Amrita School of Architecture

Amrita Vishwa Vidyapeetham

PhD in Architecture

PhD Core Courses Detailed Syllabus

26AC801	Climate Resilience and Sustainable Building Science	L – T – P	2-1-0	Credits - 3

Course Description

This doctoral seminar-based core course provides a rigorous scientific and methodological foundation for research into the built environment's role in the global climate crisis. It moves beyond design theory into the realm of **quantitative building science**, requiring scholars to master physics-based modelling, advanced environmental simulations, and life-cycle carbon accounting. The course emphasizes the synthesis of high-end computational tools with traditional vernacular knowledge to develop scalable, climate-resilient architectural solutions.

Course Outcomes (COs)

Upon successful completion of this course, the doctoral candidate will be able to:

- **CO1:** Analyze complex, coupled human-environment-energy systems and physics-based phenomena influencing building performance and failure mechanisms.
- **CO2:** Evaluate the efficacy and limitations of advanced computational environmental modeling software and data-driven approaches in predicting building performance metrics.
- **CO3:** Create novel, climate-responsive design strategies by integrating advanced building technologies with localized, traditional vernacular knowledge systems.
- **CO4:** Analyze embodied and operational carbon impacts across a building's lifecycle and formulate comprehensive net-zero emissions strategies.
- **CO5:** Evaluate policy instruments and design interventions necessary for enhancing the adaptive capacity and resilience of vulnerable populations and urban scales.

Mapping of COs to PhD Program Outcomes (POs) & Key Learning Outcomes (KLOs):

Course Outcome	PO1	PO2	PO3	PO4	KLO1	KLO2	KLO3	KLO4
CO1	3	2	3	1	3	3	1	2
CO2	3	3	3	1	3	2	2	3
CO3	2	3	3	3	3	3	2	2

CO4	3	2	3	2	2	3	1	3
CO5	2	2	2	3	2	3	2	3

Detailed Syllabus

Module 1: Foundational Building Physics and Performance Metrics

- **Theme:** Transitioning from passive design theory to quantitative analysis.
- **Contents:** Review of thermodynamic principles, heat transfer dynamics (conduction, convection, radiation), moisture transport, and psychrometrics. Mastering physics-based and data-driven approaches for investigating building energy usage and occupant comfort (PMV/PPD models). Application of these models to inform design optimization and decision-making.

Module 2: Advanced Environmental Modeling and Simulation Techniques

- **Theme:** Methodological mastery of Environmental Assessment Techniques (EAT).
- **Contents:** Advanced proficiency in modeling software (EnergyPlus, OpenStudio, DesignBuilder, Ladybug Tools, Climate Studio, Envi-MET). Detailed climate analysis and TMY data processing. High-fidelity daylighting simulation and thermal bridging calculations. Introduction to Computational Fluid Dynamics (CFD) for urban wind and natural ventilation studies. Appraising design viability through predictive performance.

Module 3: Net Zero Carbon Design and Embodied Energy Analysis

- **Theme:** Decarbonization strategies across the construction lifecycle.
- **Contents:** Distinctions between Net Zero Energy (NZE), Net Zero Emissions, and Net Zero Cost. Advanced Life-Cycle Assessment (LCA) methodologies for embodied carbon. Passive/low-energy design as a foundation for NZE. Coupling financial and design strategies to offset utility taxes, distribution fees, and peak demand charges. Policy and economic challenges of deep decarbonization.

Module 4: Material Resilience and Climate Adaptation

- **Theme:** Integrating material science with climate vulnerability.
- **Contents:** Impact of climate change and pollution on material degradation (stone, wood, concrete, ceramic). Strategies for adaptive re-use. Vulnerability assessment and design interventions for extreme conditions (e.g., floodplains). Defining resilience through the relationship between material lifespan and local adaptive capacity.

Module 5: Integrated Optimization and Climate-Resilient Futures

- **Theme:** Synthesis of Indigenous knowledge and advanced technology.
- **Contents:** Combining vernacular knowledge systems with green building technologies. Multi-scalar resilience (building to urban scale). Parametric optimization techniques to integrate environmental analysis with structural and material constraints. Quantifying

the resilience achieved through the scientific combination of traditional and modern methods.

Recommended Reading Material

- **Hensen, J. L., & Lamberts, R. (Eds.).** (2019). *Building Performance Simulation for Design and Operation*. Routledge.
- **Moe, K.** (2014). *Insulating Modernism: Isolated and Non-isolated Thermodynamics in Architecture*. Birkhauser.
- **Pallasmaa, J.** (2012). *The Eyes of the Skin: Architecture and the Senses* (for qualitative context in building science). Wiley.
- **Cabeza, L. F. (Ed.).** (2021). *Encyclopedia of Renewable and Sustainable Materials*. Elsevier.
- **Intergovernmental Panel on Climate Change (IPCC).** *Assessment Reports (Working Group III: Mitigation of Climate Change)*.
- **Underwood, C. P., & Yik, F. W.** (2004). *Modeling Methods for Energy in Buildings*. CRC Press.

Evaluation Pattern: As per Amrita Vishwa Vidyapeetham PhD Policy

26AC802	Traditional Knowledge Systems and Vernacular Heritage	L – T – P	2-1-0	Credits - 3

Course Overview

This seminar is dedicated to the theoretical and material analysis of **Indian Knowledge Systems (IKS)** as applied to vernacular heritage. The research focus extends beyond conventional architectural history to include a rigorous, science-based analysis of material properties, structural systems, and ecological efficiency inherent in India's diverse indigenous building practices. The course critically evaluates these systems—characterized by their "perfection in purpose"—to determine how they can inform contemporary conservation, sustainable development, and climate adaptation research in the Indian subcontinent.

Course Outcomes (COs)

Upon successful completion of this course, the doctoral candidate will be able to:

- **CO1:** Analyze the historical, socio-cultural, and ecological contexts (Desha, Kala, and Patra) underpinning diverse Indian vernacular traditions.
- **CO2:** Evaluate the performance and production methods of traditional Indian materials (Laterite, Mud, Lime, Bamboo) against contemporary sustainability standards.
- **CO3:** Create systematic methodologies for documenting endangered Indian vernacular heritage and associated *Shilpa Shastra* or oral construction traditions.
- **CO4:** Analyze climate-responsive strategies in Indian indigenous architecture, focusing on passive cooling, thermal mass, and localized resource management.
- **CO5:** Evaluate the ethical and technical feasibility of integrating IKS into modern construction for achieving India's net-zero and resilience goals.

Mapping of COs to PhD Program Outcomes (POs):

Course Outcome	PO1	PO2	PO3	PO4	KLO1	KLO2	KLO3	KLO4
CO1	2	1	2	3	3	2	1	2
CO2	3	3	3	2	2	3	1	3
CO3	3	2	2	3	3	3	2	3
CO4	2	3	3	2	3	2	1	2
CO5	2	3	3	3	3	3	2	3

Detailed Syllabus

Module 1: Theories, IKS, and Historiography of Indian Vernacular

- **Theme:** Canonical debates and the philosophy of *Architecture without Architects* in the Indian context.

- **Contents:** Reviewing Rudofsky and Glassie through the lens of Indian regional diversity; The concept of "nearly immutable" architecture in Indian villages; Understanding *Vastu Vidya* and *Shilpa* as living traditions rather than frozen texts; The relationship between community identity and non-pedigreed building forms.

Module 2: Indian Materials Science and Construction Ecology

- **Theme:** Technical study of indigenous materials (Earth, Laterite, Lime, Timber).
- **Contents:** Material physics of Indian Earth construction (Cob, Adobe, Rammed Earth); The science of Indian Lime (*Chuna*) and its carbon-sequestration properties; Performance of Laterite in coastal Kerala/Goa; Structural properties of Bamboo and Thatch; Analyzing low embodied energy and the potential for "Cradle-to-Cradle" recycling in traditional Indian systems.

Module 3: Climate-Responsive Design: Indigenous Passive Systems

- **Theme:** Sophisticated thermal management in India's diverse climatic zones.
- **Contents:** Analysis of courtyard morphologies for ventilation; Thermal mass in hot-arid Rajasthan (Stepwells/Baolis and Jharokhas); High-precipitation strategies in the North-East and Malabar; Performance of *Jali* screens in controlling solar radiation; Investigating the reduction in efficiency of traditional styles due to rapid climate shifts in India.

Module 4: Conservation, Documentation, and IKS Protection

- **Theme:** Methodological frameworks for protecting intangible heritage.
- **Contents:** Advanced documentation techniques for *Sthapathis* and traditional guilds; Digital preservation of vernacular settlements; Review of Indian legal frameworks (Archaeological Survey of India, INTACH, and local Panchayat laws); Ethics of documenting and "owning" traditional community knowledge.

Module 5: Integrating IKS in Modern Sustainable Development

- **Theme:** Synthesis for climate-resilient futures.
- **Contents:** Case studies of successful IKS integration in modern India (Laurie Baker, Hunnarshala, Auroville); Combining indigenous practices with advanced building science (e.g., computational fluid dynamics for traditional wind towers); Socio-economic challenges of re-introducing traditional materials into urban building codes.

Required Foundational Reading (India-Centric)

- **Dallapiccola, A. L. (Ed.).** (1980). *The Indian Village: Images and Realities*. South Asia Institute.
- **Fathy, H.** (1986). *Natural Energy and Vernacular Architecture: Principles and Examples*. University of Chicago Press.
- **Jain, K., & Jain, M.** (2000). *Architecture of the Indian Desert*. Aadi Centre.

- **Oliver, P. (Ed.).** (1997). *Encyclopedia of Vernacular Architecture of the World* (Asia Section). Cambridge University Press.
- **Rewal, V. V.** (2013). *Traditional Indian Architecture: A House for Every Community*. Lustre Press.

Advanced Research References

- **Cooper, I., & Dawson, B.** (1998). *Traditional Buildings of India*. Thames & Hudson.
- **Saksena, R. K.** (2020). *Traditional Knowledge Systems of India*. Springer.
- **Steele, J.** (2005). *The Ecological History of Architecture*. Routledge.
- **Tipple, G.** (2000). *Extending Themselves: User-led Transformations of Government-built Housing in Developing Countries*. Liverpool University Press.

Evaluation Pattern: As per the current Amrita Vishwa Vidyapeetham PhD Policy

26AC803	Digital Technologies, Computation, and Generative Design	L – T – P	2-1-0	Credits - 3

Course Overview

This seminar-based course offers an in-depth study of the theoretical frameworks and practical applications of advanced computational methods in architecture, with a primary focus on **Generative Design (GD)**. The program examines computation as an essential "intermediary agent" for the seamless integration of analysis, material constraints, and advanced fabrication—specifically **Additive Manufacturing (3D Printing)**—into complex architectural processes. Doctoral candidates are required to develop mastery in algorithmic foundations, parametric systems, evolutionary solvers, and the emerging, transformative role of **Machine Learning (ML)** and **Artificial Intelligence (AI)** in augmenting or automating architectural creativity.

Course Outcomes (COs)

Upon successful completion of this course, the doctoral candidate will be able to:

- **CO1:** Analyze the historical evolution and theoretical foundations distinguishing parametric, algorithmic, and generative design methodologies.
- **CO2:** Evaluate the capacity of algorithmic frameworks, such as formal grammars, Voronoi, and Delaunay algorithms, to generate performative spatial and structural organizations.
- **CO3:** Create novel computational tools that effectively link digital and physical models to incorporate material constraints and additive manufacturing parameters into the design loop.
- **CO4:** Analyze the operational principles, ethical implications, and limitations of using evolutionary computation, machine learning, and neural networks in architectural design.
- **CO5:** Create an advanced generative system, potentially utilizing Generative Adversarial Networks (GANs), to produce and critically evaluate original, fabricatable architectural solutions.

Mapping of COs to PhD Program Outcomes (POs):

Course Outcome	PO1	PO2	PO3	PO4	KLO1	KLO2	KLO3	KLO4
CO1	2	2	1	3	3	2	1	2
CO2	3	3	2	2	2	3	1	3
CO3	3	3	3	2	3	3	2	3
CO4	3	2	2	3	2	2	2	3
CO5	2	3	3	3	3	3	2	3

Detailed Syllabus

Module 1: Computational Thinking and Algorithmic Design History

- **Theme:** Computation as an intermediary agent between analysis and materialization.
- **Contents:** Theoretical distinctions between parametric, algorithmic, and generative design; History of scripting cultures (Burry, 2012); Formal logic and "Digital Continuity"; Critiquing the limitations of digital conformity; Understanding "disparate modeling" as a precursor to discovery.

Module 2: Parametric Systems and Computational Anatomy

- **Theme:** Rule-sets and behavioral simulations.
- **Contents:** Application of parametric relationships for Generative Objects; Computational anatomy and anthropometry; Physical and behavioral simulations for spatial optimization; Synthesizing cross-domain knowledge (rule-sets from music, poetry, and narrative) into formal architectural logic.

Module 3: Structural and Spatial Generation

- **Theme:** Algorithms for self-organizing systems and technical viability.
- **Contents:** Designing with Formal Grammars and Growth Algorithms (L-Systems); Advanced geometry: Voronoi diagrams, Delaunay triangulation, and routing algorithms; Integration of optimization criteria (structural performance, cost, daylighting); Direct link between generative patterns and material constraints.

Module 4: Evolutionary Computation, Optimization, and Fabrication

- **Theme:** Navigating complex optimization landscapes for physical production.
- **Contents:** Evolutionary solvers and Genetic Algorithms (Galapagos, Wallacei); Multi-objective optimization (MOO); Data analysis and performance feedback loops; **Additive Manufacturing (AM) integration**: Designing for 3D printing constraints (support structures, tool-path optimization, material extrusion logic); Case studies of large-scale 3D printed architecture.

Module 5: Generative Inference, AI, and Future Practice

- **Theme:** Bridging abstract digital models and physical practice through AI.
- **Contents:** Machine Learning (ML) and Neural Networks in architecture; Generative Adversarial Networks (GANs) for style transfer and spatial synthesis; Diffusion models for conceptual ideation; **Generative Fabrications**: AI-driven real-time monitoring of 3D printing processes; Ethical considerations, intellectual property, and the impact of AI on professional authorship.

Recommended Reading Material

Required Foundational Reading

- **Meibodi, M. A.** (2016). *Generative Design Exploration: Computation and Material Practice*. KTH Royal Institute of Technology.

- **Burry, M.** (2012). *Scripting Cultures: Architectural Design and Programming*. John Wiley & Sons.
- **Pottmann, H., Asperl, A., Hofer, M., & Kilian, A.** (2017). *Architectural Geometry*. Bentley Institute Press.
- **Frazer, J. H.** (1995). *An Evolutionary Architecture*. Architectural Association.

Advanced Research References

- **Menges, A., & Ahlquist, S. (Eds.).** (2011). *Computational Design Thinking*. John Wiley & Sons.
- **Tedeschi, A.** (2014). *AAD_Algorithms-Aided Design: Parametric Strategies using Grasshopper*. Le Penseur.
- **Saggio, A.** (2020). *Artificial Intelligence and Architecture: From Research to Practice*. Routledge.
- **Garca, J. E., & Duarte, J. P.** (2020). *Digital Fabrications: Architecture and Design*. Routledge.
- **Tamke, M., et al.** (2021). *Machine Learning and the Built Environment*. Springer.
- **Diez, J. G., & Ervin, S. M.** (2022). *3D Printing in Architecture and Design*. Wiley.

Evaluation Pattern: As per the current Amrita Vishwa Vidyapeetham PhD Policy

26AC804	Critical Issues in Urbanization and Built Environment	L – T – P	2-1-0	Credits - 3

Course Overview

This seminar-based course provides the essential critical theoretical foundation for advanced doctoral research in the built environment, emphasizing **political economy, spatial justice, and advanced planning theory**. The curriculum engages canonical debates concerning urban processes, the formation of the built environment under capitalist regimes, and the resultant conflicts regarding land use, equity, and governance. Special attention is paid to the **Indian context**, exploring how global theories of urbanization intersect with the unique socio-spatial realities of the Global South. Students are required to master the theoretical literatures and utilize both quantitative and qualitative methods necessary to produce methodologically rigorous scholarly work.

Course Outcomes (COs)

Upon successful completion of this course, the doctoral candidate will be able to:

- **CO1:** Analyze foundational Marxist and post-structuralist theoretical frameworks that explain contemporary processes of urbanization and built environment formation.
- **CO2:** Evaluate the role of finance, land rent, and the "secondary circuit of capital" in shaping urban morphology, development strategies, and systemic economic crises.
- **CO3:** Create theoretically informed research questions and conceptual models addressing normative theories of social justice, equity, and the production of urban space.
- **CO4:** Analyze the complex interaction of human agency, political ecology, and pressing environmental concerns within dynamic urbanization and global city formation.
- **CO5:** Evaluate advanced quantitative and qualitative research methodologies appropriate for conducting rigorous, multidisciplinary critical urban studies.

Mapping of COs to PhD Program Outcomes (POs):

Course Outcome	PO1	PO2	PO3	PO4	KLO1	KLO2	KLO3	KLO4
CO1	3	1	2	2	3	2	1	3
CO2	2	2	3	2	2	3	1	3
CO3	3	2	2	3	3	2	2	3
CO4	2	2	3	3	2	3	1	2
CO5	3	3	2	2	2	3	2	3

Detailed Syllabus

Module 1: Foundational Debates in Critical Urban Theory

- **Theme:** Mastery of canonical traditions and the production of space.
- **Contents:** Henri Lefebvre's *The Production of Space* (lived space, perceived space, and conceived space); Manuel Castells' *The Urban Question* regarding urban social movements and Marxist approaches; Advanced planning theory and "good city form." **Indian Perspective:** Examining the "Post-colonial City" and the critique of Eurocentric urbanism through the works of Ananya Roy and Partha Chatterjee.

Module 2: Political Economy of Urbanization and Capital

- **Theme:** David Harvey, the "Spatial Fix," and urban morphology.
- **Contents:** Social justice and the city; The "secondary circuit of capital" (investment in housing and infrastructure); Theories of urban land rent and economic geography; Financialization of urban development. **Indian Context:** The role of land mafias, real estate speculation in tier-1 cities, and the political economy of Special Economic Zones (SEZs) in India.

Module 3: Normative Theories of Social Justice and Equity

- **Theme:** The Just City and socio-spatial inequality.
- **Contents:** Susan Fainstein's *The Just City*; Analyzing poverty, urban exclusion, and land-use zoning; Transportation policy through a justice framework. **Indian Context:** Issues of "Slum Clearance" vs. *in-situ* rehabilitation; The politics of the Right to Information (RTI) in urban governance; Equitable distribution of basic services (water, sanitation) in Indian metros.

Module 4: Global Flows, Urban Political Ecology (UPE), and the Environment

- **Theme:** Human agency, global cities, and ecological power dynamics.
- **Contents:** Urban Political Ecology (UPE) foundations (Swyngedouw and Heynen); Saskia Sassen's *The Global City*; The "Urban Age" debate (Brenner and Schmid). **Indian Context:** Urban flooding and the destruction of wetlands (e.g., Chennai, Mumbai, Bengaluru); The political ecology of waste management and informal labor (waste pickers) in Indian cities.

Module 5: Critical Research Methodologies and Scholarly Leadership

- **Theme:** Methodological depth and doctoral independence.
- **Contents:** Mastery of diverse methods: from quantitative/deductive to qualitative/inductive; Ethnographic research in urban settings; Spatial analysis using GIS as a critical tool; Comparative urbanism; Preparing for high-impact dissemination in high-research activity university settings.

Recommended Reading Material

Required Foundational Reading

- **Harvey, D.** (1973). *Social Justice and the City*. Johns Hopkins University Press.
- **Lefebvre, H.** (1991). *The Production of Space*. Blackwell Publishing.

- **Castells, M.** (1977). *The Urban Question: A Marxist Approach*. MIT Press.
- **Fainstein, S. S.** (2010). *The Just City*. Cornell University Press.

Advanced Research References (Global & India Focus)

- **Roy, A., & Ong, A.** (2011). *Worlding Cities: Asian Experiments and the Art of Being Global*. Blackwell.
- **Sassen, S.** (2001). *The Global City: New York, London, Tokyo*. Princeton University Press.
- **Brenner, N., & Schmid, C.** (2014). "The 'Urban Age' in Question". *International Journal of Urban and Regional Research*.
- **Swyngedouw, E., & Heynen, N.** (2003). "Urban Political Ecology". *Antipode*.
- **Bhan, G.** (2016). *In the Public's Interest: Evictions, Citizenship, and Inequality in Contemporary Delhi*. University of Georgia Press.
- **Shaw, A.** (2012). *The Making of an Indian Metropolis: Colonial Governance and Public Culture in Bombay*. Oxford University Press.

Evaluation Pattern: As per the current Amrita Vishwa Vidyapeetham PhD Policy