M. Arch (Sustainable Architecture)

MSAR211 - Design Studio - III - (Whole Building Simulation and Evaluation)

II Year, III Semester 2026-27

SYLLABUS CONTENTS:

Introduction of simulation strategies related to thermal, visual, embodied energy performance of different components and parameters, energy analysis for building covering approximate methods, correlation methods, analytical methods, and numerical methods. Periodic heat transfer model of a non –air conditioned building comprising of heat balance equations for inside air, periodic heat flux through walls, roof, isothermal mass, conduction through floor/ ground, windows and heat loss through ventilation and infiltration etc., analysis of thermal trap roof and walls, solar thermal models for direct and indirect gain such as underground floor storage , earth air tunnels, earth covered structures, rock bed storage, phase change materials for conditioned and non-air conditioned buildings. DOE and TRNSYS, Energy Plus, Design Builder, IES and Radiance etc., simulation programmes for energy, light quantification for buildings. Calibration and validation studies for simulated contemporary and internationally recognised models / soft wares.

The simulation studio shall culminate into critical evaluation of applied strategies using advanced computation and simulation tools. The scale, size and typology of design are left to the faculty. Simulation studio requires a substantial dedication, and investment of student's time and skills, both during and after official class hours for using the tools and running the simulation. As a part of their involvement, students are required to actively participate in all lectures, discussions, readings, assignments, design tasks as a class group and/or individually. The design and lab-oriented work must be actively in progress on a daily basis for collection readings and development of design.

Studio Brief for M. Arch (Sustainable Architecture) III Semester Students

Studio Title:

Decoding Chandigarh's Grid: Micro- and Building-level Heating and Cooling Mitigation Strategies for the Housing Sector

Objective:

This studio challenges students to decode Chandigarh's planned urban grid through the lens of Local Climate Zones (LCZs) and climate-responsive, context-specific design, exploring heat-mitigation strategies at both urban and building scales. Using LCZ classification, real climatic data, building

physics, GIS, urban climate analysis, and building energy simulation tools, students will investigate how variations in urban morphology, built density, surface characteristics, landscape, housing typologies, and LCZ characteristics influence microclimate, thermal performance, and energy demand. Representative residential LCZs and housing typologies will be analysed to understand the interactions between urban form, outdoor thermal conditions, building performance, passive environmental design, and occupant behaviour. The studio aims to develop evidence-based LCZ-specific and building-level interventions that mitigate urban heat, improve outdoor and indoor thermal comfort, reduce heating and cooling energy demand, and enhance the climate resilience of Chandigarh's residential neighbourhoods while responding sensitively to the city's distinctive planning and architectural legacy.

Project Description:

The studio will investigate Chandigarh's residential sectors as interconnected urban–building climate systems, examining how the city's grid, sector morphology, open-space structure, vegetation, street geometry, housing typologies, building envelopes, and occupant practices influence heating and cooling requirements. A key analytical layer will include the Local Climate Zone (LCZ) framework, used to classify and compare different urban fabrics based on their form, density, surface cover, and thermal behaviour, enabling a more structured understanding of spatial climate variation across sectors. Students will select representative residential sectors and housing typologies and undertake a multi-scalar assessment, beginning with climatic and spatial mapping at the neighbourhood level and progressing to detailed building-performance analysis. Field measurements, GIS-based mapping, LCZ classification, microclimate assessment, building physics, and energy simulation will be used to establish existing thermal and energy performance baselines and to identify critical heat gain, heat loss, and comfort conditions across seasonal variations. Based on these findings, students will develop and test micro-level interventions such as shading, vegetation, surface and landscape modification, and improvements to outdoor thermal environments, alongside building-level strategies addressing orientation, envelope performance, glazing, solar control, natural ventilation, thermal mass, cool materials, passive heating/cooling, and occupant-responsive operation. LCZ-based comparisons will help evaluate how different urban forms respond to and amplify these interventions. Alternative intervention scenarios will be quantitatively evaluated for their impact on indoor and outdoor thermal comfort, heating and cooling loads, and overall energy demand. The studio will culminate in an integrated set of climate-responsive retrofit and design strategies for Chandigarh's housing sector, demonstrating how evidence-based interventions, supported by LCZ-informed urban analysis, can improve thermal resilience and energy performance while remaining sensitive to Chandigarh's distinctive architectural and planning legacy.

Focus Areas:

1. LCZ-Based Microclimate Assessment – spatial and seasonal variations in urban heat and thermal conditions
2. Housing Typology & Building Performance – relationship between LCZs, housing forms, envelope characteristics and energy demand
3. Indoor & Outdoor Thermal Comfort – influence of morphology, vegetation, shading, materials and occupant behaviour
4. LCZ-Specific Mitigation Strategies – micro- and building-level heating and cooling interventions

Tools and Software:

1. QGIS/Google Earth Engine (GEE) / WUDAPT – LCZ classification, LST, vegetation and satellite-based analysis
2. ENVI-met – LCZ/micro-level microclimate and outdoor thermal comfort simulation
3. Design Builder / Energy Plus – housing energy, envelope and indoor thermal performance simulation
4. Field Measurements & Thermal Imaging – validation of microclimate and building-performance conditions

Expected Deliverables:

1. LCZ Map & Climate Profile of Chandigarh's residential sectors
2. LCZ-wise Heat and Thermal Comfort Assessment identifying critical residential areas and housing typologies
3. Baseline Building Performance Models linking LCZ characteristics with indoor comfort and heating/cooling demand
4. LCZ-Specific Micro- and Building-Level Mitigation Scenarios with quantified performance improvements
5. Climate-Responsive Housing Retrofit Framework with LCZ- and typology-specific design guidelines for Chandigarh

Department of Architecture

Course: MSAR211 - Design Studio - III
(Whole Building Simulation and Evaluation)
Instructors: Dr. Faiz Ahmed |Vedula Shanmuka Teja (TA)

Class: MSAR211 AY -26-27
Internal Assessment: 50
External JURY Exam: 50
Total Marks: 100
Credits: 15
50 % in Aggregate

Contact Periods/ week: 15 periods
Time Table: Monday-Thursday-Friday
Attendance: Min 75% **Min. Passing Marks:** 50% each in Internal & External Assessments

Objective:

To investigate how Local Climate Zones (LCZs), urban morphology, and housing typologies influence thermal comfort and energy demand in Chandigarh, and to develop evidence-based micro- and building-level heating and cooling mitigation strategies for climate-resilient residential environments.

The outcome of the Course:
Students completing this course will be able to:

1. Analyse and classify Local Climate Zones (LCZs) and evaluate their influence on urban microclimate and residential thermal performance.
2. Assess indoor and outdoor thermal comfort and energy performance using field measurements, microclimate analysis, and building simulation tools.
3. Develop and evaluate micro- and building-level heating and cooling mitigation strategies appropriate to different LCZs and housing typologies.
4. Formulate climate-responsive retrofit and design guidelines to improve thermal comfort, energy efficiency, and climate resilience in residential environments.

WEEK - PLAN

WEEK	KEY ACTIVITIES & EXPECTED OUTPUT	Remarks
1	**Introduction to Decoding Chandigarh's Grid;** studio objectives, methodology, scales of intervention, LCZ framework, deliverables and formation of student groups.	**Introduction to Studio & Design Brief**
2	**Critical reading and literature review** on zero-carbon buildings, climate-responsive design, passive heating/cooling, thermal comfort and building energy performance. *Output: Literature review and precedent studies.*	**Reading & Review: Designing Zero Carbon Buildings**
3	**Participation in the SPARC International Workshop;** exposure to building physics, thermal performance, climate-adaptive design, energy simulation and contemporary/decolonised approaches to environmental design. Output: Workshop documentation and learning synthesis.	**International SPARC Workshop**
4	**Collection of Chandigarh Master Plan/sector plans**, housing drawings, climatic data, satellite imagery, land-use, vegetation, building typologies and available energy/microclimate information prior to fieldwork.	**Secondary Data & Drawing Collection**
5	**Preparation of GIS base maps;** preliminary LCZ classification of residential sectors; mapping of built	**Base Map & LCZ Mapping**

	density, building heights, street geometry, open spaces, vegetation, surface cover and housing typologies. *Output: Preliminary LCZ map and identification of representative sectors and housing typologies for field investigation.*	
6	**Field documentation of selected sectors and housing typologies;** microclimatic measurements, thermal imaging, building documentation, material/envelope survey, vegetation/shading assessment and occupant observations/interactions.	**Chandigarh Site Visit & Primary Data Collection**
7	**Organisation and review of field data**; validation of base maps and LCZs; preparation of measured microclimate profiles, housing typology documentation and identification of preliminary thermal-performance issues.	**Data Compilation, Validation & Review**
8	**Presentation of LCZ mapping**, context analysis, field documentation, housing typologies, climatic analysis and preliminary identification of heat/thermal-comfort issues. Outcome: Finalisation of sectors/sites/buildings for detailed investigation.	**MID-SEMESTER REVIEW**
9	**Detailed analysis of urban morphology**, solar exposure, SVF, vegetation, surface characteristics, shading and microclimatic behaviour. Identification of LCZ-specific thermal hotspots and vulnerabilities.	**Context, LCZ & Microclimate Analysis**
10	**Detailed assessment of representative housing typologies**: envelope, orientation, openings, solar gains, ventilation, thermal comfort and heating/cooling demand using building-performance simulation. Output: Baseline performance models.	**Building Performance Analysis, Calibration & Validation**
11	**Development and simulation of interventions** addressing urban morphology, green-blue infrastructure, street shading, vegetation, surface albedo and neighbourhood-scale thermal conditions.	**Mitigation I – Neighbourhood / LCZ Level**
12	**Strategies for building arrangement, orientation**, open spaces, landscape, shading, ventilation corridors, courtyards, pedestrian spaces and site-surface treatments.	**Mitigation II – Site / Housing Cluster Level**
13	**Development and testing of passive heating/cooling and retrofit strategies** involving building form, envelope, natural ventilation, solar control, thermal mass, daylight and operational strategies.	**Mitigation III – Building Level**
14	**Detailed design and performance optimisation of roofs, walls, windows**, glazing, shading devices, insulation, cool materials and other envelope components. Output: Before-and-after performance comparison.	**Mitigation IV – Building Component Level**
15	**Integration of neighbourhood, site, building and component-level strategies;** cross-scale performance evaluation and refinement. Development of LCZ- and housing-typology-specific mitigation matrix and design guidelines.	**Integrated Design Review - Baseline vs. proposed performance matrix**

16	**Final presentation of the complete evidence-based proposal:** Integrated climate-responsive housing retrofit framework for Chandigarh.	**Review / Jury**
S. No.	**Stages of Evaluation**	**Weightage**
1	First stage: Assessment –1	10
2	Second stage: Mid-semester Examination	20
3	Third stage: Assessment –3	20
	Total	50

References:

1. Jankovic, L. (2024). Designing zero carbon buildings: Embodied and operational emissions in achieving true zero (3rd ed.). Routledge.
2. Anderson, K. (2014). Design energy simulation for architects: Guide to 3D graphics. Routledge.
3. Oke, T. R., Mills, G., Christen, A., & Voogt, J. A. (2017). Urban climates. Cambridge University Press.
4. Košir, M. (2026). Climate adaptability of buildings: Bioclimatic design in the light of climate change (2nd ed.). Springer.
5. Mainini, A. G., Poli, T., Speroni, A., Cavaglià, M., & Blanco Cadena, J. D. (2024). Unlocking the potential of building envelopes: Sustainable and people-centred approach to reduce the environmental footprint of the built environment. Springer.

Course Instructors:
sd/-
Dr. Faiz Ahmed C

Head of Department:
sd/-
Prof. Dr. Amitava Sarkar