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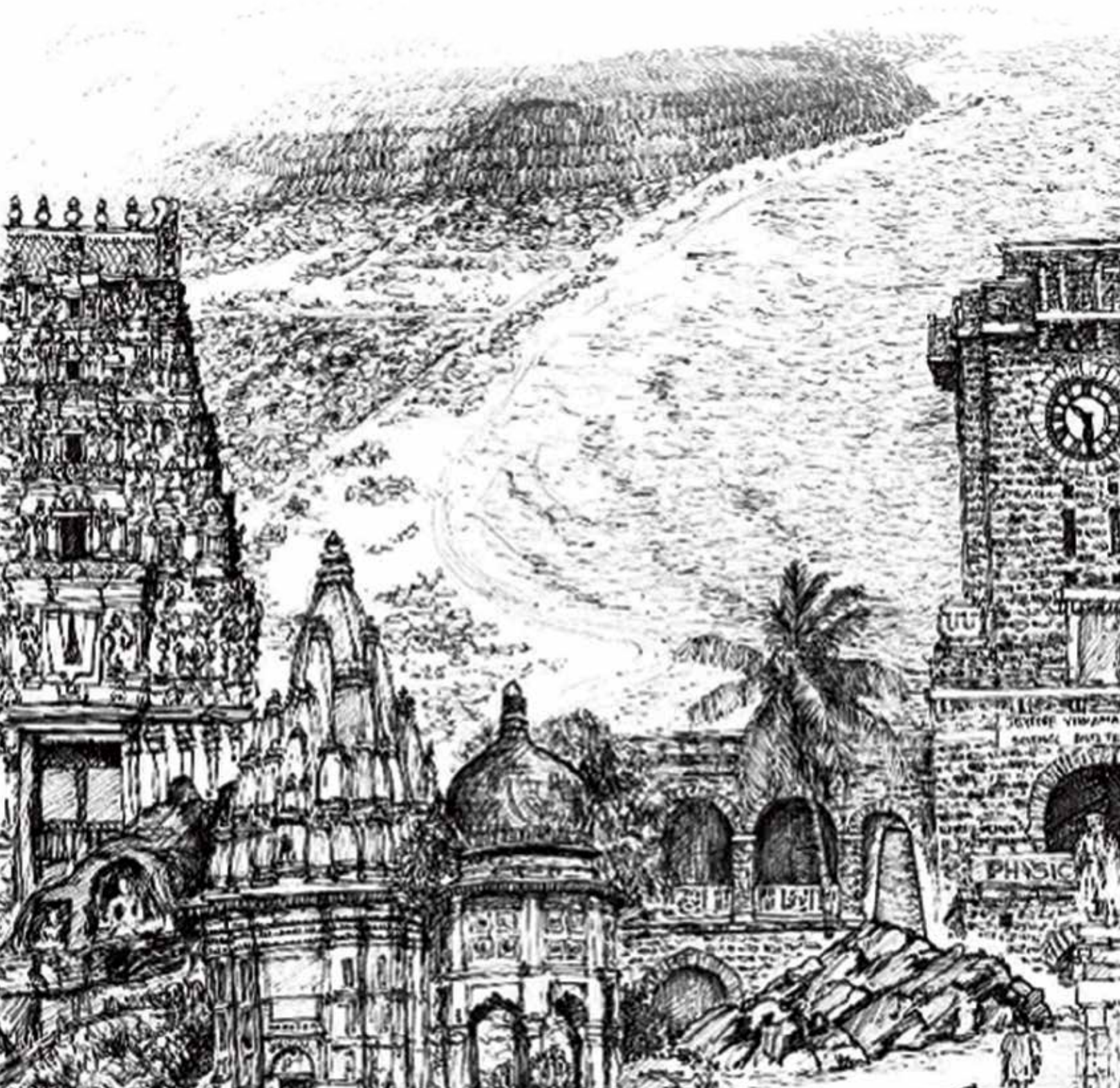

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VISAKHAPATNAM

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"Where light shapes space,
and design celebrates life."

|| Shubh Deepavali ||

THE INDIAN INSTITUTE OF ARCHITECTS

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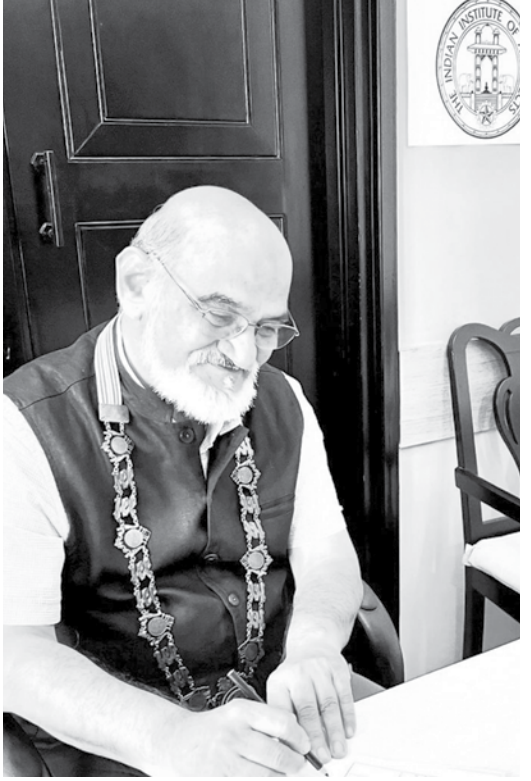
PRESIDENT'S MESSAGE



Dear Fellow Members

As we observe World Habitat Day 2025, India stands at a defining juncture in its urban journey. With over 1.4 billion citizens and more than 543 million urban dwellers across 8,000 urban centres, our nation represents one of the largest and most dynamic urban systems in the world. The scale of our urban transformation offers immense opportunity but also brings formidable challenges that demand foresight, collaboration, and innovation.

This year's global theme, "Urban Crisis and Response," resonates deeply with India's realities. Rapid and often unplanned urbanisation has led to issues of population stress, poverty, pollution, and inequitable development. As architects, planners, and custodians of the built environment, we hold a profound responsibility to respond with creativity, sensitivity, and resolve.

At the Indian Institute of Architects, we reaffirm our commitment to shaping cities that are sustainable, resilient, and inclusive. We pledge to apply our collective expertise toward improving the quality of urban life, promoting responsible use of natural resources, and aligning every endeavour with the Sustainable Development Goals. Our efforts will focus on enhancing collaboration across all IIA chapters and centres, engaging local architects as partners in driving meaningful transformation.

We will continue to strengthen ties with academic and professional institutions to ensure architectural education remains forward-looking and technologically empowered embracing tools such as AI, AR, VR, and BIM to make our cities more efficient and humane. We are equally committed to nurturing the next generation of architects by involving students in research and design initiatives that address real urban challenges.

Through dialogue, seminars, and shared platforms, IIA will continue to celebrate innovation, foster exchange, and inspire leadership among architects. Together, we will strive to create cities that are not only functional and beautiful but also socially vibrant and environmentally sound.

On this World Habitat Day, let us renew our resolve to design for dignity, to build for inclusivity, and to shape a future where every Indian can thrive in sustainable, resilient, and humane habitats.

Together, lets imagine and create a better urban tomorrow.

Ar. Vilas Avachat
President, The Indian Institute of Architects

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EDITOR'S NOTE

Deepavali Greetings to all IIA members.

Let this festival of lights bring happiness and prosperity to all of us.

October holds a special significance for architects worldwide, as we celebrate World Architecture Day, reaffirming our shared commitment to shaping environments that are resilient, inclusive and forward-looking. The theme for this year, *Building for the Future* compels us to reflect upon our professional and ethical responsibilities in an era defined by rapid transformation.

Across India, the architectural landscape is undergoing a profound shift. Cities are expanding, technologies are evolving and environmental concerns are becoming increasingly urgent. In this context, architecture must transcend its role as a response to demand and emerge as an instrument of direction, one that anticipates the needs of communities and contributes meaningfully to the quality of life.

As we celebrate this month of architectural reflection, it is essential to recognise that building for the future is not only about innovation or form; it is equally about continuity, sustainability, and cultural identity. The values embedded in India's diverse architectural traditions offer enduring lessons in adaptability and human connection, lessons that remain vital as we pursue newer methods and materials.

The Indian Institute of Architects continues to uphold its role as a platform for dialogue, research and professional advancement. Through The JIIA, we strive to present perspectives that inspire critical thought, share knowledge, and document the evolving discourse of Indian architecture.

This issue brings together contributions that examine the intersections of design, policy, technology and heritage. They remind us that the profession's progress depends not only on innovation but also on collaboration among architects, planners, engineers, policymakers, and communities.

As we look ahead, let us reaffirm our collective resolve to build responsibly, thoughtfully, and inclusively ensuring that every structure we conceive stands as a testament to our commitment to the future generations it will serve.

We extend our sincere gratitude to all our fellow IIA members whose commitment and dedication continue to foster vibrant spaces for dialogue, learning, and exchange of ideas. Your passion and perseverance propel Indian architecture forward and ensure that our collective voice is heard with strength and respect on the global stage.

Our heartfelt appreciation also goes to the authors and contributors whose thoughtful writings enrich this publication and make our shared journey truly meaningful.

We urge all members of the Institute to remain actively engaged with these initiatives and to continue showcasing the depth, diversity, and leadership of Indian architecture before the world.

Let us stay united in purpose and steadfast in progress.

Jai Hind.

Prof. Vinit Mirkar
Editor, JIIA

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Visakhapatnam

A City of Confluence

By Ar. B. M. N. Chakravarthy

An architect's reflection on memory, culture and the evolving fabric of a coastal city.

My earliest memories of Visakhapatnam begin at the RK Beach, where the vast sea meets the city's spirit. The iconic Scandal Point (seen in the lower right corner), once conceived as a simple landmark on the shore, has, over time, become an emotional anchor for generations. It is where countless evenings, stories, and silhouettes of childhood were framed against the horizon.

Acknowledging the British establishments that contributed immensely to the city's development across various sectors, one cannot overlook the Physics Department at Andhra University (top right side). This landmark stands as a reminder of the colonial era's architectural legacy, where proportion, detail, and purpose came together to inspire learning and progress.

Along the same coastal stretch stands the Kurupam Tomb (second in lower left corner)- a structure I initially recognized simply as one of Vizag's iconic silhouettes against the skyline. Only later did I come to understand the profound story behind it: a memorial built out of love, blending Mughal, Rajasthani and European influences in exquisite stone craftsmanship. It is, in many ways, the city's own *Taj Mahal*- a poetic expression of emotion through architecture.

Further inland, the sacred Simhachalam Temple rises (top left)- its Dravidian grandeur blending Orissan, Chalukyan and Chola influences. For centuries, it has defined the spiritual skyline of Vizag, representing the city's devotion and craftsmanship.

Beyond that lies Bojjannakonda (lower left corner), the ancient hill of the Buddha. Dating back to the 4th to 9th centuries CE, it speaks of a time when peace, learning and faith flowed through these hills- marking Vizag's connection to one of India's earliest spiritual movements.

Above it all, the aerial view of Visakhapatnam tells a story of its geography and growth. The rhythmic meeting of mountains and sea, the linear development along the coast, the green belts that breathe life into the city, and the harbour that anchors its economy- together form a unique urban landscape.

This cover illustration is not just a composition of places; it is a narrative of memory. It reflects how I have seen Vizag evolve- from a city of childhood impressions to an architectural mosaic shaped by history, culture and the constant dialogue between nature and man.

This is my tribute to the city that taught me to observe, to imagine, and to design- Visakhapatnam, The City of Confluence.

Ar. B. M. N. Chakravarthy (A29870) is the Principal Architect and Founder of Eternal Frames Architecture Studio in Visakhapatnam and Hyderabad since 2014, leading varied architecture and interior projects. Influenced by art and travel, he sketches extensively. A former NASA Zone 4 President, he now heads the Andhra University Alumni Association and remains active in IIA and IIID with multiple recent awards.
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JIIA Call
for Papers, Articles, Projects

The Journal of the Indian Institute of Architects invites original and unpublished contributions from members **ONLY** (academicians, practitioners and students) under the following FIVE categories. Submission in each category is strictly only through the respective google forms.

In order to be accepted for publication, all material sent in these categories should have the following components:

1. MS Word document file with text only. Please do not format it in anyway. The numbered captions for all the images will also be in this document.
2. Folder with all images (minimum 300 dpi), numbered according to the captions given in your text file
3. Photograph of the author/s (minimum 300 dpi).
4. Author biodata – Maximum 50 words.
5. PDF (optional)– showing the intended layout. This pdf should include text and all images, with numbered captions.

Category 1 : Articles

google form link: https://forms.gle/7pDFva1HDH4hfUyj8

Essays, interviews, articles (1500- 2500 words), book reviews (600 and 750 words), travelogues, sketches and photo-essays in the areas of architecture, planning, urbanism, pedagogy, heritage, technology, ecology, theory and criticism, visual design, practice or any other relevant subject pertaining to the built environment. (Details of the format will be available on the JIIA website).

- For a design project, please include the 'Fact File' with the following details : Project Name, Location, Plot area, Total built up, Structural consultants, Project completion. Also please give the photo captions and credits. Please ensure that the image is referred to within the text. For eg, "As seen in Figure 1…". This is essential for the layout.
- For design projects, plans and sections of the project are desirable along with the photographs.
- Book reviews should be only of books by Indian authors. please include the "Fact File" with the following details: book title, author name, publisher, year of publication, ISBN, language the book is written in, genre (technical/ fiction/ etc.), no of pages, dimensions (in cm), type (Kindle/ paperback/ hardback), available at (amazon.in/ flipkart.com/ others).
- Please send a write-up of about 200-300 words along with sketches and photo-essays.

Category 2 : Student Work

google form link: https://forms.gle/8wDCYFusLb7hWcpa6

Summaries of dissertations (2000-3000 words) at the level of B.Arch. & M.Arch., and theses at the Ph.D. level. The Guide for that work will be mentioned as the Co-author. (Format will be available on the JIIA website).

Category 3 : Contributions from Chapter Correspondents

google form link: https://forms.gle/Ru4JBLSHwaYEBTcg7

(a) *Chapter News:* This includes various interesting activities from the Centres of your Chapters (maxm. 500 words for the news from the *entire* Chapter).

(b) News of conferences by the academic institutes in your respective Chapters.

(c) *Obituaries :* Obituaries of IIA members should consist of the photograph of the departed soul, the dates of birth and death and a short 50-word note.

Category 4 : Research Papers

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Research papers (2000-5000 words) in the prescribed format. The research may be based on their ongoing or completed research. (Format is available on the JIIA website). All contributions in this category will be double blind peer-reviewed before being accepted for publication by academic experts of repute.

Category 5 : Cover Design

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Students from affiliated colleges are invited to design the cover page theme. This should be a graphic based on some aspect of Indian Knowledge Systems. The submission will include the graphic file (jpeg or corel draw); a theme note (with a title) of about 500 words explaining the concept of the graphic.

Please note that the image you send will be adjusted as per the layout requirements of the JIIA Cover.

Please note:

1. All submissions will be accepted only through google forms.
2. Submissions will **NOT** be accepted through email.
3. Any queries to be addressed to : jiiaeditorial@gmail.com.
4. When you correspond with us, please give your email id (that you regularly use) and your cell no. (preferably with WhatsApp).
5. It is compulsory to mention your IIA regn. No. Submissions will **NOT** be accepted from non-members.
6. The review process takes anywhere between 4-6 weeks. Since it may not be possible to respond to all authors who send in their work, we will definitely revert if and when your work is accepted.
7. JIIA does not charge any fees for publication of any professional or academic work.
8. It is understood that submission from an author is an original work, unpublished anywhere else, and that IIA and JIIA are in no way responsible for any matter or dispute arising out of the publication of the same.
9. All authors are requested to refer to further detailed information available on the JIIA website.

IIA Declaration on World Habitat Day

Housing more than 1.4 billion people and home to one-sixth of the world's population, India has been globally recognised as the most populated nation in the world. Housing more than 543 million urbanites in more than 8000 urban centres, with the level of urbanisation currently placed above 37%, India has been ranked as the second largest urban system in the world after China.

Looking at the existing scenario of growth and development, India as a nation, remains different and distinct, offering numerous challenges and opportunities in the domain of planning, designing, developing and management of human settlements in general and urban settlements in particular, with cities occupying the centre stage and becoming the promoters of economy, employment, hope of opportunities, prosperity, infrastructure, services, skill and entrepreneurship. Large proportion of Indian population is opting for urban centers as their preferred destination of residence and employment. Presence of large population in the Indian cities presents both an opportunity and a formidable challenge.

As India is urbanising rapidly, with the majority of cities growing in unplanned, irrational and haphazard manner largely led by urban sprawl, has created numerous operational and developmental problems of population, poverty and pollution. role, relevance and importance of cities, to emancipate communities and nation becomes critical.

Recognising the presence of the large proportion of urban population and the critical role of cities in emancipation/regeneration, UN HABITAT has accepted "Urban Crisis and Response", as the universal theme for World Habitat Day, to be celebrated on October 6, 2025.

Considering the UN mandate and recognising the critical role, relevance and importance of architects, in making cities more productive and human living more qualitative we, the members of the Indian Institute of Architects (IIA), do hereby solemnly resolve, undertake, commit, dedicate and reaffirm as under:

- *That IIA, shall use all its available resource, professional skill, knowledge and understanding related to architecture, in overcoming the existing urban challenges and evolve options for transforming cities and communities, to make them more livable and qualitative.*
- *That IIA, shall use all its available resource, professional skill, knowledge and understanding to make cities more sustainable and resource efficient.* aligned with sustainable development goals.
- *That IIA, shall actively support all endeavors of embedding designing sustainable buildings by optimising the use of nature and natural resource, as integral part of teaching-learning of Architecture.*
- *That IIA, shall take all possible steps to co-operate and collaborate with all its Chapters, Centres and sub-centres of the IIA, to involve local architects, as an active and productive partner, in ensuring urban transformation and building sustainable cities.*
- *That IIA, shall continue to hold dedicated seminars, discussions and workshops at the national and local level for professional Architects, for creating a common platform, to showcase their ideas, vision, talent, skill and innovations, to make cities more livable and sustainable.*
- *That IIA, commits itself to create an enabling environment and dedicated structure to leverage the strength, talent, energy and ideas of learned professional architects, to improve the quality of social living and making cities more socially vibrant and environmentally sustainable.*
- *That IIA, shall work in close partnership with academic and professional institutions, locally and globally, for making all efforts to review, revise and redefine course curricula, to make architectural education more qualitative, productive and focused.*

- *That IIA, partnering with architectural institutions commits to involve students of Architecture in undertaking studies, carrying out analysis, in identifying urban issues and defining realistic options/ programs for overcoming existing challenges to make urban development more sustainable.*
- *That IIA, shall focus on leveraging the technological skill, including AI, AR, VR, BIM etc., available with the young professionals for urban transformation and making built environment more qualitative, cost-effective, resource-efficient and productive.*
- *That IIA, undertakes to work, in close collaboration with various parastatal agencies operating at national and state levels, in the domain of urban development to provide necessary support and to make urban India, safer and more sustainable besides making built environment more qualitative and productive.*
- *That IIA, while working with urban local bodies, and local communities shall provide all professional support, to make urban planning, development and governance process, more meaningful, focused and community oriented.*
- *That IIA, shall assist, advise, co-operate and collaborate with all professional agencies to evolve rational and realistic strategies for making built environment more sustainable, and making cities more safe, inclusive and resilient.*
- *That IIA, while recognising the role and importance of professional architects, shall dedicates itself to create options of affordable housing for achieving the national goal of 'housing for all', so that nobody is left behind.*
- *That IIA, commits itself to create a dedicated platform for spacing all profession Architects, to interact, discuss, deliberate and innovate out of box options for making cities more sustainable and livable.*
- *That IIA, undertakes to use all its knowledge, experience and expertise, to evolve rational strategies and develop actionable programs, to overcome the emerging urban challenges and climate crisis for achieving the universal good of humanity, communities, environment and ecology besides achieving the agenda defined under 17 Sustainable Development Goals, to transform cities into make them sustainable and better places to live and work.*

Ar. Vilas Avachat
President,
The Indian Institute of Architects Date: 6th October 2025.

RESEARCH PAPER

This research paper was presented at the IIA ANVESHAN Research Conference held at MCAP, Thiruvananthapuram, Kerala, 29-31 August 2024, under the Stream: The Significant Present.

Restructuring the Public Transportation of Hubbali Dharwad by Bus Rapid Transit System

By Kalpeshkumar Patel

Abstract

Public transportation is growing as a major urban issue in India. Many cities and towns are suffering due to a lack of efficient public transportation, which results in traffic congestion, pollution and overall image degradation. The Bus Rapid Transit System (BRTS) is used worldwide as a means of efficient public transportation. BRTS is a bus-based, high-quality and capacity system that delivers fast, convenient, accessible, comfortable and cost-effective urban mobility. Hubbali and Dharwad are twin cities, in the phase of their growth and expansion and the cities of that scale require an affordable, reliable and safe public transit network to enable people to commute to different destinations in the shortest possible time and in the easiest possible manner. Hubbali-Dharwad BRTS (HDBRTS) is a strategic intervention to ease existing traffic congestion, integrate existing infrastructure and create opportunities for improvement in land use, allowing fast and inexpensive implementation. The objectives of this study are to discuss the introduction of BRTS as a major public transportation system in Hubbali-Dharwad and understand its design, implementation and management. Through interviews, statistical data from the respective authorities, user surveys and experiencing the HDBRTS corridor and transit infrastructure, the study strives to establish the challenges faced to arrive at a functional and appropriate design, which suited the local conditions and fulfilled the aspirations of the people to travel between the twin cities and concludes by highlighting the need to have capacity building to meet the challenges of designing, implementation and managing of BRTS efficiently, cost effective and timely completion of the project for operation.

Keywords: BRT System, Public Transport, Urban Mobility

1. Introduction and Context

Hubbali-Dharwad, the twin cities of Karnataka, are spread across an area of 203.3 sq.km, forming the second-largest city in the state after Bengaluru. Known as Chota Mumbai, Hubbali is the central business and manufacturing hub comprising organisations like Infosys, Sandbox, and others. Standing on the seven hills, Dharwad, on the contrary, is well known for its rich culture as well as for imparting quality education. It is an educational hub comprising universities such as Karnataka University (KUD), Karnataka State Law University, University of Agricultural Sciences, IIT-D and IIIT-D. Nevertheless, these cities are interconnected and interdependent. According to the 2011 Census, 0.94 million people reside in the twin cities and are expected to grow up to 1.5 million by 2031. The twin cities were in a phase of growth and expansion, hence an affordable, reliable and safe public transit network would improve their connectivity, a foundation for future development.

Buses have been the backbone of urban transport in India. Hubbali- Dharwad also relies on this mode of transportation. In the year 2010, the average bus commuters in Hubbali-Dharwad (combined) per day was around 0.292 million and about 0.135 million bus commuters moved between Hubbali and Dharwad. The public transportation mode share for this twin city is 30%. 7% bus share carries approximately 70% of the fleet on PB road. 45% of commuters are over-aged. The population increased by 3% and the vehicles increased by 10% annually.

The existing buses were congested and unreliable, affecting the modal share of buses. In 2010, it was planned to upgrade the existing two-lane roads to four-lane roads, but it could not have fully resolved urban transit and traffic congestion issues. The overloaded buses, inadequate infrastructure, and paucity of last-mile connectivity demanded better infrastructure. The twin cities evaluated several alternatives, such as Metro, LRT, Monorail, Suburban Rail, BRTS, etc. The metro rail needed a ridership of 30,000 to 80,000 PHPDT and cost up to 250 crores/km. The monorail and LRT options needed a ridership of 15,000 PHPDT and cost up to 120 crores/km. As Hubbali-Dharwad did not have enough ridership, these options were economically unfeasible. The suburban rail option was explored; it was an existing system, yet it had accessibility issues as the existing tracks were away from the existing urbanised areas. Also, the lack of sufficient ridership, land acquisition for better accessibility and a lack of coordination with Indian Railways were the other issues for opting out of the suburban rail option. Although BRTS isn't well-branded like the metro, monorail and LRT, it has proven to be the most suitable option with its safe, convenient, reliable and sustainable aspects. Every single bus would contribute to lowering the congestion. The greater the comfort, the more promising it was for the customers to use this mode over private vehicles, as it has been proven to reduce travel time. Hence, the embryonic thought of the Hubbali-Dharwad Bus Rapid Transit System started to evolve.

Amongst the multiple options discussed, debated and analysed, Hubbali-Dharwad BRTS was the most suitable strategic intervention. It promised to ease existing traffic congestion, integrate existing infrastructure and create opportunities for improvement in land use, allowing quick and inexpensive implementation. In 2010, 110 North West Karnataka Road Transport Corporation (NWKRTC) buses plied between Hubbali-Dharwad along with 41 private buses. Headway of approximately 1 minute was maintained in the Hubbali-Dharwad Service. Figure 1(a) and Figure 1(b) show the composition and commuters' preference survey data statistically. The survey shows that time and comfort are the major factors that mattered to the users the most.

2. Bus Rapid Transit System (BRTS)

BRT System is a high-quality bus-based transit system that delivers fast, comfortable and cost-effective services at metro-level capacities through the provision of dedicated lanes, with busways and iconic stations typically aligned to the center of the road, off-board fare collection, fast and frequent operations. It is a Rapid Mode of transportation; it can provide the quality of 'Rail Transit' at the 'Flexibility & Cost of Bus'. In short, it can also be described as a metro on the road. Also, it is not about moving buses but 'Moving People".

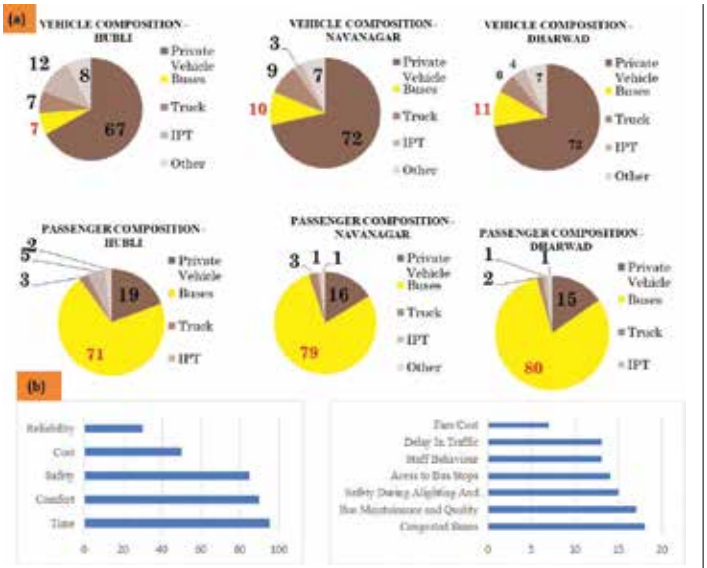

Figure 1(a) Vehicle and Passenger Composition; (b) commuter preference survey
Source: CoE UT, CEPT University, Ahmedabad

2.1. Benefits of the BRT system

The BRT system saves commuting time. As the commuting time decreases, the frequency of commuters will increase. It provides metro standards and comfort at the cost of a bus. This not only reduces city fuel consumption but also makes it more sustainable. Efficient use of road space reduces traffic congestion, thereby providing increased safety on roads. It provides a safer access to all commuters. It is thus an environmentally friendly transit.

2.2 Elements of the BRT system

- Segregated Lanes (exclusive infrastructure)
- Express Services
- High-Capacity Stations
- Elevated Platforms
- Central stations
- High-Capacity Buses
- Quick Passengers Access
- Integrated Fare: Intelligent Card
- Operational Efficiency and Real-Time Passenger
- Passenger Information System

2.3 Evolution of BRTS (Figure 2)

The initial seed of thought of the Bus Rapid Transit System was planted in 1972 by Jaime Lerner, as the Mayor of Curitiba. Being an Architect-Urban Planner, he transformed the usual movements of buses and brought them onto dedicated lanes. BRTS played a major role in controlling Curitiba's congestion and sprawl. It was called ''the most innovative cities in the world" by the then Chairman of Habitat-II. After learning from Curitiba, the city of Bogota combined all the good points from the system, later it was later opened to the public. Other cities across the world took inspiration from the idea or concept of BRTS later. Currently, approximately 158 countries have implemented BRT systems or priority bus corridors, serving around 27 million daily passengers worldwide.

In India, the BRT system was first implemented in Pune, followed by Delhi (partial corridor). Later, it was initiated in other cities such as Ahmedabad, Surat, Indore, Bhopal, Jaipur, Vishakhapatnam, Hubbali-Dharwad, etc.

Delhi BRTS was developed with only one main Corridor (Ambedkarnagar to Moolchand) without integrating it into a city-wide network. The choice of the corridor was not right at first. It did not have any group of people being serviced or receiving the benefit. It had safety & accessibility concerns, poor enforcement and lane discipline; it was planned for 14 km but only 5 km was operational. Hence, Delhi BRTS failed to serve the people of Delhi.

Figure 2 (a) BRT cities in India and their current status
Source: BRT governance and challenges by Prof. Shalini Sinha

HDBRTS is designed with learnings from the failures of Delhi BRTS and the successes of Ahmedabad BRTS. The choice of corridor for the HDBRT) was made after careful analysis of existing travel patterns, urban growth trends, road conditions, and traffic demand between the twin cities. HDBRTS is implemented with central lanes with overtaking bays at stations for differentiated services. It's improved pedestrian connectivity by providing safe foot-over-bridges and ensuring station accessibility via signalised crossings. It also included traffic discipline enforcement and intelligent transport systems (ITS) for real-time monitoring and invested in public awareness campaigns and stakeholder engagement to ensure community acceptance.

3. Hubbali Dharwad BRTS (HDBRTS) – "Chigari"

HDBRTS is the first BRT system in the state of Karnataka, India. It has an uninterrupted 22 km of exclusive lanes connecting the cities of Hubbali and Dharwad. Running daily at a ridership of about 75,000, it is the highest capacity BRT in India with 12,000 PPHPD. HDBRTS is developed on a corridor of 108 sq. km. area under the Sustainable Urban Transport Project (SUTP) with the support of the World Bank and GEF. The project has several key partners, such as HDMC, NWKRTC, HDUDA, KRDCL, etc. Branded as "Chigari" (meaning Deer in the local Kannada dialect), it aimed to run with the speed and accuracy of a deer. Transit system development was done through comprehensive planning. Design efficiency was aimed to be achieved through innovation and technology. Ensuring safety, reliability, comfort and speed with the branding strategies followed, it is now running successfully.

The BRT lanes are proposed to connect major institutional and work zones of the twin cities in a loop so that they cater more to the larger working and studying population. With the travel time between the twin cities reduced by 15 minutes, a major shift from private mode to public transit mode is expected. Thus, HDBRTS forms the major public transport as it connects schools, colleges and offices, allowing key movement of commuters.

3.1 How BRTS for Hubbali – Dharwad evolved?

In 2010, the Government of Karnataka's Comprehensive Traffic Transportation Plan (CTTP) for Hubli-Dharwad recommended 70 km of BRTS in Hubli-Dharwad. A feasibility study was done by CEPT University, Ahmedabad, for the Directorate of Land Transport (DULT), Govt of Karnataka, in 2011. Accordingly, a Detailed Project Report

(DPR) was initiated and approved in January 2012. Processes were then started and approved by the Government of India and the World Bank in March 2012. HDBRTS company was formed as a Special Purpose Vehicle under the Companies Act 2012. All the project packages were tendered and awarded between March 2013 and March 2015. Service level agreement between NWKRTC and HDBRTS Company Initiated. Trial Run of operations was started on 2nd October 2018. HDBRTS was officially inaugurated on 2nd February 2020 in the presence of the Honorable Vice President of India, Shri Venkiah Naidu.

3.2 Key Partners and Agencies for HDBRTS Project (Table 1)

3.3 Project Funding (Figure 3)

According to the DPR 2012, the estimated cost of the project was INR 692 crores or $ 133.6 million (including land acquisition and support infrastructure). The World Bank initiated a loan of INR 291.1 crores ($55.0 million). The Global Environment Facility (GEF) also provided funding. After the project completion in February 2020, the cost of the project was INR 1058 crores. The cost escalation is due to land acquisition compensations and the delays in project completion. Major funding was provided by the Government of Karnataka and supported by the Government of India through the JNNURM. The World Bank loan was INR 354.48 crores and the GEF grant was INR 24.49 crores.

3.4 Land Acquisition

As per the HDBRTS DPR 2012, widening of the existing road required land acquisition of 26.62 hectares. As per the 15 (1) of the Karnataka Highway Act, 1964 notification, the total land to be acquired

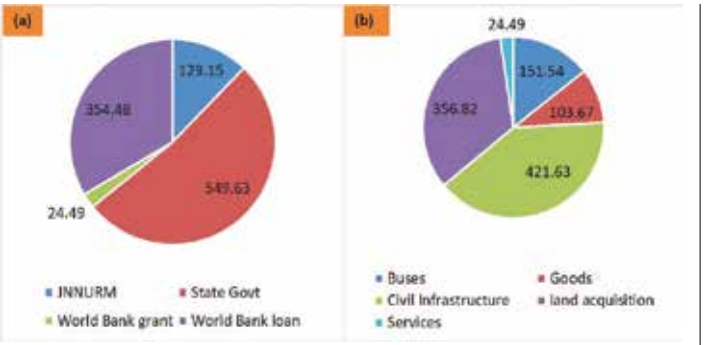

Figure 3 (a) Total project cost (1058 crores);(b) Fund utilisation in crores
Source: HDBRTS Co Ltd

was notified in November 2012, with 20.84 hectares (82%) the land belonging to private parties and the remaining 5.78 Hectares (18%) of land pertained to the government. Public consultation meetings were held in both Hubbali and Dharwad cities. The Government of Karnataka had constituted a Price Negotiation Committee to negotiate the price of the land to be acquired under the chairmanship of the Deputy Commissioner of Dharwad. The negotiation committees finalised the rate for all the villages/ towns and submitted it to the government for approval. In total, 29.56 hectares have been acquired under the Karnataka Highway Act, 1964. The Special Land Acquisition Officer had passed 576 consent awards and the remaining 200 were general awards. 17 community assets such as Ramalingeshwar Temple, Muller Memorial Church, Barikoppa Darga etc. were identified for demolition or relocation, or reconstruction all along the corridor. HDBRTS company officers had visited several times and negotiated for all the community assets. Only two community assets are shifted and renovated and

Table 1: Agencies Involved in the project
Source: HDBRTS Co Ltd

Sl No	Agency Name	Responsibilities
1	Ministry of Urban Development	Funding and Monitoring
2	Sustainable Urban Land Project	Funding and Monitoring
3	World Bank	Funding and Monitoring
4	Global Environmental Facility	Funding and Monitoring
5	State Government of Karnataka	Funding and Monitoring
6	Directorate of Urban Land Transport	Monitoring
7	Hubli Dharwad BRTS Co Ltd	Implementing
8	Karnataka Road Development Authority	Implementing
9	Hubli Dharwad Municipal Corporation	Stake Holders
10	North West Karnataka Road Transport Corporation	Operational agency
11	Centre of Excellence, Urban Transportation CEPT University	Design Consultants
12	LEA associates	PMC for Civil works
13	IBI	PMC for ITS works

they have expressed satisfaction with compensation. Resettlement Action Plan (RAP) was prepared and executed in accordance with the stipulations and guidelines of the Environmental and Social Management Framework of SUTP implemented by GEF, World Bank's Operational Policy on Involuntary Resettlement – OP 4.12, and National Resettlement and Rehabilitation Policy 2007.

3.5 Community Outreach Programme

Community outreach was very essential as BRTS was a completely new concept in the city context. This programme was vital in bringing awareness to the people of Hubbali Dharwad. Project orientation programmes, exhibitions, media workshops and project presentations were given in schools, colleges and institutes. Project logo launch and public consultation workshops are conducted to reach out to the masses. Workshops were conducted with Elected Representatives (MP, MLAs, and MLCs) and Media personnel from Hubbali-Dharwad at Ahmedabad by CoE, UT, CEPT University, to reach out to the public by focusing on the need for system, public transit service levels and expected social benefits. As part of the workshop, Janmarg BRTS rides were conducted for delegates to experience the level of service that can be achieved on a road-based public transit system. The delegates were informed about salient features and components that ensure fast, reliable, safe, high-capacity public transit service. It was highlighted that strong leadership, accountable ownership and public support are required for such mega projects to bring success.

3.6 Environmental Impact Assessment (EIA) & Environmental Management Plan (EMP) – Green BRTS

An EIA report was prepared for the project. Around 4,000 trees were cut for road widening for 8-laning and other infrastructure development. No major impact was envisaged on water bodies except Rayapur pond. EMP was prepared for road and transit infrastructure, indicating mitigation measures for the commencement of works. A total of 25,400 saplings were planted in government buildings, schools, colleges and eco-parks over five years. The planted saplings are geo-tagged and periodically monitored. The survival rate has been checked and is 72%. 5000 saplings are planted along the BRT corridor to make it as sustainable as possible.

3.7 HDBRTS Design and Planning

3.7.1 HDBRTS Corridor

The total length of the HDBRTS corridor is 22.25 km. The width of the cross sections ranges from 44m to 35m. Both the cross sections have 3 to 4 lanes for BRTS and 4 lanes for mixed traffic. The BRTS corridor includes segregated bus lanes, controlled bus stations, off-board ticketing, feeder services, ITS, and high-quality AC buses. The corridor is designed for both regular and express services. It consists of 2 lanes for BRTS buses on either side of the median bus station, facilitating overtaking lanes for express services. The design of the corridor is strategically planned to connect the hotspots of Hubbali-Dharwad. Educational institutions such as engineering colleges, arts and science colleges and government and private higher secondary schools are linked through the corridor. It connects hospitals like cancer hospital, government/private hospitals, government offices, HESCOM, Income Tax Office, Commercial Tax Office, HDUDA, Police Commissioner's Office, and religious establishments. Figure 4 (a) shows the HDBRTS corridor and Figures 4 (b) & (c) show cross-sections for a 35m & a 44m wide road, respectively.

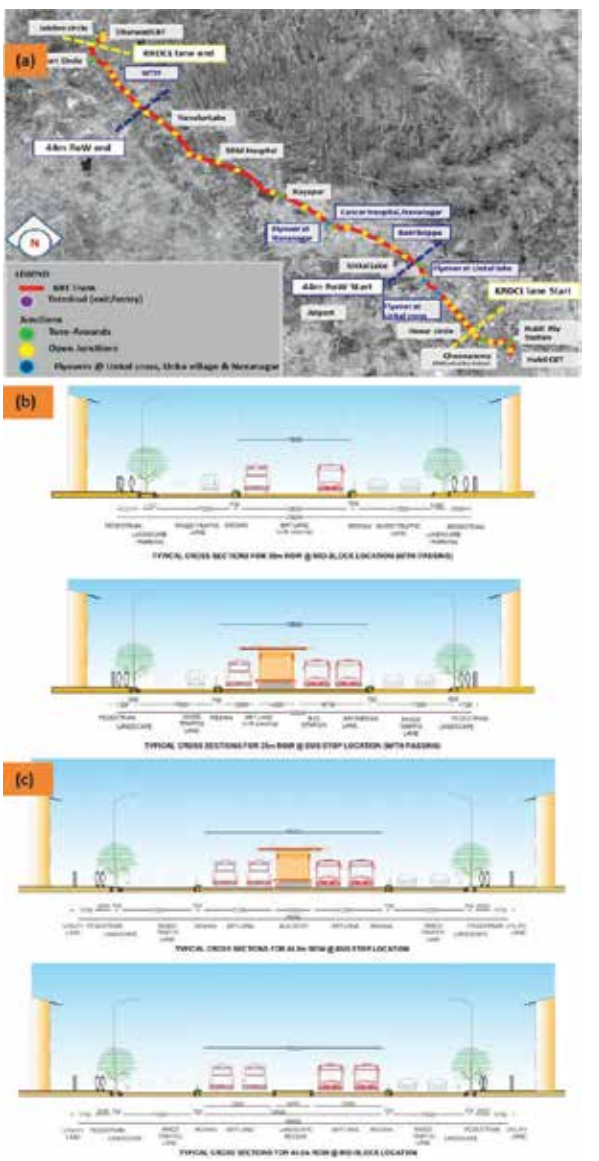

Figure 4 (a) HDBRTS corridor; (b) HDBRTS corridor – 35m section; (c) HDBRTS corridor – 44m section
Source: CoE UT, CEPT University, Ahmedabad

3.7.2 BRT Buses

High-capacity vehicles such as best-of-class AC 12m BRT buses, BS-IV compliant buses meeting UBS-II specifications, are used with multiple doors for quicker movements. On-board Intelligent Transit System for real-time passenger information, In-Bus Public Information System, CCTV Surveillance, PA system and other extensive infrastructure facilities are provided, aiming at the long-term horizon for HDBRTS. Comprehensive route rationalisation with trunk-feeder services helps in route optimisation.

3.7.3 Intelligent Transit System (ITS)

The ITS provides high reliability, convenient access to the bus stations using smart cards and QR tickets, automatic validation by flap-gates and provides seamless travel with all public transport services within the cities, reduction in travel time, real-time information of all the buses with display at bus station locations and terminals. This helps the users to know the estimated time of arrival. The users can avail these services through a mobile or a web-based application.

HDBRTS celebrates one of the most comprehensive transit ITS implementations in the country, which includes:

- Central monitoring of all ITS systems
- Integrated business intelligence module for informed decision making
- Redundant architecture for communications to ensure no single point failures
- End-to-end fiber-optic implementation on the BRT corridor to ensure high-fidelity communications between bus stations and the control room
- Holistic automated fare collection system (AFCS) for all city buses (BRT and non-BRT)
- Automated vehicle locating systems
- Transit management systems.
- Passenger information systems.
- Incident Management System
- City Mobility Centers

3.7.4 Traffic Signals

A state-of-the-art adaptive traffic signal control system is used to facilitate smooth traffic flow. Transit Signal Priority (TSP) is installed to minimise waiting time for BRT buses at intersections.

3.7.5 Violation detection and enforcement

A traffic violation detection system for private vehicles on the BRT corridor is installed to detect the violated rules and regulations. This helps to achieve the desired speed and thereby minimises accidents.

3.8 HDBRTS Road Infrastructure (Figure 5)

The components of Road Infrastructure include:

- Lane Mixed Traffic for 18.84 Km length
- Dedicated 4 Lanes BRT Corridor for 11.75 Km length
- Dedicated 3 Lanes BRT Corridor for 7.09 Km length
- Rail over Bridge (ROB) of 2 Lanes on either side of the existing ROB for 1.32 km length
- 2 Nos of 2 Lane BRT Grade Separators, one 625 meters' length and the other 475 meters' length
- 3 Lane BRT Grade Separator for 824 m length
- Non-Motorised Transport for 11 Km length
- 7 Foot over Bridges and 1 Underpass.
- 24 signalised and 4 non-signalised Traffic Junctions
- 33 Central BRT Bus stations in the Dedicated BRT Corridor.

Figure 5(a) HDBRTS corridor; HDBRTS corridor with 3 Lane BRT Grade Separator
Source: HDBRTS Co Ltd

3.9 HDBRTS Transit Infrastructure

3.9.1 BRTS Stations (Figure 6)

HDBRTS is the first BRT system in India with a Bus Station provision for articulated buses (18m buses). In total, there are 33 bus stations. The design ensures visibility, light, and enough ventilation using half-height automated passenger station doors. There are flap gates at entry and exit points for off-board fare collection through smart card and QR render. Other facilities, such as a PA system, PIS display, CCTV cameras, etc., ensure safety and reliability.

Fully covered stations with seating provisions make the waiting time more comfortable as they are shaded and protected. The average distance between two bus stops is 630m (500m in city limits). 53 existing bus stops have been rationalised to 33 BRT Stations. The central stations are accessed by BRT users through Junctions (21 Stations), through foot-over-bridges (7 stations) and through only mid-block crossings (7 stations). The central stations help to achieve seamless physical interchange, thereby increasing the speed. This increases safety on the edge and serves safety for mixed traffic, helping to ease traffic management. Median bus stations help in rapid alighting and off-board ticket collection aids in controlled access. The width of the station is 4 m with a 900 mm elevated platform to match the floor height of the buses. This helps in easy alighting for the physically challenged and senior citizens. Bus station access by ramps serves the purpose fully. Bus stations are either two or three bays: the standard or 2-bay bus stations are designed to accommodate one articulated or two regular buses on each side and 3-bay bus stations are designed to accommodate two articulated or three regular buses on each side.

Figure 6: (a) HDBRTS corridor with BRT stations location (b) Bus station design for 18m long articulated buses; (c) Bus station with BRT Buses; (d) Bus station Interiors

Source (a) and (b): CoE UT, CEPT University, Ahmedabad; (c) and (d) Author

3.9.2 Foot Over Bridges (FOB)

FOBs have been developed at seven locations to suit high demand, pedestrian movement and safety needs. 4 Half FOBs are constructed for one side only based on the pedestrian demand and three Full FOBs are constructed for both sides. Ramps are provided in almost all the FOBs to facilitate pedestrian movement, along with an elevator for the movement of the specially-abled and elderly persons.

3.9.3 BRT Terminals

Two terminals for BRT buses are constructed at Hubbali and Dharwad. Hubbali CBT BRT Terminal has five BRT bus bays, which manage thirty departures per hour and four NWKRTC city bus bays. Dharwad Mitra Samaj Terminal has six BRT bus bays, which manage sixty departures per hour. It is connected with the Dharwad suburban bus terminal by an FOB.

3.9.4 BRT Depots

Two depots for BRT Buses are provided at Hubbali and Dharwad. Hubbali BRT depot is located beside the Hubbali NWKRTC New Bus Stand with a capacity of 113 buses. Dharwad BRT Depot is located beside the Dharwad NWKRTC New Bus Stand with a capacity of forty buses. Both depots have working bays for standard and articulated buses.

3.9.5 Hosur Interchange (Figure 7)

Hosur interchange is designed to facilitate interchange and connectivity between HBRTS, regional and city services. The 17-acre site development includes a city bus depot, a regional terminal, a feeder bus terminal, an HDBRTS office and control center and an interchange with BRT. A 2.5-acre area was retained for future development of a pay-and-park facility on a Public-Private-Partnership model. The feeder bus terminal has 8 bus bays for feeder service and the regional terminal has 23 bus bays for regional service.

3.9.6 Dharwad Suburban Bus Terminal

The suburban facility is developed over an area of 2.5 acres. The facility consisted of two rows of platforms

Figure 7 : (a) Hosur Interchange; (b) Hubbali BRT Depot
Source: HDBRTS Co Ltd

with 16 bays, an administrative building, a canteen and a driver facility building. It acts as an interchange with the Mitra Samaj BRT terminal and Dharwad CBT.

3.9.7 Divisional Workshop, Hubbali

A divisional workshop developed on 3.9 acres in Hubli is equipped with all the machinery for major repairs/damages. The facility is used by both city service buses and suburban service buses. There are 17 working bays in the facility.

4. HDBRT Bus Operations

HDBRTS bus services are operated by NWKRTC between Hubbali and Dharwad. Operating two types of services (Express & Regular) (Table 2) and six routes, the BRT was commissioned on 2nd October 2018.

4.1 HDBRT Trial Run and Operational Growth

The trial Run began with the service of five buses. As demand for the frequency increased, buses were added to provide the bus service and to ply on the BRT corridor. Fig. 9 (a) and Table 3 show the BRT operational growth. After the successful trial run and operations, HDBRTS was completely operational with 100 buses.

4.2 HDBRT Full Operation

Currently, HDBRTS is operational with 100 BRT buses and with 93 to 96 schedules. Daily run is approximately 26,000 km and a total of 600 trips. Average Cost per Kilometer (CPKM) is INR 72 and Earning Cost per Kilometer (EPKM) is INR 40. The average total revenue per day is around INR 10 Lakhs. Passengers travelling by HDBRTS are 70,000 to 75,000 per day (Table 4). Additionally, 38 NWKRTC

Table 2: HDBRTS Types of service and journey time
Source: HDBRTS Co Ltd

Type of Service	No. of Buses	No. of Stops	Average Journey Time
Express (Limited Stops)	24	07	30-35 Mins
Regular (All Stops)	76	34	45-55 Mins
Total	100	-	-

Table 3 : HDBRTS Operational Growth
Source: HDBRTS Co Ltd

Induction Phase	No. of Buses	Avg. Passenger Travelled per day	Avg. Revenue (in Rs.) per day	EPKM
Phase 1 (Oct-18)	5	1600-1750	6,000-8,000	17
Phase 2 (Oct-2018)	10	3550-4000	15,000-19,000	23
Phase 3 (Oct-2018)	20	9000-9500	90,000-99,000	28
Phase 4 (Nov-2018)	45	16000-17000	1,70,000-1,80,000	30
Phase 5 (Dec-2018)	55	22000-25000	3,00,000-3,50,000	31
Phase 6 (Dec-2018)	70	30000-35000	4,00,000-4,50,000	33
Phase 7 (Dec-2018)	80	35000-40000	5,00,000-5,50,000	34
Phase 8 (Jan-2019)	90	50000-60000	6,00,000-6,50,000	34

and 40 Private buses currently operate in the mixed lanes and carry 35,000 passengers. Both these services are to be withdrawn shortly and 30 BRT buses will be augmented to meet the travel demand. NWKRTC operates 205 buses as the Hubbali Intra City Service and 131 buses as the Dharwad Intra City Service. 70 buses will be used as feeder service as part of HDBRTS.

4.3 HDBRTS Ridership in comparison with other BRT Systems in India

India has Nine Operational BRT Systems. HDBRTS has more passengers per kilometer and Bhopal BRTS has more corridor length. Table 5 shows the BRT Systems in India with respect to corridor length and passengers.

4.4 User Satisfaction Survey (Figures 8 (a) and (b))

HDBRTS has been successful in shifting 18% users from private vehicles. A 19% shift is witnessed from the private bus service operating parallel to the corridor. 77% users are regular users who have work and education purposes for their trips. Over 85% users have rated the system favorably for cleanliness and services.

92% users are satisfied with the available frequency. 89% users agree on the reliability of the In-Bus & In-Station Information System. 85-90% users are comfortable with fare payment and have adapted to it. 90-94% of users feel safe during bus rides, boarding, and alighting, compared to previous services. 36% users indicated that more measures are to be taken for safety at the bus stop.

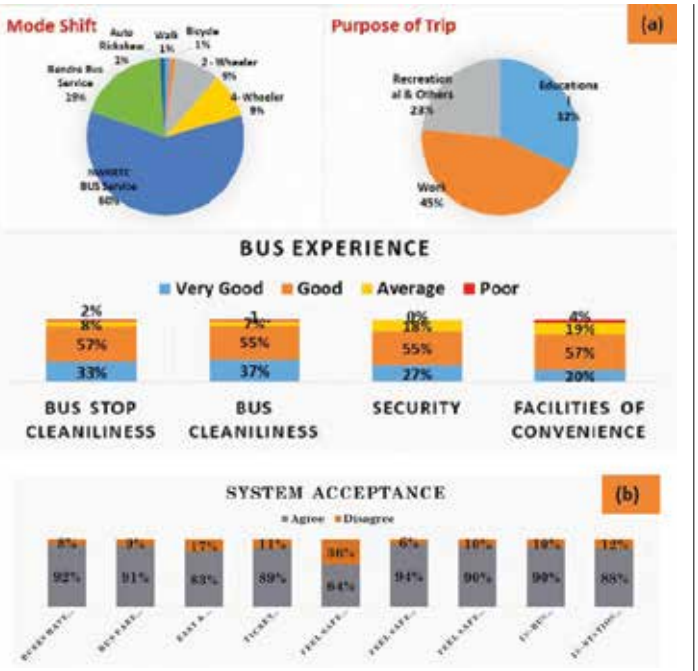

Figure 8 (a) user satisfaction survey data; (b) system acceptance
Source: Author

Table 4: HDBRTS Ridership
Source: HDBRTS Co Ltd

MONTHS	TOTAL PASSENGERS	MONTHLY AVERAGE
SEPT 2019	2380891	79,363
DEC 2019	2255779	72,767
FEB 2020	2021568	72,198
MAR 2021	1276527	42551
MAR 2022	1494576	49819
MAR 2023	1803688	58183
SEP 2023	2206416	73547

Table 5: Ridership of BRT systems in India in 2019
Source: http://brtdata.org/

SI No.	BRT System in India	BRT Corridor Length in Kms	Passengers per Day	Passengers/ Km
01	Ahmedabad	125	1,35,000	1,080
02	Surat	114	1,25,000	1,096
03	Indore	12	50,000	4,167
04	Jaipur	7	6,622	946
05	Pune and Pimpri Chinchwad	61	67,000	1,098
06	Rajkot	11	15,000	1,364
07	Bhopal	186	1,25,000	672
08	Hubbali Dharwad	22	75,000	3,410
09	Amritsar	31	91,000	2,935

4.5 Route Rationalisation (Figure 9)

NWKRTC also runs city bus services in Hubbali and Dharwad. BRT and city buses should act as a single integrated system. BRT acts as a trunk corridor and city buses should act as feeders. This may increase system coverage with adequate frequency in areas not covered by BRT. An integrated high-frequency system would allow easy transfer of passengers. Route Rationalisation with a principle of "Do Minimum" is envisaged. Focus is on organising trunk and feeder routes structure by keeping current routes as they are to the possible extent by retaining, withdrawing, truncating, consolidating, modifying and merging. A route with no significant overlap with the trunk BRT corridor has been retained as it is. A route with predominant overlap (more than 90%) with the trunk BRT corridor has been withdrawn. A route operating in the city network and also overlapping with the BRT corridor has been truncated to remove the overlapping segment along the BRT. A set of routes with predominant overlaps (in the city network) has been consolidated along the city corridor to provide a smaller number of routes but with improved service frequencies. Minor changes in the route to facilitate slight alignment alterations or extensions for turn-around / integrating with BRT have been made. In some cases, small segments of truncated routes have been merged to form new routes. Route Rationalisation implementation is in progress. It is a huge task to implement as most of the city routes have been running for many years. The citizens also have a sense of association and nostalgia, even though the travel demand has reduced or there is a mismatch between demand and supply, they may resist the new development.

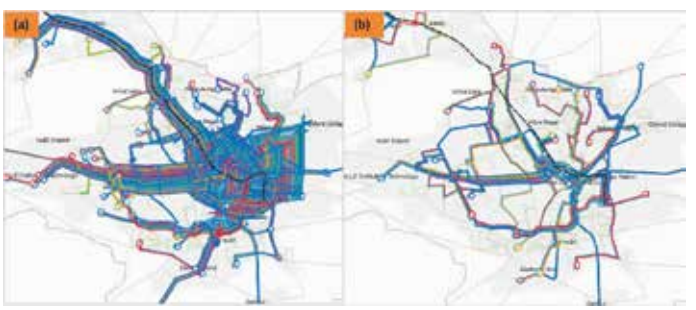

Figure 9 (a) Existing routes structure in Hubbali; (b) Proposed routes structure in Hubbali

Source: CoE UT, CEPT University, Ahmedabad

4.6 Last Mile Connectivity (Figure 10)

Last-mile connectivity has been achieved through comprehensive planning to upgrade pedestrian infrastructure for accessing public transit. Focus was given to disability-friendly design, a comfortable and safe walking environment and enhanced quality of life for all. Paver blocks, street furniture, road

Figure 10 (a) last mile connectivity at Hubbali; (b) last mile connectivity at Dharwad

Source: CoE UT, CEPT University, Ahmedabad

signage, dustbins, lane markings, designated parking, etc. are incorporated in the design. An NMT of 11 km is implemented as a demonstration project. Streets falling within a 1 km radius of public transit have been planned for upgradation in the first phase and 60 km has been identified for this purpose.

5. Challenges Faced

HDBRTS witnessed various problems during its implementation. Land acquisition was a major hurdle, as it received major objections from property owners; many cases had to be resolved by the court. Fixing up consent rates accordingly was a herculean task. Frequent transfers of Managing Directors of HDBRTS Company and NWKRTC hindered the project pace. Also, the project being a new concept, the government officers and engineers were not trained and experienced to deliver the desired results. Coordination with various stakeholders and shifting of utilities had to be taken care of. Since components are dependent on multiple contracts (Civil and ITS) and interdependency of decisions at each level kept adding to the time frame. Managing property access while designing for a safe ride and implementing on hilly terrain with provision of utilities and drainage system along the corridor was also considered. The resistance of locals to environmental impact due to road widening had to be taken into consideration. This initiated the idea of green BRT & inclusion of citizens in EMP to resolve the matter.

6. Conclusion

This research has investigated the restructuring of public transportation in Hubbali-Dharwad with BRTS. If public transportation is not well provided, there will be increased congestion, pollution and carbon emissions in the city, which drastically impacts the city's social and economic conditions. The study helps to understand and design a better BRT System and Transit infrastructure. BRTS in Tier-II cities could bring enormous benefits in the long run. Although HDBRTS is not a profitable venture but in terms of sustainability and providing affordable services to the people, it is highly successful. It needs funding and subsidies from the local government to keep

operating and providing services. Maintenance costs of transit infrastructure should be taken into account while designing and implementing the project so that it does not become a burden to the system. HDBRTS has created a benchmark service providing reliable, dependable, safe and affordable travel to commuters. Implementing the project of this magnitude requires good leadership and political will. The system operation and maintenance are done by NWKRTC, a government entity and experienced in operating bus services for decades. Capacity building and training for officers and staff involved in implementing, maintaining and operating should be mandatory and monitored for better performance. The project requires support from people, institutions and the media. People should own the project and use the service for their benefit. Also, realise that the BRT trunk corridor is not a state highway but an urban road, which will have junctions and there will be speed delays. BRTS is a continuous system and not a project. There will be shortcomings and lacunae in the system and there is always scope to improve and upgrade.

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RESEARCH PAPER

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LULC Changes in Wetlands and Its Impact on Land Surface Temperature

A Case of Thrissur Wetlands

By Ar. Sahadiya Sainab M and Ar. Liza R S

1. Introduction

The increasing urbanisation trend over the decades has resulted in the rapid transformation of land use and land cover (LULC) patterns worldwide. This change acts as a prominent force that alters the local and regional environments. The major consequence includes the degradation and deterioration of resources. Due to the deterioration of the environment and human health, natural and human-induced environmental changes in urban environments are of concern today. In a study by Praveen Lal C.S. and Sajini B. Nair, the state of Kerala recorded the highest increase in urban growth rate for any state in India from 2001–2011. Rapid growth was recorded in Malappuram, Thrissur, Kollam, and Kasaragod districts.

Rapid urbanisation has been achieved through the expansion of urban land uses. Natural land surfaces have been transformed into various impervious surfaces such as roads, buildings, and so on. This approach has resulted in extensive environmental deterioration (Yuan et al. 2018). Such transformations significantly impact the ecological environment, such as wetlands, water bodies, forest cover, and other land uses. Wetlands are generally considered fragile and vulnerable ecosystems that face huge transformations and land alterations. Kerala has the largest proportion of land area under wetlands among all the states of India. Compared to other states of the country, wetlands in Kerala are under severe anthropogenic threats primarily because of high population density and the peculiar distribution of human habitations in the state.

Urbanisation created a boom in the construction industry and a change in settlement patterns. This led to a great increase in landfilling, especially wetlands. Wetlands play a major role in maintaining biodiversity. The degradation of wetlands causes many ecological issues, and it affects the natural ecosystem. It consists of many ecosystems which contribute to the well-being, and it is also referred to as nature's kidney, as they have a great influence in maintaining groundwater level. They have a major role in controlling the microclimate by absorbing heat and increasing evaporation during droughts. Changes in land use and land cover (LULC) can directly harm ecosystems and cause wetland stress by fragmenting them and lowering their quality. In addition to the loss of ecosystem services including ground-water recharge, nitrogen cycling, heavy metal retention, and flood control, the destruction of wetlands directly contributes to the extinction of populations of plants and animals which will lead to the permanent habitat loss.

In Kerala, rivers, lagoons, reservoirs, beaches, ponds, water-logged places, and ponds/tanks make up most wetland types. Ramsar convention is an international treaty which aims at the conservation and sustainable use of wetlands. It entered into force in 1975 and this convention includes protection of

palustrine, riverine, estuarine, lacustrine wetlands and near shore including reefs. According to Ramsar convention, wetlands are defined as : “areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters”. There are 42 Ramsar sites in India, in which 3 are in Kerala designated as an internationally important wetland. This includes the Ashtamudi wetland, Sasthamkotta lake and Vembanad Kol - wetlands. 160590 acres of the total area is covered by these wetlands. Vembanad Kol - wetlands are in Ernakulam, Alappuzha, Kottayam, and Thrissur.

Land Use is human centric that is being practiced on a piece of land that varies with the purpose. This includes food production, shelter, recreation, material extraction and processing, and so on. On the other hand, Land cover is the cover over the land surface which includes soil, vegetation etc. Land cover change indicates the alteration of the vegetation, as well as changes in biodiversity, soil quality, runoff, erosion, sedimentation, and land productivity. The earth’s atmosphere, temperature, and biological processes are all impacted by changes in land use and land cover (LULC). Human activity-induced changes in land cover are a substantial cause and key component of environmental change on a global scale. Maps of an area’s land use and land cover (LULC) give consumers information to aid in understanding the current landscape.

The radiative skin temperature of the land obtained from solar radiation is known as land surface temperature (LST) (AnsarKhan, 2021). LST determines the quantity of thermal radiation emitted from the land surface when incoming solar energy interacts with and warms the ground or canopy surface (AnsarKhan, 2021). Whereas the Normalised Difference Vegetation Index (NDVI is a systematic approach to assess strong vegetation. If the NDVI levels are high, the vegetation will be high.

Previous studies have predominantly focused on wetland depletion and its environmental impacts. This study aims to investigate the LULC changes in the wetlands of Thrissur and their impacts on LST. By analysing the NDVI, the study seeks to identify the existing vegetation cover in the region and explore the correlation between LULC and LST. This research addresses a significant gap in the literature by focusing on the specific impacts of urbanisation on wetland ecosystems and their implications for regional climate and environmental health. The findings will contribute to a better understanding of how urban expansion affects ecological balance and inform future conservation efforts.

1.1 Aim and Objectives

The aim of the study is to investigate the Land Use and Land Cover (LULC) changes and the degradation of wetlands in Thrissur, as well as their impact on Land Surface Temperature (LST). To accomplish this aim, the following objectives were established:

- To evaluate the Land Use and Land Cover changes that have occurred over time.
- To analyse the variations in Land Surface Temperature over the years.
- To examine the relationship between changes in Land Surface Temperature and alterations in the LULC of wetlands.
- To investigate the correlation between LULC and LST.

2. Literature Review

Wetlands are crucial ecosystems that provide a wide range of ecological services, including water filtration, flood protection, carbon sequestration, and biodiversity support (Mitsch & Gosselink, 2007). However, these ecosystems are highly vulnerable to land use and land cover (LULC) changes driven by human activities such as agriculture, urbanisation, and industrial development (Ramsar Convention Secretariat, 2010). Understanding the impacts of LULC changes on wetlands and their subsequent effects on land surface temperature (LST) is vital for sustainable environmental management and policy-making.

Globally, wetlands have been subject to significant transformations due to anthropogenic pressures. Studies have shown that conversion of wetlands to agricultural lands, urban areas, and industrial zones leads to a loss of wetland functions and services (Davidson, 2014). For example, Brander et al. (2013) found that over 50% of wetlands worldwide have been lost since 1900, primarily due to agricultural expansion and urban development.

In India, wetlands cover approximately 4.63% of the total geographical area, with significant variations across different states (Space Applications Centre, 2011). Indian wetlands are under severe threat from LULC changes, driven by population growth, urbanisation, and economic development. For instance, Prasad et al. (2002) reported that wetlands in India have declined by nearly 38% over the past few decades, with major losses occurring in urban and peri-urban areas.

The need for conservation of wetlands is most important for the balance of the ecosystem. As per the study by Kemarau, Ricky & Eboy, Oliver. (2021), LULC change in wetlands influence the temperature of that region. The objective of the study was to examine the influence of land cover change in wetlands and vegetation on land surface temperature between the years 1988 and 2019 in Kuching, Malaysia. Using the Geographical Information System (GIS), changes to land cover and LST change between the years 1988 and 2019 was determined and correlations between LST and the wetland were analysed. The results showed that between 1988 and 2019, the land cover had changed. Wetland and vegetation-covered sections of the land decreased, whereas urban areas grew. The research area's land cover greatly altered the effects of LST. The LST increased as wetland areas decreased. The study also discovered that wetlands and vegetation play a critical role in reducing the impact of the urban heat island effect, which is essential for ensuring and providing a comfortable environment for the residents of Kuching while indirectly reducing the demand for power.

Thrissur, located in the central part of Kerala, India, is known for its rich wetland ecosystems, which include paddy fields, backwaters, and riverine wetlands (Biju et al., 2000). These wetlands play a crucial role in maintaining the hydrological balance, supporting agriculture, and providing habitat for various flora and fauna. However, rapid urbanisation and changes in agricultural practices have led to significant alterations in the LULC patterns in the region (Sreebha & Padmalal, 2011).

The Land use categories were mapped using topography data from 1966 in Neelakantan R's 2013 study on LULC change in the Thrissur district. Paddy, mixed crops, built-up land, coffee, eucalyptus, forests, rubber, teak, land with scrub, Stoney waste, rivers, and water bodies are among the land use practices that are mapped. A close examination of the study area confirms that clay mining operations at the period did not significantly affect land use practices. The region's productive grounds are used for traditional paddy farming. And the study finds the LULC had changed drastically in 2010 when compared to 1966. Thus, this study proves that rapid urbanisation is happening in the Thrissur region. The built-up area has increased, and the area of paddy fields has decreased. Thus, the change in land use pattern shows the degradation of wetlands. In 1966, 21% of the district was paddy fields and in 2010 the area decreased to 13.15%. And built-up area got increased from .62% to 3.15%

From the above studies and literature, the depletion of wetlands and its drivers and impacts are most evident. Major changes in LULC change of wetlands is due to the rapid urbanisation, population growth, lack of awareness and over exploitation of wetlands. Thus there is a need to assess the Land Surface Temperature that happened over the years and compare with the Land Use Land Cover changes, in order to find out the correlation between Land Use Land Cover (LULC) and Land Surface Temperature (LST).

3. Methodology

The LULC changes of wetlands can be assessed using various software such as QGIS, ArcGIS, and Bhuvan. The selected study area was the wetlands of Thrissur. This study was carried out using Bhuvan and ArcGIS, along with other secondary data.

3.1 Macro-Level Analysis

Macro-level Land Use and Land Cover (LULC) changes were carried out using Bhuvan. The study area, which had undergone rapid urbanisation was identified through this process. Various secondary data were collected by referring to several documents and literature, which enabled the assessment of macro-level Land Use Land Cover changes.

3.2 Micro-Level Analysis

Study area was identified by Macro Level Analysis. After identifying the study area, a micro-level analysis of LULC was conducted using ArcGIS software. LULC maps were generated for the years 2005 to 2022 using Landsat images. Specifically, Landsat 7 images were used to generate the maps for 2005 and 2012, and Landsat 8 images were used to generate the maps for 2020 and 2022.

3.3 Generating LST Maps

After generating the LULC maps, the LST maps were generated using the thermal bands. The necessary values for generating the LST maps were brightness temperature and emissivity.

- Brightness Temperature: A measurement of the radiance of microwave radiation rising from the top of the Earth's atmosphere is the brightness temperature.
- Emissivity: The effectiveness of longwave energy re-entering the atmosphere from the surface of the skin is known as emissivity.

To find the brightness temperature, the spectral radiance value was calculated.

- Spectral radiance: It is the radiance of a surface per unit frequency or wavelength, depending on whether the spectrum is seen as a function of frequency or wavelength.

To find out the emissivity, NDVI and Proportion of vegetation are calculated.

3.4 Data Integration and Analysis

Thus LULC, LST and NDVI maps were generated. These maps are compared and correlation between these was identified.

4. Data Analysis and Findings

4.1 Study Area

As per the analysis of the LULC changes in macro level, major wetland depletion happened after 2010. It is mainly in the Puzhakkal wetland region at Thrissur. Further changes in urban built-up are also found on either side of the Thrissur – Kunnamkulam road (Figure 1). Thus, major depletion of wetlands is evident in this region. Therefore, an area in the Puzhakkal region is taken as the study area for my study. This wetland region comes under the Kole wetlands of Thrissur.

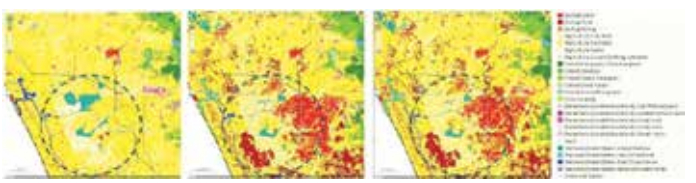

Figure 1: Land Use Land Cover Changes: 2005- 2006, 2011 – 2012, 2015 – 2016
Source: https://bhuvan-app1.nrsc.gov.in/thematic/thematic/index.php

The study area is located in the middle basin of Puzhakkal - North Kole of Thrissur Kole. The site has an area of about 32 Km². The major land use is Paddy. The location is a Ramsar site and an Important Bird and Biodiversity Area (IBA). It provides 40% of Kerala's rice needs and serves as a natural drainage system for Thrissur City and the surrounding district. It is located along the Central 24 Asian bird migration route. When the water table is low in the summer, farming is done in these wetlands, which are inundated during the monsoon. The Kole wetlands are threatened by a number of activities, including mining, sand and clay quarrying, fishing, and the harvesting of aquatic resources (Figure 2).

4.2 Population of the study area

Although the population of the district increased by roughly 3 lakhs every ten years between 1981 and 1991, it increased by just 2.4 lakhs over the last ten years, showing a fall in the district's population

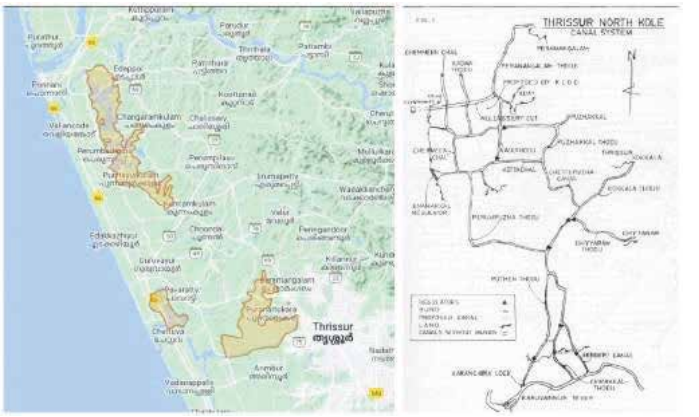

Figure 2: Location Map
Source: https://cess.unical.in/wp-content/uploads/2023/12/CESS-Working-Paper-No.89.pdf

growth rate. Between 1981 and 2001, the overall population increased in Thrissur and Kerala. However, at the same time period, the proportion of population growth is declining in both Kerala and the Thrissur District. It is noticeable that the Thrissur district grows in a manner similar to the state (Figure 3).

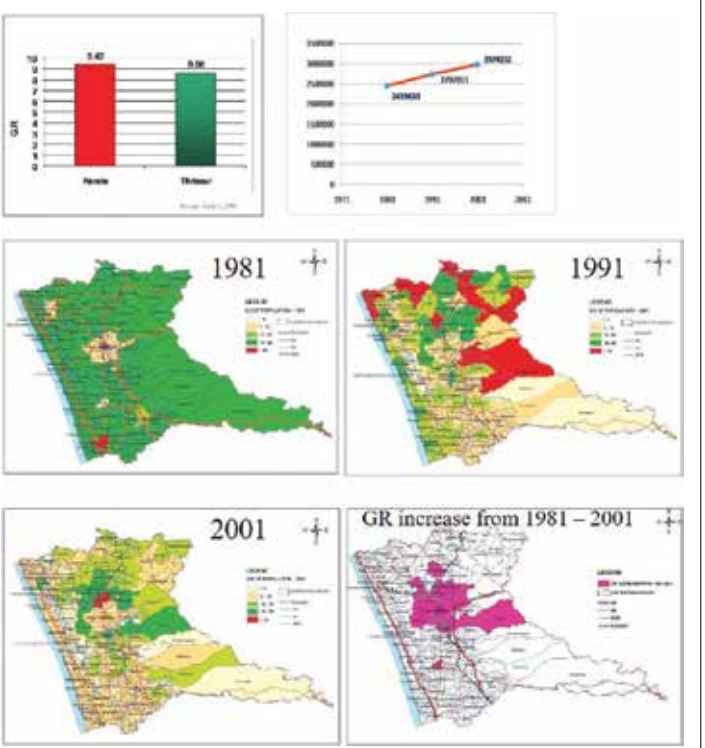

Figure 3: Population and Gross Population Maps
Source: District Spatial Plan, Thrissur, https://townplanning.kerala.gov.in/town/wp-content/uploads/2019/04/dsp_thrissur.pdf

From the study, it is found that the major depletion of wetlands is caused due to population growth, mining, and loopholes in the legal framework. Thus, major drivers for the depletion are population growth, and mining. Due to the pressure on wetlands, state changes are happening such as the loss of ecosystems. Impacts caused are Changes in microclimate, changes

in the water table, groundwater depletion, flooding, etc. Thus, to understand more about the impacts on microclimate, further study must be done such as LST change in the wetland region.

4.3 Micro-level analysis of LULC changes

During the year 2005, some of the lands were converted to built-up lands. And almost 0.4 Km² area of land had undergone conversion. And about 0.16 Km² is built-up land. While analysing the 2012 LULC map, the converted lands have become urban built-up lands. And the area of converted lands and built-up lands had increased to 0.5 Km².

In the year 2020, the urban built-up increased. Converted lands had changed to built-up lands. Thus the change in land use can be seen more evidently. The converted land area increased to 0.55 Km² and built-up area also increased to .55 Km² In 2022, the built-up area increased to 1 Km² (Figure 4). Thus, the depletion of wetlands increased from .01 Km² to 1 Km² gradually within 10 years i.e., 3.1% of wetlands were depleted. If the urbanisation rate increases, more areas will be depleted by 2030.

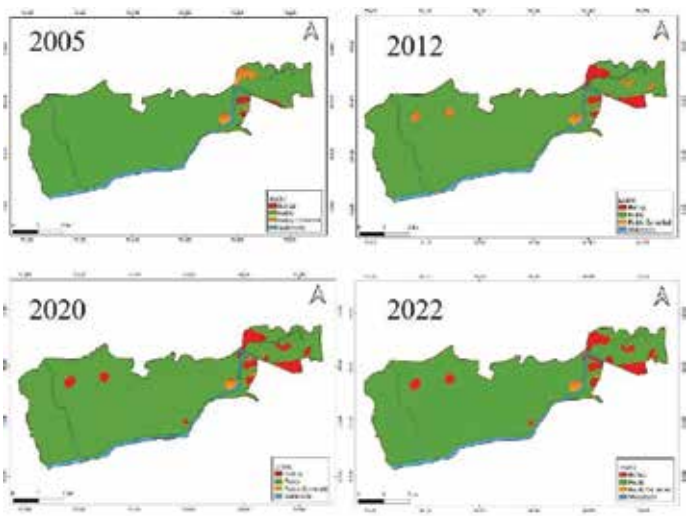

Figure 4: LULC maps – 2005, 2012, 2020, 2022
Source: Author

4.4 Micro-level analysis of LST

As per the LST analysis of 2005, the eastern region was found to have more LST with the highest value of 32.12°C and less LST in the western portion of the study area with the lowest value of

22.29°C. When analysing the 2012 LST map, LST in the eastern portion of the study area has the highest value of 30.59°C and in the western portion with low LST at 21.37°C.

As per the LST analysis of 2020, the eastern region was found to have more LST with the highest value of 32.75°C and less LST in the western portion of the study area with the lowest value of

23.56°C. When analysing the 2022 LST map, LST in the study area increased. The temperature change can be seen in both the eastern portion and the western portion of the study area (Figure 5). The highest value of LST is observed as 30.59°C and the lowest value of LST is observed as15.59°C.

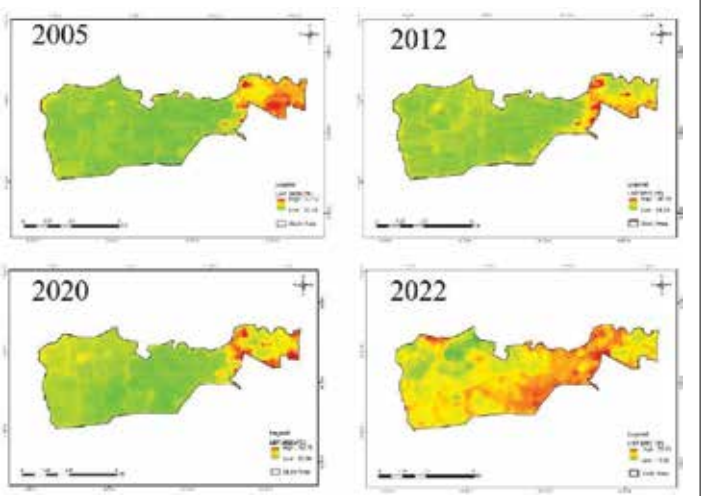

Figure 5: LST maps – 2005, 2012, 2020, 2022
Source: Author

4.5 Micro-level analysis of NDVI

According to the NDVI analysis, in 2005, the vegetation index was high in the eastern portion of the study area and low in other parts of the region. The highest NDVI value recorded was 0.39, while the lowest was -0.74. When analysing the NDVI of 2012, a decrease in vegetation cover was observed in the eastern portion of the site. The highest value recorded in 2012 was 0.28, and the lowest was -0.92.

According to the 2020 map, the NDVI in the study region showed improvement. The lowest NDVI values were observed in the built-up areas and the northwestern portion of the study region (Figure 6). The highest NDVI value recorded was 0.83, while the lowest was -0.04. However, when comparing these values with the 2022 NDVI data, the lowest value increased to 0.00, and the highest value decreased to

0.61. This indicates a decrease in the NDVI within the study region during the year 2022.

4.6 Mean yearly temperature and precipitation analysis

Mean early temperature during the year 2005 was 27.4°C and in 2012 the temperature increased to

27.6°C. While analysing the temperature during 2020 and 2022, the annual temperature increased to

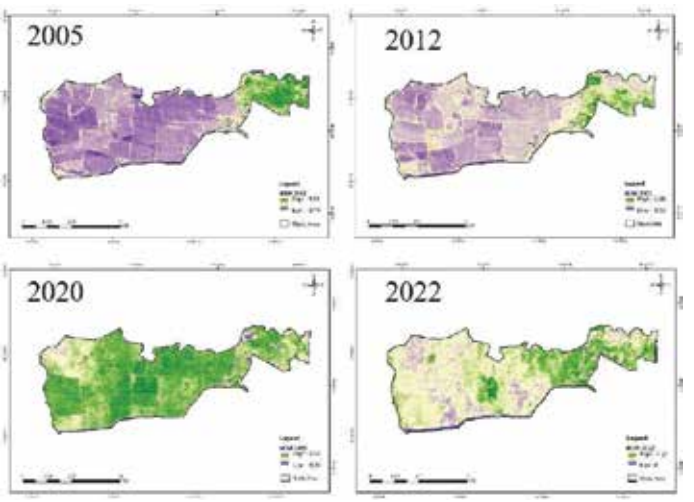

Figure 6: NDVI maps – 2005, 2012, 2020, 2022
Source: Author

28.1°C. Thus between 2005 – 2022, the mean yearly temperature increased by 0.7°C.

By analysing the mean yearly precipitation during the years 2005 – 2022, the less rainfall experienced was during 2012 and 2005 with 2506.3mm and 2162.6mm respectively. Highest rainfall with 3157.3mm was during 2022.

5. Results and Discussion

5.1 Comparative analysis of LULC, LST, and NDVI: 2005 - 2022

In 2005, paddy cultivation was the predominant land use. Approximately 0.4 square kilometers of land were converted for other uses, and 0.1 square kilometers were developed as built-up land. The maximum Land Surface Temperature (LST) observed was 32.12°C, while the minimum was 22.29°C. The highest Normalised Difference Vegetation Index (NDVI) value recorded was 0.39, and the lowest was -0.74. By comparing the maps with the mean yearly temperature and precipitation patterns, it was found that LST was higher in areas near urban settlements. Additionally, the NDVI values indicated low vegetation and drought conditions in the study area during this period.

In 2012, the major land use remained paddy cultivation, with approximately 0.5 square kilometers of paddy fields converted to built-up areas. The maximum Land Surface Temperature (LST) recorded was 30.59°C, while the minimum was 21.37°C. The highest Normalised Difference Vegetation Index (NDVI) value observed was 0.28, and the lowest was -0.92. By comparing these maps with the mean yearly temperature and precipitation patterns, it was found that LST was higher in regions near urban settlements. The NDVI values indicated

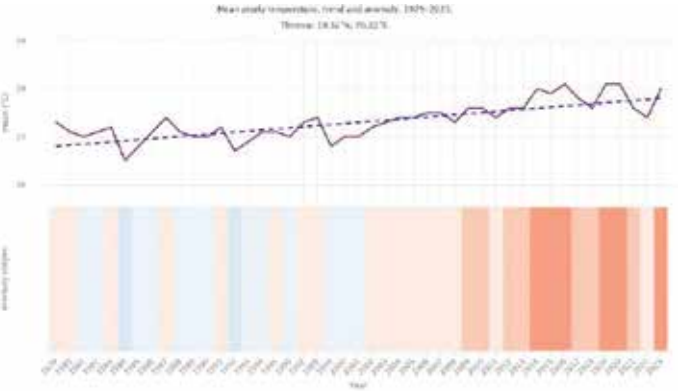

Figure 7: Mean yearly temperature - 1979 – 2022
Source: https://www.meteoblue.com/en/climate-change/thrissur_india_1254187

Figure 8: Mean yearly Precipitation - 1979 –2022
Source: https://www.meteoblue.com/en/climate-change/thrissur_india_1254187

low vegetation, primarily due to reduced cultivation during this period.

In 2020, land use patterns began to change significantly. There was an increase in converted and built-up land by 0.55 square kilometers. This change contributed to a rise in Land Surface Temperature (LST), with a maximum LST of 32.75°C and a minimum LST of 23.56°C recorded during the year. The Normalised Difference Vegetation Index (NDVI) for the study area showed an improvement compared to previous years, with a maximum value of 0.83 and a minimum value of -0.04 observed in certain parts of the area. The increase in vegetation is attributed to the introduction of the Padashekhara Samithi in 2014, which enhanced cultivation and productivity.

In 2022, land use changes became more pronounced, with the built-up area expanding to 1 square kilometer. This expansion was reflected in the changes in Land Surface Temperature (LST), with a maximum observed LST of 35.98°C and a minimum of 15.59°C. The Normalised Difference Vegetation Index (NDVI) value decreased to 0.61 compared to the previous year, with a minimum NDVI value of 0.00. Although the region receives

substantial rainfall, the combination of high mean temperatures and reduced vegetation cover has led to localised warming, impacting the overall climate and ecosystem health.

These above results (Figure 9) indicate that as NDVI values decrease and built-up areas increase, LST also rises. The comparison of Land Use/Land Cover (LULC), LST, and NDVI maps reveals that for every 1 square kilometer loss of wetlands, the LST increases by 3°C

5.2 Future Projection

Based on a study by Khaiwal Ravindra, a temperature increase of 2°C is projected for India by 2050. This rise in global temperature is expected to impact the Land Surface Temperature (LST) in the study area as well. Additionally, the depletion of wetlands by up to 12.5% will significantly contribute to an increase in the region's LST.

By 2050, the Land Use and Land Cover (LULC) will undergo substantial changes, as depicted by the LULC map for 2050. The built-up area, which was 1 square kilometer in 2022, is expected to expand to 4 square kilometers by 2050. Consequently, 12.5% of the wetlands will be depleted. Additionally, approximately 0.98 square kilometers of paddy land will be converted to other land uses. As a result, the LST is anticipated to increase from 35.96°C to 44°C within 2050.

6. Conclusions and Recommendations

The study findings on the depletion of the Puzhakkal wetlands confirm that the degradation of wetlands has been ongoing since 2005. The study area was estimated to have experienced a reduction of approximately 3.1% in vegetation cover, indicating wetland depletion from 2005 to 2022. This led to an average increase in Land Surface Temperature (LST) of 3°C. The built-up area increased significantly in 2022 by 1 square kilometer, and a low NDVI value was recorded during this year, contributing to a peak LST of 35.98°C. The primary causes of wetland depletion have been identified as inadequate legal framework and a lack of awareness.

In conclusion, the study results show a significant association between the decline in healthy vegetation cover (i.e., NDVI) and the rise in LST. Additionally, it has been shown that the rising LST contributes considerably to regional, national, and global warming, which opens the door for the emergence of the Urban Heat Island (UHI) phenomenon both regionally and globally.

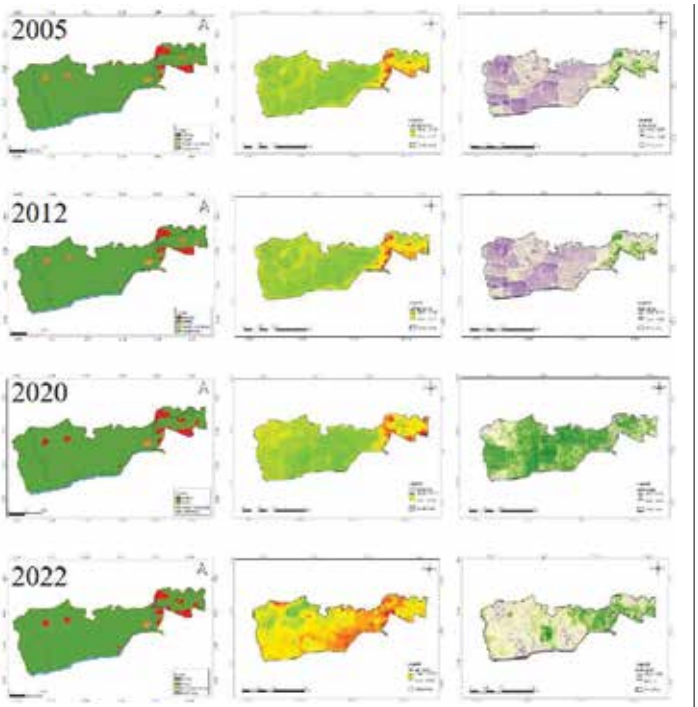

Figure 9: LULC, LST, NDVI map – 2005, 2012, 2020, 2022
Source: Author

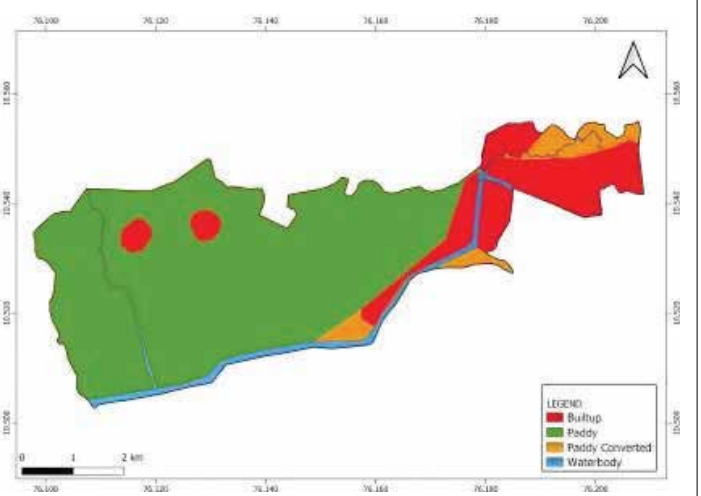

Figure 10: LULC map – 2050
Source: Author

By analysing the LULC changes, it was found that rapid urbanisation has occurred since 2012 and continues to this day. The LST analysis indicates that the temperature is increasing steadily. High LST is observed in areas with low vegetation cover and high built-up areas. Thus, it is evident that wetlands play a crucial role in regulating temperature at the micro level. Therefore, enhancing vegetation cover in wetlands is essential to reduce LST and maintain the ecosystem in the region.

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RESEARCH PAPER

Mapping Gendered Spaces and Women's Mobility

A Case Study of Premnagar Village, Haryana

By Ar. Namita Singh and Dr. Suruchi Modi

ABSTRACT

This study examines the lived experiences of women in Premnagar village, Haryana, by mapping the gendered spaces that influence their daily mobility and sense of agency. Drawing on ethnographic observation, spatial mapping and intergenerational interviews, the research uncovers how public spaces—such as *baithaks* and plinths—are dominated by men and act as informal sites of surveillance, confining women largely to the home and adjacent "safe" areas. Younger women experience a little more freedom, yet remain subjected to the persistent male gaze and restrictive norms. The lack of gender-sensitive infrastructure and entrenched traditions limits women's fuller participation in social and economic life. Despite these challenges, women demonstrate resilience through adaptive strategies and collective hopes for dignity and equity. The findings underscore the urgent need for gender-inclusive design and community engagement, revealing that addressing spatial inequality in rural India is critical for advancing social justice. This work highlights both ongoing barriers and the daily courage of Premnagar's women.

Keywords: Gendered spaces, women's mobility, rural India, spatial segregation

Introduction

The concept of gendered spaces has been widely studied in both urban and rural environments, reflecting how spatial arrangements can reinforce or challenge societal norms related to gender. Gendered spaces refer to areas that are predominantly associated with one gender, often perpetuating existing power dynamics and influencing the behavior, mobility and opportunities available to individuals based on their gender. In many societies, these spaces are not just a physical reality but also a manifestation of cultural practices and social expectations that dictate how different genders interact with their environment.

In rural India, where traditional gender roles are often more rigidly enforced, the delineation of gendered spaces is particularly pronounced. Public areas such as markets, community spaces and streets are frequently male-dominated, limiting women's access and participation in social and economic activities. These gendered spaces have significant implications for women's mobility, autonomy and overall quality of life, as they often face societal pressures and restrictions that confine their movements to specific areas deemed "appropriate" for their gender.

This study focuses on Premnagar village in Bhiwani district, Haryana, to explore the intersection of spatial arrangements and gender dynamics in a rural setting. By examining how space is organised and utilised in Premnagar, this research aims to uncover the socio-cultural factors that shape women's mobility and their access to public and private spaces. Previous studies on gendered spaces and women's mobility (Siwach, 2020; Gupta, 2024) have provided valuable insights into these dynamics in both urban and rural contexts. However, there remains a need to understand how these factors operate in specific rural environments, where the interplay between tradition, space and gender can be particularly complex.

In addition to contributing to the broader discourse on gendered spaces, this study also aims to provide practical insights for designing more inclusive environments that promote gender equity. By mapping the gendered spaces within Premnagar and analysing the patterns of movement and interaction among women, this research offers a detailed case study that highlights the challenges and opportunities for enhancing women's mobility in rural India.

The study is structured around four research questions that clarify the link between spatial arrangements and women's mobility in Premnagar village:

1. **Spatial segregation** – How are public and private spaces organised along gender lines and what boundaries (social or physical) reproduce these divisions?
2. **Mobility patterns** – How do daily movement paths differ across generations of women (grandmothers, mothers, daughters)?
3. **Norms and surveillance** – In what ways do informal surveillance, expectations of propriety and fear shape when, where and how women move?
4. **Inclusive design** – Which context-specific planning interventions can improve perceived and actual safety and broaden women's access to public space?

These questions appear at the end of the introduction to provide a sharp focus and coherence between aims, methodology and findings.

Literature Review

The concept of gendered spaces has been widely examined across various disciplines, revealing how physical spaces perpetuate or challenge societal norms related to gender. In rural contexts, where traditional gender roles are often more deeply entrenched, spatial segregation significantly affects women's mobility, autonomy and access to resources. Research has shown that spatial arrangements reinforce gender inequalities by limiting women's access to certain areas while privileging men. In Mitathal village, Haryana, public spaces such as markets and community spaces are male-dominated, further marginalising women within the community by restricting their participation in social and economic hubs. This spatial exclusion reflects deeper socio-cultural norms about what is considered appropriate for women (Siwach, 2020).

In urban settings, although the environment is more complex, similar patterns of gendered mobility persist. In Banaras, India, women must navigate public spaces by altering their routes and schedules to avoid potential threats, reflecting how social expectations and physical infrastructure shape mobility. These daily negotiations illustrate how urban design and policies can either mitigate or exacerbate spatial inequities. The urban environment presents different challenges, but the gendered nature of space remains constant, as public spaces often reflect societal norms that limit women's autonomy (Gupta, 2024).

Research on the intersection of spatial dynamics and women's mobility emphasises how physical space either facilitates or restricts movement. In Bogotá, Colombia, poorly designed urban areas, such as dimly lit streets, intensify women's fears of violence, further limiting their mobility and participation in public life. This finding aligns with similar studies in rural settings, suggesting that gendered mobility challenges are a universal issue, with contextual variation in the specific barriers (Pucci et. al, 2023). Studies from Gauteng, South Africa, reveal that geography plays a pivotal role in shaping gendered experiences, stating the need for gender-sensitive urban planning that accounts for women's safety and access to transportation (Rubin & Parker, 2023).

The use of digital mapping technologies has provided new methodologies for studying gendered spaces. Digital mapping aids a feminist geographical analysis of how spatial arrangements affect gender dynamics, offering insights that can be applied to urban planning. By making visible the gendered experiences of space, this method allows for a deeper understanding of how physical space is differently experienced by different genders (Fileborn, 2023). Similarly, research on smart cities emphasises the need to integrate gender-sensitive design into technological advancements to avoid reinforcing traditional gender inequalities (Anushka, 2022).

The relationship between gender, work patterns and spatial arrangements has also been a focal point in the literature. Spatial designs can either hinder or facilitate women's participation in the workforce. Studies on Indian cities reveal that gendered spatial policies play a critical role in shaping work patterns, with significant implications for gender equity. These findings highlight the importance of urban design in supporting women's participation in economic activities (Vakulabharanam & Motiram, 2023). Historical research on Renaissance Florence further demonstrates how public spaces have long been used to control women's movements, a practice that continues in different forms in modern society (Rombough & Strocchia, 2022).

The concept of the "geography of fear" describes how women's movements in public spaces are restricted by fears of violence. In Greater Cairo, inadequate infrastructure exacerbates these fears, leading to a significant reduction in women's mobility. This research highlights the importance of addressing both social and physical factors in creating safe and inclusive public spaces (Nasser & Hassan, 2022). Further, urban mobility planning often fails to account for the specific needs of women, underscoring the necessity of more inclusive approaches that prioritise the safety and accessibility of public spaces (Uteng, 2021).

Methodology

This study employs a mixed-methods approach to explore the gendered nature of spaces and women's mobility in Premnagar village, Haryana, by integrating ethnographic observations, spatial mapping and in-depth interviews. Ethnographic observations focus on public spaces such as markets and *baithaks* to examine gendered spatial practices. Spatial mapping, aided by GIS, visualises male- and female-dominated areas and tracks the movement of women across generations. Thirty semi-structured interviews were conducted to explore women's experiences with mobility, safety and social norms. The study also incorporates secondary data analysis and digital mapping as feminist tools to contextualise findings and suggest interventions for inclusive spaces.

Sampling and recruitment. Thirty women residents were selected using purposive, maximum variation sampling to capture the diversity of age, household type and caste. Interviews continued until thematic saturation (i.e., no new themes emerged) and participants were recruited through trusted women's networks to reduce gatekeeping and encourage openness. This sampling rationale prioritises depth of insight over statistical representativeness.

Analytical strategy and triangulation. Interview transcripts were thematically coded using deductive codes derived from the research questions and inductive codes that emerged from participants' narratives. Codes were verified against ethnographic fieldnotes and GIS mapping layers (male nodes, female-friendly lanes and routine paths) to corroborate findings. Descriptive frequency patterns are reported to complement qualitative interpretation and movement traces are interpreted in relation to mapped visibility and surveillance.

Results and Findings

The study's findings reveal a complex interplay between gender, space and societal norms in Premnagar village, highlighting how spatial arrangements both reflect and reinforce gendered power dynamics. The analysis of ethnographic observations, spatial mapping and interviews provides a detailed understanding of the ways that constrain women's mobility and how certain spaces are gendered, influencing who has access to public and private areas.

Quantitative/Comparative Addendum

To enhance data analysis, descriptive frequencies were calculated from coded interviews (N = 30). Table 1 below summarises how often key themes were mentioned. Illustrative quotes (Q#) correspond to specific interview excerpts (not reproduced here) and may be cited in the main text. Table 2 compares behaviors across generations, expressed as the percentage of women within each generation who

Table 1 – Frequency of key themes in interviews (N = 30)
Source: Authors

Theme	Count (n)	Share (%)	Quote ID
Informal surveillance at *baithaks*/plinths	24	80	Q1
Route avoidance of male nodes	26	86.7	Q2
Daylight-only travel (self-imposed curfew)	21	70	Q3
Escort required (male or group)	15	50	Q4
Experienced harassment (any)	12	40	Q5
Feels safer in lanes near home	24	80	Q6

Table 2 – Mobility behaviors by generation
Source: Authors

Behavior	**Grandmothers (%)**	**Mothers (%)**	**Daughters (%)**
Avoids the *baithak* zone	100	90	70
Daylight-only travel	100	80	60
Ever harassed	10	15	50
Uses back lanes	80	70	60

reported the behavior. This generation comparison highlights how mobility constraints vary with age cohort.

1. Gendered Spatial Segregation

As shown in Figure 1, men used spaces during the day. These spaces are along main roads within the settlement. Figure 2 maps male congregation points (e.g., the *chaupal*, *baithaks*, raised plinths) and sight-lines between them. The network of lines reflects how men occupying these nodes can observe multiple paths, reinforcing surveillance.

Figure 1: Male-Dominated Spaces in Premnagar Village
Source: Authors

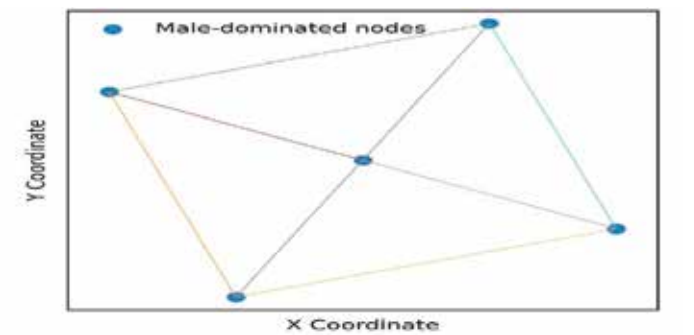

Figure 2 – Male-dominated nodes and sight-lines
Source: Authors

The spatial mapping of Premnagar village reveals a clear division of spaces along gender lines. Public areas such as plinths and *baithaks*, which are central to social life in the villages, are predominantly male-dominated. As seen in Figure 1, these spaces serve as gathering points for men, where they engage in recreational activities such as playing cards, smoking hookah and socialising. These activities are not just social but also serve as a form of informal surveillance, where men monitor the movement of individuals, particularly women, within the village. This surveillance creates a gendered space that is largely inaccessible to women, who tend to avoid these areas due to the scrutiny they face.

In contrast, as seen in Figure 3, the spatial mapping identified certain areas, particularly narrower streets and spaces adjacent to homes, as being more accessible to women. These spaces are often

Figure 3: Female-Dominated Spaces and Safe Movement Areas in Premnagar Village
Source: Authors

perceived as safer because they are frequented less by men and are closely monitored by women themselves. However, these areas are also limited in scope and do not allow for significant interaction with the broader community. As a result, women's movements are largely confined to these "safe" spaces, reinforcing their exclusion from the more central, male-dominated areas.

As shown in Figure 3, the entrances to female-dominated spaces are narrow, which is in relation to security. In Figure 4, female-frequented spaces (e.g., door-front areas and narrow lanes) are shown as discrete points, while dashed lines represent safer back-lane corridors that women use to avoid male-dominated areas. The map illustrates the fragmented nature of women's accessible space.

2. Generational Differences in Women's Mobility

The study found significant generational differences in how women navigate and experience space within Premnagar village. As seen in Figure 3, Older women, particularly grandmothers, have very restricted mobility, with their movements largely confined to their homes and immediate surroundings. This limited mobility is deeply rooted in traditional norms that dictate that older women should not be seen in

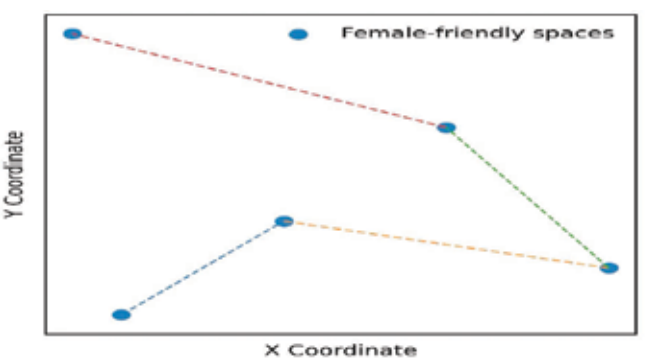

Figure 4 – Female-friendly spaces and safer movement corridors
Source: Authors

public spaces, particularly those dominated by men. Their interaction with public spaces is limited to essential activities, such as fetching water or visiting the local temple and even these activities are carried out during specific times of the day when men are less likely to be present.

Younger women, especially daughters, exhibit slightly more mobility, often extending their movements to schools, local shops and occasionally the homes of friends or relatives. However, their mobility is still heavily constrained by social norms and the pervasive male gaze. The study found that young women are acutely aware of the informal surveillance conducted by men in public spaces and often alter their routes or avoid certain areas altogether to minimise interaction with men.

Figure 5 depicts the Average daily activity radius (approximate kilometers) plotted for three generations. Older women rarely travel beyond 0.5 km from home, whereas mothers reach about 1 km and daughters about 1.5 km. The bar graph visualises how mobility increases with each successive generation, yet remains limited. As shown in Figure 6, the depiction of the movement pattern in the settlement of females across generations.

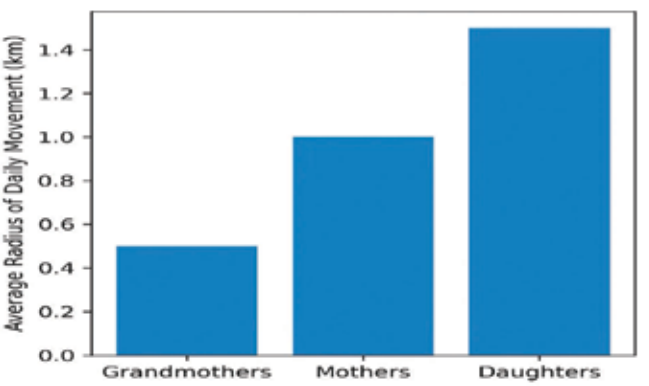

Figure 5– Generational patterns of women's movement radius
Source: Authors

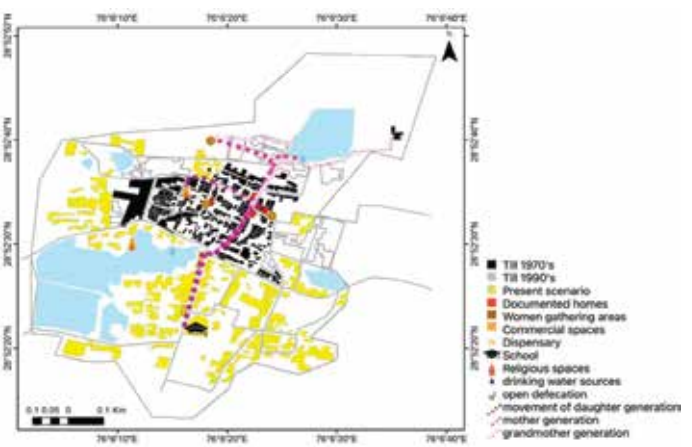

Figure 6: Map of Movement Patterns among Different Generations of Women in Premnagar Village
Source: Authors

3. The Role of Surveillance in Shaping Women's Mobility

Surveillance, both formal and informal, plays a significant role in shaping women's mobility in Premnagar village. The study found that male-dominated spaces, such as *baithaks* and public plinths, function as informal surveillance points where men monitor the movement of women throughout the day. This constant scrutiny not only limits where women can go but also influences when they can move about the village. For example, many women reported feeling uncomfortable passing by *baithaks* during peak social hours (late morning and early evening) when they are the most occupied with men.

This surveillance creates an environment of fear and caution, where women are continuously aware of being watched and judged. As a result, women in Premnagar are more likely to confine their movements to spaces that are not visible from these male-dominated areas, further reinforcing the gendered segregation of space within the village.

4. Socio-Cultural Norms and Restricted Mobility

The study reveals that socio-cultural norms highly influence women's mobility in Premnagar village. Traditional gender roles dictate that women should prioritise household responsibilities and limit their engagement with public life. These norms are particularly stringent for older women, who are expected to adhere strictly to traditional practices that confine them to the home.

Younger women, while slightly more mobile, still face significant restrictions. Social expectations about modesty, propriety and the potential for gossip discourage young women from frequenting public spaces, particularly those associated with men. These norms are reinforced by the older generation, who often police the behavior of younger women, ensuring that they conform to established gender roles.

5. Impact of Physical Space Design on Gendered Mobility

The design and organisation of physical spaces in Premnagar village play a crucial role in shaping gendered mobility. The study found that areas with better visibility, such as open streets and spaces near homes, were more accessible to women, while enclosed or semi-enclosed spaces, like *baithaks* and certain public plinths, were predominantly male-dominated. This spatial organisation creates physical barriers to women's mobility, limiting their access to key areas of social and economic interaction.

Furthermore, the lack of gender-sensitive infrastructure, such as adequate public restrooms and well-lit pathways, exacerbates the challenges women face in navigating public spaces. These deficiencies make it difficult for women to feel safe and comfortable in public areas, further restricting their mobility.

6. Digital Mapping Insights

The use of digital mapping in this study provided valuable insights into the spatial dynamics of gender in Premnagar village. By visualising the gendered distribution of spaces and movement patterns, the study identified specific areas where interventions could be made to enhance women's mobility. For instance, areas with poor visibility and high levels of male surveillance were identified as key targets for redesign, potentially transforming them into more gender-inclusive spaces.

7. Comparative Analysis with Urban Studies

The findings from Premnagar align with similar studies conducted in urban contexts, such as those by Pucci et al. (2023) and Rubin & Parker (2023), which highlight the impact of spatial design on women's perceived safety and mobility. However, the rural context of Premnagar presents unique challenges, particularly in terms of deeply ingrained socio-cultural norms that are less prevalent in urban areas. This comparative analysis underscores the need for context-specific approaches to addressing gendered spaces and mobility while addressing the distinct challenges faced by women in rural environments.

Actionable Policy Recommendations (Implications)

1. **Lighting for safety** – Install solar street lights at identified "fear spots" and along **school–home** and **market–home** corridors; maintain clear sight-lines by trimming vegetation.
2. **Safe pedestrian links** – Pave and widen the back-lanes most used by women; add reflectors and wayfinding markers; ensure barrier-free access for elders and people with disabilities.
3. **Women-friendly communal space** – Create a centrally located, well-lit community courtyard reserved for women and families, equipped with seating, shade and toilets and used for self-help group meetings, skills classes and health services.
4. **Gender-sensitive facilities** – Provide clean, secure public toilets with lighting and running water near the market and temple; include bins for menstrual hygiene disposal.
5. **Mobility options** – Pilot a woman-focused e-rickshaw or shuttle service at fixed hours (school runs and market days) and promote girls' bicycle access with safe parking at the school and market.
6. **Community norms and oversight** – Facilitate sensitisation dialogues with the Panchayat, elders and youth; establish a mixed-gender community watch and a simple reporting protocol for harassment; run annual safety audits using participatory mapping.
7. **Women in planning** – Form a Village Women's Council to co-prioritise lighting, paths and facilities and to monitor their implementation.
8. **Implementation and monitoring** – Work with local government to integrate gender-sensitive infrastructure into village development plans and track progress through annual reports.

Discussion

The evidence shows that patriarchal power relations are materially embedded in Premnagar's spatial fabric: male congregation nodes centralise sociability and surveillance, while women's presence is relegated to peripheral, discontinuous lanes. This corresponds with feminist geographic arguments that space is produced through power relations and aligns with the literature on the "geography of fear," where fear and the male gaze reshape women's routes and timing. Norms of propriety and restrictions on women's movement interact with physical conditions such as lighting and path quality. Addressing only social norms or infrastructure will not suffice; both need to be addressed together. The generational comparison highlights incremental shifts in mobility – daughters travel further than their mothers or grandmothers – yet surveillance and fear continue to constrain them. A sustained effort involving community dialogue, inclusive planning and targeted infrastructure improvements is therefore essential for durable change.

Conclusion

This study has provided an in-depth exploration of the gendered spatial dynamics in Premnagar village, Bhiwani district, Haryana, highlighting the significant impact of spatial arrangements and socio-cultural norms on women's mobility. Through a combination of ethnographic observations, spatial mapping and interviews, the research has uncovered how public and private spaces in the village are distinctly gendered, leading to the restriction of women's access to key areas of social and economic life.

The findings reveal that male-dominated spaces, such as plinths and *baithaks*, function as centers of social activity and informal surveillance, creating environments that are largely inaccessible to women. This surveillance not only limits where women can go but also dictates when they can move about the village, reinforcing traditional gender roles that confine women to more private, domestic spaces. The study also identifies generational differences in mobility, with younger women exhibiting slightly more freedom of movement than older generations, while still facing significant constraints due to societal expectations and the pervasive male gaze.

The study's insights emphasise the crucial role of spatial design in either reinforcing or challenging gender inequalities. In Premnagar, the lack of gender-sensitive infrastructure, coupled with deeply ingrained social norms, contributes to the continued segregation of space along gender lines. To address these issues, the research suggests the need for targeted interventions that focus on both the physical and social dimensions of space. This includes improving public infrastructure, such as lighting and safe pathways, as well as fostering community initiatives that promote greater gender equity and challenge traditional gender norms.

The broader implications of this research extend beyond Premnagar, offering valuable lessons for understanding and addressing gendered spaces in rural India and similar contexts. By integrating gender-sensitive approaches into spatial planning and rural development policies, it is possible to create more inclusive environments that support women's mobility and participation in public life. Additionally, the use of digital mapping and other technological tools can aid in making gendered spatial inequalities more visible and actionable for policymakers and planners.

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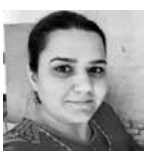

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RESEARCH PAPER

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Understanding the Material Fabric of Kalidas Jethabhai House (KJH) through the Characterisation Process

By Ar. Rathod Jigar Ajaybhai, Er. Nigar Shaikh and Dr. S Thirumalini

ABSTRACT:
Understanding the durability and resistance of building materials in historical structures involves examining their response to various environmental conditions and the chemical reactions within their molecular structure. These reactions can either enhance or weaken the material depending on its composition, making material characterisation vital for effective conservation efforts. In this study, mortar and brick samples were collected from two locations: one of the two wings of the house rear wing, from where most of the materials were dismantled due to the dilapidated condition of the structure, and the material shed where all the dismantled materials were stored. Adhering to established protocols, these samples were carefully documented and analysed using advanced techniques. Field X-ray fluorescence (XRF), field emission scanning electron microscopy (FE-SEM) and Fourier-transform infrared spectroscopy (FT-IR) were employed to assess the microstructure, composition and quality of the samples, including the binder-to-aggregate ratio. The mortar samples revealed a binder composed of 26% clay minerals, primarily calcium, with a binder-to-aggregate ratio of 1:2.83 and 1:2.54, as determined by acid loss analysis. FT-IR analysis detected organic components while FE-SEM identified degraded products like syngenite and gypsum, indicating deterioration. The presence of calcite, silicates and hydrothermal products such as gyrolite and okenite was noted. Field XRF and FT-IR also showed the presence of titanium which helps prevent algae growth on fired clay bricks and mud mortar. The findings highlight the good bonding quality of some samples as confirmed by modern analytical techniques. This research supports the development of compatible repair materials for conservation and provides valuable insights for sourcing materials in contemporary construction projects.

Keywords: Material Characterisation, Historical Structures, Binder-to-Aggregate Ratio, Analytical Techniques, Conservation Materials

1. INTRODUCTION

The historic settlement of Dharmaj, known for its dense vernacular architecture and influences from neoclassical, art deco and colonial styles, reflects a rich cultural heritage despite challenges such as migration and abandonment. The Kalidas Jethabhai House, a notable example of timber-lashed brick masonry construction, has experienced significant neglect and structural damage over time. This has led to a mix of traditional materials such as timber, lime and mud with modern interventions like cement.

The house features two wings around a central courtyard: Wing (1) is a ground-plus-one-storey structure facing the road, while Wing (2) is a ground-plus-two-storey structure at the rear. Recent efforts by the institutional team involved safeguarding Wing (1) and dismantling the severely deteriorated upper storey of Wing (2), ensuring careful preservation of materials for future restoration (Figure 1).

Figure 1: Image showing the Kalidas Jethabhai house demarking the wing 01, courtyard and wing 02
Source: Author

The purpose of this research is to analyse the material composition of the Kalidas Jethabhai House through a detailed characterisation process. This study aims to provide a comprehensive understanding of the materials used in the context of Dharmaj, focusing on vernacular materials such as mud and lime. By studying these materials—typically naturally available and long-lasting—the research will offer insights into their physical, mechanical and chemical properties along with the traditional design mixtures. This analysis will be crucial for developing effective conservation and repair strategies, including a detailed examination of mineralogical composition, binder-aggregate ratios and carbonation processes. The findings will provide valuable guidance for researchers and conservation professionals on material compatibility for future interventions and assist in the restoration of similar historic structures.

1.1 Aim and Objectives

The aim of this research is to assess the characteristics of the masonry materials used in the construction of the Kalidas Jethabhai House in order to develop a compatible repair material. The research will document and map the various materials used in the structure over time, focusing on identifying their chemical, physical and mechanical properties. It will explore the role of these materials through characterisation processes to develop compatible materials for conservation and repair. Additionally, the study will examine how different binding materials affect the properties of the masonry, aiming to provide insights for selecting appropriate materials and ensuring the structural integrity and longevity of similar historic buildings.

1.2 Scope and Limitations

By producing and analysing test samples according to established codes, this research will aid in developing compatible materials for conservation and support similar studies on historic structures. The study of the structure is constrained by available stakeholder input, references and materials, and the historic building's materials may have altered properties due to long-term weathering. The research findings will be applied to the Kalidas Jethabhai House and similar structures, though results may vary based on the tools and tests used, which are conducted at the CEPT Conservation Laboratory and VIT Laboratory.

2. LITERATURE REVIEW

In Gujarat, mud and wood have historically been key construction materials, with wooden architecture being especially prominent in the central and northern regions due to the availability of local and overseas wood sources. The vernacular architecture of Gujarat features mud houses, timber and wattle houses, stone houses, half-timbered houses and brick houses, with wooden framing being prevalent from 1600 to 1900 A.D. before the emergence of colonial hybrid structures (Pramar, 1989).

2.1 Brief on Dharmaj and Kalidas Jethabhai House

The design and structure of a city or town significantly influence its identity and foster a sense of attachment and pride among its inhabitants. In Dharmaj, the impact of migration has introduced various architectural and technological influences which current residents have endeavoured to preserve. Consequently, the town's urban layout showcases a blend of global trends from different eras, reflected in its diverse architectural styles.

The building spaces in Dharmaj, used for social and cultural events, engage the community and connect them with other khadkis or the wider society. The Kalidas Jethabhai House is particularly significant as it represents one of the architectural typologies found in the village, constructed with locally available materials such as timber, bricks and mud-lime mortar, and reflects regional architectural styles and historical context.

2.2 Understanding the material characterisation need

Each material used in historic buildings has distinct physical, chemical, mechanical and mineralogical properties that influence its function and structure. In conservation and regeneration, understanding these properties is crucial for appropriate material utilisation and placement. Proper bonding of

different materials can significantly impact the preservation of historic structures, making the study and characterisation of historic materials essential for developing compatible repair materials.

Historic buildings hold immense architectural, social, economic, cultural and associational value, necessitating their careful preservation. Architectural value, which includes construction techniques, materials and styles, is vital for maintaining the building's original character. To effectively conserve or restore these structures, a deep understanding of the materials and structural systems is required. Producing compatible materials ensures that the building retains its original physical and mechanical properties while meeting standards for strength, durability and weather resistance (De la Torre, 2002).

The conservation of historic buildings is a complex process that relies on scientific testing to achieve optimal results. Materials exhibit unique properties and behaviours that change over time, making thorough testing essential before undertaking repairs or restoration. This approach ensures that conservation efforts address the specific needs and strengths of each material effectively (Harries, 2019).

Material characterisation is key for successful repairs, as new materials must match the old in visual, physical, mechanical and chemical properties while offering enhanced durability. They must also align with the technical characteristics of both the historic and surrounding materials, considering the effects of weathering. Furthermore, the new material should not surpass the strength or rigidity of the original to prevent disrupting the building's structural equilibrium (Bais Sangeeta, 2018).

3. METHODOLOGY

The study of the Kalidas Jethabhai House and the Dharmaj structure begins with a detailed examination of their histories and materials, including the identification of related structures and materials along a timeline. Documentation of the structure involves creating comprehensive plans, sections, elevations and detailed material mapping. This is followed by exploring and understanding various characterisation methods such as field X-ray fluorescence (XRF), field emission scanning electron microscopy (FE-SEM), Fourier-transform infrared spectroscopy (FT-IR), wet chemical analysis and developing a framework for testing.

Field visits are conducted to identify and mark samples of materials representative of areas undergoing deterioration, decay or repair work on the drawings. Testing is carried out at two different institutes, with results analysed to create compatible materials for the Kalidas Jethabhai House (Figure 2).

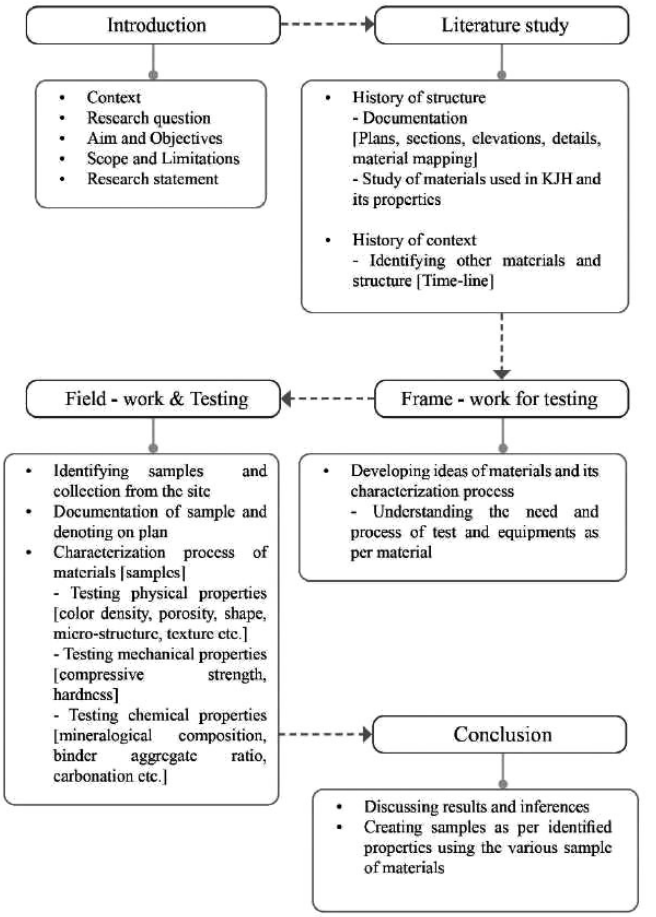

Figure 2: Research methodology
Source: Author

A total of four samples were tested for the analysis, including bricks and mortar collected from the inner core and outer surface of the wall (Table 1).

To perform the modern analytical testing, field XRF, FE-SEM, FT-IR and wet chemical separation techniques were used. All the samples were ground using appropriate equipment such as a sieve, chisel, hammer and pestle, and were prepared as per the code for individual testing.

Field XRF (X-ray fluorescence): This method is primarily used to determine the atomic or molecular composition of the collected samples. All the samples were tested using this technique. Field emission scanning electron microscopy (FE-SEM): This technique is used to study the morphology of the sample surface.

Fourier-transform infrared spectroscopy (FT-IR): This method is mainly used to identify the mineral phases of the sample.

Wet chemical analysis: This technique is used to determine the binder-to-aggregate ratio in the sample.

4. DATA ANALYSIS AND FINDINGS

All the samples collected from the Kalidas Jethabhai House, as listed in Table 1, have undergone characterisation tests to identify their properties and for further analysis.

4.1 Field XRF (X-ray Fluorescence)

To determine the crystalline nature and composition of the lime–mud mortar and brick powder, an X-ray diffraction (XRD) analysis was conducted on the sample.

a. DMJ/KJH/Mortar/02

Upon conducting an elemental composition analysis of the sample, it was observed that it comprised 17.8% calcium (Ca) and 11.9% silicon (Si). These results indicate the presence of lime content and other pozzolanic material, which are crucial components of lime mortar. Additionally, aluminium (Al) and iron (Fe) were also present in the sample. Furthermore, the sample contained other elements, the details of which are provided below (refer to Table 2 and Figure 3a).

b. DMJ/KJH/Mortar/04

The sample designated as mud mortar exhibits a higher concentration of silicon (Si), as expected. The presence of potassium (K) in the sample suggests naturally occurring organic components. The sample also contains low to medium levels of potassium oxide, which is conducive to achieving the desired compressive strength (de Pádua, 2022). Furthermore, the sample contains other elements, the details of which are provided below (refer to Table 3 and Figure 3b).

c. DMJ/KJH/Brick/10

The sample under analysis was derived from a fired clay brick and exhibited a relatively high silicon (Si) content. The sample also contained structural iron (Fe) with a value of 1.91, which has a significant impact on the chemical and physical properties and behaviour of the inorganic fraction of natural soils and sediments (Stucki, 2006). Moreover, the presence of titanium (Ti) in the form of titanium dioxide (TiO_2) has the potential to disrupt the bonds between microorganisms and the substrate. Consequently, it is used to prevent algal growth on fired clay bricks (Graziani, 2014). Furthermore, the sample contained

Table 1: Sample name/code and type
Source: Author

DMJ/KJH/Brick/10	Brick
DMJ/KJH/Mortar/01	Mortar
DMJ/KJH/Mortar/02	Mortar
DMJ/KJH/Mortar/03	Mortar

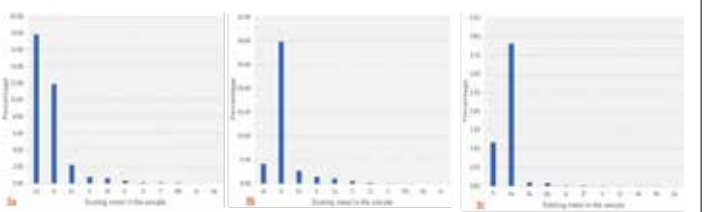

Figure 3(a) Field XRF sample: DMJ/KJH/Mortar/02; 3(b) Field XRF sample: DMJ/KJH/Mortar/04; 3(c) Field XRF sample: DMJ/KJH/Brick/10
Source: Author

Table 2: Available element in the sample DMJ/KJH/Mortar/02
Source: Author

Ca	17.8	S	0.1	Zr	0.007	As	0.002
Si	11.9	P	0.097	Ni	0.006	Y	0.002
Fe	2.2	Mn	0.076	Rb	0.005	Cd	0.002
K	0.78	Sr	0.032	Zn	0.004	Cu	0.001
Al	0.64	Ba	0.02	Ag	0.003	Nb	0.001
Ti	0.33						

Table 3: Available element in the sample DMJ/KJH/Mortar/04
Source: Author

Al	4.14	Cl	0.16	Zr	0.008	Cr	0.002
Si	29.8	S	0.076	Rb	0.006	Ag	0.002
Fe	2.63	Mn	0.037	Zn	0.004	Y	0.001
K	1.44	Ba	0.034	V	0.004	Br	0.001
Ca	1.07	Sr	0.018	Ni	0.004	As	0.001
Ti	0.51						

other elements, the details of which are provided below (refer to Table 4 and Figure 3c).

4.2. Field Emission Scanning Electron Microscopy (FE-SEM)

a. DMJ/KJH/Mortar/02

In the FE-SEM spectrum, along with $CaCO_3$, other elemental oxides such as Mg, Al, Si, K and Fe were found. These elemental compositions indicate a pozzolanic nature and assist in various stages of the lime process by increasing workability or aiding carbonation. (Refer to Tables 5 and 6)

In the FE-SEM spectrum 18 (Table 6 and Figure 4), the clay (Si) content in the sample was found to be almost similar to calcium (Ca) in the form of the elemental oxide, which possibly indicates a higher proportion of clay in the lime mortar. The texture visible in spectrum 25 (refer to Figure 5) shows mud and other formations, and the observed layering can be identified as lime carbonation.

b. DMJ/KJH/Mortar/03

In the FE-SEM spectrum 1, along with the clay content, signs of Ca (lime) were also found. The identified Na and Cl highlight the presence of salt in crystalline form, indicating that the sand used in the preparation of the mortar sample might have been collected either from a river or a seashore in the nearby area. In spectrum 2, carbon (C) is absent and the silica content is higher compared to spectrum 1 (refer to Table 8 and Figure 5).

In spectrum 5 (refer to Table 9 and Figure 6), the presence of titanium (Ti) in the form of titanium dioxide (TiO_2) has the potential to disrupt the bonds between microorganisms and the substrate.

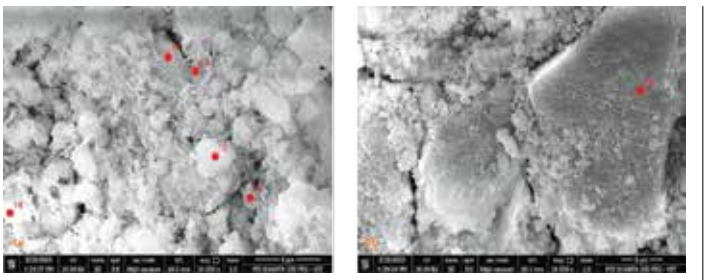

Figure 4(a) FE-SEM image showing spectrum for marked location (sample DMJ/KJH/Mortar/02); 4(b) FE-SEM image showing spectrum for marked location (sample DMJ/KJH/Mortar/02)
Source: Author

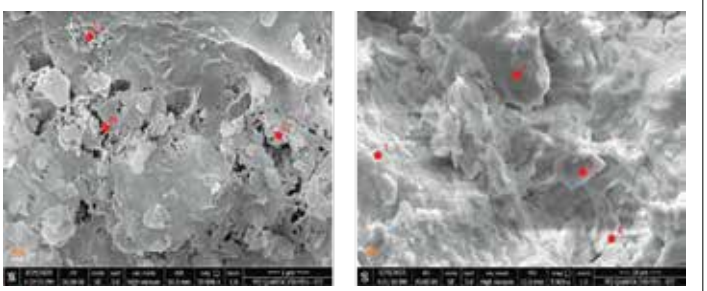

Figure 5(a) FE-SEM image showing spectrum for marked location (sample DMJ/KJH/Mortar/02); 5(b) FE-SEM image showing spectrum for marked location (sample DMJ/KJH/Mortar/03)
Source: Author

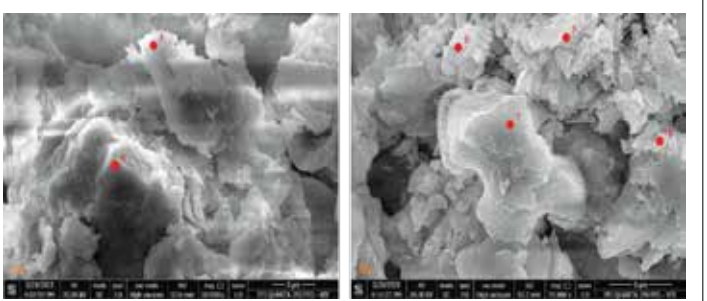

Figure 6(a) FE-SEM image showing spectrum for marked location (sample DMJ/KJH/Mortar/03); 6(b) FE-SEM image showing spectrum for marked location (sample DMJ/KJH/Mortar/03)
Source: Author

Table 4: Available element in the sample DMJ/KJH/Brick/10
Source: Author

Ti	1.17	As	0.001	V	0.011	Rb	0.007
Cr	0.008	Sr	0.018	Mn	0.081	Y	0.001
Fe	3.81	Zr	0.017	Ni	0.008	Nb	0.001
Cu	0.002	Ba	0.098	Zn	0.005	Th	0.001

Table 5: Elemental content in the sample DMJ/KJH/Mortar/02 – Spectrum 13 & 14
Source: Author

Element	Atomic %	Element	Atomic %	Element	Atomic %	Element	Atomic %
C	22.19	Si	4.41	C	23.37	Si	3.98
O	59.19	K	0.33	O	60.75	K	0.30
Mg	0.54	Ca	11.31	Mg	0.62	Ca	9.27
Al	1.63	Fe	0.41	Al	1.18	Fe	0.51
Spectrum 13				Spectrum 14			

Table 6: Elemental content in the sample DMJ/KJH/Mortar/02 – Spectrum 15 & 16
Source: Author

Element	Atomic %	Element	Atomic %	Element	Atomic %	Element	Atomic %
C	25.28	Si	2.13	C	18.79	Si	5.69
O	63.35	K	0.14	O	56.97	K	0.42
Mg	0.43	Ca	7.69	Mg	0.94	Ca	13.88
Al	0.81	Fe	0.17	Al	2.41	Fe	0.91
Spectrum 15				Spectrum 16			

Table 7: Elemental content in the sample DMJ/KJH/Mortar/02 – Spectrum 17 & 18
Source: Author

Element	Atomic %	Element	Atomic %	Element	Atomic %	Element	Atomic %
C	18.82	Si	3.62	C	27.99	Si	23.60
O	61.35	K	0.26	O	45.66	Ca	1.82
Mg	0.53	Ca	14.06	Mg	0.27	Fe	0.26
Al	1.18	Fe	0.18	Al	0.39		
Spectrum 17				Spectrum 18			

Table 8: Elemental content in the sample DMJ/KJH/Mortar/02 – Spectrum 1 & 2
Source: Author

Element	Atomic %	Element	Atomic %	Element	Atomic %	Element	Atomic %
C	19.95	Si	9.13			Si	22.47
O	61.70	Cl	0.18	O	62.11	Cl	0.48
Na	2.53	K	0.32	Na	3.41	K	0.52
Mg	0.82	Ca	0.28	Mg	0.76	Ca	0.53
Al	4.47	Fe	0.63	Al	8.14	Fe	1.59
Spectrum 1				Spectrum 2			

Table 9: Elemental content in the sample DMJ/KJH/Mortar/02 – Spectrum 5 & 6
Source: Author

Element	Atomic %	Element	Atomic %	Element	Atomic %
C	16.27	Si	10.42	O	74.81
O	62.49	Cl	0.35	Al	5.85
Na	0.98	K	0.60	Si	15.68
Mg	1.41	Ca	0.46	K	3.65
Al	5,65	Fe	1.26	Spectrum 6	
Ti	0.10				
Spectrum 5					

Consequently, it is used to prevent algal growth (Graziani, 2014).

In spectra 8, 9 and 10 (Tables 10 and 11; Figure 8), the presence of sulphur (S) was identified as a pollutant, possibly indicating the formation of gypsum (syngenite), which contributes to the degradation of the mortar.

4.3. Fourier-Transform Infrared Spectroscopy (FT-IR)

The sample was prepared for testing by placing it in a holder and grinding it with a glass blade (razor blade).

a. DMJ/KJH/Brick/10
(Table 12)(Figure 7)

b. DMJ/KJH/Mortar/01
(Table 13)(Figure 7)

c. DMJ/KJH/Mortar/02
(Table 14)(Figure 7)

d. DMJ/KJH/Mortar/03
(Table 15)(Figure 7)

4.4. Wet Chemical Separation (Acid Dissolution)

The ratio derived after performing the test was found

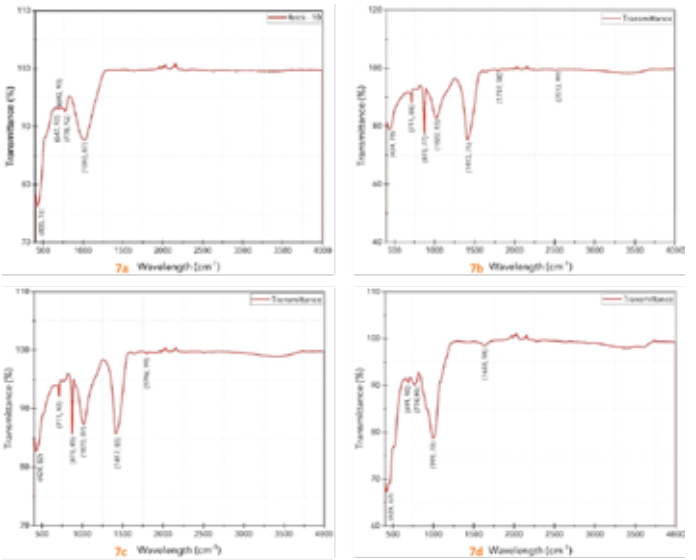

Figure 7(a) FT-IR for sample DMJ/KJH/Brick/10; 7(b) FT-IR for sample DMJ/KJH/Mortar/01; 7(c) FT-IR for sample DMJ/KJH/Mortar/02; 7(d) FT-IR for sample DMJ/KJH/Mortar/03
Source: Author

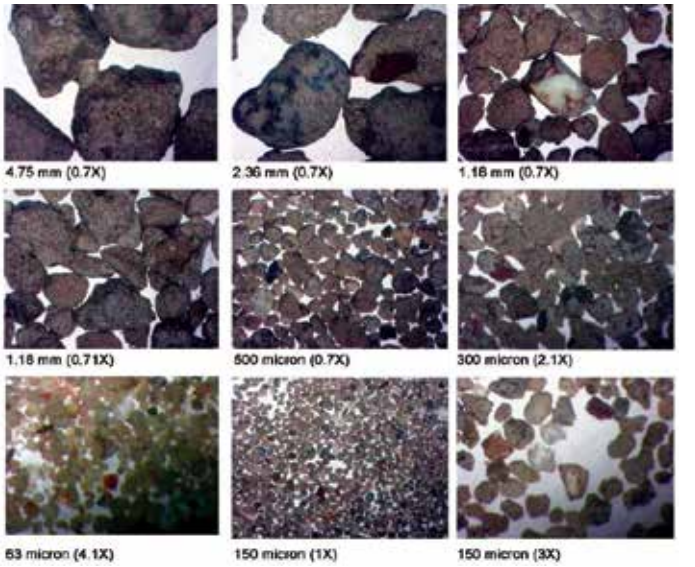

Figure 8: Stereo zoom microscopy images for DMJ/KJH/Mortar/01
Source: Author

Table 10: Elemental content in the sample DMJ/KJH/Mortar/02 – Spectrum 7 & 8
Source: Author

Element	Atomic %	Element	Atomic %	Element	Atomic %	Element	Atomic %
O	77.92	K	0.14	C	12.47	S	5.61
Al	0.88	Ca	0.16	O	73.79	K	0.13
Si	20.57	Fe	0.17	Al	0.75	Ca	4.86
Cl	0.15			Si	2.19	Fe	0.20
Spectrum 7				Spectrum 8			

Table 11: Elemental content in the sample DMJ/KJH/Mortar/02 – Spectrum 9 & 10
Source: Author

Element	Atomic %	Element	Atomic %	Element	Atomic %	Element	Atomic %
O	80.06	K	0.17	C	17.32	Si	7.27
Al	0.94	Ca	7.83	O	62.97	S	2.96
Si	2.19	Fe	0.23	Na	0.77	Cl	0.18
S	8.58			Mg	0.78	K	0.49
Spectrum 9				Al	3.56	Ca	2.92
						Fe	0.79
				Spectrum 10			

Table 12: Bond or elemental identification for DMJ/KJH/Brick/10
Source: Author

Wavelength (cm -1)	Bond or elemental identification
435	Silicates peaks
647	C – H alkenes (strong)
692	C – H alkenes (strong)
778	C – H calcium
1018	Si – O (stretching)

Table 13: Bond or elemental identification for DMJ/KJH/Mortar/01
Source: Author

Wavelength (cm -1)	Bond or elemental identification
434	Silicates peaks
711	C – H Calcite
873	C – H Calcite
1022	C – S – H
1413	C – C, - CO (Calcite)
1797	C=O (Acid chlorides)
2513	O-H bend stretch (Carboxylic acid)

Table 14: Bond or elemental identification for DMJ/KJH/Mortar/02
Source: Author

Wavelength (cm -1)	Bond or elemental identification
424	Silicates peaks
711	C – H Calcite
873	C – H Calcite
1020	C – S – H
1417	C – C, - CO (Calcite)
1796	C=O (Acid chlorides)
2112	C = C
2513	O-H bend stretch (Carboxylic acid)

to be 1:2.83 and 1:2.54, which is approximately 1:3, indicating maximum carbonation in the sample (Rowland, 2001). As the 1:3 ratio contains a higher proportion of aggregate compared to 1:2, the carbonation process accelerates due to increased carbon dioxide diffusion (Gameiro, 2014). The sample's strength ratio may be high because the structure is located in an area with a relatively stable climate and a high level of relative humidity (Moropoulou, 2000). The good condition of the mortar was also confirmed through other characterisation tests (refer to Table 16).

Table 15: Bond or elemental identification for DMJ/KJH/Mortar/03
Source: Author

Wavelength (cm -1)	Bond or elemental identification
424	Silicates peaks
691	C – H Calcite
774	C – H Calcite
999	C – S – H
1633	N – H bend (Amides)
2112	C – C, - CO (Calcite)

Following the acid loss wet chemical separation technique for lime mortar samples DMJ/KJH/ Mortar/01 and 02 (refer to Tables 17 and 18, Figures 8 and 9), a sieve analysis was conducted using stereo zoom microscopy to examine the particles and components present in the samples. Different zoom levels ranging from 0.7x to 4.5x were used to observe the particles. The majority of the particles appeared to have rounded corners, and the presence of surkhi was observed in both samples. On the surface of the aggregate, a few unburnt lime particles and organic components were also identified. Angular particles in the range of 1.18 mm to 300 microns were identified, mostly from surkhi or crushed stones. From 500 microns to 63 microns, the surface of the particles was smooth, and towards the lower micron

Table 16: Wet chemical analysis
Source: Author

Sample ID	DMJ/KJH/Mortar/01	DMJ/KJH/Mortar/02
Sample Weight (g)	30.954	30.916
Aggregate	22.869	22.184
Insoluble Binder	5.462	6.378
Aggregate + Insoluble Binder	28.331	28.562
Soluble Binder	2.623	2.354
Binder	8.085	8.732
Binder aggregate ratio	1:2.83	1:2.54

Table 17: Stereo zoom microscopy observation for DMJ/KJH/Mortar/01
Source: Author

Size of sieve	Observation
4.75 mm	Rounded corners, surkhi, Organic component (on surface of aggregate - Sap)
2.36 mm	Rounded corners, surkhi, Unburnt lime on aggregate surface
1.18 mm	Angular and Rounded aggregate, surkhi, Unburnt lime on aggregate surface
500 microns	Surkhi, Semi-angular aggregate, smooth and rough texture aggregate, flat surface aggregate
300 microns	Semi-angular aggregate, semi translucent, chipped and crushed aggregate
150 microns	Semi angular – Semi translucent aggregate, unburnt lime particles
63 microns	Rounded fine particles, Shiny surface minerals

Table 18: Stereo zoom microscopy observation for DMJ/KJH/Mortar/02
Source: Author

Size of sieve	Observation
4.75 mm	Rounded corners, surkhi, unburnt lime on the surface of aggregate
2.36 mm	Rounded corners, surkhi and unburnt lime on aggregate surface
1.18 mm	Angular and Rounded aggregate, surkhi
500 microns	Surkhi, Semi-angular aggregate, rough texture aggregate, flat surface aggregate
300 microns	Semi-angular aggregate, semi translucent, chipped and crushed aggregate
150 microns	Semi angular – Semi translucent aggregate, unburnt lime particles, crystalline particles
63 microns	Rounded fine particles, Shiny surface minerals, mica, quarts

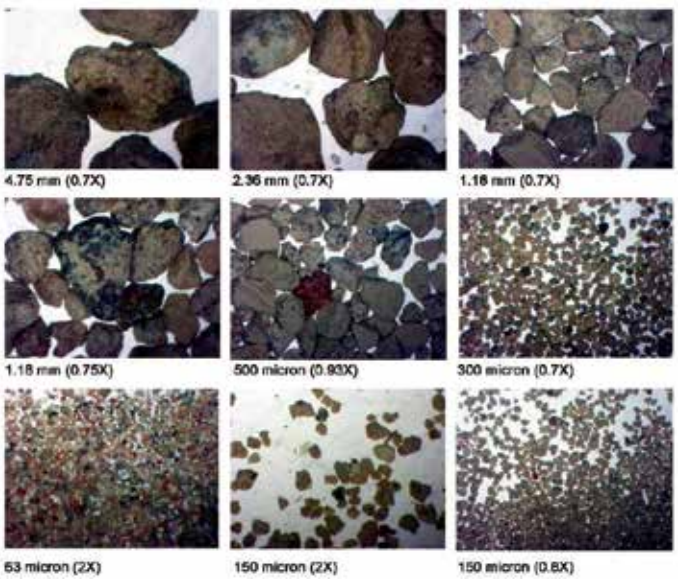

Figure 9: Stereo zoom microscopy images for DMJ/KJH/Mortar/02
Source: Author)

range, translucent and shiny surface minerals were also visible in the samples.

5. Discussion

The mortars obtained from the Kalidas Jethabhai House were found to have binder-to-aggregate ratios of 1:2.83 and 1:2.54. The presence of clay minerals, which constitute approximately 26% of the binder, suggests that the mortar is hydraulic in nature. Additionally, the aggregate grains were identified as having rounded, semi-angular and angular morphologies.

By using advanced analytical techniques such as field XRF, FE-SEM and FT-IR, impurities such as Fe_2O_3, Al_2O_3 and SiO_2 were identified in a sample of lime mortar. The presence of these impurities is beneficial as it improves the workability and durability of the mortar and also indicates the use of hydraulic lime. FE-SEM was used to confirm good bonding between the binder and aggregate, which is indicative of a high-quality mortar sample. The hardening of the mortar is primarily due to the hydration of calcium silicate, resulting in the formation of a network of fibrous crystals of calcium silicate hydrate (CSH). Wet chemical analysis revealed a clay content of 16%, which suggests that the lime was prepared from limestone containing 12–18% clay content, known as moderately hydraulic lime. The presence of CSH was confirmed by the FT-IR peak at wavelengths of 1020 and 1022 cm^{-1}. The presence of hydrothermal CSH in the mortar sample suggests that hot lime technology was employed during the manufacturing process. This technique contributes to the self-repairing properties of the mortar and enhances its longevity.

The mud mortar sample was analysed using field XRF, FE-SEM and FT-IR techniques to identify its properties. The presence of potassium (K) in the sample suggests the use of local organic components in its preparation, which contribute to its mechanical properties such as compressive strength, plasticity and consistency. FE-SEM analysis identified the crystalline nature of the mortar, indicating the presence of Na and Cl elements, which may have been sourced from the nearby river area. The presence of sulphur (S) was also observed, which is likely due to pollutants from nearby industries. This suggests the presence of a degrading component, syngenite (gypsum), which can cause the mortar to deteriorate when exposed to water and harsh weather conditions. Along with clay, lime content was also identified in the mud mortar sample through all the testing techniques.

Upon analysis of the mud mortar and brick samples using field XRF and FE-SEM techniques, the presence of titanium (Ti) was detected. This element can effectively prevent the growth of algae on the surface of the mortar or fired clay bricks, thereby enhancing their durability and longevity.

6. Conclusions and Recommendations

The outcome of this research will be used for the restoration of the Kalidas Jethabhai House. The results will assist in matching the properties of the new design mixture by creating a mortar with similar characteristics, thereby helping to achieve equilibrium.

Based on the findings discussed in Section 5, *Results and Discussion*, the following recommendations are proposed for the preparation of lime mortars for restoration purposes:

Firstly, select a moderately hydraulic lime binder from a local vendor. Use river sand passing through a 2.36 mm sieve as fine aggregate. Adopt a 1:3 (binder:aggregate) ratio, which is a proven combination for improved carbonation of lime mortars. Next, prepare a natural admixture by fermenting 5% (w/v) jaggery solution for 14 days, or use another locally available organic substance. Samples with varying compositions should then be prepared and tested to match the properties of the historic mortar samples.

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The Architecture for Preparedness

Disaster Management and Research Institute at Rudraprayag, Uttarakhand

By Ar. Piyush Agrawal Guide: Dr. Abhijit Natu

1. Introduction

Mountainous regions like Uttarakhand are highly vulnerable to natural disasters and environmental degradation due to their fragile ecosystems. Frequent hazards such as floods, landslides, earthquakes and forest fires severely impact land, forests and human life. Despite its vulnerability, the Himalayas attract over 25 millions of pilgrims and tourists annually, leading to unregulated tourism and unplanned construction, which exacerbate disaster risks. Events like cloudbursts and heavy rainfall, especially during monsoons, often trigger landslides—over 1600 in recent times—causing widespread destruction, loss of life, property and long-term psychological trauma to affected communities. In 2023, the Himalayan region has borne witness to an onslaught of disasters, from the sinking of Joshimath in Uttarakhand to floods and landslides in Himachal Pradesh. The prevailing development model of the Himalaya, spanning from Ladakh to Arunachal Pradesh, poses a significant threat to the ecosystem of the mountains.

1.1 Significance of the Project

A disaster is a significant situation that occurs over time and causes widespread human, material, economic, environmental loss that is greater than the afflicted community's ability to deal with its own resources.

In November 2023, 41 workers were trapped in the *Silkyara* Tunnel in the Uttarkashi district of Uttarakhand, after a portion of the same collapsed. After much efforts from experts, all were trapped workers were rescued. After this incident, Uttarakhand's Honourable CM Shri. Pushkar Singh Dhami said that even if the state faced continuous disasters and damage due to natural activities, there is no such institute or centre in Uttarakhand where people can be made aware of the disasters and their effects beforehand and receive training for preparedness. So, he proposed to establish a centre and institute for Disaster Management and Mitigation. Hence, taking up it as an architectural thesis project will be a contribute to this cause (refer Figure 1).

1.2 Intent of the project

"We cannot stop natural disasters, but we can arm ourselves with knowledge; so many lives wouldn't have to be lost if there was enough disaster preparedness." – Petra Nemcova

'Disaster Management = Prevention and preparedness, response, and recovery'

It may be beyond human control to stop natural disasters, but their effects can surely be reduced by preparedness, awareness and care. The intent

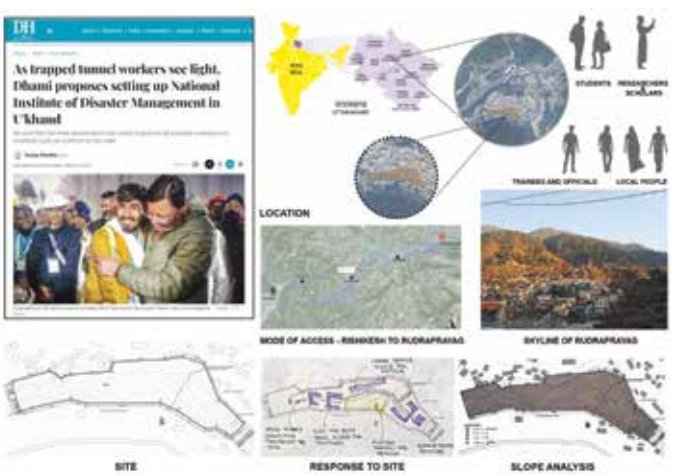

Figure 1: Project Significance and background Study

of this thesis is to design an institute and training centre for Disaster Management and Research that will train people for disasters in hilly terrain, generate awareness and build capacity to cater to the situation.

1.3 Aim

To design an institute and training centre for Disaster Management and Research that will provide disaster management knowledge and training for various stakeholders.

1.4 Objectives

- To study the structure and functioning of NIDM (National Institute of Disaster Management) and NDMA (National Disaster Management Authority), for identifying various aspects of disaster management and mitigation.
- To identify the training courses and ways of hands-on training needed for the mitigation and evacuation during disasters and the spaces required for that.
- To study the traditional knowledge systems of the state to reduce the impact of modern technology on the environment and terrain and to identify a suitable site in Uttarakhand for the centre.
- To design a sustainable building for an institute for imparting knowledge and training in disaster risk mitigation and management to its stakeholders.

1.5 Methodology

- Background Research – Reviewing literature related to the topic
- Primary Data Collection - Visiting similar spaces as case studies to understand and analyse the program in detail in terms of spaces and the translation of vision into spaces, with photographic documentation and information, discussing with various experts about the aspects and requirements of such a centre
- Secondary case studies
- Formulating a design program based on primary and secondary data
- Selecting a suitable site with potential to fulfil the requirements of the project
- Analysing the site and understanding its compatibility
- Studying Uttarakhand building byelaws and technical guidelines for construction practices to understand the traditional knowledge system
- Evolving a design concept and proposal

1.6 Scope and Limitations

The project shall include detailed site planning, architectural design of various built and unbuilt spaces, a conceptual idea of structure and services and required design details. The project shall not include detailed design for structure, services and interiors.

2. Review of literature - What is a disaster?

A disaster is defined as a disruption on massive scale, either natural or man-made, occurring in short or long periods. Disasters can lead to human, material, economic and environmental hardships that are beyond the bearable capacity of the affected society.

2.1 What is Disaster Management?

The Disaster Management Act, 2005 defines Disaster Management as an integrated process of planning, organising, coordinating and implementing measures that are necessary for

a. Prevention of the threat of any disaster
b. Reduction of the risk of any disaster or its consequences
c. Readiness to deal with any disaster
d. Promptness in dealing with a disaster
e. Assessing the severity of the effects of any disaster
f. Rescue and relief
g. Rehabilitation and Reconstruction

2.2 Agencies involved in Disaster Management in India

1. National Disaster Management Authority (NDMA)
2. National Executive Committee (NEC)
3. State Disaster Management Authority (SDMA)
4. District Disaster Management Authority (DDMA)
5. Local Authorities

2.3 Disaster Prevention and Mitigation

Proper planning and mitigation measures can play a leading role in risk-prone areas to minimise the worst effects of hazards. The key areas to be addressed to achieve this objective:

- Risk Assessment and Vulnerability Mapping
- Increasing Trend of Disasters in Urban Areas
- Critical Infrastructure
- Environmentally Sustainable Development
- Climate Change Adaptation

2.4 Aftermath of Disasters

- The disaster-affected population, particularly those engaged in petty business and representing weaker sections of society, faced significant challenges in replenishing their lost productive assets.
- The study highlights importance of insurance for economic recovery post-disaster, especially for small business operators. It suggests that the state should focus on providing suitable risk transfer instruments.
- The study concludes that effective disaster relief strategies should prioritise asset replenishment and insurance coverage to facilitate economic recovery for all affected sectors.

2.5 Regional Challenges in Uttarakhand

Uttarakhand faces significant challenges in terms of economic development, infrastructure and natural disasters.

- Natural Disasters: Prone to devastating natural disasters having significant impacts on the region's infrastructure, economy and human lives.
- Disaster Management: This involves not only responding to disasters but also implementing measures to prevent and mitigate their impacts.
- Technology and Innovation: Can play a crucial role in addressing the challenges.

3. Case studies

3.1 Secondary sources - Internet/Book/Web Case Studies

The case studies included several notable institutions and architectural examples. The first was the Gujarat Institute of Disaster Management in Gandhinagar, followed by the Lal Bahadur Shastri National Academy of Administration in Mussoorie, which provided insights into the design and functionality of buildings situated in hilly regions. Another important study was conducted at the Sher-i-Kashmir International Convention Centre in Srinagar, highlighting design considerations in diverse climatic and geographic contexts.

From these case studies, several key points were derived for consideration in future designs. Together, these principles form the foundation for designing efficient, sustainable and context-sensitive institutional campuses.

- A holistic approach to site integration is crucial, taking into account the site's unique topography, climate and vegetation to achieve harmony with the natural environment.
- Environmental stewardship and sustainable construction practices should be prioritised by utilising local materials and techniques that promote resilience.
- Promoting interaction through outdoor gathering spaces, pedestrian walkways and recreational zones helps build a sense of community and collaboration.
- Effective landscape design should be seamlessly integrated with the built environment, while functional connectivity through plazas and other shared spaces ensures smooth circulation and unity across the campus.
- Considering the local material palette and construction techniques ensure sustainability and resilience.

3.2 Live Case Studies

The live case studies included visits to prominent institutions and discussions with experts in the field. The first case study was conducted at YASHADA (Yashwantrao Chavan Academy of Development Administration) in Pune, focusing on the Centre for Disaster Management and the Emergency Operation Centre, where participants gained insights into disaster preparedness and response mechanisms. The second case study took place at the 5th Battalion of the National Disaster Response Force (NDRF) in Sudumbre, Pune, providing a practical understanding of emergency response operations and field-level coordination. Additionally, a discussion was held with Dr. Vasudha Gokhale from BNCA, Pune, to gain academic and professional perspectives on disaster management practices and architectural resilience

The architectural program, resulting from the various case studies and discussions, broadly consists of the spaces represented in Table 1

5. Site selection and analysis

Rudraprayag holds significant religious importance as one of the Panch Prayag, located at the confluence of the Alaknanda and Mandakini rivers. It lies on the Char Dham Yatra route, with Kedarnath just 86 km

Table 1: The architectural space program
Source: Author

Sr. No.	Space	Objective	Target population
1.	**Administrative areas**	Operational and control hub	General public, trainees, local residents and institute officials
2.	**Emergency Operation Centre(EOC)**	24/7 emergency unit for disaster response and recovery	Rescue officials
3.	**Information Centre**	Main public area focused on local awareness of disaster preparedness. Educate visitors on disaster scenarios, mitigation methods, rescue tools through various galleries and audio-visual demonstrations.	Tourists, locals and students
4.	**Academic Block**	Prepare trainees to reduce life losses from upcoming natural disasters.	Locals and professionals
5.	**Auditorium**	Space for cultural or social gatherings.	Locals and people on campus
6.	**Accommodation**	Residential area for individuals associated with the campus.	Trainees, staff, professional visitors and scholars
7.	**Public plaza and Congregation space**	Landscape features to enhance the feel and essence of the campus while facilitating various activities and interactions.	People on campus
8.	**Training ground**	Primary space to practice and perform various exercises and tasks related to handling unforeseen situations.	Trainees
9.	**High Rise Tower**	A training structure for ropeway operations, simulation of flood rescue scenarios and emergency response techniques practice.	Trainees
10.	**Dog squad kennel**	Kennels for the trainee dogs.	Dogs
11.	**Helipad**	Emergency landing and take-off of the rescue helicopters.	Rescuers and officials

away. Situated at an elevation of 690–895 m above sea level and falling within the temperate climate zone, it offers stunning mountain views.

5.1 Why Rudraprayag?

Site selection is a critical aspect of the project, requiring a location that meets all programmatic needs while ensuring safety and accessibility. Areas like Kedarnath, Chamoli, Uttarkashi and Joshimath were avoided despite high disaster frequency, as such conditions could compromise the institute's functionality. Similarly, the Kumaon region was excluded due to the presence of NDRF center in Udham Singh Nagar. Dehradun and Rishikesh, though stable, are too distant from affected zones. Rudraprayag in Uttarakhand was chosen for its proximity to disaster-prone areas and relatively stable terrain, making it ideal for emergency response training. The site lies on a gentle slope above the river basin and is well-connected by road. Due to absence of a formal development plan, land use and site selection were conducted using Google Earth and verified through site visits and coordination with local officials. As the centre aims to strengthen regional resilience by running awareness campaigns, training programs and community initiatives that equip individuals with the knowledge and skills to effectively respond to disasters, Rudraprayag was selected as the suitable location for it.

5.2 Architectural Character and Site Context

Rudraprayag, nestled amidst the tranquil beauty of the Himalayas, boasts architectural characteristics that reflect both its historical significance and contemporary aspirations. The town's architecture is defined by its linear building forms, with structures gracefully following the natural contours of the landscape which results in long, singly loaded corridors. The facades are adorned with artistic chajjas, intricately designed overhangs that not only provide shade but also their repetition create a visually striking aesthetic. Metal grills and railings embellish windows and balconies. Planning in levels enhances the visual appeal of Rudraprayag's urban landscape, creating a dynamic interplay between different elevations. Buildings cascade down the hillsides in a terraced fashion, reducing disaster risks and minimising erosion. While no distinct vernacular architecture is found in Rudraprayag, the architectural character is a blend of contemporary design principles and functional efficiency, harmonising with the surrounding natural beauty to create an enchanting urban tapestry set against the backdrop of the majestic Himalayas.

5.3 Local Techniques and Local Material Palette

The local construction techniques and materials reflect a deep understanding of the region's climatic and topographical conditions. Conventional RCC structures are commonly used, complemented by arched openings that enhance thrust and shock transfer, improving the building's structural performance. Articulation in the *chajja* form provides aesthetic detailing while offering functional shading and protection. Buildings are often aligned along the natural contours of the site, resulting in elongated facades and corridors that harmonize with the terrain. Cladding is employed on facades both as a decorative feature and to mitigate the impact of cold weather. Raft foundations are preferred as they act as a single unit during settlement or sliding, ensuring overall stability and uniform support for the structure.

The local material palette primarily includes burnt brick made from river sand, white river sand and *rodi*—a locally produced crushed aggregate derived from available stones such as gneiss and chlorite schist. These materials not only ensure structural durability but also reflect the use of sustainable, locally sourced resources that blend with the regional architectural identity.

5.4 Geology

Rudraprayag district features high denudational mountains and river valleys within the Lesser Himalayas, separated from the Siwaliks by the Krol thrust. The mature topography shows active erosion and includes features like glacial valleys, river terraces and faults. Soils in the region are natural, dynamic and non-renewable, formed from rocks such as granite, schist and slate in a cool, moist climate. The area is characterised by steep hills and glacio-fluvial valleys with shallow, well-drained, sandy to loamy skeletal soils that are slightly acidic and have low water retention. These soils, classified as Lithic/Typic Cryorthents, support sparse vegetation.

7. Conceptual Development and Design Solution

The design concept for the project is deeply rooted in addressing sensitive issues while capitalising on the unique characteristics of the site, particularly its sloping and linear profile. The limited access from the road serves as a catalyst for the design decisions, prompting a thoughtful approach to site circulation and organisation. One prominent natural feature, a seasonal stream that divides the site, becomes a deciding factor of design and is channelled and developed to enhance its aesthetic and functional value.

All public areas are strategically positioned near the entrance, fostering a sense of arrival. A central plaza serves as a welcoming hub, inviting interaction and engagement. The relatively flat terrain adjacent to the entrance is utilised as training ground.

As one progresses deeper into the site, the layout unfolds sequentially, with the academic block and residential units arranged in a logical progression along the central spine pathway. This arrangement not only optimises space but also fosters connectivity and a sense of cohesion among the various functions of the campus (refer Figure 2 and 3). The zoning diagram has been developed as per the site compatibility study and the contours (refer Figure 4 and 5).

Landscape elements play a crucial role in enhancing the user experience and intuitiveness of navigation within the campus. Rock gardens, for example, are strategically integrated to create visual interest, define spaces and guide movement throughout the site. Their natural aesthetic also reinforces the site's connection to its surroundings, promoting a sense of harmony and integration with the environment.

Overall, this design concept embodies a holistic approach that not only responds to the site's physical constraints but also embraces its inherent qualities

to create a harmonious and functional campus environment. Through thoughtful planning and attention to detail, the design seeks to foster a sense of community, promote connectivity and enhance the overall user experience.

7.1 Material Palette and Structural System

Generally, 230-thick brick masonry walls with stonecrete plaster are used in buildings. Confined masonry technology is used in which slabs transfer

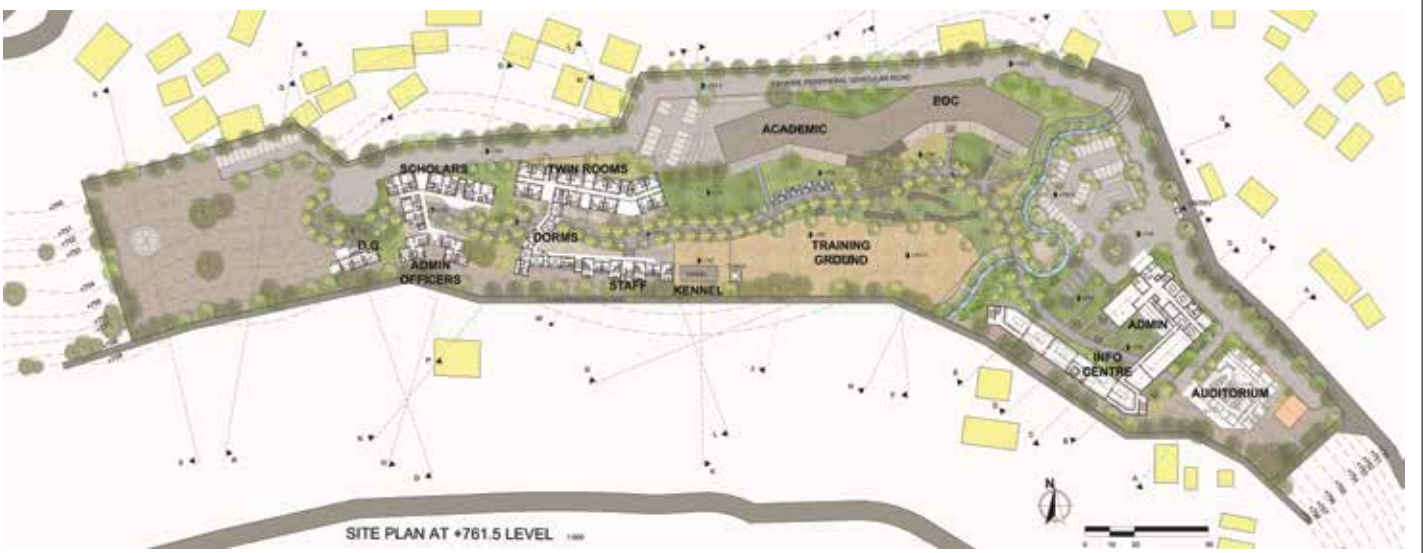

Figure 2: Site plan at 761.5 m level

Figure 3: Site plan at 758 m level

Figure 4: Site sections

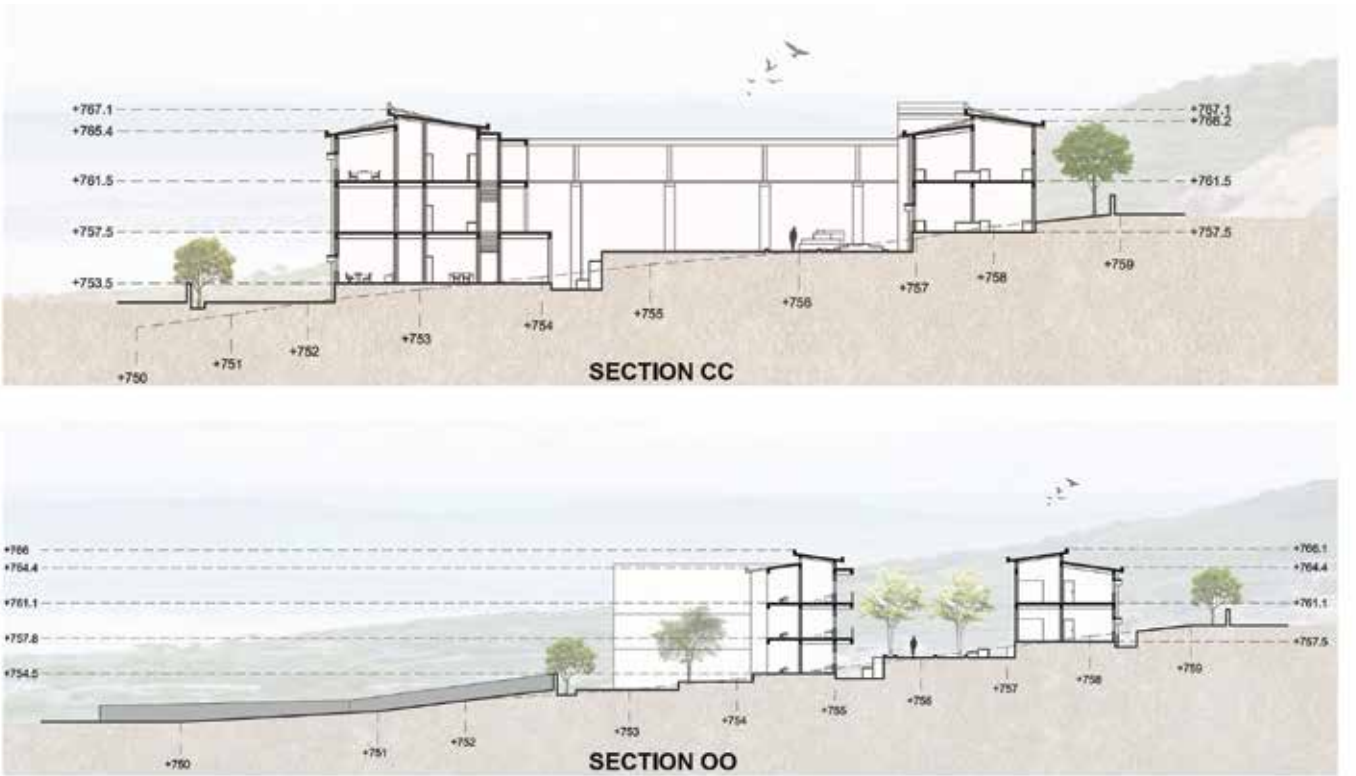

Figure 5: Site sections

Figure 6: Site sections

the load to RCC beams to columns to the RCC raft to avoid sliding movement effects on the structure. Random rubble stone masonry walls for effective structural stability in the soil. Bricks for walling with gneiss or schist stone for stonecrete plaster, *Rodi* as an aggregate and stone for paver blocks and retaining walls have been used (refer Figure 6).

7.2 Landscape

Existing trees are preserved and local species are planted to promote biodiversity. Landscape elements are designed to reflect the essence of the centre while fostering a strong connection with nature throughout the campus. Few of them are explained below.

Public plaza: Emphasises intuitive understanding and connection to the region's geological vulnerabilities. Local undressed rocks, marked with dates and disaster narratives, serve as powerful reminders of past events, enhancing awareness and grounding visitors in the land's history. This immersive design blends education with a deep sense of place, encouraging reflection on disaster preparedness and resilience (refer Figure 7).

Seasonal stream cum pathway: Thoughtfully channelised and designed, blends functionality with aesthetic appeal. Lined with smooth pebbles, it maintains a tranquil ambiance even when dry, while boundary stones of varying sizes add texture and define its edges. This feature enhances the landscape, inviting visitors to connect with the serenity of nature. (refer Figure 8).

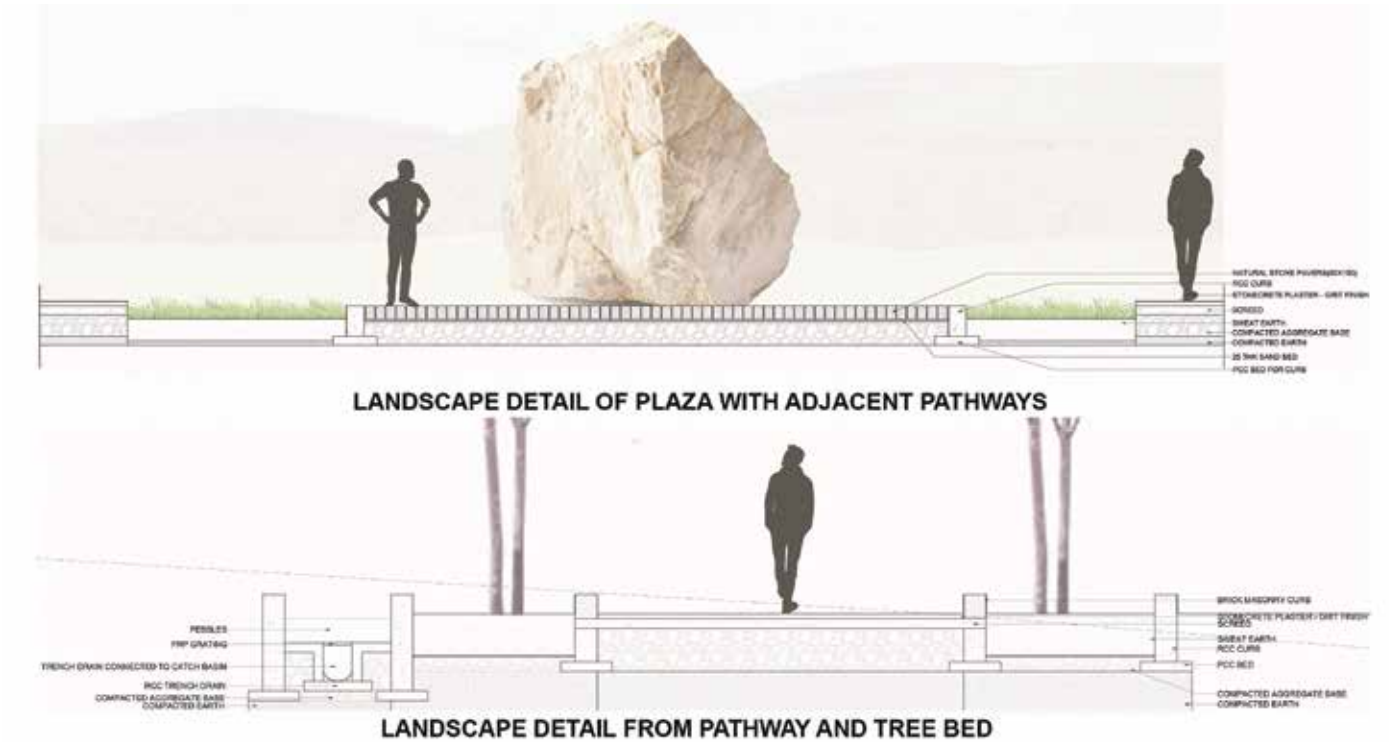

Figure 7: Landscape details

Figure 8: Immersive visuals

Figure 9: Immersive visuals

Water cascade: Adds aesthetic value while symbolically reflecting the institute's core. The sound of flowing water evokes the threat of floods, creating a tangible link to disaster awareness. This feature reinforces the importance of disaster preparedness and resilience. (refer Figure 9).

8. Summary of the Design Project

The disaster management centre and institute represent a holistic approach to disaster preparedness and response, covering all phases of the disaster management cycle. For mitigation, it offers training and awareness programs to build community and

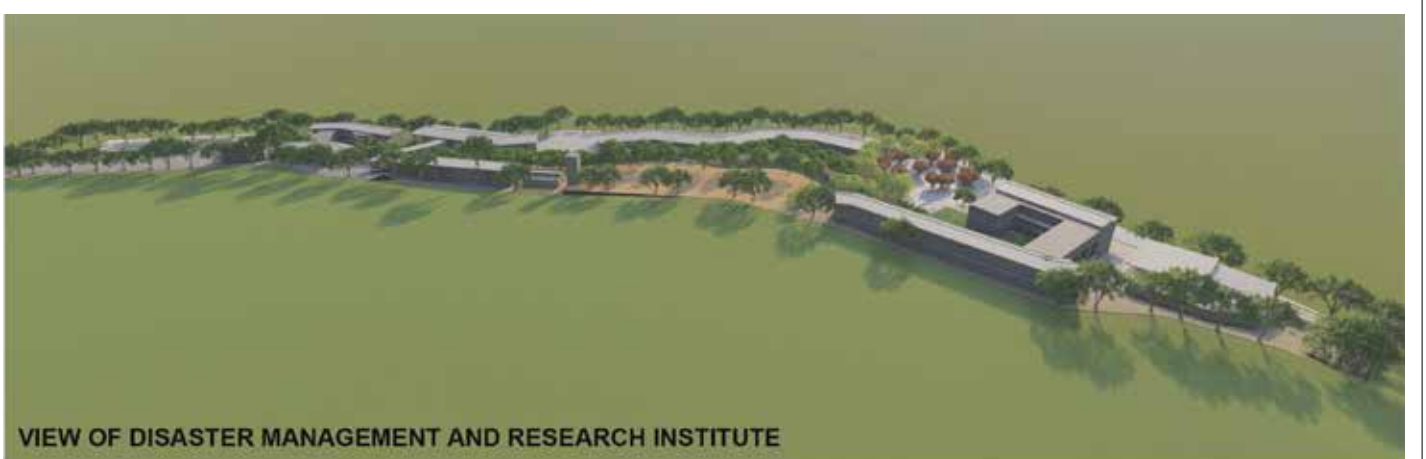

Figure 10: Aerial perspective

official capacity. As a preparation hub, it functions as a 24/7 Emergency Operations Centre, equipped with advanced technology and rapid response capabilities. During disasters, it acts as a command centre, coordinating trained personnel for swift and effective response. In the recovery phase, it supports relief efforts, assessments and long-term resilience planning. Additionally, the facility emphasises the importance of learning from past disasters to better prepare for future ones**.**

Overall, the centre strengthens community resilience through integrated mitigation, preparedness, response and recovery strategies (refer Figure 10).

All images courtesy authors

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ARTICLE

Exhibitions

The Quest for Ongoing Awareness and Education for Architects!

By Ar Mrinalini Sane

Everyday, we Architects come across new information regarding our profession. It may be in the context of design or construction or legal aspects. Our quest to remain updated is helped through the means of Exhibitions. These cover materials, methods, technology as well as sourcing information like suppliers. IIA as the national body of Architects, has been playing an active role in organising such exhibitions that help Architects in their day-to-day professional lives. Here, we bring you reports on three exhibitions held in three cities of Maharashtra - Nagpur, Pune and Mumbai.

In each of these exhibitions, IIA has played a major role. The Nagpur exhibition, Rachana, in fact, has been solely organised by IIA Nagpur Centre. Constro from Pune has seen the participation of IIA Pune Centre as the Co-Sponsor. IIA Brihanmumbai Centre has lent its expertise as a knowledge partner to more than 1 exhibition - Confex and WOFX. The supporting role played by IIA Pune and Brihanmumbai Centre is extremely important. Knowledge enhancement takes place through seminars and panel discussions on topics that are relevant to all the construction professionals.

Rachana 2025 Exposition by IIA Nagpur Centre

The Indian Institute of Architects, Nagpur Centre, Maharashtra Chapter, is the second oldest Centre of the IIA, having been established in 1973. It has been acknowledged as the Best Centre at the national level several times, winning 9 Best Centre Awards and 5 Runners-up awards and has the proud privilege of winning the IIA BEST CENTRE AWARD for four consecutive years from 2007 to 2010. One of the flagship events of the Centre since several years is the 'Rachana' exposition.

Rachana was initiated in 1988 and has received many accolades and praises at the National level. The Centre recently successfully conducted the 25th Edition of 'Rachana' – an exposition of building and interior design materials, office and home automation systems, building services and construction equipment, from 10th to 13th January 2025. A special logo was also designed to commemorate the Silver Jubilee of Rachana.

Rachana exposition (a registered trademark under the Copyright Act), a combination of creation and affiliation and a repository of up-to-date knowledge, is known for its excellence. It is a 4-day exposition which is a unique forum for manufacturers, processors, exporters, dealers, suppliers, vis-a-vis for designers, builders, developers, buyers and end users. Rachana offers a modern, stylish, unique and upmarket design vocabulary and offers great opportunities to interact, learn, network, explore, exchange ideas and grow businesses.

Rachana 2025 received an overwhelming response from all the participants - Architects, Interior Designers, Engineers, Builders, Developers, Students and general public from various fields from the whole of Vidarbha, Madhya Pradesh and Chhattisgarh. The overall footfall observed over 4 days was almost 45,000 visitors!

"Over the years, Rachana has consistently delivered unparalleled value to the fraternity, showcasing cutting-edge innovations, fostering meaningful connections and driving industry growth. Such expositions serve as a pivotal platform for architects, manufacturers and suppliers to converge, share knowledge and explore new possibilities, profoundly impacting the profession and the built environment," states Ar Raviraj Sarwate, Convenor, Rachana.

In this 25th edition of Rachana more than 100 stalls dealing with building and interior designing materials, home and office automation systems, building services and construction equipment were set up. There were separate pavilions for the corporate sector, which included Gold, Silver and Bronze sponsors. The structure of the exhibition was designed as a perfect show case for the latest applied and advanced technology.

1st, 2nd, 3rd and Consolation prizes were awarded to the best designed, arranged, presented and managed stalls. Certificates of Participation were also awarded to each participant / exhibitor. Free visitor's admission, plenty of space for the movement of up to 5000 visitors per day with free and adequate parking is the hallmark of Rachana.

The entire Rachana 2025 Organising Team consisting of the Convenor Ar. Raviraj Sarwate, Co-Convenor Ar. Rahul Lokhande, Chairman IIA NC Ar. Parag Yelne, Vice Chairman Ar. Aniket Khodwe, Hon. Treasurer Ar. Rajesh Kakde, Hon. Secretary Ar. Parikshit Choudhari, Exe. Member Mah. Chapter Ar. Priyadarshan Nagpurkar, Ar. Sunil Degwekar, Ar. Jiten Srivastava, Ar. Subodh Chinchmalatpure, Ar. Ziyaullahkhan Pathan, Ar. Veepa Jariwala, Ar. Husain Karori, Dr. Sampada Peshwe, Ar. Anuradha Tikkas, Ar. Sunny Gupta, Ar. Kapil Kawle, Ar. Rahul Dandekar and Ar. Vishal Khedikar worked hard for the grand success of Rachana 2025.

Constro 2025

A group of visionary architects and engineers came together in 1983 in Pune to form PCERF - Pune Construction Engineering Research Foundation. It was a platform for the overall benefit of designers, constructors as well as real estate developers for improved synergy. At that time with no computers, no Internet, no mobile phones, few telephones, information dissemination about new construction materials and technologies was difficult. Hence, a specialised exhibition meant particularly for construction professionals was envisaged. This led to the birth of Constro in 1985. For the last 3 years, with increasing popularity and demand for a larger space, the current venue is Pune International Exhibition and Convention Centre, Moshi, about 25 km from Pune. Constro is now an annual feature.

Constro has always been associated with numerous sister professional organisations as co-sponsors. IIA has been one of them. Our current IIA President, Ar Vilas Avachat, was invited as the Chief Guest of Constro 2024. His address about high rise structures was much appreciated by the audience. IIA Pune

Figure 1: Inauguration of Rachana at the hands of Hon. Gadkariji
Source: Ar Sampada Peshwe from IIA Nagpur Centre

Figure 2: Team Rachana celebrates!
Source: Ar Sampada Peshwe from IIA Nagpur Centre

Figure 3: Panel Discussion in Constro 2025
Source: Dr Uday Phatak from Pune Construction Engineering Research Foundation

Centre supported and participated in Constro 2025 under the dynamic leadership of Ar Vikas Achalkar. He believes that the design fraternity needs to be more involved in exploring new materials and technologies. Hence, interaction with the providing agencies is a must. So, the efforts put in by the PCERF team in organising Constro are much appreciated for creating a platform for knowledge sharing,

networking and collaboration among architects, builders and industry captains. IIA Pune Centre is proud to have been an active participating member.

Constro 2025 held from 30th January to 2nd February 2025, offered some innovative ideas that have the potential to transform the method of construction. The event brought together the best of construction industry, showcasing innovative technologies, sustainable solutions and cutting-edge designs. As a result, the approach of architectural design is likely to see a sea change in the years to come.

Let us look at two examples displayed in the Hall of Innovations:

1. VIIT college of engineering students have created a Non-Newtonian Fluid Speed Breaker: The purpose of reducing speed of a vehicle is primarily safety; however, it causes health issues due to the jerk caused by the bump of the speed breaker, even at low speeds. This innovative speed breaker filled with Non-Newtonian Fluid, offers no resistance to a vehicle travelling at 40kmph. As a result, the vehicle travels smoothly without any jerk. A speeding vehicle, on the other hand, will perceive the speed breaker with a jerk due to the resistance offered by this special Non-Newtonian Fluid. A law-abiding citizen will have an easy ride, literally!
2. J Kumar Infraprojects Ltd., a well-known construction company from the field of infrastructure projects, has diversified to fulfil the special construction related demands of our Armed Forces. On their stall, we see a variety of innovative products like
    - concrete made without cement
    - reinforcement with fibres, stronger than steel
    - corrosion resistant concrete
    - light weight, fire resistant and stronger concrete
    - runways that can be made within 2 hours
    - bunkers that can be made in, hold your breath, in 5 minutes, by 1 person
    - powder form concrete for easy transport and for use in -40° C like Siachen
    - bridges that can be made without cement and steel, and without foundation
    - concrete that is infused with CO_2 which helps in environment conservation
    - and so many more…

Figure 4: View of the stalls in Constro 2025
Source: Dr Uday Phatak from Pune Construction Engineering Research Foundation

Figure 5: Confex inauguration
Source: Ar Nilesh Dholakia from IIA Brihanmumbai Centre

Figure 6: Ar Nilesh Dholakia being felicitated by the event organiser
Source: Ar Nilesh Dholakia from IIA Brihanmumbai Centre

These materials have such fantastic properties and qualities, that the real estate sector is likely to see a revolution of sorts, in the days to come. It would be important for architects across India to take note of these developments and learn about the optimal usage of such materials.

IIA Brihanmumbai Centre – Knowledge and Supporting Partner

D-arc Build Expo in association with supporting Partners -IIA- Brihanmumbai centre, PEATA (India) (Practising Engineers, Architects and Town Planners Association -India), ISOLA, Smart Habitat Foundation, HPMF (Hospitality Purchasing Managers Forum), AESA (Architects, Engineers and Surveyors Association), ICEA (The Institute of Civil Engineers and Architects- Surat), NASA (National Association of Students of Architecture), WAI (Waterproofers Association of India) and BAI (Builders Association of India) held **Confex 2025** at Mumbai's Bombay Exhibition Centre, Goregaon (East) on 28th February 2025 and 1st March 2025.

IIA- Brihanmumbai centre at the Confex 2025 had organised specially for its members, an interactive session and Panel Discussion on "Congestion to Connectivity – Building Efficient Urban Transport System" along with a presentation by Ar Qutub Mandviwala at the venue.

According to IIA Brihanmumbai Chairman Ar Nilesh Dholakia, "Confex Mumbai 2025 was an attempt to showcase the works of eminent Architects and also have an informal, freewheeling chat with them. In addition, an attempt was made to address the present issues faced by the city this event and find a direction to the solution through an interaction with panellists from different fields and the audience. Since it was a restricted event, the suppliers and manufacturers and sponsors were able to have a one-on-one meeting with stall visitors. Hence, it was a win-win situation for all – Architects, Sponsors and Manufacturers as well as the event organisers. It is a wonderful and enriching experience to attend such exhibitions!"

IIA- Brihanmumbai has been supporting various Associations in promoting networking with suppliers, manufacturers, architects, interior designers and related professionals. Earlier in December 2024, IIA- `Brihanmumbai centre has been a supporting knowledge partner with WOFX- World Furniture Expo and wherein both the organisers as well as Architects benefitted from this Expo.

Such exhibitions go beyond mere stalls displaying materials or construction equipment. They play a big role as a B2B facilitator. They also are a great method to teach architecture students about the innovations and new applications. As these exhibitions are held in Metro cities, architects from the semi-urban and rural areas also benefit from the visits to such exhibitions. IIA as a national body, plays at times, a direct role and at times, an indirect role in this ongoing quest for knowledge and awareness!

A practising architect and interior designer with 35 years of experience, **Mrinalini Sane** (A10915) has also been involved with architectural education as a visiting faculty member in various colleges since 1993. Actively involved with the profession as Editor for Smaranika – IIA Maharashtra Chapter Souvenir, she has also been associated with PCERF – Pune Construction Engineering Research Foundation – as an Executive Committee member for more than 20 years. She is also now a Member of the JIIA Editorial Board. She has contributed to the profession in a unique way as an ISO Auditor, Consultant and Trainer and she offers Quality Management Systems as a tool to improve the office working efficiency of construction professionals. She has also represented India through the Rotary Group Study Exchange programme.
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ARTICLE

This article was presented at the IIA ANVESHAN Research Conference held at MCAP, Thiruvananthapuram, Kerala during 29-31 August 2024, under Stream 3: The Significant Present

Spanning without Steel and Shuttering

By Prof. Surya Kakani, Prof. Jaai Kakani and Ar. Prakriti Saxena

1. Introduction

For many reasons, the ceiling of roof is the most difficult part of the project of any building; and to this the architect generally gives his attention, knowing that any excess or default of material in the ceiling or roof affects not only its stability, strength and economy, but also the walls, columns and foundations, that is, the sustaining parts (Gustavino, 1892). The genus of the idea stems from a generational preoccupation with the dominance of reinforced concrete roofs replacing all other vernacular forms of roofing. Traditional roofing systems did not satisfy the generational shift in needs for a quick and permanent all weather proof roof, something that RCC answered. Parallel experiments with alternate materials that responded to concerns of cost, speed, availability, climate appropriateness and mass manufacturing, and more personal concerns over social equity, agency, autonomy, local upskilling, embodied energy and resource consciousness, continue to hold. Reinforced concrete has thus far, hence, permeated and flourished more or less as fait accompli.

Through the course of our practice (Kakani Associates), as we worked to include the various facets of sustainable design, ranging from load bearing construction, right-sizing of structural members, thermal comfort and ventilation through active and passive technologies, it became more clear that the roof remained elusive to alternatives that were viable in the multitude of factors that require to be satisfied for a technology to proliferate in the built environment. There existed little to no literature on alternative spanning methods until we came across the work of the Gustavino Company, through the writings of John Ochsendorf, a professor at the MIT University. The Gustavino brothers had been using time tested architectural and structural principles that had been evolving in Medeival Europe, and coalesced in Catalonia in the 1800s. In an attempt to replace the wooden roofing systems that were highly susceptible to fires, they had very successfully deployed the tile-clad timbrel vaulting system (Fig 1).

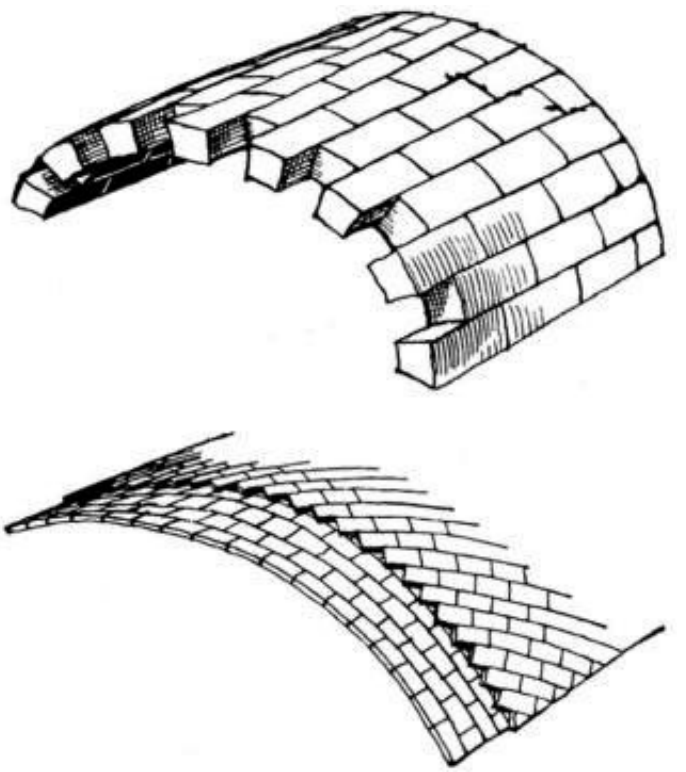

Fig 1: Traditional stone vault above Gustavino tile vault
Source : Moya, 1947. Published in the article – Gustavino Masonry Shells by John Ochsendorf, Ph.D. in the May 2014 issue of the STRUCTURE Magazine

Sr. Gustavino, armed with this knowledge moved from Catalonia to the New World (America), where he got his first break to build structural tile vaulting throughout the Boston Public Library, contracted to him by the firm McKim Mead and White in the 1890s. His son, Rafael Jr., after apprenticing under his father, went on to build some of the most daring masonry structures in history (Ochsendorf, 2014). The Gustavino Company built prolifically across the East Coast, with large scale spanning structures for churches, subways, train stations, libraries etc.

However, post 1910s, with the introduction of mass manufactured cement that was quick setting, easy to handle with abundantly available shuttering and thus allowing for both speed and many more possibilities of form play, slowly the practice of the timbrel, carefully crafted by skilled hands disappeared. While researching for information on the construction technique and methodology, we found the that the timbrel roofing had been used across Latin America and Africa. However, we found no information available on the exact structural calculation method nor any clues on the "magic paste" that masons used to hold the gravity defying roof structures during the construction period. This paper traces the experiments of our practice with the Timbrel vault, and the analyses of the learning and outcomes, with its large potential as a viable alternate to spanning without steel and shuttering.

Around the same time the practice was introduced to the master craftsman Azad Singh, from Rothak, Haryana, who, endowed with the generational knowledge and construction system of shallow brick domes. Upon visiting Rothak to observe first hand, the exciting technology in practice, another potential option of spanning without steel and shuttering was presented in the form of the very mundane brick, endowed with excellence of skill (Fig 2). As the practice began to work with Azad and his team, we were mesmerized by this technology, and connected with various structural engineers to analyze the constructional and structural logic of the domes, through extensive documentation across sites. This paper collates these observations and analyses.

1.1 Aim and Objectives

We aim to present the two construction systems – the Timbrel Vault and the Rohtak Dome as viable alternatives for spanning without steel or shuttering, through built examples of the body of work of our practice – Kakani Associates. The larger objective is to address questions of autonomy (of mass manufactured materials), agency (up-skilling local communities to be able to independently build pucca),

Fig 2: Master craftsman Azad Singh constructing the shallow dome in Alluva, Gandhinagar
Source: Kakani Associates

social equity (skill as infrastructure and opportunity), embodied carbon (resource consciousness and local materials) and climate appropriateness (thermal gain and protection from weathering).

Across the world and back home here, there has been much made about the Timbrel and the attractive forms it can generate through the simple module of a tile. Timbrel technology offers a huge potential to a larger issue that plagues all of architecture – the non-disposability of the pucca concrete roof. With the possibility of 2 skilled masons being able to construct an entire pucca structure from the structural foundation to vertical load bearing walls to the spanning roof, the practice sees a huge potential in the as yet, many unbuilt hinterland homes. With a population 1.4 billion strong today, there are more people in India than anywhere else in the World. There is an immediate need to enhance indigenous construction capabilities and create more awareness of the economic value of local materials to meet the urgent need for housing (Ochsendorf, 2014). And with this in mind, the practice went about understanding the making of the Timbrel vault and Rohtak Dome and their resolution of forces.

2. Literature Review

British fan vaulting, Catalan thin-tile vaulting and Mexican 'leaning brick' vaulting are the three enduring methods of construction in thin shell masonry – each associated with their associated structural theory and constructional praxis – representing the three primary methods of spanning space in unreinforced masonry (Block and Davis, 2010).

We know that a construction on the "Cohesive System" will have stability when set. The "Timbrel Arch" is not entirely new. It is as ancient as the "Cohesive System" and may be as old as its opposite, which may be called the "Gravity System."

We will begin by investigating the way in which this kind of arch works. A "Timbrel Vault" of a single thickness of brick or tile has no more resistance than an arch or vault built on the "Gravity System"; because, no matter how good the mortar may be, there is only one vertical joint, and the bricks or tiles are working as voussoirs. But if we put another course over the first, breaking joints, and laid with hydraulic material, we will have the action of cohesive force. In this way the mortar laid over the first course, or extrados, takes bond with it, and also with the course laid on top. As soon as the cement sets, we will have shearing resistance represented by 17,820 pounds per square foot. So we introduce a new additional strength to the arch which is a peculiarity of the Timbrel Arch System (Guastavino,1892).

The layered tile vault can be remarkably thin when it has a suitable structural form. A funicular shape is the most efficient geometry to resist loads as it acts in pure axial tension or compression like a catenary (Fig 3). It acts in pure tension (with no bending moments) under self-weight only, allowing it to be thin. Another funicular geometry is created with an inverted hanging chain in compression. In order to develop arch action in this compression structure, the arch needs support at its ends, to resist the outward "thrust". The proposed vaulting system takes advantage of funicular geometry to limit the amount of material required, and to avoid tensile reinforcements (Block, DeJong, Davis and Ochsendorf, 2010).

Any structure built from masonry must satisfy three main structural criteria in order to be safe and serviceable - strength, stiffness, and stability. Masonry has no tensile strength; it has compressive strength and failure by sliding will not occur. For unreinforced masonry structures, the stability and design of the structure is governed by the geometry of the structure rather than the material strength because the actual stresses are lower than the material capacity. Based on these assumptions, equilibrium and graphical analysis methods have been developed to determine the stability of masonry structures. All of the different methods are based on the fact that the self-weight of the structure, and any imposed loads, are carried as compressive forces through the structure in what are called as thrust lines. Under a specific loading condition, masonry structures have many thrust line configurations and load paths within the thickness of the arch. An arch will remain stable as long as the thrust line is maintained within the thickness of the structure from the crown and towards the base (Dugum, 2013).

The same basic principles and assumptions of arch analysis are applicable to the analysis of masonry domes. Masonry blocks of the dome are assumed to have infinite compressive strength, zero tensile strength, and no failure by sliding. With that, the analysis methods of an arch can be expanded with a few more details and be applied to the analysis of masonry domes. The meridional forces transfer gravity loads from the crown towards the base of the dome. The hoop forces act in the latitudinal direction as concentric rings (Fig 4). The self-weight of the dome and any imposed loads are carried through these internal forces, and the distribution of forces within these orthogonal paths causes the dome to remain in equilibrium (Dugum, 2013).

3. Methodology

This paper illustrates the explorations of the practice in the construction of the Timbrel vault through a series of experiments, followed by applications in built projects. The methodology adopted for the Rohtak domes is through observation and analyses

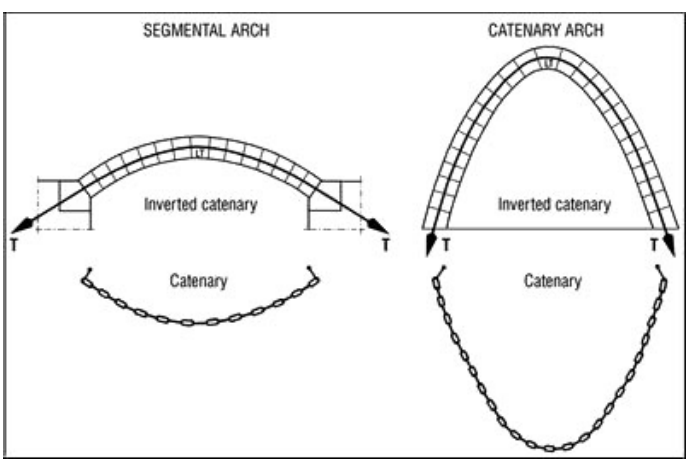

Fig 3: Catenary curves in segmental and catenary arches
Source: by Jesuibee from the from the WordPress Photo Directory: https://designontopic.wordpress.com/2014/01/18/catenaries-first-report/

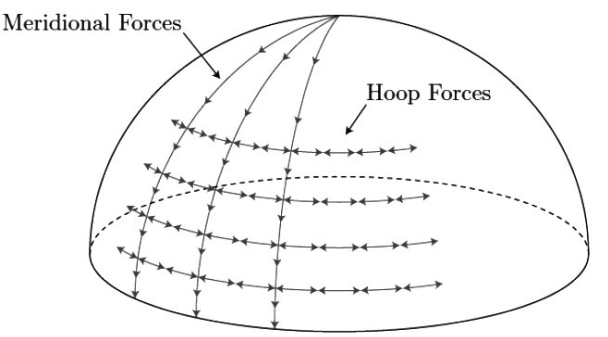

Fig 4: Primary forces acting in a dome
Source: Thesis by Hassan Dugum on the Structural Assessment of the Guastavino Masonry Dome of the Cathedral of Saint John the Divine, MIT University, June 2013

of its construction by master craftsman Azad Singh and his team (Fig 5,6,7).

Fig 5: Starting from 2 opposite corners
Source: Kakani Associates

Fig 6: All 4 corners meeting to form a complete course, dome taking a fish-eye form
Source: Kakani Associates

Fig 7: One of the completed Rohtak Domes at SOACH NGO, Alluva
Source: Kakani Associates

4. Data Analysis and Findings

4.1 How does it work?

A catenary, the shape of a hanging chain is the most efficient geometry in resisting loads since it acts in pure compression with no bending moments (Fig 8). The load is uniformly distributed on the arch and its horizontal thrust is countered by a concrete ring beam. Tie rods are used to stabilize arch against horizontal forces during earthquakes.

Fig 8: A catenary arch with our design span (4.47m) & rise (447mm) was traced from a hanging chain
Source: Kakani Associates

"As hangs the flexible line, so, but inverted, will stand the rigid arch" – Hooke's second law.

4.2 Layering

Tiles are laid such that joints in each layer break the joint of the previous layer so that individual compressive strengths add towards the total compressive strength of the vault (Fig 9, 10, 11).

Fig 9: Construction of the 3m span vaults at SOACH NGO
Source: Kakani Associates

Fig 10: Layer 4 to complete the vault of 80mm thickness
Source: Kakani Associates

Fig 11: The office team loading the successful vault
Source: Kakani Associates

4.3 Advantages

No steel needed in spanning

Thinness of vault reduces thrust, reducing the size of ring beams required, efficiently using resources. Reduced carbon footprint compared to conventional roofing

Multiple floors can be constructed over each vault (Fig 12).

4.4 Multiple floors

Multiple floors possible as shallow vaults can be filled / leveled to create a floor above, some studies further recommend leveling and adding an upper slab to further strengthen vaults. The results show a very important collaboration between the vault and backfill, where both membrane and bending stresses along the arches reduce. Particular static improvement is obtained with the construction of a thin non-structural slab at the floor level (Giuriani, Gubana and Arenghi, 2010).

Fig 12: The completed 4.75m span vault at SOACH NGO
Source: Kakani Associates

4.5 Comparison between Timbrel and RCC

Table 1 and Table 2

As one scours the internet, there are various ongoing studies to test the strength and performance of masonry vaults and domes given their many advantages. Most studies use complex 3-D form finding tools for analyzing complex geometries. One popular tool is the Thrust Network Analysis (TNA) tool, that allows the generation of novel 'free-form' shapes for funicular, compression-only structures (Davis, Rippmann, Pawlofsky and Block, 2012).

The larger aim is to collaborate with structural engineers and create standard IS codes for such structures, to be able to scale up the proliferation of the same armed with structural assurance.

5. Conclusions and Recommendations

As we reorient ourselves from the highs of 20th century battles, we are realizing the depths of

Table 1: Strength in compression- 5 samples of size 350 x 215 x 55mm and 3 layers were tested
Source: Kakani Associates

	Timbrel vault	**RCC slab**
Average compressive strength	12.22 N/sq mm	1.5 N/sq mm
Factor of safety	3	1.5
Working compressive strength	4.07	10

Table 2: Strength in flexure- 3 samples of size 450 x 215 x 55mm and 3 layers were tested
Source: Kakani Associates

	Timbrel vault	**RCC slab**
Average flexure strength	2.86 N/sq mm	2.90 N/sq mm
Factor of safety	3	1.5
Working flexure strength	0.95	1.93

the scars that fast-paced technologies, industrial processes and new age materials can inflict on daily human and environmental resilience. The current climate crisis and human suffering, directly related to environmental damage and disasters, has led international watchdogs like the UN to call out for nations to work towards Sustainable Development frameworks by outlining the SDGs at length.

While the carbon footprint of developing nations like India has thus far been relatively less compared to the developed world, our large population and increasing movement towards adopting the fast-paced industrial development paradigm of the west, poses its own concerns, for us particularly, as also the world at large. If we are to just look at the housing market in the global south, which is exploding, as also unemployment, which too is perilously on the rise, we cannot escape questioning how we build.

There has been a lack of imagination deployed in finding more appropriate solutions for our particular context, that include climate appropriate materials and systems of construction for urban and rural India, and an employment enabling vision that can tap into locally available skills, construction knowledge and materials. For the global south, a large population still lives in rural geographies. To believe that only materials, skills and construction technologies that rely upon urban infrastructure can provide lasting solutions, should alert us to a lack of true developmental understanding.

Concrete, steel, glass, and other industrial age materials do not just increase environmental temperatures in their built environments, but they also have utilised immense energy in their production processes, causing environmental, social and human discomfort beginning with mining, transportation and leading to its final production and packaging. There is an urgent need to be concerned about the embodied energy of materials being used in the building industry. Climate responsiveness is imperative to the way we construct and design, and this begins with us thinking about the construction of structural systems and the building materials.

The experiments undertaken by our practice have been in this spirit. Over a period of 8 years, we feel certain that alternative roofing systems that align with contemporary needs and concerns are possible, while also answering the call for sustainable local technologies. To the question we posed in our practice, that can technologies become knowledge systems that allow for their localisation- we have found that the simple vault of the timbrel technology as well as the shallow domes of Rohtak provide us ample hope in potentially addressing and alleviating some of the challenges mentioned above.

It is with this intent and hope that one presents this paper, not as some original ground breaking research (as much of this research exists with substantial technical understanding), but as removing the blinkers that took away our imaginations from possibilities of what history has endowed with. It is a simple collation of knowledge systems that lie amongst us as answers to our present challenges.

The more pertinent task on hand now is to get our engineering fraternity on the same page, enlisting their support in getting these systems into standards and codes. Ease of proliferation is possible largely through this legitimising.



Surya Kakani (A 24743)**, Jaai Kakani and Prakriti Saxena** represent Kakani Associates, a collaborative between architecture and design. Founded in 1995 by Surya and Jaai, an underlying ethos of the practice has been to achieve efficiency in operation, minimise waste and match form and expression closely to the imperatives of the chosen construction systems and processes, broadly related to resource conscious design. The practice was awarded the Michael Ventris Award 2021 for their work on the timbrel construction.
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ARTICLE

Urban Green Pockets

Small Interventions, Big Impact

By Gunja Goyal

1. Introduction

In the fast-paced urbanisation of Indian cities, vacant plots, leftover spaces and derelict corners are common sights. These dead spaces contribute to environmental degradation, heat islands and a loss of community interaction. Urban green pockets — small, accessible and community-centric green interventions — present a transformative solution to this growing urban malaise.

As shown in figure 1, transforming a dead urban plot into a vibrant community space can serve as a powerful demonstration of how micro-interventions address larger urban challenges. Drawing inspiration from traditional Indian settlement patterns where *chowks*, *kunds* and *ghats* serve both ecological and social functions, this article explores how small green interventions can revive the urban fabric.

2. Need for Urban Green Pockets

Urban landscapes have witnessed a progressive erosion of open spaces due to rampant construction, vehicular dominance and shrinking public commons. Small green pockets offer a highly adaptable strategy to counter this decline, particularly in dense cities where acquiring large land parcels is impractical.

The benefits of these micro-interventions span across multiple domains, as summarised in Table 1.

Figure 1: Transformation of a dead urban plot into a pocket park
Source: Author

2.1 Strategies for Implementing Green Pockets

Urban green pockets can be developed using a variety of flexible, low-cost strategies. These interventions prioritise human experience, environmental benefit and community engagement.

2.1 Modular Design Approach

Modular designs allow for small urban sites to be activated systematically. Elements such as benches, planter boxes, play zones and shaded areas can be configured based on site dimensions and user needs.

As illustrated in figure 2, a modular park layout divides a typical vacant plot into interactive zones, facilitating a flexible and adaptable green pocket.

2.2 Community Participation Model

A key element in the success of green pocket projects

Table 1: Benefits of Urban Green Pockets
Source: Author

Benefit Category	Description
Environmental	Mitigates heat island effect, improves air quality and supports biodiversity.
Social	Provides spaces for social interaction, community events and recreation.
Psychological	Reduces stress, enhances mental well-being and fosters a sense of belonging.
Economic	Increases nearby property values, supports local micro-economies (street vendors, markets).

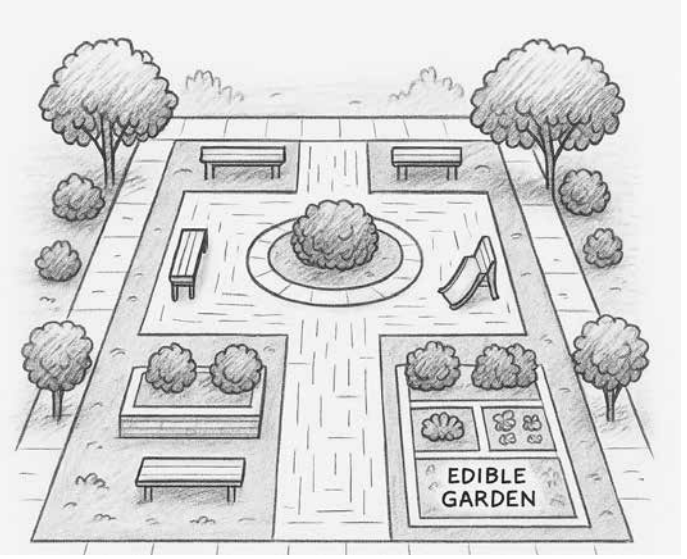

Figure 2: Modular green pocket park layout
Source: Author

is community involvement. Community participation ensures not only design relevance but also long-term maintenance and social ownership. As shown in figure 3, the process typically begins with local identification of a neglected space, followed by participatory planning sessions, volunteer-based execution and continued stewardship by residents.

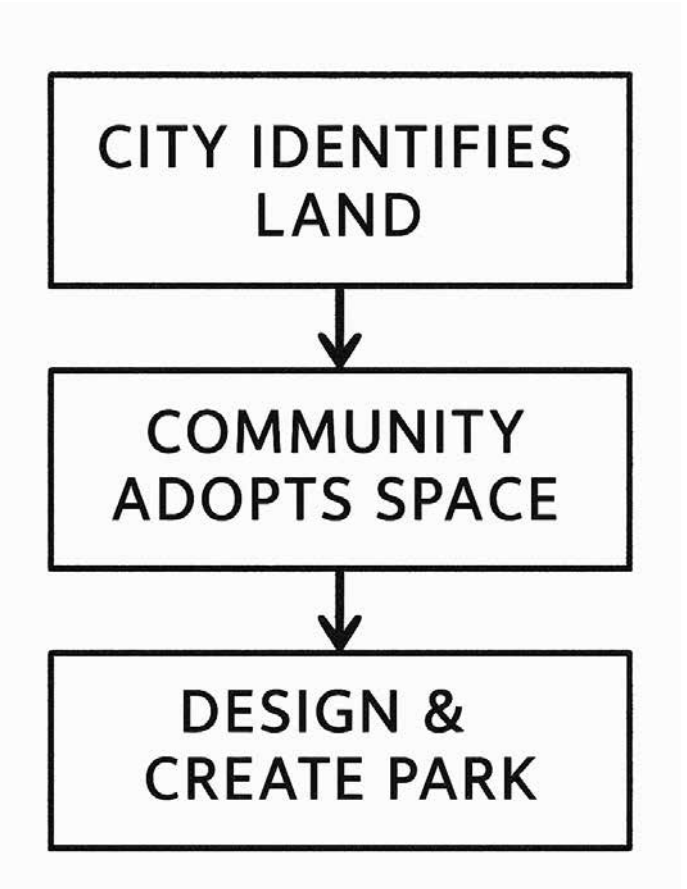

Figure 3: Community participation flowchart for urban green pockets
Source: Author

2.3 Tactical Urbanism

Tactical urbanism refers to quick, low-cost and scalable interventions that transform underutilised spaces temporarily or permanently. Examples include painted pedestrian zones, moveable planters, pop-up gardens and temporary seating.

Figure 4 presents a conceptual sketch of how a neglected street corner can be revitalised using tactical urbanism techniques.

Figure 4: Example of tactical urbanism activation for dead corners
Source: Author

Conclusion

Designing urban green pockets is not just about aesthetics; it is about restoring the ecological, social, and psychological balance of cities (figure 5). By focusing on small, meaningful interventions, architects and planners can unlock significant environmental benefits and promote vibrant, resilient communities. Figure 6 illustrates a typical pocket park section — showing shaded trees, sidewalks, and open green patches — reinforcing how thoughtful micro-interventions can reclaim the vitality of the urban fabric, one space at a time.

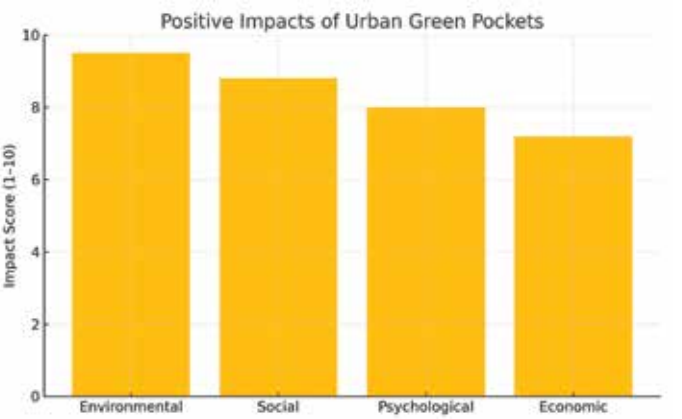

Figure 5: Positive impacts of urban green pockets
Source: Author

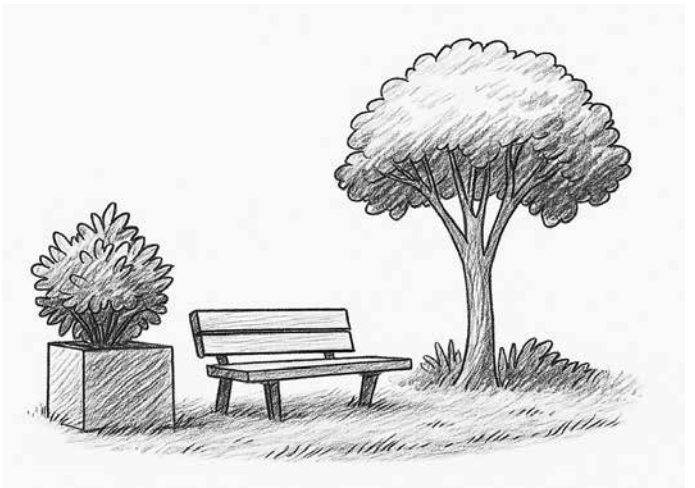

Figure 6: Sectional view of a pocket park showing trees, benches and pathways
Source: Author

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Women in Weed Craft of India – Moonj

By Dr. Nirmita Mehrotra

Introduction

Craftwomen of Mahewa, Naini from many generations derive their identity and strength from this local craft. In a small town of Prayagraj, Uttar Pradesh, material culture prospers from *Moonj* Grass. Mahewa Naini is popularly known for its *Moonj* Craft, a coiling basketry technique practiced by rural women in Prayagraj. The craft gets its name from the *Moonj* and *Kaasa* grasses – wild grasses that abundantly grow near the banks of the river Yamuna and Ganga and in and around the vast areas of Prayagraj.

The motifs of basketry are created by adding coloured grass in between. These natural products are ideal to serve daily life purposes and can be used as containers, food storage devices and wall decor. As seen in figure 1, the products are very simple, attractive and eco-friendly with coloured patterns integrated in them.

Location

Mahewa Patti Pashchim Uparhar in UP is ranked as a census town (Census 2011) with 6,408 people, but locals still refer to it as 'Mahewa village' (figure 2a & b). Located in Karchhana tehsil, it lies a few kilometres from Sangam – the confluence of the Yamuna and Ganga rivers and an important site of

Figure 1: Geometrical Pattern in Moonj Basketry
Source: https://www.directcreate.com/craft/moonj-basketry

Figure 2a: Location Karchhana tehsil in Prayagraj district
Source: www.mapsofindia.com

Hindu pilgrimage. Prayagraj is one of the oldest cities in India, situated at the confluence of three rivers- Ganga, Yamuna and the invisible Saraswati. The Kumbh mela held in every six years and Mahakumbh in every 12 years at Prayagraj are the largest gatherings of pilgrims on Earth.

The Naini area of Prayagraj is known for its *Moonj* craft. Easy availability of raw materials has enabled this craft to flourish in the district. The market is flooded with a variety of products made from *Moonj* like basket (daliya), coaster stand, bags, decorative items and more. Eco-friendly *Moonj* products have the potential to do well in the national as well as international markets. Nearly 90% of womenfolk in

Figure 2b: Location of Mahewa town in Karchhana tehsil
Source: www.mapsofindia.com

Naini are involved in *Moonj* basket making. *Moonj* and *Kaasa* are the types of wild grass that richly grows near the banks of the river in and around Prayagraj (figures 3a & b). *Moonj* is outer layer of the grass which is peeled and knotted. This art is being practiced from the last 60 to 70 years. The grass is cut during the winter and the peel of the stalks is left out in dew for days to lighten its color. Many spilts are dyed in bright colours and binding is done these days with plastic strips, tinsel or cloth.

Prayagraj is a famous city of Uttar Pradesh where an industrial area is located called Naini, known for its *Moonj* craft. The easy availability of raw materials has enabled the craft of *Moonj Baratar Katiyahi* (moonj craft village) situated at the bank of Mansiyta, a subsidiary river of the holy Ganga of Uttar Pradesh,

Figure 3a: Sarpat grass at the river bank
Source: https://www.dailyexcelsior.com/sarkanda-a-multipurpose-medicinal-plant/

Figure 3b: Gatta (bundle) of sarpat grass
Source: https://www.hintoftradition.com/post/moonj-craft

to flourish in Prayagraj. The *Moonj* craft of Prayagraj has been awarded a Geographical Indication (GI) tag, opening new export opportunities. This milestone under the One District One Product (ODOP) initiative of the government will enhance global recognition and support to moonj artisans.

Nature-based Raw Material and Eco-Friendly Products

Sarpat grass, which reaches a height between 7 and 12 feet, plays the leading role in *Moonj* craft (figure 4). Playing a supporting yet important part, is another grass – a thinner reed called *kaasa* which is used to bind the tougher *moonj. Kaasa* is barely visible in the final product. Sold in tightly-tied handfuls, this grass is available in plenty on the river banks, selling for Rs 5 to10 for a bunch. *Mallahs* or boatmen who

Figure 4: Moonj balla – knots made to preserve it for later use
Source: https://www.doorbeencreatives.com/moonj-basket-weaving

traverse the Yamuna's banks bring *moonj* and sell it as a *gatta* (bundle) roughly weighing 2-3 kilos. With a *gatta* of *moonj,* an artisan can expect to make roughly two 12 by 12 inch baskets that are sold for Rs 1500. Baskets of this size are normally used to grow plants or to store clothes. *Moonj (balla)* is not available throughout the year. It grows only once in a year the month of October along the banks of Ganga and Yamuna rivers. Its limited supply causes a shortfall of raw-material in other months. Due to the uncertainty of market demand, traders' take orders of these products. *Moonj*-craft makers are not able to maintain sufficient stock of raw-material and when they get order from any trader, they purchase raw material at comparatively higher prices which further increases the cost of making craft and reducing profit margins for them.

Socio-economic Status of Moonj Crafts Artisans

In Naini Mahewa, there are around 130-150 families who are engaged in making of different products from Moonj and Kaasa grass. The majority of artisans are women. Most of their families do not have any other productive assets except the land on which their houses are built. Men, in addition to their involvement in marketing of moonj products, also work in city shops, as drivers or do petty jobs in nearby industries. Weaving moonj baskets is part of their daily routine. They dedicate 3-4 hours daily to this craft and weave all kinds of products by coiling method. Nowadays, weaving is done for products in demand like coasters, placemats and earrings. The village is home to approximately 400-500 artisans who earn their livelihood from this craft. The community is characterized by its *pukka* houses, reflecting a well-established and resilient way of life. Literacy level of both men and women are very low, but women are highly skilled in the craft which makes them unique in the state. Two important social aspects are at play here. First, when a girl gets married in a family, she goes to her in-laws' home with her skill and knowledge of this craft and continues to make these crafts. Secondly, when a boy gets married, the elderly women of the family teach the new daughter-in-law to make moonj craft. In their spare time, they also help others in making of this craft. In this way, the art of making these beautiful products pass from generation to generation.

The Coiling Method

The manufacturing processes of *moonj* craft involves simple and traditional techniques which is done skillfully by using natural grass and locally-made tools. The raw materials needed are:

1. *Moonj* and *kaasa*
2. *Kaccha rang* (colour) to make the grass colourful.
3. Edible salt to add with the dye solution.

Similarly, the tools important in making of moonj craft include:

1. Scissors (*kainchi*) to cut the grass
2. A needle with wooden handle (*sirahi*)
3. Plastic tub to soak the *moonj* grass
4. Aluminum container which is used in the dying process to boil the colour solution

Moonj and *Kaasa* are important raw-materials in making *Moonj* products. *Moonj* is basically an outer layer of *sarpat* grass. This layer is peeled and knotted as it is easy to store and dry. These knots are locally called as *balla*. *Moonj* baskets are made using a traditional coiling method. The dried *balla* is soaked for a few minutes in cold water to ensure flexibility and is then wrapped around the dried *kaasa* to make coils (figure 5). These coils are wound in a series to make the base of the basket (figure 8). The same technique is used to make the walls of the baskets. To further strengthen the structure, these coils are stitched together. The motif patterns of the baskets are created by incorporating the dyed grasses into the knotting pattern (figure 6).

The art of making containers baskets from *sikki* and *moonj* grass is practiced from decades in eastern Uttar Pradesh and Bihar. The *sikki* grass grows on the banks of river and is torn of its stalk, dried, coloured and then formed into coils and braids to make basket and other products. The technique is called coiling. Moonj is much cheaper and more abundant, so it is used to give basic shape and strength in *sikki* products. At first, *moonj* is coiled and then it

Figure 5: Coiling of Grass
Source: https://test1.ruralindiaonline.org/en/articles/women-bank-on-moonj-grass-in-mahewa/

Figure 6: Colouring with natural dyes
Source: https://test1.ruralindiaonline.org/en/articles/women-bank-on-moonj-grass-in-mahewa/

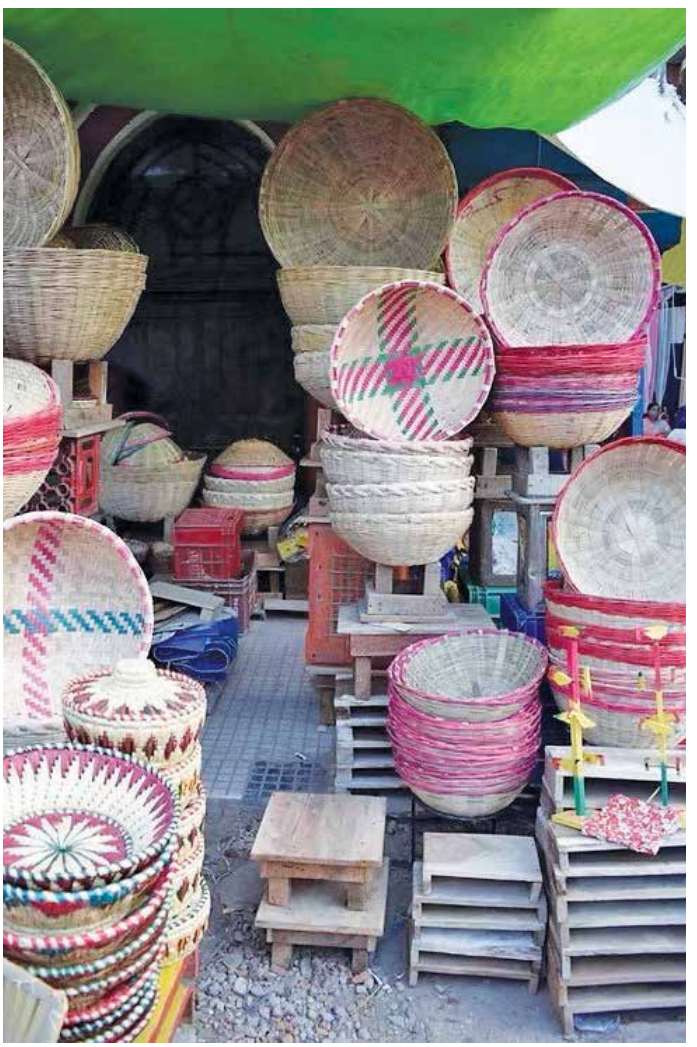

Figure 7: Moonj shop with varieties of products
Source: https://www.hintoftradition.com/post/moonj-craft

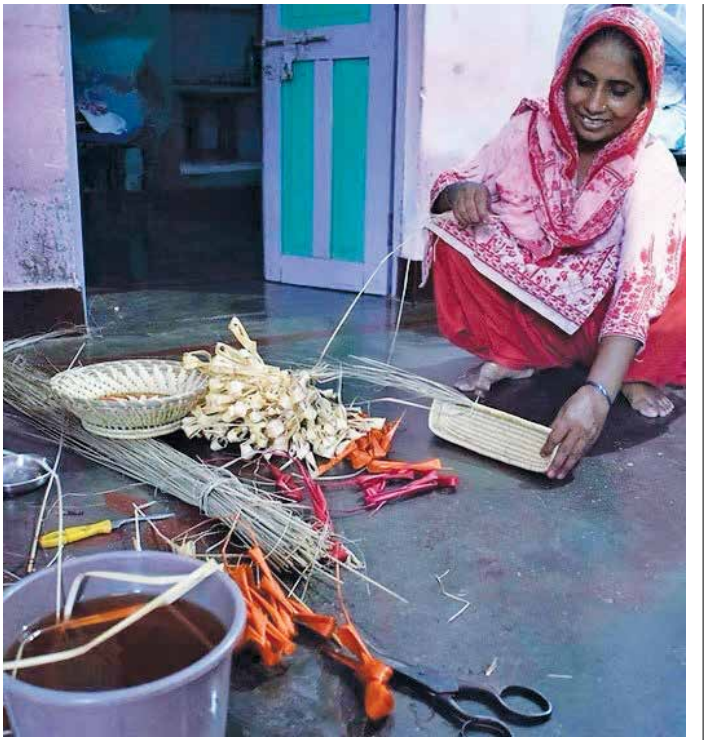

Figure 8: Using colour ballas in the coil
Source: https://www.hintoftradition.com/post/moonj-craft

is covered with *sikki* grass. The main tool used by the women is a 5-6 inches long needle-shaped iron object with a rounded head for grip is called *takua.*

Religious and Mythological Importance of Moonj Grass

Moonj basketry is in much demand amongst locals and tourists. The Yamuna is a vital link that runs through the lives and livelihoods of the people of Mahewa. These craftswomen also supply small baskets woven from palm leaves filled with flowers and other offerings for pilgrims at Sangam. There are many women's self-help groups (SHG) working with women basket weavers. *Moonj* products are in high demand during the wedding season as it's used in some wedding rituals. Brides take some baskets filled with wedding sweets and gifts to her inlaw's home. *Moonj* is considered sacred as it is one of the ten types of *kush*(grass) that is believed to have purifying properties and the virtues of Lord Vishnu.

Prayagraj serves as a center of this form of weaving in Uttar Pradesh. The tribal areas of the Tharus, one of the dominant tribes of the state also sees practice of this form of weaving but their motifs are normally more animalistic or gigantic. The women of Prayagraj and Gorakhpur normally make geometrical figures and the baskets are circular in shape. The simple, attractive and eco-friendly products are very popular in the market particularly for wedding and other religious ceremonies. (figure 7).

Promotion Schemes

Around a decade ago, demand for *Moonj* had dried up– the number of women practising the craft had fallen and there were few products on sale. Help came with an unexpected development – in 2013, the UP government launched its One District One Product scheme and *Moonj* was chosen as the distinct product for Prayagraj, its history dating back at least seven decades. The ODOP status has increased demand and sale, so many craftswomen are returning and new people are also joining. The Government of Uttar Pradesh also started many schemes under ODOP for branding, skill development and marketing which included Marketing Development Assistance Scheme, Finance Assistance Scheme, Skill Development Scheme, Common Facility Centre (CFC) Scheme, etc to promote this craft. The main objectives of ODOP scheme are:

1. Preservation and development of local crafts/ skills and promotion of the art.
2. Increase in the income and local employment by organized production.
3. Improvement in product quality and skill development.
4. To make a facility centre where raw material can be procured at rational prices.
5. Transforming the products in an artistic way through packaging, branding etc.
6. To connect the production of handicrafts with tourism.
7. To resolve the issues of economic differences and regional imbalance.
8. To take the concept of ODOP to national and international level after successful implementation at the state level.

The role of government is key in supporting these handicraft-based livelihoods. Facility centres containing raw materials and work spaces can be a great asset to preserve this craft and encourage its practice and transfer amongst family members.

Conclusion

In the present day, other than Prayagraj, the major centers that are engaged in *Moonj* Basketry are Gorakhpur and Bahraich. Despite material availability issues, there is an increasing demand for products made from *Moonj* as they are aesthetically pleasing and sustainable. In the context of potential of export growth of Indian handicrafts, this ecofriendly product's standing remains a question mark.

The lack of institutionalized channel of marketing increases the sensitivity and vulnerability of the women artisans, while the clever traders try to make their profit by creating surplus value. This art may be saved from disappearing by assigning actual recognition to the *Moonj* crafts, branding, advertisements and creating demand for these products. A display center for *Moonj* products and workshops can help to promote the craft and encourage more women to join in the production of these eco-friendly products. Creating an awareness about this ecofriendly craft could be the first step for increasing the utilisation and consumption of these everyday useful traditional products which has given strength and identity to the women of Mahewa.

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Time-Bound Design Problems

A Strategy for Outcome-Based Education in the Age of AI

By Dhiraj Salhotra

The advent of Artificial Intelligence (AI) has brought about a paradigm shift in various industries, and education is no exception. While AI has the potential to augment human capabilities, it also poses a significant threat to the traditional education system. The overwhelming use of AI tools can lead to a lack of development of human instinct skills, which are essential for creative problem-solving, critical thinking and innovation. The overdependence on technology rather than a tool to expedite or as a think buddy is gradually replacing the human intervention through intuition, use of mindful judgment and ability to conceptualise.

To counter this impact, educators are exploring new strategies to develop outcome-based education that focuses on human-centric skills. One such approach is the introduction of time-bound design problems. The concept of time-bound design problems can be used to develop outcome-based education that prepares students for the AI-driven world. The model of developing the assignment is a skillful art as the mentor must have lot of clarity while setting up the time-bound problem regarding the desired outcome based on the application of acquired knowledge.

What are Time-Bound Design Problems?

Time-bound design problems are a type of design challenge that requires students to solve a complex problem within a limited timeframe. These problems are designed to simulate real-world scenarios and students are expected to apply their knowledge, skills and creativity to develop innovative solutions. The time-bound nature of these problems adds an element of pressure, which helps students develop critical thinking, problem-solving and decision-making skills. The critical success of the exercise underlies on the ability of the problem to evoke the critical thinking and generate opportunity through trigger points that enable the problem solver to deep dive and find innovative solutions. These assignments should not be miscued for being mere exercises for skill differentiation but it must be aimed to trigger the aspect of rigour and ability on self to deliver without external distractions.

Benefits of Time-Bound Design Problems

1. Develops Human Instinct Skills

Time-bound design problems help students develop human instinct skills such as creativity, critical thinking, and problem-solving, which are essential for success in the AI-driven world. The aspect of intuitive thinking is essential – the primary response to site, climate, topography, culture and our overall grasp of the way human life dwell is all part of the critical thinking while the use of data-driven decision making comes handy for providing alternative ways towards problem-solving.

2. Enhances Collaboration and Communication

These problems require students to work in teams, communicate effectively and collaborate to develop innovative solutions. As a social being having diversified thinking as a tool to inhibit design solutions is an essential aspect to any sensitive project. The idea to communicate, gain insight and share experiences acts as the real-time stimulants to generate design ideas.

3. Fosters Adaptability and Flexibility

Time-bound design problems help students develop adaptability and flexibility, which are critical in

Figure1: Conceptualisation using tools and techniques.
Source: Author

Figure 2: Critical thinking exercises as peer learning.
Source: Author

Figure 3: Graphical tools and techniques with use of overlays act as quick thinking tools.
Source: Author

today's fast-paced and rapidly changing world. In the fast paced world today, while critical thinking is essential, also significant is time-bound problem-solving that comes only through the sense of urgency and ability to apply single-minded focus. These are the essential skill sets for deep-diving and coming out with solutions in short period of time.

4. Prepares Students for Real-World Scenarios

These problems simulate real-world scenarios, preparing students for the challenges they will face in their professional lives. A quick and time-bound problem solving exercise creates opportunities for experimenting with multiple scenarios and situations. A single large problem can be broken down in to multiple smaller exercises and each one could be attacked with same sense of urgency and critical thinking as the whole.

Implementing Time-Bound Design Problems in Education

To implement time-bound design problems effectively, educators can follow these steps:

1. Define Clear Objectives

Clearly define the objectives of the design problem, including the skills and knowledge that students are expected to demonstrate. It is essential to map the desired outcomes and also state clearly the scope that is expected to be covered. All essential details pertaining to the problem must be stated and the data made available before hand, leaving no room for gaps.

2. Design Realistic Scenarios

Design realistic scenarios that simulate real-world problems and provide students with the necessary context and resources. A problem that is imbued in the course of daily action and is part of the aspiration needs thorough experienced outcomes of the exhibitor and has to be at the core of all planning. A known scenario or a situation is an ideal set up for creating a learning experience that is truly inspiring and leaves no scope for imaginary or purely data-driven solution.

3. Set Time Limits

Set time limits that are realistic and challenging, allowing students to develop solutions within a reasonable timeframe. The potential judgment of the students' calibre, skill sets and maturity levels must be well-gauged while setting up the project size, scale, complexity and the outputs.

4. Encourage Collaboration

Encourage students to work in teams and provide them with the necessary resources and support. A perfect synergy in a time-bound exercise can be achieved when these exercises are done as a part of team or peer learning exercises. When such exercises are designed for group participation, individual inhibitions are shattered while the collaborations help bring out the best results.

Figure 4: Peer learning and collaboration of ideas.
Source: Author

Figure 5: Time-bound exercises bring focus and optimises efficiency.
Source: Author

5. Provide Feedback

Provide students with feedback on their performance, highlighting areas of strength and weakness and suggesting areas for improvement. Any form of feedback is essential for not only measuring the success but also essential for making the appropriate gap analysis. When the exercise ends making presentations, sharing the solutions, discussions on the possibilities are steps that can lead to highest order of learning and prove more effective than the entire exercise itself. The outcome of such discussions when aimed at finding more possibilities based upon available facts is more essential than arriving at differentiation of right from wrong.

Conclusion

The introduction of time-bound design problems is a strategic approach to developing outcome-based education that prepares students for the AI-driven world. By focusing on human-centric skills such as creativity, critical thinking and problem-solving, educators can help students develop the skills they need to succeed in a rapidly changing world. As AI continues to transform industries and societies, it is essential that educators adapt their teaching methods to prepare students for the challenges and opportunities of the future.

Dhiraj Salhotra (A11237) has over 25 years of professional and teaching experience and is currently the Principal of Thakur School of Architecture & Planning in Mumbai. He is a doctoral research scholar and his area of research is identifying design pedagogy while creating a social response in managing urbanisation. He has presented on sustainability and humanising agenda in several national and international conferences and seminars.
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Evolution of Temple Architecture in Tamil Nadu

Worship Worthy ASR (Artist's Social Responsibility)

Author: Ar. J. Ramanan and Vrinda Ramanan
Reviewer: Ar. Harshad Bhatia

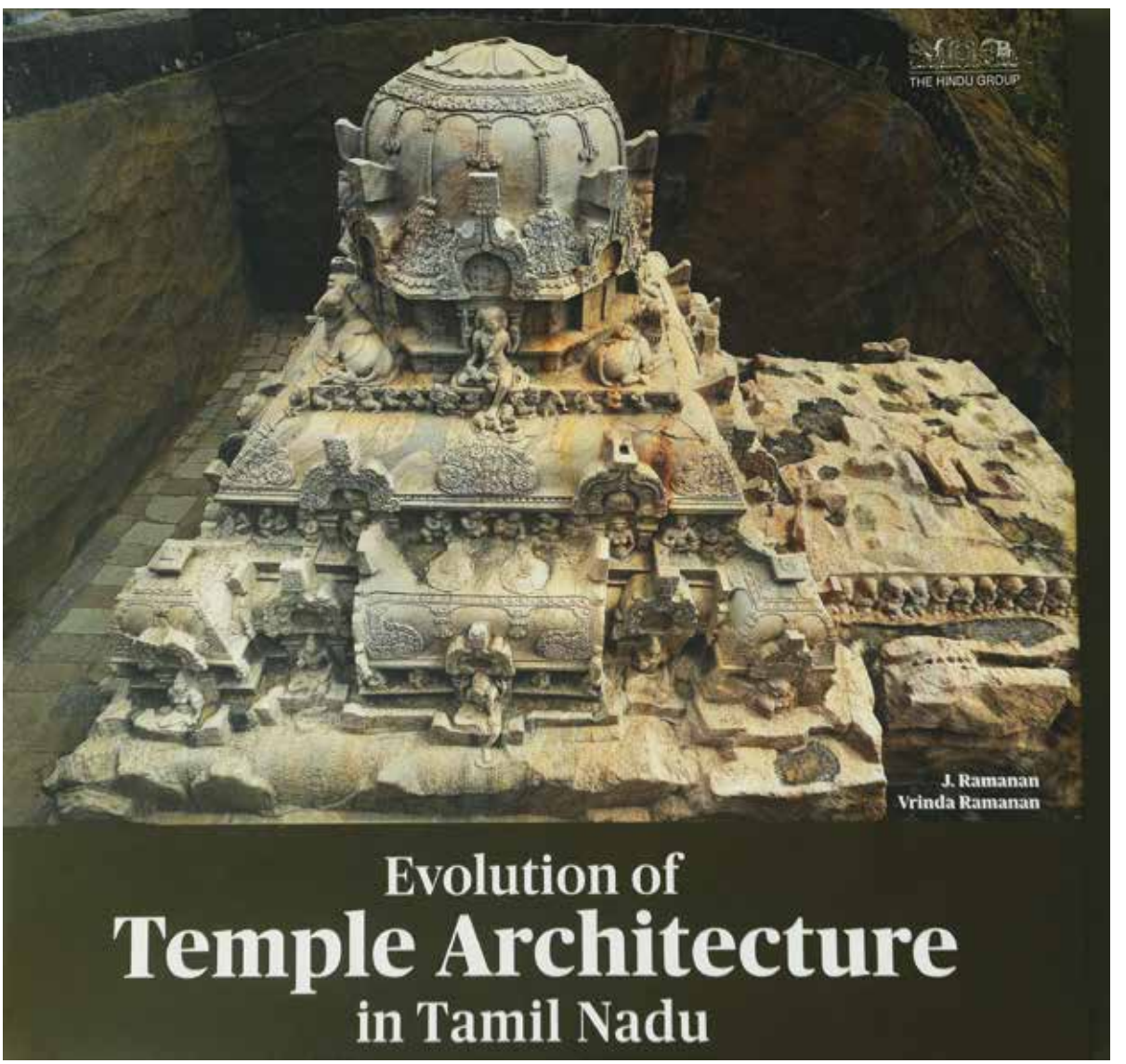

Figure 1: Book cover - Evolution of Temple Architecture in Tamil Nadu

ISBN: 978-93-87791-70-1
Genre: Non-fiction - Architecture History
Language: English
Publisher: THG Publishing Private Limited (The Hindu Group)
No. of pages: 357
Year of publication: 2025

This is an intriguing book. It opens with foreword notes each from Smt. Nirmala Lakshman, on behalf of the publisher THG, the Padma Vibhushan awardee Dr. Padma Subrahmanyam, a Bharatanatyam legend and Dr. Arunraj T., Director of Pt. Deendayal Upadhyaya Institute of Archaeology, ASI, Ministry of Culture, Government of India. Furthermore, this being a book on the subject of architecture, it contains a message from Ar. Abhay V. Purohit, President, Council of Architecture (COA), India.

To begin, each of these noted persons provides a meaningful insight to the book from their experienced eye and goodwill. THG, that is, The Hindu Group, its publisher, having successfully established publishing of other books by the authors, who have written and photographed India's cultural heritage like temple towns and natural bounty such as the Himalayas, puts across the facts of this interesting volume. From over 75 illustrations to 250 photographs having an explanatory and fascinating narrative of woven history of architecture and the intangible together for a wide range of readers.

After poring through the book as a reader, without bias, it must be told that the opening note of Dr. Padma Subrahmanyam is thoughtfully perceptive and well explains the value of the title theme in the spirit of intent. The book's content is aptly understood and presented and as she states "*the authors … have done justice to this valuable subject in this attractive, aesthetic and authentic coffee table book. Even the mere turning of the pages can give an illusion of undergoing a pilgrimage, sitting in one's drawing room.*"

From the angle of archaeology today, Dr. Arunraj. T, has left no stone unturned by noting the timely understanding of this as "*a prodigious book …*" Earlier, he mentions "*In this context, the Archaeological Survey of India (ASI), commissioned 'The Temple Survey Project' (TSP) in 1955, to study the numerous temples in different parts of our country.*" Since then, there is a marked difference in technological advancement for documentation and also representation. Seen from the archaeologist angle, the illustrations fall a bit short as relying on computer aided drafting (CAD) has not yet reached

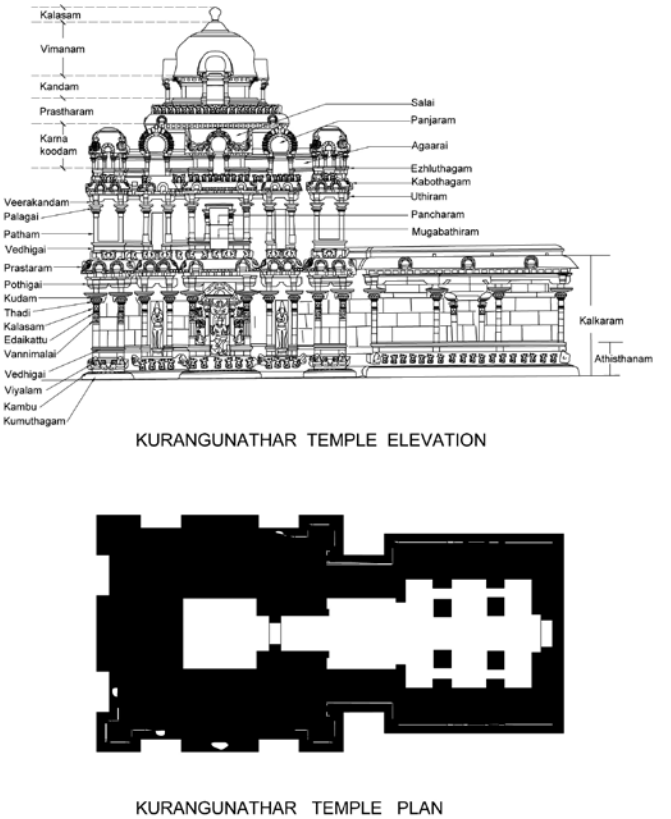

Figure 2: Kurangunathar Temple Elevation and Plan

the finesse of manual drawing during the times of Henri Cousens. However, the book being a photographic and an architectural representation, the effort seems appropriate to identify the elements rather than a drawing showing the fabric status and texture grain.

In the following, the message from Ar. Abhay Purohit, President, COA India, is motivational and inspiring for the fraternity to take such initiatives in earnest. About the authors, as individuals J. Ramanan is a practicing architect, town planner and an avid photographer and Vrinda Ramanan is a Graduate in English Literature, a qualified Bharatanatyam dancer and teacher. The married couple, both professionals are also trained mountaineers and share their interests and beliefs to do ASR, that is Artist's Social Responsibility, which includes research and documentation of cultural and natural heritage of India. This book is the outcome of their commitment to ASR, among over 10 other books published to date.

Going by the book's title, 'Evolution of Temple Architecture in Tamil Nadu', it covers the progression with a wider understanding of such architecture. Not restricted to location, space and time, there is a systematic approach applied in the research. About the coffee table book, it is a 11" by 11" square format, hard cover with jacket and a slipcase. It has 357 pages, light gloss paper with historical

Figure 3: Dharasuram-Chola

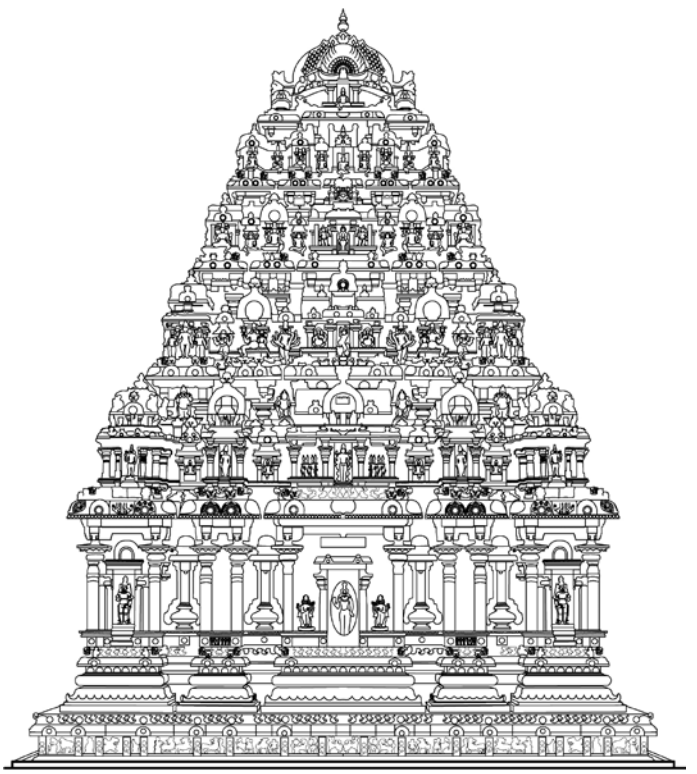

Figure 4: VimanaDharusuram

narrative text, including captioned photographs and illustrations. The content has the authors' note, acknowledgement, bibliography and 19 chapters, which trace the evolution of temple architecture in Tamil Nadu through the geographical width and temporal depth that form the historical layers of India. Within these, the authors also attempt to have a comprehensive look by covering the globally known sites in South East Asia and the significance of sacred mount Kailash with temple architecture.

It is a coffee table book, rich in visual appeal and the subject of this volume includes depth in research and narrative content. Considering the serious topic, the 'Bibliography' needed to be expanded and exhaustive to include other references and readings that have dealt with the subject, in history, archaeology and the present-day value status of the sites cited within. Similarly, such topics need a 'Glossary' section to define the meanings of local terminology and an 'Index' to ease a search for the technical, historical and other words.

Nonetheless, set against a broad historical frame, the authors look at the influences of religion, culture, trade and the overseas in shaping the built environment of these enduring monuments. Sharp and eye-catching photographs of the Nagara, Dravidian and Vesara type forms that flourished across India come alive and are aptly articulated with informed prose. Image and text join to explain the architectural aesthetics, technological ingenuity and symbols of these sacred landmarks.

There are various books on the historical and architectural research of such sites connected to

empires. By presenting the evolution of temples from modest origins to the grand structures of the Guptas, Chalukyas, Pallavas, Rashtrakutas, Cholas and Pandyas, the book provides a wider noting of other empires across India. Recognising the truth that religion is not region specific, temple architecture needs to be seen alongside that of the Jain and Buddhist traditions. Accordingly, the book's chapters flow in chronological sequence from the dawn of mankind with rock cut caves and Vedic dwellings to the timelessness of the temple as a cosmic unit as was built by the Cholas.

The opening page of each chapter contains the title, a captioned image and a brief note outlining the observations of that period, place, people or polity. The text is legible in size and an easy read that comforts the eye and mindfully written to explain the aspects of history, layout, spatial hierarchy, materials and construction methods including traditional terms in temple architecture. The types of images used include captioned photographs, freehand sketches and line drawing graphics for maps and from micro details of elements to building plans, sections and elevations for reference. Two chapters are largely designated for the drawings, as plates, to explain the various forms of temple architecture in their horizontal layout, vertical massing from the base to top and in expression from the whole to part viz. from building volume to each element like arched openings, pillars to friezes, inscriptions and such.

There is a chapter on 'Temples of South East Asia', which includes UNESCO listed World Heritage sites from Cambodia, Indonesia and Vietnam. Likewise, the book has a chapter for 'The Mountain of Kailash and Temple Architecture', wherein the trained mountaineers write "*The sacred mountain of Kailash, undoubtedly triggered the imagination of humans to build temples resembling its form and we find several places of worship, spread all over our country, constructed with the same ambience and on the same lines.*"

To recall the words of Dr. Padma Subrahmanyam here, the content creates a vivid picture of being on a pilgrimage. There is a somewhat virtual sensorial perception at play from cover to cover in this published document. In the tangible sense, the covers are given textured tactility to feel the difference in paper gloss and a rock cut stone surface. Before that sense of touch can be felt, the eye is drawn towards the cover photographs that do not go unnoticed. The book informs with intended clarity through researched content. The pièce de resistance, or most effective and outstanding parts of the book are the crisp, clear photographs that capture miniature details with sharpness and a narrative that chronicles the evolution. While the eyes pore over the still images, discovering something new that was missed in the earlier visit to the page, the text supports them by its easy flow of words that speak like a storyteller's prose. While the photography by J. Ramanan captivates with visual clarity, the narrative text by Vrinda Ramanan at the beginning "*In the Image of Man, From Formless to Form*" till the poetic words on the last page and in between, elevate the senses to visualise being there in space and time.

All images are pages from the book

Authors

J. Ramanan (F10435), an architect with a postgraduate degree in Town and Country Planning, is a professional practicing for 45 years. His passion for photography, mountaineering and writing has led him to author books on the Himalayas, South Indian temples and the history of temple architecture in Tamil Nadu.
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Vrinda Ramanan, a qualified Bharatanatyam dancer and English Literature graduate, shares her passion for writing, the mountains and India's cultural heritage through her collaborative works with her husband, J. Ramanan. Together, they founded Bala Kala Vidhanam, an academy for Indian classical arts and The Science and Adventure Club for children, pursuing all their initiatives under the banner of Artists' Social Responsibility.
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Reviewer

Harshad Bhatia (A6923) is a skilled urban designer and architect, Ekistics intellectual and writer-editor based in Mumbai, India. From 2007 he became a hired brain solo practitioner. Currently he is also Professor and Design Chair at VESCOA (Vivekanand Education Society's College of Architecture) in Mumbai.
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ILLUMINO 2025

Designing with Light

By Ar. Emandi Vijay Bhaskar, Ar. Rajesh Nagula

The IIA Visakhapatnam Centre successfully organized a three-day architectural programme, *ILLUMINO: Role of Light in Architecture* from 24 – 26 October 2025. The program featured an *Architecture and Interior Expo,* a curated series of technical knowledge sessions on architectural lighting, and the inaugural edition of *the IIA Vizag UltraTech Design X Awards*, celebrating excellence in architectural practice across Andhra Pradesh.

The event commenced on 24 October with the inauguration of the *Architecture and Interior Expo* at the Novotel Visakhapatnam, by the Honourable Member of Parliament, Shri M. Sri Bharat. The Expo hosted 40 exhibitors showcasing contemporary building materials, lighting solutions, furniture, finishes and interior products. The exhibition was open to architects, designers, students and the general public, drawing an enthusiastic footfall on all three days.

Later in the evening, the Technical Knowledge Sessions were inaugurated at Hotel The Park, Beach Road, by the IIA National President, Ar. Vilas Avachat, in the presence of IIA Vice President, Ar. Jitendra Mehta; the IIA Andhra Pradesh Chapter Chairman, Ar. Vijay Bhaskar and the IIA Visakhapatnam Centre Chairman, Ar. Rajesh Nagula. This year's knowledge program, curated under our Centre's annual learning initiative, was titled *ILLUMINO : Role of Light in Architecture.* The academic curation was led by Ar. S.L N. Sastry, IIA Visakhapatnam Centre.

The series featured three insightful sessions over two days:

Day 1: Ar. Nirmit Jhaveri, architect and lighting designer, shared perspectives on integrating light as a spatial element.

Day 2 : In the morning session, Mr. Linus Lopez, renowned Lighting Designer, presented methodologies for designing with light across scales.

During the afternoon session, Ar. Sai Thallapragada discussed the synthesis of architectural intent and luminaire strategy in contemporary design.

The highlight of the event was the Grand Awards Night - the first edition of the *IIA Vizag UltraTech Design X Awards*. These Awards were instituted to acknowledge and celebrate architects practicing in Andhra Pradesh for their exemplary built work. Award entries were evaluated through a transparent and rigorous jury process conducted by eminent architects, Ar. Kurian George and Ar. Diwakar Chinthala. The Awards were presented in a memorable beach-front ceremony at The Park, Visakhapatnam, honouring both emerging practices and established firms.

In conjunction with the event, the IIA National Council Meeting was also hosted at Visakhapatnam on 25 October, marking a moment of pride for the Centre.

The three-day celebration concluded on 26 October with the Valedictory Ceremony of the Architecture and Interior Expo. The Best Stall Awards were presented to *Light Craft, JK Cements* and *Urban Furnishings* for their outstanding presentation and engagement.

ILLUMINO 2025 successfully brought together architects, designers, students, industry partners and thought leaders, reinforcing the role of Visakhapatnam as an active contributor to architectural discourse and professional development.

Ar. Emandi Vijay Bhaskar (A11925)
IIA Andhra Pradesh Chairperson

Ar. Rajesh Nagula (F13197)
IIA Vishakhapatnam Chairperson

PHOTO REPORT

ILLUMINO 2025

Designing with Light

By Ar. Emandi Vijay Bhaskar, Ar. Rajesh Nagula

Architecture & Interior Expo inaugurated by the Honourable Member of Parliament, Shri M. Sri Bharath, Visakhapatnam

Architecture & Interior Expo at Novotel, Visakhapatnam

Illumino-25 was inaugurated with the lighting of the lamp by IIA President Ar. Vilas Avachat, Vice President Ar. Jitendra Mehta, Andhra Pradesh State Chairman Ar. E. Vijay Bhaskar, Visakhapatnam Centre Chairman Ar. Rajesh Nagula, and Illumino-25 Convenor Ar. S. L. N. Sastry.

ILLUMINO – Role of Light in Architecture, a curated series of technical knowledge sessions on architectural lighting for two days.

IIA Visakhapatnam Centre team along with IIA President Ar. Vilas Avachat.

IIA Visakhapatnam Centre honoured its first woman architect, Smt. A. Subba Lakshmi, with the Lifetime Achievement Award, which was presented and felicitated by IIA President Ar. Vilas Avachat,Junior Vice President Ar. Tushar Sogani & Trustee Ar. Jit K. Gupta

IIA Visakhapatnam Centre team with Honourable Member of Parliament Shri M. Sri Bharat during the lighting of the lamp at the AI Expo.

IIA Visakhapatnam Centre team with Honourable Member of Parliament Shri M. Sri Bharat during the AI Expo Stalls Visit

Illumino event title sponsor JK Cements was felicitated by Trustee Ar. Jit K. Gupta, along with IIA Visakhapatnam Centre Chairman Ar. Rajesh Nagula and Illumino-25 Convenor Ar. S. L. N. Sastry.

Illumino-25 was inaugurated with the lighting of the lamp by IIA President Ar. Vilas Avachat, Vice President Ar. Jitendra Mehta, Andhra Pradesh State Chairman Ar. E. Vijay Bhaskar, Visakhapatnam Centre Chairman Ar. Rajesh Nagula, and Illumino-25 Convenor Ar. S. L. N. Sastry.

The National Council meeting was held on 25th October at The Park Hotel, Visakhapatnam.

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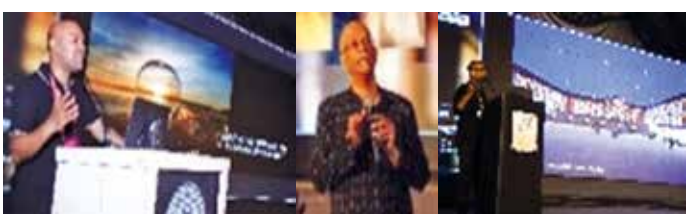

Illumino-25 featured speakers: Ar. Sai Krishna Tallapragada, Ar. Linus Lopez, and Ar. Nirmit Jhaveri

IIA Visakhapatnam Centre Chairman Ar. Rajesh Nagula, Hon. Secretary Ar. Ramji, Vice Chairperson Ar. Mridula, and the Ultratech Awards Committee with the Ultratech Award recipients.

Cultural stage performances by student architects during the event.

Cultural stage performances by student architects during the event.

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Address by IIA President Ar. Vilas Avachat at Illumino-25

Ar. Nirmit Jhaveri leading the lighting workshop for both architects and student at Illumino-25

IIA Visakhapatnam Centre team with Honourable Member of Parliament Shri M. Sri Bharat during the lighting of the lamp at the AI Expo.

Ar. Nirmit Jhaveri leading the lighting workshop for both architects and student at Illumino-25

IIA Visakhapatnam team releasing the Illumino-25 souvenir.

Ar. Emandi Vijay Bhaskar (A11925)
IIA Andhra Pradesh Chairperson

Ar. Rajesh Nagula (F13197)
IIA Vishakhapatnam Chairperson

NEWSLETTER OCTOBER

IIA ANDHRA PRADESH CHAPTER

IIA Kakinada Centre

IIA Kakinada Centre organised a *Meet and Greet* event titled *Samaaroh* on 6 September 2025 at *Sarovar Portico*, Kakinada. Prof. Ar. Bheemesh, founder of *Vinootna Architecture & Appropriate Ventures* and Ar. Venkata Krushnarao Palukuri, Green Building consultant, were invited as speakers for the session. Ar. M.V. Venkatesh, Hon. Secretary; Ar. B. Srinivas, Vice Chairman and Ar. V.V.L.N. Murthy, Chairman of the Centre elaborated on the developments and aims of the IIA and the Kakinada Centre.

Samaaroh at IIA Kakinada Centre

IIA Tirupati Sub-Centre

IIA AP Chapter initiated the formation of a new sub-Centre at Tirupati. The installation was held at *Marasa Sarovar Premiere,* Tirupati on 12 September 2025. Architects from Rayalaseema region formed this Sub-Centre and made Tirupati as Head Quarters, electing Ar. Polu Sai Srikanth as Chairman of Tirupati Sub-Centre. The event was graced by the IIA Imm. Past President, Ar. C.R. Raju; Ar. Vijay Bhaskar, Chairman IIA Andhra Pradesh Chapter, Office Bearers and other members of the IIA Andhra Pradesh Chapter.

IIA Tirupati Sub-Centre installation event

World Habitat Day 2025

World Habitat Day 2025 on the theme *Urban Crisis Response and World Architecture Day* on the theme *Design for Strength* was a collaborative event organised on 6 October 2025 by School of Planning and Architecture (SPA) Vijayawada in association with *The Indian Plumbing Association*, (Amravati Chapter), *Institute of Urban Designers, India* (Hyderabad Centre), *Institution of Engineers India* (AP State Centre), *The Indian Institute of Architects* (AP Chapter) and *Institute of Town Planners India* (AP Chapter). The session included insightful discussions, expert perspectives, and collaborative dialogues focused on addressing urban challenges through innovative design and planning approaches.

IIA College Affiliations

IIA AP Chapter also took the initiative of enabling the Institutional Membership for two Colleges of Architecture recently- *Andhra University, College of Engineering* and *GITAM University* apart from *School of Planning and Architecture Vijayawada*. The IIA Chapter Chairman Ar. Vijay Bhaskar and Hon. Secretary Ar. Subba Rao have been conducting outreach programmes proactively and have been instrumental in increasing new memberships and upgradations from Associates to Fellows.

IIA MAHARASHTRA CHAPTER

World Architecture Day

IIA Chhatrapati Sambhaji Nagar

To cater to the social responsibilities, IIA CSN Centre arranged a Blood Donation Camp on 5 October 2025 on occasion of *World Architecture Day.* Around 50 persons visited the camp. It was a gesture to support local hospitals as the collected blood donations support local hospitals to help save lives. The Blood donation camp encourages community engagement and promotes social awareness. The Centre Chairman, Ar. Shyam Shelar was invited as a Guest Speaker for the *IGBC Connect* event on 14 October.

IIA Nandurbar Sub-Centre

IIA Nandurbar Sub-Centre celebrated World architecture Day on 8 October with the presentation by Ar. Natin Kute from Nashik. The theme was *Design for Strength*. He covered various projects ranging from high-rise structures to bungalows. It was

attended by over 100 professionals, both architects and engineers.

IIA Chandrapur Sub-Centre
The newly-formed IIA Chandrapur Centre celebrated *World Architecture Day* with a presentation by Ar. Ketan Jawdekar, Mumbai, Guest of Honour in the presence of the Chief Guest, Ar. Abhay Purohit, President COA.

IIA Solapur Centre
IIA Solapur Centre celebrated *World Architecture Day* with a special presentation and workshop by Ar. Praveen Mali with *Shri Siddheshwar Shikshan Mandal's College of Architecture*.

IIA Yavatmal Centre
IIA Yavatmal Centre organised a *Design Walk to Design Talk: Ghar pe Charcha*, a panel discussion with A.r Abhay Purohit, President COA, as Chief Guest, Ar Milind Gunjal, HOD, IDEAS, Nagpur as Special Guest and Ar. Sarvesh Chafle, Asst. Director of Town Planning, Yavatmal to celebrate *World Architecture Day.*

IIA Satara Centre
IIA Satara Centre invited Ar. Shabbir Unwala for an audio-visual presentation on the occasion of *World Architecture Day*.

IIA Brihan Mumbai Centre
IIA Brihan Mumbai Centre organised an exclusive site visit to the newly constructed airport at Navi Mumbai on 25 October. This included exposure to the runway and other areas along with interaction with their technical personnel.

IIA Pune Centre
IIA Pune Centre celebrated the festival of Deepavali with a *pooja* in the IIA office at Pune. It was well attended by the Executive Committee Members of the Centre, which was lit up and decorated for the festive season.

IIA Kalyan Dombivali Centre
IIA Kalyan Dombivali Centre hosted the 11th Maharashtra Chapter EC Meeting and the *4th General Body Meeting* on 11 October. These meetings were followed by the event *Manthan,* a panel discussion on UDCPR and BPMS. Mr. Jitendra Bhople, Director of Town Planning, Govt. of Maharashtra, was the Chief Guest. Mr. Santosh Doiphode, Assistant Director Town Planning, Kalyan Dombivli Municipal Corporation (KDMC), Mr. Shailendra Bendale, Former Dept. City Engineer of Thane Municipal Corporation

(Left to Right) Ar. Keshav Chikodi, Chairperson, IIA KD Centre; Ar. Nilesh Chavan, IIA representative to the COA; Ar. Sandeep Prabhu, Chairperson, IIA Maharashtra Chapter; Mr. Shailendra Bendale, Former Deputy City Engineer, TMC; Mr. Santosh Doiphode, Assistant Director Town Planning KDMC; Mr. Jitendra Bhople, Director of Town Planning, Government of Maharashtra; Ar. Jitendra Mehta, Vice President, IIA National; Ar. Sandeep Bawdekar, Joint Honorary Secretary, IIA National; Ar. Uday Satavalekar, Secretary, IIA KD Centre and Ar. Vilas Avachat, President, IIA National Council addressing the gathering

was the Guest of Honour. Ar. Vilas Avachat, President IIA; Ar. Jitendra Mehta, Vice-President IIA; Ar. Sandeep Bawdekar, Jt. Hon Secretary, IIA. Ar Nilesh Chavan, Western Region IIA Representative to COA and Ar. Sandeep Prabhu, Chairman, IIA Maharashtra Chapter were the other Guests of Honour. During this panel discussion, issues faced by the professional community across Maharashtra in the context of UDCPR and BPMS were discussed. About 200 architects and related professionals were a part of the *Manthan* event.

IIA as a professional body gave due weightage to the problems faced individually by architects and other construction professionals during the course of their projects. These were appreciated by the officials. The government officials were quite positive in their approach to solve them. The proceedings will be officially submitted to them in order to resolve the issues faced. The KD Centre Chairman, Ar. Keshav Chikodi and Hon. Secretary, Ar. Uday Satavalekar were the organisers of this day-long programme which was appreciated by all the guests who came from across Maharashtra.

New Members Elected at the IIA 17th Council Meeting of the Term 2023-2025 at Vishakhapatnam, Andhra Pradesh on 25 October 2025

Sr. No.	Associate to Fellow	Chapter	Membership No.
1	Ar. G Vijay Krishna	Tamil Nadu	F19178
2	Ar. Mahesh Vijay Bhusari	Maharashtra	F24566
3	Ar. Vivek Khanna	Punjab	F13745
4	Ar. Chandrakant Dinkar Nehete	Maharashtra	F06159
5	Ar. Rajendra Gopal Joshi	Maharashtra	F16734
6	Ar. Asim Anil Sindgi	Maharashtra	F17506
7	Ar.Manoj Ramesh Marda	Maharashtra	F10573
8	Ar. Indranil Ghosh	West Bengal	F13325
9	Ar. Teby K Kurian	Kerala	F14722
10	Ar.Sathya Shankar T	Tamil Nadu	F16567
11	Ar. Santosh Govind Tawade	Maharashtra	F14436
12	Ar. Bijay Kumar Das	Bihar	F15565
13	Ar. Kanhaiya Sonraj Bhurat	Maharashtra	F24562
14	Ar.T S Deepak	Tamil Nadu	F19235
15	Ar.Israel Ginanaraj	Tamil Nadu	F10353
16	Ar.Aashish Raichuraa	Tamil Nadu	F18099
17	Ar.Shrinee Bipinkumar Bhatiya	Tamil Nadu	F18506
18	Ar.Nagappan A	Tamil Nadu	F19889
19	Ar.Sadiq Moosa Sahulhameed	Tamil Nadu	F24732
20	Ar.Leena Hemant Nimbalkar	Maharashtra	F22609
21	Ar.Nagabhushana Rao Jagarapu	Andra Pradesh	F14802
22	Ar.Sudas Duddey	Andra Pradesh	F15684
23	Ar.Pranav Atul Desai	Maharashtra	F08949
24	Ar.Nilesh Harshad Dholakia	Maharashtra	F09234
25	Ar.Piyush Ramanbhai Patel	Gujarat	F20175
26	Ar.Nikunj Rasikbhai Sayani	Gujarat	F19679
27	Ar.Sujoy Dhar	West Bengal	F17906
28	Ar.Raman Senthil	Tamil Nadu	F14149
29	Ar.Somunaidu Gorripotu	Andra Pradesh	F22683
30	Ar.Yeriku Naidu Bandaru	Andra Pradesh	F18547
31	Ar.Ravindran Ramesh Babu	Tamil Nadu	F14391
32	Ar.Mayur Nandkishor Gandhi	Maharashtra	F17578
33	Ar.Sanjay Kumar	Punjab	F24064
34	Ar.Ashutosh Bhargava	Rajasthan	F09992
35	Ar.Rajan Tangri	Punjab	F16031
36	Ar.Mohan Singh	Punjab	F14511
37	Ar.Neelratn	Tamil Nadu	F21379
38	Ar.Nimish C Daftary	Maharashtra	F17392
39	Ar.Sajo Joseph	Kerala	F17913
40	Ar.Paul Jacob Kizhakkedeth	Tamil Nadu	F12160
41	Ar.Vaibhav Singhai	Madhya Pradesh	F20267
42	Ar.Aysha Banu B A	Tamil Nadu	F12847
43	Ar. Shabbir Abdeali Unwala	Maharashtra	F24588
44	Ar.Suresh Kumar Bandaru	Andra Pradesh	F17134

45	Ar.J Mohana Krishna	Tamil Nadu	F18172
46	Ar.V Balakrishnan	Tamil Nadu	F09906
47	Ar.Balakrishnaa Anjaneysh	Tamil Nadu	F16254
48	Ar.Abhishek Gupta	West Bengal	F22505
49	Ar.Rohit	Maharashtra	F14772
50	Ar.Sasi kumar Srinivasan	Tamil Nadu	F18939
51	Ar. Vivek Mohan Shanbhag	Maharashtra	F10492
52	Ar.Venkateswara Prabu Suruli	Tamil Nadu	F11914
53	Ar.Roshan Nageena Sabeer	Kerala	F15746
54	Ar.Rajinder Pal Singh	Punjab	F14476
55	Ar.Valliappan Ramanathan	Tamil Nadu	F14733
56	Ar.Sarvesh Anand	Bihar	F16594
57	Ar.Liju T.V.	Kerala	F16933
58	Ar.S Ganesan	Tamil Nadu	F15819
59	Ar. Rangasami K. N.	Tamil Nadu	F15942
60	Ar. Chitra Mary Thomas	Kerala	F17608
61	Ar. Polu Sai Srikanth	Andra Pradesh	F18996
62	Ar. Kranthi Matluru	Andra Pradesh	F18992
63	Ar. Sudarshan Khemka	Tamil Nadu	F19895
64	Ar. Ashok S B	Tamil Nadu	F17934
65	Ar. Mayil Vahanan T	Tamil Nadu	F13818
66	Ar. Ramesh Naidu Kota	Andra Pradesh	F18945
67	Ar. Anas Ahammed	Kerala	F17064
68	Ar. Sri Harsha Kilikematham	Andra Pradesh	F17618
69	Ar. Laxhminaaraayan Raa	Tamil Nadu	F26398

Sr. No.	Direct Fellow	Chapter	Membership Number
1	Ar.Gopi Guntuka	Telangana	F30492
2	Ar.Anupama Verghese	Kerala	F30493

Sr. No.	Associate Members	Chapter	Membership Number
1	Ar.Ravi Narendrabhai Pipalia	Gujarat	A30494
2	Ar.Tamboli Hemal Jayeshbhai	Gujarat	A30495
3	Ar.Bhairavi Kishore Dhoot	Gujarat	A30496
4	Ar.Harshad Dhanjibhai Mistry	Gujarat	A30497
5	Ar.Agam Arunkumar Shah	Gujarat	A30498
6	Ar.Ankur Mahendrakumar Sanghvi	Gujarat	A30499
7	Ar.Prathyush Sathyan C K	Kerala	A30500
8	Ar.Shruti Sharad Nagdeve	Chhattisgarh	A30501
9	Ar.Mayur Ashok Shinde	Maharashtra	A30502
10	Ar.Swati Kumari	Jharkhand	A30503
11	Ar.Meghana Pradeep Dhamal	Maharashtra	A30504
12	Mr.Rupak Chakraborty	Delhi	A30505
13	Ar.Tarkesh Prasad Mishra	Odisha	A30506
14	Ar.Palak Nitinkumar Shah	Gujarat	A30507
15	Ar.Tanmay Shrimali	Madhya Pradesh	A30508
16	Ar.Uttam Kumar	Madhya Pradesh	A30509
17	Ar.Subham Kumar Jain	Andhra Pradesh	A30510
18	Ar.Lavanya Latha Akarapu	Telangana	A30511
19	Ar.Kurimilla Uday Maheshwar	Telangana	A30512
20	Mr.Sher Singh	Himachal Pradesh	A30513

21	Ar.Niranjan Kar	Assam	A30514
22	Mr.Vipan Kumar	Jammu And Kashmir	A30515
23	Ar.Maduri Anudeep	Telangana	A30516
24	Ar.Gaayatri Sreekumar	Kerala	A30517
25	Ar.Mohammad Saleem Pasha	Telangana	A30518
26	Ar.Krupa Niteshkumar Patel	Gujarat	A30519
27	Ar.Saket Sagar	Jharkhand	A30520
28	Ar.Ankit Kumar	Jharkhand	A30521
29	Ar.Divya Pandey	Madhya Pradesh	A30522
30	Ar.Pranali Mayur Bodke	Maharashtra	A30523
31	Ar.Sameep Ganesh Vidya Paranjpe	Maharashtra	A30524
32	Ar.A C Tharun Aathithya	Tamil Nadu	A30525
33	Ar.Abhijith Sarvadevabhatla	Telangana	A30526
34	Ar.Sreeja Kamarapu	Telangana	A30527
35	Ar.Sumayya K A	Kerala	A30528
36	Ar.Pooja Avadheshkumar Jaiswal	Gujarat	A30529
37	Ar.Kabya Pran Borah	Assam	A30530
38	Ar.Chowdavarapu Gowtham	Telangana	A30531
39	Ar.Shashirekha Ramanathan	Tamil Nadu	A30532
40	Ms.Monidipa Paul	West Bengal	A30533
41	Ar.Alok Kumar Kureel	Uttar Pradesh	A30534
42	Ar.Polaboina Sindhuja	Telangana	A30535
43	Ar.Mukesh Kumar	Jharkhand	A30536
44	Ar.Evelyn Jeny V	Tamil Nadu	A30537
45	Ar.Kamsani Sriram Reddy	Andhra Pradesh	A30538
46	Ar.Harivansh Singh	Uttar Pradesh	A30539
47	Ar.Birinder Singh Bhogal	Punjab	A30540
48	Ar.Manvir Singh Ahluwalia	Chandigarh	A30541
49	Ar.Atinderpal Kaur	Punjab	A30542
50	Ar.Ritik Kumar	Jharkhand	A30543
51	Ar.Ankit Pradhan	Odisha	A30544
52	Ar.Vishakha Girdhar	Punjab	A30545
53	Ar.Nishant Malhotra	Punjab	A30546
54	Ar.Shourya Behal	Punjab	A30547
55	Ar.Aaditya Badhan	Odisha	A30548
56	Ar.Iqbal Khan	Punjab	A30549
57	Ar.Abhisek Choudhury	Odisha	A30550
58	Ar.Eshan Vaishy	Uttar Pradesh	A30551
59	Ar.Hersh Vardhan Singh Parmar	Punjab	A30552
60	Ar.Pooja Aditya Sharma	Uttar Pradesh	A30553
61	Ar.Vedagiri Venkata Vivek	Andhra Pradesh	A30554
62	Ar.Aniket Ravindra Salunkhe	Maharashtra	A30555
63	Ar.Sahib Hussain Ansari	Punjab	A30556
64	Ar.Amit Lalchand Mahajan	Maharashtra	A30557
65	Ar.Akhilesh Sharma	Punjab	A30558
66	Ar.Sandeep Kaur	Punjab	A30559
67	Ar.Rohit Kumar Sharma	Jammu And Kashmir	A30560
68	Ar.Shrusti Sonker	Uttar Pradesh	A30561
69	Ar.Anshul Agarrwal	Maharashtra	A30562
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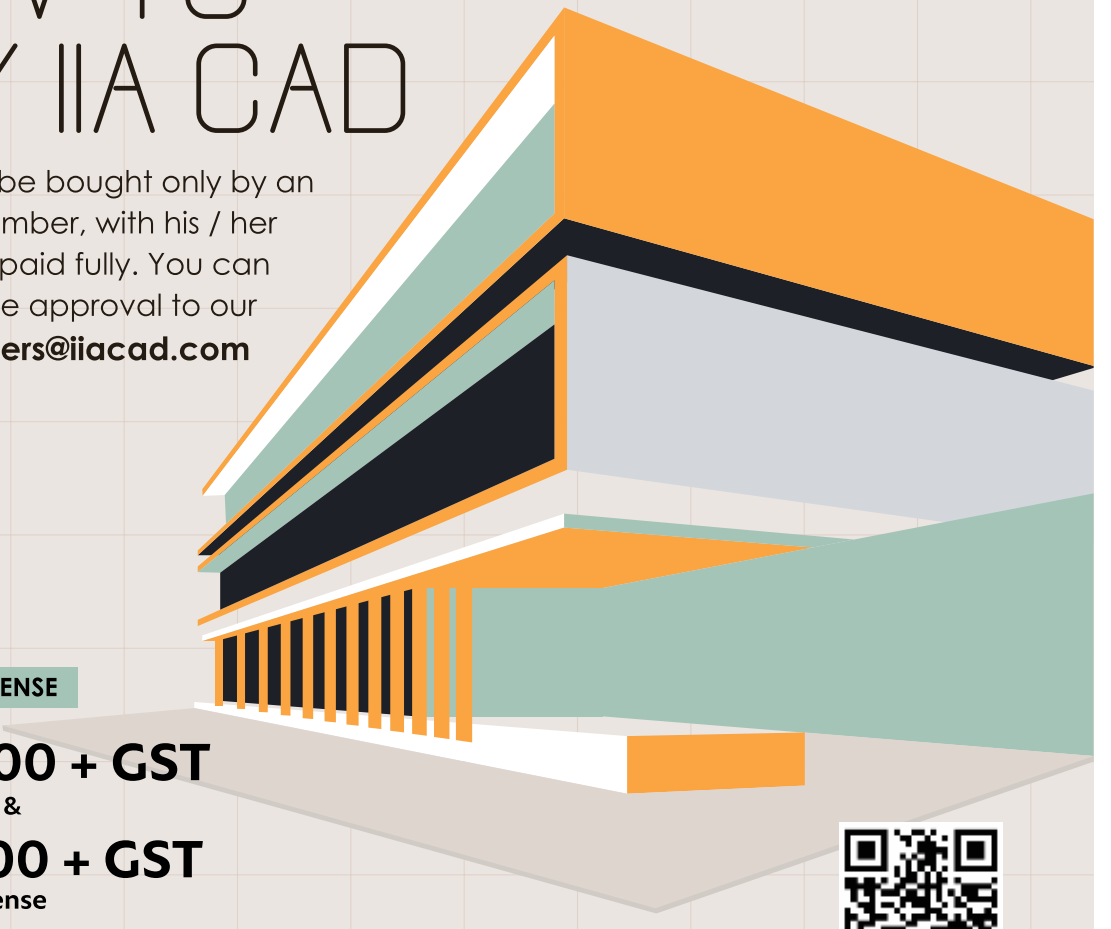

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