Course title: Building energy and green buildings			
Course code: ENR 115	**No. of credits:** 3	**L-T-P:** 13-17-24	**Learning hours:** 54
Pre-requisite course code and title (if any): N.A.			
Department: Department of Energy and Environment			
Course coordinator: Dr Aviruch Bhatia	**Course instructor:** Dr Aviruch Bhatia		
Contact details: aviruch.bhatia@terisas.ac.in			
Course type: Elective	**Course offered in:** Semester 3		

Course description

Building on concepts of passive solar architecture practices covered in ENR 151, students will attain further knowledge of green building techniques, materials and practices. Utilizing costs/benefits analysis, life cycle costs, embodied energy evaluation, and overall sustainability of various materials and methods students will learn basic methods of green building design, technique, documentation and certification.

Course objectives

This elective course aims to train the student in understanding and familiarization of different heat flow calculations and building simulation software. Several case studies will be presented to demonstrate how the various passive, low energy and energy saving concepts have been applied to real life buildings. The concepts of green buildings will be introduced and different rating systems for green buildings will be explained.

Course contents

Module	Topic	L	T	P
1	**Introduction** Review of topics on thermal comfort Classification of climate zones Review of traditional architecture	2		
2	**Heat flow calculations in building** Unsteady heat flows through walls, roof, windows etc. Direct heat gains through windows Convective gains/losses, air exchange rates Gains from people, appliances etc. Air conditioning load calculations		2	6
3	**Passive and low energy concepts and applications** Passive cooling/heating concepts Building form and orientation Internal and external shading devices Ventilation, passive concepts for composite climates, evaporative and nocturnal cooling Earth–air tunnel, sky- therm system Solar chimney-based hybrid system	2	2	
4	**Building simulation** Introduction and use of different building simulation software for modeling of non-air conditioned spaces such as TRNSYS, ECOTECT etc.	2	2	12
5	Case studies of non-air conditioned buildings		4	

6	Introduction and use of different building simulation software for modeling of air conditioned spaces such as VISDOE, EPLUS etc.	1	1	6
7	Case studies of air conditioned buildings		4	
8	**HVAC systems** Description of different components of HVAC systems	2	2	
9	Rating systems in different countries. Green building rating systems such as LEED and GRIHA. BEE and ECBC	4		
	Total	**13**	**17**	**24**

Evaluation criteria

- Assignments/Tutorials: 30%
- Test 1: 20%
- Test 2: 20%
- Test 3: 30%

Learning outcomes

- This course is designed to enlighten students to the current green building trend, and to help them realize the impact and applications of green building as a practice not just a trend. Upon completion of the course, students will be:
- having an understanding of core building science fundamentals (to include but not limited to: thermodynamics as related to wind, air, moisture, pressure, and heat).
- able to perform some building sustainability concepts (to include, but not limited to, site layout, building design, advanced framing, and insulation)
- able to understand energy efficiency in relation to cost performance, ROI, etc.
- able to understand and perform some building performance testing (ex. energy audit, Rating) and be exposed to different agencies involved in the testing.
- able to understand and perform some weatherization fundamentals.

Pedagogical approach:

A combination of class-room interactions, tutorials, assignments and projects.

Materials:

Recommended readings

Minke, G., 2006. Building with Earth: design & technology of a sustainable architecture, SpringerLink

Givoni, B., 1969. Man, Climate and Architecture. Elsevier Publishing Company Ltd.

Givoni, B., 1998. Climatic Considerations in Buildings and Urban Design, John Wiley & Sons, Canada

N. K. Bansal, Gerd Hauser, Gernot Minke, 1994. Passive building design: a handbook of natural climatic control, Elsevier Science B.V.

Krishnan, A., Baker, N., Yannas, S., Szokolay, S., (Eds) 2001. Climate Responsive Architecture- A Design Handbook for Energy Efficient Buildings, Tata McGraw-Hill, New Delhi

Givoni, B., 1994. Passive and Low Energy Cooling of Buildings, John Wiley &Sons Inc., New York

Santamouris, M., 1996. Passive Cooling of Buildings, James & James (Science Publishers) Ltd., London

Karlen, M and Benya, J., 2004. Lighting Design Basics, John Wiley &Sons Inc., New York
American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE): Fundamentals, Equipment
Indian Society of Heating, Refrigerating and Air-Conditioning Engineers (ISHRAE) Standards
Richard R Janis and William K Y Tao, 2008. Mechanical and Electrical Systems in Buildings, Prentice Hall
Vedavarz, A., Kumar, S. and Hussain, Md., 2007. HVAC: Heating, Ventilation and Air-Conditioning Handbook for design & Implementation, Industrial Press, New York
Jan F. Kreider, Peter S. Curtiss and Ari Rabl, 2010. Heating and Cooling of Buildings- Design for efficiency, revised second edition, CRC Press, USA
BEE, 2007. Energy Conservation Building Code
http://www.usgbc.org/, United States Green Building Council, USA
http://www.igbc.in ,Indian Green Building Council, LEED India
http://www.grihaindia.org/ , GRIHA Website, India
TERI, 2004. Sustainable Building Design Manual, Vols 1 & 2.

Additional information (if any):N.A.

Student responsibilities

Attendance, feedback, discipline: as per university rules.

Course reviewers:

1. Dr. Vinod Gupta, Space Design Associates, New Delhi
2. Prof. Ashok Lal, School of Planning and Architecture, Delhi
3. Mr. Pradeep Kumar, TERI, Delhi