adopted in your projects?

One aspect was that I was not big on using cranes, so that's something we will have to bridge in the future. We will definitely look at new ways of doing things in the future. Nothing against cranes, but a lot of heavy machinery may affect the site, especially if the site is very eco-sensitive, which would call for a lot more work. But I think we need to be balanced; this is a learning process. Sometimes, for a larger agenda, you might have to give up on certain smaller agendas.

Lastly, what would be your advice to young architects in creating and energising one's design through material choices and resource management?

My advice is to be passionate and be in touch with your soul; we do not need to compare our life to anyone else, because every individual person is special and unique by itself, so you need to be truthful to your calling, keep walking your path, irrespective of your pitfalls. Be true to whatever the situation is, and surrender to it. We only talk about success measured in the work we do and how much money we earn, which is not necessary for everyone. That's something I would like to tell everyone. Design sensibly and understand the material. There is no right or wrong, good or bad.

Interviewee's profile :

Ar.Senthil Kumar Doss

Senthil Kumar Doss, graduated from (NIT) Regional Engineering College, Trichy in 1999, began his Architectural career with his Internship at the Internationally renowned Architect B.V. Doshi's office based in Ahmedabad. Having spent 5 years of working with Dominic Dube, Senthil went on to establish his own practice under the banner Play Architecture. Play Architecture tested various "Isims" in Architecture, complementing and successfully integrating research and practice since 2005 and has been recognised through various Indian awards and publications in international journals. Apart from practice, Senthil is an academician, researcher and Guest lectures/ Conduct workshops at various schools of Architecture in India and Dubai.

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16.

Living, breathing, moving buildings aren't new to fantasy enthusiasts. From the whomping willow to howl's moving castle, many have imagined buildings that are alive in a literal sense. One can wonder if it is really possible

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Construction industry contributes to approximately 36% of global CO2 emissions; cement and concrete alone constitutes about 8%. Yet, it is the most preferred building material owing to the attributes such as scalability, feasibility, durability, cost, time of construction, etc. What could be the alternative that provides structural strength and the rest of the characters of concrete, yet capture carbon rather than emitting it? The answers are hidden in nature.

Biomineralization processes are induced or controlled processes carried out by various organisms that result in production of solid formations that are either byproducts of their metabolic activities or generated for a particular physiological purpose. Oxalates, silicates, carbonates form building blocks of various skeletal structures. Biofabrication involves complex living processes incurred through cellular compositions, molecules and matrices. Worldwide research is gaining pace on biomineralization carried out by colonies of various micro and macro organisms that can help build structural blocks. For example, Stromatolites formations which are the oldest living life forms on the planet. Cyanobacterial communities that grow over hundreds of years result in formation of layered rocks with biomineralization. Blue-green algae grow on tiny surfaces forming a network of colonies that binds these surfaces not only can bring structural strength but also sequester carbon through photosynthesis.

No need to mention that these are long processes that require suitable environments and triggers to perform, yet, it is definitely not impossible to mimic these processes in today's day and age for potential innovation.

What if these processes are imbibed within the production of construction material? Immense opportunities lie here in order to materialise carbon negative living architecture that can bring a paradigm shift from the currently perceived mainstream built environment towards sustainable one. Interdisciplinary research between biology, biotechnology and architecture taking shape globally as a recent endeavour of Engineered Living Materials (ELMs), Hybrid Living Materials (HLMs) and many more.

Peek into the works of research practices who are exploring these materials and its arenas of application points towards revolutionising the building industry for actual good. The three research practices mentioned here are OXMAN led by Prof. Neri Oxman, TATTVA research project by Prantar Tamuli and PROMETHEUS materials as a reference. The selected practices venture into arenas of understanding and translating various natural processes, phenomena in order to produce a tangible product. The products that may have applications in multitudes of industries ranging from medical sciences, material sciences, construction and technology to even space programmes. Necessity drives the innovation, as it rightly says, for professionals and researchers associated with the built environment studies, the doors are open to the new world of living materials.

- Ajinkya Kanitkar
Architect I Urban and Regional Planner

17. Navigating Terrain, Tradition and Tomorrow.

Conversation with **Ar. Ravi Sarangan,** Co-founder and Director of Edifice Consultants Pvt Ltd.

Kalpa, Vol.04, 2023, pp. 94-97

Intent :
The intent of choosing an interview about a commercial project for this edition was to explore how architecture negotiates sustainability and contemporary luxury to create aesthetically pleasing and environmentally conscious spaces, with a focus on the selection of environmentally conscious materials. The selected project, Taj Resort and Spa in Rishikesh by Edifice Consultants, aims to illustrate and achieve these objectives. A set of questionnaires was framed outlining the strategies of material choice and management specific to the Resort project. Architect Ravi Sarangan, co-founder and Executive Director of Edifice Consultants, Mumbai provided an insight into how materials and their usage can be dealt with in the real world.

What architectural elements of the Taj Resort and Spa in Rishikesh are influenced by the local context, including the natural terrain and indigenous construction knowledge? Additionally, how does the layout of the resort contribute to an enhanced guest experience, particularly through the strategic placement of functional spaces?

Taj Resort and Spa is the morphology of the traditional Himalayan village with a structure that negotiates and creates a dialogue with the contours. The relationship of the design with the rivers and rivulets in the valleys, the materiality, local construction knowledge and memorable collaborations are all crucial determinants of the architectural concept. The location of Taj at the foothills of the Himalayas and the serendipitous presence of the holy river Ganges marked the advent of its design language. Formerly used for stepped farming, the natural terrain of the site invited us to place the built structures on the flat terraces, thereby allowing the untouched parts of the landscape to remain natural and pristine.
The main entrance opens on either side that free flows into different functional spaces. The most extensive flat land transformed into the Welcome House comprises the main building which houses the reception, dining area, bar, banquets and guest rooms. The basement has services and parking with services marked at the highest point of the site. The lowest part of the site, which has a steep drop, houses the swimming pool with an infinity edge overlooking the river Ganges – like the natural extension of the sacred water body. The visitors at the Restaurant placed at the highest point on the site carve out unmatched panoramic views of the river turning – a place of relaxation and repose suspended in mid-air with signature soulful sounds of the river rapids. The main block of the hotel that overlooks the valley creates the image of a traditional Darbargadh[1]. It provides a central location for gathering all the primary services

Taj Resort and spa, Himalayas (Source : Edifice consultants)

[1]Darbargadh : Maharajah's palace, an old royal residence that reflects the fusion of Rajput and European styles of architecture.

of the resort: the reception, restaurant, bar, boutique, library, and more. The Central Courtyard plays a vital role and binds all the functional spaces together. The naturally lit open corridors allow functional spaces and a properly ventilated outdoor environment for the guests to experience the stunning views and unique glimpses of the lush green backdrop of nature.

In what ways does the design of Taj Resort and Spa in Rishikesh embrace local architectural traditions and materials, fostering a connection with the natural surroundings and reflecting the essence of traditional Himalayan villages?

The design merges with the neighbourhood and magnifies the rustic settings of nature. The site planning mimics the traditional Himalayan villages, anchored around a Darbargadh, the traditional residence of local Rajahs or lords which further translates into the design. The walled courtyard of traditional Darbargadh or the fortress-palace-temples, offer at their heart protection to the villagers in times of war or serve as socialising space promoting community life in harmonious times. Local materials like - stone for cladding the structure along with hardwood battens in ceilings, raw carved wood as bands along with the organic colour palette merge with the green oasis outside.

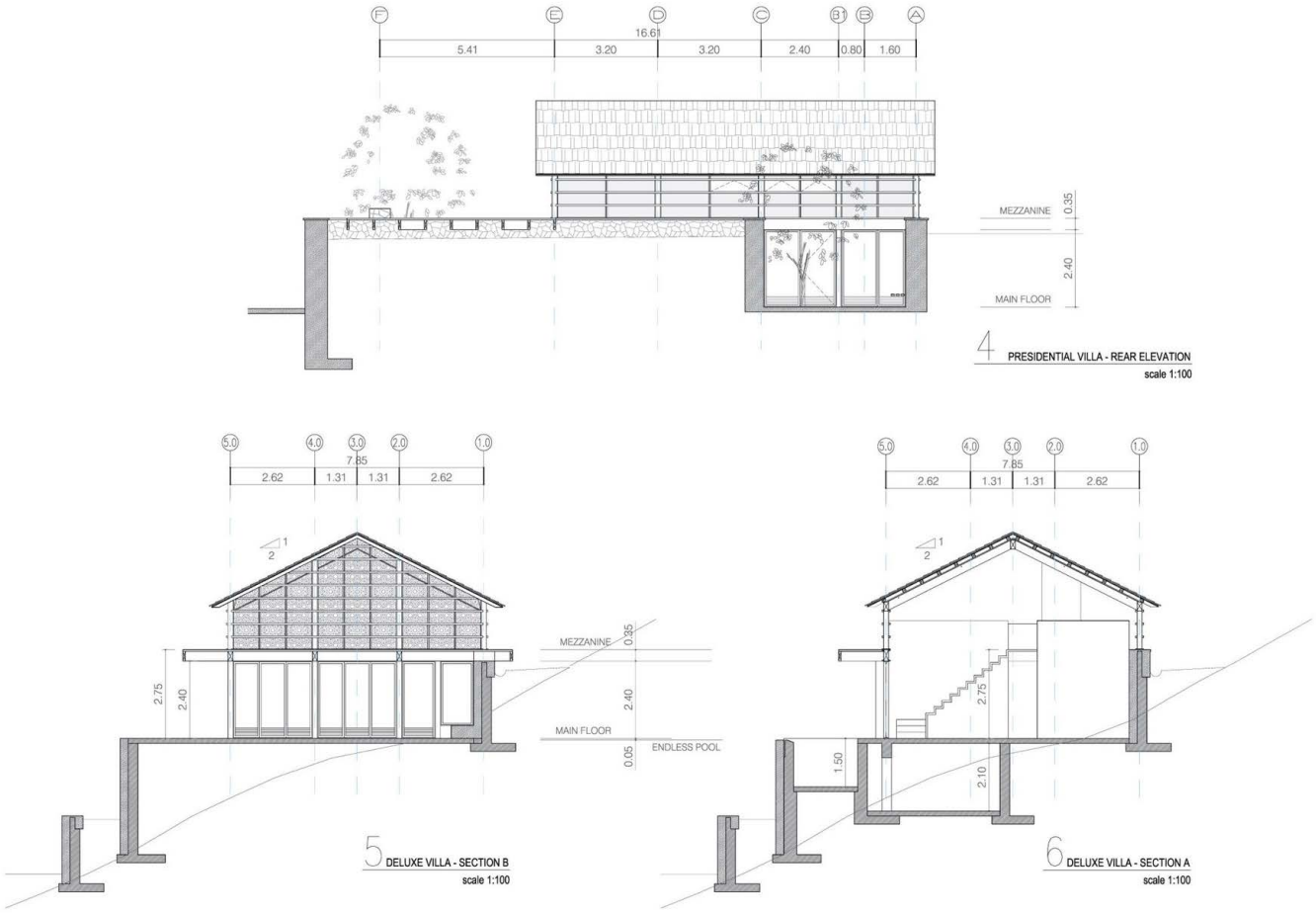
We often demonstrate sustainable designs as a system i.e., it endures a cyclical process of resource management. This may happen at the scale of site/ contextual analysis, design/form orientations, and the choice of facade. What were some of the decisions that animated this project as a sustainable system?

Sustainability has multi-fold aspects of this project. First, there is an aspect of social sustainability; a responsible attitude towards understanding the built environment of the region and faithfully complementing the typology and spatial structure in a contemporary designer environment. Secondly, sustainability is addressed in the use of materials. For the most part, materials used in this project are sourced regionally and have been treated to reflect their true character, texture, colour, and nature. Our ideas of sustainability, respect for local architecture, and the desire for a space to relax and repose, find a voice in our materiality and detailing - local stone cladding, wooden finishes and the slate roof brings out the vernacular familiarity in the buildings. The interior spaces are the design extension of the exteriors. The social spaces designed to enjoy the verdant views of the river and the greenery makes Taj an exclusive getaway for the explorers.

Technology has its implications on the quality of material, its utility and the innumerable choices we have as designers. What are some of the advanced systems that have been adopted in your projects?

At the start of the project, we were engaged in significant research on techniques to clad a concrete wall with large and heavy 200 mm thick stones. The solution lies in devising an ingenious technique to hold the traditional stone wall in place using modern drywall cladding techniques. This process entailed using a single continuous metal strand weaving through the whole surface of stones for that particular façade -- a construction format specially developed for the project. The 200mm thick lightweight walls and 200mm thick stones ensure that there is a temperature difference

Aerial view of Taj Resort and spa, Himalayas (Source : Edifice consultants)



Sections and elevations of a typical villa of the resort (Source : Edifice consultants)

between the exteriors and interiors. The whole of the roof covered with 6mm thick black slate has been fixed to the metal framing below.

Installed solar (panels) technology generates hot water, which is then added back to the system. Whereas, construction of the villas along the contours resulted in less excavation and filling. The open corridors allow for the air to flow through the building and keep the space fresh and natural. An STP (Sewage Treatment Plants) system placed at the lower level provides the water required for the landscape, and no water is discharged away from the site. This also maintains the water table and ecosystem of the site.

The right proportion of natural stone and timber is used in the exterior to simulate a realistic feel and become one with nature. The metal columns make the structure look thin and merge with the trees in the backdrop.

Lastly, what would be your advice to young architects in creating and energising one's design through material choices and resource management?

The next decade bears the potential to define the growth of Indian infrastructure. However, development confines its own pros and cons. The growth of G.D.P. is accompanied by several positive social impacts, including improved access to food, education, employment opportunities as well as investments in real estate. On the contrary, we must acknowledge the cons of such policies, resulting in poverty alleviation and disposable incomes causing waste.

After careful analysis, our approach to design for need rather than excessive build — 'Building Less For More' is the way forward. Moving towards sustainable cities provides a new perspective on resource management— its causes and consequences. Preventing inconvenience and finding sustainable ways to allow organisational planning that does not sever neighbourhoods is a crucial aspect of urban redevelopment and resource management. Architects, designers, and industry leaders must adopt a forward-looking approach to designing and developing spaces that serve their purpose while minimising environmental impact.

Promoting education and awareness of sustainable practices among the larger community, from clients to end-users, can significantly drive this change forward. To ensure a better future for the coming generations, it is essential to make children aware that all resources on our planet are finite and must be used judiciously. We must educate young minds from primary schools by conducting interactive workshops and hands-on activities on critical environmental issues such as climate change, greenhouse gas emissions, ozone depletion, alternative energy sources, and the conservation of trees and wildlife. Incorporating environmental sciences into the school and professional curriculum, including S.T.E.M., Law, Commerce, Architecture, and Arts can help raise awareness and emphasize the direct impact of these issues on our daily lives.

Interior views of Taj Resort and spa, Himalayas
(Source : Edifice consultants)

Interviewee's profile :

Ar. Ravi Sarangan

Ar. Ravi Sarangan is the co-founder and Director of Edifice Consultants Pvt Ltd. He oversees Edifices brand management, handles essential clients, and develops the creative design process. With more than three decades of a design-focused approach,design efficiency, design excellence and project delivery experience, Ravi is recognized for his leading expertise extending to the scope of master planning and urban design. He has worked on award-winning projects, including India's first Net-Positive Energy Campus and the highly energy-efficient Atal Akshaya Urja Bhawan. Recognized for his significant contribution towards evolving trends,Ravi's work at Edifice is driven towards creating a better and sustainable built environment.
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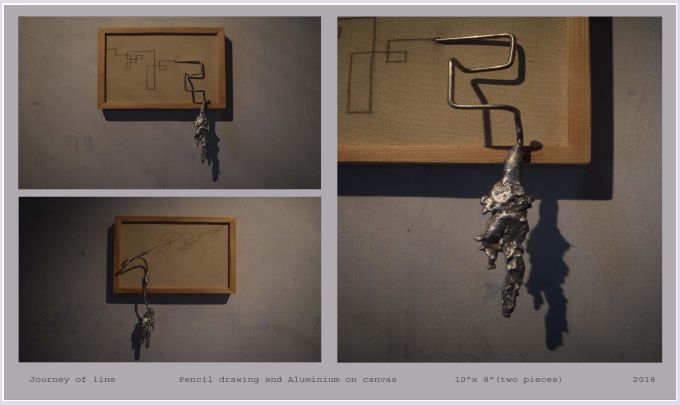
Artist statement :

Prof. Sangeetha



Growing up in a city like Bangalore and choosing to practice art has made me realise the importance in observing the details of simplicity in livelihood and the rapid changes as the city grew over the years.

The contradictions that we see now was and is forcefully implemented upon nature and its changes. Creating forms that dominate one another to show its superiority. All of which is also major qualities of human beings in their fast moving society. Capturing these changes according to my observation and implementing them onto solid materials such as stone, metal, clay, wood and fabric which represents five basic elements of nature such as fire (agni), earth (pritvi), water (jal), wind (vayu) and ether (akash) The behavior of each material coming in conflict with another represents the kind of imbalance which we have created in nature over the decades.The kind of struggle that a tree goes through crawling its way out of a concrete building or through large rocks clearly shows the tension bursting out over a period of time.
The natural texture on materials has a language of its own. I believe that I am a listener and conveyer of this language through the means of creating visual forms in correspondence to nature and our surroundings.

My artworks are based on universal concepts like struggle of growth/ force and changing transitions in landscapes and nature. I try to strike a visual representation of nature's way of language to us. My activities in sports, dance and martial arts influenced my idea of body; notions of dynamism and movement, depicting force and growth and crossing borders through change. A sense of congestion strikes when change occurs through what we call unfamiliarity.

All of which, the process interests me the most.

Thank you
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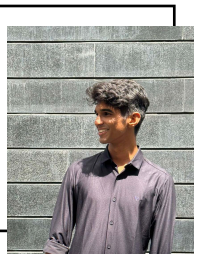

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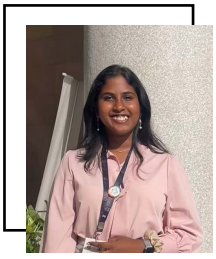

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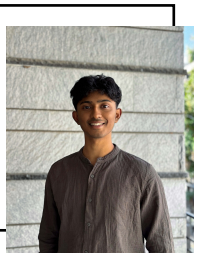

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