Master of Architecture

(Sustainable Architecture)

Course Structure and Detailed Syllabus for
Two-Year Masters Degree Programme in Architecture

Effective from the Academic Year 2024-25 onwards

(As Approved by the Senate in its 17th Meeting held on 27.05.2024)

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Master of Architecture (Sustainable Architecture)

Course Structure

FIRST SEMESTER

SL. NO.	SUBJECT CODE	SUBJECT TITLE	Distribution of Periods per week			Total Periods Per Week	CREDITS
			L	T	S/P		
1	MSAR111	Design Studio I (Simple Passive Strategies)	3	-	12	15	15
2	MSAR112	Building Physics and Sustainability	2	1	-	3	3
3	MSAR113	Sustainable Materials & Construction Techniques	2	1	-	3	3
4	MSAR114	Daylight and Lighting Design	1	-	2	3	3
5	MSAR115	Environmental Codes and Energy Ratings	2	1	-	3	3
6		**Elective I**	2	1	-	3	3
	MSAR1110	Traditional Wisdom and Sustainability Concepts					
	MSAR1111	Resource Conservation and Efficiency					
		Open Elective (MOOC courses) as PBOC	-	-	-	-	-
TOTAL			**12**	**4**	**14**	**30**	**30**

SECOND SEMESTER

SL. NO.	SUBJECT CODE	SUBJECT TITLE	Distribution of Periods per week			Total Periods Per Week	CREDITS
			L	T	S/P		
1	MSAR121	Design Studio II (Advance Passive Strategies)	3	-	12	15	15
2	MSAR122	Solar Passive Design	2	1	-	3	3

3	MSAR123	Urban Climate and Thermal Comfort	2	1	-	3	3
4	MSAR124	HVAC & IAQ	1	-	2	3	3
5	MSAR125	Research Methodology	2	1	-	3	3
6		**Elective II**	2	1	-	3	3
	MBEM1211	Waste Management					
	MBEM1212	Healthy Buildings					
	MUD125	Liveable Cities					
		Open Elective (MOOC courses) as PBOC	-	-	-	-	-
TOTAL			**12**	**4**	**14**	**30**	**30**

THIRD SEMESTER

SL. NO.	SUBJECT CODE	SUBJECT TITLE	Distribution of Periods per week			Total Periods Per Week	CREDITS
			L	T	S/P		
1	MSAR211	Design Studio III (Whole Building Simulation and Evaluation)	3	-	12	15	15
2	MSAR212	Decarbonizing Buildings- Embodied and Operational Carbon	2	1	-	3	3
3	MSAR213	Energy Audit & Post Occupancy Evaluation of Buildings	2	1	-	3	3
4	MSAR214	Dissertation	-	-	6	6	6
5		**Elective III**	2	1	-	3	3
	MSAR2110	Project Management					
		Sustainable and Energy Efficient Landscape					
		Open Elective (MOOC courses) as PBOC	-	-	-	-	-
TOTAL			**9**	**3**	**18**	**30**	**30**

FOURTH SEMESTER

SL. NO.	SUBJECT CODE	SUBJECT TITLE	Distribution of Periods per week			Total Periods Per Week	CREDITS
			L	T	S/P		
1	MSAR221	Thesis	3	-	24	27	27
2		**Elective IV**	2	1	-	3	3
	MBEM222	Building Information Modelling and Management					
		Open Elective (MOOC courses) as PBOC	-	-	-	-	-
TOTAL			**5**	**1**	**24**	**30**	**30**

Detailed Syllabus
for

Master of Architecture
(Sustainable Architecture)

FIRST SEMESTER

MSAR111 - Design Studio - I (Simple Passive Strategies)	Subject Category	SC
	Number of Credits	15
	Lecture Periods per Week	03
	Studio/Lab/Workshop/Practical's	12
	Total Periods per Week	15

Objective:

To understand and analyse, climate and its elements at both micro and macro level and design projects of varied scales with passive strategies.

To use concepts learn in other theory subjects in semester 1, reg. Thermal properties of building materials and appropriate bio climatic analysis using various software and other tools, in the design projects. As part of the studio project, a real time building site visit, documentation, assessment of architectural strategies incorporated and quantitatively analyzing through a preliminary exercise.

Design Studio that explores strategies for sustainable practices, design, theoretical and/or technological issues that focus for proper scientific architectural thought and practice to lead to climate-responsive, energy efficient and environmentally friendly solutions. Our built environment has a substantial impact on energy consumption and material resources as well as being a critical determinant of health, comfort, environmental quality and productivity for occupants. In response, there are numerous local, national, and international entities adopting green, sustainable criteria for new construction and renovations. This studio design approaches sustainable development for buildings by examining physiology required for human function (comfort, ergonomics, and respiratory requirements, as well as sensory perception) and then by considering how building components and systems affect human performance and well-being. Sustainable development starts with site planning and evaluation, and proceeds through design, construction, commissioning, and occupancy phases. The strategies explored during the course shall culminate into design application. The scale, size and typology of design are left to the faculty. Incorporating context-appropriate simple passive strategies requires a substantial dedication and investment of student's time and skills, both during and after official class hours. For the same, the students are to use appropriate software and other relevant tools for bio-climatic analysis using psychrometric chart, for identifying the appropriate passive design strategies. Students are also needed to develop understanding of the thermal properties of building materials and apply the same while designing to ensure enhanced climate responsiveness and energy-efficiency in the built forms they design.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 data collection and development of design

Total: 240 Periods

MSAR112 - Building Physics and Sustainability	Subject Category	TC
	Number of Credits	3
	Lecture Periods per Week	2
	Tutorial Periods per Week	1
	Total Periods per Week	3

Objective:

The aim of the course is to introduce climatic and building physics parameters and understand the role of building physics in designing a climate responsive and energy efficient building for enhanced occupant comfort.

Unit-I **10**

Earth-Sun relationship, Global Climate, Scales & magnitude of impact: Global Scale, Local Scale, Building Scale, Climatic zones in India, Interpretation of climatic elements through Climate Data, Sun Path diagrams and solar geometry, Psychrometric Charts, Bioclimatic charts and their applications. Thermal comfort, indoor and outdoor thermal comfort, thermal comfort indices .Use of instruments like data loggers/ anemometer for thermal/ wind data recording and carrying out related studies/exercises.

Unit-II **10**

Heat insulation, absorptivity, emissivity, reflectivity, thermal conductivity, thermal damping, thermal performance index, thermal resistance, thermal transmittance, thermal time constant and time lag. Thermal behaviour of multi layers: body, surface conductance, air-to-air resistance, cavity resistance, solar control, radiation calculations, solar heat gain - periodic heat flow calculations

Unit-III **10**

Calculation of principle building energy gains and losses. Estimation of building energy performance for heating and cooling for different climatic contexts. Use of instruments like data loggers/ anemometer for thermal/ wind data recording and carrying out related studies/exercises.

Unit-IV **9**

Reduction Heat Transfer or Enhancement, insulation properties of materials and built forms. Radiation versus other Heat Transfer Methods, Evaluating various built form (Vernacular, State of art and other buildings) and its components / or materials for comfort conditions with respect to thermal, visual and air movement.

Unit-V **9**

Appropriate Case Studies

Total: 48 Periods

Outcome:

Students shall learn the physics of buildings, how building works with respect to climate, material usage, form etc. The science behind heat transfer etc shall also be discussed.

References

1. Hens, H. S. L. C. (2023). Building Physics - Heat, Air and Moisture: Fundamentals, Engineering Methods, Material Properties. With Exercises. Germany: Ernst & Sohn.
2. Pinterić, M. (2021). Building Physics: From Physical Principles to International Standards. Germany: Springer International Publishing.
1. Martin Zeumer, Sebastian El Khouli, and Viola John (2015)., 'Sustainable Construction techniques., Detail Green Books., First Edition.
2. Mark DeKay (2011)., 'Integral Sustainable Design: Transformative Perspectives'., Earthscan., First Edition.
3. Andrew Scott (1998)., 'Dimensions of Sustainability'., E & FN SPON, Routledge.
4. K. Steemers and Nick Baker (2000)., 'Energy and Environment in Architecture: A Technical Design Guide'., Taylor & Francis.
5. David Thrope (2014)., 'Energy Management in Buildings: The Earthscan Expert Guide'., Routledge.
6. Marko Pinterić (2017)., 'Building Physics: From physical principles to international standards., Springer.
7. T.R.Oke (2002)., 'Building Layer Climates'., Second Edition, Routledge.
8. Steven V. Szokolay, Introduction to Architectural Science: The basis of sustainable design, Architectural Press, 2004.
9. DeKay, M., & Brown, G (2001)., Sun, Wind & Light: architectural design strategies, Tehran: Parham Naghsh.

MSAR113 - Sustainable Materials and Construction Techniques	Subject Category	TC
	Number of Credits	3
	Lecture Periods per Week	2
	Tutorial Periods per Week	1
	Total Periods per Week	3

Objective:

To introduce the concepts of sustainable building materials and construction techniques

Unit-I **10**

Introduction to Sustainable Building Materials: Environmental impact of building materials, physical & thermal properties of materials etc. Embodied energy and Life cycle assessment of materials, steel, fly ash bricks, gypsum, steam cured bricks, mud, bamboo, eco-boards etc

Unit-II **10**

Classification of Building materials, selection of materials, Life Cycle assessment of Materials – Biodegradable & Non-Biodegradable Materials, bio materials - Concept of Recyclable and salvaged materials – Nontoxic materials, low VOC paints, adhesives, alternative flooring materials

Unit-III **10**

Traditional Building Materials & techniques – Introduction to traditional and alternative materials & construction techniques: Fly ash bricks, gypsum, steam cured bricks, mud, bamboo CSEB, steam cured blocks etc., & Cavity walls, core unit slabs, filler slabs, composite beam and panel, funicular shells, filler slabs, reinforced concrete masonry, vaulted roofs, ferro-cement walls etc

Unit-IV **9**

Efficiency of materials for sustainability: Minimization of natural resource & water utilization, use of demolition waste, salvaged material - High volume fly ash concrete, geo polymer concrete etc., Importance of envelope material for thermal control – Specifications for walls and roofs for different climates – case studies

Unit-V **9**

Smart & innovative materials for green construction- GFRC, Mycelium, Hempcrete, timbercrete blocks, WPC, SCIP etc., latest technologies in construction- 3D printing, Building Integrated Photo Voltaic (BIPV), smart finishes for walls.

Total: 48 Periods

Outcome:

At the end of the course, students should be able to

a) Understand about sustainable building materials and construction techniques
b) Comprehend about properties of the building materials and its impact on environment
c) Know about traditional building materials and construction techniques relevant to the present context
d) Comprehend about efficiency of the building materials and embodied energy component
e) Know about technologically innovative and smart building materials

References

1. Ross Spiegel (2012), Green Building Materials, Wiley
1. TERI, (2004),Sustainable Building - Design Manual Pt 1 & 2, The Energy and Resources Institute.
2. Spiegel, R., & Meadows, D. (2010). Green building materials: a guide to product selection and specification. John Wiley & Sons.
3. Jagadish. K.S.(2008) Alternative Building Materials and Technologies, New age International Pvt Ltd Publishers.

2. Rider, T. R., Glass, S., & McNaughton, J. (2011). Understanding green building materials. WW Norton & Company.
3. Van Lengen, J. (2008). The barefoot architect: a handbook for green building. Shelter Publications, Inc..
4. Sinopoli James (2010), Smart Building materials For Architects, Owner, Builders, Butterworth Heinemann
5. Eccleston, Charles H, (2013), Environmental impact assessment: a guide to best professional pracatices, Boca Raton
6. Glasson, John and Therivel, Riki, (2005), Introduction to environmental impact assessment, Routledge
7. Linda Reeder, (2010), Guide to Green Building Rating System, Wiley
8. Steve Goodhew, (2016), Sustainable Construction Process, Wiley
9. Satyajit Ghosh and Abhinav Dhaka (2016), Green Structures: Energy Efficient Buildings, CRC Press
10. Kibert, C. J. (2016). Sustainable construction: green building design and delivery. John Wiley & Sons.

MSAR114 - Daylight and Lighting Design	Subject Category	JC
	Number of Credits	3
	Lecture Periods per Week	1
	Studio/Lab/Workshop/Practical's	2
	Total Periods per Week	3

Objective:

To impart the scientific aspects of daylight and environmental lighting.

Unit-I **10**

Electromagnetic spectrum. Visual response visual acuity, Glare & visual comfort, adaptation glare, Colour perception, Concept of Kruith of curve, Visual Task Requirements. Side lighting concepts, Top lighting concepts.

Unit-II **10**

Daylight Controls. Daylighting Design, Daylighting in Architecture, Indoor and outdoor light, Illuminance levels for different types of activities as per National Building Code, 2016 standards, Daylighting Analysis Electrical light sources and Luminaires.Daylight metrics for Task requirements such as point-by-point method, Lumen method, simulation tools. Qualitative calculations and Supplementary Artificial Lighting.

Unit-III **10**

Lighting Design – Effect of light on user orientation, room comprehension, form, structure and materials.Lighting in peripheral and core zones, Impressions of visual clarity, spaciousness, relaxation, privacy etc. Interior lighting design requirements for offices, factories, commercial interiors, museums and galleries, etc.

Unit-IV **9**

Exterior lighting: Functional requirements, buildings and facades, pedestrian routes and surrounding areas, parking areas and landscape lighting. Designing Atria / Light Courts. Emergency lighting: Escape lighting, shutdown lighting and standby lighting, equipment and system design. Integration of daylight and artificial lighting. Economics of supplementary lighting.

Unit-V **9**

Cost-effective daylighting design, energy efficiency and maintenance. Lighting cost, performance of lamps and luminaries. Estimating energy use. Energy saving developments.

Total: 48 Periods

Outcome:

Students shall learn the appropriate metrics of artificial and daylight, processes of quantification and their applications.

References

1. Susan M. Winchip (2017)., 'Fundamentals of Lighting'., Fair Child Books, Bloomsbury., 2nd Edition.
2. Mark DeKay , G. Z. Brown (2014)., 'Sun, Wind & Light'., Wiley., Third Edition.
3. Michael Wilson and Peter Tregenza (2011)., 'Daylighting: Architecture and Lighting Design'., Routledge.
4. Norbert Lechner (2009)., 'Heating, Cooling, Lighting: Sustainable Design Methods for Architects'., Wiley.
5. Hopkinson, R. G (1963)., 'Architectural Physics – Lighting', HMS Office, London.
6. MEBc Schiler (1992)., 'Simplified Design of Building Lighting'., John Wiley & Sons, Inc., New York.

7. Nick V. Baker, A. Fanchiotti, K. Steemers (2017)., 'Daylighting in Architecture: A European Reference Book', Earthson from Routledge.
8. Boubekri, Mohamed. (2008) Day Lighting, Architecture and Health - Building Design Strategies, Architectural Press, Elsevier, ISBN: 978-0-7506-6724-1.
9. Szokolay, Steven V. (2014), Third Ed., Introduction to Architectural Science-The Basis of Sustainable Design, Routledge, ISBN:0750687045

MSAR115 - Environmental Codes and Energy Ratings	Subject Category	TC
	Number of Credits	3
	Lecture Periods per Week	2
	Tutorial Periods per Week	1
	Total Periods per Week	3

Objective:

To expose students the various environmental codes and energy ratings as on date.

Unit-I **10**

Global Energy issues & Environmental crisis, Resource extractions, The Energy scenario and use in different sectors, Energy and built environment, Sustainable Development goals, different milestones on sustainable development and related environmental protocols, Construction sector and sustainability.

Unit-II **10**

Role of Ministry of New & Renewable Energy (MNRE) and Bureau of Energy Efficiency (BEE) in Sustainable Development, Introduction to Energy Codes & Energy efficiency in Buildings, Energy Conservation Building Code (ECBC-2017) – Commercial & Eco-Niwas Samhita (ECBC-R) (ENS-2018), guidelines & evaluation & certification procedure, Role of ECBC Expert/Design professional .

Unit-III **10**

Introduction to Green Building Certification & Rating systems, International rating systems like BREEAM, LEED, Green Mark, BEAM etc, Indian Rating systems like, GRIHA (National Green building rating system of India), IGBC etc, Role of The Energy resource Institute (TERI), overview of Rating system & Certification procedure, Incentives to green buildings, Green Building Accreditation & role of Green building Consultant, case studies of rated buildings

Unit-IV **9**

The Energy Conservation Act, 2001 & Amendment Act, 2010, Objectives of Bureau of Energy Efficiency (BEE), Energy efficiency schemes and measures like Star Rating of Appliances, National Mission for Enhanced Energy efficiency (NMEEE), Demand Side Management, Buildings Energy Efficiency, Awareness and Institutional mechanism

Unit-V **9**

The Environment (protection) Act 1986, rules to regulate environment pollution and Prevention, control and abatement of environmental pollution and institutional mechanism.

Total: 48 Periods

Outcome:

Awareness about applicable environmental codes, and relevant energy rating system procedures and protocols shall be explored.

References

1. International Building Code – 2012., International Code Council., 2011.
2. National Building Code – 2016., Bureau of Energy Efficiency., Ministry of Power., Govt. of India.
3. Linda Reeder (2010)., 'Guide to Green Building Rating System'., Wiley.
4. The Environment (protection) Act 1986. Link: https://indiacode.nic.in/bitstream/123456789/4316/1/ep_act_1986.pdf – accessed on 06.07.2019.
5. The Energy Conservation (Amendment) Act 2001, and Amendments - http://extwprlegs1.fao.org/docs/pdf/ind167070.pdf – accessed on 06.07.2019.

6. Energy conservation building code 2017. Link: https://beeindia.gov.in/sites/default/files/BEE_ECBC%202017.pdf - – accessed on 06.07.2019.
7. Eco-Niwas Samhita 2018. Link: https://www.beeindia.gov.in/sites/default/files/ECBC_BOOK_Web.pdf – accessed on 06.07.2019.
8. National building code – India. NBC 2016 Vol 01 - Link: https://ia800601.us.archive.org/13/items/nationalbuilding01/in.gov.nbc.2016.vol1.digital.pdf. . NBC 2016 Vol 02 - Link: https://ia800601.us.archive.org/11/items/nationalbuilding02/in.gov.nbc.2016.vol2.digital.pdf. – accessed on 06.07.2019.
9. International building code. IBC 2018. Link: https://www.ci.independence.mo.us/userdocs/ComDev/2018%20INTL%20BUILDING%20CODE.pdf – accessed on 06.07.2019.
10. International Energy Conservation Code.IECC2018 Link: https://basc.pnnl.gov/resources/2018-iecc-international-energy-conservation-code – accessed on 06.07.2019.
11. Bureau of Energy Efficiency, Ministry of Power, Govt. of India. Link: https://beeindia.gov.in/ – accessed on 06.07.2019.
12. LEED. Link: https://igbc.in/ – accessed on 06.07.2019.
13. GRIHA. Link: http://www.grihaindia.org/ – accessed on 06.07.2019.

SECOND SEMESTER

MSAR121 - Design Studio - II (Advance Passive Strategies)	**Subject Category**	**SC**
	Number of Credits	**15**
	Lecture Periods per Week	**03**
	Studio/Lab/Workshop/Practical's	**12**
	Total Periods per Week	**15**

In this Design Studio students learn and hone their architectural design skills and are required to apply the knowledge gained from theory courses in the design solutions. Typically, at the end of the Design Studio, each student or team is required to explain the key concepts and integrated design philosophy with evidence based output of application of advanced passive systems. In order to propagate knowledge and learning, it is important to create networks, establishing platforms that can encourage sharing of ideas and information. The design process should facilitate the same. Subjects with high technical content need elaboration with examples as well as explanation of basic rules of thumb that are widely used in the profession. This results in application of building physics, review of literature from previous design works and energy efficiency concepts with the overall building design sensibility. A broad spectrum of topics such as Solar passive cooling strategies, solar passive heating strategies, energy efficiency, Building Physics, Building Diagnostics which is climate responsive, role of building and energy appliance codes, in designing sustainable buildings with the help of primarily laboratory and supported by simulation software tools is expected. 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 The strategies explored during the course shall culminate into design application. The scale, size and typology of design is discretionary.

Incorporating advanced passive strategies requires a substantial dedication, and understanding in addition to investment of student's time and skills, both during and after official class hours. As 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 understanding the advanced passive strategies theoretically, its application with the help of case studies and development of design as a response to the climate type.

Total: 240 Periods

MSAR122 - Solar Passive Design	Subject Category	TC
	Number of Credits	3
	Lecture Periods per Week	2
	Tutorial Periods per Week	1
	Total Periods per Week	3

Objective:

The main objective of this course is to equip the students with the understanding of advanced solar passive design techniques in traditional architecture and modern scientific theories in buildings.

Unit-I **10**

Introduction of passive solar architecture, evolution of built forms in response to climate, appreciation of built form for different climates, building clusters and solar exposure, thermal environment, advantages of solar passive design strategies.

Unit-II **10**

Passive heating: direct gain heating, indirect gain heating: thermal storage wall - Trombe wall, Water wall and Transwall, thermal storage roof / skytherm and convective loop, isolated gain heating: sun space / attached solarium / conservatory. Case studies

Unit-III **10**

Passive cooling: natural cooling, shading, convective cooling. Passive cooling strategies, thermal sinks of passive cooling. Approaches to passive cooling- night ventilation cooling, ventilation cooling, radiative cooling and evaporative cooling - direct and indirect evaporative cooling.

Unit-IV **9**

Earth sheltered / earth bermed structures, cool roofs, green roofs. Various augmentation techniques: Earth Air Heat Exchanger (earth-air tunnels), wind tower, solar chimney.

Unit-V **9**

Modern and postmodern passive architecture, methods, strategies, systems, and construction details emphasizing the passive architecture and non-active services. Appropriate Case studies

Total: 48 Periods

Outcome:

Students shall learn about the various solar passive design strategies and their applications in design of buildings.

References

1. Engström, J. (2024). Reducing energy demands of modern buildings: Utilizing vernacular architecture, passive solar design & natural materials.
2. Haggard, K., Bainbridge, D. A., & Aljilani, R. (2016). Passive solar architecture pocket reference. Routledge.
3. Chen, C. J. (2024). Physics of Solar Energy and Energy Storage. John Wiley & Sons.
4. Bainbridge, D., & Haggard, K. (2011). Passive solar architecture: heating, cooling, ventilation, daylighting and more using natural flows. Chelsea green publishing.
5. Givoni Baruch, "Passive and Low Energy Cooling of Buildings", Van Nostrand Reinhold, New Yord, 1994.
6. Sodha, M., Bansal, N. K., Bansal, P. K., KuMEB, A., and Malik, M. A. S., "Solar Passive Buildings", Pergamon Press, Oxford, 1986.
7. Bansal Narendra, K., Hauser Gerd and Minke Gernot, "Passive Buildings Design: A Hand book of Natural Climatic Control", Elsevier Science, Amsterdam, 1994.
8. Goulding, John, R., Lewis, Owen, J., and Steemers, Theo, C., "Energy in Architecture", Bastford Ltd., London, 1986.

MSAR123 - Urban Climate & Thermal Comfort	Subject Category	TC
	Number of Credits	3
	Lecture Periods per Week	2
	Studio/Lab/Workshop/Practical's	1
	Total Periods per Week	3

Objective:

The main objective of this course is to equip the students with the understanding of urban climate scales, energetic basics of outdoor thermal comfort and data and instrumentation for outdoor thermal comfort studies.

Unit-I **8**

Fundamentals of Urban Climate- Urban Climate and Urban Scale. Scale of Climatic Study: Atmospheric Scales - Urban Climate and Urban Scale. Scale of Climatic Study: Climatological Scales - Urban Climate and Urban Scale.

Unit-II **10**

Urban Morphology - Urban Canopy Models. Geometry of an Urban Canyon - Urban Canopy Models. Air-flow and Albedo in Urban Canopy Layer - Urban Canopy Models.

Unit-III **10**

Energy Efficient Urban Development - Energy Efficient Neighbourhoods and Cities. Energy Balance of Urban Surfaces. Energy Balance of Vegetated Surfaces. Energy Balance of Water Systems.

Unit-IV **8**

Thermal Comfort Basics - Outdoor Thermal Comfort Basics. Thermal Comfort Indices - Outdoor Thermal Comfort. PET and UTCI - Outdoor Thermal Comfort

Unit-V **12**

Instrumentation, sensors, field measurements, tools and techniques for data collection. Use of computer applications and tools in urban climate studies

Total: 48 Periods

Outcome:

Students shall learn the fundamentals of urban physics, metrics for comfort studies and their applications in neighbourhood level studies.

References

1. Oke, T. R., Mills, G., Christen, A., & Voogt, J. A. (2017). Urban climates. Cambridge University Press.
2. Lau, K. K., Tan, Z., Morakinyo, T. E., & Ren, C. (2021). Outdoor thermal comfort in urban environment: Assessments and Applications in Urban Planning and Design. Springer Nature.
3. Parsons, K. (2019). Human thermal comfort. CRC Press.
4. Stewart, I. D., & Mills, G. (2021). The urban Heat Island. Elsevier.
5. Paolini, R., & Santamouris, M. (2022). Urban climate change and heat islands: Characterization, Impacts, and Mitigation. Elsevier.

MSAR124 - HVAC & IAQ	Subject Category	JC
	Number of Credits	3
	Lecture Periods per Week	1
	Studio/Lab/Workshop/Practical's	2
	Total Periods per Week	3

Objective:

To educate the students on the concepts and techniques of HVAC systems and IAQ

Unit-I **10**

Ventilation systems (Natural and Mechanical), designing for natural ventilation, impact of building form, layout and window design on ventilation systems (outdoor and indoor), comfort ventilation, process ventilation, ventilation requirements for various building functions, ventilation standards, estimating air changes, urban wind characteristics, boundary layer and wind pressure coefficient, Types of ventilation, night purging (ventilation), structural cooling, mechanical and mixed mode ventilation systems, Mechanical ventilation systems for residential and commercial, industrial buildings.

Unit-II **10**

History and evaluation of mechanical cooling systems, basics of Air Conditioning (AC), Carnot refrigeration cycle, Psychrometry: terms and air-conditioning processes; Thermal comfort, Type of cooling and heating systems, terminology; humidification and dehumidification, fans, evaporative cooling systems, unitary systems (Window AC, Split AC) to packaged air conditioning and central AC systems; water cooled and air-cooled systems, precision air conditioning, components of chilled water plants, cooling towers, condensers, air handling units, supply and return air ducts

Unit-III **10**

Cooling/ heating load estimation, fresh air requirements; heat recovery systems, sustainable air conditioning, Global warming potential (GWP) of refrigerating materials, environmental friendly refrigerants, advanced air conditioning systems, energy efficiency in air conditioning, hybrid cooling/ heating systems, direct-indirect evaporative cooling systems heat pumps for cooling and heating, solar air conditioning, vapour compression systems.

Unit-IV **9**

Indoor air quality (IAQ), building related illness (BRI), sick building syndrome (SBS), types of outdoor and indoor pollutants and health impacts, Indoor pollution mitigation methods, filtration, dilution by ventilation, portable air filtration systems, dampers and duct design for ventilation, kitchen hoods, exhaust systems, jet ventilation systems, Outdoor and indoor air quality standards (NBC, ASHRAE, etc.,), methods and models for designing desirable levels IAQ. IAQ and health, Causes of SBS, air contaminants of indoor origin, International standards, IAQ in offices, residential and commercial and Industrial buildings etc., NBC, ASHRAE guidelines for ventilation.

Unit-V **9**

Building management system (BMS), controls in air conditioning, dampers, instrumentation, field surveys, data collection, measurements and methods for testing building air tightness, concentration decay methods, water table and wind tunnel methods for measuring natural ventilation and wind profile, basics of building energy components and air conditioning/ ventilation system audit.

Total: 48 Periods

References

1. Wines James & Jodido Philip, "Green Architecture – The Art of Architecture in the age of Ecology", Tachen Publishers, New York, 2000.
2. Mackenzie Dorothy, "Green design: design for the Environment", Laurence King, London, 1997.
3. Farmer John & Richardson Kenneth, "Green Shift: Changing attitudes in architecture to the Natural World", Architectural Press, Boston, 1999.
4. The European Commission, "A Green Vitruvius: Principles and Practices of Sustainable Architectural Design", James & James, London, 1999.
5. Fred A. Stitt, "The Ecological Design Handbook", McGraw Hill, New York, 1999.
6. Scott Andrew, "Dimensions of Sustainability: Architecture, Form, Technology, Environment & Culture", F&FN Spon, London, 1998.

MSAR125 - Research Methodology	Subject Category	JC
	Number of Credits	3
	Lecture Periods per Week	2
	Tutorial Periods per Week	1
	Total Periods per Week	3

Objective:

1. To impart the basics of research methods in architecture
2. To enable students to write research papers
3. To equip students with skills to articulate findings of their research

Unit-I: Introduction to Research **9**

What is research? Research versus faith, research versus project, philosophical and theoretical basis; Research philosophies – positivistic, phenomenological, anthropological; Research terminology; Types of Research – exploratory, descriptive, analytical, predictive; Research approaches – quantitative/ qualitative/mixed, basic/ applied, deductive/ inductive.

Unit-II: Research Components **9**

Elements of research process: finding a topic - Writing an introduction - Stating a purpose of study identifying key research questions and hypotheses - Reviewing literature using theory, defining, delimiting and stating the significance of the study, advanced methods and procedures for data collection and analysis - illustration using research samples.

Unit-III : Review of Literature **10**

Library and archives - Internet: new information and the role of internet, finding and evaluating sources of misuse - Test for reliability ethics.

Unit-IV: Data Collection and Analysis **10**

Methods of data collection - From primary sources: observation and recording, interviews structured and unstructured, questionnaire, open ended and close ended questions and the advantages, sampling - Problems encountered in collecting data from secondary sources, processing and analysis of data.

Unit-V: Technical Writing **10**

Writing & publishing the research work in journals - Research writing in general - Components: referencing - Writing the bibliography - Developing the outline – presentation etc. - Case studies - illustrating how good research can be used from project inception to completion - Review of research publications. Ethics in Research – Plagiarism – Thesis Chapter Development – Time Schedule – Publication and Peer Review Process related to particular subject domain.

Total: 48 Periods

Outcome:

Students shall learn about the different research methods application and relevant for them. Reading and writing papers and research proposals shall also be discussed.

References

1. Wayne C Booth, Joseph M Williams, Gregory G Colomb, The Craft of Research, 2nd Edition, Chicago guides to writing, editing and publishing, 1995
2. Iain Borden, Kaaterina Ruedi, The Dissertation: An Architecture Student's Handbook, Architectural Press, 2000
3. Ranjith Kumar, Research Methodology - A step by step guide for beginners, Sage Publications, 2005
4. John W Creswell, Research design: Qualitative, Quantitative and Mixed method approaches, Sage Publications, 2002
5. Linda N. Groat, David Wang, Architectural Research methods, Wiley, 2nd edition, 2013

THIRD SEMESTER

MSAR211 - Design Studio - III (Whole Building Simulation and Evaluation)	Subject Category	SC
	Number of Credits	15
	Lecture Periods per Week	03
	Studio/Lab/Workshop/Practical's	12
	Total Periods per Week	15

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, and simulation methods. Students have to gain a deep understanding of various aspects of sustainable building such as energy performance, water performance, embodied energy, embodied carbon, response to disaster (resilience), financial implications, innovative approaches and value additions through wholistic studies. These learnings have to be applied in their design and proved using simulation. The process could also be evidence-based approach to arrive at the best results.

The simulation studio shall culminate into critical evaluation of applied strategies using advanced computation and simulation tools of how efficient the building is in terms of energy performance, water performance, embodied energy, embodied carbon, response to disaster (resilience), financial implications, innovative approaches and value additions. The scale, size and typology of design is discretionary. However, the output has to be in terms of acceptable numbers layered with a design output sensitive to the social, cultural and economic context. 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.

Total: 240 Periods

MSAR212 - Decarbonizing Buildings- Embodied and Operational Carbon	Subject Category	TC
	Number of Credits	3
	Lecture Periods per Week	2
	Tutorial Periods per Week	1
	Total Periods per Week	3

Objective:

To create awareness, exposure and educate the students with ways of decarbonizing buildings by understanding the embodied carbon of building materials and operation carbon of buildings

Unit-I **6**

Introduction to GHG and the role of buildings in its reduction, GHG, GWP, Sectors contributing to GHG, Global initiatives to reduce GHG, India's Initiative to reduce GHG, India's current scenario in Economic, Social, Environmental and Energy , India's commitment to reduce GHG, Net-zero commitment, Mission 2070

Unit-II **10**

Strategies to reduce GHG in Building Industry, Bioclimatic Architecture, Renewable energy integration, Low carbon Materials, Low carbon footprint, Energy Efficient Technologies. Environment friendly materials and construction processes that suggest future value; concepts such as designing for adaptability, disassembly, reuse, reduced waste or energy self-sufficiency promise new innovations

Unit-III **10**

Embodied energy, embodied Carbon, Ways to reduce embodied Carbon, EPD, Material and system selection strategies, building disassembly, reuse-reduce-recycle building materials, Cradle to gate, India's measures to reduce Embodied and operational carbon, Embodied energy of building materials, building materials, high embodied energy, low embodied energy, recycled building materials, whole life carbon, Comparison of Embodied carbon of various materials, High carbon, low carbon and carbon negative building, embodied energy of recycled materials, sequestered carbon, recycled materials

Unit-IV **10**

Operational energy, Operational Carbon, measures to reduce Operational Energy, Integration of renewable energy systems, Energy Efficient fixtures, Star Rating of Appliances, Sensor application, Occupant Behaviour, building sector energy transformation potential in India, Factors influencing operational energy, strategies, Efficient building operations, building envelope, HVAC systems, Lighting systems, Building Management systems, smart technology, Carbon offsetting, Challenges to reduce Operational Energy

Unit-V **12**

Appropriate Market and Case Studies, Use of Tools to assess Embodied and operational carbon, EDGE, Athena, One Click LCA, EPIC.

Total: 48 Periods

Outcome:

At the end of the course, students should be able to

- Recognize the basic concepts of embodied carbon and the distinctions between energy usage, embodied carbon, carbon emissions, and energy savings throughout the course of a building's life.
- Understand the problems, constraints of the present, and potential developments in data, whole-life building optimization, and embodied carbon.
- Be aware of how to use tools and resources to help with technical and design practice understanding and application of embodied carbon solutions.

- Be able to resolve embodied carbon issues in real-world situations and develop Skills to be able to use design strategies to minimize the whole of life carbon impact of a project.

References

1. Jankovic, L. (2024). Designing Zero Carbon Buildings: Embodied and Operational Emissions in Achieving True Zero. Taylor & Francis.
2. Azari, R., & Moncaster, A. (Eds.). (2023). The Routledge Handbook of Embodied Carbon in the Built Environment. Taylor & Francis.
3. Smith, A. D., & Gill, G. (2011). Toward zero carbon: The Chicago central area decarbonization plan. Images Publishing.
4. Clark, D. (2019). What Colour is your Building?: Measuring and reducing the energy and carbon footprint of buildings. RIBA Publishing.
5. Kuittinen, M., Organschi, A., & Ruff, A. (2022). Carbon: A Field Manual for Building Designers. John Wiley & Sons

MSAR213 - Post Occupancy Evaluation and Energy Audit of Buildings	Subject Category	JC
	Number of Credits	3
	Lecture Periods per Week	1
	Studio/Lab/Workshop/Practical's	2
	Total Periods per Week	3

Objective:

To impart the post-occupancy evaluation and Energy Audit tools and techniques prevalent in the field.

Unit-I **9**

Understanding of the conceptual frameworks underlying different types of post-occupancy. Evaluation. POE objectives and needs. The generic attributes such as to identify and formulate the problems and to envisage, enact processes in response to them. Assessing existing buildings on their energy use, environmental impact and occupant satisfaction. Building performance benchmarks – rating and comparison of buildings.

Unit-II **9**

Techniques, methods & procedures of Post Occupancy Evaluation. It also covers the user satisfaction survey identifying areas of deficiency, particularly in maintenance, and facilitates the assessment of the overall performance of the building

Unit-III **9**

General Aspects of Energy Management & Energy Audit. Energy Efficiency in Thermal Utilities and Energy Efficiency in Electrical Utilities, Energy Performance Assessment for building envelope, fenestration and embodied energy, it also emphasizes Equipment and Utility systems.

Unit-IV **9**

Detailed energy audit, quantify energy consumption and establish baseline energy information, Construct energy and material balance, · Perform efficiency evaluation of energy & utility systems, compare energy norms with existing energy consumption levels, · Identify and prioritization energy saving measures and analysis of technical and financial feasibility of energy saving measures, study of energy efficient technologies and alternate energy sources.

Unit-V **12**

Appropriate Case Studies: Students are required to carry out post-occupancy evaluation of a building document the relationship between building design, energy use, occupant satisfaction, and environmental impact and report their observations.

Total: 48 Periods

Outcome:

Students shall learn the required post-occupancy and energy audit procedures and protocols for assessing the buildings for their performance and suggesting appropriate retrofit measures.

References

1. Moncef Krarti (2011). Energy Audit Of Building Systems An Engineering Approach. CRC Press. Florence. Taylor & Francis Group.
2. Li P, Froese TM, Brager G, Post-occupancy evaluation: State-of-theart analysis and state-of-the-practice review, Building and Environment (2018), doi: 10.1016/j.buildenv.2018.02.024.
3. Alejandro Vásquez-Hernández and Mario Fernando Restrepo Álvarez, Evaluation of buildings in real conditions of use: Current situation, Journal of Building Engineering, http://dx.doi.org/10.1016/j.jobe.2017.04.019.
4. Ye, C.; Yao, L.; Meng, Y.; Zhang, Y.; He, G. Post-Occupancy Evaluation of Green Technologies for a High-Rise Building Based on User Experience. Sustainability 2022, 14, 9538. https://doi.org/10.3390/su14159538

MSAR214 - Dissertation	Subject Category	JC
	Number of Credits	6
	Lecture Periods per Week	--
	Studio/Lab/Workshop/Practical's	6
	Total Periods per Week	6

Objective:

To make the students understand the process of carrying out research and to effectively identify and formulate problems for the Thesis in the next semester.

Topics related to various aspects of sustainable architecture and built environment would be chosen in consultation with faculty members.

1. Introduction, definition, objectives of research, types of research
2. Research process, research design, types of research designs,
3. Collection of primary data, data tabulation, and analysis, to draw inferences.
4. Application of above in the dissertation topic chosen.
5. Writing and communication skills for written and oral presentations; professional communications.

Comprehensive study and research on chosen topic, presentation of findings in a series of seminars by individual students. Documentation and formal presentation as a Dissertation at the end of the semester.

Total: 96 Periods

Outcome:

The students shall prepare a thesis proposal to be carried out in the subsequent semester. This course shall help the students in developing literature, methods, tools and techniques to be adopted and develop a comprehensive proposal.

References

1. Wayne C Booth, Joseph M Williams, Gregory G Colomb, The Craft of Research, 2nd Edition, Chicago guides to writing, editing and publishing, 1995
2. Iain Borden, Kaaterina Ruedi, The Dissertation: An Architecture Student's Handbook, Architectural Press, 2000
3. Ranjith Kumar, Research Methodology - A step by step guide for beginners, Sage Publications, 2005
4. John W Creswell, Research design: Qualitative, Quantitative and Mixed method approaches, Sage Publications, 2002
5. Linda N. Groat, David Wang, Architectural Research methods, Wiley, 2nd edition, 2013

FOURTH SMESTER

MSAR221 - Thesis	**Subject Category**	**Thesis**
	Number of Credits	**27**
	Lecture Periods per Week	**03**
	Studio/Lab/Workshop/Practical's	**24**
	Total Periods per Week	**27**

The Thesis gives the student an opportunity to apply the discipline and skills of the programme to an individually selected research topic, requiring a measure of original development, providing a vehicle for conducting an in-depth investigation, analysis and critical review of relevant material. The Thesis should reflect the Philosophy of Sustainable Architecture and the technical knowledge gained from the entire course which may include the simulations. The Thesis is the culmination of work done on the programme and is considered to be of prime importance. The process of producing the Thesis consists of a number of Thesis Workshop day long events followed by group discussions and one to one tutorial.

Each student is allocated a Thesis supervisor who is responsible for academic guidance through the process. All students are encouraged to produce a publishable paper based on the Thesis material.

At the end of the semester each student is expected to submit all the original drawings as per the department's specifications. Three copies of the report in the prescribed format set by the department have to be submitted after taking approval from the supervisor/guide.

The department shall schedule a date for the viva-voce as per the academic calendar. The performance sheet submitted by the Guide/supervisor and the Thesis committee should be the basis for allowing the student to appear for the final viva-voce.

Total: 432 Periods

ELECTIVE I

MSAR1110 - Traditional Wisdom and Sustainability Concepts	**Subject Category**	**TC**
	Number of Credits	**3**
	Lecture Periods per Week	**2**
	Tutorial Periods per Week	**1**
	Total Periods per Week	**3**

Objective:

To impart the importance of traditional wisdom and knowledge, and its relevance today.

Unit-I **10**

Socio-cultural aspects in the spatial formation of traditional buildings under different climate zones in India. Concepts of Sacred build-up and Landscape, An Architectural and Theological Interface, Indigenous knowledge, antiquity, Indian vernacular architecture concepts covering informal, functional architecture of structures, built of local materials and designs to meet the needs of the local people and the intricate variations in local social customs, craftsmanship and climate.

Unit-II **10**

The interpretations and reintroduction of spatial elements such as columns, brackets, jaalis, zarokhas, chhajas, stairs and cupolas to the remake of spatial themes such as courts, terraces, pavilions and caves related to sustainable concepts.

Unit-III 10

Sustainable Architectural concepts in history covering Indus valley, Aryan cultures, Buddhist, Dravidian, Indo Aryan, Hoysala Architecture, Islamic, provincial style, Mughal, colonial and post-colonial architecture and components of consideration such as materials, high ventilated roofs, integrated design, lighting, ventilation, vegetation and adopting to natural environment.

Unit-IV 9

The Architectural concepts to emphasize local conditions, geography of region and peoples mind to emphasize traditional wisdom and sustainable concepts. Reposing faith in traditional wisdom, continuum of Vernacular concepts in contemporary Indian architecture.

Unit-V 9

Appropriate Case Studies

Total: 48 Periods

Outcome:

Students shall learn the traditional concepts and techniques from various cases studies across the country for understanding the traditional concepts for coping up with sustainability issues.

References

1. Wines James & Jodido Philip, "Green Architecture – The Art of Architecture in the age of Ecology", Tachen Publishers, New York, 2000.
2. Mackenzie Dorothy, "Green design: design for the Environment", Laurence King, London, 1997.
3. Farmer John & Richardson Kenneth, "Green Shift: Changing attitudes in architecture to the Natural World", Architectural Press, Boston, 1999.
4. The European Commission, "A Green Vitruvius: Principles and Practices of Sustainable Architectural Design", James & James, London, 1999.
5. Fred A. Stitt, "The Ecological Design Handbook", McGraw Hill, New York, 1999.
6. Scott Andrew, "Dimensions of Sustainability: Architecture, Form, Technology, Environment & Culture", F&FN Spon, London, 1998.

MSAR1111 - Resource Conservation and Efficiency	Subject Category	TC
	Number of Credits	3
	Lecture Periods per Week	2
	Tutorial Periods per Week	1
	Total Periods per Week	3

Objective:

To sensitize and equip the students with understanding on various natural resources, assessment and conservation techniques.

Unit-I 10

Energy Efficiency – Energy Conservation – Recourse Consumption – Introduction – Distribution of Energy use in India – Factors affecting the Energy use in Buildings – Pre-Building Stage, Construction Stage & Post Occupancy stages.

Unit-II 10

Types of natural resources including human, material, economic etc. Need for conservation of resources. Carbon footprint assessment, concept of ecological capacity etc.

Unit-III 10

Overview of Environmental Sciences pertaining to the above, including assessments, mapping tools and methods etc. Human interventions and ecosystem disturbances, Impact of human activities on natural resources and biodiversity, changing of the ecosystem cycles etc.

Unit-IV 9

Local, regional and global impacts on the Environment. Introduction to wasteland creation & barren land formation, soil erosion at regional level; Kyoto Protocol, Paris Climate Change Agreement, India's climate change policy and stand. Efficient utilization of resources with case studies.

Unit-V 9

Impacts of Urbanization on Ecology and Environment. Water management, waste and land management systems. Extreme Climate. Zero Energy Buildings, carbon neutrality.

Total: 48 Periods

Outcome:

Students shall learn about the resource conservation concepts, ideas and strategies that are applicable for design efficient buildings.

References

1. P.S. Ramakrishan (2002) Ecology and Sustainable Development: Working with Knowledge and System, National Book Trust
2. Michal L McKinney, Robort M Schoch, Logan Yonavjak (2013) Environmental Sciences: System and Solutions, John and Barttett learning
3. Ping Chi and Qiang Chion (2015) Climate Change and Sustainability, Delve Publishing
4. P.N. Prasad (2010) Environmental Air Pollution: Causes, Effect and Control, Crescent Publishing Corporation
5. Steve Goodhew, (2016), Sustainable Construction Process, Wiley

Open Elective (From SPAV)	**Subject Category**	**TC**
	Number of Credits	3
	Lecture Periods per Week	2
	Tutorial Periods per Week	1
	Total Periods per Week	3

ELECTIVE II

MBEM1211 - Waste Management	**Subject Category**	**TC**
	Number of Credits	3
	Lecture Periods per Week	2
	Tutorial Periods per Week	1
	Total Periods per Week	3

In line with MBEM Syllabus

MBEM1212 - Healthy buildings	**Subject Category**	**TC**
	Number of Credits	3
	Lecture Periods per Week	2
	Tutorial Periods per Week	1
	Total Periods per Week	3

In line with MBEM Syllabus

MUD 125 - Liveable Cities	Subject Category	TC
	Number of Credits	3
	Lecture Periods per Week	2
	Tutorial Periods per Week	1
	Total Periods per Week	3

In line with MUD Syllabus

Open Elective (From SPAV)	Subject Category	TC
	Number of Credits	3
	Lecture Periods per Week	2
	Tutorial Periods per Week	1
	Total Periods per Week	3

ELECTIVE III

MSAR222 - Project Management	Subject Category	TC
	Number of Credits	3
	Lecture Periods per Week	2
	Tutorial Periods per Week	1
	Total Periods per Week	3

Objective:

To impart the requirement project management skills in handling real-time project, and also to expose students the practical issues concerning projects in general.

Unit-I **10**

Introduction to Project finance & Management. Project Management: Construction projects, Project development process, project management, main causes of project failure.

Unit-II **10**

Project formulation: Generation and Screening of Project Ideas - Project identification – Preliminary Analysis, Market, Technical, Financial, Economic and Ecological - Pre-Feasibility Report and its Clearance, Project Estimates and Techno-Economic Feasibility Report, Detailed Project Report.

Unit-III **10**

Project Planning Process: Plan development process, time planning process, work scheduling process, resource planning process, Importance of planning, scheduling and controlling projects.

Unit-IV **9**

Project Finance: Introduction to project finance Means of financing, Costs associated with projects, estimates, Economic analysis of project, economic studies, sensitivity analysis. Cost estimating principles. Detailed estimates, cost concepts, classification of costs, elements of costs, Private sector participation in Infrastructure Development Projects - BOT, BOLT, BOOT.

Unit-V **9**

Working Capital Management: Concept, Need and types of Working Capital; Determination of Working Capital; Estimation of Working Capital Needs; Financing of current assets – Matching, Conservative Approach, Aggressive Approach (Problem and Theory).

Total: 48 Periods

Outcome:

Student shall learn the various stages and phases of projects; tools and techniques available for effective implementation of projects.

References

1. Gupta, B.L. and Gupta, Amit., Construction Management, Machinery and Accounts, 3rd ed. Standard Pub, 2005.
2. Loraine, R.K, Construction Management in Developing Countries. Thomas Telford, London, 1993
3. Srinath, L.S., PERT and CPM Principles and Applications, 3rd ed. Affiliated East-West Press, New Delhi, 2003.
4. Singh, Harpal., Construction Management and Accounts 14th ed. Tata McGraw-Hill Pub., New Delhi, 1981
5. Gould, E.Frederick and Joyce, E.Nancy., Construction Project Management. Prentice Hall, New Jersey, 2000
6. Shrvastava, U.K., Construction Planning and Management, 3rd ed. Galgotia Pub., New Delhi, 2004

7. Chitkara, K.K, Construction Project management: Planning. Scheduling and Controllling. Tata McGraw-Hill Pub., New Delhi. 1999.
8. Sharma, S.C, Construction Equipment and its Management, 4th ed. Khanna Pub., New Delhi, 2004.

MLAR213 - Sustainable & Energy Efficient Landscape	Subject Category	TC
	Number of Credits	3
	Lecture Periods per Week	2
	Tutorial Periods per Week	1
	Total Periods per Week	3

In line with MLAR syllabus

Open Elective (From SPAV)	Subject Category	TC
	Number of Credits	3
	Lecture Periods per Week	2
	Tutorial Periods per Week	1
	Total Periods per Week	3

ELECTIVE IV

MBEM212 - Building Information Modelling and Management	Subject Category	TC
	Number of Credits	3
	Lecture Periods per Week	2
	Tutorial Periods per Week	1
	Total Periods per Week	3

In line with MBEM Syllabus

Open Elective (From SPAV)	Subject Category	TC
	Number of Credits	3
	Lecture Periods per Week	2
	Tutorial Periods per Week	1
	Total Periods per Week	3