Sushant University

Criteria 2.6. Student Performance and Learning Outcomes

2.6.1 The institution has stated learning outcomes (Program and Course outcomes), graduate attributes, which are integrated into the assessment process and widely published through the website and other documents, and the attainment of the same is evaluated by the institution



||Sushant ||University

Academic Year 2024-2025



School of Art and Architecture, Sushant University

Course File

Academic Session: ODD SEM - 2024-25

Program: B.Arch.

Sem: 5

Course Name: Allied Field 3 (Sustainable Materials and Green Buildings)

nl

Course Code: 21BAR6AL31S

Faculty Name: Dr. Purva Mujumdar





Course Activity Sheet (Planning and Review)

Academic Year 2024 – 25
Programme B. ARCH.
Semester5
Course Name ALLIED FIELDS 3 (SUSTAINABLE MATERIALS & GREEN BUILDINGS)
Course Code 21BAR 6 AL31S BUILDINGS)
SCHOOL OF ART & ARCHITECTURE
Faculty Dr. PURVA MUJUMDAR

. No	Activity	Status
1	Is the syllabus copy maintained and submitted by the faculty member?	Yes/No
2	Is lecture plan signed and updated by the faculty member?	Yes
3	Is Time Table made available?	Yes
4	Number of Assignments planned	4
5	Number of quiz planned	
6	Digital Learning LX (Review) Is it updated with following (suggestive): Syllabus Reference material Quiz/Assignment	Yes
7	Is mapping of students available on ERP along with the timetable?	Yes
8	Suggest atleast one innovative way for better engagement of students in this course	Research base learning about new age upon sustainable mais is recommended.

Preva mijunden 9.10.2024

(Signature of Faculty Member with Date)

(Signature of Dean with Date)



Mid-Semester Review

.No	Activity	Status
1.	Is the attendance updated on ERP?	Yes/No
2.	Percentage of students who are not meeting the attendance criteria of 75%	37 1.
3.	Pass percentage in Internal Assessment so far	75%
4.	Identification and motivation advanced learners (Advanced learner sheet attached)	RESEARCH ON UPCOMING SUSTAI
5.	Identification and remedial classes for slow learners (Slow learner sheet attached)	

Dean's Review and recommendatio	ended for the alchitecture students
to have in dep	their enelicular & is beneficial plactice.
for future	plactice.
2000 und	replied

(Signature of Faculty Member with Date)

(Signature of Dean with Date)

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End-Semester Review

S.No	Activity	Status
1.	Is the attendance updated on ERP?	Yes/No
2.	Percentage of students who are not meeting the attendance criteria of 75%	26%
3.	Pass percentage	75%
4.	Summary of CO attainment	
5.	Student Feedback	
6.	Exit Feedback by faculty member for improvement in future	CURRENT TRENDS &
		CURRENT TRENDS TRENDS CONCEPTS OF CONCEPTS OF SUSTAIN ABLE SUSTAIN ABLE MATERIALS MATERIALS GREEN BUILDING WILL BE TAKEN IN FUTI
		TAKEN IN FUT

Celen buildings & net zero energy buildings all need of home those days. Strongly le commended for etwenty of architecture.

(Signature of Faculty Member with Date)

(Signature of Dean with Date)

01:25-02:15 02:20-03:10 03:15-04:05 04:10-17:00 5th Period 6th Period 7th Period 8th Period	entation 1	Bhupender,Payal Taneja	23BAR-1AR21S Architectural Representation 3 -Digital Skills	Prof Himanshu Sanghani, Arjun Kamal	21BAR-2LD31S Landscape design and site planning	Shruti Hippalgaonkar,Pallavi Keswani	21BAR-3SS41T Structural System and Design 6	Purva Majumdar	NCENON NEWSCOTT NEWSC	24BAR-1SA11S Sustainable Approaches – Climatology, 21ENG12 English	Communication Sustainability and best Practices Communication	Bhupender Sagarika Goswami	General Elective 2-MOOC/ VAC/ VC	Avitesh Vaishnavi Nayak,KIran Singh	21BAR-3SS31T Structural System and Design 4	Purva Majumdar,Payal Taneja	Self Study				21ENG12 English Communication	Sagarika Goswami	238AR-15A21S	Sustainable Approaches Settlement Studies	Value Added Cources Savar Suri	(VAC) 19BAR-3SE31T Specification and estimation	Md.Anees,Bhupender			
12:45-01:25 Lunch Break	a v				Lunch			ľ							to di										4000	ranca				
09:10-10:00 10:05-10:55 11:00-11:50 11:55-12:45 12:45-01:25 1st Period 2nd Period 3rd Period 4th Period Lunch Break	24BAR-1DS11P Design Studio 1	Prof. Aruna Bhardwaj, Pallavi Keshwani, Keerti Mishra, VF	23BAR-1DS21P Design Studio 1	Shruti Hippalgaonkar, Sindhuree Iyengar ,Harsha Yadav ,VF	21BAR-1DS31P Architectural Design 5	Himanshu Sanghani,Robbin Dwivedi,Arjun Kamal,Prarthana	21BAR-1DS41P Architectural Design 7	Prof. Pooja Lalit Kumar,Sehba Saleem,Kiran Singh,Prerna Hazarika,Pratibha Malik,Amrita Das Gunta		24BAR-3AA11P Art & Art Appreciation 1		Harsha Yadav,Savar Suri	Electives Basket	Elect	TDCC Mond.Anees Sehba Saleem	Elective 3 (Intermediate) Shiv Manwah	Arjun kamal Pursa kajundar	ELECTIVE 5(Advanced)	Himanshu Sanghani Aparajita Shrivastav	Elective 7 (Online Compulsory Elective) Pallani Keswani	23BAR-2CS11P Construction Systems Studio 1	Avitesh Vaishnavi Nayak,Bhupender,Pratibha Malik,Anurag Roy	23BAR-2CS21P Construction Systems Studio 3 - Materials, Techniques,	Structural Systems, Surveying and Services	Deepak,Payal Taneja,Md.Anees,Manish Ahuja	218AR-2BC31P Building Construction and Materials 4	Robbin Dwivedi, Purva Majumdar, Keerti Mishra, JS Bedi	Thesis Seminar	Prof Himanshu Sanghani	
	IA	18	24	28	3A	38	44	48	5A 5B		14	18	2A	28	3A	38	\$	48	2A	85	14	18		2A	28	3A	38	44	48	5.A
	Room No E 506	Room No E 507	Room No E 406	Room No E 407	Room No E 408	Room No E 409	Doom No E 309	Room No E 307	On Internship On Internship		Room No E 506	Room No E 507	Room No E 406	Room No E 407	Room No E 408	Room No E 409	KOOM NO E 3US	Room No E 307	On Internship	On Internship	Room No E 506	Room No E 507		Room No E 406	Room No E 407	Room No E 408	Room No E 409	Room No E 308	Room No E 307	On Internship
					MONDAY										TUESDAY										WEDNESDAY					

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			24BAR-1DS11P Design Studio 1	24BAR-3HT11P Histo	24BAR-3HT11P History, Theory & Criticism 1
	Room No E 506	14		Sindhi	Sindhuree Ivengar
	Room No E 507	18	Prof. Aruna Bhardwaj,Pallavi Keshwani,Keerti Mishra,VF	Sa	Savar Suri
	Room No F 406	24	23BAR-1DS21P Design Studio 1		
	Room No E 407		Shruti Hippalgaonkar, Sindhuree Iyengar ,Harsha Yadav ,VF		
			21BAR-1DS31P Architectural Design 5	21BAR-5TM31S Theory and method 5	THE RESIDENCE OF THE PARTY OF T
THIIDCDAY	Room No E 408	88 SA	Himanshu Sanghani,Robbin Dwivedi,Arjun Kamal,Prarthana	Prof.Aruna bhardwaj,Bhupender	
Š			21BAR-1DS41P Architectural Design 7	21BAR-1DT41P Dissertation	21BAR-1DT41P Dissertation
	Room No E 307	44 84	Prof. Pooja Lalit Kumar,Sehba Saleem,Kiran Singh,Prema Hazarika,Pratibha Malik,Amrita Das Gupta	Himanshu Sanghani(Seminar) Prerna Hazarika (Seminar)	Prerna Hazarika, Jejwant Singh Brar, Pooja Lalit kumar, Purva Majumdar, Shruti H, Shanu Jain, Sindhuree Vengar, Sehba Saleem, Pallavi Keswani, Kiran Singh, Robin Dwivedi, harsha Yadav, Md. Anees, Payal Taneja, Avitesh Vaishawi Nayak, Savar
	On Internshin	5A	· · · · · · · · · · · · · · · · · · ·		
	On Internship	28		· · · · · · · · · · · · · · · · · · ·	
		(12) (2)	238AR-2C511P Construction Systems Studio 1		
	Room No E 507	# E	Avitesh Vaishnavi Nayak, Bhupender, Pratibha Malik, Anurag Roy	Site visits/ Industry Visits / Outdoors Studies	
			23BAR-2C521P Construction Systems Studio 3 - Materials, Techniques, Structural Systems, Surveying and Services	Site visite / Industry Visite / Duthone Studiae	
	Room No E 406	ZB 28	Deepak, Payal Taneja, Md. Anees, Manish Ahuja	Company of Court Allegant Court And	Faculty Meeting / Mentor Mentee
FRIDAY	Room No F 408	3.4	19BAR-3BS31T Building Services 3	Lunch Gibo ujcite / Jaduseba Vicite / Dusdages Chudiae	Sessions University
	Room No E 409		Prerna Hazarika	חופ אופוס / הושמפון אופוס / סמנמססום חוממנסם	
	Room No E 308	44	21BAR-2BC41P Building Construction & Materials 6	21BAR-2BC41P	
	Room No E 307		Dr.Tejwant Singh Brar, Kiran Singh, Shanu Jain, Shiy Marwah		
	On Internship	5A		Elective 8 (Online)	
	On Internship	58		Harsha Yadav, Pratibha Malik	lik







ELECTIVE COURSE

Course Title

: Allied Fields 3 (Sustainable Materials and Green Buildings)

Course Code

: 21BAR6AL31S

Course Credits

: 3

Teaching Mode

			CHING S/WEEK		EXAMINATION SCHEME					
COURSE CODE	COURSE TITLE	Lecture	Lecture Studio		Internal Assessm ent	External Jury	External Exam			
21BAR6AL31S	Allied Fields 3 (Sustainable Materials and Green Buildings)	1	2	3	100	NA	NA			

Course Objectives

To understand the concept of Sustainability in the context of buildings and conventional engineered building materials.

Course Outcomes

The student will be able to

CO1: Understand the role of materials in the Building sector and other disciplines.

CO2: Determine embodied energy and carbon content of buildings.

CO3: Explore performance rating of green buildings and zero energy building.

Course Content

Module 1:

Introduction and definition of Sustainability. Carbon cycle and role of construction material such as concrete and steel, etc. CO2 contribution from cement and other construction materials. Construction materials and indoor air quality. No/Low cement concrete.

Module 2:

Recycled and manufactured aggregate. Role of QC and durability. Life cycle and sustainability. Components of embodied energy, calculation of embodied energy for construction materials. Exergy concept and primary energy. Embodied energy via-a-vis operational energy in conditioned building. Life Cycle energy use.

Module 3:

Control of energy use in building, ECBC code, codes in neighboring tropical countries, OTTV concepts and calculations, features of LEED and TERI Griha ratings.

Module 4

Role of insulation and thermal properties of construction materials, influence of moisture content and modeling. Performance ratings of green buildings. Zero energy building.

PEDAGOGY

- Lecture about the given topic
- Predominantly, discussions in the classroom
- Research on topics
- Site Visits relevant to the topics being studied

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- Analysis based learning
- Case Studies

Text Book:

- Newman, J. and Choo, Ban Sang, Advanced Concrete Technology-Constituent Materials, 1st Edition, Elsevier, 2003
- McQuiston, F.C., and Parker, J.D. Heating, Ventilating, and Air Conditioning, Analysis and Design, Fourth Ed. John Wiley & Sons, Inc, 1994.
- Green Building Basics, California Integrated Waste Management Board (www.ciwmb.ca.gov/GREENBUILDING/Basics.htm#What)

Resources:

Suggested Readings

- 1. Kubba, S, LEED Practices, Certification, and Accreditation Hand book, 1st ed. Elsevier, 2010.
- 2. TERI-Griha's Green Design practices (www.teriin.org/bcsd/griha/griha.htm)
- 3. Minsitry of Power, Energy Conservation Building Code 2018, Revised Version, Bureau of Energy Efficiency, 2018

Course Assessment Scheme

Intermediate Reviews by Internal Faculty

: 100 Marks

Total

: 100 Marks

IN	TERNAL 1 (I1)	IN'			
Continuous Evaluation (Assignment, Presentation)	Time Problem / Seminar (Open Book*)	Internal Test / Quiz / Project Presentation	Continuous Evaluation (Assignment, Presentation)	Time Problem	Internal Test / Quiz / Project Presentation (External**)	MSE + 5 (I1 + I2)
20 %	10 ½	10	30	10	20	100

PROGRAM OUTCOME - (PO)

Upon successful completion of this program of study, the graduates shall:

PO1	Demonstrate a high degree of critical thinking, technical competence and skills related to thebuilt environment (knowledge and skill)
PO2	Exhibit knowledge of emerging tools and techniques in the field of architecture (tools andtechnology)
PO3	Illustrate understanding of the social, cultural, political and ecological factors affecting the built environment (context)
PO4	Examine and analyse the built environment through research and critical thinking (criticalthinking)
PO5	Show the ability to represent the ideas/concepts using appropriate media and skill sets. (communication)
PO6	Exhibit high degree of ethical and professional standards. (ethical and professional understanding)

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PO7	Demonstrate the ability to work in a collaborative environment. (collaborative engagement)
PO8	Understand the importance and impact of proposed solutions on environment for a sustainable development (environment and sustainability)
PO9	Exhibit resilient leadership and the ability to evaluate situations to achieve goals (leadership and management)

PROGRAM SPECIFIC OUTCOME (PSO)

- PSO1: Demonstrate design thinking through technical, theoretical, conceptual and analytical skills of architecture for enriching the lives of communities
- PSO2: Apply the knowledge and skills gained through fundamental/foundation of hands on learning, critical thinking, heritage, sustainability and arts in the built environment
- PSO3: Implement the understanding gained through experiential learning, industry connect national and international collaborations in the field of architecture
- PSO4: Show the ability to evaluate, adapt and achieve goals, acknowledging the changing trends and technology in the built environment

Mapping of COs and PSOs

	PSO1	PSO2	PSO3	PSO4
CO1	L	M	L	L
CO2	M	L	M	L
CO3	L	L	L	M

Note: $H = High\ relationship\ (covers\ up\ to\ 75-95\%\ of\ the\ desired\ outcome);\ M = Medium\ (covers\ up\ to\ 50\ to\ 75\%);\ L = Low\ (covers\ up\ to\ 10-50\%\ of\ the\ desired\ outcome)$

Mapping of COs and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	L	M	L	M	M	L	M	M	L
CO2	Н	L	M	L	L	M	L	L	M
CO3	L	M	L	L	M	L	M	L	L

Note: $H = High\ relationship\ (covers\ up\ to\ 75-95\%\ of\ the\ desired\ outcome);\ M = Medium\ (covers\ up\ to\ 50\ to\ 75\%);\ L = Low\ (covers\ up\ to\ 10-50\%\ of\ the\ desired\ outcome)$



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School Of Art and Architecture

Program: Bachelor of Architecture (B.Arch.) COURSE OUTLINE- [LESSON PLAN]

Course Title: Allied Fields 3 (Sustainable Materials and Green Buildings)

Course Code: 21BAR6AL31S

Semester: 5th Academic Session: Core/Elective: Elective Credits: 3 Odd - 2024-25 Course Designed by: Dr. Purva Mujumdar Course Instructor: Dr. Purva Mujumdar E-mail: purvamujumdar@sushantuniversity.edu.in purvamujumdar@sushantuniversity.edu.in

Pre-requisites: NA

SUSTAINABLE

APPROACHES

1. Course Outcomes: Upon successful completion of the course, the student should be able to

CO1: Understand the role of materials in the Building sector and other disciplines.

CO2: Determine embodied energy and carbon content of buildings.

CO3: Explore performance rating of green buildings and zero energy building.

2. Text Books

- 1. Newman, J. and Choo, Ban Sang, Advanced Concrete Technology-Constituent Materials, 1st Edition, Elsevier, 2003
- 2. McQuiston, F.C., and Parker, J.D. Heating, Ventilating, and Air Conditioning, Analysis and Design, Fourth Ed. John Wiley & Sons, Inc, 1994.
- 3. Green Building Basics, California Integrated Waste Management Board (www.ciwmb.ca.gov/GREENBUILDING/Basics.htm#What)

3. Reference Books

- 1. Kubba, S, LEED Practices, Certification, and Accreditation Hand book, 1st ed. Elsevier,
- 2. TERI-Griha's Green Design practices (www.teriin.org/bcsd/griha/griha.htm)
- 3. Minsitry of Power, Energy Conservation Building Code 2018, Revised Version, Bureau of Energy Efficiency, 2018

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4. Lecture Plan (Total Sessions -15)

SESSI	SESSION	UNIT	DAT	E			
ON NO.	TOPIC / SUB- TOPIC DESCRIPTION	NO.	PLANNED	TAKEN	METHODOLOG Y USED (PPT, WHITE BOARD, AUDIO/VIDEO, PRACTICAL, VISIT, SELF STUDY BASED)	DEANS REMARKS WITH DATE	
Week 1	• Introduction and definition of Sustainability		13.08.2024	13 08	PPT + Self Study Based	concepts who so so discumed	ov 1.
Week 2	• Carbon cycle and role of construction material such as concrete and steel, etc. CO2 contribution from cement and other construction materials.		20.08.2024	20 08	PPT + White Board	Sustainability concepts the so & Goals who so & Goals be discurred cabon cabon cabon cabon cost points of all fuction constrains materials is recommercial	
Week 3	 Construction materials and indoor air quality. No/Low cement concrete. 		27.08.2024	27/08	PPT + White Board	Equipments 2 technique to measure pradit indoor air discurre to be discurre	S. S.
Week 4	 Recycled and manufacture d aggregate. Role of QC and durability. 		3.09.2024	9109	PPT + White Board	rateral isto	he t
Week 5	• Life cycle and sustainability.		10.09.2024	10/09	PPT + White Board	le commended.	
Week 6	 Components of embodied energy, calculation of embodied energy for 		17.09.2024	17/09	PPT + White Board	RCA distorminated is to material is an energy of material in contract of materials in contract o	re

Reva

THE IT	adegraph 1						
	construction materials.						
Week	• Energy		24.09.2024	-100	PPT + White Board	150	d
	concept and primary			24 00		Embuoris	
	energy. Embodied					otion	al
	energy via-a-					oper is	
	vis operational					energy	
	energy in conditioned					Embodie Operation energy is	
Week	building. 1	.10.202	4 (Mid Term	Submission	n)	40%	
8							
Week 9	• Life Cycle energy use.		8.10.2024	8 10	PPT + White Board	ECBC Coo	be interduce
Week	• Control of		15.10.2024		PPT + White Board		
10	energy use in building,			15/10	Boarta	OTTV Concepts & LEFD 6 RIMA Rating discuss	
	ECBC code, codes in					Concepts	
	neighboring					& LEFO	, TERI
	tropical countries,					MA	
	OTTV					6 RIM	
	concepts and calculations,					Raturg	2
	features of LEED and					liscus	<i>9</i> 6
	TERI Griha					00	
Week	ratings.			Line Harris			
11	• Role of insulation		22.10.2024	4/11	PPT + White Board	Theemal	
	and thermal			7 10		lete	\sim
	properties of construction		*		4	mille	dings
	materials,					un los	port
	influence of moisture				\alpha	1 secon	t
	content and					implan	dings font tou alls ussed.
9.10.	modeling.					disc	ussea.
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			AND ONLY OF THE PARTY OF THE PA		Architecture of		
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Week 12	Performance ratings of		5.11.2024	5 11	PPT + Software Demo	performe	cluen
	green buildings.					rating of	was
	Zero energy building.					done wil	was to Niwas Samhita
Week 13			12.11.2024				3 our
Week 14	19.11.2024 (End Term Submission)					60%	
Week 15		26.11.	2024 (Remedi	al Week)			

Aim/ Objectives

The aim of this course is to expose the students to the concepts of sustainability in the context of building and conventional engineered building materials, such as concrete, bricks, and achieving the same through lower carbon cements, superior brick kilns and recycled aggregate minimizing consumption of natural resources including water. VOC and indoor air quality. Exposing the student to concepts of embodied, operational and life cycle energy, minimizing energy consumption by optimal design, use of BIPV. The course also intends to make student aware of ECBC, LEED, GRIHA etc.

Course Description

This course deals with the Sustainable Materials and Green Buildings minimizing carbon content of the Buildings and energy consumption.

Teaching Method

- Lecture about the given topic
- Predominantly, discussions in the classroom
- Research on topics
- Site Visits relevant to the topics being studied
- Analysis based learning
- Case Studies

Approach

This course shall be taught with class lectures on the relevant topics, class presentations with involvement of students, case studies, site visits, class discussions etc. The goal is to achieve basic qualitative understanding of sustainable materials and green buildings theory in order to minimize carbon content of the buildings. Introduction of project related topics and assignments for presenting technical information to students.





Deliverables

Assignment No.	Assignment Type	Specifications	Weightag e	Submission Date	Course Outcomes
Assessment 1	Individual (A4 Print)	Presentation/Report on Traditional Building Materials and their Carbon Content	20%	3.09.2024	CO1
Assessment 2	Individual (A4 print)	Presentation/Report on Sustainability and Embodied energy	20%	1.10.2024	CO2
Assessment 3	Individual (A4 Print)	Presentation/Report on Life cycle energy use, ECBC, GRIHA and LEED Rating	30%	22.10.2024	CO1, CO2, CO3
Assessment 4	Individual (A4 Print)	Presentation/Report on Performance rating of green buildings and zero energy building	30%	19.11.2024	CO3

Assessment Scheme

IN	TERNAL 1	(I1)	IN	TERNAL 2	(I2)	
Continuous Evaluation (Assignment, Presentation)	Time Problem / Seminar (Open Book*)	Internal Test / Quiz / Project Presentation	Continuous Evaluation (Assignment, Presentation)	Time Problem	Internal Test / Quiz / Project Presentation (External**)	MSE (I1 + I2)
20	10	10	30	10	20	100





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GRADING CRITERIA AND ASSESSMENT RUBRICS APPLICABLE ON ALL **ASSIGNMENTS**

Dimension	Below Average (0 to 5)	Average (5 to 6)	Above average (6 to 7)	Good (7 to 8)	Excellent (8 to 10)
Understandin g of the Topic: Technical Knowledge	Lacked technical knowledge	Little knowledge not adequate to understand	Fair knowledge capable of understanding	Good knowledge and inquisitive	Excellent, Able to answer queries
Application of the Knowledge	Unaware of application of various sustainable materials	Little awareness application of various sustainable materials	Fair and capable of identification various sustainable materials	Good understanding of application of various sustainable materials	Very Good understanding of application of various sustainable materials
Presentation: Quality of work	Poor quality/ incomplete work	Quality of work not up to standard of the class	Fair quality of completed work	Good quality of work includes lucid drawings and well- organized set of drawings with graphics	Very good quality of work includes well drawn drawings, with graphics, text neatly organized thereby resulting in a professional quality work.
Finishing of presentation	Inactive and lack of participatio n	Active but less involved with group members	Active and involved	Active and involved with complete interest	Active and involved with leadership qualities
Compilation of data	Copied	Not adequate	Fair inputs visible	Good work relevant to the topic	Very good work with respect to the topic
Analysis of data	Inability	Unable to explain	Fair inputs visible	Good work relevant to the topic	Very good work with respect to the topic
Participation in class and projects	Poor	Moderate	Adequate	Full	Full





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Plagiarism

What is Plagiarism?

The theft of ideas (such as the plots of narrative or dramatic works) or of written passages or works, where these are passed off as one's own work without acknowledgement of their true origin; or a piece of writing thus stolen.

-- The Oxford Dictionary of Literary Terms. 2008. Oxford University Press.

Common Forms of Plagiarism

- Copying directly from others without acknowledgement of the original source
- Using ideas or rephrasing text from without acknowledgement of the original source
- Using charts, tables, pictures or diagrams from others without referencing
- · Reusing some parts of your previous work
- · Submitting other people's work as your own

How to avoid plagiarism?

- Use your own ideas.
- Paraphrase + give proper credit to the original source.
- Use quotation marks when using exact words from other authors + give proper credit to the original source.
- Organize and track your sources and materials





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School of Art and Architecture - Sushant University

Odd Semester (Aug-Dec) 2024-25

Students List

Program: B.Arch.

Course Name: Allied Fields 3

Faculty: Dr. Purva Mujumdar

Total No. of Students enrolled in the course: 19

Sem: 5

Course Code: 21BAR6AL31S

Student Name	Roll No
Chirag Yadav	220BARCH026
Rongsennukla Yaden	220BARCH046
Annanya Bindal	220BARCH016
Ishita Gupta	220BARCH053
Simran thakran	220BARCH008
Manaj Baweja	220BARCH001
Amritam Gupta	220BARCH022
Abeer Bhasin	220BARCH036
Naveen Chauhan	220BARCH048
Raghav Sethi	220BARCH054
Dhruv Dogra	220BARCH062
Aarushi Agrawal	220BARCH010
Harshita Dang	220BARCH047
Ronnit Garg	220BARCH046
Rudra Pratap Singh	220BARCH024
Rushil Soni	220BARCH018
Shriya Khurana	220BARCH018
Sudevi Gayen	220BARCH015
Shweta Sharma	220BARCH005





Prints

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Sustainability in Building and Construction: Revising Definitions and Concepts

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² PhD candidate, Department of Art and Architecture, Science and Research Branch, Islamic Azad University, Tehran, Iran.

¹h.zabihi@srbiau.ac.ir, ² architecture.doc@srbiau.ac.ir, ³ mirsaeedi@iaugonbad.ac.ir

Abstract. Building construction challenge, in recent years, is reduction of social, economical and environmental impacts of buildings along with their economical nature and increasing of life quality, and for these aims sustainable construction becomes important as building construction has important role in sustainable development. Sustainable development in any fields as construction and architecture defines in any words and from different point of views. In this study by review and studying definitions and concepts of sustainability in building and architecture sector, as sustainable design, architecture and construction, a comprehensive definition as Building sustainability model have been presented. Also, some aspects and main categories of sustainability in architecture and building are presented. Sustainability aspects in the building are categorized in four groups of environmental, social, economical and technical issues. In each group some of general factors are shown. The mentioned characteristics are some items consistent with sustainability principles and goals and they are effective in fulfilling goals of sustainability.

Keywords: Sustainability, sustainable design, Sustainable Construction, Sustainable architecture, definitions and concepts, Building sustainability model.

1. INTRODUCTION

Building construction has important role in sustainable development, it is not only due to participation in national economy, but it is due to the fact that constructed environment has great influence on life quality, comfort, security, health, etc.

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Construction, maintenance and updating of constructed environment have potential effects on environment, and buildings consume most of unrecoverable resources and create great amount of waste, and buildings create half of the total carbon dioxide .[1] The current building construction challenge is creating economical buildings that increase life quality while reducing social, economical and environmental effects.[1] Achieving sustainability in architecture and construction is the goal emphasized more these days. There are many theoretical basics but some of them are not practical. Vernacular architecture due to some of characteristics has many sustainability aspects, but Architecture without sustainability as a serious challenge appeared after industrial revolution. The technology and its achievements are mainly considered, and architecture converts from "part of environment" to "separate from environment". So, architecture destroys environment and it would be changing and also noneconomic without adequate qualities. [2] In result, new solutions should be proposed to benefit from technology in addition to interaction with environment.in this regard, sustainability approach presented and defined in building and architecture sector to improve these challenges.

2. DEFINITIONS AND CONCEPTS OF SUSTAINABILITY

2.1- Sustainability and sustainable development

Several attempts have been made to describe sustainability concept. Sustainable development defines in any words and from different point of views. Sustainable development is about ensuring a better quality of life for everyone, now and for generations to come. This requires meeting four key objectives at the same time in the world as a whole: [3]

- Social progress which recognizes the needs of everyone;
- Effective protection of the environment;
- Prudent use of natural resources:
- Maintenance of high and stable levels of economic growth and employment.

The main idea of sustainability is to concentrate on environmental conditions to achieve a designed product with maximum internal attributes of environment so that it can minimize the undesirable aspects of these constructions. Buildings must reply to environment from design stage and settling when they are to decrease confronting with nature. [3] Figure 1 presents another concept of sustainability principles. In table 2 some of definitions about sustainability and sustainable development are presented.





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Table 2- selected concepts of sustainability

1	Sustainability	the concept of sustainability to be used in the corporate	Cooper (2002)	[4]
		community, developing the principle of triple bottom line. Triple bottom line refers to the three prongs of social, environmental and financial performance, which are directly tied to the concept and goal of sustainable development. They are highly interrelated and are of equal importance	(2002)	
2	Sustainability	Sustainability as a three-legged stool, with a leg each representing ecosystem, economy and society. Any leg missing from the 'sustainability stool' will cause instability because society, the economy and the ecosystem are intricately linked together.	Young (1997)	[4]
3	Sustainable development	" Requires meeting the basic needs of all people and extending opportunities for economic and social advancement. Finally, the term also implies the capacity of development projects to endure organizationally and financially. A development initiative is considered sustainable if, in addition	Bread for the World, 1993.	[5]
		to protecting the environment and creating opportunity, it is able to carry out activities and generate its own financial resources after donor contributions have run out."		
4	Sustainable development	"[uses] natural renewable resources in a manner that does not eliminate or degrade them or otherwise demise their renewable usefulness for future generations while maintaining effectively constant or non-declining stocks of natural resources such as soil, groundwater, and biomass.	Guide to the Global Environ ment, 1992.	[5]
5	Sustainable development	"[is based on the premise that] current decisions should not impair the prospects for maintaining or improving future living standards This implies that our economic systems should be managed so that we live off the dividend of our resources, maintaining and improving the asset base.	R. Repetto, 1986.	[5]
7	Sustainable development	" Is the search and the carrying out of rational strategies that allow society to manage, in equilibrium and perpetuity, its interaction with the natural system such that society, as a whole, benefits and the natural system keeps a level that permits its recuperation."	San Jose, 1993.	[5]





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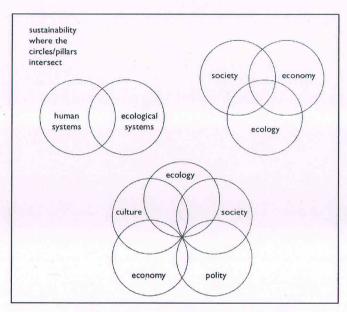


Figure1- pillar concepts of sustainability [6]

2.2- Sustainable Design and Architecture

In recent years, there has been an increasing amount of literature on sustainable building and architecture. The main idea of sustainability is to concentrate on environmental conditions to achieve a designed product with maximum internal attributes of environment so that it can minimize the undesirable aspects of these constructions. Buildings must reply to environment from design stage and settling when they are to decrease confronting with nature. The aims of sustainability in environmental design as follows: [3]

- Maximizing the human comfort
- Efficient planning
- Design for change
- Minimizing waste of spaces
- Minimizing construction expenses
- Minimizing buildings maintenance expenses
- Protecting (keeping) and improving natural values

Sustainability in architecture is referred to imagination of design and construction for future. Sustainability not only aimed at physical Sustainability, but also sustaining and protection of earth and its energy resources. Sustainable architecture is integrating two aims include technology and human's aims. International Council of Building (CIB)



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in 1994 defined the purpose of sustainable architecture creating and innovate an artificial healthy environment based on ecologic design and resources efficiency. A sustainable building is a building with the lowest inadaptability with artificial and natural environment and it is including the building itself, surrounding environment, regional and global environment. [7, 8]

In general and comprehensive definition, sustainable architecture is: sustainable architecture is an architecture replying and interacting with environmental and local conditions and it is trying to apply contexts ecological abilities to create desirable environmental conditions; consequently, it is ecological equilibrium means it has minimum damages on ecology in addition to its flexibility, adaptability and continuity to changes and needs, and it is distinctive since it has some local attributes." [3,9]

2.3- Sustainable Construction

Sustainable construction is defined as "the creation and responsible management of a healthy built environment based on resource efficient and ecological principles". [5] The OECD project has identified five objectives for sustainable buildings: [5]

- Resource Efficiency
- Energy Efficiency (including Greenhouse Gas Emissions Reduction)
- Pollution Prevention (including Indoor Air Quality and Noise Abatement)
- Harmonization with Environment (including Environmental Assessment)
- Integrated and Systemic Approaches (including Environmental Management System)

To sum up, in table 4 some selected definitions about sustainable construction and building are shown.

Table 4- selected definitions of sustainable buildings and construction

1	Sustainable construction	Sustainable construction refers to construction activities whose negative impacts are minimized and positive impacts		[10]
	(SC)	maximized so as to achieve a balance in terms of environmental, economic and social performance.		
2	Sustainable construction (SC)	A high-performance property that considers and reduces its impact on the environment and human health	Yudelson 2008	[10]
3	Sustainable construction (SC)	Healthy facilities designed and built in a resource- efficient manner, using ecologically based principles	Kibert 2008	[10]
4	Sustainable building	"Sustainable building" can be defined as those buildings that have minimum adverse impacts on the built and natural environment, in terms of the buildings themselves, their immediate surroundings and the broader regional and global	OECD Project	[6]





Preva De setting. "Sustainable building" may be defined as building practices, which strive for integral quality (including economic, social and environmental performance) in a very broad way. Thus, the rational use of natural resources and appropriate management of the building stock will contribute to saving scarce resources, reducing energy consumption (energy conservation), and improving environmental quality.

3 MATERIALS AND METHODS

In recent years, there has been an increasing interest in sustainability in construction industry, especially in developing countries, however the major problem with construction is sustainability. In this regard the aim of this paper is to review and study recent researches into subject of sustainability in the field of construction and architecture. Previous studies of sustainability in construction industry have not deal with practical attributes and guides for developing countries, also researchers often have not treated attributes of sustainable building and architecture in detail.

This paper follows review of resources with in-depth analyses of concepts and summarizing and concluding data to reach a model for sustainability in construction field. In this study by review and studying definitions and concepts of sustainability in building and architecture, a comprehensive definition fulfilled, also aspects and main categories of sustainability in architecture and building are presented.

4 SUSTAINABLE BUILDING INDICATORS AND MODEL

Achieving sustainability in architecture and construction is the goal emphasized more these days. There are many theoretical basics but some of them are not practical.

Perception and interpretation of building's sustainable development have been changed in recent years. At first the important point was emphasis on resources limitation namely energy and the method for reduction of its impact on natural environment. In the past decade, the emphasis was on technical issues of building and construction such as materials, building parts and components, construction techniques and energy. Today, most of non-technical issues were taken into consideration and economical issues and social development were raised as sustainable development indices.[11] Thus, using some solutions such as selection of good construction materials and applying new building engineering systems (such as industrial production and prefabricated systems), environmental goals and sustainable development in the industry of building are pursued.

Optimized use of construction materials, making the consumption of raw material minimum and recovering them, building industrialized production and maintaining





building by minimum costs are factors which influence on achieving sustainable development in building industry.[12]

One of the most important aspects of sustainable development goals in constructed environment is adaptability with social, economical, and environmental conditions and one of its important characteristics is efficient planning, facilitation of adaptation and changeability, and design for change, reducing costs, protection and improving natural and environmental values [3].

Sustainability aspects in the building are categorized in four groups of environmental, social, economical and technical issues. In fig2 some of the main issues in sustainability are presented.

As result, Sustainable development objectives are as below and all indicators must be toward them:

- Increasing the asset and economic
- Reducing the impact and increasing
- increasing the social usefulness
- Increasing the quality and optimization

In each group some of general indicators are shown. The mentioned characteristics are some items consistent with sustainability principles and goals and they are effective in fulfilling these goals, so the model of parameters of building sustainability presented in figure 3.

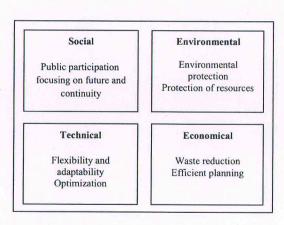


Fig2. The main issues in sustainability





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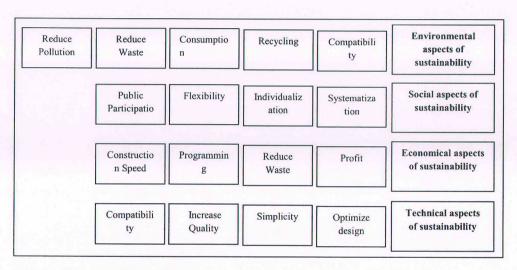


Fig3. Building sustainability model

5 CONCLUSION

The purpose of the current study was to determine the main attributes of sustainability in the field of construction, and make a comprehensive definition of sustainability in this field. As conclusion, the model of sustainable building (fig3) summarize in four categories that main and essential aims in each one are presented. Generally, features of sustainable building are connected with four major objectives in social, economic, technical, technological, environmental groups and these four objectives include enhancing the finance and economic savings, reducing the impact on environment and increasing the compatibility with environment, increasing the social efficiency and usefulness, enhancing the quality, and optimizing the building. This model generally indicates and proposes features which building should have in order to achieve sustainability.

This result is in agreement with previous researches and further support the idea of sustainability in construction field but indicate practical and detailed indicators, so attempts to draw a guideline to application of choices toward sustainability. However, more research on this topic needs to be undertaken in case studies and practical solutions must be designed for developing countries.





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ACKNOWLEDGEMENT

This paper is based on PhD theses in architecture entitled "Industrialization Approach In Connection With Environmental Sustainability in Contemporary Housing Design & Construction" developing under supervision of Dr. Hossein Zabihi and consultation of Dr. Farah Habib in department of Art and Architecture, science and research branch, Islamic Azad University, Tehran, Iran.

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School of Art and Architecture - Sushant University

Odd Semester (Aug-Dec) 2024-25

Individual Assignment

Program: B.Arch.

Course Name: Allied Field 3

Faculty: Dr. Purva Mujumdar Submission Deadline: 18.09,2024 Sem: 5

Course Code: 21BAR6AL31S

Maximum Marks: 20

Course Outcomes

CO1: Understand the role of materials in the Building sector and other disciplines.

CO2: Determine embodied energy and carbon content of buildings.

CO3: Explore performance rating of green buildings and zero energy building.

Assignment:

Q.1 (CO1) Prepare a review report on types of traditional building materials, their sources, carbon content and their sustainable alternatives explored so far.

- 1. It is a complete research based assignment through latest articles, journals and similar studies.
- 2. Sources of all the information need to be mentioned in the report.
- 3. Relevant data, tables and figures should also be included in the report.





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SAMPLE ASSIGNMENT

Life Cycle Assessment of Construction Materials: Past vs. Present

Aim

The aim is to analyze the life cycle assessment of past and present construction materials, examining the shift in embodied and operational energy values, environmental impacts, and efforts to achieve sustainability in future construction practices.

Introduction

Construction practices have evolved significantly from using natural, locally sourced materials to highly processed and manufactured ones. These changes have affected the environmental impact and sustainability of the built environment. The life cycle assessment (LCA) of construction materials is a method used to quantify the environmental impacts of a building from raw material extraction to end-of-life disposal. This paper aims to compare the life cycle of materials used in traditional and modern buildings, focusing on embodied energy and operational energy, two key factors in sustainable building design.

Definitions

- 1. **Embodied Energy**: Embodied energy encompasses all the energy used in the extraction, manufacturing, transportation, and assembly of building materials. It is often quantified in terms of megajoules (MJ) or kilowatt-hours (kWh) per unit of material (e.g., kg).
- 2. **Operational Energy**: Operational energy is the energy consumed during a building's functional life. This includes energy for heating, cooling, ventilation, lighting, and equipment operation. Operational energy is typically measured annually and can vary widely based on building design, usage patterns, and energy sources.
- 3. **Assessing Embodied Energy:** involves evaluating the total energy consumed throughout the life cycle of a building material, from raw material extraction to manufacturing, transportation, installation, use, maintenance, and disposal. This assessment is crucial for understanding the environmental impact of construction materials and making sustainable choices in building design.

1. Understanding Life Cycle Assessment (LCA)

Life cycle assessment is a comprehensive analysis of the environmental impacts associated with all stages of a product's life cycle, from raw material extraction (cradle) to end-of-life disposal (grave). For construction materials, the LCA covers several phases:

- 1. Raw Material Extraction: Includes energy consumption and environmental damage during extraction, such as mining for metals or harvesting timber.
- 2. **Manufacturing and Production**: Energy required for converting raw materials into usable building components.
- 3. Transportation: Energy used to move materials from production sites to the construction site.
- 4. **Construction**: Energy consumed during the actual construction process, including the use of heavy machinery.
- 5. **Use and Maintenance**: Energy required for heating, cooling, and maintaining the building during its operational life.

6. End-of-Life: Involves energy for demolition, recycling, or disposal.

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This assessment helps designers and engineers make informed decisions about material selection, aiming to minimize both embodied and operational energy, thereby reducing the building's overall carbon footprint.

2. Life Cycle of Traditional Construction Materials

Traditional materials include mud, stone, timber, clay bricks, and lime, which were widely used in rural and historical buildings in India and other parts of the world.

2.1 Embodied Energy of Traditional Materials

The embodied energy of traditional construction materials encompasses the total energy required for extraction, processing, and transportation of natural building components like mud, stone, timber, lime, thatch, straw, and various forms of bricks. These materials generally exhibit much lower embodied energy compared to modern materials due to their minimal processing and reliance on local resources. For instance, materials like mud and adobe bricks require little to no energy for additional processing, while straw and thatch are simply cut, dried, and used directly for construction without needing complex manufacturing steps. Stone, which is often utilized in its natural form, necessitates only basic extraction and shaping, making it an energy-efficient choice. Timber, though having a higher embodied energy based on drying and transportation, remains a sustainable option when sourced locally. Lime plaster involves some energy costs from calcination. Fired bricks, while more durable, have a considerably higher embodied energy due to the energy-intensive kiln firing process.

The table below summarizes the embodied energy characteristics of these traditional materials:

Material	Embodied Energy (MJ/kg)	Key Characteristics
Mud/Adobe	0.3 - 0.5	Sun-dried, no firing required, locally sourced
Stone	0.85	Minimal shaping needed, mainly used in raw form
Timber	8.5	Requires drying and transport, varies by source location
Lime Plaster	1.1	Involves calcination
Thatch/Straw	0.2	Cut, dried, and directly used, no additional processing
Sun-Dried Bricks	0.3 - 0.5	Naturally dried, no kiln firing
Fired Bricks	3	Energy-intensive kiln firing

The low values of embodied energy associated with these materials can be attributed to several factors:

- Minimal Processing: Traditional materials like mud, thatch, and straw require little to no energyintensive processing, relying instead on natural drying or simple harvesting methods. This significantly reduces their overall energy consumption.
- Local Sourcing: Many traditional materials can be sourced locally, minimizing transportation energy.
 For example, mud and straw are often found in close proximity to building sites, which further lowers their embodied energy.
- Natural Characteristics: Materials such as stone and timber possess natural structural properties that require less modification and energy for shaping or treatment compared to modern materials that often undergo extensive industrial processes.
- Simplicity of Production: The methods used for creating traditional materials, such as sun-drying bricks, do not require the high energy inputs typical of modern manufacturing techniques, such as firing bricks in kilns or producing concrete.

2.2 Operational Energy and Environmental Impact

Traditional buildings often have thick walls made of high thermal mass materials, which naturally regulate indoor temperatures, reducing the need for mechanical heating or cooling systems. This passive approach results in minimal operational energy consumption. Furthermore, these materials are locally sourced and biodegradable, leading to a low carbon footprint and minimal environmental impact.

2.3 End-of-Life Considerations

Traditional materials can be easily reintegrated into the environment. For instance, mud walls decompose and return to the soil, while stone and timber can be reused or repurposed without generating significant waste. This end-of-life scenario ensures that traditional materials have a circular life cycle, contributing to sustainable construction practices.

3. Life Cycle of Modern Construction Materials

Modern construction relies on materials like reinforced concrete, steel, glass, synthetic insulation, and advanced composites. These materials offer structural strength and versatility but come with a high environmental cost.

3.1 Embodied Energy of Modern Materials

The embodied energy of modern construction materials includes the total energy consumed during the extraction, manufacturing, transportation, and installation of materials such as reinforced concrete, steel, glass, and synthetic insulation. Unlike traditional materials, modern materials often require extensive processing and are frequently sourced from various locations, leading to higher embodied energy values. For instance, reinforced concrete is a widely used structural material that has significant energy consumption due to the energy-intensive processes involved in cement production and aggregate processing. Steel, known for its strength and durability, has an even higher embodied energy, largely attributed to the energy-intensive smelting and refining processes required to produce it from iron ore. Glass, commonly used in facades and windows, requires high temperatures to melt silica and form glass products, resulting in substantial embodied energy. Additionally, synthetic insulation materials, while effective for energy efficiency, have varying embodied energy values depending on the type and manufacturing process.

The table below summarizes the embodied energy characteristics of key modern materials:

Material	Embodied Energy (MJ/kg)	Key Characteristics
Reinforced Concrete	1.1 -1.5	Widely used for structures, high energy in cement production
Steel	20 – 25	Very strong, energy-intensive smelting and refining
Glass	28	High energy for melting silica at extreme temperatures
Synthetic Insulation	16.8 – 28	Commonly used for thermal performance, varies by type





The high values of embodied energy associated with these materials can be explained by several factors:

- Energy-Intensive Manufacturing: Modern materials often require complex manufacturing processes
 that consume large amounts of energy. For example, the production of cement involves heating
 limestone to high temperatures, which releases significant amounts of CO2 and consumes fossil
 fuels.
- Transporting Raw Materials: Many modern materials are sourced from multiple locations, leading to
 increased transportation energy costs. For instance, steel production often involves transporting iron
 ore from mines to smelters, while glass may require silica from different geographic areas.
- Advanced Processing Techniques: Materials like glass and synthetic insulation undergo advanced processing techniques that require significant energy inputs. The melting of silica for glass production, for example, demands extremely high temperatures, further contributing to its embodied energy.
- Use of Non-Renewable Resources: Many modern materials are derived from non-renewable resources, which not only increases their embodied energy but also raises concerns about resource depletion and sustainability.

3.2 Operational Energy and Environmental Impact

Urban buildings constructed with modern materials often feature large glass façades and rely on active heating, ventilation, and air-conditioning (HVAC) systems. These systems consume large amounts of energy, especially in hot climates like urban India, leading to high operational energy costs. However, advancements in insulation and energy-efficient systems can mitigate some of these impacts.

3.3 End-of-Life Considerations

Modern materials present significant end-of-life challenges. Concrete, steel, and glass require energy-intensive demolition processes, and the resulting waste is often non-biodegradable. While steel and some glass can be recycled, the energy required to do so is substantial. Moreover, composite materials and synthetic insulations are often non-recyclable, ending up in landfills and contributing to environmental degradation.

4. Comparative Analysis of Rural and Urban Construction in India

The connection between traditional construction materials and rural areas of India is deeply rooted in the region's cultural and environmental contexts. In rural settings, materials such as mud, thatch, and bamboo are commonly used, reflecting a vernacular approach that prioritizes local resources and low embodied energy. These materials are well-suited to the climatic conditions of rural India as well the past, providing thermal comfort and resilience. In contrast, modern materials like reinforced concrete, steel, and glass dominate urban construction, driven by the demands of rapid urbanization and the need for durability and aesthetic appeal in densely populated areas. This shift towards modern materials in urban India often leads to higher energy consumption and environmental impacts, emphasizing the need for a balance between traditional and contemporary practices to promote sustainability in both settings. This dynamic highlights the importance of adapting building methods to local contexts while considering the environmental implications of material choices.

Embodied and Operational Energy of Materials: Past vs. Present

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Material	Time Period	Embodied Energy (MJ/kg)	Operational Energy
Adobe/Clay Brick	Past	0.3-0.5	Low: Used passive cooling, minimal heating needs due to thermal mass properties
Concrete (Old)	20th Century	1.1	Medium: Dependent on external heating/cooling systems
Concrete (Present)	Present	1.5	Medium: Often includes insulation improvements for reduced operational energy
Wood (Traditional)	Past	8.5	Low: Good insulation properties, minimizing heating/cooling requirements
Modern Timber	Present	12 (e.g., Glulam)	Low: Similar to past but enhanced insulation reduces energy usage further
Steel	Past	20-25	High: No inherent insulation, relies on active systems for temperature control
Modern Steel	Present	20.1 (recycled)	High: Often requires extensive HVAC systems, contributing to high operational energy
Stone/Marble	Past	2	Low: Good thermal properties, used passively for heating/cooling
Modern Glass	Present	28	High: Transparent, needs active systems for temperature regulation
Insulation (Rockwool)	Present	16.8	Very Low: Reduces operational energy significantly due to high R-values
Aerated Blocks	Present	3.5	Low: High thermal efficiency, leading to reduced operational energy costs

Embodied Energy: Historically, natural materials like adobe, timber, and stone had low embodied energy. Modern materials, especially those that are heavily processed (e.g., concrete, steel, and glass), have higher embodied energy due to the energy-intensive manufacturing processes.

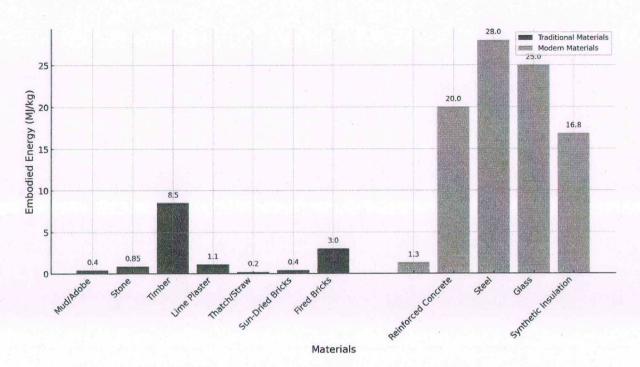
Operational Energy: Traditional materials often had better passive thermal properties, reducing the need for heating or cooling. In contrast, modern materials sometimes require active systems (HVAC), leading to higher operational energy. However, advancements in insulation have reduced operational energy in modern buildings.

Shifts in Energy Usage: The shift from low-embodied-energy materials to high-embodied-energy ones like concrete and steel has increased the environmental impact of modern construction. But, with better insulation and energy-efficient design, operational energy requirements can be significantly lower today.

Sustainability Considerations: Embodied energy is now a crue all consideration in sustainable design, with a focus on using materials like recycled steel or low-carbon concrete to reduce the overall carbon footprint.

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5. Conclusion



The change in energy values and material patterns is primarily due to the evolving needs of construction, driven by urbanization and rapid population growth, which demanded stronger and faster-building solutions. As a result, traditional low-energy materials were replaced by modern materials like concrete and steel, which, although offering durability and scalability, required energy-intensive manufacturing processes, leading to a spike in embodied energy values. Over time, the push for sustainability and innovation has focused on reducing these high energy values through recycling, green manufacturing techniques, and improved efficiency, reflecting a gradual shift back towards eco-friendly practices.

Thus, while the transition from traditional to modern materials has resulted in greater environmental impact, the evolving emphasis on sustainability is driving efforts to minimize energy consumption and environmental damage, ensuring that future building materials are both advanced and ecologically responsible.

Understanding and analyzing both embodied and operational energy is essential for achieving sustainability in the building sector. By conducting life cycle assessments, stakeholders can make informed decisions that minimize energy consumption and reduce environmental impacts. Future research should focus on developing innovative materials and construction methods that lower both embodied and operational energy, promoting a holistic approach to sustainable building practices.

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Annexure IV

School of Art and Architecture - Sushant University

Odd Semester (Aug - Dec) 2024-25

Course Title: Allied Fields 3

Semester: 5

Course Code: 21BAR6AL31S

Course Faculty: Dr. Purva Mujumdar

Programme: B.Arch.

RESULT

Sr. No.	Name of the Student	Marks Obtained (Out of 20)
1	Chirag Yadav	11
2	Rongsennukla Yaden	18
3	Annanya Bindal	10
4	Ishita Gupta	16
5	Simran thakran	17
6	Manaj Baweja	12
7	Amritam Gupta	0
8	Abeer Bhasin	0
9	Naveen Chauhan	0
10	Raghav Sethi	0
11	Dhruv Dogra	0
12	Aarushi Agrawal	11
13	Harshita Dang	15
14	Ronnit Garg	11
15	Rudra Pratap Singh	10
16	Rushil Soni	12
17	Shriya Khurana	14
18	Sudevi Gayen	16
19	Shweta Sharma	12

Signature of Course Coordinator/Faculty

Programme Coordinator

Dean



ANNEXURE-I

School of Art and Architecture - Sushant University

Academic session: Odd Sem - 2024-25

Course Title: Allied Field 3

Semester: 5

Course Code: 21BAR6AL31S

Course Faculty: Dr. Purva Mujumdar

Programme: B. Arch.

Sir/Madam,

Following students mentioned in the list are identified as Slow learner/Advanced learner based on guidelines issued by IQAC after first assessment (assignment/quiz).

S.No	Name of the student	Roll No	Slow learner/Advanced learner	
1	Amritam Gupta	220BARCH022	Slow Learner	
2	Abeer Bhasin	220BARCH036	Slow Learner	
3	Naveen Chauhan	220BARCH048	Slow Learner	
4	Raghav Sethi	220BARCH054	Slow Learner	
5	Dhruv Dogra	220BARCH062	Slow Learner	
6	Rongsenukkala Yaden	220BARCH046	Advanced Learner	
7	Simran Thakran	220BARCH008	Advanced Learner	

Signature of Course Coordinator/Faculty

Programme Coordinator

Dean Huslikul



SCHOOL OF ART AND ARCHITECTURE- SUSHANT UNIVERSITY

ATTENDANCE SHEET - SLOW LEARNER

REMEDIAL CLASSES SCHEDULE CUM ATTENANCE SHEET FOR SLOW LEARNERS

Academic Session: Odd Semester -2024-25

B.Arch. Program/Batch:

21BAR6AL31S Allied Fields 3 Course Code: Course Title:

Semester:

Dr. Purva Mujumdar 3.09.2024 Faculty Name: Date:

	<u> </u>			=	6		12
	Remarks (Outcome)		Activity	Stone	atta de		
Date:	Time:	Student Signature		1	1	1	1
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Date: 10.09.2024	Time: 4-5 PM	Student Signature	first	There	المرابع	(month)	10
Date: 9.09.2024	Time: 4-5 PM	Student Signature	John John John John John John John John	Afre	went)	(most	
	Student name		Amritam Gupta	Abeer Bhasin	Naveen Chauhan	Raghav Sethi	Dhruv Dogra
	Enrollment No.		220BARCH022	220BARCH036	220BARCH048	220BARCH054	220BARCH062
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Annexure IV

RESULT - POST REMEDIAL

School of Art and Architecture - Sushant University

Odd Semester (Aug - Dec) 2024-25

Course Title: Allied Fields 3

Semester: 5

Course Code: 21BAR6AL31S

Course Faculty: Dr. Purva Mujumdar

Programme: B.Arch.

RESULT SHEET

Sr. No.	Name of the Student	Marks Obtained (Out of 20)
1	Chirag Yadav	11
2	Rongsennukla Yaden	18
3	Annanya Bindal	10
4	Ishita Gupta	16
5	Simran thakran	17
6	Manaj Baweja	12
7	Amritam Gupta	0
8	Abeer Bhasin	0
9	Naveen Chauhan	0
10	Raghav Sethi	10
11	Dhruv Dogra	0
12	Aarushi Agrawal	11
13	Harshita Dang	15
14	Ronnit Garg	11
15	Rudra Pratap Singh	10
16	Rushil Soni	12
17	Shriya Khurana	14
18	Sudevi Gayen	16
19	Shweta Sharma	12

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Signature of Course Coordinator/Faculty

Programme Coordinator

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Traditional Building Materials, Their Sources, SLOW **Carbon Content, and Sustainable Alternatives**

ASSIGNMENT-1

RAGHAV SETHI 220BARCH054

1. Introduction -Building materials have historically played a significant role in architecture, construction, and cultural expression. Traditional materials such as wood, stone, clay, and metals were primarily sourced locally, driven by regional availability. However, the environmental impact of these materials, particularly their carbon footprint, has become a critical concern in modern construction practices. This report explores common traditional building materials, their sources, associated carbon content, and potential sustainable alternatives that can contribute to reducing environmental impact.



- Brick
- Timber
- Slate
- Lead
- Mud!
- Plaster (gypsum)









- 2. Traditional Building Materials
- a. Wood

Furce: Wood is a natural material derived from trees. It has been widely used for construction, especially in housing, furniture, and structural elements. Different types of wood, such as hardwood (oak, maple) and softwood (pine, spruce), offer varying properties like durability and workability. Carbon Content: Wood is a carbon-sequestering material, meaning it stores carbon dioxide absorbed by trees during their growth. However, its carbon footprint is affected by factors like deforestation, transportation, and energy used in processing. If sourced sustainably, it can have a relatively low carbon footprint compared to other materials.

Sustainable Alternative: Sustainable timber, harvested under certified forest management practices (e.g., FSC certification), and engineered wood products like cross-laminated timber (CLT) are alternatives that enhance sustainability.



b. Stone

Source: Stone has been used for centuries in construction, ranging from granite and marble to limestone and sandstone. It is quarried from natural rock formations and is highly durable and fire-resistant.

Carbon Content: Stone itself does not release significant carbon dioxide during its use. However, quarrying, cutting, and transportation are energy-intensive processes that contribute to its carbon footprint. The environmental impact also varies based on the distance it is transported from its source to construction sites.

Sustainable Alternative: Reclaimed stone and local sourcing can reduce transportation emissions. Additionally, using less energy-intensive materials such as stabilized earth blocks can serve as alternatives in some applications.



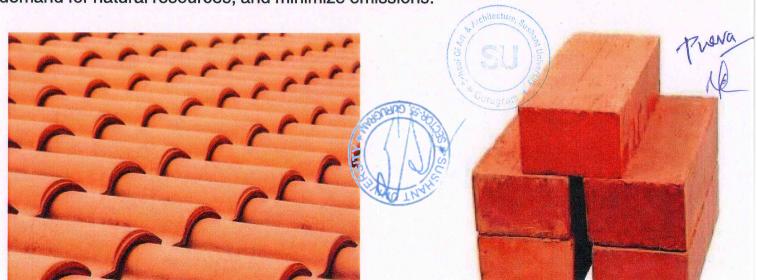


Clay (Bricks and Tiles)

Source: Clay is a naturally occurring material that has been extensively used for making bricks and roofing tiles. It is extracted from soil and baked at high temperatures to achieve durability and strength.

Carbon Content: The process of firing clay to make bricks is energy-intensive and generates gnificant carbon emissions. The production of clay-based materials also involves land disturbance due to mining.

Sustainable Alternative: Fly ash bricks, compressed earth blocks (CEBs), and rammed earth offer sustainable alternatives. These materials use less energy during production, reduce the demand for natural resources, and minimize emissions.



. Concrete

Source: Concrete is made from a mixture of cement, sand, gravel, and water. It is one of the most widely used construction materials due to its strength and versatility. Carbon Content: Cement production, a key ingredient in concrete, is one of the largest single contributors to global carbon emissions. The process involves the release of large amounts of CO2 from the calcination of limestone and the energy-intensive nature of kilns. Sustainable Alternative: Green concrete, which incorporates industrial waste products like fly ash, slag, and recycled aggregates, can reduce the carbon footprint of traditional concrete. Additionally, using geopolymer concrete, which substitutes cement with materials like fly ash and slag, can drastically cut emissions.





e. Metals (Steel and Aluminum)

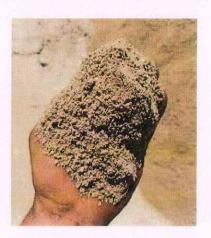
Source: Metals like steel and aluminum are heavily used in construction for structural support, cladding, and roofing. Steel is produced from iron ore, while aluminum is derived from bauxite ore.

Carbon Content: The extraction and processing of metals are highly energy-intensive and result in substantial carbon emissions. Steel production accounts for around 7-9% of global carbon emissions, while aluminum production is similarly carbon-heavy due to the high energy required for smelting.

Sustainable Alternative: Recycled steel and aluminum have a lower carbon footprint as they reduce the need for new raw materials and energy-intensive production. Advances in green steel technologies, including the use of hydrogen-based processes, aim to decarbonize the industry.

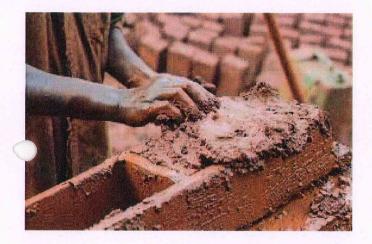


Lime and Gypsum: Both materials are essential for finishing processes like plastering. Lime is known for its slow hardening and significant volume shrinkage, while gypsum offers strong moisture absorption properties and ease of manipulation in construction





- Raw Earth Materials: Such as mud, are particularly popular in non-urbanized areas of India, East Africa, and South America, where earth remains an abundant and cost-effective building resourceS
- . Ice: In Arctic regions, ice is historically used to construct igloos, highlighting the adaptability of building materials based on regional climate











- 4. Sustainable Alternatives to Traditional Building Materials Emerging sustainable alternatives present viable solutions to reduce the environmental impact of traditional materials.
- Bamboo: A rapidly renewable resource, bamboo has a low carbon footprint and exhibits extraordinary tensile strength, making it an excellent candidate for construction.
- Hempcrete: Made from hemp, lime, and water, this material is energy-efficient and offers low carbon emissions during production. Its insulation properties make it favourable for modern sustainable constructions.
- Recycled Steel: Sourcing steel from recycled materials significantly decreases emissions associated with new steel production. It is durable and can be endlessly recycled without compromising its properties.
- Rammed Earth: Utilizing local soil, rammed earth construction utilizes minimal energy for production and provides a high thermal mass, ensuring energy efficiency in buildings.
- Reclaimed Wood: Using previously used wood decreases the demand for new wood and minimizes waste, contributing positively to the ecological balance. It is favoured for its unique aesthetics and historical significance.
- Other Materials: Emerging materials such as bio composite cement made from algae and mycelium processed into structural elements are being explored for their low environmental footprints and sustainability

The environmental impact of traditional building materials, particularly their carbon content, is a ajor factor in the ongoing efforts toward more sustainable construction practices. Sustainable alternatives such as recycled materials, low-carbon manufacturing processes, and energy-efficient innovations are crucial in reducing the carbon footprint of the construction industry. By adopting these alternatives, the industry can move towards more eco-friendly and carbon-neutral buildings, which will contribute to combating climate change and resource depletion.







SCHOOL OF ART AND ARCHITECTURE- SUSHANT UNIVERSITY

LIST OF ADVANCED LEARNERS

Program/Batch: B.Arch.

Course Code: 21BAR6AL31S

Course Title: Allied Field 3

Academic Session: ODD-2024-25 Semester: 5 Faculty Name: Dr. Purva Mujumdar

Acuvilles dolle 10 illotivate AD valveed learners	Student name	Enrollment No.	S.no
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Asked to participate in Solar Decathlon India Competition Asked to participate in Solar Decathlon India Competition myimmaen Rongsenukkala Yaden Simran Thakran - Mary 220BARCH046 220BARCH088 Faculty Signature:



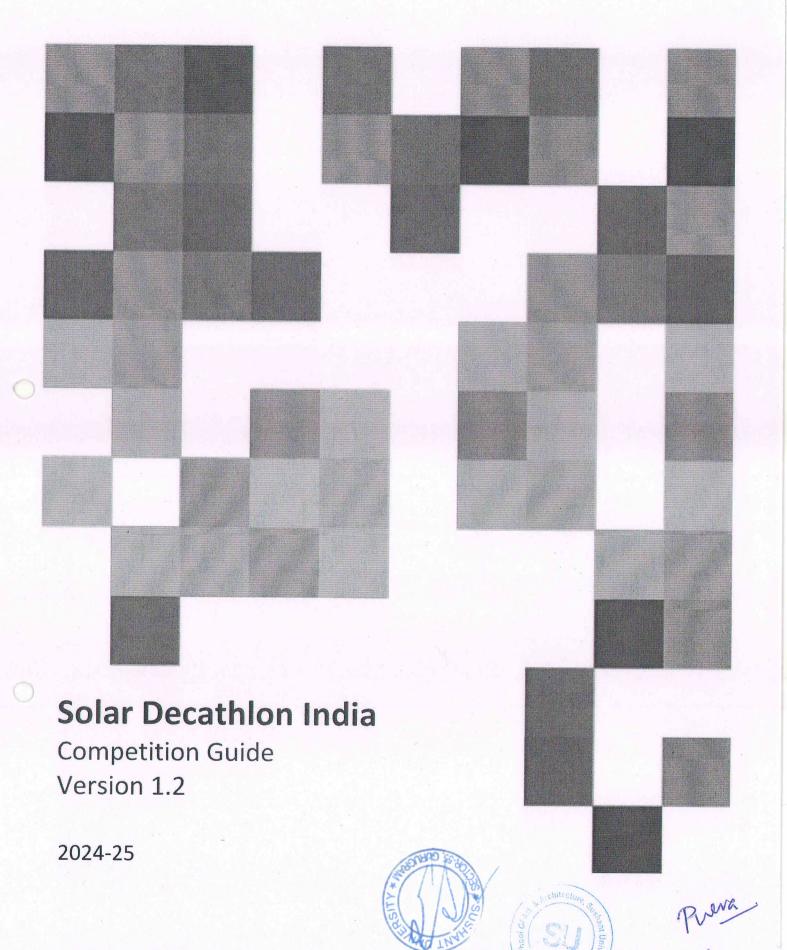










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This is a guidance document for the participants of the Solar Decathlon India (SDI) 2024-25 Net Zero Building Challenge. It contains information about the competition divisions, ten contests, resources made available to the participating teams, requirements, and rules for this year's challenge.

SDI invites post-graduate and undergraduate students from Indian institutions to join forces to combat climate change. This is an opportunity for student teams to develop innovative and climate-resilient building solutions, contributing to solving real projects and real problems, and by partnering with industry leaders and professionals. SDI helps students stay a step ahead and introduce innovative, affordable, and market-ready solutions that enable a clean energy transition. This is the resilient and carbon-neutral way forward for sustainable buildings and communities in India. SDI is conducted by the Indian Institute for Human Settlements (IIHS) and the Alliance for an Energy Efficient Economy (AEEE) under the aegis of the Indo-US Science and Technology Forum (IUSSTF).

India is the third-largest carbon emitter, accounting for 7% of global emissions in 2020. Summer temperatures in many cities cross 40°C, and extreme weather events leave large sections of the population vulnerable to climate change risks. Urbanisation and economic growth will lead to 70% more building stock by 2050. India's Nationally Determined Contribution under the Paris Agreement for up to 2030 target a 45% reduction in carbon emissions. Climate resilient net-zero energy buildings (NZEB) are the way forward. To that end, SDI focuses on creating capacity amongst students and creating partnerships with the industry.

SDI provides the platform and resources necessary for students to learn and design net-zero buildings and contribute to a sustainable future. They get hands-on experience in developing solutions for real buildings and learning product innovation.





2. The Challenge

Teams can choose to compete in any one of the Divisions in the 2024-25 Challenge. The 2024-25 Challenge includes 5 Building Divisions and 1 Product Division. The Building Divisions are challenges to design an entire building for a building owner or a developer who acts as a Project Partner. The Product Division is a challenge to design, develop, and test a working prototype as a product solution, with a product, material, or equipment manufacturer acting as an Industry Partner.



Figure 1: Competition Divisions in SDI 2024-25

2.1 Tasks

- Read this Competition Guide thoroughly.
- Form a team (Refer <u>Section 4.6</u> for Building Divisions and <u>Section 5.2</u> for Product Division).
- Register your team.
- Identify a Project Partner/ Industry Partner.
- Ensure that all team members complete all mandatory online learning modules.
- Study the resources provided by SDI.
- Identify additional partnerships for the areas of the competition that need collaboration.
- Check your emails for regular updates and announcements. Consult the <u>SDI website</u> and the <u>FAQ</u> page for more information.
- Design and document your work, in compliance with the requirements listed in this guide, and its subsequent updates.
- Submit all Deliverables before the deadlines.

2.2 Registration and Fees

Team Leads will register their teams on the portal which can be accessed through the SDI website. The registration fee for the 2024-25 Challenge is INR 7,500 (inclusive all taxes) per team, which is non-refundable.

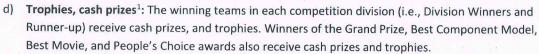
2.3 Benefits

- a) Alumni: Students from teams who submit Deliverable 3 become Alumni of Solar Decathlon India.
 The SDI Alumni Group on LinkedIn frequently lists job openings and other opportunities.
- b) Career development: As part of SDI, students gain real-world industry experience while working alongside project partners and implementing their ideas on live projects. The benefits of this are far-reaching and include developing industry connections, gaining exposure to multiple technologies, and coaching by mentors.
- c) Career fair: SDI conducts a career fair at the Finals event, which gives students from finalist teams access to organisations leading the work on climate action.





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e) **Certificates**: Team members who complete the Self Learning Modules receive a completion certificate. Students from teams who submit Deliverable 3 will receive participation certificate. Finalists, winners and runners-up will also receive certificates.





¹ The relevant Faculty Lead is responsible for distributing any cash prizes. The competition organisers are not responsible once the funds are disbursed to the team. The competition organisers only ask for details for transferring the funds, which must be signed off by the Faculty Lead. Participation does not guarantee any compensation or award.

3. Schedule

Stage 1 of the competition formally begins on 01 September 2024. However, teams that register earlier are welcome to start working before that. Similarly, Stage 2 of the competition formally begins in January 2025. However, teams are encouraged to start working on Stage 2 in December, soon after submitting Deliverable 2.

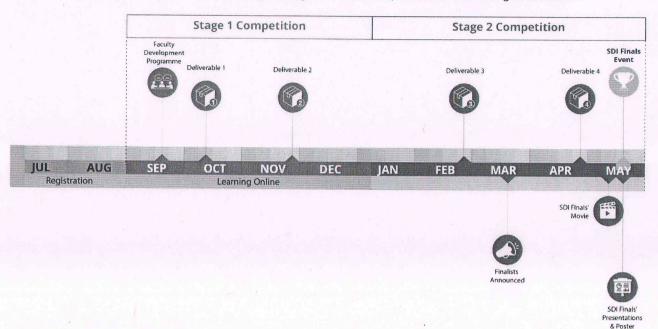


Figure 2: Solar Decathlon India 2024-25 Schedule

3.1 Deliverables and Milestones²

- a) Registration closes at 5 pm on 31 August 2024.
- b) Team name to be finalised by 16 September 2024.
- c) Division and Project Partner to be finalised by 16 September 2024.³
- d) Deliverable 1: Due by 5 pm on 8 October 2024.
- e) Deliverable 2: Due by 5 pm on 26 November 2024.
- f) Team composition finalisation (addition or removal of team member) by 5 pm on 10 January 2025.
- g) Self-learning Modules to be completed by 5 pm on 10 January 2025. *
- h) Deliverable 3: Due by 5 pm on 25 February 2025.
- i) Deliverable 4: Final Design Report: Due by 5 pm on 21 April 2025.
- j) Movie: Due by 5 pm on 8 May 2025.
- k) Division Jury Presentation slides: Due by 5 pm on 19 May 2025.
- l) Grand Jury Presentation slides: Due by 5 pm on 19 May 2025.
- m) Posters: Due by 5 pm on 19 May 2025.

*Note: All team members who do not finish the SLMs before the deadline will be removed from the team. Teams with less than 5 or more than 15 members will be disqualified.

3.2 Events and Other Milestones

a) Faculty Development Programme for Faculty Leads and Faculty Advisors: 18-21 September 2024.





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² All times are in IST.

³ Only applicable to the Building Divisions.

- b) Finalists' Announcement: The finalists' teams of the 2024-25 Challenge will be declared on 12 March 2025. Faculty Leads and Team Leads of all the Finalists' team will be informed via email.
- c) SDI Finals⁴: The selected teams (Finalists) will present their work during the SDI Finals on 23-25 May 2025. Details of the event will be shared with Faculty Leads and Team Leads closer to the event.
- d) **Grand Jury:** Division Winners will present their work in a 5-minute pitch to the Grand Jury on 24 May 2025. Division Winners will be announced on the morning of 24 May 2025.





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⁴ Format, date, and nature of these events are subject to change due to the government regulations or events beyond our control.

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ADVANCED

LEARNER ACTIVITY

PROOF

TRADITIONAL BUILDING MATERIALS AND THEIR CARBON CONTENT ELECTIVE ASSIGNMENT 1

NAME - SIMRAN THAKRAN ROLL NO. - 220BARCH008

INTRODUCTION

Traditional building materials are derived from natural resources and are often used in low-rise, low-density settings. They are often sustainable and environmentally friendly, and can be beneficial to developing countries.

TRADITIONAL BUILDING MATERIALS

Mud

It is the most commonly used material in house construction. Ever since man felt the necessity of a house, mud is widely used. Its main features are as follows.

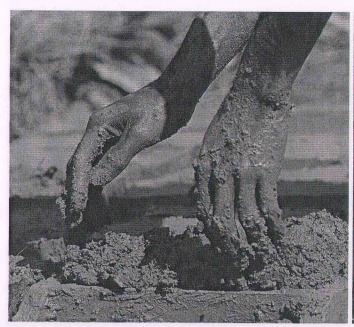
- 1. Abundantly available natural material.
- 2. Cost is cheap.
- 3. Easily made and repaired.
- 4. Sufficiently lasting.
- 5. Maintain equitable temperature both in winter and summer.
- 6. Highly useful for low-income people.

The use of mud mixed with chopped straw and cow dung helps for coating the inner and outer walls of the house. A thin coating of mud and cement maintains the surface in a good condition.





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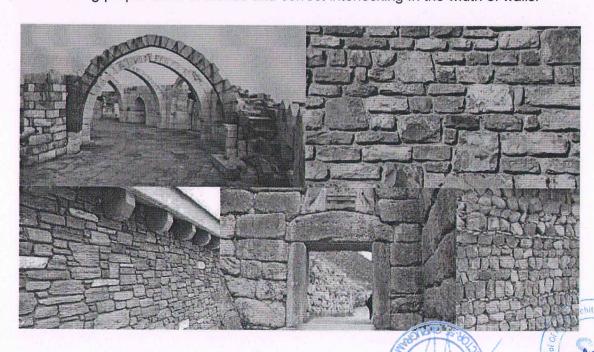




Stone

Stone is a natural material of construction and is obtained from quarries. Since prehistoric days, it has been used for

- Constructing different components of buildings like foundation, walls, lintels, floors, roofs etc.
- The stones used for foundation and walls should be sound and free from cracks and decay.
- Stones of different forms such as granite, marble, slate, sandstone and limestone are commonly used as building materials.
- · Waxing and polishing make them more attractive.
- Gravel which are stones not larger than 2 cm is essentially needed for building. Care should be taken in using proper sizes of stones and correct interlocking In the width of walls.

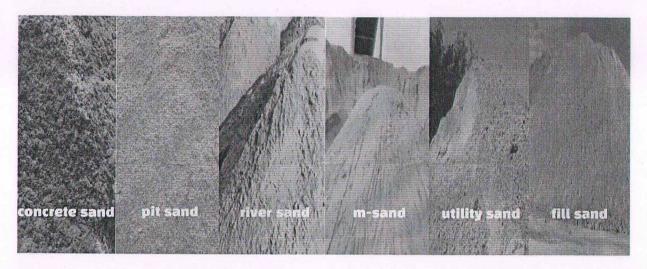


Traditional building materials

Sand

It consists of small grains of silica and is formed by the disintegration of rocks caused by weather. Sand should have the following qualities.

- •It is hard, durable, clean, free from organic matter and does not contain appreciable amount of clay.
- · It does not contain harmful impurities such as iron pyrites, salts,
- · Coal, mica, alkaline or other materials, which will affect hardening.
- This should be coarse, clean, hard, strong, uncoated and free from clay, dust, mica and soft flanky particles such as of shell.
- Crushed stone is also used but it should be free from excessive proportion of very fine particles like dust.
- Sand required for mortar for brick work needs to be sieved through a 3/8 in. Mesh sieve.



Surkhi

- Where sand is not available or is very costly, surkhi is substituted in preparing lime mortar. It generally consists of crushed brickbats. When these are not available in large quantities, round balls of clay are made, burnt into kilns and crushed or ground to fine powder.
- The best surkhi is made of clays containing 10 to 20 % of lime kunkar and this should be under burnt. Clay containing little or no lime must be thoroughly burnt to bring out the excellent quality of surkhi from it.
- Surkhi should not be used in lime mortar for plaster, since it is likely to disintegrate after a time due to destructive agencies of the atmosphere.

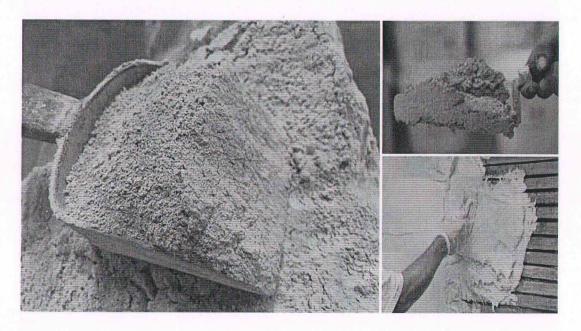


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Lime

- Lime has been used as a cementing material since time immemorial. In India till recently, lime has been extensively used for all types of construction purposes. Big palaces, forts, monuments, temples, bridges that were constructed centuries back and that still exist in good condition substantiate that the use of lime for constructional purposes had reached perfection in the past.
- Lime mortars have some advantageous properties like good workability, plasticity, less shrinkage on drying and durability.
- · Lime is cheaper and easily available, even though cement has replaced the use of lime.



Asbestos

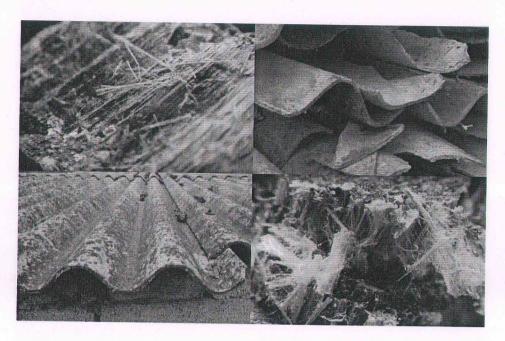
It is available in nature as a mineral in Marwar , Garhwal (Uttar pradesh) and Bhandra in Madhya Pradesh.

- It is silicate of calcium and magnesium found in the form of very thin fibres which are elastic and capable of being woven into fabrics.
- It can withstand high temperatures and acids without any change its used for roof, bathroom doors and partitions.

Traditional building materials

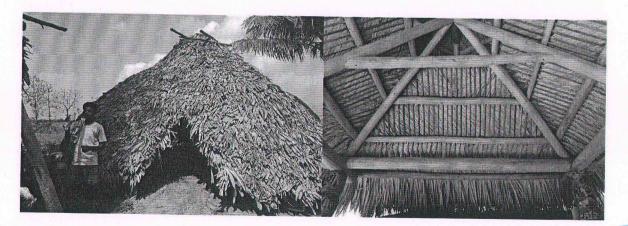
Preva.

 However it is not advisable to use asbestos as a roofing material essentially in our country since they transfer heat.



Leaves

Grass, palm leaves and Palmyra leaves are used for roof structure. They are temporary and highly inflammable.



Wood

It is the nature's most abundant useful building material.

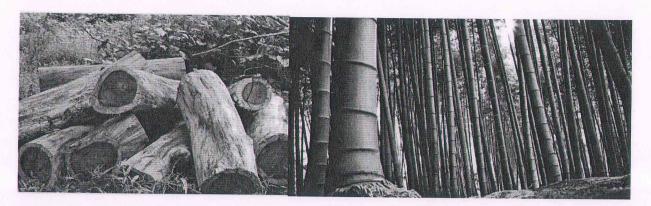
- It is comparatively inexpensive, strong, durable and easy to work with.
- Mainly wood is used for paneling, ceiling, roofing, partitions, doors, windows and for making veneers and plywood.
- Plywood is made of odd number of wood piles or layers laminated with plastic resins under high temperature and pressure.
- It is used for doors, cupboards and decorative paneling.



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Traditional building materials

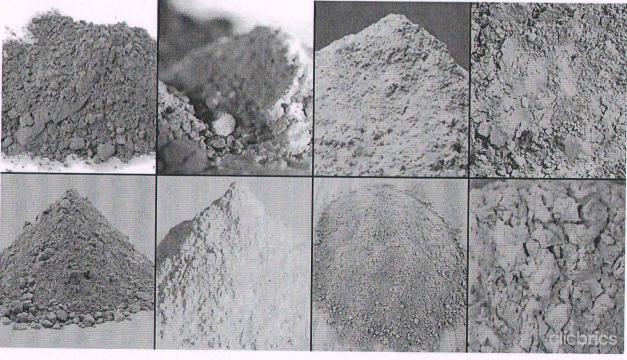
• Deodar, teak, mango, jack, toon, mahogany and bamboo are some of the common Indian timber trees used for building purposes.



Cement

Cement should be used for the purpose of durability and strength of buildings.

- It has the quality to bind together loose particles of gravel, broken stones or other aggregates.
- Its quick setting property, strength and ease with which it can be used under a variety of conditions has revolutionized the concept of construction.
- Hence it has become the most popular cementing material.
- Concrete is a building material made by mixing cement, sand, gravel and water, which becomes rock hard, when dry and set.
- It is fireproof, sturdy and can withstand high pressure.
- Because of these qualities, almost all huge structures are molded by concrete.



Traditional building materials



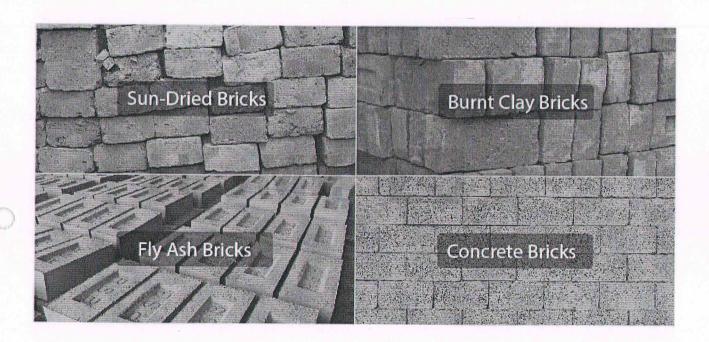


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Brick

The most extensively used construction material because it is locally available, cheap, strong, and durable and it has the good insulating property against heat and sound. It can be moulded to any shape or size. The standard size of bricks is 9" X 4 ½ " X 3" (230 X 115 X 75 mm), though the size varies according to local practice in India. The characteristics of a good brick are that

- It should be so hard that it should not be possible to make a scratch on the surface with the finger nail
- · It should give a ringing sound when struck
- It should be heavy, and if allowed it should not absorb water more than ½ of its own weight
- · If kept immersed for two hours in water.
- It should be free from any lumps and the most important test is that, if 5 or 6 bricks, selected at random, be kept immersed in water overnight, none of them should show a crack and a tendency to fall to pieces
- If this happens, it may be assumed that the brick contains particles of lime kunker in its clay, which have been converted into quick lime by burning. These bricks are unsuitable for work.
- Color of bricks is no test, because it depends upon the nature and constituents of the clay and the fuel used for burning.







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CARBON FOOTPRINT OF THE TRADITIONAL BUILDING MATERIALS

Material	Embodied CO2/ kg
Concrete	0.159
Bricks	0.24
Marble	0.116
Stainless steel	6.15
Timber	0.72
Glass wool	1.35
Clay tile	0.45
Aluminum	8.24
MDF	0.72
Plywood	1.07
Glass	0.85
Iron	1.91

SUSTAINABLE ALTERNATIVES TO TRADITIONAL BUILDING MATERIALS

1. **Bamboo:** A versatile, renewable, and lightweight material that can be used for flooring, roofing, walls, and furniture. Bamboo is strong, flexible, and absorbs more carbon dioxide than trees.

Traditional building materials

Pulla

- Rammed earth: A mixture of dirt, sand, and gravel that's compressed into strong walls.
 Rammed earth structures are energy-efficient, have a low carbon footprint, and can naturally control temperature.
- 3. **Recycled glass:** A flexible and lightweight material that's easier to install and transport than traditional concrete.
- 4. Recycled metal: A durable, strong, and weather-resistant roofing material.
- 5. **Cork:** A renewable and recyclable resource that's commonly used for insulation in European construction. Cork is harvested by hand from the cork oak tree without killing it.
- 6. **Natural insulation materials:** These include cellulose, flax, reed, and paludiculture crops.
- 7. **3D printing:** A technology that allows companies to manufacture raw materials on-site using additive manufacturing.
- 8. Papercrete: An aggregate replacement that can help reduce energy consumption.

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- 2. https://pliteq.com/news/building-vs-carbon-footprint/#:~:text=Stone%20emits%20about%20237kg%20embodied,pun%20intended)%20for%20building%20materials.
- 3. https://www.ucem.ac.uk/whats-happening/articles/sustainable-building-materials/





Preva

ASSIGNMENT 1 & 2

AMRITAM GUPTA 220BARCH022

ASSIGNMENT 1- A Review of Traditional Building Materials, Their Carbon Content, and Sustainable Alternatives

1. Introduction

- Overview of Traditional Building Materials: Introduction to commonly used materials in the construction industry such as concrete, steel, brick, and timber, and their environmental impact, particularly in terms of carbon emissions.
- Purpose of the Review: To analyze the carbon content of traditional materials and explore sustainable alternatives that have been researched and adopted in modern construction practices.
- Research Sources: Journals such as Building and Environment, Journal of Cleaner Production, and reports from the International Energy Agency (IEA) will be cited.

2. Traditional Building Materials and Their Carbon Content

2.1 Concrete

- Source: Concrete is a composite material made from cement, sand, gravel, and water.
- Carbon Content: Cement, the main binding component of concrete, is responsible for 8% of global CO₂ emissions due to the calcination process in its production.
- CO₂ Emissions: 0.9 kg CO₂ per kg of cement.





Prove

• Environmental Impact: Large amounts of energy are required to produce cement and transport materials, making it one of the most carbon-intensive materials used in construction.



2.2 Steel

- Source: Steel is produced from iron ore, coal (as a reducing agent in blast furnaces), and other metals.
- Carbon Content: The production of steel results in 1.85 tonnes of CO₂ per tonne of steel produced.
- Steel is responsible for 7-9% of global CO₂ emissions.
- Environmental Impact: Mining, energy-intensive manufacturing processes, and transportation contribute significantly to the material's high carbon footprint.



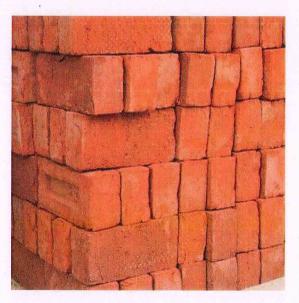


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2.3 Brick

- Source: Made from clay, which is fired in kilns to form hard bricks.
- Carbon Content: Firing bricks in kilns requires large amounts of energy, typically derived from fossil fuels, leading to significant CO₂ emissions.
- CO₂ Emissions: Around 0.2 kg CO₂ per brick.
- Environmental Impact: The carbon intensity of bricks depends on the firing method and energy source used during production.



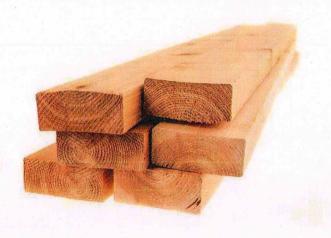




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2.4 Timber

- Source: Timber is sourced from trees, primarily softwoods such as pine, fir, and hardwoods like oak and teak.
- Carbon Content: Unlike other materials, timber can act as a carbon sink, storing carbon dioxide absorbed during tree growth.
- CO₂ Emissions: Negligible during use but can vary depending on harvesting and processing methods.
- Environmental Impact: Timber's sustainability depends on forestry management practices and its renewability.



3. Sustainable Alternatives to Traditional Building Materials

3.1 Geopolymer Concrete

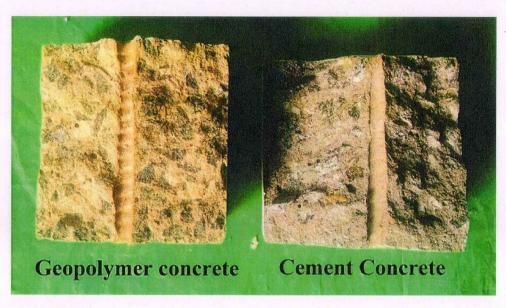
- Source: Made using industrial waste such as fly ash or slag instead of traditional Portland cement.
- Carbon Content: Geopolymer concrete has the potential to reduce CO₂ emissions by up to 80% compared to conventional concrete.





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• Sustainability Benefits: Reuse of industrial by-products reduces reliance on virgin materials and lowers carbon emissions during production.



3.2 Recycled Steel

- Source: Steel is one of the most recycled materials globally, with over 85% of steel used in construction being recycled.
- Carbon Content: Producing recycled steel can reduce CO₂ emissions by up to 60% compared to virgin steel.
- Sustainability Benefits: Reduces the need for raw material extraction and energy consumption.





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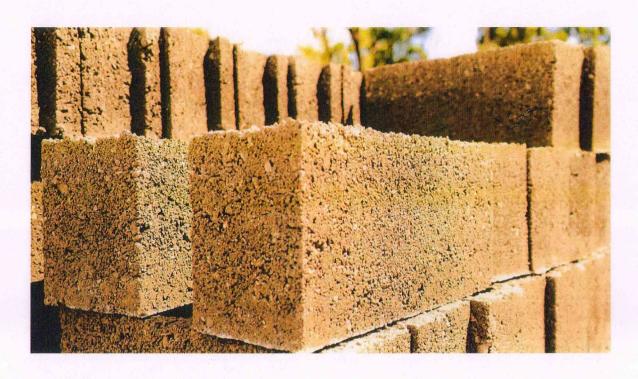
3.3 Hempcrete

- Source: A bio-composite made from hemp fibers mixed with a lime binder.
- Carbon Content: Hemp actively sequesters carbon during growth, and its production emits much less CO₂ than traditional concrete.
- CO₂ Emissions: Negative, as it can act as a carbon sink.
- Sustainability Benefits: Renewable, biodegradable, and low-energy material. Hempcrete buildings are also well-insulated, reducing operational energy needs.





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3.4 Cross-Laminated Timber (CLT)

- Source: Manufactured from layers of wood glued together at right angles to form structural panels.
- Carbon Content: CLT stores carbon, and its production has a much lower carbon footprint than steel or concrete.
- CO₂ Emissions: Similar to timber, but with added durability and strength.
- Sustainability Benefits: Renewable, sustainable forestry practices can ensure CLT is an environmentally friendly alternative to steel and concrete.





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3.5 Rammed Earth

- Source: Made from earth, sand, and stabilizers like cement or lime, compressed into formwork.
- Carbon Content: The CO₂ emissions are low due to minimal processing, though adding cement can increase the carbon footprint.
- CO₂ Emissions: Varies depending on stabilizers used.
- Sustainability Benefits: Uses locally sourced materials, reducing transportation-related emissions. Provides good thermal mass and durability.



4. Case Studies and Applications

4.1 Geopolymer Concrete in Infrastructure

- Case: The Toowoomba Wellcamp Airport in Australia used geopolymer concrete for large parts of its infrastructure, achieving a significant reduction in the carbon footprint.
- Impact: Reduced CO₂ emissions by 40,000 tonnes during construction compared to traditional concrete.

4.2 CLT in Tall Buildings

- Case: The Mjøstårnet Building in Norway is one of the tallest timber buildings in the world, using CLT panels for construction.
- Impact: CLT construction sequestered more carbon than was emitted during the production and assembly processes, making the building a carbon sink.

4.3 Hempcrete Residential Buildings

- Case: Hempitecture, a US-based company, has developed several residential buildings using hempcrete.
- Impact: The buildings boast high thermal efficiency and reduced energy consumption during the operational phase, while sequestering CO₂ during the hemp's growth phase.

5. Challenges and Opportunities

5.1 Barriers to Adoption

- Cost: Sustainable materials like geopolymer concrete and CLT can be more expensive upfront compared to traditional materials.
- Supply Chain Limitations: The production and supply of sustainable alternatives, like hempcrete and rammed earth, can be limited based on region and scalability.

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• Standardization and Building Codes: Many regions lack standard building codes for new materials like geopolymer concrete, hampering large-scale adoption.

5.2 Future Opportunities

- Innovation in Material Science: Research in bio-based and nano-enhanced materials could lead to even more sustainable and carbon-negative options.
- Circular Economy in Construction: Emphasizing reuse and recycling of materials can reduce the carbon footprint of construction significantly.
- Government Policies and Incentives: Policies promoting low-carbon materials, like tax credits for buildings made with sustainable materials, can accelerate adoption.

6. Conclusion

- Summary: Traditional building materials like concrete, steel, and brick have high carbon footprints, while sustainable alternatives like geopolymer concrete, recycled steel, and hempcrete offer significant reductions in embodied carbon.
- Future Directions: The building industry is moving toward low-carbon solutions, but further research, investment, and policy support are necessary to make these alternatives mainstream.
- Recommendations: Promote sustainable materials through government incentives, standardization of building codes, and investments in research to lower the cost and improve scalability.

7. References

 Sources from journals such as Building and Environment, Journal of Cleaner Production, Energy and Buildings, and industry





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School of Art and Architecture - Sushant University

Odd Semester (Aug-Dec) 2024-25

Individual Assignment

Mid Term

Program: B.Arch.

Course Name: Allied Field 3 Faculty: Dr. Purva Mujumdar Submission Deadline: 1.10.2024 Sem: 5

Course Code: 21BAR6AL31S

Maximum Marks: 20

Course Outcomes

CO1: Understand the role of materials in the Building sector and other disciplines.

CO2: Determine embodied energy and carbon content of buildings.

CO3: Explore performance rating of green buildings and zero energy building.

Assignment:

Q.1 (CO2) Prepare a review report on Embodied and Operational energy of a building, their components, Life cycle assessment of a building's embodied energy in terms of energy consumption.

- 1. It is a complete research based assignment through latest articles, journals and similar studies.
- 2. Sources of all the information need to be mentioned in the report.
- 3. Relevant data, tables and figures should also be included in the report.



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SAMPLE ASSIGNMENT (MID TERM)

Some

Review of Embodied and Operational Energy of a building

Submitted by:

Rongsennukla Yaden rongsennukla. 220barch046@sushantuniversity.edu.in



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1. Introduction

Buildings demand energy in their life cycle right from its construction to demolition. Buildings are constructed for residential, office and commercial purposes all over the world. They are major contributors to socio-economic development of a nation and also utilize a large proportion of energy and available natural resources. Worldwide, 30–40% of all primary energy is used for buildings and they are held responsible for 40–50% of greenhouse gas emissions According to the United Nations Environment Program (UNEP), the construction sector is responsible for up to 30% of all greenhouse gas emissions. It is therefore essential for the building construction industry to achieve sustainable development in the society. Sustainable development is viewed as development with low environmental impact, and high economical and social gains. To achieve the goals of sustainability it is required to adopt a multi-disciplinary approach covering a number of features such as energy saving, improved use of materials including water, reuse and recycling of materials and emissions control.

Extensive focus on operational energy research has positively impacted both academia and policymakers, facilitating new strategies that reduce the energy consumed by building occupants. Much less emphasis has, however, been given to embodied energy. Consequently, although studies now show that embodied energy can be responsible for up to 50% of a building's life cycle energy, little is known about the embodied energy associated with the construction of buildings, materials, and components in the study context.

2. Embodied Energy of Buildings

In order to define "embodied energy", it is necessary to understand that energy is associated with every stage of a building's life cycle. Before building construction commences, the building already has begun to consume a significant amount of energy. There are direct and indirect energies associated with every building, while direct energy is the energy related to the construction of the building, indirect energy is associated with the extraction and manufacture of raw materials used in the construction. Thus, there is energy used directly onsite and offsite during construction and related processes, as well as indirectly in relation to the use of materials and equipment. There are three components of embodied energy

I. Initial embodied energy (IEE) refers to all energy associated with the initial construction, including the energy used in material manufacture, transportation, and delivery.





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- II. Recurrent embodied energy (REE) is the energy that is consumed or associated with servicing the building during its lifespan; it relates to repair, replacement, and general maintenance of the building.
- III. There is the energy associated with demolition and disposal at the end-of-life stage of the building.

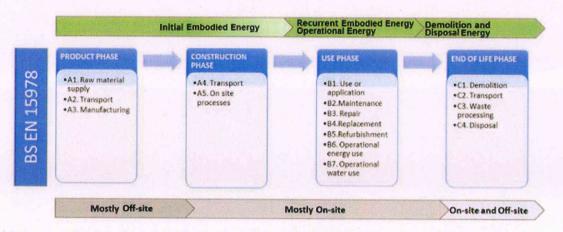


Figure 1. Life cycle stages of a building as defined by BS EN 15978 and associated energy.

3. Operational energy

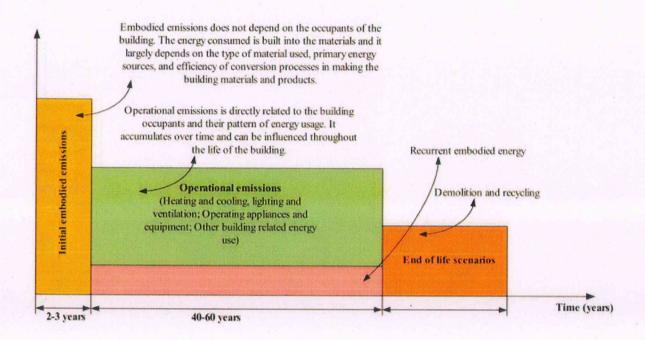
Operational energy is the energy used to operate a building by operating processes such as heating and cooling, lighting and appliances and maintaining the building after its construction.

Any improvement in order to reduce the operational energy is possible at any stage of the building's life. But decisions taken at the early design concept stage in regard to the selection of building materials can have very significant implications for reducing the overall embodied energy of a building. Once the building is constructed the embodied energy goes on increasing with the life of the building as one alters or renovates the building over its lifetime.





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4. Life cycle energy analysis (LCEA)

Life cycle energy analysis is an approach that accounts for all energy inputs to a building in its life cycle. The system boundaries of this analysis include the energy use of the following phases: manufacture, use, and demolition. Manufacture phase includes manufacturing and transportation of building materials and technical installations used in erection and renovation of the buildings. Operation phase encompasses all activities related to the use of the buildings, over its life. LCA is a process whereby the material and energy flows of a system are quantified and evaluated. Typically, upstream (extraction, production, transportation and construction), use, and downstream (deconstruction and disposal) flows of a product or service system are inventoried first. Subsequently, global and/or regional impacts (e.g. global warming, ozone depletion, eutrophication and acidification) are calculated; based on energy consumption, waste generation, etc





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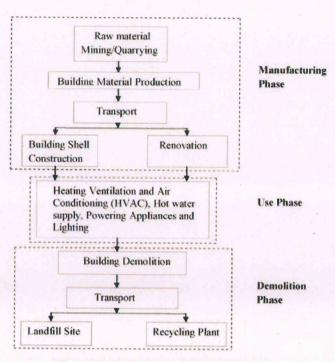


Fig. 1. System boundaries for life cycle energy analysis.

A paper titled "Life cycle analysis and embodied energy: A review by Abhishek R. Patil and Suraj D. Shinde" discusses the various types of embodied energy considered in the life cycle analysis of building and various methods along with their applications and limitations in the Calculation of Embodied energy. The total embodied energy is primarily divided into two parts:

Initial Embodied Energy

The energy in buildings represents the energy consumed in the acquisition of raw materials, their processing, manufacturing, transportation to the site, and construction. The initial embodied energy has two components. The direct energy, that is the energyused to manufacture and transport building products to the site and to construct the building. The indirect energy is the energy useassociated with processing, transporting, converting and delivering fuel and energy to its point of use.

EEi=∑ miMi + Ec[2]

Where EEi= initial embodied energy of building; mi=quantity of building material (i); Mi= energy content of material (i) per unit quantity; Ec= energy used at site for the construction of building.

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Recurring Embodied Energy

A large variety of materials are being used in building construction. Some of them may have a life span less than that of the building. As a result, they are replaced to rehabilitate the building. In addition to this, buildings require some regular annual maintenance. The energy incurred for such repair and replacement (rehabilitation) needs to be accounted during the entire life of

the buildings. The sum of the energy embodied in the material, used in the rehabilitation and maintenance is called recurring embodied energy and can be expressed as:

EEr=∑ miMi [(Lb/Lmi) - 1][2]

Where EEr = recurring embodied energy of the building; Lb= life span of the building; Lmi = life span of the material (i)

Embodied energy largely depends on the type of the materials used, primary energy sources of energy, building techniques, and efficiency of conversion processes in making building materials and products.

Operating Energy

The operating energy of the building is the amount of energy that is consumed by a building to satisfy the demand for heating, cooling, ventilation, lighting, equipment and appliances. Operating energy is convenient way to compare the energy consumption of different building system as it is independent of material used.

 $OE = EOA \times Lb[2]$

Where OE = operating energy in the life span of the building; EOA = annual operating energy; Lb= life span of the building.

Demolition energy

At the end of buildings' service life, energy is required to demolish the building and transport the waste material to landfill sites and/or recycling plants.

DE = ED + ET[2]

Where DE= demolition energy; ED = energy incurred for destruction of the building; ET = energy used for transporting the waste materials.

Life Cycle Energy





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Life cycle energy of the building is the sum of all the energies incurred in its life cycle. It is thus expressed as

LCE = EEi+ EEr + OE + DE[2]

At present, there are three commonly used LCA methods for assessing the environmental impact of products or systems over its life cycle, including input-output LCA (I-O LCA), process LCA and hybrid LCA. Various literatures have reported different LCA methods in related studies. The merits and drawbacks of each method were also discussed and compared by many researchers. The advantage of the process LCA method is that a large amount of detailed data can be obtained through the analysis of different stages in the entire life cycle, that would guarantee the accuracy and reliability of the results and help improve the environmental performance. While the process LCA method has been used in many LCA studies of buildings, truncation error becomes an inevitable problem because of the impossibility to consider all of the upstream processes, especially the higher order upstream. Conversely, the input-output LCA method succeeds in establishing a complete system boundary on the basis of the correlation between different parts; many building related LCA studies thus successfully used I-O LCA to assess embodied energy and emissions of building components. The I-O LCA method makes it possible for researchers to analyze a product including services when the data is hard to get, but has its weakness when it comes to characterizing various processes within the same sector. For instance, if two materials come from the same building sector, the embodied energy of them cannot be compared with each other using I-O LCA method.

Many scholars have committed to solving the contradiction between system boundary and data accuracy. Treloar et al. proposed a hybrid method called I-O based hybrid LCA to overcome weakness of process and I-O LCA. This method has been used in related life cycle studies by several researchers. These studies show that the analysis results of embodied energy or carbon emissions values by I-O based hybrid LCA method are obviously higher than those by equivalent process LCA method. Although I-O based hybrid LCA method covers an integrated system boundary, it suffers from the same uncertainty problem as I-O LCA method, for example, input-output data is out of date, newer product information is not enough, and so on.

In the paper titled "Embodied and operational energy and carbon emissions of passive building in HSCW zone in China: A case study by Xing Su, Shaochen Tian, Xiaolu Shao, Xuan Zhao, embodied and operational energy and carbon emissions of a passive building are evaluated. Passive building is generally regarded as the energy-efficient building to reduce the primary energy consumption and related carbon emissions. It is suggested that the most effective way to minimize the space heating energy demand is





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to decrease heat loss by enhancing the thermal and airtightness performance of building envelopes. And it is suited to the buildings in cold climates for decreasing space heating energy consumption which dominates the operational energy. However, the appropriate design strategy of building depends on climates. In HSCW (hot summer and cold winter) zone in China, for instance, space heating is just one issue of energy demand in the operational stage, the energy use for cooling and dehumidification in summer also accounts for a considerable proportion in the operational stage of buildings. In this case, detailed life cycle analysis of embodied and operational energy use and carbon emissions of a passive building is given and then compared with a conventional building in the same unique climate zone. The embodied energy consumption and carbon emissions of the passive building is 7.31 GJ/m2 and carbon 0.98 t CO2 eq/m2, 37.6% and 16.2% higher than that of conventional building respectively. Due to the benefits on the operational stage, the total life cycle energy requirement and carbon emissions of passive building is 17.4% and 22.7% lower than that of conventional building, respectively.

A conference paper titled "Embodied and operational energy for a single storied residential building at Chennai, India, 2004" concludes that in order to achieve total energy conservation, the heat gain into the building must also be considered. This is directly related to the thermal mass of the envelope. Heat transfer value through the envelope of the building is called 'Overall Thermal Transfer Value' (OTTV). Therefore, Overall Thermal Transfer Value is a measure of heat gain into the building through the building envelope. Hence it acts as an index for comparing the thermal performance of buildings. Control of OTTV implies the control of heat transfer through the building envelope. If heat gain is controlled then the load on the air conditioner can be reduced, leading to lesser consumption of electricity. Thus the operational energy can be controlled. Complete energy efficiency can be achieved if building materials which are low in embodied energy as well as which give less OTTV are used.

A study titled "Embodied and Operational Energy of a Case Study Villa in UAE with Sensitivity Analysis" by Abdul Rauf Daniel Efurosibina Attoye and Robert Crawford has focused on the calculation of the life cycle energy for a case study villa in the UAE. The analysis showed that the embodied energy and operational energy of the villa, over a 50-year life span, were found to be 34% and 66% of the life cycle energy, respectively. The initial embodied energy was about 57% of the life cycle embodied energy and 19% of the life cycle energy of the building. The recurrent embodied energy was about 43% of the life cycle embodied energy and 14% of the life cycle energy of the building. These results suggest that embodied energy is critical in life cycle energy assessments and represents a significant percentage of the life cycle energy consumption of residential buildings. In addition, considering that the type of materials selected impacts the overall embodied energy, it is necessary for both designers and clients to be made aware of the







life cycle consequences of their design decisions. A sensitivity analysis was carried out to review the potential changes in life cycle energy proportions due to the adoption of renewable energy using a rooftop solar PV system. The analysis showed that the adoption of a solar PV system resulted in a significant increase (from 34% to 45%) in the proportion of embodied energy. This shows that an increase in the use of more renewable sources of energy in future building sectors will necessitate a focus on efforts to reduce the embodied energy consumption of buildings. A sensitivity analysis was also carried out to review the potential changes in life cycle energy proportions due to +20% or -20% variation in the life cycle embodied energy (LCEE), as well as operational energy (OPE). The analysis showed that in a scenario where the LCEE is varied, its proportion could range from 29% to 38% of the life cycle energy, while the OPE share could range from 62% to 71% of the life cycle energy. If, however, the OPE was varied, its share in life cycle energy could range from 61% to 70% while the share of LCEE would range from 30% to 39% of the life cycle energy. This confirms that the impact of embodied energy is irrefutable and will become a bigger challenge if efforts are made to only reduce the operational energy.

On the basis of the significance of operational and embodied energy shown in this study, these results may be applicable in other countries where climatic conditions and construction methods are similar. As opposed to the operational energy requirements to cool the buildings in the harsh climate of the UAE, regions with less harsh climates may result in further increases in the significance of life cycle embodied energy. This confirms that in order to reduce the environmental impacts associated with the building sector, every possible effort should be made to reduce the embodied energy consumption of buildings along with the operational energy. This study has focused on the calculation of the life cycle energy for a case study villa in the UAE. The analysis shows that the embodied energy and operational energy of the villa, over a 50-year life span, were found to be 34% and 66% of the life cycle energy, respectively. The initial embodied energy was about 57% of the life cycle embodied energy and 19% of the life cycle energy of the building. The recurrent embodied energy was about 43% of the life cycle embodied energy and 14% of the life cycle energy of the building. These results suggest that embodied energy is critical in life cycle energy assessments and represents a significant percentage of the life cycle energy consumption of residential buildings. In addition, considering that the type of materials selected impacts the overall embodied energy, it is necessary for both designers and clients to be made aware of the life cycle consequences of their design decisions. A sensitivity analysis was carried out to review the potential changes in life cycle energy proportions due to the adoption of renewable energy using a rooftop solar PV system. The analysis showed that the adoption of a solar PV system resulted in a significant increase (from 34% to 45%) in the proportion of embodied energy. This shows that an increase in the use of more renewable sources of energy in future building sectors will necessitate a focus on efforts







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The paper titled "Embodied versus operational energy in residential and commercial buildings: where should we focus? by Ayşegül Demir Dilsiza, Juliana Felkner b, Guillaume Habert c, Zoltán Nagya analyzed 100 case studies, which were conducted in 23 countries, and contrast their data on embodied and operational energy in residential and commercial buildings. The case studies included conventional, retrofit, low-energy, passive, and net-zero energy buildings and the buildings have different lifetimes varying from 25 to 100 years. Their results showed that operational energy significantly dominates the life cycle energy of the buildings by an average of 419 MJ/m2 per year and an average share of 72%. The share of embodied energy increases with decreasing operational energy. However, the overall LCE decreases significantly when the operational energy decreases. Naturally, the assumptions on the lifetime of the buildings have a great impact on the LCE. We conclude that operational energy should be primarily reduced in order to decrease greenhouse gas emissions from the existing building stock because most of the buildings are already built and changes in the embodied energy are often obtained only through new construction or deep retrofit strategies. Depending on the strategy to decrease OE, the share of EE was found to show wide fluctuations within the case studies, ranging from 4% up to 100%. In addition, most of the operational energy consumption has been reported by using energy simulation tools. Only about 14% of the case studies had metered operational energy data. In order to create more accurate data, metering of buildings should be considered in future case studies.





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In a study, "Embodied energy and operational energy computations for a typical G+3 residential building in Vijayawada city of Andhra Pradesh, India, an attempt was made to compute the EE and OE values of a residential building situated in Vijayawada, Andhra Pradesh. In particular, the EE values of the various building materials were estimated in this work. The case study wasan example of an RCC structure with ground + three floors. The cement used for building was observed to contribute 36% to the total EE, followed by steel (33%) and bricks (17%). The total computed EE was calculated to be 3.1GJ/m2. Alternative measures for reducing the EE in buildings, including the usage of recycled materials, transportation, using solar energy, replacing cement with fly-ash and GGBS, building interior products. As the total OE is calculated to be approximately 3.76 GJ/m2, without AC, the only OE of AC load is calculated to be 3.78 GJ/m2. The AC load contribution to the OE for a typical residential building in a city located in a hot and dry region such as Vijayawada is almost equivalent to the total load. This clearly shows that the thermal comfort of the building is significantly affected, and considerable load results from cooling the rooms in the building from the inside. Measures must be taken to decrease the heat transfer in a building through the building envelope. The EE content is incurred once apart from the upkeep and Renovation, whereas OE accumulates over time and can be affected throughout the lifespan of the building. The study quantified the lifespan that is the energy and cost and steps to minimize by concentrating on embodied, useful, and transportation of energy requirements. It permits testing of various energy reduction actions together with the identification of the most economical and useful steps. This study offers a foundation for future power reduction strategies for residential structures by giving recommendations for reducing energy consumption to every single contributor associated with the built environment centered on the quantified benefits. This can ultimately reduce the adverse impact of energy consumption on the environment and create a healthier built environment.

Embodied carbon is the "upfront carbon" that is generated before the building is used. 40% of annual CO2 emissions come from the built environment, and 13% of those come from upfront, or embodied, carbon. If only 13% of emissions from buildings come from embodied carbon, why do we focus on it? Because that carbon is being released into the atmosphere now, not over the next 50 or more years. If we can reduce embodied carbon now, we can have a significant impact on reducing the overall effects of climate change more quickly. Making buildings more energy efficient has lowered carbon operating emissions. But as operational carbon goes down, embodied carbon will account for a larger percentage of total carbon. By the year 2050, almost half of the carbon footprint in new construction will come from embodied carbon. Canada, Sweden, and Norway are already seeing an almost 50/50 embodied carbon vs. operating carbon split.





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- Embodied and Operational Energy of a Case Study Villa in UAE with Sensitivity Analysis Abdul Rauf, Daniel Efurosibina Attoye1 and Robert Crawford https://www.mdpi.com/2075-5309/12/9/1469
- Embodied and operational energy for a single storied residential building at Chennai, India may 2004 <u>Vijayalaxmi Jeyasingh</u> file:///C:/Users/acer/Downloads/CIB10140-1.pdf
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- https://oneclicklca.com/en/resources/articles/embodied-carbon-vs-operational-carbon





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Annexure IV

School of Art and Architecture - Sushant University

Odd Semester (Aug - Dec) 2024-25

Course Title: Allied Fields 3

Semester: 5

Course Code: 21BAR6AL31S

Course Faculty: Dr. Purva Mujumdar

Programme: B.Arch.

RESULT SHEET

Sr. No.	Name of the Student	Marks Obtained (Out of 40)
1	Chirag Yadav	27
2	Rongsennukla Yaden	35
3	Annanya Bindal	22
4	Ishita Gupta	34
5	Simran thakran	33
6	Manaj Baweja	28
7	Amritam Gupta	0
8	Abeer Bhasin	0
9	Naveen Chauhan	0
10	Raghav Sethi	20
11	Dhruv Dogra	0
12	Aarushi Agrawal	28
13	Harshita Dang	30
14	Ronnit Garg	26
, 15	Rudra Pratap Singh	0
16	Rushil Soni	27
17	Shriya Khurana	30
18	Sudevi Gayen	29
19	Shweta Sharma	28

Signature of Course Coordinator/Faculty

Programme Coordinator

Dean Dean



ANNEXURE-II

School of Art and Architecture- Sushant University

Academic Session: Odd Sem - 2024-25

Course Title: Allied Field 3

Semester: 5

Course Code: 21BAR6AL31S

Course Faculty: Dr. Purva

Mujumdar

Programme: B. Arch.

Sir/Madam,

Following students mentioned in the list are identified as Slow learner/Advanced learner based on guidelines issued by IQAC after second assessment (declaration of Mid-term marks).

S.	Roll No	Name of the student	Slow learner / Advanced Learner
No			
1	220BARCH046	Rongsennukla Yaden	Advanced Learner
2	220BARCH053	Ishita Gupta	Advanced Learner
3	220BARCH008	Simran Thakran	Advanced Learner
4	220BARCH022	Amritam Gupta	Slow Learner
5	220BARCH036	Abeer Bhasin	Slow Learner
6	220BARCH048	Naveen Chauhan	Slow Learner
7	220BARCH062	Dhruv Dogra	Slow Learner
8	220BARCH024	Rudra Pratap Singh	Slow Learner

Signature of Course Coordinator/Faculty

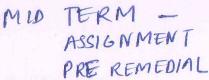
Programme Coordinator

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ASSIGNMENT 2- Embodied and Operational Energy of a Building and Life CycleAssessmentUnderstanding

1. Introduction

The construction and operation of buildings account for a significant portion of global energy consumption and carbon emissions. As urban populations continue to grow, the need for energy-efficient buildings becomes increasingly urgent. Understanding the dynamics of embodied and operational energy can guide architects, engineers, and policymakers in making informed decisions that lead to sustainable building practices. This report provides a detailed exploration of these energy types, their measurement, and their implications for sustainability.

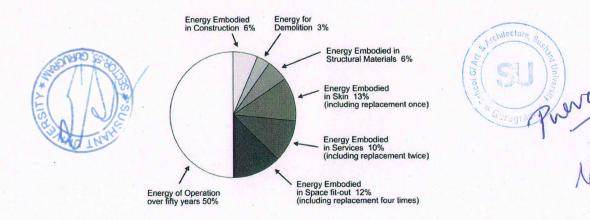
2. Definitions

2.1 Embodied Energy

Embodied energy refers to the total energy required to produce and maintain a building over its life cycle, encompassing the extraction, processing, transportation, assembly, maintenance, and eventual demolition of materials. It is measured in megajoules (MJ) per unit area or volume of the building.

2.2 Operational Energy

Operational energy is the energy consumed during the occupancy phase of a building for heating, cooling, lighting, and powering appliances. This energy demand is influenced by factors such as building design, climate, and user behavior, and is also measured in megajoules (MJ) per unit area.



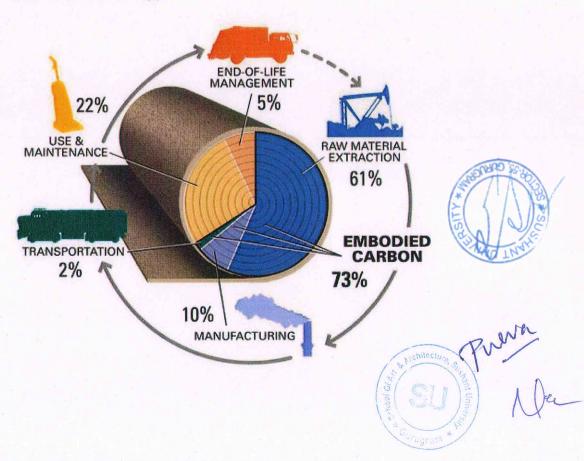
Graph showing operational energy consumed over the life cycle of typical building

3. Importance of Energy Assessment in Buildings

Assessing embodied and operational energy is essential for several reasons:

- 1. **Environmental Impact**: Buildings contribute to approximately 40% of global energy-related CO2 emissions. Understanding energy consumption patterns can help mitigate environmental damage.
- 2. **Economic Benefits**: Reducing energy consumption can lead to significant cost savings for building owners and occupants.
- 3. **Regulatory Compliance**: Many regions are implementing stringent building codes and standards that require energy assessments as part of the permitting process.
- 4. **Market Demand**: There is a growing market demand for sustainable and energy-efficient buildings, making energy assessment a competitive advantage.

4. Embodied Energy



4.1 Components of Embodied Energy

Embodied energy can be broken down into several distinct components:

- 1. **Material Extraction**: The energy consumed during the extraction of raw materials varies widely depending on the material type. For instance, mining metals requires substantially more energy than harvesting timber.
- 2. **Material Processing**: The transformation of raw materials into finished products often involves significant energy inputs. For example, producing one ton of steel can consume up to 20,000 MJ.
- 3. **Transportation**: This encompasses the energy used to transport materials from their extraction sites to manufacturing facilities and then to construction sites. Transportation energy consumption can range from 5 to 20 MJ/kg.
- 4. **Construction**: The energy expended during construction includes the operation of machinery, tools, and labor. Studies suggest this can vary from 10 to 30 MJ/kg, depending on the project scale and complexity.
- 5. **Maintenance and Repair**: Throughout a building's lifespan, maintenance activities also contribute to its embodied energy. Regular upkeep of HVAC systems, roofing, and other elements can cumulatively require substantial energy.

4.2 Measurement and Calculation Methods

Assessing embodied energy involves several methodologies:

- 1. **Process Analysis**: This involves evaluating the energy consumed in each stage of a material's life cycle. This method requires detailed data on each phase.
- 2. **Input-Output Analysis**: This economic-based method uses national or regional input-output tables to estimate energy use based on material production statistics.
- 3. Hybrid Methods: A combination of process and input-output analyses, these methods provide a more holistic view of embodied energy across various materials and processes.



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ATTENDANCE SHEET - SLOW LEARNER

REMEDIAL CLASSES SCHEDULE CUM ATTENANCE SHEET FOR SLOW LEARNERS

Academic Session: Odd Semester -2024-25

21BAR6AL31S B.Arch. Program/Batch: Course Code:

Allied Fields 3 Course Title:

Dr. Purva Mujumdar 1.10.2024 Faculty Name: Semester: Date:

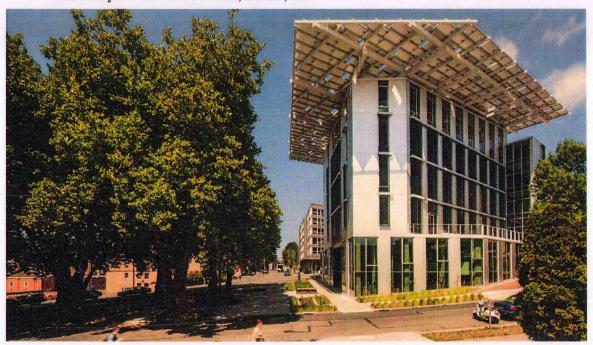
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4. **Environmental Product Declarations (EPDs)**: Many manufacturers now provide EPDs, which give a standardized assessment of the environmental impact of their products, including embodied energy.

Case Studies

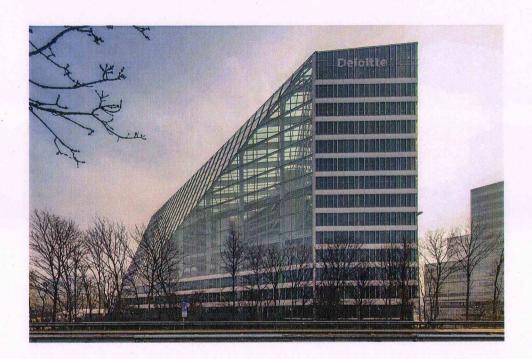
Case Study 1: The Bullitt Center, Seattle, WA



The Bullitt Center, often referred to as the greenest commercial building in the world, has an embodied energy of approximately 550 MJ/m². Its design prioritizes local materials and sustainable practices, resulting in reduced energy consumption during construction.



Case Study 2: The Edge, Amsterdam, Netherlands



The Edge is known for its innovative use of technology and energy efficiency. Its embodied energy is calculated at around 700 MJ/m², with a significant focus on using recycled materials and energy-efficient construction methods.

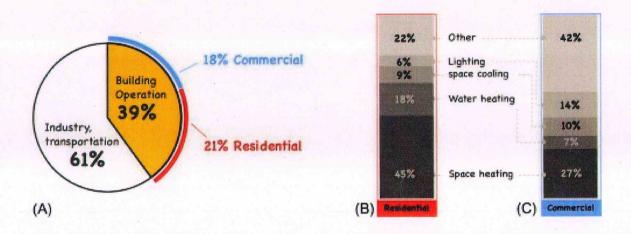
Table 1: Embodied Energy of Common Building Materials

Material	Embodied Energy (MJ/kg)	Common Uses
Concre te	1.0 - 1.5	Foundations, walls
Steel	20 - 30	Structural frames
Wood	3 - 5	Framing, finishes

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Insulati	2.0 - 3.0	Thermal insulation
on		
(EPS)		

5. Operational Energy



5.1 Factors Influencing Operational Energy

Operational energy consumption is influenced by various factors, including:

- 1. **Building Design**: Key design elements such as orientation, window placement, and insulation can significantly reduce heating and cooling demands. For example, passive solar design can reduce operational energy by 20-50%.
- 2. **HVAC Systems**: The efficiency of heating, ventilation, and air conditioning systems plays a crucial role. High-efficiency systems can reduce energy consumption by up to 40%.
- 3. **Building Envelope**: A well-insulated building envelope minimizes energy loss and reduces the load on HVAC systems.
- 4. User Behavior: Occupant habits, such as thermostat settings and appliance usage, greatly influence operational energy consumption. Studies have shown that user behavior can account for up to 30% of energy savings potential.

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5.2 Measurement and Calculation Methods

Operational energy can be assessed using several approaches:

- 1. **Energy Monitoring Systems**: Smart meters and building management systems provide real-time data on energy consumption, helping identify inefficiencies.
- 2. **Energy Simulation Software**: Tools like EnergyPlus and eQUEST allow architects to simulate energy use based on various design scenarios and climatic conditions.
- 3. **Post-Occupancy Evaluations (POEs)**: These evaluations assess actual energy use after a building is occupied, providing insights into discrepancies between predicted and actual performance.
- 4. **Benchmarking**: Comparing a building's energy performance against similar buildings can help identify areas for improvement.

5.3 Case Studies

Case Study 1: The Empire State Building, New York, NY

Following a comprehensive energy retrofit, the Empire State Building achieved a 38% reduction in operational energy use, saving approximately \$4.4 million annually. Upgrades included high-performance windows and a modern HVAC system.

Case Study 2: One Central Park, Sydney, Australia

One Central Park utilizes a combination of green design features and energy-efficient systems, achieving a reduction of 50% in operational energy use compared to conventional buildings of similar size.

Figure 1: Operational Energy Use by Building Type (Hypothetical link)

6. Life Cycle Assessment (LCA)

6.1 Overview of LCA



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Life Cycle Assessment (LCA) is a systematic method for evaluating the environmental impacts associated with all stages of a product's life, from raw material extraction through production, use, and disposal. LCA is essential for identifying opportunities for improving environmental performance.

6.2 LCA in Building Design

In the context of building design, LCA provides a comprehensive view of energy consumption and environmental impacts. The LCA process typically includes the following stages:

- 1. Goal and Scope Definition: Establishing the objectives of the assessment, including the functional unit, system boundaries, and assumptions.
- 2. **Inventory Analysis**: Collecting data on energy inputs, emissions, and waste generated throughout the building's life cycle.
- 3. **Impact Assessment**: Evaluating potential environmental impacts based on the inventory data, which may include global warming potential, ozone depletion, and resource depletion.
- 4. **Interpretation**: Analyzing the results to identify areas for improvement and informing decision-making.

6.3 Limitations and Challenges

Despite its advantages, LCA has several challenges:

- 1. **Data Availability**: Reliable and comprehensive data for all materials and processes can be challenging to obtain, leading to potential inaccuracies.
- 2. **Complexity**: The LCA process can be complex and resource-intensive, requiring specialized knowledge and tools.
- 3. Variability: Results can vary significantly based on the assumptions made during the assessment, making consistency difficult.





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- Raw material extraction
- A2 Transport to manufacturing site
- A3 Manufacturing
- A4 A5 Construction stage
- A4 Transport to
- construction site A5 Installation / Assembly
- **B2** Maintenance **B3** Repair **B4** Replacement
- **B5** Refurbishment
- **B6** Operational energy use **B7** Operational water use
- C1 C4 End of life stage B1 Use
 - C1 Deconstruction & demolition
 - C2 Transport **C3** Waste processing
 - C4 Disposal

D - Renefits and loads beyond system

Reuse, recovery and/or recycling potentials, expressed as net impacts and benefits

7. Comparative Analysis of Embodied and Operational Energy

The interplay between embodied and operational energy is critical in designing sustainable buildings. While operational energy dominates the energy consumption profile of most buildings during their lifetime, the embodied energy associated with construction materials can be substantial.

Table 2: Comparative Analysis of Energy Types

Energy Type	Characteristics	Implications for Design
Embodie d Energy	Associated with material production	Prioritize low-energy materials

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Operatio nal Energy	Related to energy use during occupancy	Optimize systems for efficiency
Synergy	Efficient design can reduce both types	Integrated design approaches needed

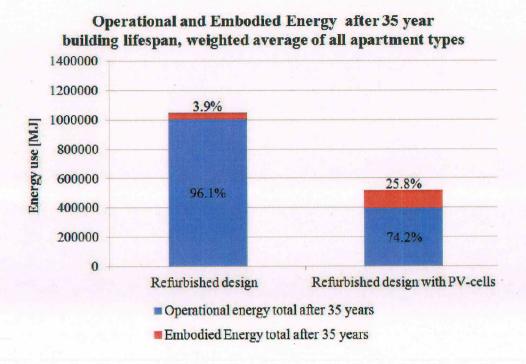
Key Insights

- 1. **Total Energy Consumption**: Research indicates that for most buildings, operational energy accounts for about 80-90% of total energy consumption over the life cycle, with embodied energy accounting for the remaining 10-20%. However, this ratio can shift significantly depending on building materials and design.
- 2. **Lifecycle Costs**: The initial cost of materials with high embodied energy may be offset by lower operational costs, leading to overall cost savings. For instance, investing in high-performance insulation may have higher upfront costs but can significantly reduce heating and cooling expenses.
- 3. **Policy Implications**: Understanding the balance between embodied and operational energy can inform building codes and regulations, encouraging the use of sustainable materials and energy-efficient systems.





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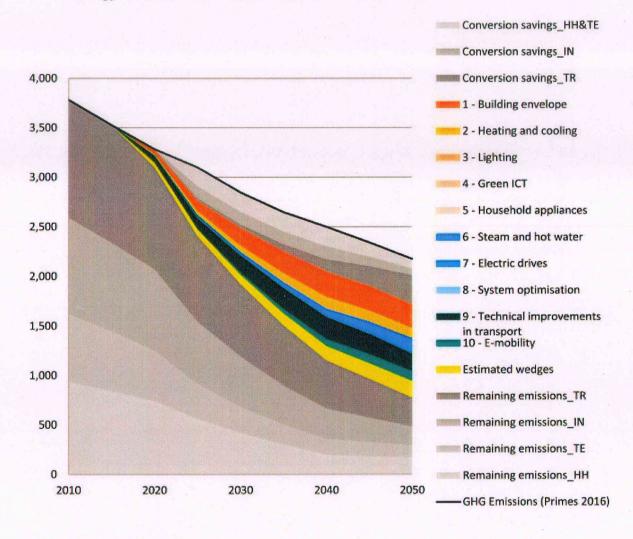
8. Future Directions in Energy Efficiency

To enhance energy efficiency in buildings, several strategies can be pursued:

- 1. Innovative Materials: Research into low-embodied energy materials, such as recycled or biogenic materials, is essential. Innovations in prefabrication and modular construction can also reduce energy consumption during construction.
- 2. **Building Automation**: Implementing smart building technologies, such as automated lighting and HVAC systems, can optimize operational energy use. Data analytics can help predict and manage energy demand.
- 3. **Policy Frameworks**: Governments should implement policies that promote energy-efficient building practices. This includes providing incentives for sustainable design, such as tax credits or grants for using renewable materials and energy systems.

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- 4. **Education and Training**: Educating architects, engineers, and builders about the importance of embodied and operational energy can lead to more informed decision-making and innovative solutions.
- 5. **Integration of Renewable Energy**: Incorporating renewable energy sources, such as solar panels and geothermal systems, can offset operational energy demands and reduce reliance on fossil fuels.



9. Conclusion

A thorough understanding of embodied and operational energy is essential for advancing sustainable building practices. By focusing on both energy types, stakeholders can make informed decisions that enhance building performance while reducing environmental impacts. Continued research and innovation in

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materials, technologies, and policies are critical for achieving energy efficiency in the built environment.

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Annexure IV

School of Art and Architecture - Sushant University

Odd Semester (Aug - Dec) 2024-25

Course Title: Allied Fields 3

Semester: 5

Course Code: 21BAR6AL31S

Course Faculty: Dr. Purva Mujumdar

Programme: B.Arch.

RESULT SHEET

Sr. No.	Name of the Student	Marks Obtained (Out of 40)
1	Chirag Yadav	27
2	Rongsennukla Yaden	35
3	Annanya Bindal	22
4	Ishita Gupta	34
5	Simran thakran	33
6	Manaj Baweja	28
. 7	· Amritam Gupta	18
8	Abeer Bhasin	17
9	Naveen Chauhan	18
10	. Raghav Sethi	20
11	Dhruv Dogra	16
12	Aarushi Agrawal	28
13	Harshita Dang	30
14	Ronnit Garg	26
15	Rudra Pratap Singh	14
16	Rushil Soni	27
17	Shriya Khurana	30
18	Sudevi Gayen	29
19	Shweta Sharma	28

Signature of Course Coordinator/Faculty

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SCHOOL OF ART AND ARCHITECTURE- SUSHANT UNIVERSITY

LIST OF ADVANCED LEARNERS

Program/Batch: B.Arch.

Course Code: 21BAR6AL31S

Course Title: Allied Field 3

Academic Session: ODD-2024-25

Semester: 5

Faculty Name: Dr. Purva Mujumdar

S.no	S.no Enrollment No. Student name	Student name	Activities done to motivate ADVANCED learners
	220BARCH046	Rongsenukkala Yaden	Asked to participate in Solar Decathlon India Competition
7	220BARCH053	Ishita Gupta	Asked to participate in Solar Decathlon India Competition
3	220BARCH008	Simran Thakran	Asked to participate in Solar Decathlon India Competition
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ADVANCED LEARNER

ACTIVITY PROOF

Sustainable Materials and Green Buildings

ASSIGNMENT - 2

Report on Embodied and Operational Energy of a building, its components and Life cycle assessment of a building's embodied energy



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BY:-

ISHITA GUPTA 220BARCH053

Table of Contents

- 1) Introduction
- 2) Embodied and Operational Energy
- 3) Components of Embodied Energy
- 4) Components of Operational Energy
- 5) Life Cycle Assessment (LCA) of Embodied energy in buildings
- 6) Energy consumption across a building's cycle
- 7) Impacts of Embodied and Operational Energy on Carbon
 Emissions
- 8) Strategies to reduce Embodied energy in buildings
- 9) Strategies to reduce Operational energy in buildings
- 10) Case Studies
- 11) Future Trends
- 12) Challenges





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- 13) Conclusion
- 14) References

INTRODUCTION

1.1 Overview of Building Energy Consumption

Buildings are significant consumers of energy worldwide, responsible for nearly 30% of global energy use and about 40% of CO2 emissions. The energy used by buildings spans their entire lifecycle, from material production to operation, maintenance, and eventual demolition. This energy consumption supports functions such as heating, cooling, lighting, and powering appliances. As urbanization and population growth increase, buildings' energy demand is projected to rise, making it critical to manage energy use effectively throughout a building's life.

1.2 Importance of Energy Efficiency in the Building Sector

Energy efficiency in buildings is vital for reducing operational costs and mitigating climate change. Energy-efficient buildings reduce both energy consumption and greenhouse gas (GHG) emissions, offering benefits such as lower energy bills, improved comfort, and increased property value. Enhancing energy efficiency is a cost-effective solution to reduce global carbon emissions, especially as more buildings aim for net-zero energy performance.

1.3 Differentiating Between Embodied and Operational Energy

Building energy consumption can be classified into two major categories: embodied and operational energy.

• **Embodied Energy** is the total energy used throughout a building's lifecycle to extract, manufacture, transport, and assemble materials, as well as to maintain and demolish the structure. This upfront energy investment occurs before the building becomes operational.

• **Operational Energy** refers to the energy consumed during a building's functional life, such as heating, cooling, lighting, and appliance use. Operational energy is ongoing and typically accumulates throughout the building's lifespape.

building's lifespan.

Historically, the focus has been on reducing operational energy, but with advancements in energy-efficient technologies, the significance of embodied energy has become more apparent. Both forms of energy must be addressed to reduce the overall environmental impact of buildings.

Embodies and Operational Energy

Embodied Energy

Embodied energy refers to the total energy required to produce a building. This includes energy used in every phase of the building's creation, from raw material extraction, processing, and manufacturing to transportation and on-site construction. It also encompasses the energy used for maintenance, renovation, and ultimately demolition and disposal of building materials. This energy is embedded in the materials and structure of the building, representing the **upfront energy** invested before it becomes operational.

For example, the energy consumed in producing materials like steel, concrete, and glass, as well as transporting them to the construction site, are key contributors to embodied energy.

Operational Energy

Operational energy is the energy consumed during the use phase of a building. This includes the energy used for heating, cooling, lighting, ventilation, and running appliances or equipment within the building. Operational energy is ongoing and directly related to the day-to-day functions of the building, typically accruing over decades of use.

For instance, the energy required for running HVAC systems, powering lights, and operating appliances is considered operational energy.

Key Differences

The main difference between embodied and operational energy is **timing and scope**:

- **Embodied Energy** is mostly a one-time expenditure, concentrated during the construction phase and in periodic maintenance activities.
- **Operational Energy** is consumed throughout the building's lifecycle, recurring daily as the building is used.

While **embodied energy** is fixed after the building is constructed, **operational energy** continues to accumulate for as long as the building is in use.

Significance in the Building Lifecycle

Both types of energy are crucial to understanding the full environmental impact of a building. Traditionally, the focus has been on reducing **operational energy** through energy-efficient design, appliances, and systems. However, as buildings become more energy-efficient and operational energy decreases, the significance of **embodied energy** grows. Reducing embodied energy, through material selection and construction practices, is essential for minimizing a building's overall carbon foctorint, especially in the context of sustainable building practices. Addressing both is to achieving lower energy consumption over the building's entire life cycle.

Components of Embodied Energy

1. Initial Embodied Energy

Initial embodied energy is the energy used during the early stages of a building's life cycle. This includes:

- **Material Extraction**: Energy consumed in mining or harvesting raw materials like metals, wood, and stone.
- **Manufacturing**: The energy required to process these raw materials into usable building products, such as concrete, steel, and glass.
- **Transportation**: Energy spent in transporting building materials from factories to construction sites.
- **Construction**: The energy involved in assembling materials and erecting the building on-site, including the use of machinery, labor, and equipment.

This energy is consumed before the building is ready for use.

2. Recurring Embodied Energy

Recurring embodied energy refers to the energy used over the building's lifecycle for:

- **Maintenance**: Energy required for repairs or upkeep, such as repainting or replacing worn materials.
- **Renovations**: Energy used in remodeling parts of the building, which may involve new materials and construction processes.
- **Replacements**: Energy expended in replacing building components like windows, insulation, or roofing.

This energy recurs periodically during the building's operational life.

3. End-of-life Embodied Energy

End-of-life embodied energy involves the energy required for:

- **Demolition**: Energy used to dismantle or demolish the building at the end of its lifecycle.
- **Recycling**: The energy required to process reusable materials from the building's remains.
- **Waste Disposal**: Energy expended in managing and transporting building waste to landfills or recycling facilities.

This phase is crucial for reducing waste and improving resource efficiency through recycling and reuse.



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Components of Operational

Energy

Operational energy refers to the energy consumed during the building's use phase, ensuring comfort and functionality. The main components are:

1. Heating, Ventilation, and Air Conditioning (HVAC)

HVAC systems regulate indoor climate, consuming a large portion of operational energy. Heating provides warmth in colder months, ventilation ensures air circulation, and air conditioning cools spaces in warmer weather. Efficient HVAC systems with proper insulation and controls can significantly reduce energy consumption.

2. Lighting

Lighting energy is used to illuminate interior and exterior spaces. The type of lighting (incandescent, fluorescent, LED) affects energy use, with LEDs being the most energyefficient. Advanced lighting designs, such as daylight integration and motion sensors, can help minimize energy waste.

3. Appliances and Plug Loads

This includes the energy used by appliances like refrigerators, computers, and other electronic devices. Though often overlooked, these "plug loads" contribute significantly to overall energy use. Using energy-efficient appliances and reducing standby power (unplugging devices when not in use) can help lower this energy consumption.

4. Water Heating

Water heating systems provide hot water for domestic and industrial purposes. Traditional electric or gas water heaters are energy-intensive, but high-efficiency models and solarpowered systems can reduce the energy required to heat water.

5. Building Automation Systems (BAS)

BAS integrates and controls HVAC, lighting, and other systems, optimizing energy use by adjusting settings based on occupancy, weather, and time of day. BAS reduces unnecessary energy use by automating energy management, improving overall efficiency, especially in large commercial buildings.

Together, these components represent the major energy-consuming systems in a building, and improving their efficiency is key to reducing operational energy use.

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Life Cycle Assessment (LCA) of Embodied Energy in Buildings

What is LCA?

Life Cycle Assessment (LCA) is a systematic method used to evaluate the environmental impacts of a product, process, or service throughout its entire life cycle. In the context of buildings, LCA measures the embodied energy and associated emissions from material extraction to demolition. It provides insights into how to reduce energy consumption and environmental footprints over a building's lifetime.

Stages of LCA for Embodied Energy

• Raw Material Extraction

This stage includes the energy consumed during the extraction and processing
of raw materials, such as mining ores for steel or harvesting timber for wood.
 This phase represents the first point of energy use in the building's lifecycle.

Manufacturing and Transportation

 Once materials are extracted, they undergo processing and manufacturing to become usable construction products like concrete, glass, and insulation.
 Transportation to the construction site also consumes energy, contributing to embodied energy.

Construction Phase

 The actual assembly of materials into a building requires energy for construction activities, such as machinery use and labor. The energy used at this stage is also included in the total embodied energy.

• Operational Phase and Maintenance

Though mostly contributing to operational energy, maintenance activities (such as repairs, renovations, and replacements) also contribute to recurring embodied energy. This includes materials and energy required for periodic upkeep.

• End-of-life and Deconstruction

The energy involved in demolishing a building and managing its waste (through recycling, disposal, or reuse) is part of the end-of-life embodied energy. This phase also includes the energy saved by recycling materials, which reduces the demand for new raw materials.

Tools and Methods for LCA Analysis

1. ISO Standards for LCA

 ISO 14040 and ISO 14044 are international standards that provide guidelines for conducting LCAs, ensuring a consistent and comprehensive approach.
 These standards outline the framework, methodology, and reporting requirements for LCA studies.

2. Popular LCA Tools

SimaPro: A widely used tool for LCA analysis, enabling detailed modeling of environmental impacts across different stages of a building's life cycle.

- **OpenLCA**: An open-source software that provides LCA modeling and impact assessments, making it accessible for academic and professional users.
- OneClick LCA: A specialized tool for assessing the environmental performance of buildings, focusing on both embodied and operational energy impacts.

Energy Consumption Across a Building's Lifecycle

Comparative Analysis of Embodied vs. Operational Energy

- Embodied Energy is consumed during the construction phase, including material extraction, manufacturing, transportation, and construction. It represents the upfront energy required to build a structure and, depending on the materials and methods, can make up a significant portion of total energy consumption, especially for energy-efficient buildings.
- Operational Energy, on the other hand, accumulates over time as the building is
 used for heating, cooling, lighting, and appliances. Historically, operational energy
 has been the larger share of total energy consumption, especially for less energyefficient buildings. However, in modern buildings designed for high energy efficiency,
 the embodied energy becomes a larger percentage of the total energy over the
 building's lifecycle.

Factors Affecting Energy Distribution

- **Building Type**: High-rise commercial buildings often have higher operational energy due to HVAC and lighting demands, while smaller residential buildings may have lower operational energy but relatively higher embodied energy.
- Lifespan: Longer-lasting buildings accumulate more operational energy over time.
 Shorter-lived buildings may see a higher proportion of their total energy as embodied energy.
- **Location**: Climate affects operational energy, with buildings in extreme climates using more energy for heating or cooling. Local availability of materials and construction practices also influence embodied energy.





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Impacts of Embodied and Operational Energy on Carbon Emissions

Relationship Between Embodied Energy and Carbon Emissions

Embodied energy is closely linked to carbon emissions, as the energy consumed during material extraction, manufacturing, and construction often derives from fossil fuels. The **carbon footprint** associated with embodied energy reflects the total greenhouse gas (GHG) emissions generated during these processes. For example, the production of cement and steel has a particularly high embodied carbon due to the energy-intensive methods involved. Reducing embodied energy through sustainable material choices and efficient manufacturing processes directly decreases the associated carbon emissions.

Role of Operational Energy in Greenhouse Gas (GHG) Emissions

Operational energy primarily impacts GHG emissions during the building's use phase. Energy consumption for heating, cooling, lighting, and appliances usually relies on electricity and fossil fuels, contributing to ongoing emissions. Buildings that are inefficient in their energy use generate higher operational carbon footprints over their lifespan. By implementing energy-efficient technologies and renewable energy sources, operational energy consumption—and therefore associated emissions—can be significantly reduced.

Embodied vs. Operational Carbon Footprints Over a Building's Life Cycle

The comparison of embodied and operational carbon footprints over a building's life cycle highlights important trends:

- **Embodied Carbon Footprint**: This is a one-time carbon emission represented at the beginning of a building's life and accumulates from the production and transportation of materials. For many buildings, this footprint can be substantial, especially in resource-intensive structures.
- **Operational Carbon Footprint**: This footprint continues to accumulate throughout the building's operational life, reflecting ongoing energy use. In many buildings, operational emissions can surpass embodied emissions over the lifespan, particularly if the building is used for several decades.

In energy-efficient designs, the embodied carbon may represent a larger percentage of the total carbon footprint as operational emissions decrease. Ultimately, understanding both embodied and operational carbon footprints is essential for assessing the overall environmental impact of buildings and informing strategies for reducing GHG emissions throughout their life cycles.



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Strategies to reduce Embodied Energy in Buildings

Use of Sustainable Materials:

• Opt for recycled or low-energy materials that require less energy for production, such as bamboo, reclaimed wood, and recycled steel.

Efficient Material Selection and Sourcing:

 Choose locally sourced materials to minimize transportation energy and carbon emissions; prioritize materials with lower embodied energy profiles.

Modular and Prefabricated Construction Methods:

• Implement modular construction techniques that allow for off-site fabrication, reducing waste and energy consumption during the construction process.

Life Cycle Design Principles:

 Apply life cycle thinking in design to evaluate and minimize embodied energy impacts from the outset, focusing on long-lasting and adaptable designs.

Material Reuse and Recycling Strategies at the End of Life:

 Develop plans for deconstruction that prioritize the reuse and recycling of building materials, reducing waste and embodied energy in future constructions.

Strategies to reduce Operational Energy in Buildings

Energy-Efficient Building Design:

• Incorporate passive design principles, effective insulation, and strategic window placement to maximize natural light and minimize energy loss.

Use of Renewable Energy:

• Install solar panels, wind turbines, or geothermal systems to generate clean energy and reduce reliance on fossil fuels.

Smart Building Management Systems (BMS):

• Implement BMS for real-time energy monitoring, automated controls, and optimization of HVAC, lighting, and other systems.

Integration of Energy-Efficient Appliances and Lighting:

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• Use ENERGY STAR-rated appliances and LED lighting to lower energy consumption significantly.

Retrofitting Existing Buildings:

• Upgrade insulation, HVAC systems, and windows in existing buildings to improve energy efficiency and reduce operational energy use.

Case Studies

Example 1: Bullitt Center, Seattle

The Bullitt Center is often referred to as the "greenest commercial building in the world." This net-zero energy building features sustainable design practices that minimize both embodied and operational energy. It utilizes renewable energy sources, including solar panels, and emphasizes the use of locally sourced, sustainable materials. The building's design incorporates extensive natural lighting and ventilation, significantly reducing operational energy consumption.

Example 2: One Angel Square, Manchester

One Angel Square is recognized for its commitment to low embodied carbon. This innovative office building was constructed using sustainable materials with reduced carbon footprints, including recycled content. It employs energy-efficient systems and renewable energy sources, allowing it to achieve significant operational energy savings. The design prioritizes sustainability, making it a benchmark for environmentally responsible construction in urban settings.

Example 3: Edge Building, Amsterdam

The Edge Building is celebrated for its advanced smart building technologies. Designed to optimize energy efficiency, it incorporates intelligent systems for lighting, heating, and cooling that adapt based on occupancy and environmental conditions. The building features extensive use of renewable energy, minimizing its operational energy footprint. Its innovative design and technology integration make it a leader in sustainable urban architecture.





Future Trends

The Role of Circular Economy in Reducing Embodied Energy

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The circular economy promotes the sustainable use of resources by designing buildings for reuse, recycling, and regeneration. By emphasizing material lifecycle, buildings can be constructed with lower embodied energy through the use of recycled materials and the design of products that can be easily disassembled and reused. This approach not only reduces waste but also minimizes the demand for new raw materials, contributing to lower carbon emissions.

Net-Zero Energy Buildings and the Move Toward Carbon Neutrality

Net-zero energy buildings (NZEBs) are designed to produce as much energy as they consume over a year, typically incorporating renewable energy systems like solar or wind. The increasing focus on carbon neutrality aims to reduce both operational and embodied energy, leading to substantial reductions in overall carbon footprints. This trend is driving innovation in building design, materials, and energy systems, making NZEBs a central goal in sustainable architecture.

Role of Technology and Innovation in Improving Energy Efficiency

Advancements in technology play a crucial role in enhancing energy efficiency in buildings. Innovations such as smart grids, energy management systems, and IoT devices allow for real-time monitoring and optimization of energy use. Additionally, new construction materials and methods, such as 3D printing and advanced insulation technologies, are helping to reduce both embodied and operational energy significantly.

Challenges

- Cost and Availability of Sustainable Materials: Sustainable materials can be
 more expensive and less readily available than conventional materials, making them
 less appealing to builders and developers.
- Lack of Standardized LCA Data and Methodologies: Inconsistent LCA data complicates the assessment of embodied energy, making it difficult to compare materials and designs accurately. Standardized methodologies are needed for reliable evaluations.
- Barriers to Adopting Renewable Energy in Older Buildings: Retrofitting
 existing structures to accommodate renewable energy technologies can be
 challenging due to structural limitations, costs, and regulations.
- Regulatory and Policy Challenges: Existing building codes and regulations may
 not prioritize sustainability, creating barriers to the adoption of energy-efficient
 practices and technologies. Advocating for updated policies is essential for fostering
 innovation in the building sector.

Conclusion

Addressing both embodied and operational energy is critical for reducing the overall environmental impact of buildings. By minimizing energy consumption throughout a

prenty

building's lifecycle, we can significantly decrease carbon emissions and contribute to global sustainability goals.

- 1. Emphasize sustainable material selection and lifecycle assessments in design
- 2. Adopt net-zero energy and circular economy principles to enhance resource efficiency.
- 3. Invest in smart technologies and renewable energy systems to optimize energy use.

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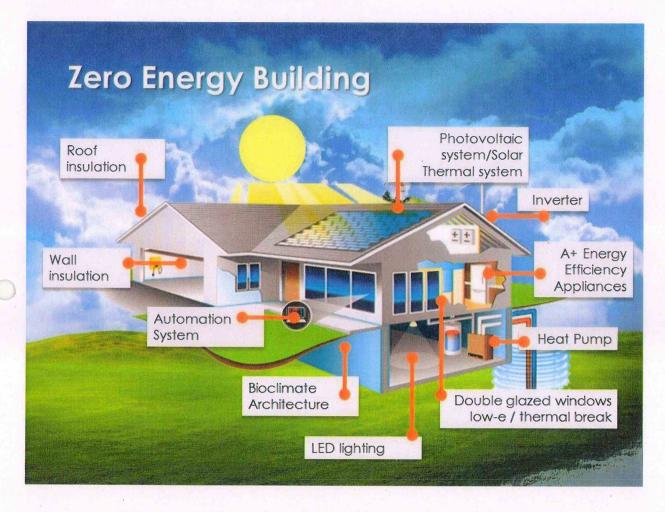
NETZERO ENERGY

CASE STUDIES

ANNANYA BINDAL 220BARCH016

INTRODUCTION

NET-ZERO ENERGY BUILDINGS



- A zero net energy building is designed to ensure zero net consumption, which means the total amount of energy consumed by the building annually
 - should roughly equal the amount of renewable energy created on site.
- The construction of these buildings has gained prominence in the last few years, since they contribute significantly to reducing greenhouse emissions.
 - The construction of zero net energy buildings is encouraged as nations seek ways of minimizing their carbon footprint

Below are case studies of two such buildings—one in India and one internationally—that exemplify this concept.

TATA CONSULTANCY SERVICES (TCS) "SMART" BUILDING, MUMBAI, INDIA



Tata Consultancy Services (TCS), one of India's largest and most influential IT service providers, has long been committed to sustainability and innovation in its building infrastructure.

In keeping with its corporate sustainability goals, TCS has taken significant steps to design and construct Zero Energy Net Buildings (ZENBs) in various locations, including its campus in Mumbai.

These buildings aim to produce as much energy as they consume on an annual basis, contributing to reducing the company's carbon footprint and improving energy efficiency.

BJECTIVES

CS's initiative to develop Zero Energy Net Buildings at its Mumbai compus is part of a broader vision to promote environmental sustainability.

Energy Independence: Achieve net-zero energy consumption by producing enough renewable energy to meet the building's energy needs.

Reduce Carbon Footprint: Significantly lower the operational carbon footprint of TCS's buildings.

Innovative Design and Technology: Integrate cutting-edge sustainable technologies, energy-efficient designs, and renewable energy solutions.

Sustainability Leadership: Position TCS as a leader in sustainable IT infrastructure by setting a precedent for green buildings in the corporate sector.

DESIGN AND CONSTRUCTION FEATURES



1. Building Envelope Optimization

- o Thermal Insulation: The buildings at TCS's Mumbai campus are designed with high-performance insulation materials to reduce heat gain and loss. This helps to minimize the need for artificial heating or cooling.
- o Energy-Efficient Windows: Double-glazed, low-emissivity glass windows were installed to optimize natural light while preventing unwanted heat from entering or escaping. This reduces the load on air-conditioning systems.

Energy Efficient HVAC Systems

o Variable Refrigerant Flow (VRF) Systems: TCS's ZENB buildings use advanced VRF systems for heating, ventilation, and air conditioning (HVAC), which adjust the flow of refrigerant based on the demand in different zones. This allows for better energy efficiency compared to traditional systems

o Smart Thermostats and Sensors: These systems allow for real-time monitoring and optimization of the building's internal climate, ensuring that

energy is only consumed when needed.



3. enewable Energy Integration

- o Solar Panels: The most prominent feature of the ZENB is its large-scale solar photovoltaic (PV) array on the roof. The solar panels generate renewable energy that is used to power the building's operations. TCS's Mumbai campus has invested in an array that can generate a significant percentage of the energy required for the building, helping to achieve a net-zero energy goal.
- o Energy Storage: To ensure energy availability even when solar generation is low (e.g., at night), the buildings are equipped with energy storage systems like lithium-ion batteries, which store excess energy produced during the day for use at night or during cloudy weather.

4.Lighting Systems

 LED Lighting: Energy-efficient LED lighting systems, with motion sensors and daylight harvesting features, ensure that lights are only used when necessary and adjust to available natural light, further reducing energy consumption.

 Automated Controls: The lighting systems are integrated with building management systems (BMS) that track usage and adjust in eal-time,

contributing to overall energy efficiency

5. Water Efficiency

- Rainwater Harvesting: TCS's ZENB includes rainwater harvesting systems the
 collect and store rainwater for non-potable uses like irrigation, cooling, and
 toilet flushing. This reduces the building's dependence on municipal water
 supplies and lowers its overall environmental impact.
- Low-flow Fixtures: To minimize water wastage, low-flow faucets and watersaving toilets are installed across the building.

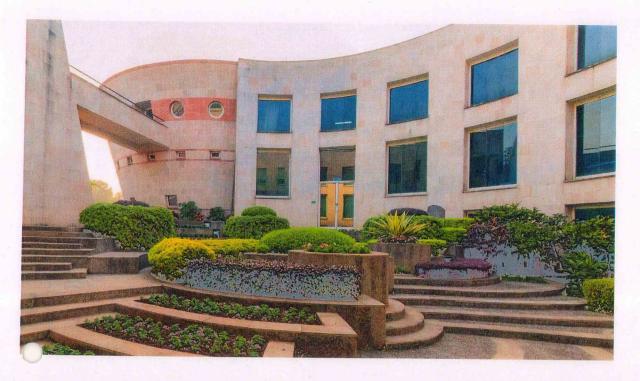
6. Smart Building Management

- Building Management System (BMS): The BMS allows real-time monitoring and control of energy consumption across various building systems. The system tracks energy use patterns, weather conditions, and occupancy data to optimize heating, lighting, and cooling in response to actual needs.
- Predictive Maintenance: Through sensors and IoT-enabled systems, the building's operations are continually monitored, and predictive analytics are used to perform maintenance before issues arise, ensuring that the building systems continue to run efficiently.

Environmental and Energy Impact

- Energy Generation vs. Consumption: The TCS ZENBs are designed to balance
 their energy usage with self-generated renewable energy. Solar PV installations
 on the building's rooftops produce a substantial portion of the energy needed,
 contributing to a net-zero energy status. The buildings' energy consumption is
 also carefully managed through a combination of energy-efficient systems,
 reducing demand and maximizing the effectiveness of the renewable energy
 produced.
- Reduction in Carbon Emissions: By integrating renewable energy sources and energy-efficient systems, TCS has significantly reduced its carbon emissions. The ZENB initiative helps offset the emissions that would otherwise be generated by traditional energy sources, particularly from fossil fuel-based electricity.
- Operational Savings: Although the initial cost of developing zero-energy buildings is typically higher, the long-term savings are significant. Reduced energy costs, lower water usage, and fewer maintenance requirements result in financial savings over time, making ZENBs a smart investment for TCS's operations.

KEY FEATURES AND STRATEGIES

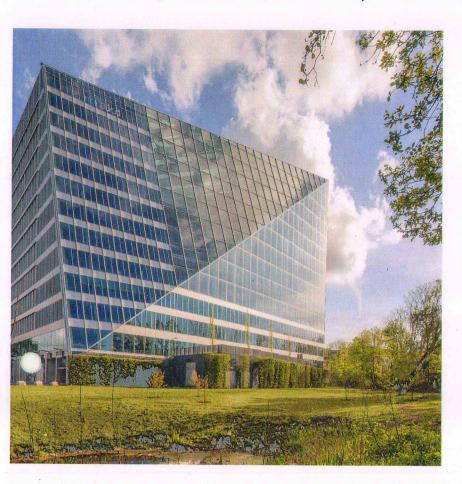


- Energy-Efficient Design: The building is designed to minimize heat gain from the sun using a combination of orientation, shading, and glazing techniques. Large overhangs and high-performance glass help control the solar heat gain.
- Natural Ventilation: A sophisticated passive cooling system using natural ventilation ensures the building uses less energy for air conditioning, reducing its dependence on mechanical cooling.
- Energy-Efficient Lighting: The building uses LED lighting and occupancy sensors that ensure lights are only on when needed, significantly reducing electricity consumption.
- Solar Panels: Rooftop solar panels are installed to harness renewable energy.

 The energy generated is used to meet the building's needs, contributing to its goal of net-zero energy consumption.
- Water Management: Rainwater harvesting and the use of recycled water for landscaping and non-potable uses help conserve water resources and reduce the building's environmental impact.

The TCS Smart Building highlights the importance of integrating passive design strategies (like natural ventilation and solar shading) with active renewable technologies (like solar panels) to achieve energy neutrality. This case study also emphasizes the role of efficient lighting, water management, and materials selection in reducing a building's overall environmental lootpant.

prove



The Edge is a globally recognized example of a smart, energy-efficient office building, located in Amsterdam. It is designed to be one of the most sustainable and energy-efficient buildings in the world, with a strong focus on minimizing environmental impact while enhancing user comfort and productivity.

The Edge has become a global benchmark for integrating cutting-edge green building technologies with innovative design, and it has gained particular recognition for its efforts in achieving **Zero Energy Net (ZEN)** status

SMART BUILDING TECHNOLOGY

The edge building is not only sustainable but also incredibly smart, with a range of nigh-tech features that make it one of the most advanced buildings in the world. these include a smartphone app that allows workers to control their workspace, from adjusting the temperature

and lighting to booking meeting rooms and ordering food.

protui

OBJECTIVES

Energy Efficiency: Design a building that generates as much energy as it consumes over a year, making it a net-zero energy structure.

Sustainability Leadership: Showcase the potential of sustainable architecture, setting a new standard for green office buildings.

Fechnological Innovation: Incorporate the latest in building management, automation, and renewable energy technologies.

Well-being of Occupants: Create an environment that optimizes human performance, wellness, and comfort, powered by sustainable energy solutions.

Operational Cost Savings: Reduce the building's operational costs through energy officiency and smart management systems.

DESIGN AND CONSTRUCTION FEATURES





Building Envelope Design

Energy-Efficient Insulation: The Edge's design focuses on minimizing energy consumption by using high-performance insulation in its walls and roof, reducing neat loss and gaining from both the interior and exterior.

Thermal Mass and Glazing: The building incorporates a façade of **triple-glazed** windows with a high thermal mass that reduces the need for mechanical heating and cooling by absorbing and storing heat during the day and releasing it at night.

Shading Systems: Smart shading devices are integrated into the exterior of the building to minimize solar heat gain and prevent overheating while maximizing natural light intake.



Renewable Energy Generation

Solar Power: The Edge is equipped with **solar photovoltaic panels** installed on its roof and integrated into the building's design. These solar panels generate a significant proportion of the building's energy needs, ensuring that the building is argely self-sustaining in terms of its energy consumption.

Energy Storage: To optimize the use of the energy generated, The Edge incorporates pattery storage systems that store excess solar energy during the day for use at night or during periods of low sunlight.

On-site Combined Heat and Power (CHP): The Edge also utilizes a CHP system to produce both electricity and heat. This system uses natural gas but operates with much greater efficiency than conventional grid-based energy generation, making it part of the building's strategy to maintain low energy consumption while achieving sustainability goals.

Intelligent Building Management System (BMS)

Connected IoT Sensors: One of the most innovative aspects of The total is its **Internet of Things (IoT)-enabled**infrastructure. Sensors placed throughout the building monitor everything from occupancy and temperature to energy usage and building representations.

Data-Driven Energy Optimization: These sensors feed data into the building's pentral Building Management System (BMS), which uses advanced algorithms to optimize energy consumption. The system adjusts lighting, heating, ventilation, and air-conditioning (HVAC) based on real-time occupancy data, ensuring energy is used only when and where it's needed.

Predictive Maintenance: The BMS also helps with predictive maintenance, which nelps detect inefficiencies and equipment malfunctions before they lead to system failures or excessive energy usage.



• Energy-Efficient Lighting and HVAC Systems

LED Lighting: The building uses energy-efficient LED lighting that is controlled through a sophisticated system of motion sensors and daylight harvesting. These systems automatically adjust light levels according to occupancy and available natural light, further reducing unnecessary energy consumption.

Efficient HVAC: The Edge employs an advanced chilled beam system for cooling, which works by circulating chilled water through beams in the ceiling, efficiently cooling the air. This system is quieter and consumes less energy than traditional air-conditioning systems. It is combined with fresh air ventilation that helps optimize ndoor air quality.

Active Chilled Ceilings: To further reduce the reliance on mechanical cooling, the puilding integrates active chilled ceilings that use radiant cooling, absorbing heat from the occupants and their surroundings without creating excessive air movement or noise.

Water Efficiency and Conservation

Rainwater Harvesting: The Edge captures and reuses rainwater for non-potable applications such as irrigation, cooling, and flushing toilets. This system significantly reduces reliance on municipal water supplies.

Water-Efficient Fixtures: Low-flow fixtures and sensors are installed throughout the building to minimize water usage, contributing to its overall sustainability goals.

Building Design for Human Comfort and Well-being

Natural Light and Biophilic Design: The design of The Edge prioritizes natural daylight, with floor-to-ceiling windows that allow occupants to enjoy an abundance of natural light throughout the day. The building also incorporates biophilic design elements, including the use of plants and natural materials to create a healthier, more productive indoor environment.

Flexible Workspaces: The office spaces are designed to be highly flexible, catering to modern work styles with open-plan layouts, collaborative spaces, and access to natural ventilation and lighting.

Indoor Air Quality: Sensors monitor air quality in real-time, adjusting ventilation and air purification systems to maintain high standards of indoor air quality.

Energy and Environmental Impact

Energy Performance

Zero Energy Net Status: The Edge produces approximately the same amount of energy as it consumes over the course of a year, meeting the strict criteria of a Zero energy Net Building. This is achieved through a combination of energy-efficient design, renewable energy generation, and advanced energy management systems

Energy Savings: The building's intelligent systems help reduce overall energy nsumption, with advanced BMS allowing for granular control of energy use across all systems. Occupants also benefit from a healthier and more comfortable environment, while the building maintains low operating costs.

Carbon Emissions Reduction

The Edge significantly reduces its carbon footprint by relying heavily on renewable energy sources (solar power, rainwater harvesting) and incorporating efficient systems that minimize energy wastage. Its CHP system ensures that even natural gas use is as efficient as possible, further reducing emissions compared to conventional energy sources.

Russey



School of Art and Architecture - Sushant University

Odd Semester (Aug-Dec) 2024-25

End Term Assignment

Program: B.Arch.

Course Name: Allied Field 3 Faculty: Dr. Purva Mujumdar

Submission Deadline: 19.11.2024

Sem: 5

Course Code: 21BAR6AL31S

Maximum Marks: 30

Course Outcomes

CO1: Understand the role of materials in the Building sector and other disciplines.

CO2: Determine embodied energy and carbon content of buildings.

CO3: Explore performance rating of green buildings and zero energy building.

Assignment:

Q.1 (CO3) Explore the case studies (minimum two) of energy efficient and net zero energy buildings in India or globally. Provide important insights to the concept of net zero buildings through building's features and strategies planned.







ELECTIVE

NET ZERO ENERGY BUILDINGS

CASE STUDIES



Aarushi Agarwal 220BARCH010



ELECTIVE ASSIGNMENT

OVERVIEW

The term net zero refers to the balance between the amount of produced greenhouse gas and the amount removed from the atmosphere. The term Net Zero Energy Building (NZEB) are characterized as zero net energy consumption buildings i.e. the total sum of energy used annually by the buildings is approximately equal to the total sum of the renewable energy produced on site. Recently, the idea of NZEBs, has changed from the study to practice. There are only a limited number of highly productive builders at present. The construction of NZEBs is becoming more and more feasible owing to advancements in building technology, renewable energy systems and academic research. Iqbal (2004) defined NZEB as the term used for the building that incorporates available renewable energy technologies commercially with energy efficiency construction methods where no fossil fuels are consumed. Kilkis (2007) defined NZEB as a building, which has a total annual amount of zero energy transfer through the building during all electric and other transfers that occur during a particular time span. Laustsen (2008) gave the general definition for ZEB: zero-energy buildings do not use fossil fuels and rely entirely on solar and other renewable energy sources to meet their energy needs. Noguchi et al. (2008) defined NZEB as the house that consume as much as energy it produces over a certain period of time.

India is facing intimidating challenges in meeting its energy needs. If India continues with a sustained growth rate of 8% per annum, its primary energy supply will need to grow by 3 to 4 times, and electricity generation capacity/ supply by 5 to 6 times compared to 2003-04. It is estimated that by 2031-32, the country's power generation capacity of 800,000 MW would be required as against the installed capacity of 160,000 MW inclusive of all captive plants in 2006-07. It has been estimated that the country is currently facing an electricity shortage of 9.9% and a peak demand shortage of 16.6%.

the NZEB approach in a country can differ depending on the climate, the resources for (green) electricity in the grid, the heating and cooling grid infrastructures. To meet energy demands of building long term strategy needed which can increase energy efficiency levels and use of renewable energy resources. The main target is new buildings by using the energy conservation measures in construction, to make energy-efficient buildings or NZEBs. Net-zero energy buildings do not exist in isolation. Despite the multiple definitions of net-zero building. The wording —net-zero|| implies interaction with a surrounding energy grid. It is expected that the accounting of the selected metric (e.g., primary energy) over a relatively long period (typically a year), will yield a net balance close to zero Designing of an NZEB typically requires successful integration and optimization of several architectural concepts and strategies such as building orientation concerning sun path, natural ventilation, solar shading, day-lighting, solar heat gains, thermal comfort as well as the deployment of well-proven insulation practices, energy-efficient glazing, air conditioning.

CASE STUDY 1

INDIA'S FIRST NET ZERO ENERGY BUILDING: INDIRA PARVAJARAN 34AWAN

This is a project of the ministry of environment and forests for the construction of new office buildings at Aliganj, Jor Bagh Road, New Delhi. The project has been designed to make the net-zero energy building. First in government sector targeted for both ratings of green building (5 STAR GRIHA LEED India Platinum) The building has won awards such as the Adarsh/GRIHA of MNRE for ideal illustration of Integration of Renewable Energy Technologies. This new office building has been constructed in a composite zone. This building sets revolutionary change into conventional building

grange -

design. The building has been designed by CPWD by using an integrated design approach with the help of multi-disciplinary fields experts like Architect, Electric Consultant, HVAC Consultant, Plumbing Consultant, Green Building Consultant, Commissioning Authority, Landscape Consultant, Structure Consultant, and other project team members. The project team emphasized on the energy conservation measure at every step of building design and construction for reducing energy demand by using passive design strategies by providing windows with shadings which again provide adequate natural light with that landscape to reduce ambient temperature and for outdoor greenery access with that energy-efficient active systems. All the possible energy-efficient and conservation practices were adopted to lessen the energy load of the building and the remaining demand load was met by an onsite solar PV System of 930 kW capacity to make the building Net Zero Energy building.



Fig. 1: Indira Paryvaran Bhawan view

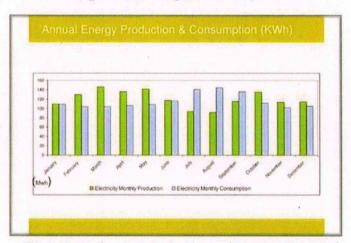


Fig. 2: Annual energy production and consumption graph

The energy consumption of Indira Paryavaran Bhawan is 67.3% less in comparison to the GRIHA benchmark. The project adopted numerous green building concepts for occupants' wellbeing and eco-friendly approaches like water conservation and rainwater harvesting. The building orientation set in the manner that it favors optimum solar access and shading. Two blocks facing north south direction have been arranged parallelly having a linear open court in the middle. Building front is a wider setback so that it can protect tree lines for occupant's outdoor view access.

Dary

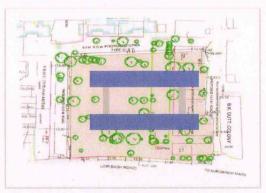


Fig. 3: Final design view of North-South blocks orientation and courtward

Native plants/trees were planted, and sprinklers and drip irrigation provided to reduce further water requirement. Local ecology was preserved as much as possible to maintain cooler microclimatic. Hard green spaces provided to elevate the greenery. Onsite STP with FAB/MBBR technology constructed to recycle the total water amount to create zero wastewater. Water consumption has been reduced by 64% by providing water-efficient fixtures. Building top, courtyard, and edges fully covered by the Solar PV panels which gives shading and create a cooler microclimate. Onsite solar energy capacity provides sufficient energy to meet the demand capacity of the building which plays an essential role to make the building Net Zero Energy Building.



Fig. 4: Onsite installed Solar PV Panels

Effective ventilation provided by orientating the building N-S and by optimum integration with nature which has been obtained by separating different blocks with connecting corridors and by providing a huge central courtyard.

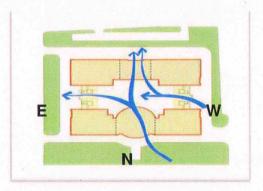


Fig.5: Effective ventilation pattern due to building design





Right

Indira Paryavaran Bhawan was designed in three stages by using an integrated design approach. All three stages -Passive design, Active design, and Renewable Design, elaborated below which helped in achieving the net-zero energy consumption of buildings.

PASSIVE DESIGN STRATEGIES:

Orientation: The building is north-south oriented, which is favourable for effective ventilation. Two separate blocks connected through corridors for optimum integration with nature and a huge central courtyard provided which again helps in better air circulation and provides skylight also. The courtyard has been provided with natural vegetation which reduces surrounding temperature, enhances air movement thus by cool air is preserved and hot air escapes easily and provides a green view. Orientation minimizes heat ingress. Window to wall ratio of the building is optimum according to the energy conservation benchmark.

Landscaping: Greater than 50% area outside the building is covered with plantation especially native plants that have been planted to reduce water consumption. Circulation roads and pathways are softly paved to enable groundwater recharge

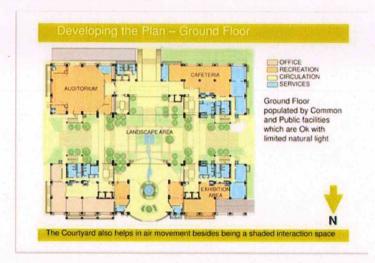


Fig. 6: Landscape designing of the courtyard

• **Ventilation**: Courtyard in the center of the building helps in air movement as natural ventilation happens due to the stack effect. Windows and jaalis add to cross ventilation.

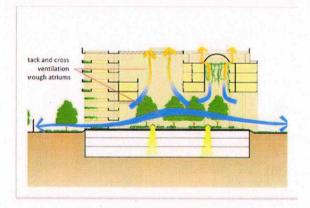


Fig. 7: Ventilation through the courtyard

Krars/

Daylighting: The courtyard provided with skylight which provides indoor natural sunlight. 75% of building floor space is provided with adequate daylight, consequently reducing dependence on artificial sources for lighting.

Building Envelope and Fenestration: Building Envelope Optimized, rock wool insulation used. The window uses high-efficiency low heat transmittance index double glazed glass of U-Value 0.049 W/m2K, VLT 0.59, SHGC 0.32. The hermetically sealed uPVC windows reduce incoming heat. Use of high reflectance terrace tiles (Cool roofs) or heat ingress, high strength, hardwearing.

Materials and construction techniques: Building constructed with the use of low embodied energy and a recycled content-based product like AAC blocks with fly ash, fly ash-based plaster & mortar. The building has been constructed by providing local stone flooring, bamboo jute composite doors, frames, and flooring. These products are of low embodied energy. High-efficiency glass, high VLT, low SHGC & Low U-value, optimized by appropriate shading which helps in energy efficiency. Light shelves have been provided for diffused sunlight. Stone and Ferro cement jaalis used.

ACTIVE DESIGN STRATEGIES:

The active design uses appliances and technologies to modify the state of the building, create comfort and energy, ie. Fans, pumps, etc. This is the main part where much of the energy conservation can be done.

Lighting Design: Building provided with an energy efficient lighting system that uses a lux level sensor to optimize the operation of artificial lighting. The total lighting power density of the building is LPD = 5 W/m2 which is much more efficient than Energy Conservation Building Code benchmarks. Installed integrated photovoltaic (BIPV) provides energy to the remaining lighting load.

Optimized Energy Systems / HVAC system: Building used chilled beam system to meet 160 TR of air conditioning load. The use of a chilled beam system lessens energy use by 50 % in comparison to a conventional system by saving AHU/FCU fan power consumption by approximately 50 kW. Chilled water is supplied at 16° C and the return temperature is 20° C. This system is used from second to the sixth floor in the building. Water-cooled chillers and double skin air handling units fitted equipped with variable frequency drivers (VFD) which reduces energy consumption on variable load. Chilled water pumping system, cooling tower fans, and AHUs use VFD. All HVAC equipment controlled & monitored through an integrated building management system. Sensible & latent heat energy recovery wheel used to precool fresh supply air from toilet exhaust air. Room temperature is maintained at 26 ±1 ° C which is again a brilliant step towards energy conservation. more efficient than ECBC requirements.





July

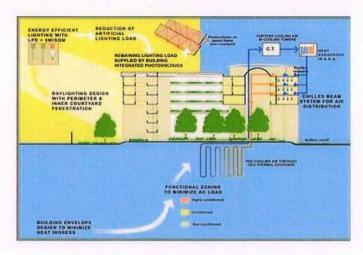


Fig. 8: Energy saving active design strategies (all in one)

The building used functional zoning to reduce air conditioning loads. With the chilled beams, drain pans are provided to drain out condensed water droplets. The overall HVAC load of the building is 40 m2/TR, which is 50%.

Geothermal Heat Exchange System: Geothermal system has been set up to meet the cooling requirement of the building which consists of 180 vertical bores to the depth of 80 meters with a minimum of 3 meters distant all over building premises. By the use of a Geothermal system, 160 TR of heat rejection is achieved without the use of a cooling tower. Each bore has an HDPE U-Loop pipe having 32mm outer diameter, connected to the condenser water pipe system in the central air conditioning plant room. Each U-loop grouted with Bentonite Slurry and one U-Loop has 0.9 TR heat rejection capacity.

RENEWABLE ENERGY:

The Indira Paryavarn Bhawan met the energy demand with the green and clean energy solution, Efficient Solar PV systems. The building has a solar PV system installed in a 6000 m2 area of 930 kW capacity. The total area covered by the panel is 4650 m2 by 2844 solar panels which generate 14.3 lakh unit annually which is huge in amount. This is the first govt. building in the country to achieve the landmark of net-zero energy building and one of the very few full fledged multifunctional office buildings in the world to do so on a tight urban site.

CASE STUDY 2

DEVELOPING A NET ZERO ENERGY BUILDING: A CASE STUDY OF AN INSTITUTION ALLIEGARY

INTRODUCTION

Building accounts for low energy 40 percent of the total energy consumption (GRIHA 2015). Indian building stock is increasing so do the energy consumption. The energy consumption in India is relatively low as compared to developed nations, but it is growing at the very high rate. To mitigate this issue energy efficiency measures and use of renewable energy is seen as solutions and will help in optimizing the energy use in the existing buildings. Low energy, near zero energy and net zero energy concepts, are coming which incorporate these two strategies. The definition of low-energy buildings is vague, and the primary energy demand for buildings depends upon country to country, For example, green buildings in central Europe is 65

kWh/m2/year for residential and 100 kWh/m2/year for office building whereas the passive house in Germany, Austria, Denmark have limit of 120 kWh/m2/year of maximum primary energy consumption (Kibert 2012). Further, The EPI value of institutes in composite climate is 117 kWh/m2/year (BEE 2017),so there is no standard definition. A zero energy building (ZEB) is a building (residential/ commercial) with greatly reduced energy performance index or energy utilization index and the energy need can be supplied with renewable energy technology, say solar photovoltaic (Torcellini et al. 2006). In recent years, researchers have tried to simulate office, residential, hospitals, etc.; Very few researchers have been done on library buildings of higher educational institutes. Library buildings belong to the large public building in which the energy consumption is significantly high. So, it provides a large area for investigation in this sector. For the study library building was taken up for finding the possibility of low energy-zero energy building. For validation purpose, PVsyst is used. PVsyst along with other whole building design software can be used for finding the likelihood of the low energy-zero energy status of building to reduce energy consumption respectively. Together these two strategies can act as twin pillars of energy policy for the institute. This study uses manual calculation for calculating the electricity requirement of the building and using PVsyst for finding the potential of implementation of the solar photovoltaic system. MNIT central library Jaipur was chosen as a case study which involves a two-story building.

BUILDING DESCRIPTION

The building of library used for study covers an area of 15,847 Sq. feet plinth area on two floors (Ground and first). The model of the library was created in eQUEST. The reading halls of the library are air-conditioned with glass partition. The library has separate stack halls for books, periodicals (current and bound volumes), videocassettes, Reference Section and book bank. Every day 1700 approx. users visit the library (www.mnit.ac.in). The model of institute library includes two stories. The floor-to-floor height is around 13 feet. The wall of the building is 15" stone masonry wall with low u value. The central lobby zone has skylight covering an area around 3.5% of the zone. The library has the various zones namely reading area, office area, computer lab area, central lobby, book stack area, etc. The reading area is located both in the ground and first-floor area. The building model created in eQUEST is shown in figure-1. Due to the operational characteristics of the university, the library is operational seven days a week with slight modification in timings on weekends. For simulation, purpose stepwise energy efficiency measures are used. The total built-up area used for simulation is 2850 sq. meter.

ENERGY CONSUMPTION PROFILE IN LIBRARY

Initially, the Energy Consumption in the library is calculated as per the reconnaissance survey. The inventory was prepared for types of electrical appliances used, their quantity, occupational time duration of users, etc., was done. The data collected through the survey is extrapolated for summer and winter months, weekdays and weekends. The detail of energy consumption in the library building is given in table 1.





Table-1: Electricity consumption profile of Institute Library

S. No.	Duration	Electricity Consumption (W/day)	Electricity Consumption (W/day)
1	Summer Week Day	1182087	1182.087
2	Summer (Weekend)	745397	745.397
3	Winter Week Day	250837	250837
4	Winter (Weekend)	220197	220197

(Source: author)

As per calculation total yearly electricity consumption comes out to be 274922 KW per year, which comes out to be Rs. 14 lacks (approximately) as Electricity bill for the Library. Even if we take only 70 percent of the appliance working simultaneously, the total electricity consumption comes around 200MWh/year. For 200MW/year,the EPI comes out to be 70 kWhr./m2/annum approximately. The calculation is done after considering the operating hours of thelibrary in summer months and winter months along with considering weekdays. A small energy efficiency intervention can lead to decrease in EPI value and hence increasing the building performance. Figure-1 represents the Google image of the library building.



Figure 1: Google Image of Central Library, MNIT Jaipur

Assumptions for the project

Few assumptions have taken up for the study:

- 1) The roof of the Library building was considered flat, and the skylight was presumed to be directly overlooking the central lobby.
- 2) The open to sky area between main library building and old book bank area is taken up as covered unconditioned space for the simulation purpose.
- 3) The building footprint is taken with the help of reconnaissance survey and Google earth imagery. The sizes of the different area taken for simulation purpose within the library are close to actual areas.
- 4) The goal is to make library building energy efficient along the lines of NZEB. However, the electricity demand is more and area of the building is limited, so it's not possible to go for full implementation of NZEB criteria.

ENERGY EFFICIENCY MEASURES-EQUEST

Provo

The Central Library is designed with traditional wisdom incorporating thick walls, fewer windows on west façade, sufficient floor to floor height and simulation shows the EPI of 70 kWh/m2/year which is below the norms set by Bureau of energy efficiency. The central lobby has a vertical skylight which was difficult to model and hence flat roof with horizontal skylight were considered for simulation purpose. There is the good provision of daylight in building decreasing the necessity of artificial light. Though the low watt LED, light can be used in place of existing 40-wattfluorescent tube light.

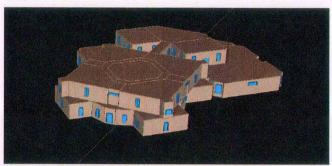


Figure 2: The 3D drawing of Central Library, MNIT Jaipur

RENEWABLE ENERGY-PVSYST

The solar photovoltaic panels simulated to produce some of the electricity that can be used in the building. For this simulation purpose, PVsyst software is used. Table 2 provides the typical losses occurred in PV Connections as per NREL

Table 2: Detail of losses in PV connection as per NREL

S. No.	Losses	Loss Fraction
1	Estimated System Losses	14.08%
2	Soiling (%)	2
3	Shading (%)	3
4	Snow (%): 0	0
5	Mismatch (%)	2
6	Wiring (%)	0.5
7	Connections (%)	0.5
8	Light-Induced Degradation (%)	1.5
9	Nameplate Rating (%)	1
10	Age (%)	0
11	Availability (%)	3

Source: http://pvwatts.nrel.gov/India/pvwatts.php

For the project 240 Wp26 V Si-mono of Helios Technology was found to be appropriate through various iterations done on PVsyst. For theinverter, Trannergy company inverter was found suitable. A total number of 10 kW inverter is 6. Each inverter has 2 MPPT inputs.

RESULT

It was found that 94.42 MWhr. /annum electricity can be generated by 431-meter square PV installation covering 500 sq. the meter of the roof of the building. That electricity generated from photovoltaic panels is equal to 47.21 percent of the total electricity consumption of the building. Further, if photovoltaic panels on southern and western façade are integrated along with using the surrounding area around library building (which should be free from any obstacle and

Baro

having good solar access) can be used for photovoltaic electricity generation. Thus if proper energy efficiency measures are used along with solar photovoltaic panels, the library building can be made low energy building.

CASE STUDY 3

THE INDIAN INSTITUTE OF MANAGEMENT (IIM) - BANGALORE, INDIA

Location: Bangalore, India

Building Type: Educational Institution **Energy Target**: Net-Zero Energy Building

Completed: 2019

INTRODUCTION

The Indian Institute of Management (IIM) Bangalore academic block stands as a pioneering example of net-zero energy buildings (NZEB) in India. As one of the most renowned business schools in India, IIM Bangalore decided to incorporate sustainability principles into its campus by building a structure that generates as much energy as it consumes. This ambitious project integrates energy-efficient design, renewable energy systems, and sustainable practices to reduce its carbon footprint and serve as a model for sustainable building design in the Indian subcontinent.



PROJECT OVERVIEW

The IIM Bangalore academic block, which was completed in 2019, is India's first net-zero evergy building. It has been designed with a focus on minimizing energy consumption, maxim zing the use of renewable energy, and incorporating sustainable practices across its operations. By achieving real-zero energy, the building not only meets its own energy needs but also demonstrates how action green building technologies can be integrated into educational institutions in India.

The project was driven by IIM Bangalore's commitment to sustainability and environmental responsibility. The academic block integrates a wide range of features, including energy-efficient design strategies, solar energy systems, water conservation techniques, and waste management solutions, all of which work together to reduce the building's environmental impact.

DESIGN FEATURES AND SUSTAINABLE STRATEGIES

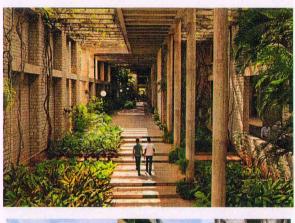
The success of the IIM Bangalore academic block lies in its integration of passive design strategies, renewable energy systems, and high-performance building components. Below are the key design features and strategies that contributed to achieving net-zero energy:

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ENERGY-EFFICIENT DESIGN

The building's design **optimizes passive cooling and daylighting**, which are fundamental strategies in minimizing energy consumption.

- Natural Ventilation: The building has been designed with ample cross-ventilation and natural
 airflow. Strategic window placement, combined with the building's orientation, ensures that
 natural ventilation is maximized, reducing the reliance on mechanical air-conditioning
 systems.
- Daylighting: The use of daylight harvesting significantly reduces the need for artificial lighting during the day. Large windows, strategically positioned skylights, and light shelves ensure that natural light penetrates deep into the building, minimizing energy use for lighting.
- Building Orientation: The academic block's orientation and layout have been carefully
 planned to minimize solar heat gain during the hotter parts of the day. The building's long
 sides face north and south, optimizing exposure to natural light while reducing the impact of
 the harsh afternoon sun.
- Passive Shading: Sunshades and louvers have been installed on the windows to reduce direct sunlight entering the building during peak hours, further reducing cooling loads.







RENEWABLE ENERGY SYSTEMS

The incorporation of renewable energy systems is a key strategy for achieving net-zero energy. The building relies on solar energy to meet its electricity needs and reduce its dependence on conventional power sources.

 Solar Photovoltaic (PV) Panels: A large array of solar photovoltaic panels is installed on the building's roof. These panels generate electricity by converting sunlight into usable power, making them one of the primary sources of renewable energy for the building. The

The street of th

installation has been carefully optimized for maximum energy production through appropriate panel orientation, tilt angles, and placement to maximize sunlight capture throughout the day.

 Solar Water Heating: The building also features solar thermal collectors for hot water generation, which reduces the need for conventional electric or gas-based water heating systems. These systems help meet the building's domestic hot water needs, such as for washrooms and kitchens, further reducing the overall energy consumption.

ENERGY STORAGE SYSTEMS

To ensure that the building can continue to meet its energy needs during non-sunny hours, the IIM Bangalore academic block incorporates energy storage systems. These systems store excess energy generated by the solar panels during the day, which can be used to power the building during the evening and night. This ensures that the building is able to achieve net-zero energy by balancing its energy consumption with renewable energy production over a 24-hour period.

HIGH-PERFORMANCE BUILDING ENVELOPE

The building envelope (walls, windows, roof, and foundation) plays a crucial role in improving energy efficiency by minimizing heat loss in winter and heat gain in summer.

- Thermal Insulation: The walls and roof of the building are designed with high-performance
 insulation materials that help reduce heat transfer. This helps to maintain a comfortable
 indoor temperature without the need for excessive heating or cooling.
- Low-Emissivity Windows: The windows are coated with Low-E glass to reduce the amount of solar heat entering the building while allowing maximum natural light to penetrate the interior. This is particularly effective in tropical climates like Bangalore, where solar heat gain can significantly increase cooling loads.

WATER CONSERVATION AND WASTE MANAGEMENT

The IIM Bangalore academic block incorporates water-efficient systems and sustainable waste management practices to minimize its ecological footprint.

- Rainwater Harvesting: A rainwater harvesting system is integrated into the building's design
 to collect and store rainwater for non-potable uses, such as landscaping and cooling. This
 reduces the building's reliance on municipal water supplies.
- Wastewater Recycling: The building employs an effective wastewater treatment system to recycle graywater for non-potable uses, such as toilet flushing and landscaping, further conserving water.
- Organic Waste Composting: Organic waste generated by the building's occupants is composted and converted into valuable organic fertilizer, which is used for landscaping within the campus.
- Recycling: The building incorporates dedicated recycling stations for paper, plastics, and metals, contributing to the reduction of landfill waste.

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CONCLUSION

The IIM Bangalore academic block is a landmark project in India's journey toward sustainable building practices and net-zero energy solutions. Through its innovative design, integration of renewable energy systems, and efficient use of resources, the building serves as a model for green buildings in the Indian educational sector and beyond.

By demonstrating that net-zero energy is achievable even in India's diverse climatic and economic conditions, the project highlights the importance of adopting holistic design principles and integrating sustainable technologies to achieve environmental goals. IIM Bangalore's commitment to sustainability not only supports the institution's academic mission but also contributes to India's efforts to address climate change and environmental degradation



RING

REFERENCES

(PDF) Developing a Net Zero Energy Building: A Case Study of an Institutional Library

 $\frac{https://ijstr.org/final-print/nov2020/Case-Study-Indias-First-Net-zero-Energy-Building-Indira-Paryavaran-Bhavan.pdf}{}$

Case Study of Net Zero Energy Buildings

Energy analysis of net zero energy buildings: a case study



Sushant University

ESE School of Art and Architecture

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B.Arch

Course Code:

Elective 3 (Intermediate) Dr. Purva Mujumdar **21BAR-6AL31S** Faculty Name: Course Name: Max Marks: A & B 5 Programme: Semester: Section: Date:

	S.NO.	Roll No.	Student Name	ESE Attendance	Internal 1 Mid-Term Marks	Internal 2 End-Term Marks	Total Marks	Permitted/ Debarred
	51			100	40	09	100	
	←	220BARCH010	Aarushi Agarwal	93.33	28	47	75	Permitted
TIS	2	220BARCH036	Abeer Bhasin	51.11	17	33	50	Debarred
	28	220BARCH022	Amritam	53.33	18	32	50	Debarred
de	7	220BARCH016	Annanya Bindal	93.33	22	45	29	Permitted
10	9 & C	220BARCH026	Chirag Yadav	84.44	27	51	78	Permitted
1	18	220BARCH062	Dhruv Dogra	33.33	16	25	41	Debarred
SUC	1	220BARCH047	Harshita Dang	93.33	30	52	82	Permitted
	90	220BARCH053	Ishita Gupta	84.44	34	53	87	Permitted
Chitos	6/	220BARCH001	Manaj Baweja	64.44	28	37	65	Debarred
1 DIV	0130	220BARCH048	Naveen Chauhan	51.11	18	32	50	Debarred
6	hant se	220BARCH054	Raghav Sethi	57.78	20	32	52	Debarred
7	152	220BARCH046	Rongsennukla Yaden	68.89	35	48	83	Debarred
)	813	220BARCH035	Ronnit Garg	26.67	26	0	26	Debarred
Woram.	14	220BARCH024	Rudra Pratap Singh	66.67	14	47	61	Debarred
	15	220BARCH006	Rushil Soni	93.33	27	44	71	Permitted
	16	220BARCH018	Shriya Khurana	80	30	54	84	Permitted
7 9	17	220BARCH005	Shweta Sharma	93.33	28	. 52	80	Permitted
70°	18	220BARCH008	Simran Thakran	93.33	33	37	70	Permitted
7	19	220BARCH015	Sudevi Gayen	93.33	29	49	78	Permitted

School of Art and Architecture

Assignment - 1

(Odd Semester 2024-25)

CO attainment (P/N)*100

Program: B.Arch.

Semester:

5 Assignment D

3.09.2024

Course

21BAR6AL31S

Course Name

Faculty Name: Allied

Dr. Purva

Code

Fields 3

Code:			Name: Fields 3		Name:	Mujumdar	
			化	Q1 (Marks)	Attainment CO1 (20 Marks)	Total Marks (20)	
S. No.	Enrolment No.	Student Name	Batch No	CO1 (20 Marks)			
1	220BARCH026	Chirag Yadav	2022-27	11	11	11	
2	220BARCH046	Rongsennukla Yaden	2022-27	18	18	18	
3	220BARCH016	Annanya bindal	2022-27	10	10	10	
4	220BARCH053	Ishita Gupta	2022-27	16	16	16	
5	220BARCH008	Simran thakran	2022-27	17	17	17	
6	220BARCH001	Manaj Baweja	2022-27	12	12	12	
7	220BARCH022	Amritam Gupta	2022-27	8	8	- 8	
8	220BARCH036	Abeer Bhasin	2022-27	7	7	7	
9	220BARCH048	Naveen Chauhan	2022-27	8	8	8	
10	220BARCH054	Raghav Sethi	2022-27	9	9	9	
11	220BARCH062	Dhruv Dogra	2022-27	6	6	6	
12	220BARCH010	Aarushi Agrawal	2022-27	11	11	11	
13	220BARCH047	Harshita Dang	2022-27	15	15	15	
14	220BARCH035	Ronnit Garg	2022-27	11	11	11	
15	220BARCH024	Rudra Pratap Singh	2022-27	0	0	0	
16	220BARCH006	Rushil Soni	2022-27	12	12	12	
17	220BARCH018	Shriya Khurana	2022-27	14	14	14	
18	220BARCH015	Sudevi Gayen	2022-27	16	16	16	
19	220BARCH005	Shweta Sharma	2022-27	12	12	12	
				Total Students	医右侧皮 排出法	19	
				Average	11.211	11.21	
				ssignment 1 (N)		18	
	Nu	mber of students scored	average% and	above marks (P)	9		

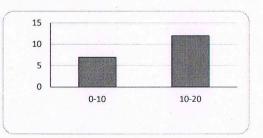
Average Marks	Max Marks	Min. Marks	Std Deviation	Less than 40%
11	18	0	4.39	5.56%

Students	0-10	10-20
Marks	0 10	10-20
Assignment	7	12

the later was a second of the		
Assessme	Attainment l	Levels
Assignme	Level1	Less than 50%
	Level2	50% to less than 60%
nt	Level3	more than 60%

Assessme	Attainment Levels		
Assignme nt	Levell	Less than 50%	
	Level2	50% to less than 60%	
	Level3	more than 60%	

CUA	CO Attainment Level				
COs	Attainment	Level			
CO1	LovelS	2			



50.00%



School of Art and Architecture

Mid Term Assignment

(Odd Semester 2024-25)

Program: B.Arch.

Semester:

5

Assignment Date

3.09.2024

Course Code:

21BAR6AL31S

Course Name:

Allied Fields 3 Faculty Name:

Dr. Purva Mujumdar

S. No.	Enrolment No.	No. Student Name	医 医复数	Q1 (Marks)	CO2 (20 Marks)	Total Marks (20)
			Batch No	CO2 (20 Marks)		
1	220BARCH026	Chirag Yadav	2022-27	16	16	16
2	220BARCH046	Rongsennukla Yaden	2022-27	17	17	17
3	220BARCH016	Annanya bindal	2022-27	12	12	12
4	220BARCH053	Ishita Gupta	2022-27	18	18	18
5	220BARCH008	Simran thakran	2022-27	16	16	16
6	220BARCH001	Manaj Baweja	2022-27	16	16	16
7	220BARCH022	Amritam Gupta	2022-27	10	10	10
8	220BARCH036	Abeer Bhasin	2022-27	10	10	10
9	220BARCH048	Naveen Chauhan	2022-27	10	10	10
10	220BARCH054	Raghav Sethi	2022-27	11	11	11
11	220BARCH062	Dhruv Dogra	2022-27	10	10	10
12	220BARCH010	Aarushi Agrawal	2022-27	17	17	17
13	220BARCH047	Harshita Dang	2022-27	15	15	15
14	220BARCH035	Ronnit Garg	2022-27	15	15	15
15	220BARCH024	Rudra Pratap Singh	2022-27	14	14	14
16	220BARCH006	Rushil Soni	2022-27	15	15	15
17	220BARCH018	Shriya Khurana	2022-27	16	16	16
18	220BARCH015	Sudevi Gayen	2022-27	13	13	13
19	220BARCH005	Shweta Sharma	2022-27	16	16	16
				Total Students		19
				Average	14.053	14.05
		Total Stu-	dents Appeared In	Assignment 1 (N)		19
		Number of students s			11	
			CO atta	inment (P/N)*100	57.89%	

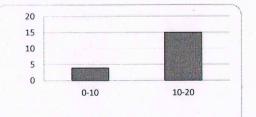
Average Marks	Max Marks	Min. Marks	Std Deviation	Less than 40%
14	18	10	2.74	0.00%

Students Marks	0-10	10-20
Assignment	4	15

Assessmen	Attainment I	Levels
A saionman	Levell	Less than 50% students
Assignmen	Level2	50% to less than 60%
L .	Level3	more than 60% students

CO	Atta	inm	ont	Level	

COs	Attainmen	t Level	
CO2	Level 2	2	





School of Art and Architecture

Assignment 3

(Odd Semester 2024-25)

Program: B.Arch.

Semester:

Assignment Date

3.09.2024

Course Coc 21BAR6AL31S

Course Name:

Allied Fields 3 Faculty Name:

Dr. Purva Mujumdar

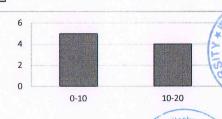
Landau attache			Widjulidai			
S. No.	Enrolment No.	Student Name	Batch No	Q1 (Marks)	Attainment	Total Marks (30
				CO2 (30 Marks)	CO2 (30 Marks)	
1	220BARCH026	Chirag Yadav	2022-27	24	24	24
2	220BARCH046	Rongsennukla Yaden	2022-27	25	25	25
3	220BARCH016	Annanya bindal	2022-27	23	23	23
4	220BARCH053	Ishita Gupta	2022-27	28	28	28
5	220BARCH008	Simran thakran	2022-27	15	15	15
6	220BARCH001	Manaj Baweja	2022-27	10	10	10
7	220BARCH022	Amritam Gupta	2022-27	10	10	10
8	220BARCH036	Abeer Bhasin	2022-27	13	13	13
9	220BARCH048	Naveen Chauhan	2022-27	17	17	17
10	220BARCH054	Raghav Sethi	2022-27	10	10	10
11	220BARCH062	Dhruv Dogra	2022-27	10	10	10
12	220BARCH010	Aarushi Agrawal	2022-27	24	24	24
13	220BARCH047	Harshita Dang	2022-27	24	24	24
14	220BARCH035	Ronnit Garg	2022-27	0	0	0
15	220BARCH024	Rudra Pratap Singh	2022-27	22	22	22
16	220BARCH006	Rushil Soni	2022-27	20	20	20
17	220BARCH018	Shriya Khurana	2022-27	29	29	29
18	220BARCH015	Sudevi Gayen	2022-27	24	24	24
19	220BARCH005	Shweta Sharma	2022-27	. 25	25	25
				Total Students	4 - 4 1 2 2 2 2	19
				Average	18.579	18.58
			tudents Appeared In A s scored average% and		11	18
		Tramper of students		ment (P/N)*100	61.11%	
			CO attain	ment (1 / 14) · 100	01.11/0	

Average Marks	Max Marks	Min. Marks	Std Deviation	Less than 40%
19	29		7.88	5.56%

Students Marks	0-10	10-20	20-30
Assignment	5	4	10

Assessment	Attainment Leve	els
A aai amman	Level 1	Less than 5070 students scoring
Assignmen	Level2	3070 to less than 0070 students
ι	Level3	more than 00% students scoring

COA	ttainment Level	
COs		Attainment Level
CO2	Lovel 2	2



Rover

School of Art and Architecture

End-Term Examination (Odd Semester 2024-25)

Program: B.Arch.

Semester:

Assignment Date

Course Cod 21BAR6AL31S

Course Nam Allied Fields 3 Faculty Name:

Mujumdar

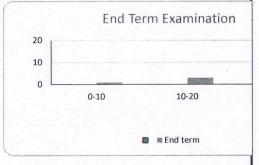
ourse Coc 21DAROAL515		Course Ivalii	Ailled Fleids 3	racuity Ivaille.	Mujumar				
S. No. Enrolment No.		Student Name	Batch No	Q1 (30 Marks) CO3 (30 Marks)	Attainment CO3 (30Marks)	Total Mark (30 Marks			
1	acon a programa (Cl: V l	2022-27	27	27	27			
1	220BARCH026	Chirag Yadav			23				
2	220BARCH046	Rongsennukla Yaden	2022-27	23		23			
3	220BARCH016	Annanya bindal	2022-27	22	22	22			
4	220BARCH053	Ishita Gupta	2022-27	25	25	25			
5	220BARCH008	Simran thakran	2022-27	22	22	. 22			
6	220BARCH001	Manaj Baweja	2022-27	27	27	27			
7	220BARCH022	Amritam Gupta	. 2022-27	22	22	22			
8	220BARCH036	Abeer Bhasin	2022-27	20	20	20			
9	220BARCH048	Naveen Chauhan	RCH048 Naveen Chauhan	220BARCH048 Naveen Chauhan	20BARCH048 Naveen Chauhan 2022-27	2022-27	15	15	15
10	220BARCH054	Raghav Sethi	2022-27	22 15	22 15	22			
11	220BARCH062	Dhruv Dogra	2022-27			15			
12	220BARCH010	Aarushi Agrawal	2022-27	23	23	23			
13	220BARCH047	Harshita Dang	2022-27	28	28	28			
14	220BARCH035	Ronnit Garg	2022-27	0	0	0			
15	220BARCH024	Rudra Pratap Singh	2022-27	25	25	- 25			
16	220BARCH006	Rushil Soni	2022-27	24	24	24			
17	220BARCH018	Shriya Khurana	2022-27	25	25	25			
18	220BARCH015	Sudevi Gayen	2022-27	25	25	25			
19	220BARCH005	Shweta Sharma	2022-27	27	27	27			
35									
					Total Students	19			
				Average	21.947	21.95			
					In Assignment 1 (N)	18			
		Number of stud	ents scored average%		and the second second				
			CO at	ttainment (P/N)*100	83.33%				

Average Marks	Max Marks	Min. Marks	Std Deviation	More than 90%
22	28	0	6.24	0.0%

Students	0-10	10-20	20-30
Marks			3
End term	1	3 (4)	15

Assessmen	Attainment Levels	
	Level1	Less than 50% students scoring
End term	Level2	50% to less than 60% students
	Level3	more than 60% students scoring

CO A	ttainment Level		
COs	At	tainment Level	
CO3	Level 3	3	







					Total	LOIAL	2	5	3	1 E 1 E 1 E 1 E 1 E 1 E 1 E 1 E 1 E 1 E					
	5)	Sem: Course Code: 21BAR6AL31S Date of Analysis:				End Term	0	3	3	nal)	· 医多种 医多种 医多种	Total	8.0	2.6	1.8
ERSITY	rchitecture nester 2024-2	Sem: Course Code: 211 Date of Analysis:	nent (Internal)	Term 60	t Tools	End				Internal+Exter	ernal 0	End Term (ESE)	0	3	3
SUSHANT UNIVERSITY	School of Art and Architecture Result Analysis (Odd Semester 2024-25)	B.Arch. Allied Fields 3 Dr. Purva Mujumdar	Consolidated CO Attainment (Internal)	Mid term 40: End Term 60	Assessment Tools	Mid-Term	2	2	0	Consolidated CO Attainment (Internal+External)	Internal 100: External 0	Internal (Mid term)	2	2	0
		Program: Course Name: Faculty Name:				SOO	C01	C02	CO3			soo	CO1	C02	CO3





Presson Nec

School of		Architecture-			y, Guru	gram	
	Acad	lemic Year - Oc	ld Semes	ter- 2024-25			
		Course E	xit Surve	y			
Program: Course Name: Faculty Name:	B.Arch. Allied Fie Dr. Purva	lds 3 Mujumdar		Sem: Course Code: Date of Surve		21BAR6AL31S	
		CO1		CO2		CO3	
Student Full Name	Exit survey	Attainment of CO1	Exit survey	Attainment of CO2	Exit survey	Attainment of CO3	
Chirag Yadav	Excellent	20	Excellent	20	Excellent	20	
Rongsennukla Yaden	Excellent	20	Excellent	20	Excellent	20	
Annanya bindal	Excellent	20	Excellent	20	Excellent	20	
Ishita Gupta	Excellent	20	Excellent	20	Excellent	20	
Simran thakran	Excellent	20	Excellent	20	Excellent	20	
Manaj Baweja	Excellent	20	Excellent	20	Excellent	20	
Amritam Gupta	Satisfactory	11	Satisfactory	11	Satisfactory	11	
Abeer Bhasin	Satisfactory	11	Satisfactory	11	Satisfactory	-11	
Naveen Chauhan	Satisfactory	11	Satisfactory	11	Satisfactory	11	
Raghav Sethi	Excellent	20	Excellent	20	Excellent	20	
Dhruv Dogra	Satisfactory	11	Satisfactory	11	Satisfactory	11	
Aarushi Agrawal	Excellent	20	Excellent	20	Excellent	20	
Harshita Dang	Excellent	20	Excellent	20	Excellent	20	
Ronnit Garg	Satisfactory	11	Satisfactory	11	Satisfactory	11	
Rudra Pratap Singh	Excellent	20	Excellent	20	Excellent	20	
Rushil Soni	Excellent	20	Excellent	20	Excellent	20	
Shriya Khurana	Excellent	20	Excellent	20	Excellent	20	
Sudevi Gayen	Excellent	20	Excellent	20	Excellent	20	
Shweta Sharma	Excellent	20	Excellent	20	Excellent	20	
Average		17.54		17.54		17.54	
No of students >=Avg		14		14		14	
Total students		19		19		19	
Attainment Level (%)		73.68%		73.68%		73.68%	
Attainment Level		3		3		3	

Assessment Methods		Attainment Levels	
	Level1	Less than 50% students scoring more than average% marks.	
Assessment	Level2	50% to less than 60% students scoring more than average % marks.	
	Level3	more than 60% students scoring more than average % marks in internal assessment tools	

CO	Attainment Level	
COs	Attainment Level	
CO1	Level 3	3
CO2	Level 3	3
CO3	Level 3	3







School of Art and Architecture CO Attainment (Odd Semester- 2024-25)

Program:

B.Arch.

Sem:

Course Name: Allied Fields 3

Course Code:

21BAR6AL31S

Faculty Name: Dr. Purva Mujumdar

Date of Analysis:

COs	Direct (80%)	Indirect (20%)	Total (100%)
CO1	0.8	3	1.24
CO2	2.6	3	2.68
CO3	1.8	3	2.04





Preva

School of Art and Architecture CO-PO-PSO Mapping (Odd Semester - 2024-25)

Program: Course Name: Faculty Name:

Course Code:

21BAR6AL31S

B.Arch.
Allied Fields 3
Dr. Purva Mujumdar

Date of Analysis:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	1	2	1	2	2	1	2	2	1	1	2	1	1
CO2	3	1	2	11	1 1	2	1	1	2	2	1	2	1.
CO3	1	2	1	1	2	1	2	1	1	1	1	1	2

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	1.84	2.48	1.24	2.48	2.48	1.24	2.48	2.48	1.24	1.24	2.48	1.24	1.24
CO2	8.04	2.68	5.36	2.68	2.68	5.36	2.68	2.68	5.36	5.36	2.68	5.36	2.68
CO3	2.04	4.08	2.04	2.04	4.08	2.04	4.08	2.04	2.04	2.04	2.04	2.04	4.08
Attainment	2.38	1.85	2.16	1.80	1.85	2.16	1.85	1.80	2.16	2.16	1.80	2.16	2.00





West 1

||Sushant ||University

Academic Year 2023-2024



School of Art and Architecture , Sushant University Course File Acdemic Session: Even semester 2023-24 Program: B.Arch Sem: 4 Course Name: Ruilding Services 2 Course Code: 19BAR-3BS22T Faculty Name: Prerana H





Course Activity Sheet (Planning and Review)

Academic Year 2023 - 24
Programme B. ARCH
SemesterL.V.
Course Name BWING SERVICES 2
Course Code 19BAR - 3B522T
School SCHOOL OF ART AND ARCHITECTURE
Faculty ASST. PROF POFRANA M

Planning Checklist

S. No	Activity	Status
1	Is the syllabus copy maintained and submitted by the faculty member?	Yes/No
2	Is lecture plan signed and updated by the faculty member?	/
3	Is Time Table made available?	
4	Number of Assignments planned	4
5	Number of quiz planned	
6	Digital Learning LX (Review) Is it updated with following (suggestive): Syllabus Reference material Quiz/Assignment	Yes
7	Is mapping of students available on ERP along with the timetable?	/
8	Suggest atleast one innovative way for better engagement of students in this course	Can include hands on workshops

(Signature of Faculty Member with Date)

(Signature of Dean with Date)





Mid-Semester Review

S.No	Activity	Status
1.	Is the attendance updated on ERP?	Yes/No
2.	Percentage of students who are not meeting the attendance criteria of 75%	43.4%.
3.	Pass percentage in Internal Assessment so far	100 1.
4.	Identification and motivation advanced learners (Advanced learner sheet attached)	700
5.	Identification and remedial classes for slow learners (Slow learner sheet attached)	Yes.

Course	Conau	itig 6	s pe	plan	Till
myd te	chu				
					••••••
			•••••••••••••••••••••••••••••••••••••••		vchil
					8 ALL

(Signature of Faculty Member with Date)

(Signature of Dean with Date)







End-Semester Review

Activity	Status
Is the attendance updated on ERP?	√es/No
Percentage of students who are not meeting the attendance criteria of 75%	2.17%
Pass percentage	100%
Summary of CO attainment	CO1: 1.92 CO2: 1:38 CO3: 0.9 CO4: 2.1 CO5: 1.5
Student Feedback	Students were satisfied with course contins of delivery Worksheps
Exit Feedback by faculty member for improvement in future	Workshops way be anaped for better understandy.
	Is the attendance updated on ERP? Percentage of students who are not meeting the attendance criteria of 75% Pass percentage Summary of CO attainment Student Feedback Exit Feedback by faculty member for improvement in future

Dean's Review	conducted	as plan No	
	Prigheightes		CONTRACTOR OF THE PARTY OF THE
	V		E June

(Signature of Faculty Member with Date)

(Signature of Dean with Date)



D.	No.	99:19-10:00 1st Period	10:05-10:55 2nd Period	B.ARCH EVEN SEM. 11:00-11:80 11:55-12:45 3rd Period 4th Period	12:45-01:2 Lunch Brea	01:26-02:15	62:20-03:10 6th Period	03:15-04:05 7th Period	04:10-17:00 6th Period		
Room N E 506	No 1A			ate Responsive DesignsStudio Il Taneja,Asst Prof Abhishek Bhardwaj, VF		Design Apprecia Asst. Prof.Avitesh, Asst. Prof	tion Lab	Visualizati	on Lab		
Room N E 507	7	3	23BAR-1DS12P	Environment Studio		Asst Prof Harsh 23BAR-1AA12S/Art & Archite	a Yadav	Model Making Digital render NF	ing Skills and Graphi		
Room N	No an	Asso.Prof.Sin	dhuree lyenger, Asso Prof Yas	il Architecture Studio h Pratap Singh Shekhawat, Asst Prof.Avitesh, VF		Community Particl		Aesthetic Art, Sketching, Visit to Art G			
E 407	No as	E. C. Service Co.		Architectural Design 4 A.L.Lab		Respective Year Co	ordinators	Asst. Prof. Abhishek Bhardwaj 21BAR-68U32S/Sustainability in Built Environ Asst. Prof. Pallavi Keswani			
E 408 Room N E 409 Room N E 308		Prof.Him	anshu Sanghani, Asso. Prof. Arj 21BAR-1DS32P /	un Kamal, Asso, Prof Robbin Dwivedi, NF, VF Architectural Design 6		Materials & Crafts Sanjay Kun	manship				
Room N E 308	No AA		Sustainable H	abitat Design Lab	Lunch	Visualization		NF Digital I	ab		
Room N E 307		Asst.Pr	of Shahroz Alam, Asst. Prof. Pre 19BAR-1DS42P/	Sehba Saleem Asst Prof.Kiran Singh, rana Hazarika,Asso,Prof.Shanu Jain,VF-1 Architectural Design 8	1	Model Making, Digital rendering	g Skills and Graphics	Digital skills, So Assoc, Prof. A			
Room N E 509	5A 5B		Materials &	craftsmanship y Kumar		Prof.Pooja Lalit Kumar, Iyenger,Asso,Prof.Robbin I	THESIS S Asso. Prof Sehba Saleem, Dwivedi, Asst. Prof. Kiran S Hazarika, Asso. Prof. A 19BAR-1TH52F	Asso.Prof.Shanu Jain,Asso.Pr ingh,Asst.Prof.Shahroz Alam, / prajita Srivastav	of Sindhuree Asst Prof Prema		
Room N E 506	60 1A	Material Lab	Desig	n Communications - Digital		Design	Communications - Man		Material Lab		
Room N E 507	lo 4D	Craftemanchin	Prof.Hlmanshi 23BAR-4AR	J Sanghani, Asso. Prof. Arjun Kamal, NF 12S / Architectural Representation 2	1, 1,	Asso.Prof.Yash Prat	st.Prof.Anees, VF	Materials & Craftsmanship			
Room N E 406	lo 2A	TDCC		2T/ Structural System and Design 3		20071117	2S / Architectural Represe	sinauon 2	Sanjay Kuma Community		
Room N		A B(A	A	sst.Prof.Purva Majumdar					Participatory Lab		
Room N E 408 Room N E 408	lo as	Asst.Prof.Payal		Asst.Prof.Kiran Singh 19BAR-4SD32T-Settlement Studies	7			Site visits/ Indust Visits/ Outdoors			
Room N		Taneja Asso.Prof. Anuj Seth	Self Study	Asst. Prof. Anees	Lunch	Prof.Aruna Bhardwaj, Asso. I	Asso.Prof.Robbin Dwivedi , Respecti				
				Assoc. Prof. Anuj Seth		Asso.prof.Shanu Jain, A Alam,Asst Prof.Avitesh,A	sst.Prof.Prerna Haza	rika, Asst.prof.Purva	Coordinators		
Room No E 308 Room No E 307	0 40	Asst.Prof,Shahroz Alam	Asso.Prof.Yash Pra	R-8CD42T / Career Planning stap Shekhawat, Asst.Prof.Harsha Yadav,		Majumdar,Facult Elective 2 (Foundations	y coordinationg MOC	C electives.			
Room No	0	Asso.prof.Robbin Dwlvedi	As	Asst.Prof.Pallavi Keswani (Advanced)/ELECTIVE 9 (Pr			iject)	Self Study			
Room No E 509		Asst.prof.Prema Hazarika Pallavi Keswani	Model Making	Digital rendering Skills and Graphics							
Room No	0		The Flementary	Construction Studio							
E 506	1A		Asst.Prof.Pallavi Keswani,	Asst.Prof.Payal Taneja, NF, VF		23BAR-3AT12T / Architec		Aesthetics Art, Sketching, Visit to Art Ga			
Room No E 507		23BAR-2CS12P/ Construction Systems Studio 2 The OCIS Basis Studio				Asso.Prof.Sindhure	e lyengar	Asst. Prof. Abhish	ek Bhardwaj		
E 406 Room No			Asst.Prof.Abhishek Bh	ardwaj, Asst.Prof. Avitesh		TDCC		Visualizatio Model Making Digital renderi			
F 407				Method 4 & 21BAR-5AP22S - Art 4		Asso.Prof.Arjun Kamal	Vels Added Courses	NF			
E 408 Room No		Asso.	The Essential Building Systems Studio Asso.Prof.Yash Pratap Singh Shekhawat, Asso. Prof. Anuj Seth , NF, VF			Asst.Prof.Payal Taneja Asso.Prof. Anuj Seth	Vale Added Cources (VAC)	Digital Lab Digital skills, Software skills			
Room No E 408 Room No E 409 Room No E 308					Lunch	The AS & CS Studio	NF NF	Assoc. Prof. Arjun Kamal Material Lab			
Room No E 307		Sr. Prof. (D	Sr. Prof. (Dr.) Tejwant Brar, Asst. Prof. Anees, Asst. Prof. (Dr.) Purva Majumdar, VF.VF				73.1	Prof. Tejwant Brar, Asst. Prof. Anees, Prof. (Dr.) Purva Majumdar		Material Materials & Craf Sanjay Ku	smanship
Room No E 508	5A			THESIS Mentorship			THESIS SI				
Room No E 509	5B 5C	20	Self Study	Prof.Himanshu Sanghani 19BAR-1TH52P / THESIS		Prof.Pooja Lalit Kumar,Asso.Prof.Se Sing	hba Saleem, Asso.Prof.S	f.Shanu Jain, Asso.Prof.Robbin Dwivedi, Asst.Prof.Ki zarika,Asso.Prof.Shruti H na Khetrapal			
Room No E 506	1A	4 4	The Environ	nment Studio		Digital Lab		Design Appreci	ation I ah		
Room No		Prof.Are	una Bhardwaj, Asst. Prof. Payal 23BAR-1DS12P / I	Taneja,Asst Prof.Abhishek Bhardwaj VF Environment Studio		Digital skills, Softwa Assoc. Prof. Arjun	re skills	Asst Prof.Avitesh, Asst. Prof. Harsh	f.Abhishek Bhardy		
Room No E 406				Architecture Studio	P (*)	The OCIS Basis 8		23BAR-1AA12S/Art & Archit	ecture Appreciation		
Room No	28		Asso.Prof.Sindhuree lyeng 21BAR-1DS22P / A	er,Asst.Prof.Harsha Yadav,VF rchitectural Design 4	100	Asso. Prof. Sindhuree lyenga Alam	r, Asst.Prof.Shahroz	Digital skills, Soft Assoc. Prof. Arji	ware skills		
E 407 Room No E 408	ЗА		REA	.L Lab		22BAR4HA22P / History o 21BAR-3SS32T / Structural Sy		Visualization	n Lab		
Room No E 409	38	Prof.Hima	21BAR-1DS32P / A	n Kamal,Asso.Prof.Robbin Dwivedi,NF, VF rchitectural Design 6	Lunch	Asst.Prof.Purva Ma	jumdar	Model Making, Digital renderin	ng Skills and Graphi		
Room No E 308	4A	Prof.	Pooja Lallt Kumar, Asso, Prof. S	bitat Design Lab Sehba Saleem Asst.Prof.Kiran Singh,		19BAR-6CD42T / Profess		Community Partic			
Room No E 307	48	Asst.Pro	of.Shahroz Alam, Asst. Prof. Prer	ana Hazarika,Asso.Prof.Shanu Jain,VF rchitectural Design 8		Sr. Prof.(Dr.) Tejwant Brar Singh, Asst. Prof. A	Asst.Prof.Kiran nees	Site visits/ Industry Visits/ Respective Year C			
Room No F 508	5A -	Site vielter Ind	try Visits / Outdoors Studies			Aesthetics La	ib	Community Partic	patory Lab		
Room No E 509	5C	one violar midus	J J	Site visits/ Industry Visits / Outdoors Studies	12	Art,Sketching,Visit to Art Galler Asst. Prof. Abhishek	ries and Museums Bhardwaj	Site visits/ Industry Visits/ Respective Year C			
Room No E 506	1A			onstruction Studio		23BAR-3ES12T /Environn	nental Studies				
Room No E 507	18	i han e	Asst.Prof.Pallavi Keswani 23BAR-2CS12P/ Constr	, Asst.Prof.Payal Taneja, VF uction Systems Studio 2		Asso, Prof. Monica K	hurana				
Room No E 406	2A			Architecture Studio	-	19BAR-3BS22T/ Building	Services - 2				
Room No E 407	28	Asso.Prof.	Yash Pratap Shekhawat, Ass 21BAR-2BC22P/ Building C	t Prof.Avitesh,Asst.Prof.Harsha Yadav, VF construction and Materials 3		Asst Prof Prema Ha	azarika	Mary Sec. A			
Room No E 408	ЗА	21BAR-3SS32T / St	tructural System and Design 5	21BAR-5RM32S/Research Methodology	Lucet	19BAR-3BS32T / Buildin	g Services 4	Faculty Meeting /	University		
Room No E 409	3B	Asst.Pro	of Purva Majumdar	Asso.Prof.Purva Majumdar Asst.Prof.Kiran Singh	Lunch	Asst. Prof. Shahroz Assoc. Prof. Anuj	Alam Seth	Mentor Mentee Sessions	Events		
Room No E 308	4A		T / Professional Practice	Aesthetics Lab							
Room No E 307	48		elwant Brar, Asst. Prof. Kiran , Asst. Prof. Anees	Art,Sketching,Visit to Art Galleries and Museums Asst. Prof. Abhishek Bhardwaj	× 1	Site visits/ Industry Visits / O	utdoors Studies				
	5A		Digita	l Lab							
Room No Room No E 509	5B 5C		Digital skills, S Assoc. Prof.			Site visits/ Industry Visits / O	utdoors Studies		the same of the latest devices t		





BUILDING SERVICES 2

(LIGHTING AND ACOUSTICS)

COURSE CODE	COURSE TITLE	COURSE STRUCTURE		CREDITS	EXAM SCHEN		ON		
19BAR-3BS22T	Building Services 2	Lecture	Tutorial	Studio	Practical	2	Internal Assessmen	External Jury	External
		2	0	0	0		50	NA	50

COURSE OUTCOMES (COs)

The students would be expected to:

- CO 1 Understand and learn day lighting and its relevance in the buildings
- CO 2 Understand and learn the artificial lighting, its need and application in the building.
- CO 3 Analyse lighting design in the buildings.
- CO 4 Understand the concepts of acoustics design, materials and its usability.
- CO 5 Understand, apply and demonstrate the acoustic planning and detail in the building

PROGRAMME OUTCOMES (POs)

DO1	Demonstrate a high degree of critical thinking, technical competence and skills related to the
101	built environment (knowledge and skill)
PO2	Exhibit knowledge of emerging tools and techniques in the field of architecture (tools and technology)
PO3	Illustrate understanding of the social, cultural, political and ecological factors affecting the built environment (context)
PO4	Examine and analyse the built environment through research and critical thinking (critical thinking)
PO5	Show the ability to represent the ideas/concepts using appropriate media and skill sets. (communication)
PO6	Exhibit high degree of ethical and professional standards. (ethical and professional understanding)
PO7	Demonstrate the ability to work in a collaborative environment. (collaborative engagement)
PO8	Understand the importance and impact of proposed solutions on environment for a sustainable development (environment and sustainability)
PO9	Exhibit resilient leadership and the ability to evaluate situations to achieve goals (leadership and management)







MAPPING OF COs AND POs

T//4-	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	Н	L	Н	L	L	L	L	Н	L
CO ₂	Н	L	Н	L	M	L	M	Н	L
CO3	Н	M	M	M	L	M	L	M	L
CO ₄	Н	H	M	L	L	Н	M	Н	L
CO5	Н	M	Н	M	Н	M	Н	M	L

MAPPING OF COs AND PSOs

	PSO1	PSO2	PSO3	PSO4
CO1	M	H	L	M
CO2	Н	M	M	L
CO3	L	L	H	Н
CO4	M	L	M	M
CO5	M	Н	L	M

H- High, M- Medium, L-Low

CONTENT

Module 1: **Day Light**: Solar radiation and visible light; colour; visual comfort; day lighting of interiors principles and techniques. Day lighting: Physical parameters of day lighting Day light penetration: Day light factor, Daylighting Design and considerations, GATE numerical, Daylight manual and software calculations.

Module 2: **Artificial Lighting**- Integrating day lighting with artificial lighting; automatic control of artificial lighting in relation to day lighting calculation of requirements of artificial lighting in relation to availability of day lighting. Electric light sources and their efficiency; Lamps, incandescent lamp etc, Lumens; lux; lighting level requirement for various functions. Lighting Design, GATE numerical, Automatic control- motion sensors, IOT.

Module 3: **Type of luminaries** – Decorative commercial, Industrial, outdoor- Methods of describing performance characteristics and performance efficiency. Artificial lighting strategies for interior lighting for various activities, Facade Lighting, Incandescent lighting, Halogens, Metal Halides, Fluorescent lamps, LED, Technical names of lights and fixtures, IP ratings of luminares, Hazer lights.

Module 4: **Acoustics and Acoustical Treatments**- Acoustical concepts- wave theory, sound power, sound intensity, decibels, sound power level, sound intensity level, sound pressure level, frequency bands concept of reflection, absorption, transmission, reverberation, sound absorbing materials, - fibrous, membrane, resonators, perforated facing, application techniques, GATE numerical. Noise control by absorption, sound transmission, transmission loss, composite barriers, noise reduction, Acoustics in Auditorium, Conference rooms, Cinema Halls, Indoor Stadiums.







ASSESSMENT SCHEME

INTERNAL 1	INTER	MSE	ESE	
Quiz(s)/ Presentation (s)/ Viva/Project (s)	Quiz(s)/ Presentation (s)/ Viva/Project (s)	Quiz(s)/ Presentation (s)/ Viva/Project (s)		
20	15	15	50	50

SUGGESTED READINGS:

- Manual of Tropical Housing and Building Otto H Koenigsberger
- SP 41 (S and T), 1987 Handbook on Functional Requirements of Buildings (Other than Industrial Buildings)
- The design of lighting Peter Tregenza
- Architectural Lighting Design A practical guide By Admir Jukanovic
- Noise control in buildings fundamental and application by Mahavir singh
- National Building Code 2016, Volume 2
- Handbook of Designing and Installing of Services in Building Complex (Er. V.K.Jain)
- Building services & Equipment (2nd Edition, Vol 2) by F. Hall

Recommended Videos

- https://youtube.com/playlist?list=PLbRMhDVUMngeGSqPVkrc8G kApltxEEos
- https://youtu.be/QeZES07wV7Y
- https://youtu.be/g8l8Q y LYw
- https://youtu.be/D7MGm6enrdo







SCHOOL OF ART AND ART ARCHITECTURE

COURSE OUTLINE

Course Title: Building Services 2

Course Code: 19BAR-3BS22T

Academic Year: 2023-24

Course Designed by: Prerana Hazarika

E-mail: prernahazarika@sushantuniversity.edu.in

Course Designed by: Prerana Hazarika E-mail:

Pre-requisites: B.Arch 4th semester

1. Course Outcomes: Upon successful completion of the course, the student should be able to :

CO1: Understand and learn day lighting and its relevance in the buildings

CO2: Understand and learn the artificial lighting, its need and application in the building.

CO3: Analyse lighting design in the buildings

CO4: Understand the concepts of acoustics design, materials and its usability

CO5: Understand, apply and demonstrate the acoustic planning and detail in the building

2. Text Books

- Noise control in buildings fundamental and application by Mahavir Singh
- Handbook of Designing and Installing of Services in Building Complex (Er. V.K.Jain)
- Building services & Equipment (2nd Edition, Vol 2) by F. Hall
- Manual of Tropical Housing and Building Otto H Koenigsberger
- The design of lighting Peter Tregenza
- Architectural Lighting Design A practical guide By Admir Jukanovic

3. Reference Books

- National Building Code 2016, Volume 2
- SP 41 (S and T), 1987 Handbook on Functional Requirements of Buildings (Other than Industrial Buildings)

4. Lecture Plan (Total Sessions - 16)

Sessi	Session Topic /	Unit	Dat	te		
on No.		No.	Planned on	Taken on	Methodology used (PPT, White Board, Audio/Video, Practical, Visit, Self Study based)	Deans Remarks with Date
1	Introduction to course. Course plan to be discussed.	1	Week 1 Date 12/01/2 024	12-01-24	Briefing and class discussion	Commence
2	Day Light: Solar radiation and visible light; colour; visual comfort; day lighting of interiors principles and techniques. Day lighting: Physical parameters of day lighting, Day light penetration: Day light factor.	1	Week 2 Date 19/01/2 024	19-01-29	Lecture and class discussion Assignment 1: Report on standards of daylighting and visual comfort	De par glan
3	HOLIDAY : REPUBLIC DAY		Week 3 Date 26/01/2 024	и-01-m	Students to work on Assignment 1 floated in class	Holiday
4	Artificial Lighting: Integrating day lighting with artificial lighting;	2	Week 4		Lecture and class discussion	Os pur plantichitectur

7	characteristics and performance efficiency. Artificial lighting strategies for interior lighting for various activities, Facade Lighting. Market study	3	Week 7 Date 23/02/2 024 Week 8	23-02-ry	Lecture and class discussion Assignment 2: Market study of different lighting sources Class presentation	Conduct as proplem
6	Type of luminaries – Decorative commercial, Industrial, outdoor- Methods of describing performance	3	Week 6 Date 16/02/2 024	16-62-24	Lecture and class discussion	Performance of fixery discount
5	availability of day lighting. Electric light sources and their efficiency; Lamps, incandescent lamp etc, Lumens; lux; lighting level requirement for various functions. Lighting Design.	2	Week 5 Date 09/02/2 024	09-02-27	Lecture and class discussion	lighrig design discumed
	automatic control of artificial lighting in relation to day lighting calculation of requirements of artificial lighting in relation to		Date 02/02/2 024	02-02-24		of par

9	REMEDIAL WEEK (08/03/24 - Shivratri Holiday)		Date 01/03/2 024 Week 09 Date 07/03/2 024	01-03-24 67-63-2		Remadial
10	Acoustical concepts- wave theory, sound power, sound intensity, decibels, sound power level, sound intensity level, sound pressure level, frequency bands concept of reflection, absorption, transmission	4	Week 10 Date 15/03/2 024	15-63-27	Lecture and class discussion	Acousies portion commend
11	Sound absorbing materials, fibrous, membrane, resonators, perforated facing, application techniques	4	Week 11 Date 22/03/2 024	22-03-27	Lecture and class discussion	A par schedul
12	Sound absorbing materials, fibrous, membrane, resonators, perforated facing, application techniques	4	Week 12 Date 29/03/2 024	29-03-29	Assignment 3: Case study of diverse spaces showcasing application of different sound absorbing materials	Condued as pur plan

Co J Male

13	Market study presentation		Week 13 Date 05/04/2 024	05-04-2 ₁	Class presentation	Poseukhi
14	Noise control by absorption, sound transmission, transmission loss, composite barriers, noise reduction. Discussion on GATE numericals	4	Week 14 Date 12/04/2 024	12-04-2	Lecture and class discussion Assignment 4: GATE numericals on lighting and acoustics	ds pe plan
15	END TERM SUBMISSION		Week 15 Date 19/04/2 4	19-04-29		Clon of contin
16	REMEDIAL WEEK AND CLOSING DISCUSSIONS		Week 16 Date 26/04/2 4	26-04-24		lemedie

Aim

The objective of the course is to provide a systematic understanding of environmental support systems as they apply to human habitat, with special reference to Light and acoustics. The course will integrate and emphasize issues related to day light, artificial lighting, acoustic comfort.

Course Description

The course emphasizes on the intricate interplay between natural and artificial lighting, and acoustics in architectural design. Students will be introduced to Daylighting principles, learning techniques for solar and visible light infusion. The integration of artificial lighting with daylight is covered, including automatic control and calculation of lighting requirements. The course also delves into acoustics, covering wave theory and sound absorption, with focus on noise control.

Teaching Method

• Lecture on the given topic





- Predominantly, discussions in the classroom
- Hands on approach through experiments and model making
- Research on topics
- Guest Lecture

Approach

Process Oriented, principles of science explained and guided research.

Assignment with group work to have co-operation, and individual etc.

Pedagogy offers practical approach of lighting and acoustics with an understanding of the working from architectural point of view.

Assignment No.	Assignment Type	Specifications	Weightage	Submission Date	Course Outcomes
Assessment 1	Individual	Report on standards of daylighting and visual comfort	10% of the total marks	Due Week 4	CO1, CO2
Assessment 2	Group	Market study of different lighting sources	15% of total marks	Due week 8	CO3
Assessment 3	Group	Case study of diverse spaces showcasing application of different sound absorbing materials	15% of total marks	Due week 13	CO4
Assessment 4	Individual	GATE numericals on lighting and acoustics	10% of the total marks	Due week 15	CO3, CO4

Assessment Scheme

INTERNAL 1 INTERNAL 2		RNAL 2	MSE	ESE
Quiz(s)/ Presentation (s)/ Viva/Project (s)	Quiz(s)/ Presentation (s)/ Viva/Project (s)	Quiz(s)/ Presentation (s)/ Viva/Project (s)		
20	15	. 15	50	50

Grading Criteria and Assessment Rubrics applicable on all assessments

Caragram *

Dimension	Excellent	Good	Average	Below Average
	(9 to 10)	(7 to 8)	(5 to 6)	(0 to 4)
Understandi ng of the Topic: Technical Knowledge	Excellent, Able to answer queries	Good knowledge and inquisitive	Little knowledge not adequate to understand	Lacked technical knowledge
Application of the Knowledge	Very Good understandi ng of application of various systems of structural design	Good understanding of application of various systems of structural design	Little awareness application of various systems of structural design	Unaware of application of various systems of structural design
Presentation : Quality of work	Very good quality of work includes well drawn drawings, with graphics, text neatly organized thereby resulting in a professional quality work	Good quality of work includes lucid drawings and well- organized set of drawings with graphics	Quality of work not up to standard of the class	Poor quality/ incomplete work
Finishing of presentation	Active and involved with leadership qualities	Active and involved with complete interest	Active but less involved with group members	Inactive and lack of participation
Compilation of data	Very good work with respect to the topic	Good work relevant to the topic	Not adequate	Copied
nalysis of lata	Very good work with respect to the topic	Good work relevant to the topic	Unable to explain	Lacking

Excellent	Good	Moderate	Poor	
	Excellent	Excellent Good	Excellent Good Moderate	Excellent Good Moderate Poor

Plagiarism

What is Plagiarism?

The theft of ideas (such as the plots of narrative or dramatic works) or of written passages or works, where these are passed off as one's own work without acknowledgement of their true origin; or a piece of writing thus stolen.

-- The Oxford Dictionary of Literary Terms. 2008. Oxford University Press.

Common Forms of Plagiarism

- Copying directly from others without acknowledgement of the original source
- Using ideas or rephrasing text from without acknowledgement of the original source
- Using charts, tables, pictures or diagrams from others without referencing
- Reusing some parts of your previous work
- Submitting other people's work as your own

How to avoid plagiarism?

- Use your own ideas.
- Paraphrase + give proper credit to the original source.
- Use quotation marks when using exact words from other authors + give proper credit to the original source.
- Organize and track your sources and materials









School of Art and Architecture - Sushant University

Even Semester (Jan-June) 2023-24

Students List

Program: B.Arch

Sem: 4

Course Name: Building Services 2

Course Code: 19BAR-3BS22T

Faculty: Asst. Prof. Prerana H

Total No. of Students enrolled in the course: 47

Student Name	Roll No
Manaj Baweja	220BARCH001
Pujan Garg	220BARCH002
Pranita Saraf	220BARCH003
Aditi Gupta	220BARCH004
Shweta Sharma	220BARCH005
Rushil Soni	220BARCH006
Palak Mediratta	220BARCH007
Simran Thakran	220BARCH008
Aarushi Agarwal	220BARCH010
Rudra Kumar Jha	220BARCH011
Aryan Gupta	220BARCH014
Sudevi Gayen	220BARCH015
Annanya Bindal	220BARCH016
Moeed Imtiyaz	220BARCH017
Shriya Khurana	220BARCH018
Ishan Shukla	220BARCH019
Ansh Jalan	220BARCH020
Chahat Suneja	220BARCH021
Amritam	220BARCH022
Rudra Pratap Singh	220BARCH024
Apoorva Goel	220BARCH025
Chirag Yadav	220BARCH026
Paavan Jain	220BARCH031
Himanshu Aggarwal	220BARCH032
Chahat Kakkar	220BARCH034
Ronnit Garg	220BARCH035
Abeer Bhasin	220BARCH036
Nikita Chawla	220BARCH037



Saanvi Gupta	220BARCH038	
Hardik Sharma	220BARCH039	
Maitreyi Rathore	220BARCH043	4
Auditya Sheoran	220BARCH044	
Harshit Khatri	220BARCH045	
Rongsennukla Yaden	220BARCH046	
Harshita Dang	220BARCH047	
Naveen Chauhan	220BARCH048	
Advait Bansal	220BARCH050	
Priyal Jain	220BARCH051	
Avani Khurana	220BARCH052	
Ishita Gupta	220BARCH053	
Raghav Sethi	220BARCH054	
Sai Satyanarayana Reddy	220BARCH055	
Shritima Sharma	220BARCH056	
Taniya Mohanty	220BARCH057	
Apaar Agarwal	220BARCH058	
Aditya Dev	220BARCH060	*
Dhruv Dogra	220BARCH062	





Sushant University

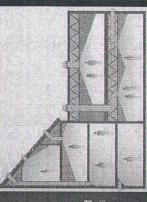
Building Services 2

LIGHTING AND ACOUSTICS | LECTURE 1

University

What is Daylighting?

- Daylighting describes the controlled use of natural light in and around buildings (Reinhart, 2014).
- It is the practice of placing windows, or other transparent media and reflective surfaces so that natural light provides effective internal illumination during the day.



uce:https://techcomlight.co.uk/ab

||Sushant ||University

University

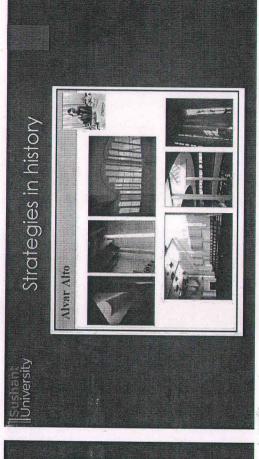
Goals of natural daylighting

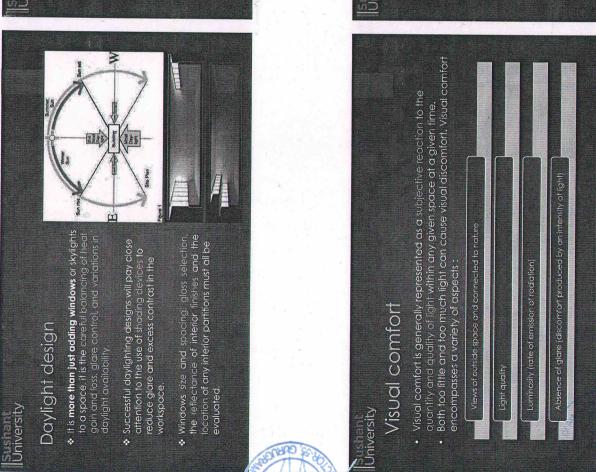
- The overall objective of daylighting is to minimize the amount of artificial light and reduce electricity costs, but it can also lower HVAC costs as well.
 - Electrical lighting produces a lot of heat, whereas, if properly
 controlled, natural lighting generates hardly any heat at all.
 For most buildings incorporating daylighting, the overall energ
- For most buildings incorporating daylighting, the overall energy savings ranges from 15 to 40 percent.
 Daylighting has a direct impact on well-being, productivity and overall.

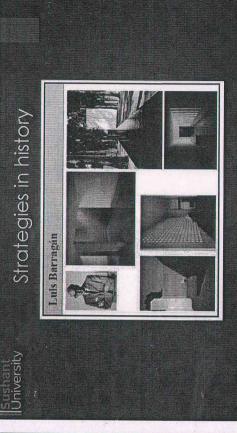
sense of satisfaction.

A.

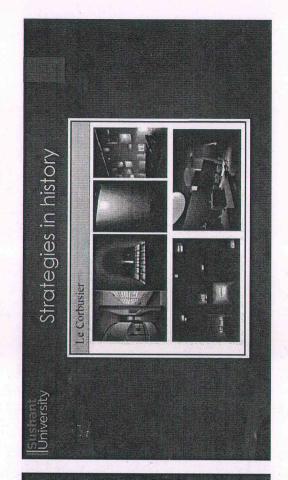
LECTURE 1 : DAYLIGHTING Fundamentals and basic concepts |

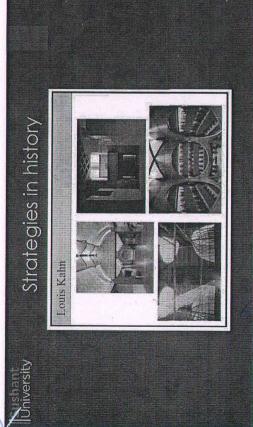








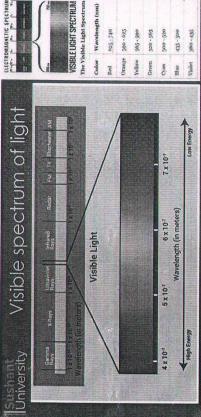






(M)





eye can view. Mare simply, this range of wavelengths is called visible light. Typically, the human eye can detect wavelengths from 380 to 700 nanometers.

Defining Daylighting Factor

Daylight Factor (DF): Daylight Factor (DF) is the ratio of the value of lighting in the rount(E) with the value of outdoor lighting(Eo) in daylight conditions.

Daylight Factor (DF) has three component factors that influence it,

• The part of the spectrum that reaches Earth from the sun is between 100 nm

Ultraviolet contains wavelengths between 100-400 nm.

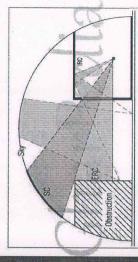
Solar radiation is radiant (electromagnetic) energy from the sun.

ELECTROMAGNETIC SPECTRUM

SOLAR SPECTRUM

What is solar radiation?

DF = SC + IRC + ERC



Sources of Daylight at a Point Within a Room

❖Visible light falls within the range of 400-700 nm, and infrared light contains wavelengths from 700 nm to over 1 mm.

Sushant University Principles of effective daylighting ORIENTATION OF THE BUILDING

* At the planning beek, orbaning buildings dong the **north-south** promote direct sunlight access, sure of shodings and reflected light from the

* East-west orientation will expose the facades for more light in summer than in winter.

surroundings.

WINTER SLIM

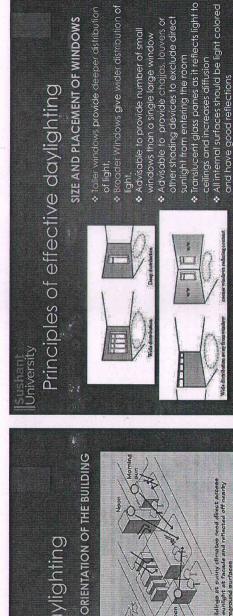
The property of t

Principles of effective daylighting

FORM OF THE BUILDING & CLIMATIC FACTORS

FORM OF THE BUILDING & CLIMATIC FACTORS

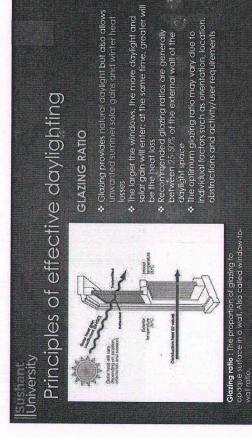
Constitution for the principle to cont. This of principle for the fight is among than one to solve the principle for the fight is among than one to solve the principle for the fight is among than one to solve the principle for the fight is among than one to solve the principle for the fight is among than one to solve the principle for the fight is among than one to solve the fight is among the fight in the fight is among the fight in the fight is among the fight in the fight in the fight in the fight is among the fight in the f

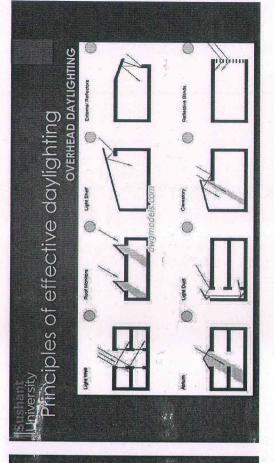


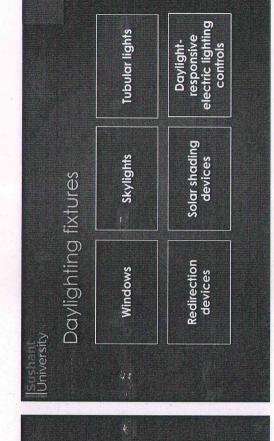
Principles of effective daylighting

Vinsternt University











Principles of effective daylighting

daylight than a vertical window]

They are domed, horizontal or slightly sloping glazed openings in the roof

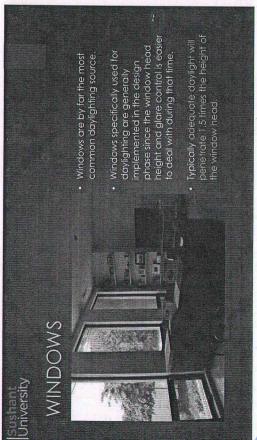
It can be used to reduce glare, heat gains, and protect internal spaces from direct sunlight, by providing an opaque roof and overhang above the glazing. Saw Tooth Lighting

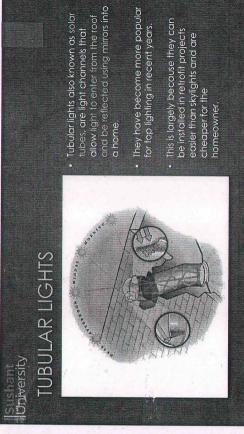
Heat gains can be reduced by filting roof lights towards the north in order to utilize

Horizontal roof lights admit more daylight (per sa,m.) of glazed area than vertical windows (a horizontal roof light is proportionately 3 times more effective as a source of OVERHEAD DAYLIGHTING

diffuse north lighting

Situated above eye levels (near the celling) | provide an effective source of natural light whilst reducing glare





University

REDIRECTION DEVICES

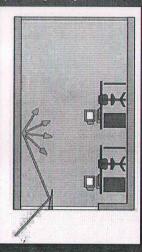
lighting source, and are implemented in the design phase.

SKYLIGHTS

Noniversity University

Skylights can be either passive or active, though the majority of

skylights are passive.

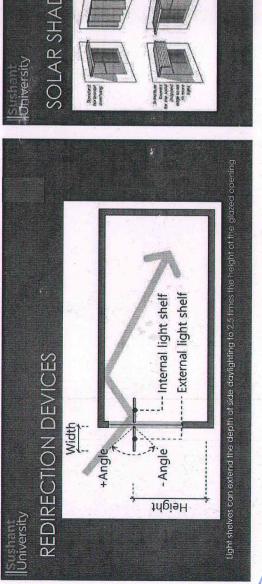


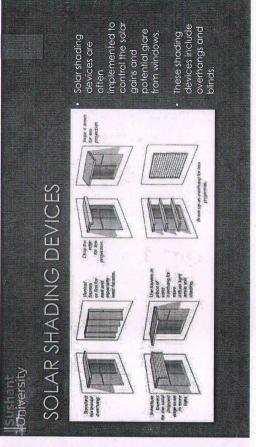
Redirection devices take incoming sunlight and direct if towards the

They aim to reduce glare and increase daylight penetration. These devices typically take on of two forms: buvered systems or a large horizontal element. Horizontal elements are commonly referred

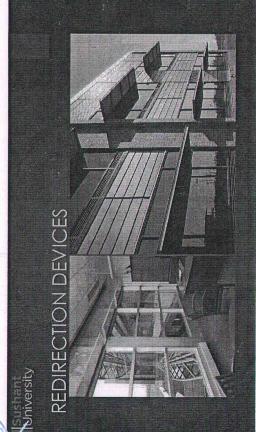


have a mirrar system within the skylight that tracks the sun, and are designed to admit more sunlight by channeling the light into the home.











ax.

University

Strategies for daylight design

- Increasing perimeter daylight zones _ extend the perimeter toofprint to maximize the usable
- monitors and clerestories will result in deeper light penetration and reduce the likelihood of Allow deeper daylight penetration in a space __Windows located high in a wall or in roof
- Reflecting daylight within a space... to increase room brightness. | A light shelf, is properly
 designed, has the potential to increase room brightness and decrease window brightness.
 Slope cellings. To direct more light into a space.
 Filter daylight... The hashness of direct light can be littered with vegetation, curtains, ouvers, or
 the like, will help distribute light.
 - Avoid direct beam daylight on critical visual tasks poor visibility and discomfort will result in
- excessive brightness differences that occur in the vicinity of critical visual tasks. Understand that different building orientations will benefit from different daylight strategies [for example, light shelves which are effective on south facades, are often ineffective on the east or west elevations of buildings]

ASSIGNMENT 1 (Part B)

- 1. Strategies for different light conditions
- 2. Daylighting Systems with and without shading
- 3. Parameters affecting visual comfort
 - 4. Design strategies for daylighting
- 5. Design guidelines for daylighting
- Daylight requirement for different building typologies according to various Indian standards (compile in a chart)
- 7. Recommended daylight factor to be maintained in different interiors

- **Brightness Ratio or Contrast**
- Candela (cd)
 - 6. Clear Design Sky 7. Central Field
- 12.Daylight Factor 13.Daylight Penetration
- 18. Illuminance
 19. Internal Reflected Component (IRC)
 20. Light Output Ratio (LOR)
 21. Light Pipe
 22. Light Phef
 23. Lumiance
 24. Luminance
 25. Luminance
 26. Luminance
 27. Maintenance Factor
 28. Reflection Factor
 29. Room Index
 30. Sky Component (SC)
 31. Ulfization Factor (Coefficient of Utilization)
 32. Visual Field

Terminologies with diagrams ASSIGNMENT 1 (Part A)

- Azimuth
- Candle Power
- 8. Color of an object 9. Color Rendering Index (CRI)
- 10. Correlated Color Temperature 11.Daylight Area
- 14.Direct Solar Illuminance
- 5.External Reflected Component





What is artificial lighting? Artificial lighting has many different applications and is used both in-home. Artificial lights are available in a wide variety of shapes, sizes, colors of light emitted, and levels of brightness. Artificial light, as opposed to natural light, refers to any light source that is light, refers to any light means. and commercially. S University Building Services 2 LIGHTING AND ACOUSTICS | LECTURE 2 Sushen: University

Sources of artificial lighting lsushant University

LECTURE 2 : ARTIFICIAL LIGHTING | Integrating day lighting with artificial | lighting |





AMBIENT LIGHTING

Ambient lighting provides overall illumination and is meant to create a general and uniform lighting

- Ensures comfortable illumination.
- glare-free environment, and appropriate brightness level, Ambient lightling selection depends on the following factors:





Natural source of light, which may enter the room and contribute to lighting the indoor environment

FUNDAMENTAL LIGHTING SYSTEMS



ambient lights, etc. with a combination of fixtures from track lights, down lights, fan lights, cove, wall scone, or any other type of lixture with the ability to produce a wide beam span can be used as ambient lighting. mounted lights, wall mounted ambient e and landing area), floor recessed

FUNDAMENTAL LIGHTING SYSTEMS University

ACCENT LIGHTING

- The main purpose of accent lighting is to highlight a specific object or an area.
 They are generally three times as bright as an pient lights.
- Accent lighting draws attention
 to features, such as planters.
 sculptures, artwork, furnishings or

Fixtures such as wall lights, recessed spot lighting, track lighting, wall-mounted picture lights are commonly used for accent lighting





FUNDAMENTAL LIGHTING SYSTEMS

Task lightling is the additional lightling of a room that goes beyond general lightling in conjugation with

TASK LIGHTING

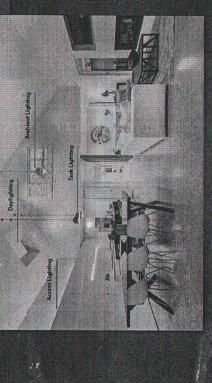
University

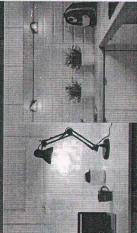
ambient lighting.

• Designed and controlled to affect

lighted.
• Task lighting control strategies vary depending on the following applications:

FUNDAMENTAL LIGHTING SYSTEMS





Examples of Task Lightling products:

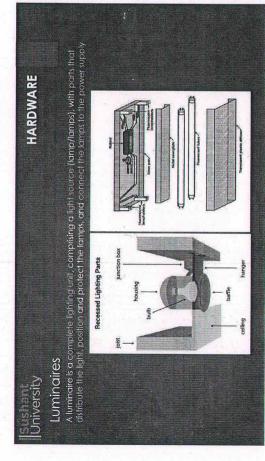
Under-cabinet lights
Guldance lights
Guldance lights
Bollard lights

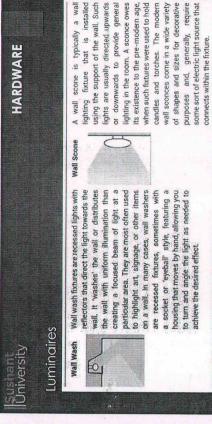
The extent of daylighting and its integration with electric lighting and the ambient lighting

The extent of ambient and accent lighting

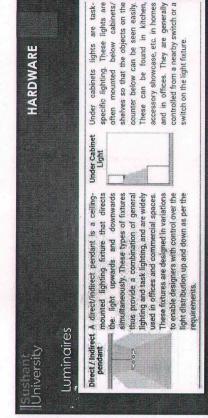








fixture that is installed



towards the wall. It is important to note that the height of the trim at the edge of the cove fixture should

be tall enough to hide the lighting fixture.

A recessed cove fixture is fixed in a light cove, which is built above the ceiling at the intersection point of the ceiling and the wall. These fixtures generally function to direct the light

Task lighting is the additional lighting of

Luminaires Task Light

State of Noniversity

lighting, it meets the demands of any specific visual task or work that is being a room, which goes beyond the general

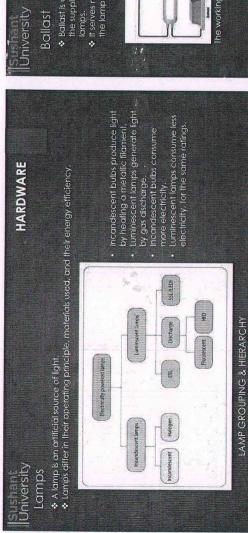
lighting. In conjugation with ambient

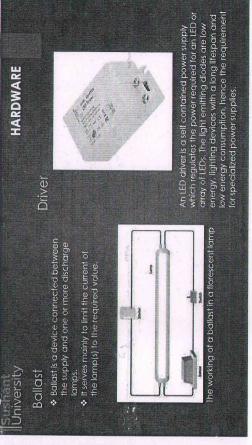
done. Task lights can be table lamps, focus lights, lights mounted to desks, under the cabinet lights, or any lighting

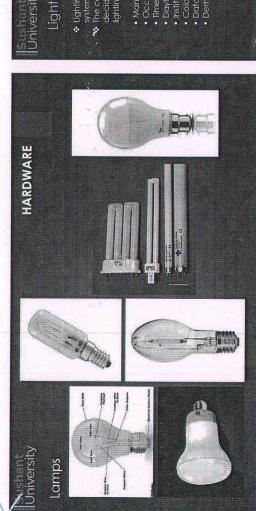
that helps people see their work better.

HARDWARE















Lighting controls

Lighting controls

Design of Sensor Octobroller

Lighting white the sensor Octobroller

Lighting white the sensor Octobroller

Lighting white the sensor Octobroller

Lighting controller

Lighting cont



Form groups of 3-4 (sectionwise) Conduct a MARKET STUDY ON DIFFERENT LIGHTING SYSTEMS AND SUPPORTING HARDWARE Conduct a MARKET STUDY ON DIFFERENT LIGHTING SYSTEMS AND SUPPORTING HARDWARE Collect catalogues, samples, photographic documentation Classify and identify brands and specifications, prices, modern lighting control systems Compile findings of online and market study, build a matrix for each category Conduct a brand contrast survey Pessent in ppt format Compile in A4 sheets and prepare a report (Submission of 1 report per group)

A precursor for market study Identity and its processor for an adversary systems. Classify and identity brands and specifications online, lighting control systems available. Make a matrix for each category: Ambient, fask, accent lighting and supporting hardware.

ASSIGNMENT 2

CLASS ACTIVITY

Sushant University







School of Art and Architecture - Sushant University

Even Semester (Jan-June) 2023-24

Individual Assignment (1)

Program: B.Arch

Course Name: Building Services 2

Faculty: Prerana H

Submission Deadline: 02-02-24

Sem: 4

Course Code: 19BAR-3BS22T

Maximum Marks: 10

Course Outcomes

CO1: Understand and learn day lighting and its relevance in the buildings

CO2: Understand and learn the artificial lighting, its need and application in the building

CO3: Analyse lighting design in the buildings

CO4: Understand the concepts of acoustics design, materials and its usability

CO5: Understand, apply and demonstrate the acoustic planning and detail in the building

Assignment:

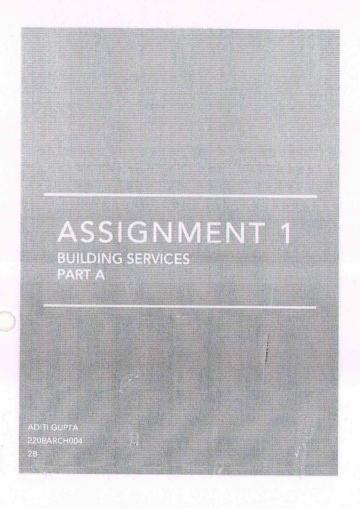
Q.1 (CO1) Write 30 terminologies on lighting complete with diagrams and sources.

Q.2 (CO2) Compile a report on Study of Lighting standards:

- 1. Strategies for different light conditions
- 2. Daylighting Systems with and without shading
- 3. Parameters affecting visual comfort
- 4. Design strategies for daylighting
- 5. Design guidelines for daylighting
- 6. Daylight requirement for different building typologies according to various Indian standards (compile in a chart)
- 7. Recommended daylight factor to be maintained in different interiors

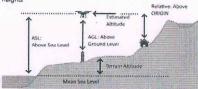




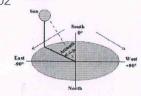


O1 ALTITUDE

The height of an object or structure above a reference level, usually above sea level or the Earth's surface. Altitude is used as a reference for heights



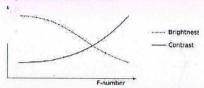
02 AZIMUTH



The azimuth angle is the compass direction from which the sunlight is coming. At solar noon, the sun is always directly south in the northern hemisphere and directly north in the southern hemisphere. The azimuth angle varies throughout the day.

03 BRIGHTNESS RATIO OR CONTRAST

Contrast ratio is the ratio of a screenps whitest white (output 1eve1 255) to its blackest black (output 1eve1 0). It is expressed in the form of "500:1", and "500" and "1" respective1y represent the relative brightness ratio of "white" to "black".



04 CANDLE POWER

Candle power (abbreviated as cp or CP) is a unit of measurement for light intensity. It describes the level of light intensity relative to the light emitted by a candle of a particular size and composition. Historical candle power equals 0,981 candlelas. In modern usage, candle power is sometimes used as a synonym for candela.

05 CANDELA

the SI unit of luminous intensity. One candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540 x 1012 Hz and that has a radiant intensity in that direction of 1/683 watt per steradian.

06 CLEAR DESIGN SKY

This is the clear sky corresponding to a solar altitude of 15 degrees. The relative luminance of the sky relative to the zenith opposite to the sun is constant for a given altitude up to 15 degrees and beyond 15 degrees it decreases as the altitude of the angle of observation increases. The corresponding exterior design illumination is taken as 8000 lux from the entire sky vault, direct sunlight being excluded.

07 CENTRAL FIELD

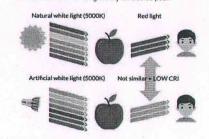
The monocular visual field consists of central vision, which includes the inner 30 degrees of vision and central fixation, and the peripheral visual field, which extends 100 degrees laterally, 60 degrees medially, 60 degrees upward, and 75 degrees downward (Figure 116.1)

08 COLOR OF AN OBJECT

The 'colour' of an object is the wavelengths of light that it reflects. This is determined by the arrangement of electrons in the atoms of that substance that will absorb and re-emit photons of particular energies according to complicated quantum laws.

OO COLOR RENDERING INDEX (CRI)

Color Rendering Index (CRI) measures the ability of a light source to accurately reproduce the colors of the object it illuminates.CRI is a convenient metric because it is represented as a single, quantified number.CRI values that are 90 and above are considered excellent, while scores below 80 are generally considered poor.



10 CORRELATED COLOR TEMPERATURE

The colour temperature of a light source is the temperature of an ideal black-body radiator that radiates light of comparable hue to that of the light source. Colour temperature is conventionally stated in the unit of absolute temperature, the kelvin (K). Colour temperature is a characteristic of visible light that has important applications in lighting, photography, videography, publishing, manufacturing, astrophysics, and other fields.

When the temperature of incandescent source is increased, more light is produced. The colour of the material changes from red at low temperature to yellow and finally to nearly white as the temperature is increased.



S CURD







11 DAYLIGHT AREA

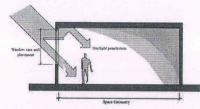
A daylight zone, also called the daylight area (expressed in square feet) is defined by the ASHRAE/IES 90.1-2010 energy standard as "the floor area substantially illuminated by daylight." In other words, it should consistently receive significant quantities of daylight.

12 DAYLIGHT FACTOR

A daylight zone, also called the daylight area (expressed in square feet) is defined by the ASHRAE/IES 90.1-2010 energy standard as "the floor area substantially illuminated by daylight." In other words, it should consistently receive significant quantities of daylight.

13 DAYLIGHT PENETRATION

It is a rule that determines the window's sill and lintel level along with the amount of daylight penetrating through it. Typically, the depth of daylight penetration is about two and one-half times the distance between the top of a window and the sill.



14 DIRECT SOLAR ILLUMINANCE

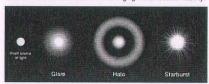
The sunlight without being diffused is known as direct soler illuminance.

1 EXTERNAL REFLECTED COMPONENT

The externally reflected component of Daylight Factor (DF) refers to the contribution of the light that is reflected off external surfaces, such as adjacent buildings or the ground, to the total amount of natural light that enters a space. The externally reflected component of DF is a measure of the amount of light that is reflected off external surfaces and into a space, and it is influenced by several factors, including the reflectivity of surrounding surfaces and the geometry of the surrounding environment.

16 GLARE

Glare is defined as an intense and blinding light that reduces visibility

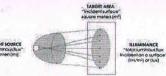


17 HUE



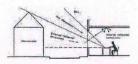
Hue represents the color being displayed, as found on a red-green-blue scale, color wheel or grayscale. The intensity of the primary colors or gray displayed grows with increased brightness, but the color itself does not change. Changing to different color values makes no difference.

18 ILLUMINANCE



19 INTERNAL REFLECTED COMPONENT

The internally reflected component (IRC) of Daylight Factor (DF) refers to the contribution of the light that is reflected off internal surfaces within a space. The IRC of DF is a measure of the amount of light that is reflected off internal surfaces and redistributed within a space, and it is influenced by several factors, including the reflectivity of the internal surfaces, the geometry of the space, and the position of the openings.



20 LIGHT OUTPUT RATIO

Light Output Ratio (LOR) is the percentage of light emitted from the light source that makes it out of the luminaire. For LED luminaires it is stated as 100%.

21 LIGHT PIPE



Light pipes are optical components that are typically used to increase the uniformity of a light source or to direct light. Light pipes may also be referred to as homogenizing rods, light guides, homogenizers, or light funnels.

22 LIGHT SHELF



A light shelf is a passive architectural device used to reflect natural daylight into a building. 'Bouncing' sunlight off a horizontal surface distributes it more evenly and deeply within a space, whereas direct sunlight can cause glare near an opening, whilst leaving dark areas further in.

Light shelves can be fixed either externally, internally or both (which often works best in providing an even illumination gradient). They are often designed as part of a broader daylight and shading strategy.

23 LUMEN



The lumen is a unit of measurement for the brightness of light. If a light bulb is blindingly bright, it produces a lot of lumens.

24 LUMINANCE

The apparent brightness of an object that appears to the human eye is known as Luminance.

25 LUMINAIRE



A complete lighting unit consisting of a lamp or lamps together with the parts designed to distribute the light, to position and protect the lamps, and to connect the lamps to the power supply.

26 LUMINOUS FLUX



Luminous flux is a measure of the power of visible light produced by a light source or light fitting. It is measured in lumens (Im).

27 MAINTENANCE FACTOR

A lighting system's maintenance factor indicates how much of the initial luminous flux remains available at the end of its service life. The maintenance factor must be determined by the planning lighting engineer and the new value of the luminous flux multiplied by it.





28 REFLECTION FACTOR

It may be defined as "the ratio of luminous flux leaving the surface to the luminous flux incident on it". Its value will be always less than 1.

29 ROOM INDEX

Room Index = Length (m) \times Width (m) Height of light fitting above the working plane(Length + width) Room Index = L \times W.

30 SKY COMPONENT

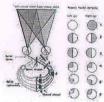


The sky component normally refers to the diffused sky, i.e. it is not used to describe direct sunlight. In other words, it can define as the ratio (or percentage) of that part of the daylight illuminance at a point on a given plane which is received directly from the sky as compared to the simultaneous exterior illuminance on a horizontal plane from the entire hemisphere of an unobstructed clear design sky.

31 UTILIZATION FACTOR

Utilization factor or co-efficient of utilization:- It is defined as the ratio of total lumens reaching the working plane to total lumens given out by the lamp.

32 VISUAL FIELD



The visual field refers to the total area in which objects can be seen in the side (peripheral) vision as you focus your eyes on a central point.

SOURCES

https://education.nationalgeographic.org/resource/altitude/

https://academic-accelerator.com/encyclopedia/candlepower

https://www.pveducation.org/pvcdrom/properties-of-sunlight/azimuth-angle

byjus.com

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https://www.eizo.com.tw/support/wp/pdf/wp_06-001A.pdf

www.merriam-webster.com

patternguide.advancedbuildings.net

www.ncbi.nlm.nih.gov

www.waveformlighting.com

www.sciencedirect.com

www.sciencedirect.com

lightingcontrolsassociation.org

www.sciencefocus.com

www.lecturio.com

lightlouver.com

www.designingbuildings.co.uk

frontdesk.co.in





ANNEXURE-

School of Art and Architecture -Sushant University

Course Title: Building Services 2

Semester: 4

Course Code: 19BAR-3BS22T

Course Faculty: Prerana H

Programme: B.Arch

Sir/Madam,

Following students mentioned in the list are identified as Slow learner/Advanced learner based on guidelines issued by IQAC after 15 assessment (assignment/quiz).

S.No	Name of the student	Roll No	Slow learner/Advanced learner
1	Aditi Gupta	220BARCH004	Advanced learner
2	Shriya Khurana	220BARCH018	Advanced learner
3	Ishan Shukla	220BARCH019	Advanced learner
4	Nikita Chawla	220BARCH037	Advanced learner
5	Simran Thakran	220BARCH008	Slow learner
6	Chahat Suneja	220BARCH021	Slow learner
7	Auditya Sheoran	220BARCH044	Slow learner
8	Rongsennukla Yaden	220BARCH046	Slow learner
9	Raghav Sethi	220BARCH054	Slow learner
10	Shritima Sharma	220BARCH056	Slow learner

Signature of Course Coordinator Faculty

Programme Coordinator



SCHOOL OF ART AND ARCHITECTURE- SUSHANT UNIVERSITY ATTENDANCE SHEET - SLOW LEARNER

REMEDIAL CLASSES SCHEDULE CUM ATTENANCE SHEET FOR SLOW LEARNERS

Program/Batch:B.Arch/2022-27Course Code:19BAR-38522TCourse Title:Building Services 2

Semester: 4
Faculty Name: Prerana H
Date:

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Remarks (Outcome		tain	fair	Fair	Mont	Fair	Fair.	
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Time: # m		83	3	-90-	-88-	Top	æ,	
Time: 4pm		18	3	Sa	- ab -	38	(A)	
Student name		Simran Thakran	Chahat Suneja	Auditya Sheoran	Rongsennukla Yaden	Raghav Sethi	Shritima Sharma	
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Types of Artificial Lighting

By Raghav Sethi, B.Arch 4th Semester

Artificial lighting is a crucial component in architectural design, enhancing the functionality, aesthetics, and ambiance of interior spaces. It is essential for creating comfortable, safe, and productive environments. There are several types of artificial lighting, each with distinct characteristics and applications. Understanding these types is vital for architects and designers to make informed decisions that balance illumination needs with energy efficiency and design aesthetics.

Incandescent lighting, one of the oldest forms of artificial light, produces light by heating a filament until it glows. Although incandescent bulbs provide a warm and inviting light, they are highly inefficient, converting only about 10% of energy into light, with the rest lost as heat. Due to their low energy efficiency and short lifespan, incandescent bulbs are being phased out in favor of more efficient technologies. However, they are still appreciated for their color rendering and ability to create a cozy atmosphere in residential and hospitality settings.

Fluorescent lighting, a more energy-efficient option, operates by exciting mercury vapor, which in turn emits ultraviolet light. This light then interacts with a phosphorescent coating inside the bulb to produce visible light. Fluorescent lights are commonly used in commercial and institutional settings due to their efficiency and longer lifespan compared to incandescent bulbs. They are available in various forms, including linear tubes and compact fluorescent lamps (CFLs). Despite their advantages, fluorescent lights have drawbacks, such as the presence of mercury, which poses environmental hazards, and a tendency to flicker, which can cause discomfort and eye strain.

Halogen lighting is a type of incandescent lighting that uses halogen gas to increase efficiency and lifespan. Halogen bulbs produce a bright, white light that closely resembles natural daylight, making them suitable for task lighting and highlighting artwork or architectural features. They are more energy-efficient than traditional incandescent bulbs but still fall short compared to modern alternatives like LEDs. Halogen bulbs also operate at high temperatures, which can pose safety risks if not properly managed.

Light Emitting Diode (LED) lighting represents the most advanced and energy-efficient artificial lighting technology available today. LEDs produce light through electroluminescence, where electrons recombine with holes in a semiconductor material, releasing energy in the form of photons. LEDs are highly efficient, converting a significant portion of energy into light with minimal heat production. They also boast an exceptionally long lifespan, reducing maintenance costs and environmental impact. LEDs are versatile, available in a wide range of colors, and can be easily integrated into smart lighting systems for dynamic control over light intensity and color temperature. Their adaptability makes LEDs suitable for almost any application, from residential to commercial, industrial, and outdoor lighting.

High-Intensity Discharge (HID) lighting, which includes metal halide, high-pressure sodium, and mercury vapor lamps, is commonly used in large-scale applications such as street lighting,

stadiums, and industrial facilities. HID lamps operate by passing an electric current through a gas-filled tube, which produces an intense light. They are more energy-efficient than traditional incandescent bulbs and provide high levels of illumination over large areas. However, HID lamps have several disadvantages, including a warm-up period before reaching full brightness, potential for color shifts over time, and the presence of toxic materials like mercury.

In conclusion, the choice of artificial lighting plays a significant role in the design and functionality of built environments. While incandescent and halogen lights offer good color rendering and warmth, their inefficiency and heat production limit their use in modern designs. Fluorescent lighting provides a more efficient alternative, though it has environmental and comfort-related drawbacks. LED lighting, with its superior efficiency, longevity, and versatility, has become the preferred choice for a wide range of applications. HID lighting remains relevant for specific high-intensity applications despite its limitations. As technology advances, it is essential for architects and designers to stay informed about the latest developments in lighting to create spaces that are both functional and aesthetically pleasing while minimizing energy consumption and environmental impact.

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Daylighting and Corresponding Usage with Artificial Lighting

By Simran Thakran, B.Arch 4th Semester

Introduction

Daylighting refers to the strategic use of natural light to illuminate building interiors. It is an essential component of sustainable architectural design, reducing the reliance on artificial lighting, minimizing energy consumption, and enhancing the quality of indoor environments. The integration of daylighting with artificial lighting is crucial in achieving an optimal balance between natural and artificial illumination, ensuring comfort, functionality, and energy efficiency. This report explores the principles, benefits, and strategies of daylighting, along with its integration with artificial lighting systems.

Principles of Daylighting

Daylighting design involves the careful consideration of various factors, including building orientation, window placement, glazing materials, and interior layout. The primary goal is to maximize the penetration and distribution of natural light while minimizing glare and heat gain. Key principles include:

- 1. **Building Orientation**: Orienting the building to optimize solar exposure, typically with longer facades facing north and south, can enhance daylight availability throughout the day.
- 2. **Window Design**: Properly sized and placed windows, skylights, and clerestories facilitate natural light entry and distribution. Glazing materials should balance light transmission, thermal performance, and glare control.
- 3. **Interior Layout**: Open floor plans, light-colored surfaces, and reflective materials can help distribute daylight deeper into the building, reducing the need for artificial lighting.

Benefits of Daylighting

The integration of daylighting in architectural design offers several advantages:







- 1. **Energy Savings**: Reducing reliance on artificial lighting decreases electricity consumption and lowers energy bills. Natural light also reduces the need for heating in cold climates and cooling in warm climates, contributing to overall energy efficiency.
- 2. **Improved Well-being**: Exposure to natural light positively impacts human health and well-being. It enhances mood, productivity, and comfort while reducing the incidence of eyestrain and headaches.
- 3. **Environmental Impact**: Daylighting reduces the building's carbon footprint by lowering energy demand and greenhouse gas emissions associated with electricity generation.

Strategies for Effective Daylighting

Effective daylighting requires a combination of design strategies and technologies to optimize natural light utilization:

- 1. **Windows and Glazing**: High-performance glazing materials, such as low-emissivity (low-e) glass, can improve light transmission while reducing heat gain and glare. Operable windows provide natural ventilation and additional daylighting control.
- Skylights and Light Tubes: Skylights and light tubes can bring natural light into spaces
 that are difficult to illuminate with vertical windows. These devices can be equipped with
 diffusers to distribute light evenly and reduce glare.
- 3. **Shading Devices**: Exterior shading devices, such as overhangs, louvers, and shading screens, can control direct sunlight and reduce glare and heat gain. Interior shading options, such as blinds and curtains, provide additional control over daylight penetration.
- 4. **Light Shelves and Reflectors**: Light shelves and reflective surfaces can redirect natural light deeper into the building, enhancing daylight distribution and reducing the need for artificial lighting.

Integration with Artificial Lighting

To achieve a seamless transition between natural and artificial lighting, it is essential to integrate daylighting with artificial lighting systems effectively:

 Lighting Controls: Automated lighting controls, such as dimmers, occupancy sensors, and daylight sensors, can adjust artificial lighting levels based on daylight availability, occupancy, and user preferences. These systems ensure optimal lighting conditions while maximizing energy savings.



- Zoned Lighting: Dividing the interior space into lighting zones allows for more precise control of artificial lighting, enabling the use of artificial light only where and when it is needed.
- 3. Complementary Lighting Design: The selection of artificial lighting fixtures should complement the daylighting design, providing adequate illumination during periods of low natural light and enhancing the overall lighting quality. Fixtures with adjustable color temperature can mimic natural light, creating a more comfortable and visually appealing environment.

Conclusion

Daylighting, when effectively integrated with artificial lighting, offers significant benefits in terms of energy efficiency, environmental sustainability, and occupant well-being. By incorporating principles of daylighting and employing advanced lighting controls and technologies, architects and designers can create buildings that harness the full potential of natural light while maintaining optimal indoor illumination. The thoughtful design and implementation of daylighting strategies are crucial for the development of sustainable and energy-efficient architectural solutions.

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SCHOOL OF ART AND ARCHITECTURE- SUSHANT UNIVERSITY

||Sushant ||University

LIST OF ADVANCED LEARNERS

Program/Batch: B.Arch/2022-27 Course Title: Building Services 2 Course Code: 19BAR-3BS22T

Faculty Name: Prerana H Semester: 4

S.no	Enrollment No.	Student name	Activities done to motivate ADVANCED learners
Н	220BARCH004	Aditi Gupta	Recommended an advanced MOOC course : Energy Efficiency, Acoustics and Daylighting in Building
			Link: https://onlinecourses.nptel.ac.in/noc24_ce47/preview
(Recommended an advanced MOOC course : Energy Efficiency, Acoustics and
7	220BARCH018	Shriya Khurana	Daylighting in Building Link : https://onlinecourses.nntel.ac.in/noc24_ce47/preview
			Recommended an advanced MOOC course : Energy Efficiency, Acoustics and
m	220BARCH019	Ishan Shukla	Daylighting in Building
			Link: https://onlinecourses.nptel.ac.in/noc24_ce47/preview
			Recommended an advanced MOOC course : Energy Efficiency, Acoustics and
4	220BARCH037	Nikita Chawla	Daylighting in Building
			Link: https://onlinecourses.nptel.ac.in/noc24_ce47/preview
Faculty Si	Faculty Signature: H		







Energy Efficiency Acoustics and Daylighting in Building

By Prof. Prof. B Bhattacharjee | IIT Delhi

Learners enrolled: 1639



The objectives of this course is to expose the students to the concepts functional design of building for thermal aspects and energy efficiency; especially in tropical climates i.e. in Indian context. Further objective is to make the student capable of performing fenestration design for natural ventilation and daylighting & design of space for externaland internal noise control.

INTENDED AUDIENCE: Civil Engineering & Architecture students and professionals

: BE/BSc. Level Physics & Mathematics PRE-REQUISITES INDUSTRY SUPPORT: All Industry involved in Building design and construction. L&T, TERI etc. CPWD and all other PWDs. Dr. Fixit Institute







Course layout

Week 1 : Environmental Factors: Factors and their representation, tropical environments and site environments, etc. Week 2 Human response to environment. Factors affecting human comfort, Human response to thermal environment, noise, visual environment etc., Comfort indices

environment; Effect of solar radiation; Thermal properties of material and sections and their influence Neek 3 : Response of building to thermal environment. Processes of heat exchange of building with Week 4 Steady and periodic heat transfer in buildings

Week 5 : Heat flow computations: Transmission matrix, Admittance method, etc.-1

Neek 6 Heat flow computations: Transmission matrix, Admittance method, etc.-2

Week 7 Structural control and design for energy efficiency. Selection of envelope elements, Orientations, shape, Glasses and shading devices

Week 8 : Natural ventilation: Purpose of ventilation, Mechanisms, Fenestration Design for natural ventilation Week 9 Noise and Building Basic acoustics and noise, Planning, Sound in free field, protection against external noise

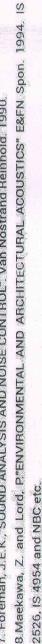
Week 10 : Internal noise sources and protection against air borne & structure borne noise.

Week 11 Day lighting Lighting principles and fundamentals

Week 12 .: Sky, Indian sky, daylight prediction and design of fenestration.

Books and references

- 1. Bureau of Indian Standards, " HAND BOOK OF FUNCTIONAL REQUIREMENTS OF BUILDINGS, (SP-41 & SP-32)", BIS 1987 and 1989.
- 2. Koenighsberger, O.H. et al, "MANUAL OF TROPICAL HOUSING AND BUILDING PART-I CLIMATIC DESIGN", Orient Longman, 1973.
- 3. Markus, T.A. & Morris, E.N., "BUILDING CLIMATE AND ENERGY" Pitman publishing limited, 1980.
- 4. Croome, J.D. &Roberts, B.M., "AIRCONDITIONING AND VENTILATION OF BUILDINGS VOL-1". Pergamon
- 5. Croome, J.D. "NOISE BUILDING AND PEOPLE" Pergamon press.
- 6. Clarke, J.A., "ENERGY SIMULATION IN List of reference materials/books/ Optional use of open source free software such as "eQUEST", Energy plus etc. 2BUILDING DESIGN" Adam Hilger Ltd. 1985. 7. Foreman, J. E.K., "SOUND ANALYSIS AND NOISE CONTROL": Van Nostrand Reinhold, 1990.









School of Art and Architecture-Sushant University

Even Semester (Jan-June) 2023-24

GROUP PROJECT (1)

Program: B.Arch

Course Name: Building Services 2

Faculty: Prerana H

Submission Deadline: 01-03-24

Sem: 4

Course Code: 19BAR-3BS22T

Maximum Marks: 20

Course Outcomes

CO1: Understand and learn day lighting and its relevance in the buildings

CO2: Understand and learn the artificial lighting, its need and application in the building

CO3: Analyse lighting design in the buildings

CO4: Understand the concepts of acoustics design, materials and its usability

CO5: Understand, apply and demonstrate the acoustic planning and detail in the building

Group Project Topic: Lighting systems market survey

- 1. (CO3) Conduct a MARKET STUDY ON DIFFERENT LIGHTING SYSTEMS AND SUPPORTING HARDWARE.
- Collect catalogues, samples, photographic documentation
- Classify and identify brands and specifications, prices, modern lighting control systems
- Compile findings of online and market study, build a matrix for each category
- Conduct a brand contrast survey

Group Project Guidelines:

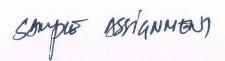
Form groups of 3-4

Present in ppt format

Compile in A4 sheets and prepare a report (Submission of 1 report per group)







Building Services Assignment 1(B)

Name : Pujan Garg Section : A Roll No: 220BARCH002

Strategies for Different Light Conditions

Strategies for diffuse skylight can be designed for either clear or cloudy skies. However, the most significant characteristic of these strategies is how they deal with direct sunlight. Solar shading always is an issue for daylighting except on facades facing the North/South pole (in the northern/southern hemisphere respectively). Solar shading and glare protection are different functions that require individual design consideration.

Cloudy Skies

Daylighting strategies designed for diffuse skylight in predominantly cloudy conditions aim to distribute skylight to interior spaces when the direct sun is not present. In this case, windows and roof lights are designed to bring daylight into rooms under cloudy sky conditions, so windows will be relatively large and located high on the walls. Under sunny conditions, these large openings are a weak point, causing overheating and glare. To avoid decreasing daylight levels under overcast sky conditions, moveable systems are usually applied.

In contrast to daylighting strategies for cloudy skies, strategies that diffuse skylight in climates where clear skies predominate must address direct sunlight at all times. Shading of direct sunlight is therefore part of the continuous operating mode of this strategy. Openings for clear sky strategies do not need to be sized for the low daylight levels of overcast skies.

Direct Sunlight

Strategies for sunlight and diffuse skylight are quite different. Direct sunlight is so bright that the amount of incident sunlight falling on a small aperture is sufficient to provide adequate daylight levels in large interior spaces. Beam daylighting strategies are applicable if sunshine probability is high. Since sunlight is a parallel source, direct sunlight can be easily guided and piped.

Daylighting Systems with and without shading

TABLE 1: Statisticance range as per cooks and

Perantetes	Codes Being	Range
Shaminance	EN 19464-1	500 kus
East work surface, fronzontalli		Immediate surrounding Summeror: 300 has
		Background area Warristance: 100 kie
	NBC 2016	300-500-750 kex
	GRIHA V - 2035	20G-609-750 km
	The WELL Building	30G+500 lux
	Standards	of armbient fighting at 300 has
	v 1 week Atay 2016-aiddenda	
	C/BSE Code for lighting	SOC kis: majorly screen-based tasks
		500 km; paper-
		based tasks

B. Surface Reflectance: Surface reflectance is the ratio of luminous flux reflected by a body (with or without diffusion) to the flux it receives. Reflectance creates a well-balanced luminance distribution.

If reflectance is more than the desired range, it will contribute to high luminance, which will cause glare.

	Codes/Reting system	Radigae			
	Control of the Contro	Celling	Walls	Magra	Furniture
effectance	£34 12464-1	0.7-0.9	9.5-0.3	82-84	0.2-0.7
	CIBSE Code for Lighting	9.7-09	0.5-0.8	0.2-0.4	0.2-0.7
	v4.1 Interior Design	asx	60%	25%	Work, Surfaces: 45% Movable Partitions: 501
	The WELL Building Standards y 1 with May 2016 ordereds	×0.8	±0.7		×9.5
	NBC 3916	For cedangs a	nd waite		************
		Dark colours - 6.1	Middle fints 0.3	Light	White and very light

TABLE 3 Surface reflectance range as our standard custor and gating restorms for production over-

* Control of	Codes/ Earling eastern			
Reflectance	ESRA Lighting Hamiltonik	60% - 98% 50 50 60 60 60	BX-60%	IN R

Daylight Systems with shading

Two types of daylighting systems with shading have been reviewed: systems that rely primarily on diffuse skylight and reject direct sunlight. To increase daylight while providing shading, advanced systems have been developed that both protect the area near the window from direct sunlight and send direct and/ or diffuse daylight into the interior of the room.

Daylight systems without shading

Daylighting systems without shading are designed primarily to redirect daylight to areas away from a window or skylight opening.

- · Diffuse light-guiding systems redirect daylight from specific areas of the sky vault to the interior of the room
- · Direct light-guiding systems send direct sunlight to the interior of the room without the secondary effects of glare and overheating

Parameters affecting visual comfort

It is relatively easy to identify a comfortable environment; however, it becomes a challenge to describe a visually comfortable environment If the space is welllighted, then the subjects usually do not experience any significant visual discomfort.

The following parameters are for visual comfort in indoor lighting:

- A. Illuminance
- B. Surface reflectance
- C. Unifor D. Glare Uniformity ratio
- A. Illuminance: It is a measure of how much the incident light illuminates the surface and is measured in lux. It is the total luminous flux incident on a surface per unit area (lumen perm2).

C. Uniformity Ratio: It plays a vital role in improving user perception, visual acuity, and overally is billity. When referring to light uniformity of an area, the task area in which the objects and immediate surroundings are considered.

TABLE 4: Uniformity ratio as per different codes and rating system

Parameter	Codes/Rating	Range
Uniformity Ratio	EN 12464-1	Task area > 0.6 Immediate surrounding illuminance > 0.4 Background area illuminance > 6.1
	GR#HA V - 2015	Min; 0.4
	NBC 2016	Min. 0.7

D. Glare: It is the sensation produced by bright areas within the field of view. It may be experienced either as discomfort glare or as disability glare. may be experienced entire as disconfirm game to as disauring grant. In interior workplaces, discomfort glare may arise directly from bright luminaires or windows. Glare from windows can be minimised either by using shading devices such as louvers, external hoods, curtains, or by cross-lighting the surroundings to a comparable level.

Design Strategies for daylighting:

There are many design strategies for daylighting in buildings as explained below. These are also fundamental to the concept of solar passive design which means that buildings are designed in response to sun and climate.

Building orientation and form

The orientation determines access to sun. Buildings can be located and oriented to take advantage of sun's movement the about the day.

 Buildings that are longer axis are better for daylighting and visual comfort.

- · Larger and taller buildings should have thinner profiles to maximize
- daylighting potential from side windows.

 Focus should be given to maximum daylight factor, increase uniformity of
- light spread, reduce glare, and minimise solar gains.

 Spaces will high ceilings can accommodate taller windows that help pull daylight further into the space.

Fenestrations

- · Determine the window size, height and glazing treatments for each facade separately.
- · Maximise southern exposure and optimise northern exposure.
- North-facing windows provide consistent indirect light with minimal heat

Shading Devices

Shading devices help bring in daylight without heat. Unlike artificial light fixtures, you can block heat from sunlight and still get light.

- South-facing windows are the easiest to shade. Horizontal shading devices are
- most effective as they can block summer sun and admit winter sun.

 East- and west-facing windows are best shaded with vertical devices, but these are usually harder to incorporate into a building, and limit views from the window.

5. Design guidelines for daylighting

- · Buildings that are longer on their east-west axis are better for daylighting and
- Limit the depth of the floor plate to maximise day-lit area
 Daylight penetration is about 1.5 times the window head
- Use skylights where side lighting cannot be used for adequate lighting of the deeper areas of the floor plate.
- North facing skylights are most suitable for work spaces
- Daylight requirements for different building typologies according to various Indian standards

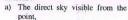
- Daylight in Buildings by SHC Summer Report
 IS 2440 (1975): Guide for Daylighting of Buildings
 Energy Conservation Building Code, 2017
 IS 7942 (1976): Code of practice for daylighting of educational buildings
 Guidelines for Optimum Visual Comfort by Teri and Mahindra Livespaces

Building Typology	Daylight Requirements	Standards/Guidelines
Residential Buildings	Bedrooms: 5% of the floor area should have direct daylighting.	National Building Code (NBC)
	Living rooms: 10-15% of the floor area should have daylight.	Bureau of Indian Standards (BIS)
Commercial Buildings	Office spaces: 6-8% of the floor area should have daylight.	NBC, BIS
	Retail spaces: 8-10% of the floor area should have daylight.	
Educational Buildings	Classrooms: 15-20 foot-candles of illumination.	NBC, BIS
	Libraries. 20-30 foot-candles of illumination.	
Healthcare Buildings	Patient rooms: 10-15 foot-candles of illumination.	NBC, BIS
Industrial Buildings	Workspaces: Adequate natural lighting for task visibility.	NBC, BIS
	A minimum level of illuminance for safety and productivity.	

Recommended daylight factor to be maintained in all interiors.

The daylight intensity at any point inside a room is subject to severe and frequent fluctuations, but it is, however, found to bear a more or less constant ratio to the simultaneous external intensity when the sky is clear or overcast throughout.

Daylight factor (DF) is a measure of all the daylight reaching on an indoor reference point from the following







b) External surfaces reflecting light directly to the point, and
c) Internal surfaces reflecting and inter-reflecting light to the point









ANNEXURE-

School of Art and Architecture -Sushant University

Course Title: Building Services 2

Semester: 4

Course Code: 19BAR-3BS22T

Course Faculty: Prerana H

Programme: B.Arch

Sir/Madam,

Following students mentioned in the list are identified as Slow learner/Advanced learner based on guidelines issued by IQAC after 2 assessment (assignment/quiz). [MIO TERM]

S.No	Name of the student	Roll No	Slow learner/Advanced learner
1	Aditi Gupta	220BARCH004	Advanced learner
2	Palak Mediratta	220BARCH007	Advanced learner
3	Aarushi Agarwal	220BARCH010	Advanced learner
4	Shriya Khurana	220BARCH018	Advanced learner
5	Ishan Shukla	220BARCH019	Advanced learner
6	Himanshu Aggarwal	220BARCH032	Advanced learner
7	Nikita Chawla	220BARCH037	Advanced learner
8	Hardik Sharma	220BARCH039	Advanced learner
9	Maitreyi Rathore	220BARCH043	Advanced learner
10	Priyal Jain	220BARCH051	Advanced learner
11	Sai Satyanarayana Reddy	220BARCH055	Advanced learner

No slow learners have been identified for the course.

Signature of Course Coordinator/Faculty

Programme Coordinator





SCHOOL OF ART AND ARCHITECTURE- SUSHANT UNIVERSITY

|Sushant |University

LIST OF ADVANCED LEARNERS

Program/Batch: B.Arch/2022-27 Course Code: 19BAR-3BS22T Course Title: Building Services 2

Semester: 4 Faculty Name: Prerana H

.no	Enrollment No.	Student name	Activities done to motivate ADVANCED learners
1	220BARCH004	Aditi Gupta	Recommended an advanced MOOC course: Energy Efficiency, Acoustics and Daylighting in Building Link: https://onlinecourses.nptel.ac.in/noc24_ce47/preview
2	220BARCH007	Palak Mediratta	Recommended an advanced MOOC course: Energy Efficiency, Acoustics and Daylighting in Building Link: https://onlinecourses.nptel.ac.in/noc24_ce47/preview
3	220BARCH010	Aarushi Agarwal	Recommended an advanced MOOC course: Energy Efficiency, Acoustics and Daylighting in Building Link: https://onlinecourses.nptel.ac.in/noc24 ce47/preview
4	220BARCH018	Shriya Khurana	Recommended an advanced MOOC course: Energy Efficiency, Acoustics and Daylighting in Building Link: https://onlinecourses.nptel.ac.in/noc24 ce47/preview
5	220BARCH019	Ishan Shukla	Recommended an advanced MOOC course : Energy Efficiency, Acoustics and Daylighting in Building Link : https://onlinecourses.nptel.ac.in/noc24 ce47/preview
6	220BARCH032	Himanshu Aggarwal	Recommended an advanced MOOC course: Energy Efficiency, Acoustics and Daylighting in Building Link: https://onlinecourses.nptel.ac.in/noc24_ce47/preview
7	220BARCH037	Nikita Chawla	Recommended an advanced MOOC course: Energy Efficiency, Acoustics and Daylighting in Building Link: https://onlinecourses.nptel.ac.in/noc24_ce47/preview
8	220BARCH039	Hardik Sharma	Recommended an advanced MOOC course : Energy Efficiency, Acoustics and Daylighting in Building Link: https://onlinecourses.nptel.ac.in/noc24_ce47/preview
9	220BARCH043	Maitreyi Rathore	Recommended an advanced MOOC course: Energy Efficiency, Acoustics and Daylighting in Building Link: https://onlinecourses.nptel.ac.in/noc24_ce47/preview
10	220BARCH051	Priyal Jain	Recommended an advanced MOOC course: Energy Efficiency, Acoustics and Daylighting in Building Link: https://onlinecourses.nptel.ac.in/noc24_ce47/preview
11	220BARCH055	Sai Satyanarayana Reddy	Recommended an advanced MOOC course: Energy Efficiency, Acoustics and Daylighting in Building Link: https://onlinecourses.nptel.ac.in/noc24_ce47/preview









Energy Efficiency Acoustics and Daylighting in Building

By Prof. Prof. B Bhattacharjee | IIT Delhi

Learners enrolled: 1639

INTRODUCTION

The objectives of this course is to expose the students to the concepts functional design of building for thermal aspects and energy efficiency; especially in tropical climates i.e. in Indian context. Further objective is to make the student capable of performing fenestration design for natural ventilation and daylighting & design of space for externaland internal noise control.

INTENDED AUDIENCE: Civil Engineering & Architecture students and professionals

PRE-REQUISITES ; BE/BSc. Level Physics & Mathematics

INDUSTRY SUPPORT: All Industry involved in Building design and construction. L&T, TERI etc. CPWD and all other PWDs. Dr. Fixit Institute









Course layout

Week 1 . Environmental Factors: Factors and their representation, tropical environments and site environments, etc. Week 2 Human response to environment. Factors affecting human comfort, Human response to thermal environment, noise, visual environment etc., Comfort indices

environment; Effect of solar radiation; Thermal properties of material and sections and their influence Week 3: Response of building to thermal environment. Processes of heat exchange of building with Week 4 Steady and periodic heat transfer in buildings

Week 5 : Heat flow computations: Transmission matrix, Admittance method, etc.-1

Neek 6 : Heat flow computations: Transmission matrix, Admittance method, etc.-2

Week 7 : Structural control and design for energy efficiency. Selection of envelope elements, Orientations, shape, Glasses and shading devices

Week 8 : Natural ventilation: Purpose of ventilation, Mechanisms, Fenestration Design for natural

Week 9 Noise and Building Basic acoustics and noise, Planning, Sound in free field, protection against external noise ventilation

Week 10 : Internal noise sources and protection against air borne & structure borne noise.

Week 11 Day lighting Lighting principles and fundamentals

Week 12 . Sky, Indian sky, daylight prediction and design of fenestration.

Books and references

- 1. Bureau of Indian Standards, " HAND BOOK OF FUNCTIONAL REQUIREMENTS OF BUILDINGS, (SP-41 & SP- 32)", BIS 1987 and 1989.
- 2. Koenighsberger, O.H. et al, "MANUAL OF TROPICAL HOUSING AND BUILDING PART-I CLIMATIC DESIGN", Orient Longman, 1973.
- 3. Markus, T.A. & Morris, E.N., "BUILDING CLIMATE AND ENERGY" Pitman publishing limited. 1980.
- 4. Croome, J.D. &Roberts, B.M., "AIRCONDITIONING AND VENTILATION OF BUILDINGS VOL-1". Pergamon
- 5. Croome, J.D. "NOISE BUILDING AND PEOPLE" Pergamon press.
- 6. Clarke, J.A., "ENERGY SIMULATION IN List of reference materials/books/ Optional use of open source free software such as "eQUEST", Energy plus etc. 2BUILDING DESIGN" Adam Hilger Ltd. 1985.
- 7. Foreman, J.E.K., "SOUND ANALYSIS AND NOISE CONTROL". Van Nostrand Reinhold. 1990.
- 8 Maekawa, Z. and Lord, P."ENVIRONMENTAL AND ARCHITECTURAL ACOUSTICS" E&FN Spon. 1994. IS 2526, IS 4954 and NBC etc.







Annexure IV

School of Art and Architecture - Sushant University

Even Semester (Jan-June) 2023-24

Course Title: Building services 2

Semester: 4

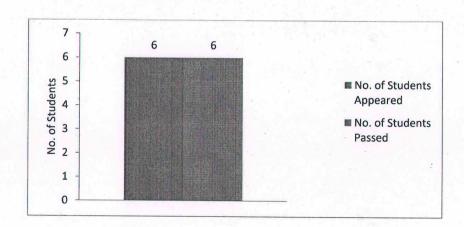
Course Code: 19BAR-3BS22T

Course Faculty: Prerana H

Programme: B.Arch

RESULT ANALYSIS

Sr. No.	Name of the Student	Marks Obtained (20)
1	Simran Thakran	12
2	Chahat Suneja	15
3	Auditya Sheoran	11
4	Rongsennukla Yaden	14
5	Raghav Sethi	14
6	Shritima Sharma	14



Signature of Course Coordinator/Faculty

Programme Coordinator

Dean Husliky









School of Art and Architecture

EVEN SEMESTER 2024 RESULT

Course Code:

19BAR-3BS22T

Programme:

B.Arch

Course Name:

Building Services 2

Section:
Date:

A/B 03 May 2024 Max Marks : Faculty Name : 50

Prerna Hazarika

220BARCH001 220BARCH002 220BARCH003 220BARCH004 220BARCH005 220BARCH006 220BARCH007 220BARCH008 220BARCH010 220BARCH010	Pujan Garg Pranita Saraf Aditi Gupta Shweta Sharma Rushil Soni Palak Mediratta	100 77 77 85 77 85 85	20 14 14 16 17	30 19.0 25.0	50 33.0	Debarred
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		77	13	19.0	32.0	Permitted
		85	15	20.0	35.0	Permitted
220BARCH025	Apoorva Goel	92	16	25.0	41.0	Permitted
220BARCH026	Chirag Yadav	92	13	23.0	36.0	Permitted
220BARCH031	Paavan Jain	85	11	27.0	38.0	Permitted
220BARCH032	Himanshu Aggarwal	77	18	21.0	39.0	Permitted
220BARCH034	Chahat Kakkar	85	14	23.0	37.0	Permitted
220BARCH035	Ronnit Garg	77	15	22.0	37.0	Permitted
220BARCH036	Abeer Bhasin	85	16	15.0	31.0	Permitted
220BARCH037	Nikita Chawla	77	18	21.0	39.0	Permitted
220BARCH038	Saanvi Gupta	85	15	15.0	30.0	Permitted
		85	17	15.0	32.0	Permitted
220BARCH043	Maitreyi Rathore	85	17	27.0	44.0	Permitted
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SUSHANT UNIVERSITY, SECTOR - 55, GURUGRAM End Semester Examination: Regular (May, 2024) B.Arch, Semester-04, Batch - 2022-27

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t				Internal	2		25		30		38		53	5	Se	,		29		7.4	The state of the s	42		51		
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ş	ZZUBAKCHUBZ	Dihruv Dogra	4.167	External	9		28		35		7			-				*				28		21	Analy	Analysis and Design of Building Elements
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Page 4 of 4









SUSHANT UNIVERSITY School of Art and Architecture Mid-Term Examination (Even Semester 2023-24)

rogram: ourse Code:	B.Arch 19BAR-3BS22T		Semester : Course Name		4 Services 2	Mid Term I Faculty Nan		Prerana H	
	T12 0 0		1 1 1 1		sO210Marks)			Attainment	Total Mar
S. No.	Enrolment No.	Student Name	Batch No	COI	CO2		CO1 (10 Marks)	CO2 (10 Marks)	(20)
1	220BARCH001	Manaj Baweja	2022-2027	8	6		8	6	14
2	220BARCH002	Pujan Garg	2022-2027	7	7		7	7	14
3	220BARCH003	Pranita Saraf	2022-2027	8	8		8	8	16
4	220BARCH004	Aditi Gupta	2022-2027	8	9		8	9	17
5	220BARCH005	Shweta Sharma	2022-2027	7	9		7	9	16
6	220BARCH006	Rushil Soni	2022-2027	8	6		8	6	14
7	220BARCH007	Palak Mediratta	2022-2027	8	9		8	9	17
8	220BARCH008	Simran Thakran	2022-2027	6	6		6	6	12
9	220BARCH010	Aarushi Agarwal	2022-2027	8	9		8	9	17
10	220BARCH011	Rudra Kumar Jha	2022-2027	7	9		7	9	16
- 11	220BARCH014	Aryan Gupta	2022-2027	6	9		6	9	15
12	220BARCH015	Sudevi Gayen	2022-2027	7	8		7	8	15
13	220BARCH016	Annanya Bindal	2022-2027	6	8		6	8	14
14	220BARCH017	Moeed Imtiyaz	2022-2027	8	8		8	8	16
15	220BARCH018	Shriya Khurana	2022-2027	8	9		8	9	17
16	220BARCH019	Ishan Shukla	2022-2027	8	9		8	9	17
17	220BARCH020	Ansh Jalan	2022-2027	6	8		6	8	14
18	220BARCH021	Chahat Suneja	2022-2027	7	8		7	8	15
19	220BARCH022	Amritam	2022-2027	5	8		5	8	13
20	220BARCH024	Rudra Pratap Singh	2022-2027	7	8		7	8	15
21	220BARCH025	Apoorva Goel	2022-2027	8	8		8	8	16
22	220BARCH026	Chirag Yadav	2022-2027	6	7		6	7	13
23	220BARCH031	Paavan Jain	2022-2027	6	5		6	5	11
24	220BARCH032	Himanshu Aggarwal	2022-2027	9	9		9	9	18
25	220BARCH034	Chahat Kakkar	2022-2027	8	6		8	6	14
26	220BARCH035	Ronnit Garg	2022-2027	9	6		9	6	15
27	220BARCH036	Abeer Bhasin	2022-2027	8	8		8	8	16
28	220BARCH037	Nikita Chawla	2022-2027	9	9	THE RESERVE	9	9	18
29	220BARCH038	Saanvi Gupta	2022-2027	9	6		9	6	15
30	220BARCH039	Hardik Sharma	2022-2027	9	8		9	8	17
31	220BARCH043	Maitreyi Rathore	2022-2027	9	8		9	8	17
32	220BARCH044	Auditya Sheoran	2022-2027	7	4		7	4	A 6 miles
33	220BARCH045	Harshit Khatri	2022-2027	0	0		0	0	0
34	220BARCH046	Rongsennukla Yaden	2022-2027	7	7		7	7	14
35	220BARCH047	Harshita Dang	2022-2027	6	7	11 12 11	6	7	13
36	220BARCH048	Naveen Chauhan	2022-2027	7	6		7	6	13
37	220BARCH050	Arivait Bansal	2022-2027	8	8		8	8	16
38	220BARCH051	Friyal Jain	2022-2027	8	9	To the second	8	9	17
39	220BARCH052	Avani Khurana	2022-2027	8	8		8	8	16
40	220BARCH053	Ishita Gupta	2022-2027	7	6		7	6	13
41	220BARCH054	Raghav Sethi	2022-2027	7	7		7	7	14
42	220BARCH055	Sai Satyanarayana Reddy	2022-2027	9	9		9	9	18
43	220BARCH056	Shritima Sharma	2022-2027	7	7		7	7	14
44	220BARCH057	Taniya Mohanty	2022-2027	8	8		8	8	16
45	220BARCH058	Apaar Agarwal	2022-2027	7	9		7	9	16
46	220BARCH060	Aditya Dev	2022-2027	8	8		8	8	16
47	220BARCH062	Dhruv Dogra	2022-2027	7	8		7	8	15
110	1002		1 2022 2027	4		Total Students		, , , , , , , , , , , , , , , , , , ,	47
	×			5 H		Average	7.319148936	7.287234043	14.61
						ared in Mid-term (N)			46
			Number	of students	scored average% a	and above marks (P)	23	30	





Average Marks	Max Marks	Min. Marks	Std Deviation	Less than 40%	More than 90%
15	18	0	2.76	2.17%	0.0%

Students Marks	0-9 10-15 16-20
Mid-term	1 22 16

Assessment	Attainment I	evels
	Levell	Less than 50% students scoring more than average% marks.
Mid-term	Level2	50% to less than 60% students scoring more than average % marks.
	Level3	more than 60% students scoring more than average % marks in internal assessment tools

	Mid-term	
25		
70		
55		
10		
S		
0		

COs	Attainment Level
CO1	2
000	



SUSHANT UNIVERSITY
School of Art and Architecture
Group Project Presentation (Even Semester 2023-24)

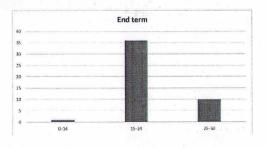
	B.Arch (19BAR-3BS22T		Semester : Course Nan	Building S	ervices 2		Presentation D Faculty Name:	ate:	Prerana H	
	- Table 1		2 St.			Q3(10 Marks		Attainment	***	Total Mar
S. No.	Enrolment No.	Student Name	Batch No	CO3	CO4	CO5			CO5 (10Marks)	(30)
1	220BARCH001	Manaj Baweja	2022-2027	7	6	6	7	6	6	19
2	220BARCH002	Pujan Garg	2022-2027	8	8	9	8	8	9	25
3	220BARCH003	Pranita Saraf	2022-2027	- 7	6	7	7	6	7	20
4	220BARCH004	Aditi Gupta	2022-2027	9	9	9	9	9	9	27
5	220BARCH005	Shweta Sharma	2022-2027	6	5	9	6	5	9	20
6	220BARCH006	Rushil Soni	2022-2027	7	8	7	7	8	7	22
7	220BARCH007	Palak Mediratta	2022-2027	6	5	4	6	5	4	15
8	220BARCH008	Simran Thakran	2022-2027	8	8	9	8	8	9	25
9	220BARCH010	Aarushi Agarwal	2022-2027	8	7	7	8	7	7	22
10	220BARCH011	Rudra Kumar Jha	2022-2027	6	5	4	6	5	4	15
11	220BARCH014	Aryan Gupta	2022-2027	6	7	7	6	7	7	20
12	220BARCH015	Sudevi Gayen	2022-2027	7	7	8	7	7	8	22
13	220BARCH016	Annanya Bindal	2022-2027	8	9	8	8	9	8	25
14	220BARCH010	Moeed Imtivaz	2022-2027	8	6	7	8	6	7	21
15	220BARCH018	Shriya Khurana	2022-2027	6	6	8	6 .	6	8	20
16	220BARCH019	Ishan Shukla	2022-2027	9	9	9	9	9	9	27
17	220BARCH020	Ansh Jalan	2022-2027	7	6	7	7	6	7	20
18	220BARCH020 220BARCH021		2022-2027	7	8	8	7	8	8	23
19	220BARCH021 220BARCH022	Chahat Suneja Amritam	2022-2027	7	6	6	7	6	6	19
20	220BARCH022		2022-2027	6	8	6	6	8	6	20
21		Rudra Pratap Singh	-	9	8	8	9	8	8	25
22	220BARCH025	Apoorva Goel	2022-2027	8	8	7	8	8	7	23
23	220BARCH026	Chirag Yadav	2022-2027	9	9	9	9	9	9	27
	220BARCH031	Paavan Jain	2022-2027	7	8	6	7	8	6	21
24	220BARCH032	Himanshu Aggarwal	2022-2027			7	8		7	23
	220BARCH034	Chahat Kakkar	2022-2027	8	8	7	7	8	7.	22
26	220BARCH035	Ronnit Garg	2022-2027	7	8			8		
27	220BARCH036	Abeer Bhasin	2022-2027	6	5	4	6	5	5	15 21
28	220BAPCH037	Nikita Chawla	2022-2027	8	8	5	8	8		
29	220BARCH038	Saanvi Gupta	2022-2027	6	6	3	6	6	3	15
30	220BARCH039	Hardik Sharma	2022-2027	5	6	4	5	6	4	15
31	220BARCH043	Maitreyi Rathore	2022-2027	9.	9	9	9	9	9	27
32	220BARCH044	Auditya Sheoran	2022-2027	5	4	6	5	4	6	15
33	220BARCH045	Harshit Khatri	2022-2027	0	0	0	0	0	0	0
34	220BARCI1046	Rongsennukla Yaden	2022-2027	7	7	6	7	7	6	20
35	220BARCH047	Harshita Dang	2022-2027	7	8	7	7	8	7	22
36	220BARCH048	Naveen Chauhan	2022-2027	6	7	6	6	7	6	19
37	220BARCH050	Advait Bansal	2022-2027	7	8	8	7	8	8	23
38	220BARCH051	Priyal Jain	2022-2027	7	7	7	7	7	7	21
39	220BARCH052	Avani Khurana	2022-2027	9	9	9	9	9	9	27
40	220BARCH053	Ishita Gupta	2022-2027	6	7	7	6	7	7	20
41	220BARCH054	Raghav Sethi	2022-2027	6	5	4	6	5	4	15
42	220BARCH055	Sai Satyanarayana Reddy	2022-2027	6	7	8	6	7	8	21
43	220BARCH056	Shritima Sharma	2022-2027	6	5	4	6	5	4	15
44	220BARCH057	Taniya Mohanty	2022-2027	7	5	8	7	5	8	20
45	220BARCH058	Apaar Agarwal	2022-2027	9	8	8	9	8	8	25
46	220BARCH060	Aditya Dev	2022-2027	6	8	5	6	8	5	19
47	220BARCH062	Dhruv Dogra	2022-2027	6	5	4	6	5	4	15
					otal Student	s				47
	NAME OF TAXABLE				Averag		6.914893617	6.85106383	6.62	20.38
			Appeared In Grou							46
2		Number of st	udents scored ave	rage% and at			28	29	29	
				00 -4-1	4 (D/M)+40	nl .	(A 000)	CY 0.494	C7 0 497	4



Average Marks	Max Marks	Min. Marks	Std Deviation	Less than 40%
20	27	0	4 73	2 17%

Students	0.14	26.24	25-30
Marke	0-14	13-24	23-30
Project Prese	1	36	10

Assessmen	Attainment I	evels
	Levell	Less than 50% students scoring more than average% marks.
Group Project/ Presentatio	Level2	50% to less than 60% students scoring more than average % marks.
	Level3	more than 60% students scoring more than average % marks in internal assessment tools





CO A	ttainment Level
COs	Attainment Leve
соз	3
COA	-9



SUSHANT UNIVERSITY School of Art and Architecture End-Term Examination (Even Semester 2023-24) End Term Date:

Caliba Mark City Maria Research Caliba Maria Res	Comparison	\$\tilde{O}\$ (14Marks) \tilde{O}\$ (14Marks) O	Attaillient	I otal Marks
ZASAMA KURDIN SAMA Registery 2022-2027 6 5 5 1 2 3 11 6 ZASAMA KURDIN SAMA REGISTERY 2022-2027 6 5 6 6 6 6 11 6 ZASAMA KURDIN SAMA REGISTERY 2022-2027 6 6 6 6 6 6 11 6 ZASAMA KURDIN SAMA REGISTERY 2022-2027 6 6 6 6 6 6 11 6 11 6 11 6 11 6 11 6 11 6 11 6 11 6 11 6 11 6 11 6 11 6 11 6 11 6 11 6 11 6 11 6 6 6 6 6 11 11 6 11 6 11 6 11 6 6 6 6 11 11 6 11 6 6 6	2200-8ACH/SHON Main Benesis 2022-2027 6 5 1 2 3 2200-8ACH/SHON Main Series 2022-2027 5 6 1 3 6 6 6 6 2200-8ACH/SHON Series 2022-2027 5 6 1 3 6 </th <th></th> <th>Jarks 04 (14Marks 05 (10Mark)</th> <th>farks (50)</th>		Jarks 04 (14Marks 05 (10Mark)	farks (50)
Decinitary Control Decinit	220BARCHONO Permis Start 220BARCHONO Permis Magnetia 220BARCHONO PERMIS Permis Magnetia		5 3	27
220RAKACHON Planch Sanch	2208-06-KCHON Depart Start Start 5 1 3 6 5 4 4 6 5 6 6 5 5 6 5 5 4 4 6 5 6 6 5 6 7 3 4 4 6 5 6 <		0 0	2
220RAKGGHON Natural Survay 2022/2017 3 6 9 9 9 220RAKGGHON Natural Survay 2022/2017 6 6 5 6 7 9 9 9 220RAKGGHON Natural Assistant 2022/2017 6 6 6 5 6 7 9 9 9 9 9 220RAKGGHON Natural Assistant 2022/2017 6 4 5 6 6 7 9 <td>220BARCHON Griefly Main Graph 2022-2027 4 5 6 5 6 7 3 220BARCHON Main Graph 2022-2027 6 4 5 6 7 7 3 220BARCHON Burble Medients 2022-2027 6 4 5 6 7 7 7 220BARCHON Sement Marken 2022-2027 6 4 5 6 7 6 4 220BARCHON Sement Marken 2022-2027 6 4 6 5 6 6 4 220BARCHON Sement Marken 2022-2027 5 4 6 5 6 6 4 220BARCHON Sement Marken 2022-2027 5 5 6 6 6 4 6 7 6 4 6 6 4 6 6 4 6 7 6 4 6 7 6 4 7 7 7 7 7 7 7 7 7 <</td> <td></td> <td></td> <td>32</td>	220BARCHON Griefly Main Graph 2022-2027 4 5 6 5 6 7 3 220BARCHON Main Graph 2022-2027 6 4 5 6 7 7 3 220BARCHON Burble Medients 2022-2027 6 4 5 6 7 7 7 220BARCHON Sement Marken 2022-2027 6 4 5 6 7 6 4 220BARCHON Sement Marken 2022-2027 6 4 6 5 6 6 4 220BARCHON Sement Marken 2022-2027 5 4 6 5 6 6 4 220BARCHON Sement Marken 2022-2027 5 5 6 6 6 4 6 7 6 4 6 6 4 6 6 4 6 7 6 4 6 7 6 4 7 7 7 7 7 7 7 7 7 <			32
2.208.RACHOR NATION STREAM STREAM 2.202.2027 4 6 6 6 7 7 9 11 2.208.RACHOR NATION STREAM STREAM 2.202.2027 6 4 6 5 6 7 3 6 1 0 7 2.208.RACHOR NATION TRANS ACCOUNTS TAKE ACCOUNTS TO THE ACCOUNTS TO THE ACCOUNTS TAKE ACCOUNTS TO THE ACCOUNTS TAKE ACCOUNTS TA	220BARCHOUND STREAM STRATUM 2022-20277 4 5 4 5 9 9 9 9 2 4 4 6 5 6 6 3 4 4 6 5 6 6 7 4 4 6 7 9 3 4 4 6 7 9 3 4 4 6 6 6 6 6 7 7 7 2 4 6 7 7 2 4 6 7 2 6 4 6 7			19
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2008-KCH4018 Stream 'Installar 2018-KCH408 Stream 'Carbon Stream 'Installar Stre	2008/ACCHOR Symmetry 2008/ACCHOR 3 0 2 4 2008/ACCHOR Strain 1 1 0 3 6 4 2008/ACCHOR Authority 2022/2027 6 4 6 5 6 4 2008/ACCHOR Authority 2022/2027 5 5 5 4 6 2 4 2008/ACCHOR Authority 2022/2027 3 5 5 4 6 2 4 2008/ACCHOR Authority 2022/2027 3 6 4 6 2 4 2008/ACCHOR Authority 2022/2027 3 6 6 6 6 6 6 6 7 7 2008/ACCHOR Authority Authority Authority 6 6 6 6 6 6 6 6 7 7 7 2008/ACCHOR Authority Authority Authority 6 <			08
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220BARCHION State Medic Capern 4 6 4 6 7 4 11 220BARCHION Ancest Intrinsic Male 2022-2027 5 4 5 6 6 4 10 7 220BARCHION Shape Numbers 2022-2027 5 4 5 6 6 6 8 1 1 1 220BARCHION ANCHON ANCHON AND ANCHON A	200BARCHORS Superior Cayer 2002-2007 5 5 4 6 4 220BARCHORS Superior Substance Cayer 2002-2007 6 4 6 6 4 6 7 220BARCHORS Superior Substance Cayer 2002-2007 6 4 3 6 6 6 4 6 7 200BARCHOR Superior Substance Cayer 2002-2007 1 5 4 8 2 2 1 2 2 2 2 2 2 2 1 2 2 1 2 2 1 2 2 2 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 4		1 4	25
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220BARCHORD Moded Intuity 2020ACT 6 4 6 4 5 4 1 7 7 220BARCHORD Moded Intuity 2020ACT 6 3 1 1 2 4 4 1<	2.010A.NCH-1010 Shiphian 2.022.2027 6 4 6 4 3 3 4 2.010A.NCH-1010 Shiphian Chuntan 2022-2027 1 4 3 1 2 2 1 8 3 4 2.010A.NCH-1010 Ishina Shuda 2022-2027 1 5 6 6 6 6 7 2 2 1 2 2 2 1 2 2 2 1 2 2 2 2 8 5 5 6 6 5 5 6 6 5 6 6 5 2 2 2 6 6 6 5 6 4 4 1 1 0 <td></td> <td>5 2</td> <td>25</td>		5 2	25
2DBARCHOR Shirkham 2022-2027 4 3 2 4 3 7 7 5 2DBARCHOR Makikham 2022-2027 1 5 4 6 6 6 6 5 7 7 7 2DBARCHOR Chart Charts Study 2022-2027 1 5 4 6 6 6 6 6 6 7 1 2 2	2.01BARCHIOS Birthy Schuran 2022-2027 5 4 3 2 1 2 3 2 2 3 2 2 3 2 3 4 4 1 4 2 2 4 4 1 4 2 2 4 4 1 4 2 2 4 4 4 4 4 4 4			30
20BIAMECHON Analy Bankin 2022-2027 3 1 2 4 8 8 3 1 1 1 2 1 2 2 4 <	220BARCHOOF Inhan Shukla 2002-2027 1 3 1 2 8 8 3 220BARCHOF Inhan Shukla 2002-2027 1 5 6 6 6 6 6 6 6 7 220BARCHOS And Radia Surgia 2002-2027 3 4 4 4 1 6 5 220BARCHOS Apoceva Goel 2002-2027 3 4 4 1 0 0 2 220BARCHOS Apoceva Goel 2002-2027 4 4 2 5 6 6 6 6 6 6 7 220BARCHOS Apoceva Goel 2002-2027 4 4 2 5 5 0 1 1 0			17
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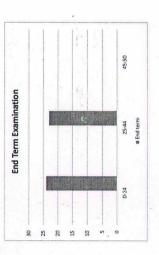
Number of students scored average% and above marks (P)
CO attainment (P/N)*100 64.44%

Std Less than More than Deviation 40% 90%	
Min. Marks	
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Students 0-24 25-44 Marks 23	45-50
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Assessmen	Assessmen Attainment Levels	els
	Levell	students scoring more than average%
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	Level3	students scoring more than average %

CO Attainment Level	Attainment Level	3	2	1	3	2
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Excellent
Very Good
Good
Fair
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		Acane	Coll	Course Exit Survey	Survey	- 6707 - 1	•			п
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Student Full Name	parameter 1		parameter2	700	parameter3	3	parameter4		parameter4	
	Excellent	20	Very Good	16	Excellent	20	Fair	8	Excellent	20
Pujan Garg	Very Good	16	Excellent	20	Excellent	20	Very Good	16	Very Good	16
Pranita Saraf	Excellent	20	Fair	80	Excellent	20	Good	12	Good	12
Aditi Gupta	Very Good	16	Excellent	20	Excellent	20	Excellent	20	Good	12
Shweta Sharma	Very Good	16	Excellent	20	Excellent	20	Cood	12	Good	12
Rushil Soni	Excellent	20	Excellent	20	Excellent	20	Very Good	16	Excellent	20
Palak Mediratta	Very Good	16	Fair	_∞	Excellent	20	Very Good	16	Excellent	20
Simran Thakran	Excellent	20	Very Good	16	Excellent	20	Very Good	16	Good	12
Aarushi Agarwal	Good	12	Good	12	Excellent	20	Excellent	20	Very Good	16
Rudra Kumar Iha	Excellent	20	Good	12	Excellent	20	Very Good	16	Very Good	16
Aryan Gupta	Good	12	Good	12	Very Good	16	Excellent	20	Fair	∞
Sudevi Gayen	Very Good	16	Excellent	20	Excellent	20	Fair	80	Good	12
Annanya Bindal	Very Good	16	Excellent	20	Excellent	20	Very Good	16	Fair	∞
Moeed Imtiyaz	Excellent	20	Good	12	Excellent	20	Excellent	20	Very Good	16
Shriya Khurana	Good	12	Good	12	Very Good	16	Good	12	Good	12
Ishan Shukla	Excellent	20	Very Good	16	Excellent	20	Fair	00	Excellent	20
Ansh Jalan	Very Good	16	Excellent	20	Very Good	16	Very Good	16	Very Good	16
Chahat Suneja	Excellent	20	Fair	8	Very Good	16	Good	12	Good	12
Amritam	Very Good	16	Excellent	20	Very Good	16	Excellent	20	Good	12
Rudra Pratap Singh	Very Good	16	Excellent	20	Fair	8	Excellent	20	Fair	∞
Apoorva Goel	Excellent	20	Fair	8	Excellent	20	Very Good	16	Excellent	20
Chirag Yadav	Excellent	20	Very Good	16	Excellent	20	Very Good	16	Very Good	16
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Himanshu Aggarwal	Excellent	20	Very Good	16	Very Good	16	Excellent	20	Excellent	20
Chahat Kakkar	Excellent	20	Excellent	20	Excellent	20	Excellent	20	Excellent	20
Ronnit Garg	Excellent	20	Very Good	16	Excellent	20	Excellent	20	Good	12
Abeer Bhasin	Good	12	Good	12	Very Good	16	Excellent	20	Very Good	16
Nikita Chawla	Excellent	20	Good	12	Excellent	20	Very Good	16	Very Good	16
Saanvi Gupta	Good	12	Good	12	Very Good	16	Excellent	20	Fair	∞
Hardik Sharma	Very Good	16	Very Good	16	Very Good	16	Very Good	16	Very Good	16
Maitreyi Rathore	Very Good	16	Excellent	20	Very Good	16	Excellent	20	Excellent	20
Auditya Sheoran	Excellent	20	Excellent	20	Excellent	20	Very Good	16	Excellent	20
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Rongsennukla Yaden	Good	12	Poop	12	Excellent	20	poog	12	Good	12
Harshita Dang	Very Good	16	Very Good	16	Very Good	16	Excellent	20	Excellent	20
Naveen Chauhan	Very Good	16	Excellent	20	Fair	89	Excellent	20	Fair	00
Advait Bansal	Good	12	Good	12	Excellent	20	Excellent	20	Very Good	16
Priyal Jain	Excellent	20	Very Good	16	Excellent	20	Excellent	20	Excellent	20
Avani Khurana	Excellent	20	Very Good	16	Excellent	20	Excellent	20	Excellent	20
Ishita Gupta	Excellent	20	Excellent	20	Excellent	20	Excellent	20	Fair	8
Raghav Sethi	Excellent	20	Fair	8	Excellent	20	Poo9	12	Good	12
Sai Satyanarayana Reddy	Excellent	20	Excellent	20	Very Good	16	Excellent	20	Excellent	20
Shritima Sharma	Very Good	16	Excellent	20	Fair	8	Excellent	20	Fair	8
Taniya Mohanty	Excellent	20	Fair	80	Good	12	Excellent	20	Excellent	20
Apaar Agarwal	Excellent	20	Very Good	16	Excellent	20	Excellent	20	Very Good	16
Aditya Dev	Excellent	20	Excellent	20	Very Good	16	Excellent	20	Excellent	20
Dhruv Dogra	Excellent	20	Excellent	20	Excellent	20	Excellent	20	Excellent	20
Average	10	17.478261		15.73913	The state of the s	17.91304		17.13043		15,30435
No of students >=Avg		24	4	30		29		2.5		28
Total students		46		- 46		- 46	of property and	- 46		46
Attainment Level (%)		52.17%		65.22%		63.04%		54.35%		60.87%
Attainment Level		2		3	2	3		2		3

Assessment Methods Attainment Levels







Less than 50% students scoring more than average% marks.	50% to less than 60% students scoring more than average % marks.	60% students scoring more than average % marks
Level1	Level2	Level3
	Assessment	







SUSHANT UNIVERSITY

School of Art and Architecture

CO Attainment (Even Semester- 2023-24)

Program:

B.Arch

Sem:

Course Name: Building Services 2

Course Code:

19BAR-3BS22T

Faculty Name: Prerana H

Date of Analysis:

COs	Direct (80%)	Indirect (20%)	Total (100%)
CO1	1.92	2	1.936
CO2	1.38	3	1.704
CO3	0.9	3	1.32
CO4	2.1	2	2.08
CO5	1.5	3	1.8







SUSHANT UNIVERSITY

School of Art and Architecture

Result Analysis (Even Semester 2023-24)

Program:

B.Arch

Sem:

Course Name: Building Services 2

Course Code: 19BAR-3BS22T

Faculty Name: Prerana H

Date of Analysis:

	Consolidated CO Attai	nment (Internal)	
	Mid term: 20, Er	nd term: 30	
COs	Assessme	ent Tools	Total
COS	Mid-Term	End term	Total
CO1	2	0	0.3
CO2	3	0	0.45
CO3	0	3	0.75
CO4	0	3	0.75
CO5	0	3	0.75

	Consolidated CO Attainment	(Internal+Externa	1)
	Internal 50 : Exte	rnal 50	
COs	Internal (Mid term+End term)	External Examination	Total
CO1	0.3	3	1.92
CO2	0.45	2	1.38
CO3	0.75	1	0.9
CO4	0.75	3	2.1
CO5	0.75	2	1.5







SUSHANT UNIVERSITY

School of Art and Architecture

CO-PO-PSO Mapping (Even Semester - 2023-24)

Course Nam Building Services 2 Faculty Nam Prerana H B.Arch Program:

Course Code: Date of Analysis:

Sem:

19BAR-3BS22T

	High relati	Medium re	Low relation				2	2	3	C)	0	
PSO5	3	2	2	3	1	PSO5	9	4	9	9	2	2.20
PSO4	Total	2	2	2	3	PS04	2	4	9	4	9	2.29
PSO3	2		2	1	2	PSO3	4	2	9	2	Section 4 margin	2,33
PS02	T	2	2	3	mental Address	PS02	2	The Age	9	9	2	2.25
PSO1	2	_	3		and Labor.	PSOI	4	2	6	2	2	2.43
90d	2	-	સ્ત્ર	2		90d	4	2	6	4	2	2.38
P05	3	2	2	Table 1	the state of	POS	9	4	9	2	2	2.25
P04	1	2	2	3	2	P04	2	4	9	9	4.000	2.25
PO3	3	Total Line	The second second	3	2	P03	9	2	3	9	4	2.13
P02	the Land	2	2	1	2	P02	2	4	9	2	4	2.33
P01	3	2	1	2	1	P01	5.52	4	3	4	2	2.07
soo .	CO1	C02	CO3	CO4	CO5	COs	C01	C02	CO3	CO4	CO5	Attainment





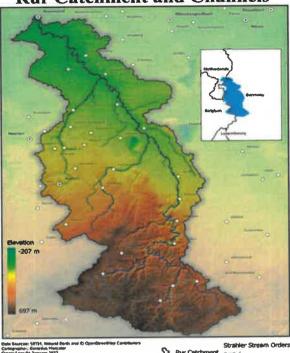


5. Water Bodies and Hydrology

Example https://images.app.goo.gl/wwhUp4uhkZhvER6q7

REFERENCE MAPS

Rur Catchment and Channels



Description of Analysis

- Hydrological Network Analysis: QGIS can be used to analyze the connectivity and hierarchy of streams and rivers, identifying major rivers, tributaries, and drainage networks.
- Flood Risk Mapping: By combining elevation data, rainfall data, and proximity to rivers, QGIS can model flood-prone areas, identifying regions at risk of inundation during heavy rainfall or storm events.
- Water Quality Assessment: Overlaying land use with hydrological data can help assess potential water contamination sources, such as agricultural runoff, industrial pollutants, or wastewater discharge.
- **Groundwater Recharge Areas:** Identify areas where rainwater percolates through the soil to replenish underground aquifers, critical for managing drinking water supplies and irrigation.

Key Attributes Involved

- River flow rates
- Lakes, ponds, and reservoirs (area, volume)
- Groundwater recharge areas
- Flood plains
- Water quality (pH, dissolved oxygen)



Housing is a councy stone for social and economic development of any nation.

Housing serves as the cornerstone of of esecurity. Access to the economic development secure security overhead having a mod stability, perotecting a lease for personal and Adequate housing untrilentes Of housing in well leeing community.

economic development. When individuals have secure



ASSIGNMENT-II

Akashdeep

M.Arch(ud) 1st Sem.

OPEN SPACES MAP (Shahjhanabad)

1. Data Set:

- Base map: Satellite imagery
- Open Spaces Data: existing and proposed **Master Plan of Delhi** or surveys from urban development authorities (e.g., Delhi Development Authority).
- Administrative boundaries: Ward boundaries, roads, street layers

2. Attributes/Layers:

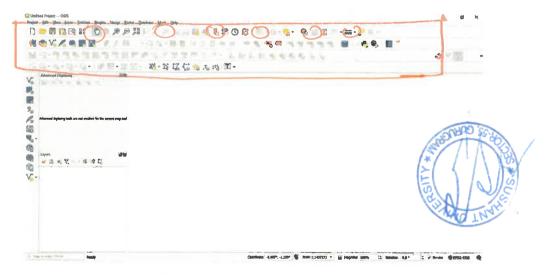


3. Steps for generating file:

Opening a New Project

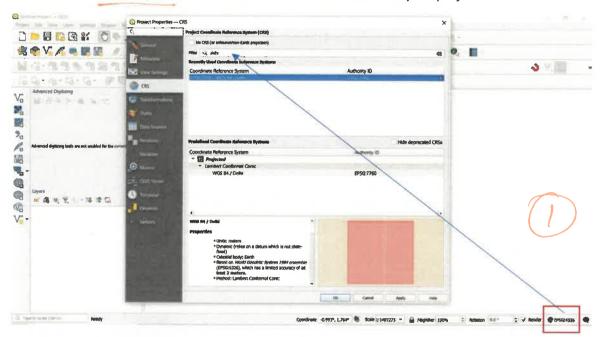
1. Create a New Project:

 Upon launching QGIS, you will see a blank canvas. Click on Project in the menu bar and select New to create a new project.



2. Set Coordinate Reference System (CRS): Expland

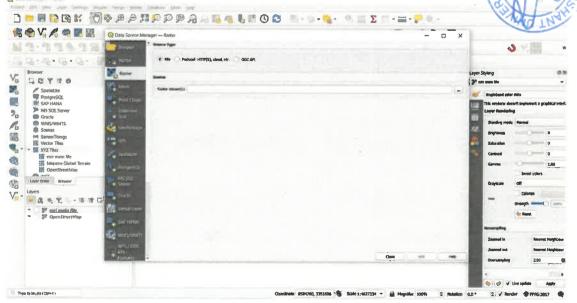
- Click on the CRS status in the bottom right corner of the window.
- In the dialog that appears, type 7760 in the filter box to find "EPSG:7760-WGS84/Delhi" and select it. Click OK to set this as your project's CRS



Loading Data Layers

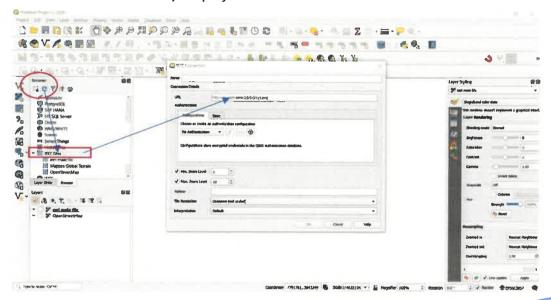
1. Open Data Source Manager:

 Click on the Open Data Source Manager button (or press Ctrl + L). This will allow you to load various types of data layers into your project.



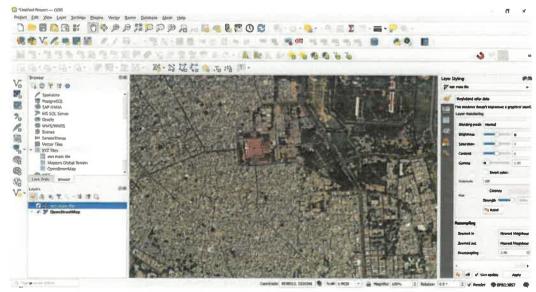
2.Add Raster Layer:

- In the Data Source Manager, select the Raster tab.
- Click on Add Raster Layer, browse to your raster file (e.g., esri), and double-click it to add it to your project.



3. Add Vector Layer:

- Still in the Data Source Manager, switch to the Vector tab.
 - Browse to your vector file (e.g https://server.arcgisonline.com/ArcGIS/rest/services/World_Imagery/MedServer/tile/%7Bz%7D/%7By%7D/%7Bx%7D) and double-click it or drag it into the main QGIS window.





Navigating Your Project

1. Zoom and Pan:

 Use the zoom tools in the toolbar to navigate around your map. You can also click and drag to pan around.

2. Layer Properties:

 Right-click on any layer in the Layers panel and select Properties to adjust styles, labels, and other settings for that layer.

3. Save Your Project:

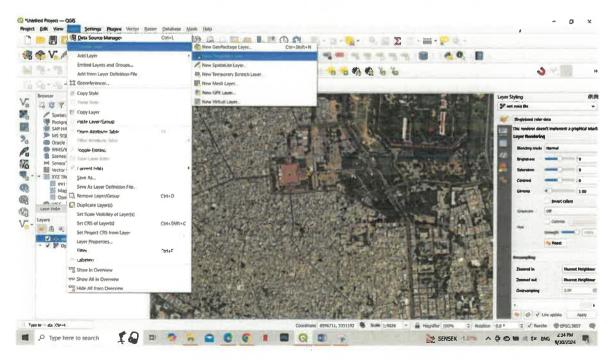
• Don't forget to save your work! Click on Project > Save As, choose a location, and give your project a name with a qgz extension.

By following these steps, you should be able to successfully install QGIS, create a new project, load data layers, and start exploring spatial data visualization.

Create a Shapefile Layer for attributes

Access the New Shapefile Layer Tool:

- Navigate to the top menu and click on Layer.
- From the dropdown menu, select Create Layer and then choose New Shapefile Layer.
 Alternatively, you can click the New Shapefile Layer icon in the toolbar if it's available



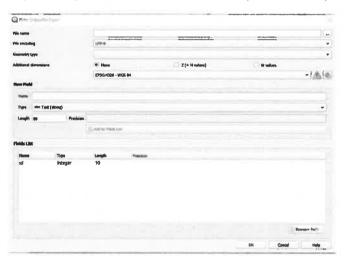
Configure Shapefile Settings:

In the New Shapefile Layer dialog that appears:

File Name: Click the browse button (...) to specify the location and name of your shapefile (e.g., my_shapefile.shp). QGIS will automatically add the .shp extension.

Geometry Type: Select the geometry type you want for your shapefile from the dropdown menu (Point, Line, or Polygon).

Coordinate Reference System (CRS): Click on the button next to CRS to choose a coordinate reference system for your shapefile. You can search for a specific CRS by its EPSG code or name.



Add Fields to Attribute Table:

- In the same dialog, you can define fields (attributes) for your shapefile:
 - Enter a Name for each attribute.
 - Choose a Type for each field (e.g., Text, Whole number, Decimal number).
 - Click on the **Add to Fields List** button after entering each field to include it in your shapefile's schema.
- A default id column is added automatically but can be removed if not needed

Finalize Creation:

 Once you have configured all settings and added fields, click OK to create your new shapefile layer. It will now appear in the Layers panel of QGIS

Key Problems Related to Open Spaces in Shahjahanabad

- 1. **Encroachment**: Unauthorized constructions are diminishing the availability of open spaces, particularly around historical landmarks.
- 2. **Deterioration of Amenities**: Public spaces often lack essential facilities like toilets and drinking water, reducing their usability.
- 3. **Overcrowding**: Severe congestion affects access to open spaces and pedestrian movement, making them less enjoyable.
- 4. Lack of Greenery: Insufficient parks and gardens contribute to urban heat and reduce aesthetic appeal.
- 5. **Neglect of Heritage Sites**: Many historical sites within open spaces are deteriorating due to neglect and lack of awareness.
- 6. **Inadequate Recreational Planning**: Existing public spaces often fail to accommodate cultural activities or community gatherings.
- 7. **Insufficient Stakeholder Engagement**: Limited involvement of local communities in planning leads to designs that do not meet residents' needs.
- 8. **Environmental Degradation**: Urban pressures are harming ecological balance and biodiversity in open areas.

<u>Inferences on Open Spaces in Shahjahanabad</u>

Cultural Significance: Open spaces, like those around the Red Fort and Jama Masjid, are vital for preserving the historical identity and cultural activities of the area.

Urban Commons: These spaces serve as shared resources that foster social interactions and community cohesion in a densely populated environment.

Urbanization Challenges: Rapid urbanization has led to encroachment and deterioration, compromising accessibility and functionality.

Participatory Planning: Engaging local communities in decision-making is essential for effective management and revitalization of open spaces.

Revitalization Potential: Transforming open spaces through pedestrianization and community events can enhance tourism and local engagement while preserving heritage.

Environmental Benefits: Improving ecological quality is crucial for addressing under heat issues and enhancing biodiversity through increased greenery.

Integration with Infrastructure: Open spaces should be linked with urban infrastructure to create pedestrian-friendly pathways that connect cultural hotspots.

Economic Opportunities: Revitalized open spaces can boost tourism and local businesses, leveraging Shahjahanabad's unique cultural assets for economic growth.

Analysis of Open Spaces in Shahjahanabad

1. Historical Context:

 Recognized as a "Special Area," Shahjahanabad's historical and cultural significance is threatened by urban pressures.

2. Urbanization Pressures:

• Rapid urbanization has led to encroachment on open spaces, particularly around landmarks like Jama Masjid and the Red Fort, disrupting accessibility.

3. Land Use Distribution:

 Public facilities, including parks, account for only 17% of the area, indicating a significant lack of recreational spaces amid residential (31.8%) and commercial (11.7%) uses.

4. Participatory Planning:

• Engaging local communities in planning is essential for effective management and revitalization of open spaces.

5. Revitalization Strategies:

 The MPD promotes pedestrian-friendly zones and heritage walks to enhance community engagement and attract tourism.

6. Environmental Considerations:

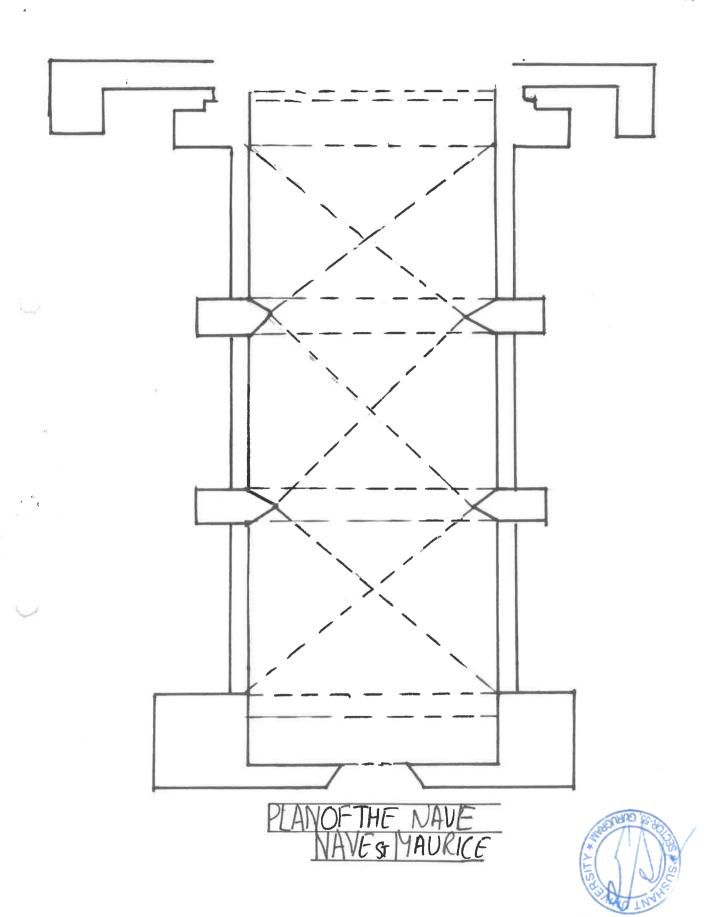
 Urban congestion leads to environmental degradation; increasing green spaces is vital for improving air quality and reducing heat.

7. Economic Opportunities:

 Revitalized open spaces can boost tourism and local commerce, enhancing Shahjahanabad's economic viability while preserving its cultural identity.

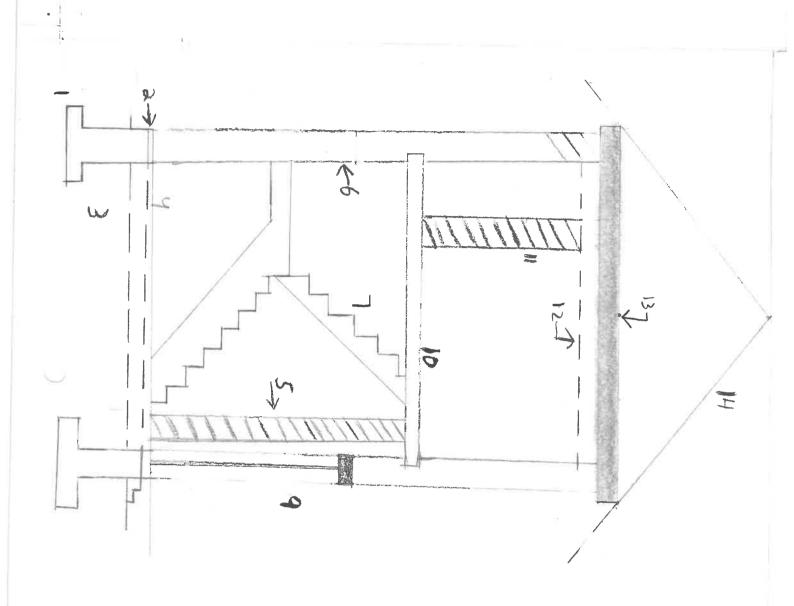
8. Infrastructure Integration:

 Integrating open spaces with urban infrastructure is crucial for improving accessibility and functionality.



Xuffer.

SACHINYAGAU





CHOVAR RAST (D)

SACHIN YADAU