

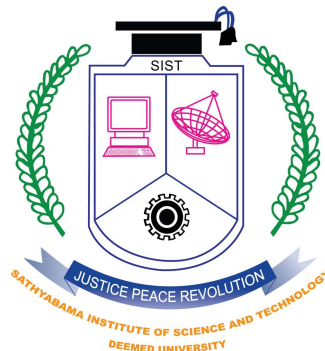
Development of a Sustainable Resort at Rambha Cluster of Chilika lake, Odisha

A Thesis

Submitted in partial fulfillment of the requirements for the award of
Master of Architecture degree in Sustainable Architecture

by

Swगतika Panda, Registration No. - 40890019



**DEPARTMENT OF ARCHITECTURE
SCHOOL OF BUILDING AND ENVIRONMENT**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade "A" by NAAC

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119

MAY 2022



SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)

Accredited with Grade "A" by NAAC

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119

www.sathyabama.ac.in



DEPARTMENT OF ARCHITECTURE

BONAFIDE CERTIFICATE

This is to certify that this Report is the bonafide work of **Swagatika Panda (Regd No. 40890019)** who carried out the Thesis entitled "**Development of a Sustainable Resort at Rambha cluster, Chilka lake, Odisha**" under our supervision from January 2022 to May 2022.

Internal guide

(AR. SEETHA
VISALAKSHI)

Internal Panel Member

(AR. SHEETAL
AMRAOTKAR)

External guide

(AR. KRITHIKHA
MUTHUKRISHNAN)

DR. DEVYANI GANGOPADHYAY
Dean, School of Building and Environment
Head of Department
Dean & Head of the Department

Submitted for Viva voce Examination held on 6th May, 2022

Internal Examiner

External Examiner

DECLARATION

I **Swagatika Panda** hereby declare that the Thesis Report entitled “**Development of a Sustainable Resort at Rambha cluster, Chilka lake, Odisha**” is done by me under the guidance of **Ar. Ar.Seetha Visalakshi** (Internal) and **Ar.Krithika Muthukrishnan** (External) at Sathyabama Institute of Science and Technology is submitted in partial fulfillment of the requirements for the award of Master of Architecture degree in Sustainable Architecture.

DATE:

PLACE:

Swagatika Panda

SIGNATURE OF THE CANDIDATE

ACKNOWLEDGEMENT

I am pleased to acknowledge my sincere thanks to Board of Management of **SATHYABAMA** for their kind encouragement in doing this Pre-Thesis project and for completing it successfully. I am grateful to them.

I convey my thanks to **Dr. Devyani Gangopadhyay, Dean and Head of the department, Dept. of Architecture, School of Building and Environment**, for providing me necessary support and details at the right time during the progressive reviews.

My special thanks to **Dr. Suresh Kuppusamy**, our Design chair and **Ar. Krithika Muthukrishnan**, (External guide) and **Ar. Sheetal Amraotkar** (Thesis Coordinator) for their valuable comments and guidance during the project work.

I wish to express my thanks to all Teaching and Non-teaching staff members of the Department of Architecture who were helpful in many ways for the completion of this Thesis.

ABSTRACT

Life is fast approaching with maximum technology and minimum interaction with the nature. The stress has been increasing on the individuals. To reduce this stress, there will not any solution other than Mother Nature. The concept of sustainable resort is to make people move from one place to another in order to relax themselves. It is considered a place for relaxation and provides entertainment for the visitors and tourists. These kinds of resorts make only a minimum impact on the environment without compromising the guest's comfort and safety. It can replace typical air-conditioned structures. The resort has to blend with the local natural and cultural environments by employing the environmentally sustainable design. It also minimizes use of energy through passive solar design. Wherever additional energy inputs are required it should utilize the renewable resources such as sun, air and water. It also has to make minimum impact on the environment by limiting waste emissions, pollution and other environmental effects. This study concludes with a few parameter recommendations aimed to deliver environmentally conscious sustainable resort at Rambha cluster in Chilika Lake. Such an approach is expected to minimize impacts on the environment as well as creating leisure experience for tourists.

TABLE OF CONTENTS

CHAPTER No.	TITLE	PAGE No.
	ABSTRACT	v
	LIST OF TABLES	xii
	LIST OF FIGURES	xiii
01	INTRODUCTION TO THE STUDY	01
1.1	INTRODUCTION	01
1.2	AIM	01
1.3	OBJECTIVES OF THE STUDY	01
1.4	SCOPE OF THE STUDY	02
1.5	NEED FOR THE STUDY	02
1.6	RESEARCH QUESTIONS	02
1.7	LIMITATIONS OF THE STUDY	02
02	RESEARCH METHODOLOGY	03
03	LITERATURE CASE STUDIES REVIEW AND ANALYSIS	04
3.1	LOTUS ECO BEACH RESORT, KONARK, ODISHA	04
3.2	KUMARAKOM LAKE RESORT, KERALA	23
3.3	TREE HOUSE SUITE, MEXICO	30
3.4	COMPARATIVE ANALYSIS	34
3.5	TAKE AWAYS FROM CASESTUDY ANALYSIS	35

04	SITE SELECTION AND JUSTIFICATION	37
4.1	INTRODUCTION	37
4.2	DEMARCATON OF CLUSTERS FOR DEVELOPMENT	38
4.3	PROPOSED TOURISM MASTER PLAN AREA AT RAMBHA CLUSTER	49
4.4	SITE SELECTION AND JUSTIFICATION	40
4.5	PROXIMITY OF THE SITE FROM THE RAMBHA BIRDS SANCTUARY	41
05	MACRO AND MICRO CLIMATE ANALYSIS OF SITE	42
5.1	LANDUSE SURROUNDING THE PROPOSED SITE	42
5.2	MICRO CLIMATE ANALYSIS OF THE SITE	42
5.3	SITE ACCESSIBILITY AND PROXIMITY ANALYSIS	44
5.4	SITE PROXIMITY ANALYSIS	45
5.5	SITE CONTOUR ANALYSIS	45
5.6	3D IMAGES OF THE PROPOSED SITE	46
5.7	SWOT ANALYSIS	47
5.8	LOCALLY AVAILABLE MATERIALS NEAR TO SITE	48
5.9	SUN PATH DIAGRAM, PREVAILING WIND DIRECTION	49
5.10	MICRO CLIMATE ANALYSIS OF THE SITE	50
5.11	FUNCTIONAL SPACE REQUIREMENT ANALYSIS	53
5.12	CODES AND STANDARDS TO BE FOLLOWED	54
5.13	GUIDELINES AND REGULATIONS TO BE FOLLOWED	55

06	ARRIVAL OF FUNCTIONAL SPACE REQUIREMENTS AND SITE ZONING	56
6.1	FORM FACTOR ANALYSIS	56
6.2	ZONING ITERATION 01	57
6.3	ZONING IETRATION 02	59
6.4	ARRIVAL OF PUBLIC, SEMI PUBLIC, PRIVATE, SEMI PRIVATE ZONE	61
6.5	ESSENTIAL STRATEGIES THOSE WILL BE INCORPORATED AT SITE LEVEL	62
07	DETAILED SITE AND BLOCK PLANNING AND SOFTWARE SIMULATION RESULTS	63
7.1	BLOCK ORIENTATION ANALYSIS WITH RESPECT TO SOLAR RADIATION	63
7.2	BLOCK ORIENTATION ANALYSIS WITH RESPECT TO WIND FLOW DIRECTION (PRESIDENTIAL COTTAGE)	66
7.3	DETAIL SITE PLANNING	69
7.4	SITE AREA MAPPING	70
7.5	VARIOUS BUILDING BLOCKS AND THEIR DETAIL PLANS	72
7.6	DETAILED AREA STATEMENT	79
7.7	DETAIL PLANNING "PRESIDENTIAL COTTAGE"	80
7.8	DETAIL PLANNING "DELUXE COTTAGE"	84
7.9	DETAIL PLANNING "FAMILY COTTAGE"	88

08	ENVELOPE MATERIAL ANALYSIS	92
8.1	STUDY OF RESEARCH PAPER	92
8.2	CURRENT AVAILABILITY OF BAMBOO IN INDIA	94
8.3	CURRENT STATUS OF BAMBOO IN ODISHA	96
8.4	WALL MATERIAL ANALYSIS	98
8.5	ROOF MATERIAL ANALYSIS	99
8.6	STUDY OF RESEARCH PAPER	101
8.7	WINDOW AND DOOR MATERIALS COMPOSITION	103
8.8	ADOPTED FOUNDATION TYPE	103
8.9	BAMBOO FLOORING	104
09	CONSUMPTION AND LIFE CYCLE COST ANALYSIS	105
9.1	ANNUAL POWER CONSUMPTION CALCULATION	105
9.2	ANNUAL SOLAR POWER PRODUCTION CALCULATION	105
9.3	LIFE CYCLE COST CALCULATION	106
10	SUMMARY AND CONCLUSION	112
	REFERENCES	113

LIST OF TABLES

TABLE No.	TITLE	PAGE No.
3.1	Comparative studies among literature case studies undertaken	34
3.2	General design parameters derived from the analysis	35
5.1	Study of design parameters derived from case study	52
5.2	Study of codes and standards to be followed	53
6.1	Form factor analysis	56
7.1	Cumulative solar radiation calculations	65
7.2	Cumulative wind speed calculations	68
7.3	Functional spaces provided in different blocks	72
7.4	Functional spaces provided in different blocks	74
7.5	Functional spaces provided in different blocks	76
7.6	Detail area statement	79
7.7	Cumulative radiation calculations - presidential cottage	81
7.8	Cumulative radiation calculations – deluxe cottage	85
7.9	Cumulative radiation calculations – family cottage	89
8.1	Lists of physical comfort parameters	91
8.2	Lists of states with bamboo growing stock	96
8.3	Recorded bamboo harvest in last two decades	97
8.4	Different types of wall material analysis	98
8.5	Different types of roof material analysis	99

LIST OF TABLES

TABLE No.	TITLE	PAGE No.
8.6	Maximum load and deflection for bamboo reinforced slab	101
8.7	Types of bio solar roof	102
8.8	Window material compositions	103
9.1	Annual power consumption calculations	105
9.2	Annual solar power production calculations	105
9.3	Life cycle cost calculation	106
9.4	Life cycle cost calculation	107
9.5	Life cycle cost calculation	108
9.6	Life cycle cost calculation	109
9.7	Life cycle cost calculation	110
9.8	Life cycle cost calculation	111

LIST OF FIGURES

FIGURE No.	TITLE	PAGE No.
1.1	Image of Konark Temple Odisha	01
3.1	Exterior images of wooden cottages of Lotus Eco beach Resort	04
3.2	Plan of Lotus Eco beach Resort	05
3.3	Interior images of the wooden cottage of Lotus Eco beach Resort	05
3.4	Images of Conference centre of Lotus Eco beach Resort	06
3.5	Outdoor seating arrangement at Lotus Eco beach Resort	06
3.6	Interior of AC Restaurant and Common house at Lotus Eco beach Resort	06
3.7	India map showing different types of climate zones	07
3.8	Temperature and rainfall graph of Odisha	07
3.9	Planning details of the wooden cottage	08
3.10	Solar radiation level on roof in the month of May at 12 PM	09
3.11	Solar radiation level on roof in the month of July at 12 PM	09
3.12	Solar radiation level on roof in the month of January at 12 PM	09
3.13	Radiation Graph pertaining to roof	09
3.14	Solar radiation level on southern facade in the month of May at 12 PM	10

LIST OF FIGURES

FIGURE No.	TITLE	PAGE No.
3.15	Solar radiation level on southern facade in the month of July at 12 PM	10
3.16	Solar radiation level on southern facade in the month of January at 12 PM	10
3.17	Radiation Graph pertaining to southern facade	10
3.18	Solar radiation level on eastern facade in the month of May at 12 PM	11
3.19	Solar radiation level on eastern facade in the month of July at 12 PM	11
3.20	Solar radiation level on eastern facade in the month of January at 12 PM	11
3.21	Radiation Graph pertaining to eastern facade	11
3.22	Solar radiation level on northern facade in the month of May at 12 PM	12
3.23	Solar radiation level on northern facade in the month of July at 12 PM	12
3.24	Solar radiation level on northern facade in the month of January at 12 PM	12
3.25	Radiation Graph pertaining to northern facade	12
3.26	Solar radiation level on western facade in the month of May at 12 PM	13
3.27	Solar radiation level on western facade in the month of July at 12 PM	13
3.28	Solar radiation level on western facade in the month of January at 12 PM	13
3.29	Radiation Graph pertaining to western facade	13

LIST OF FIGURES

FIGURE No.	TITLE	PAGE No.
3.30	Day lighting simulation results for the month of January at location 01	14
3.31	Day lighting simulation results for the month of May at location 01	15
3.32	Day lighting simulation results for the month of July at location 01	16
3.33	Day lighting simulation results for the month of January at location 02	17
3.34	Day lighting simulation results for the month of May at location 02	18
3.35	Day lighting simulation results for the month of July at location 02	19
3.36	Wind direction and speed graph	20
3.37	Autodesk flow design software simulation results	21
3.38	Autodesk flow design software simulation results	22
3.39	Image of Kumarakom lake Resort, Kerala	23
3.40	Image of Kumarakom lake Resort, Kerala	24
3.41	Image of Kumarakom lake Resort, Kerala	25
3.42	Plan and Exterior view of Presidential Suite	26
3.43	Plan and exterior view of Heritage Lakeview villas	26
3.44	Plan and exterior view of Heritage villas with private pool	27

LIST OF FIGURES

FIGURE No.	TITLE	PAGE No.
3.45	Plan and exterior view of meandering pool villas	27
3.46	Plan and exterior view of luxury pavilion rooms	28
3.47	Plan and exterior view of meandering pool duplex	29
3.48	Image showing Tree house Suite, Mexico	30
3.49	Image showing Tree house Suite, Mexico	31
3.50	Plan of Tree house Suite, Mexico	32
3.51	Image showing Tree house Suite, Mexico	33
4.1	Location of identified clusters in Chilika lake	38
4.2	Location of identified for development at Rambha Cluster	39
4.3	Demarcation of Proposed site	40
4.4	Proximity of the site from Rambha bird sanctuary	41
5.1	Temperature and sky cover range graph	42
5.3	Solar radiation and wind velocity graph	43
5.4	Relative humidity and dry bulb temperature graph	43
5.5	Locating important structures nearby proposed site	44
5.6	Photographs of important structures nearby proposed site	44
5.7	Contour maps of proposed site	45
5.8	3D views of the proposed site	46
5.9	Locally available stones in Odisha	48
5.10	Locally available timbers in Odisha	48
5.11	Sun path diagram and prevailing wind direction at site level	49
5.12	ENVI-MET software results regarding various physical parameters	50

LIST OF FIGURES

FIGURE No.	TITLE	PAGE No.
5.13	Graphical representation of ENVI-MET software results regarding various physical parameters	51
6.1	Site zoning iteration 01	57
6.2	Site zoning iteration 02	59
6.3	Site zoning bubble diagram	60
6.4	Demarcations of different zones in site layout	61
7.1	Orientation at 0° with respect to solar radiation	63
7.2	Orientation at 15° with respect to solar radiation	63
7.3	Orientation at 30° with respect to solar radiation	64
7.4	Orientation at 45° with respect to solar radiation	64
7.5	Orientation at 60° with respect to solar radiation	65
7.6	Orientation at 90° with respect to wind direction	66
7.7	Orientation at 60° with respect to wind direction	66
7.8	Orientation at 45° with respect to wind direction	67
7.9	Orientation at 30° with respect to wind direction	67
7.10	Orientation at 15° with respect to wind direction	68
7.11	Detail Site layout	69
7.12	Site area mapping	70
7.13	Site area mapping	71
7.14	Blocks demarcation in site planning	72
7.15	Detailed plan of shopping arcade, administration block	73
7.16	Blocks demarcation in site planning	74

LIST OF FIGURES

FIGURE No.	TITLE	PAGE No.
7.17	Detailed plan of service block, club house, birds watching tower, open air theatre and gazebo	75
7.18	Blocks demarcation in site planning	76
7.19	Detailed plans of care taker accommodation and restaurant cum snacks bar	77
7.20	Blocks demarcation in site planning	78
7.21	Detail Plan – Presidential cottage	80
7.22	Solar radiation analysis - Presidential cottage	81
7.23	Day lighting analysis - Presidential cottage	82
7.24	Wind flow analysis - Presidential cottage	83
7.25	Detail Plan – Deluxe cottage	84
7.26	Solar radiation analysis – Deluxe cottage	85
7.27	Day lighting analysis – Deluxe cottage	86
7.28	Wind flow analysis – Deluxe cottage	87
7.29	Detail Plan – Family cottage	88
7.30	Solar radiation analysis – Family cottage	89
7.31	Day lighting analysis – Family cottage	90
7.32	Wind flow analysis – Deluxe cottage	92
8.1	Construction process of Bamboo reinforcement structure	93
8.2	Annual Bamboo production in different states of India	94
8.3	Bamboo species production in different states of India	95
8.4	Sectional view of bamboo reinforced Concrete	98

LIST OF FIGURES

FIGURE No.	TITLE	PAGE No.
8.5	Details of Bio-Solar roof	100
8.6	Details of bamboo reinforced slab	102
8.7	Foundation details	103
8.8	Details of Bamboo door and Bamboo curtain	104

CHAPTER 01

1.1 INTRODUCTION

A sustainable resort is a lodging facility that takes active steps toward environmental sustainability and social responsibility by helping its natural surroundings and the local community. It offers a comfortable and relaxing experience to visitors. Such a resort makes **minimal impact** on the environment without compromising guests comfort and safety. It also has the ability to blend with local natural and cultural environment. It makes minimum impact on the environment by limiting waste, emissions, pollution and other undesirable effects of its operation. **Odisha**, one of beautiful Indian State, has been a religious and spiritual significance for which the state is explored by thousands of devotees across the world every year.



Fig 1.1 Konark Temple Odisha

1.2 AIM OF THE STUDY

To design a sustainable resort not only for leisure but will offer a tourist a complete eco experience.

1.3 OBJECTIVES OF THE STUDY

- To provide a recreational environment for varieties of facilities and functions.
- To provide a comfortable design that portrays an environment of leisure and promotes interaction with nature.
- To respond to climatic and energy consumption issues raised by present day architecture through sustainable design.
- To design a suitable perspective to the surrounding environment and without the environmental disadvantages.
- To locate the buildings with public spaces and common facilities for social interaction.

- f. To adopt a cost effective and functional design.

1.4 SCOPE OF THE STUDY

- a. The scope of this study is the eco resort with recreational facilities.
- b. The intention of this eco resort is to go some distance far from city so that they can enjoy the environment.
- c. The development of the eco resort will provide a lot of scope for site planning and landscaping.
- d. It will also provide the opportunity to study the local culture and heritage.

1.5 NEED OF THE STUDY

The main need of this study is to revitalize the industry which has been largely ignoring the social, environmental and cultural values of the surrounding region by limiting the interaction between the tourists and the locals.

1.6 RESEARCH QUESTIONS

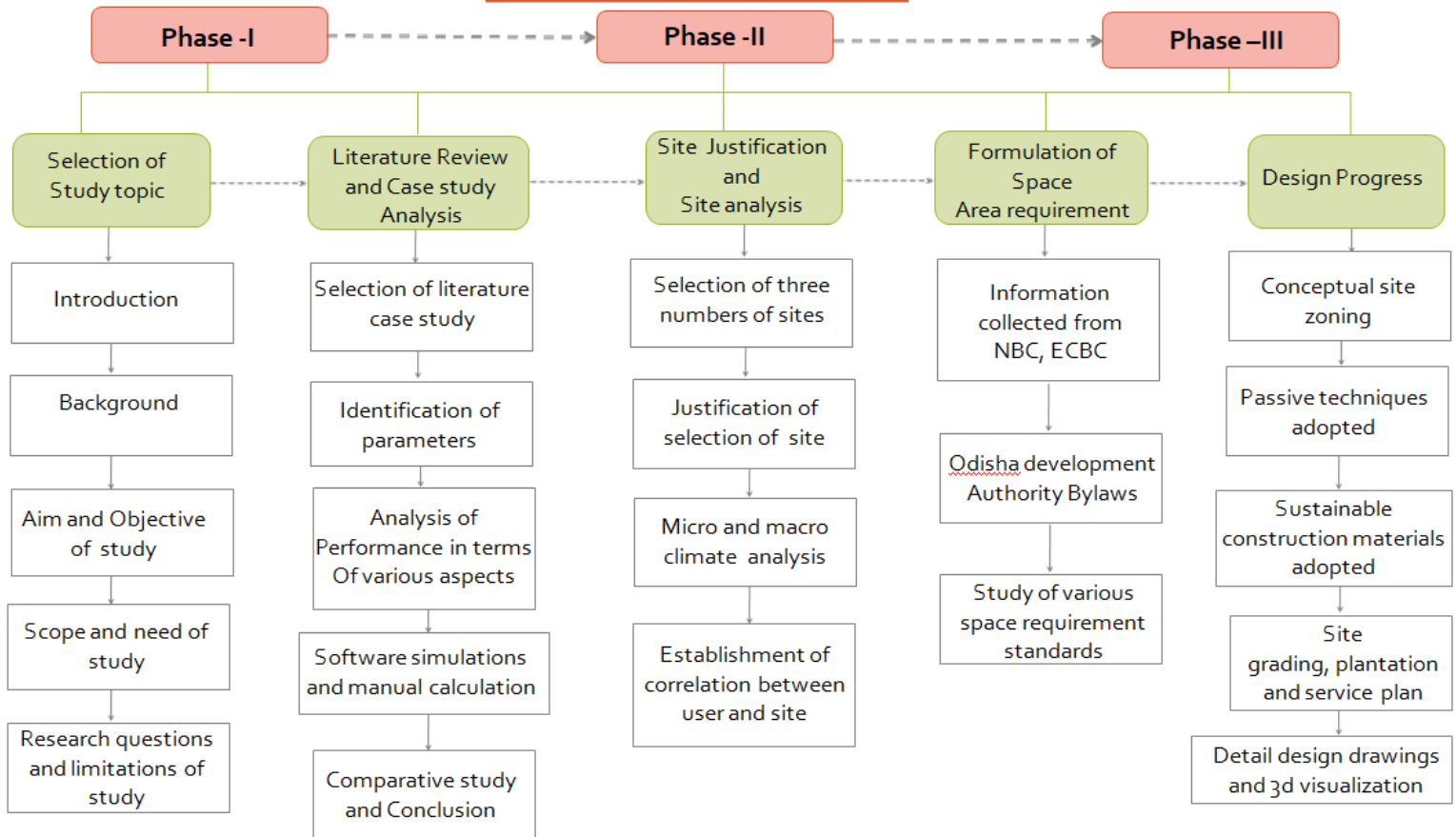
- a. What is the need to develop of an eco resort at Chilika Lake, Odisha?
- b. What are the parameters that are effecting form and planning strategies of an eco resort?
- c. What are various functions of an eco resort?
- d. How locally available materials can be useful for development of an eco resort?
- e. How soil type, topography and climatic conditions affect the development of an eco resort?
- f. What are the space requirements of an eco resort?

1.7 LIMITATIONS OF THE STUDY

- a. The analysis will be done focusing only on location at Rambha Cluster of Chilika Lake, Odisha.
- b. The study will not cover details related to landscape design.
- c. Detail environmental assessment will not be done.

CHAPTER 02

RESEARCH METHODOLOGY



CHAPTER 03

3.1 LITERATURE CASE STUDY 01: LOTUS ECO BEACH RESORT, KONARK, ODISHA

3.1.1 INTRODUCTION

- a. This eco beach resort is located at the junction point of Bay of Bengal and Kushabhadra River in Puri district.
- b. This eco resort is 89 km away from Bhubaneswar, the Capital city of state Odisha.
- c. Conveniently located just 15 minutes away from Konark Sun Temple.
- d. Various tourist attractions like water sports, boat ride, butterfly garden, kids play area, outdoor seating, seaside cafe and bar, restaurant are provided apart from villa and cottage accommodation.
- e. Locally available hard wood like Sheesham, Mahogany, Babul, Sal are used for construction of the villas.
- f. Apart from this, Bamboo columns are used to support thatched roof which protects the entire structure.



Fig 3.1 Exterior images of wooden cottages of Lotus Eco beach Resort



Fig 3.2 Plan of Lotus Eco beach Resort

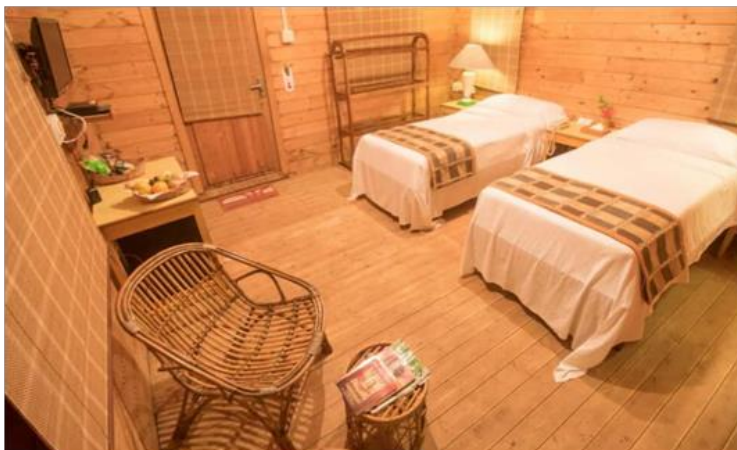


Fig 3.3 Interior images of the wooden cottage of Lotus Eco beach Resort



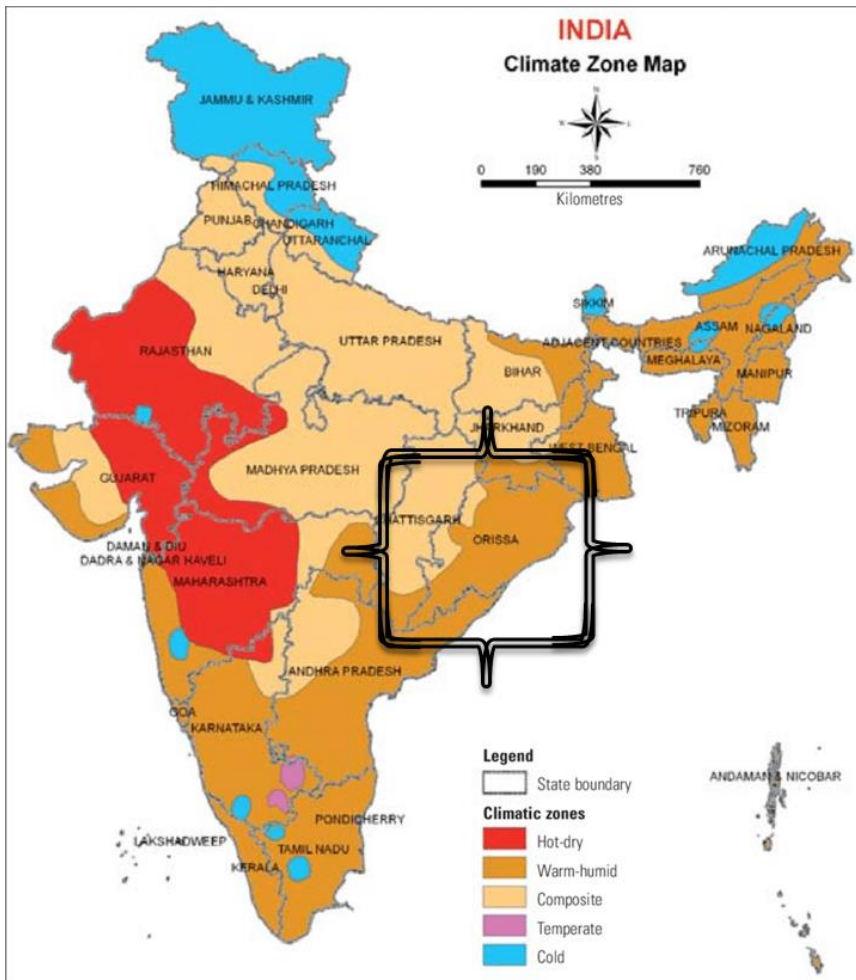
Fig 3.4 Images of Conference centre of Lotus Eco beach Resort



Fig 3.5 Outdoor seating arrangement at Lotus Eco beach Resort



Fig 3.6 Interior of AC Restaurant and Common house at Lotus Eco beach Resort



3.1.2 CLIMATE ANALYSIS

a. Lotus eco beach resort is located at the junction point of Bay of Bengal and Kushabhadra river in Puri district. Most of the districts of Odisha are undergoing **warm and humid climate zone**.

b. **Critical Months –**

Hottest Month : May (Avg Temp 30.8 degree C)

Coldest Month : January (Avg Temp 22.0 degree C)

Most rainfall Month : July (Avg. 354 mm)

Least rainfall Month : January (Avg. 10 mm)

Fig 3.7 India map showing different types of climate zones

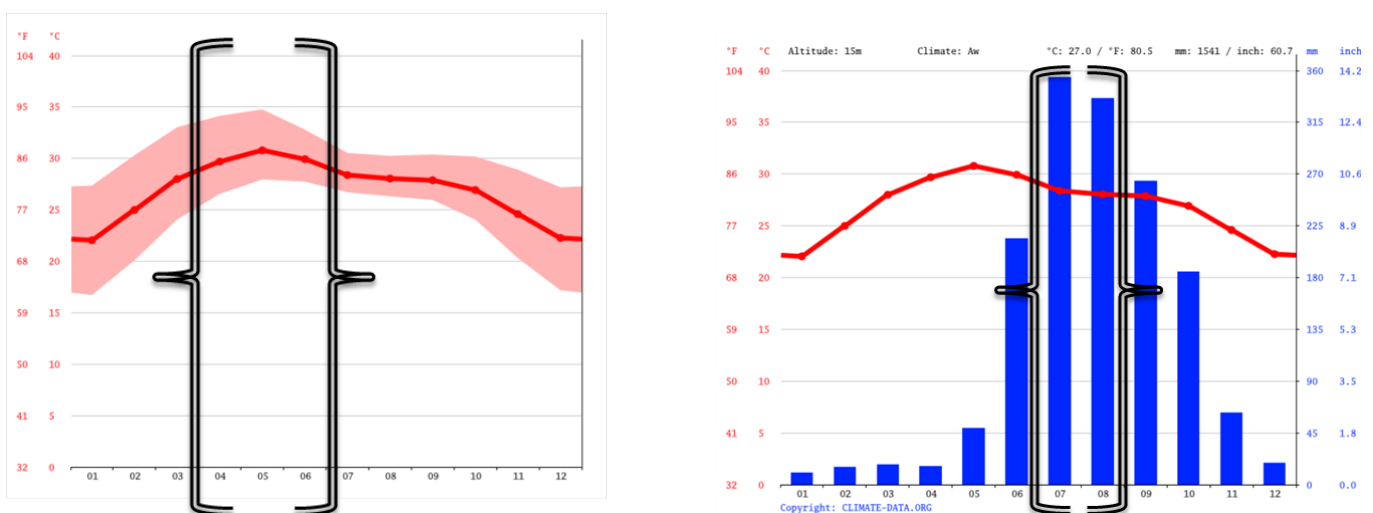
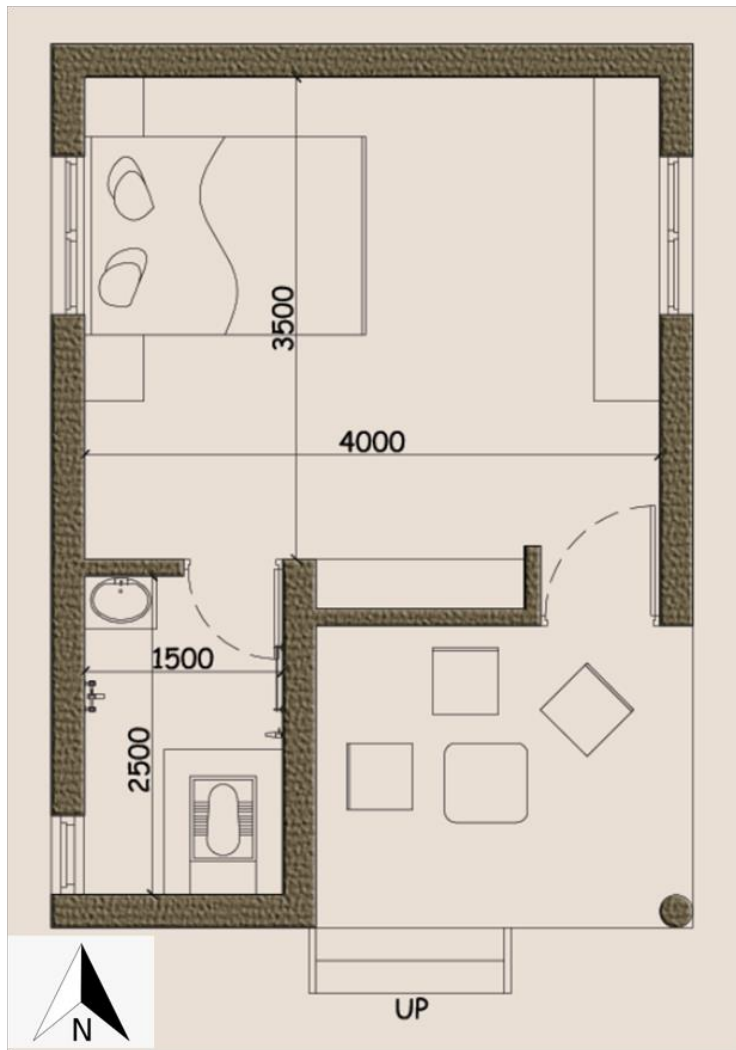


Fig 3.8 Temperature and rainfall graph of Odisha



3.1.3 DETAILS OF THE COTTAGE PLANNING

The whole wooden structure is protected under a thatched roof and an open corridor all around the building. The outer thatched roof is supported with bamboo pillars.

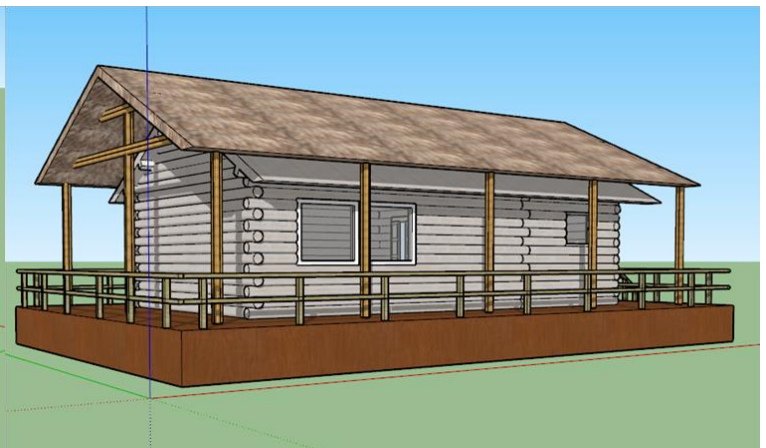
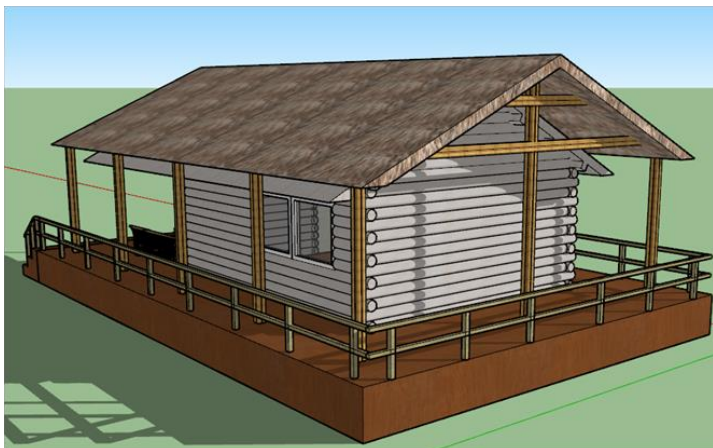


Fig 3.9 Planning details of the wooden cottage

3.1.4 SOLAR RADIATION ANALYSIS (ROOF) –

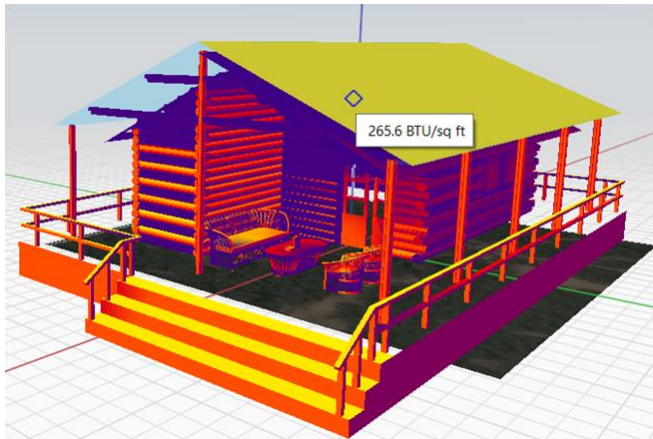


Fig 3.10 Solar radiation level on roof in the month of May at 12 PM

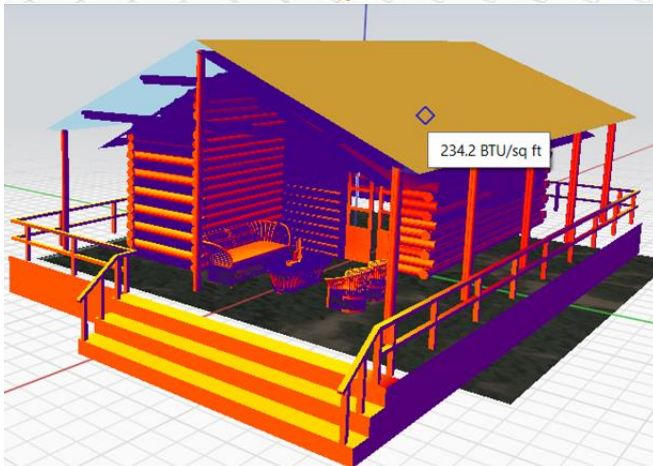
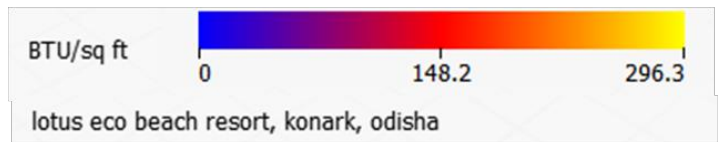


Fig 3.11 Solar radiation level on roof in the month of July at 12 PM

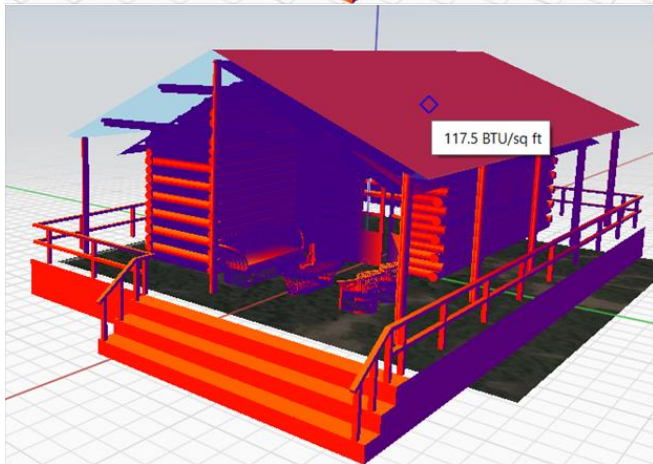


Fig 3.12 Solar radiation level on roof in the month of January at 12 PM

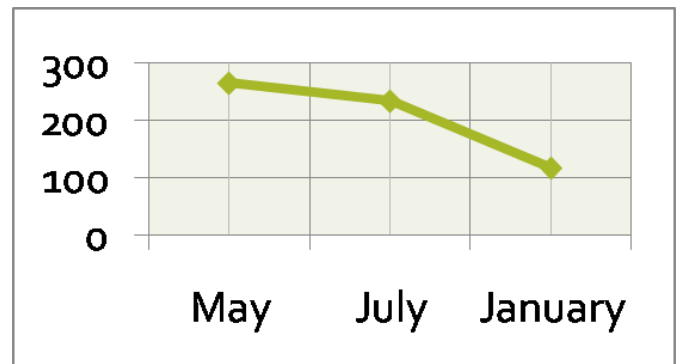


Fig 3.13 Radiation Graph

INFERENCE –

The villas are designed with double roof consisting of a wooden roof over which a thatched roof is provided. In the month of May, maximum solar radiation is hitting the roof is 265.6 BTU/Sqft. Minimum radiations 117.5 BTU/Sqft is visible in the month of January.

3.1.5 SOLAR RADIATION ANALYSIS (SOUTHERN FACADE) –

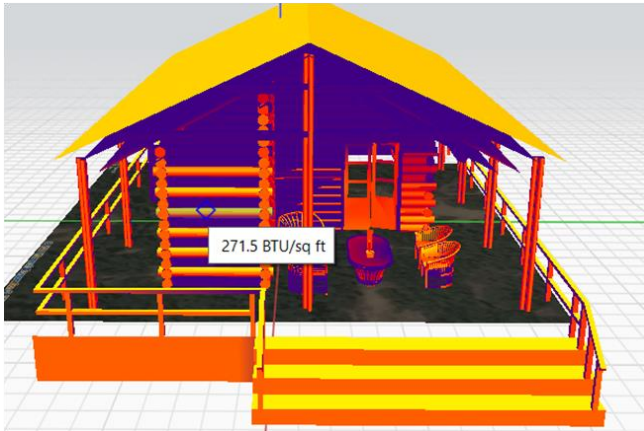


Fig 3.14 Solar radiation level in the month of May at 12 PM

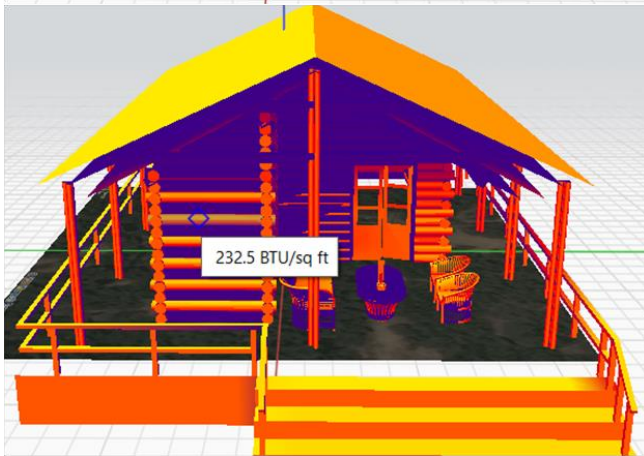


Fig 3.15 Solar radiation level in the month of July at 12 PM

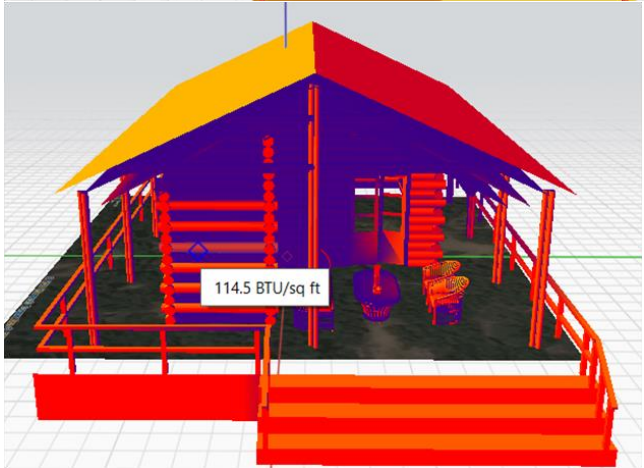


Fig 3.16 Solar radiation level in the month of January at 12 PM

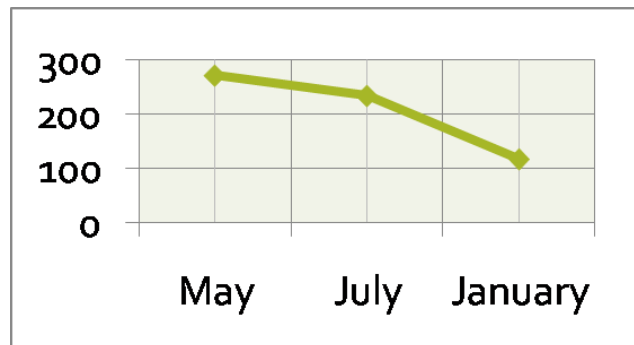


Fig 3.17 Radiation Graph

INFERENCE –

The southern facade is most affected during summer as well as monsoon months. Maximum radiation is 271.5 BTU/sqft. During winter months moderate radiation is visible. Minimum radiation is 114.5 BTU/sqft.

3.1.6 SOLAR RADIATION ANALYSIS (EASTERN FACADE) –

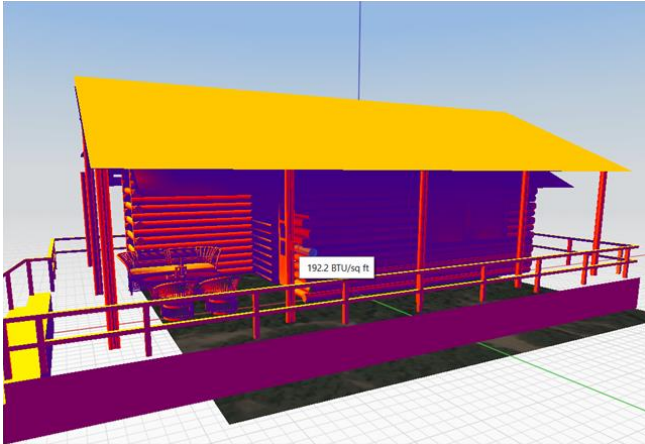


Fig 3.18 Solar radiation level in the month of May at 12 PM

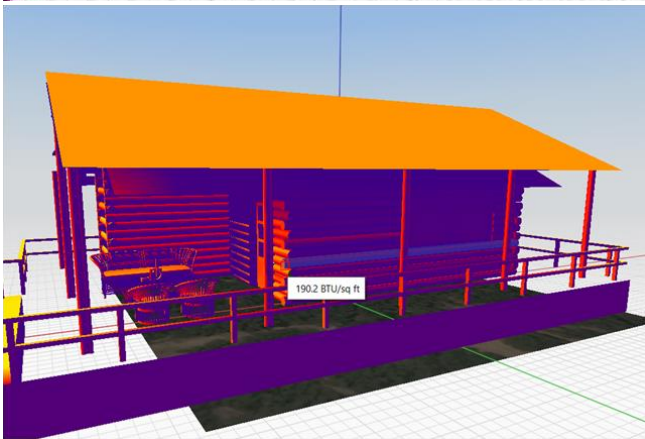
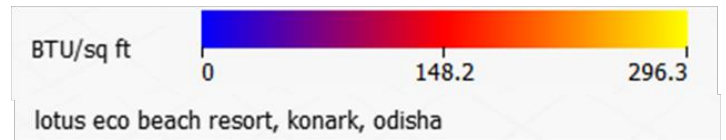


Fig 3.19 Solar radiation level in the month of July at 12 PM

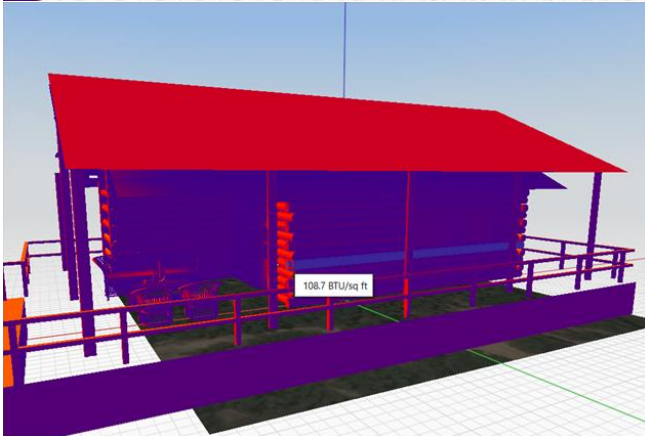


Fig 3.20 Solar radiation level in the month of January at 12 PM

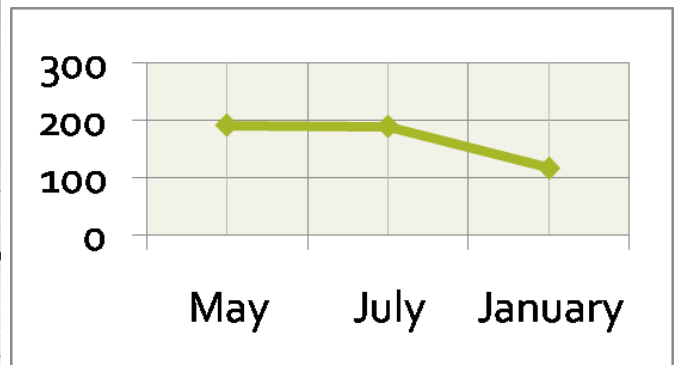


Fig 3.21 Radiation Graph

INFERENCE –

The eastern facade is very less affected throughout the year. The open corridor present all around the villa protects it from direct sun efficiently. Maximum radiation is 192. 2 BTU/sqft. Minimum radiation is 114.5 BTU/sqft during winter season.

3.1.7 SOLAR RADIATION ANALYSIS (NORTHERN FACADE) –

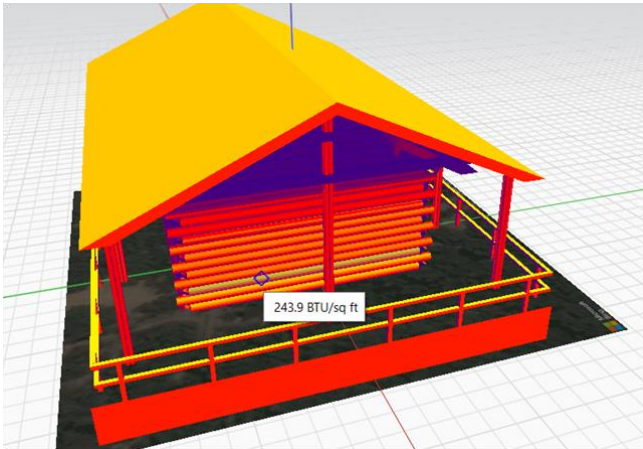


Fig 3.22 Solar radiation level in the month of May at 12 PM

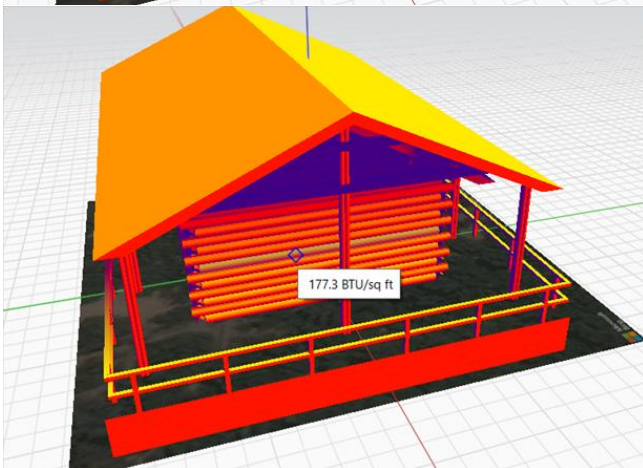


Fig 3.23 Solar radiation level in the month of July at 12 PM

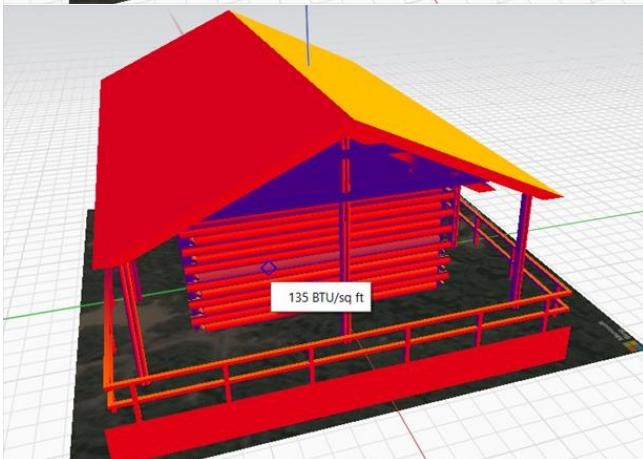


Fig 3.24 Solar radiation level in the month of January at 12 PM

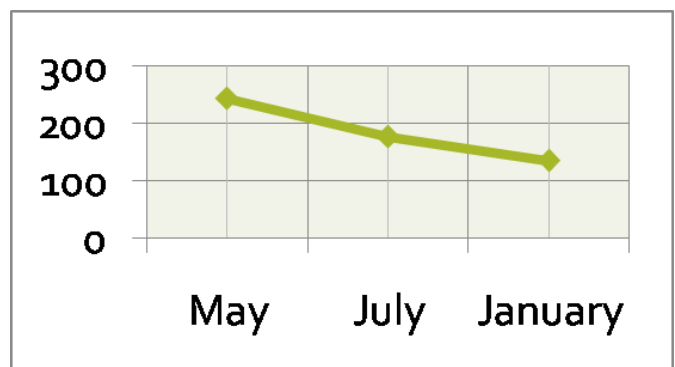


Fig 3.25 Radiation Graph

INFERENCE – The northern facade is highly affected during summer months. Maximum radiation is 243.9 BTU/sqft. Minimum radiation is 135 BTU/ sqft during winter season. Comparatively the northern facade is highly affected than other facades of the villa throughout the year.

3.1.8 SOLAR RADIATION ANALYSIS (WESTERN FACADE) –

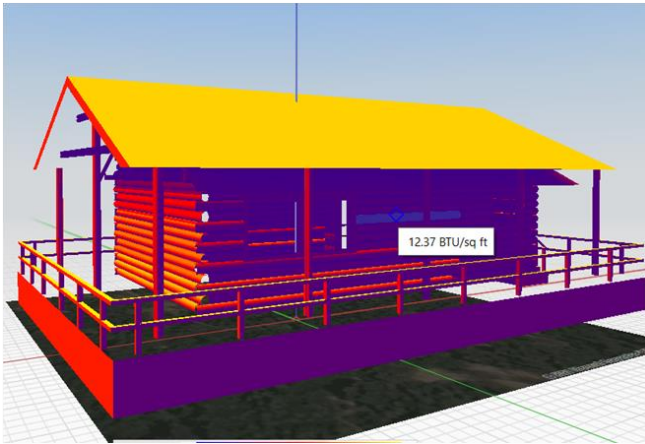


Fig 3.26 Solar radiation level in the month of May at 12 PM



Fig 3.27 Solar radiation level in the month of July at 12 PM



Fig 3.28 Solar radiation level in the month of January at 12 PM

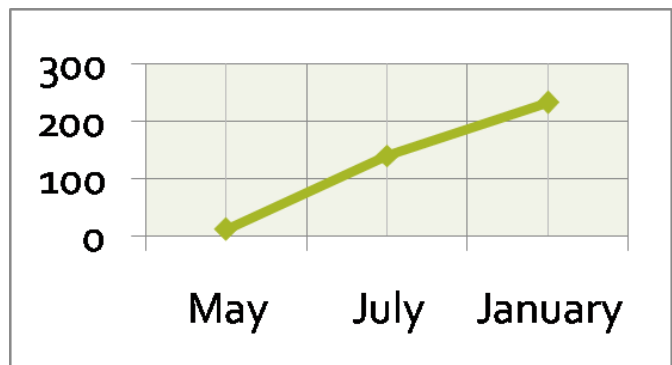
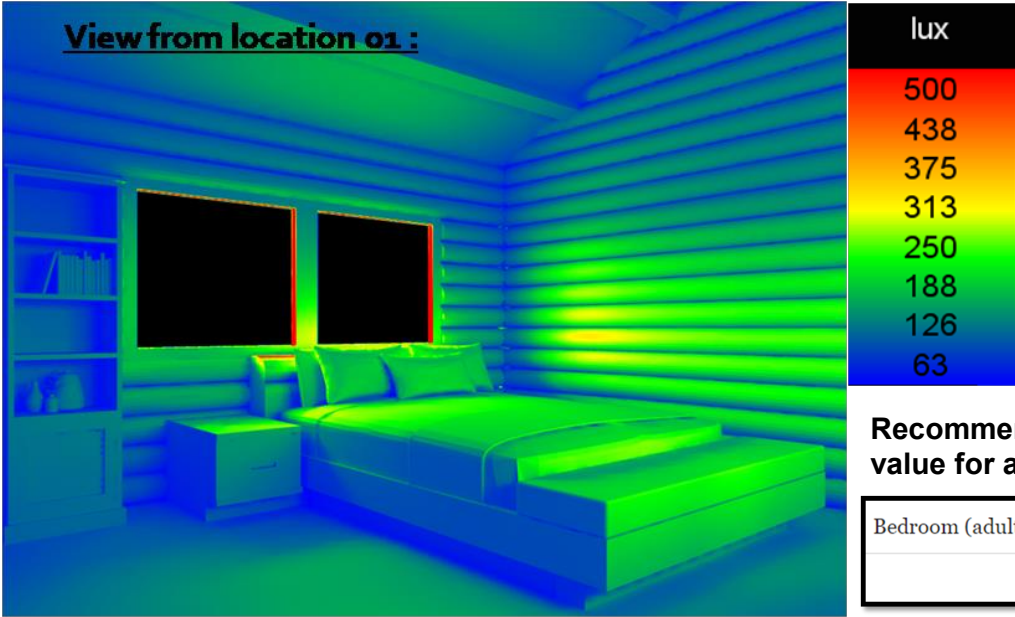
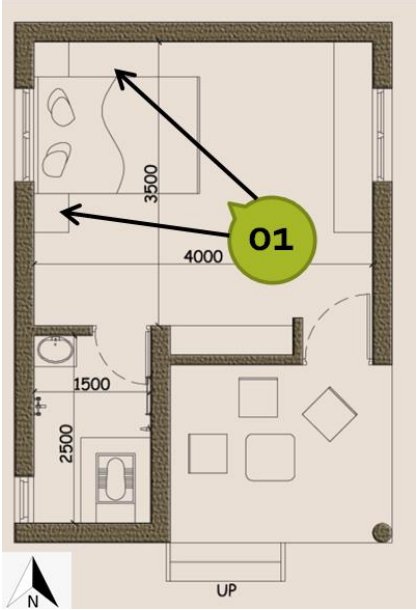
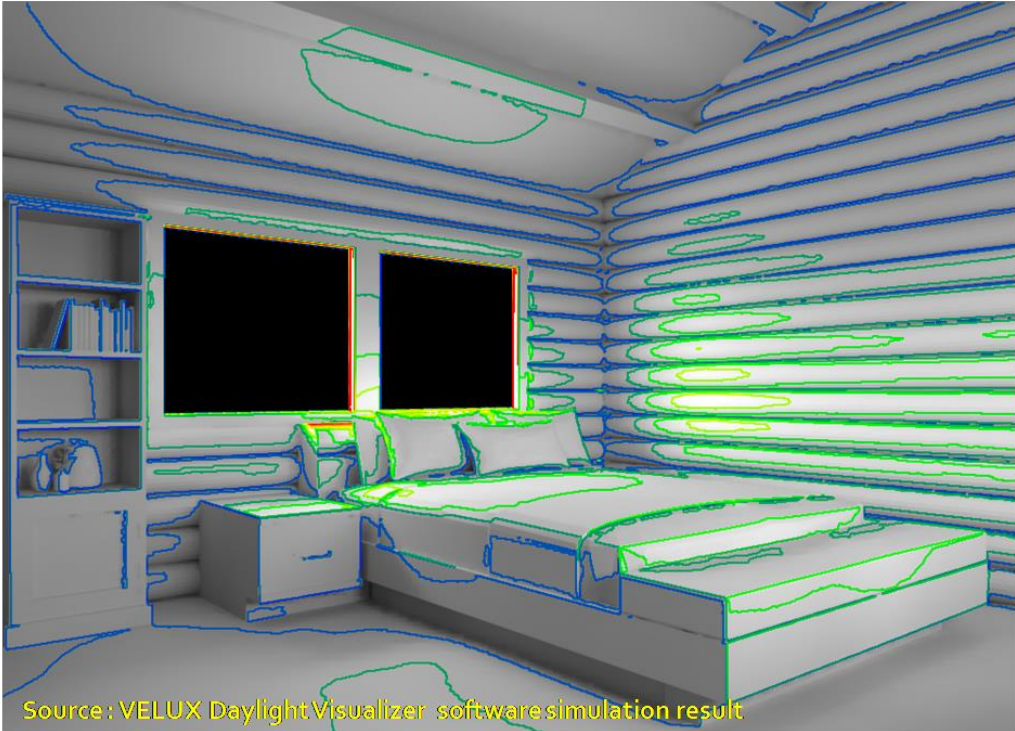


Fig 3.29 Radiation Graph

INFERENCE – The western facade is affected with radiation during winter months. Maximum radiation is 233.8 BTU/sqft. Minimum radiation is 12.37 BTU/ sqft during summer season. As we know winter sun is not harsh and does not cause discomfort, so there is no need to any extra precaution.

3.1.9 DAY LIGHTING ANALYSIS (MONTH – JANUARY AT 12 P.M.) –



Recommended day lighting level value for an adult Bedroom:

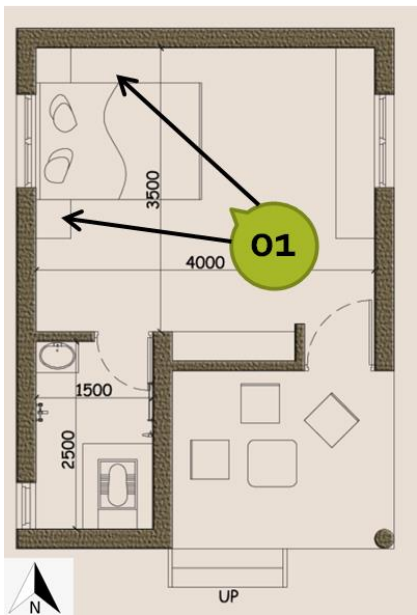
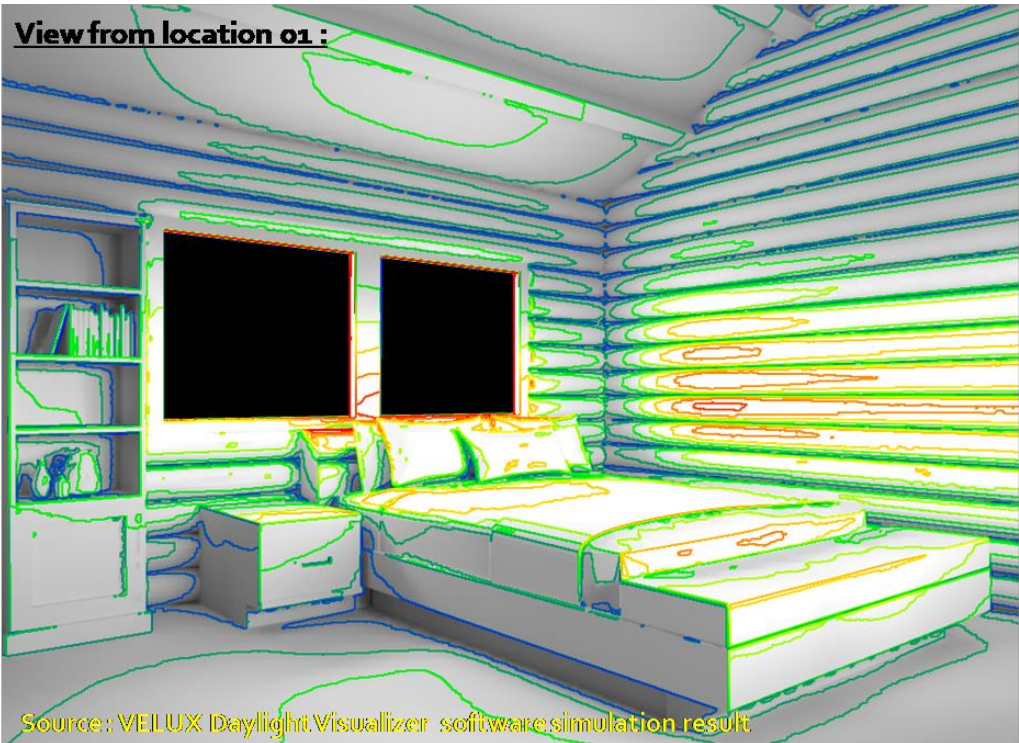
Bedroom (adult)	General	100–300 lux
	Task	500 lux

Fig 3.30 Day lighting simulation results in the month of January

INFERENCE - This bedroom is achieving recommended Lux level which is in between 100 to 300 Lux.

3.1.10 DAY LIGHTING ANALYSIS (MONTH – MAY AT 12 P.M.) –

View from location 01 :



**Recommended day lighting level value
for an adult Bedroom:**

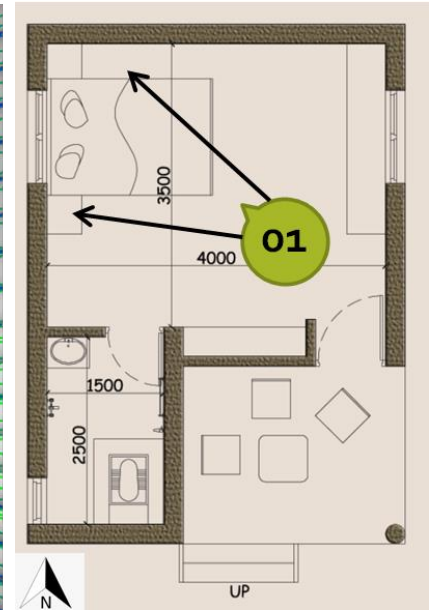
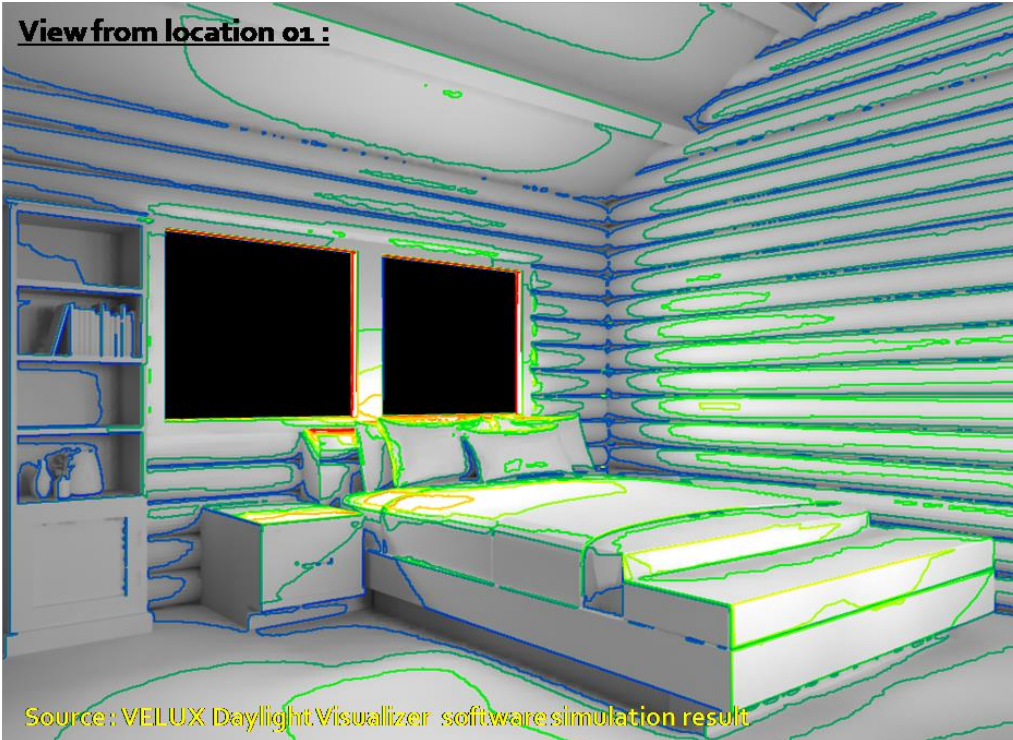
Bedroom (adult)	General	100–300 lux
	Task	500 lux

**Fig 3.31 Day lighting simulation results in
the month of May**

INFERENCE - This bedroom is achieving recommended Lux level which is in between 100 to 300 Lux.

3.1.11 DAY LIGHTING ANALYSIS (MONTH – JULY AT 12 P.M.) –

View from location 01 :



View from location 01 :



Recommended day lighting level value for an adult Bedroom:

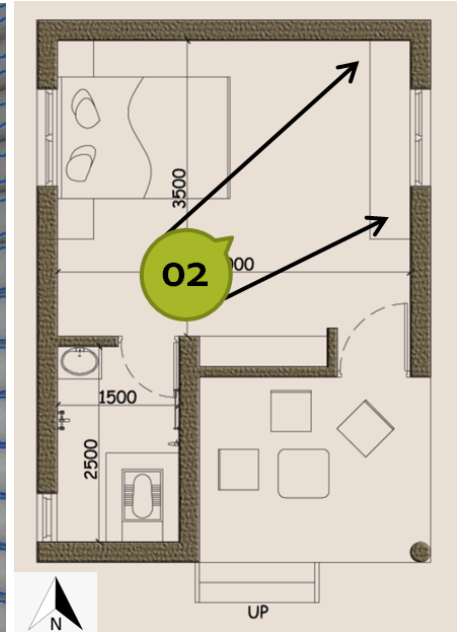
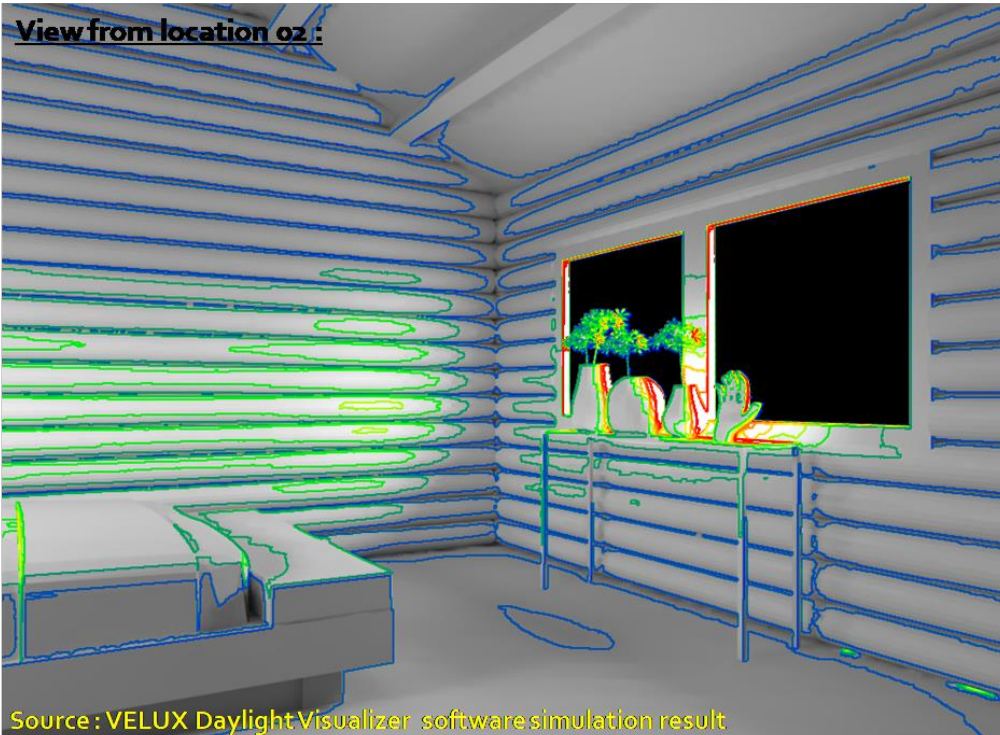
Bedroom (adult)	General	100–300 lux
	Task	500 lux

Fig 3.32 Day lighting simulation results in the month of July

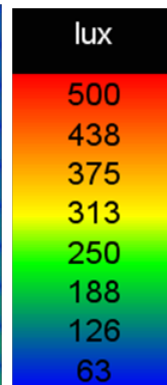
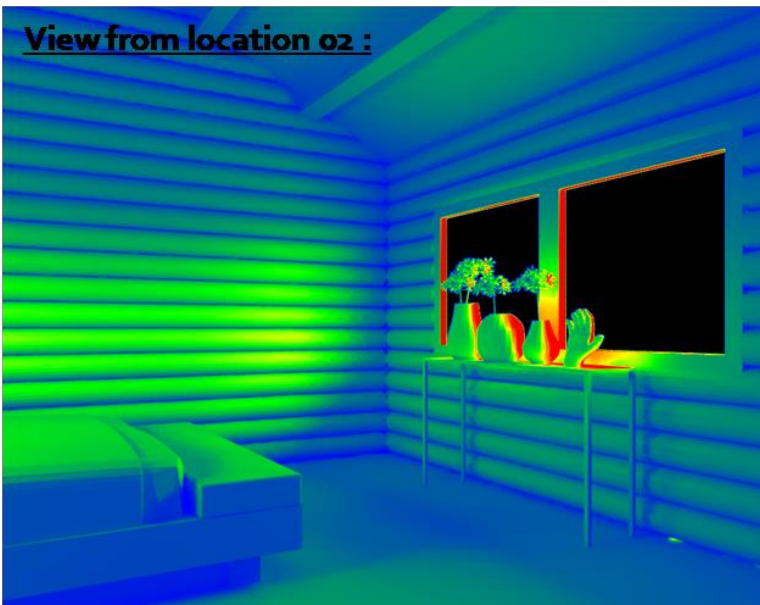
INFERENCE - This bedroom is achieving recommended Lux level which is in between 100 to 300 Lux.

3.1.12 DAY LIGHTING ANALYSIS (MONTH – JANUARY AT 12 P.M.) –

View from location 02 :



View from location 02 :



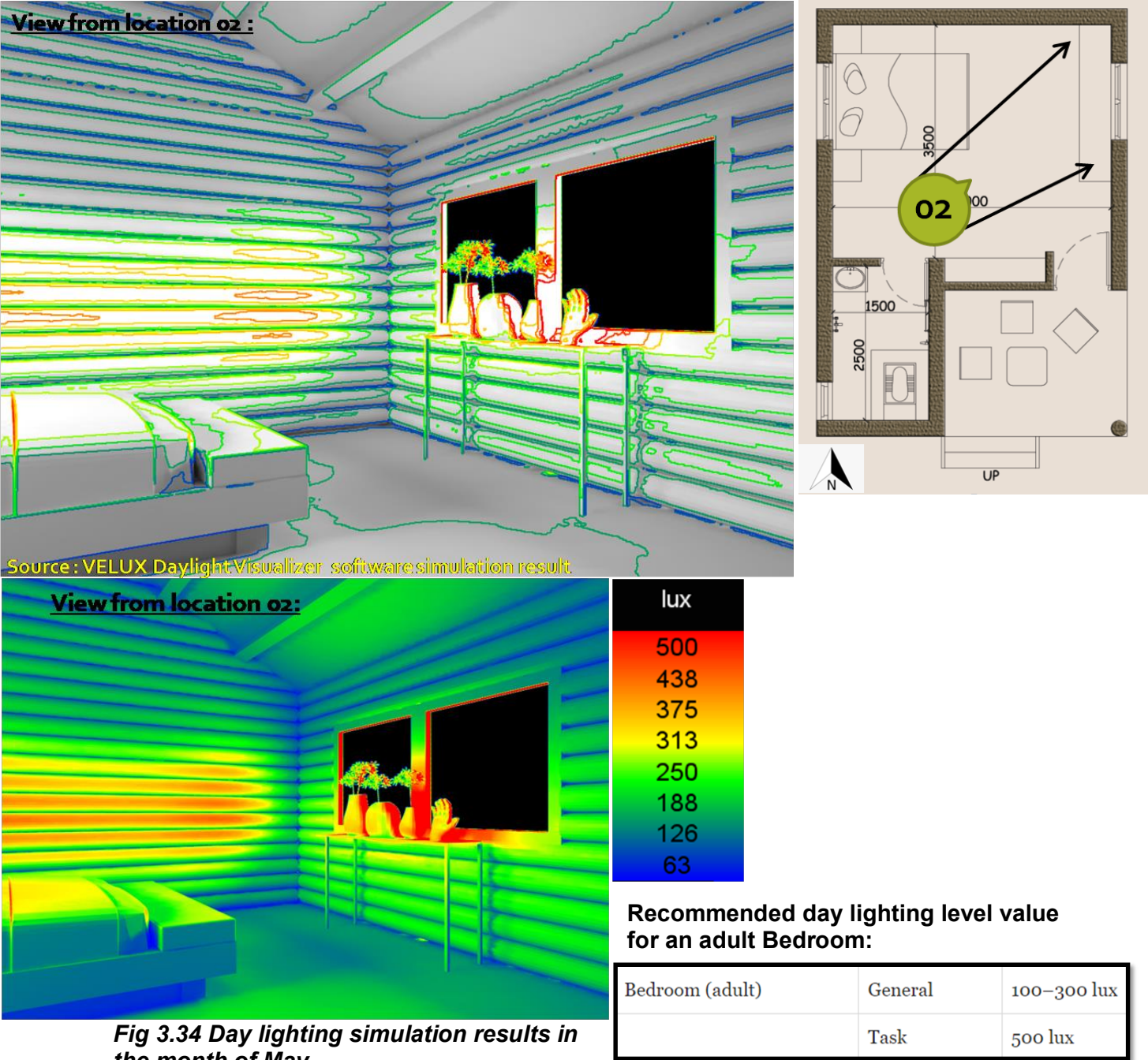
Recommended day lighting level value for an adult Bedroom:

Bedroom (adult)	General	100–300 lux
	Task	500 lux

Fig 3.33 Day lighting simulation results in the month of January

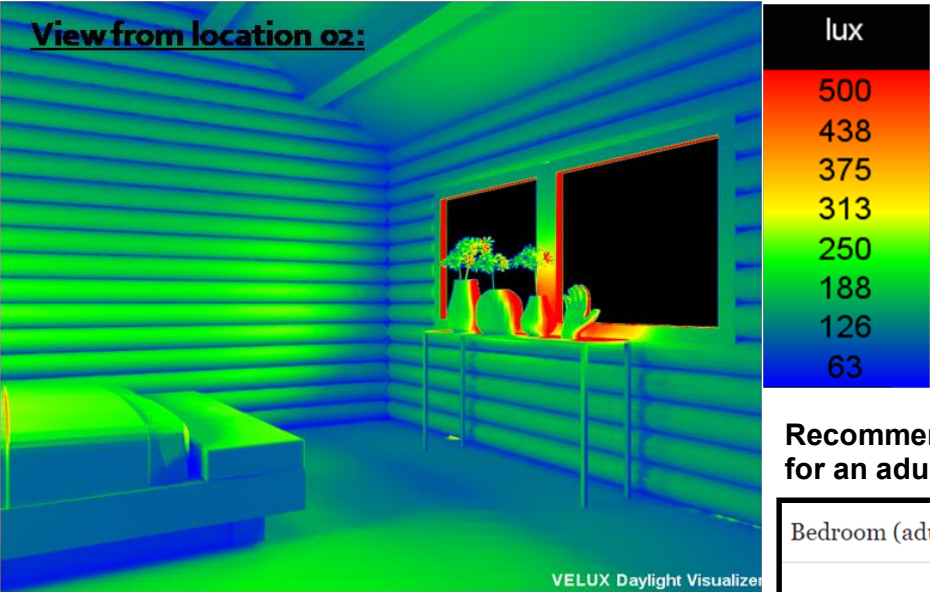
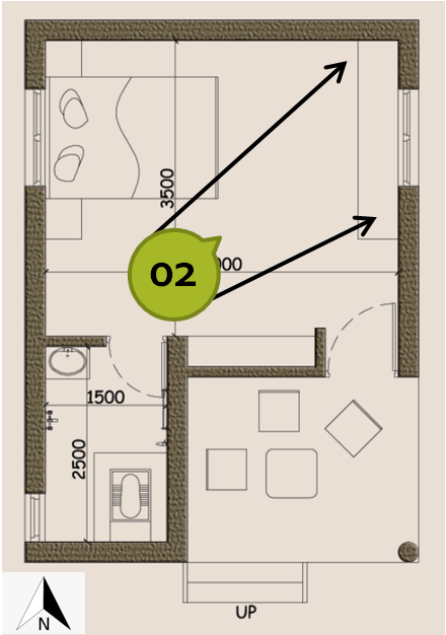
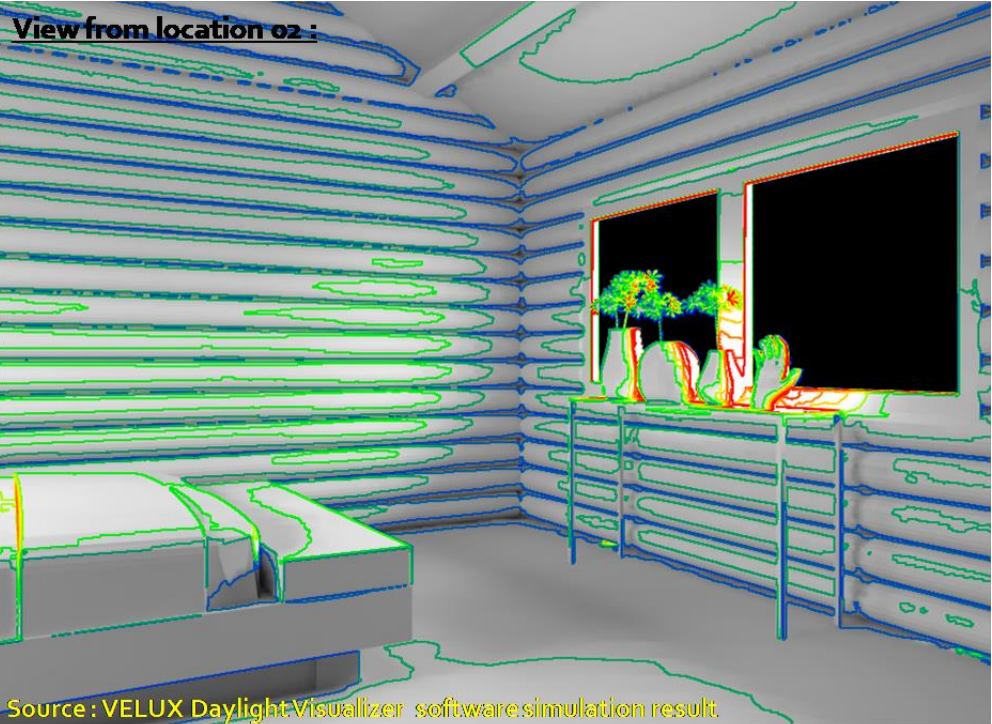
INFERENCE - This bedroom is achieving recommended Lux level which is in between 100 to 300 Lux.

3.1.13 DAY LIGHTING ANALYSIS (MONTH – MAY AT 12 P.M.) –



INFERENCE - This bedroom is achieving recommended Lux level which is in between 100 to 300 Lux.

3.1.14 DAY LIGHTING ANALYSIS (MONTH – JULY AT 12 P.M.) –



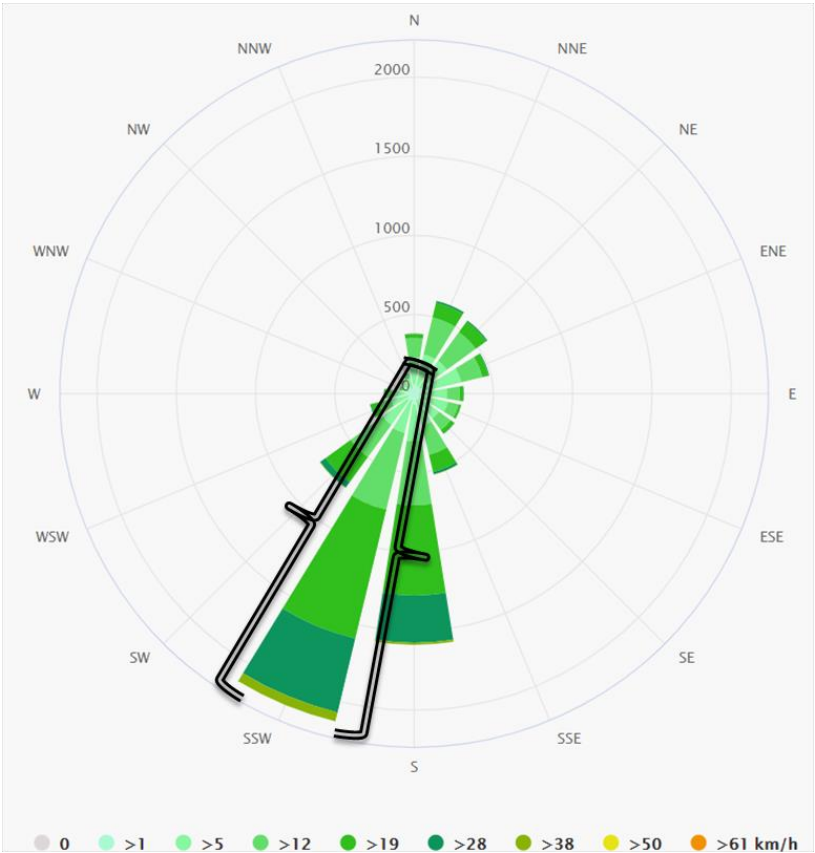
Recommended day lighting level value
for an adult Bedroom:

Bedroom (adult)	General	100–300 lux
	Task	500 lux

**Fig 3.35 Day lighting simulation results in
the month of July**

INFERENCE - This bedroom is achieving recommended Lux level which is in between 100 to 300 Lux.

3.1.15 WIND ANALYSIS (MONTH – JULY AT 12 P.M.) –



INFERENCE -
For the location Konark, in Odisha, maximum wind speed is experienced during the month of April, May and June. Wind speed is more than 38 Km/h during these months. The prevailing wind flow is from South West direction to North East direction throughout the year.

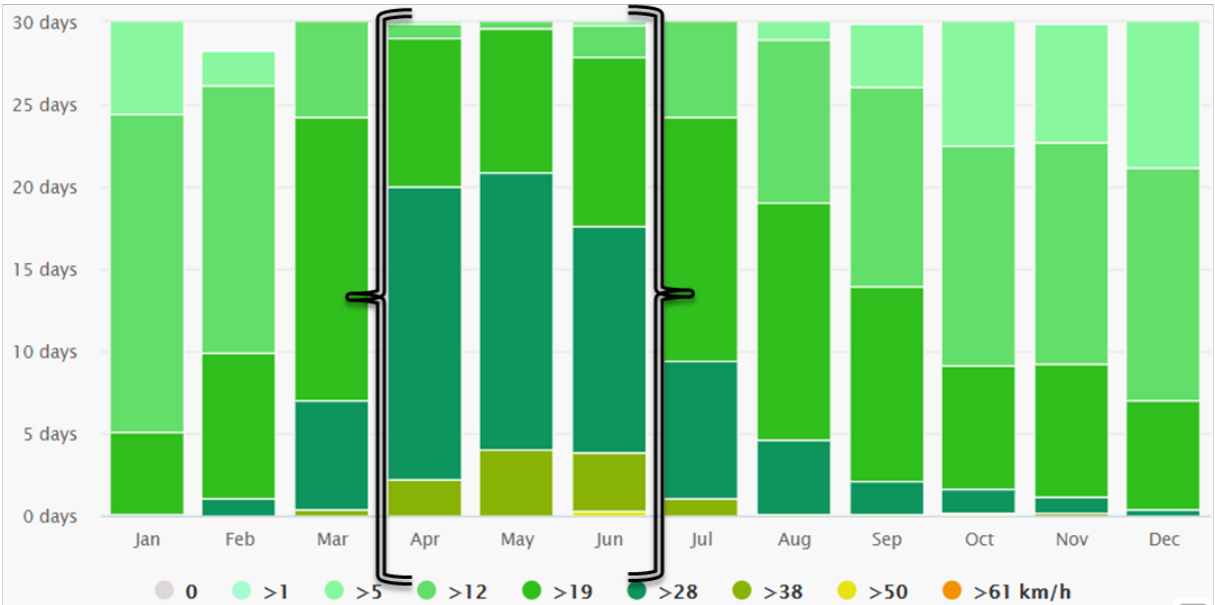


Fig 3.36 Wind direction and Speed Graph

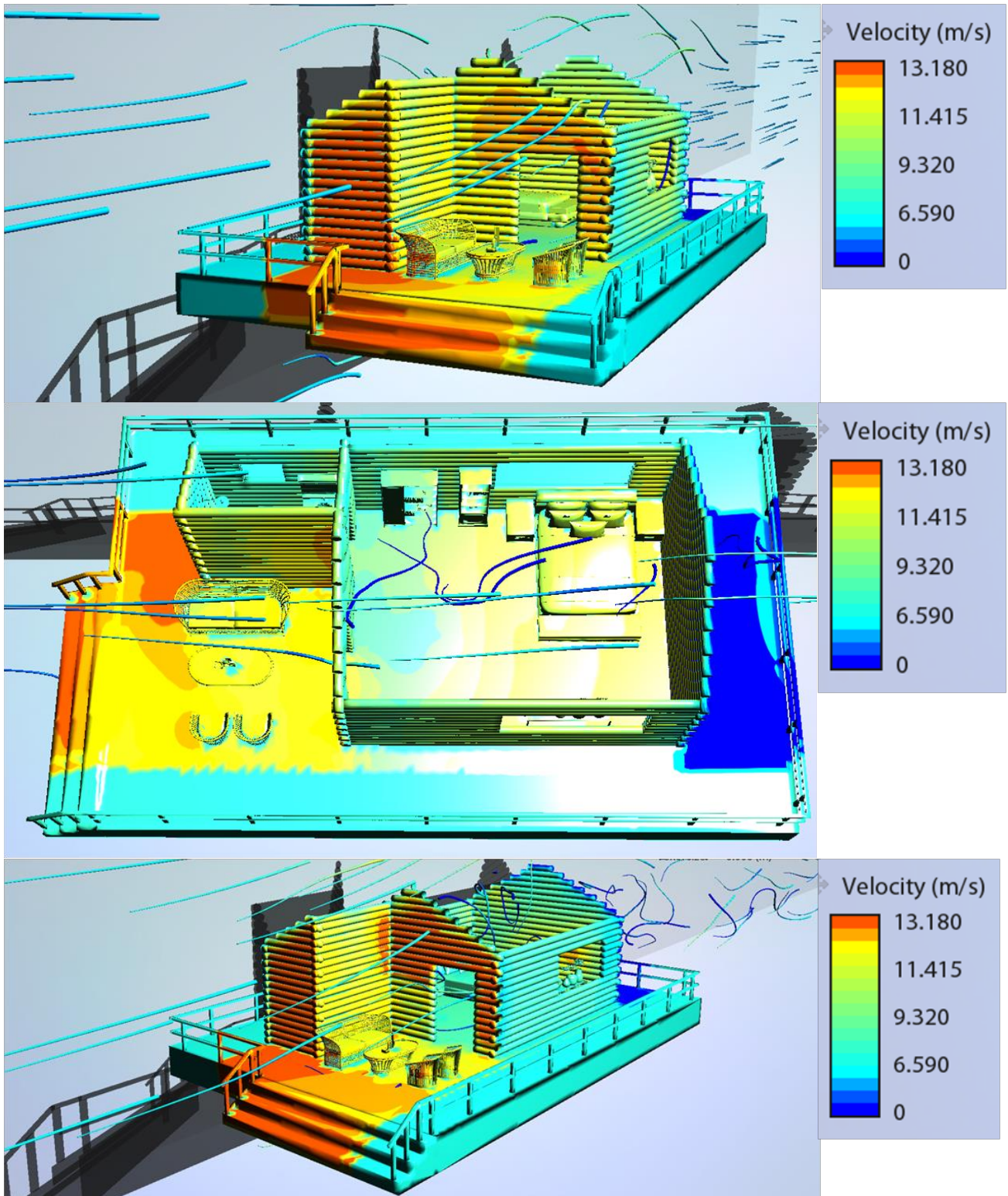


Fig 3.37 Autodesk flow design software simulation result

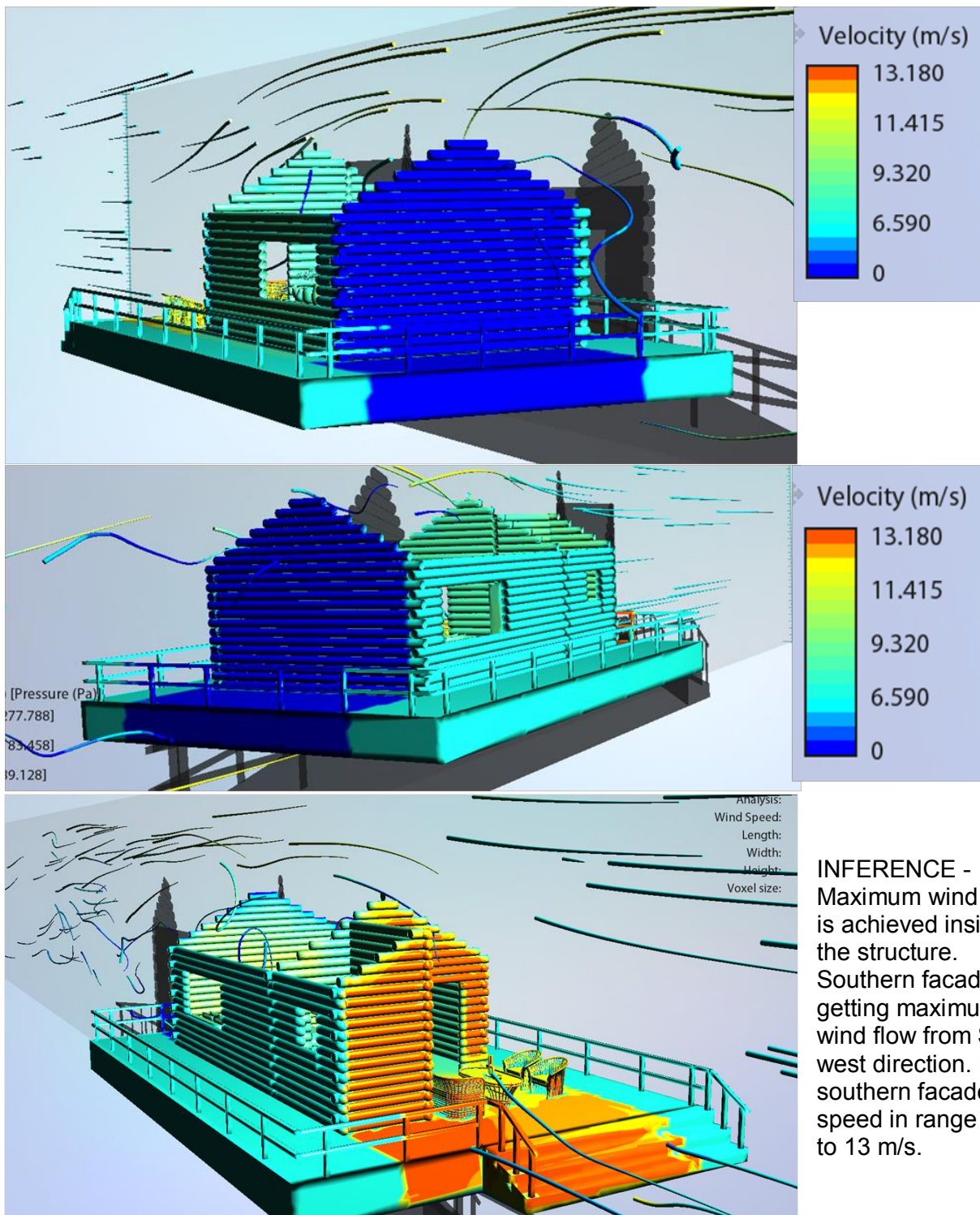


Fig 3.38 Autodesk flow design software simulation result

3.2 LITERATURE CASE STUDY 02: KUMARAKOM LAKE RESORT, KERALA

3.2.1 INTRODUCTION

- a. This lake resort is situated in Kumarakom village located on the banks of the Vembanad Lake. Soothing back waters, thick mangrove forests, green paddy fields and ripe coconut groves add the beauty of this serene stretch of land.
- b. This eco lake resort is situated on an 8.2 acre, west facing waterfront property. This lake is located at Kottayam district Kerala.
- c. There are internal waterways which run through the site, creating small artificial islands. The site is covered with buffalo grass and extensively landscaped.



Fig 3.39 Image of Kumarakom lake Resort, Kerala

- d. The entrance to the eco resort is on the east side of the site. The resort is open to Vembanad Lake on the west face of the property. Access to the waterfront is open to the tourists staying at the resort via walkways which run along the property.
- e. Kumarakom lake resort is designed by Calicut based architect Tony Joseph to showcase Kerala heritage and culture.



Types of accommodation –
 Presidential Suites
 Heritage lake view villas
 Luxury pavilion rooms
 Houseboats
 Villas for the physically disabled
 Meandering pool villas

Fig 3.40 Image of Kumarakom lake Resort, Kerala



Fig 3.41 Image of Kumarakom lake Resort, Kerala

Accommodation features –

- Refrigerated private bar
- Tea/ coffee maker
- Twice daily housekeeping services
- 24 hour in room dining
- 24 hour laundry
- Non smoking rooms
- All news cable networks
- Cordless telephones

Resort features –

The resort features an ayurvedic treatment centre which houses a yoga centre, beauty salon, consultation, message rooms, an infinity swimming pool, a conference centre, a business centre and a fitness centre.

3.2.2 PRESIDENTIAL SUITE

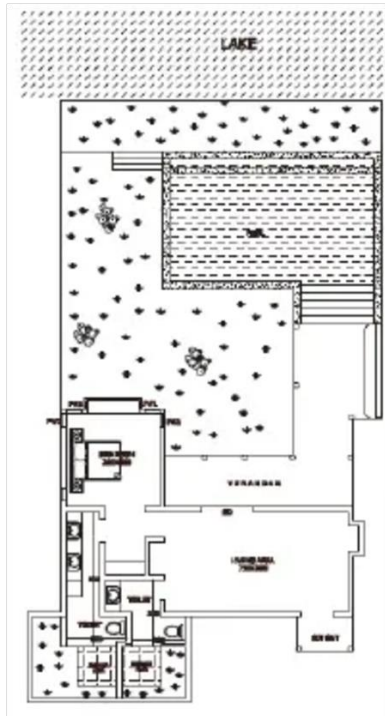


Fig 3.42 Plan and Exterior view of Presidential Suite

3.2.3 HERITAGE LAKEVIEW VILLAS WITH PRIVATE POOL

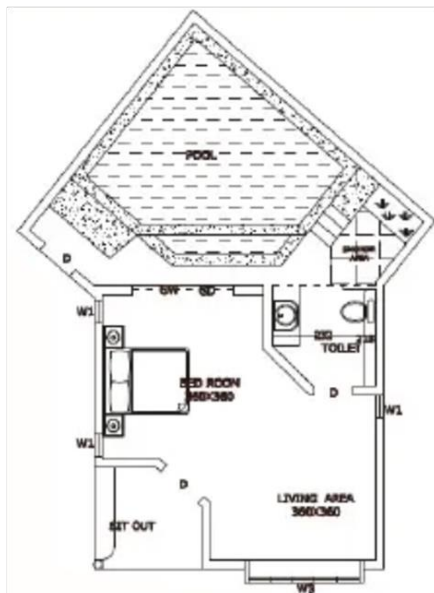


Fig 3.43 Plan and exterior view of Heritage Lakeview villas

3.2.4 HERITAGE VILLAS WITH PRIVATE POOL



Fig 3.44 Plan and exterior view of Heritage villas with private pool

3.2.5 MEANDERING POOL VILLAS



Fig 3.45 Plan and exterior view of meandering pool villas

3.2.6 LUXURY PAVILLION ROOMS

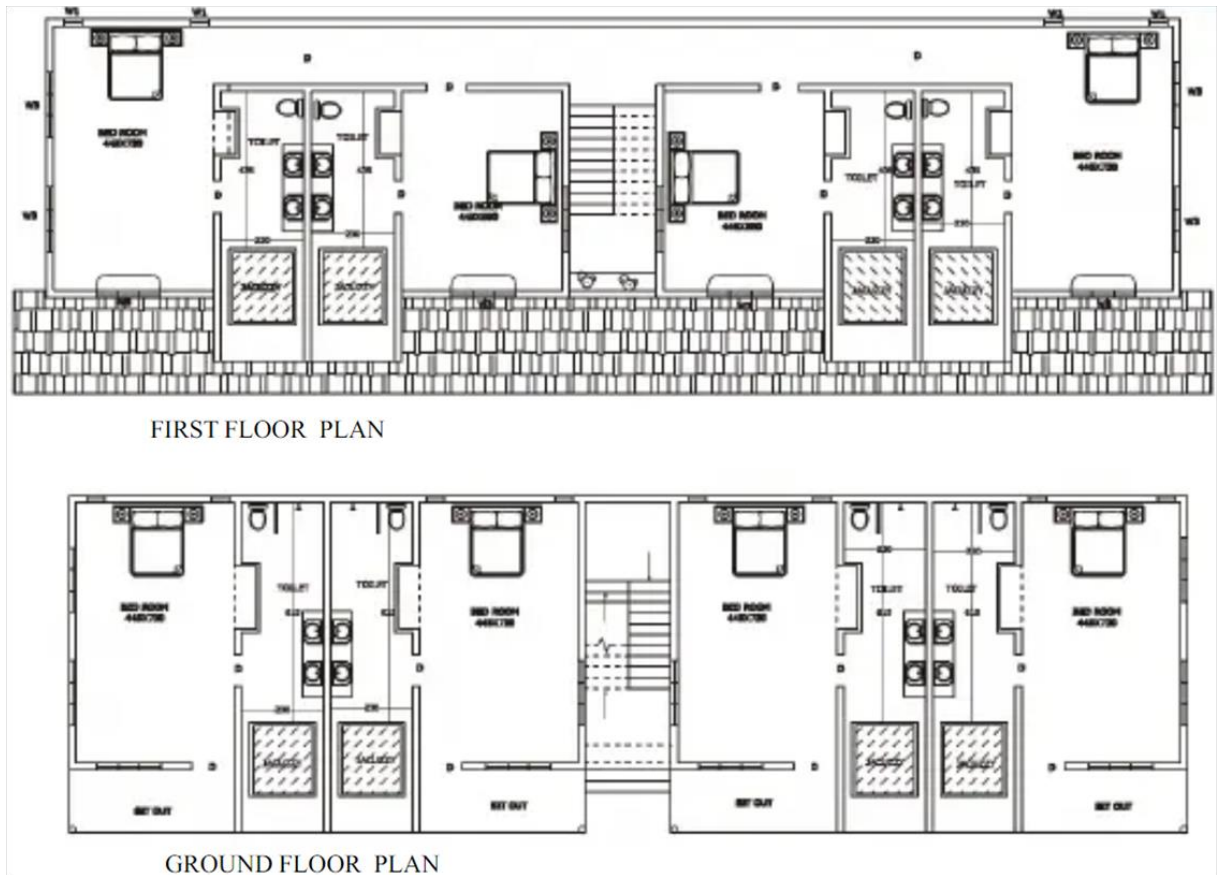
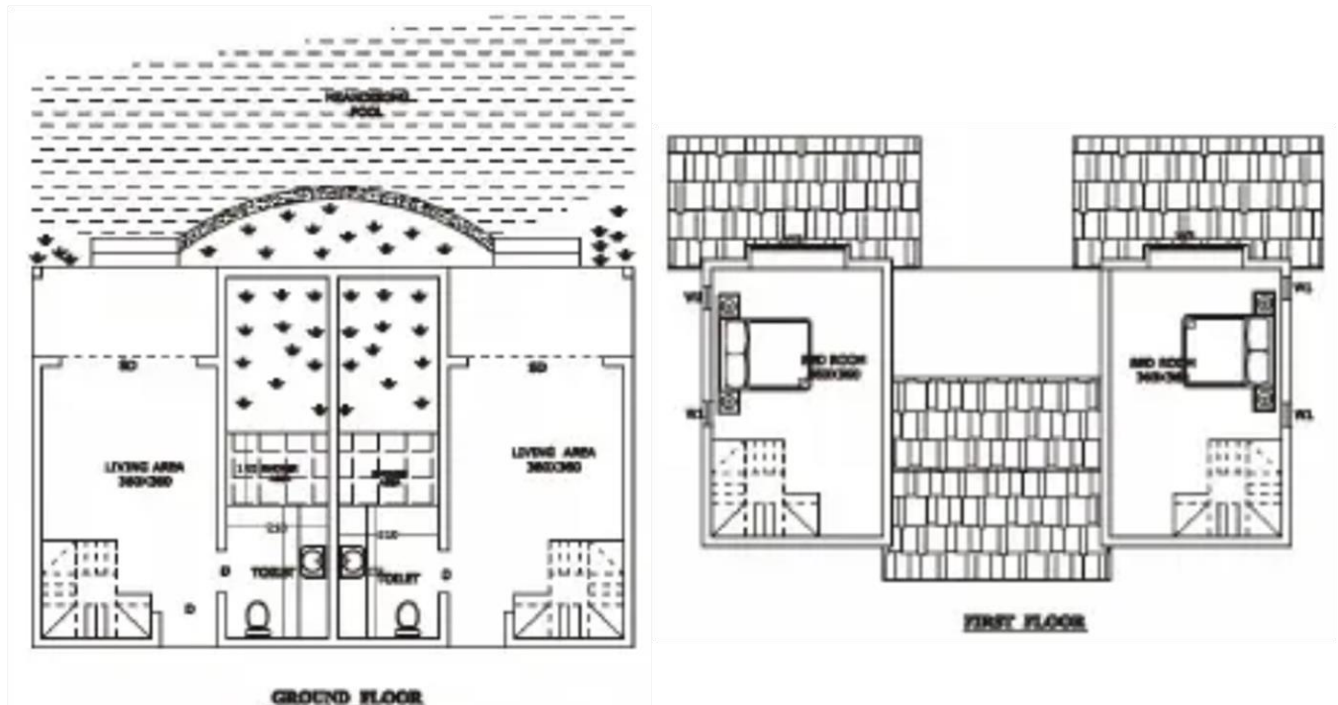


Fig 3.46 Plan and exterior view of luxury pavilion rooms

3.2.7 MEANDERING POOL DUPLEX



INFERENCE -

This resort scheme has reconstructed a mini village of *traditional architecture and adapted it to the resort's program.*

The architect has been true to the principles of the traditional architecture and with their use of materials. The site is completely gated off from the outside world in order *to create a private internal space for the resort's guests.*

Fig 3.47 Plan and exterior view of meandering pool duplex

3.3 LITERATURE CASE STUDY 03: TREE HOUSE SUITE, MEXICO

3.3.1 INTRODUCTION

Architects: Deture Culsign, Architecture Interiors

Area: 2 Acres

Year: 2015

Owner: David Leventhal

Country: Mexico



Fig 3.48 Image showing Tree house Suite, Mexico

- a. This eco resort is an elliptical shaped form with bamboo wrapping.
- b. Inside the structure, there is an open-air lower-level villa which is housing the sitting area and bathroom and upper-level platform for the sleeping area.
- c. The villa is consisted of clay tile roof and exposed wood beams.
- d. In the bathroom, locally sourced wood is used for countertop and carved stone is the vessel sink.

- e. Bamboo screening provides privacy while the roof is intentionally carved back so showering can be experienced outdoors.
- f. All needed for usage is heated by solar panels. Complete water usage recycling is incorporated inside the site.
- g. All electrical appliances used are provided by 100% solar power.
- h. The windows are designed in such a manner that it is supporting the natural ventilation as well as the passive cooling technique.
- i. Locally sourced woods and bamboo create the floor, ceiling and wall.
- j. Each element is staggered to show the randomization of elements found in nature.
- k. The design is created in such a way that it would give its guests a pleasure of suspension.



Fig 3.49 Image showing Tree house Suite, Mexico

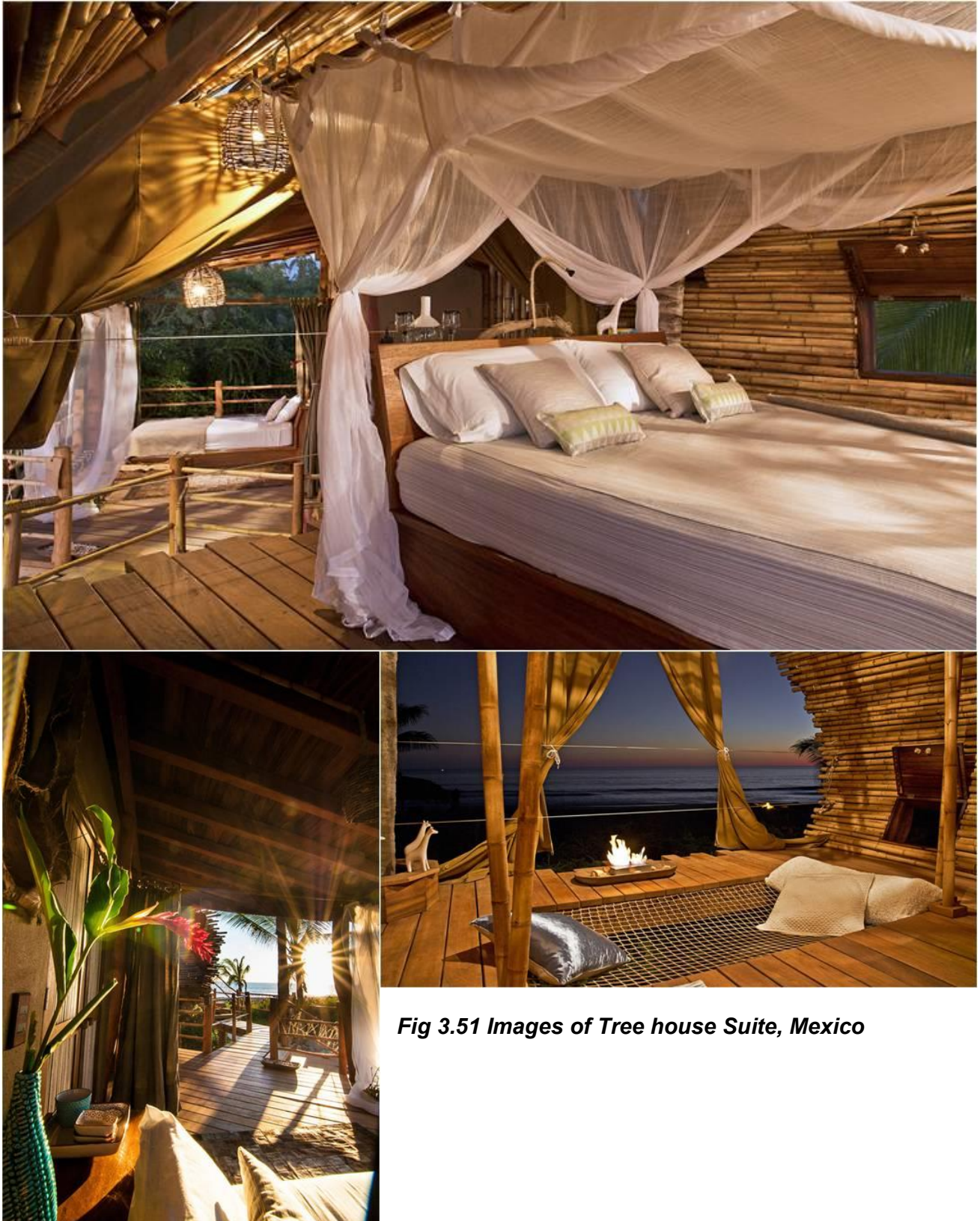


Fig 3.51 Images of Tree house Suite, Mexico

3.4 COMPARATIVE ANALYSIS BETWEEN LITERATURE CASE STUDIES UNDERTAKEN

Parameter	Literature Case study 01_Lotus Eco beach Resort, Konark, Odisha	Literature Case study 02_Kumarakom Lake Resort, Kerala	Literature Case study 03_Tree house Suite, Mexico
Roofing system	Double roofing system is designed to protect the structure from sun as well as rain. Wooden roof is again covered with a thatched roof.	Terracotta clay roof tiles are used for roofing. Traditional sloped roof is used for the entire structure.	Clay tile roof is used in this eco resort.
Wall material used	Locally available hard woods like Sheesham, Mahogany, Babul, Sal are used for construction of the villas.	Locally available hard woods like Sal, teak and bricks are used for construction of the villas.	Bamboo and locally available woods are used as walls.
Tourist attraction	Apart from the green lush surrounding water sports, boat ride, butterfly garden, kids play area, outdoor seating, seaside cafe and bar, restaurant are provided.	The resort features an ayurvedic treatment centre which houses a yoga centre, beauty salon, consultation, message rooms, An infinity swimming pool, a conference centre, a business centre and a fitness centre.	Apart from accommodation there are no such other facilities available in this structure.
Lighting system	Artificial lighting and electrical light fixtures are incorporated.	Artificial lighting and electrical light fixtures are incorporated.	Artificial lighting and electrical light fixtures are incorporated.
Sustainable features incorporated	Locally available construction materials are used. Locally grown vegetables are cooked and served.	Locally available construction materials are used. Locally grown vegetables are cooked and served.	All electrical appliances as well as water heaters used are incorporated with 100% solar power.

TABLE 3.1 Comparative studies among literature case studies undertaken

3.5 DERIVATION OF DESIGN PARAMETERS FROM ANALYSIS OF LITERATURE CASESTUDIES

Design parameters derived from the analysis of case studies which will be carrying forward for design validation:

Parameter	Descriptions
Landform	Landform is an important parameter for site selection. In case of slopes and depressions, the building must be located on windward side or crest to take advantage of cool breeze.
Open spaces and build forms	Buildings should be spread out with large open spaces in between for unrestricted air movement.
Central courtyard	In case of multi storied building, a central courtyard provided with vent at higher level can draw away the inside rising hot air.
Water bodies	Inside an eco resort, presence of water bodies will create relaxation in guests. These should not be placed near buildings as they would tend to further increase in humidity.
Orientation of the building	North-South direction is ideal from the point of view of blocking solar radiation.
Width of the walkways	The width of the walkways must be such that intense solar radiation during late morning and early afternoon can be avoided particularly on summer.
Building form	Long and narrow building form would be best for allowing cross ventilation.
Position of toilet and kitchen	Heat and moisture producing areas like toilets and kitchens must be ventilated and must be placed separated from rest of the structure.
Use of semi open spaces	Semi open spaces like balconies and porches can be used to avoid direct heating of exterior walls.

Roof form	Instead of a flat roof, sloped roof will be preferable to protect the structure from heat and rain as well. Double roof with rooftop vents would be very suitable.
Walls	Walls must be designed in such a way to promote air flow to counter the prevalent humidity. Use of baffle walls both inside and outside the building can help to divert the flow of wind inside.
Fenestration	Cross ventilation must be achieved through fenestration design. Outlet must be larger than the inlet for proper air flow. Blinds and curtains can be added for protecting from excessive solar heat gain.
Overhangs	The openings should be shaded by external overhangs. Outlets must be located at higher level to remove the hot air.
Vegetation	Adding vegetation around the site would improve the microclimate of both outdoors and indoors. Through transpiration of leaves temperature is lowered. Vegetation also helps to control humidity as free water is absorbed during day time and water is evaporated during summer months.

TABLE 3.2 Study of design parameters derived from case study analysis

CHAPTER 04

4.1 INTRODUCTION

Department of Tourism has invited proposals for “Selection of an Architecture/ Urban Planning agency for preparation of Integrated Tourism Master plan of Rambha cluster and Satapada-Sipakuda cluster of Chilika Lake” in accordance with the conditions and manner prescribed in the RFP document. I am going to focus on Rambha cluster for my proposal for an eco lake resort.

RFP for Selection of an Architecture/ Urban Planning agency for preparation of Integrated Tourism Master plan of Rambha cluster and Satapada-Sipakuda cluster of Chilika Lake



RFP No. 4149, Date. 22.04.2021
TCT-COOD-SCH-0032-2020

Department of Tourism

Paryatan Bhawan, Lewis Road, Bhubaneswar
751 014 Phone: (0674) 243 2177 | Fax: (0674)
– 243887

<https://dot.odishatourism.gov.in>

Email: info@odishatourism.gov.in / pmu@odishatourism.gov.in

4.1 Stage I Preliminary Assessment

- Preliminary analysis of the existing situation such as site analysis including-
 - Infrastructure gap assessment
 - Disaster vulnerability
 - Carrying capacity
 - Assessment of existing tourism infrastructure
 - Study of existing rules/ regulations and laws applicable to Chilika lake
 - Collection of all relevant secondary data/ reports available. Refer the ICZMP Chilika Tourism Plan, prepared by Chilika Development Authority (CDA)
- Stakeholder consultation
- Benchmarking of case studies
- SWOT Analysis

4.2 Stage II Concept Plan

- Preparation of zoning plan with detailed list individual components and sub-components
- Preparation of indicative Conceptual plan
- Proposed infrastructure for proposed components
- Block estimates

4.3 Stage III Detailed Master Plan

- Preparation of draft detailed masterplan
- Propose development strategy, phasing, implementation strategy with a view to maximize tourism potential of destination.
- Detailed drawings, walkthroughs and 3D views
- Preparation of detailed estimates
- Preparation of design guidelines and development control regulations
- Support in Identification and collection of various approvals from all projects identified under the master plan

4.2 DEMARCATION OF CLUSTERS FOR DEVELOPMENT

ICZMP Tourism master plan of the Chilika and its catchment, prepared by Chilika Development Authority (CDA), identified **4 tourism clusters** of Chilika, and they are :

- a. Rambha Cluster
- b. Satapada-Sipakuda cluster
- c. Khallikote Cluster
- d. Mangalajodi Cluster

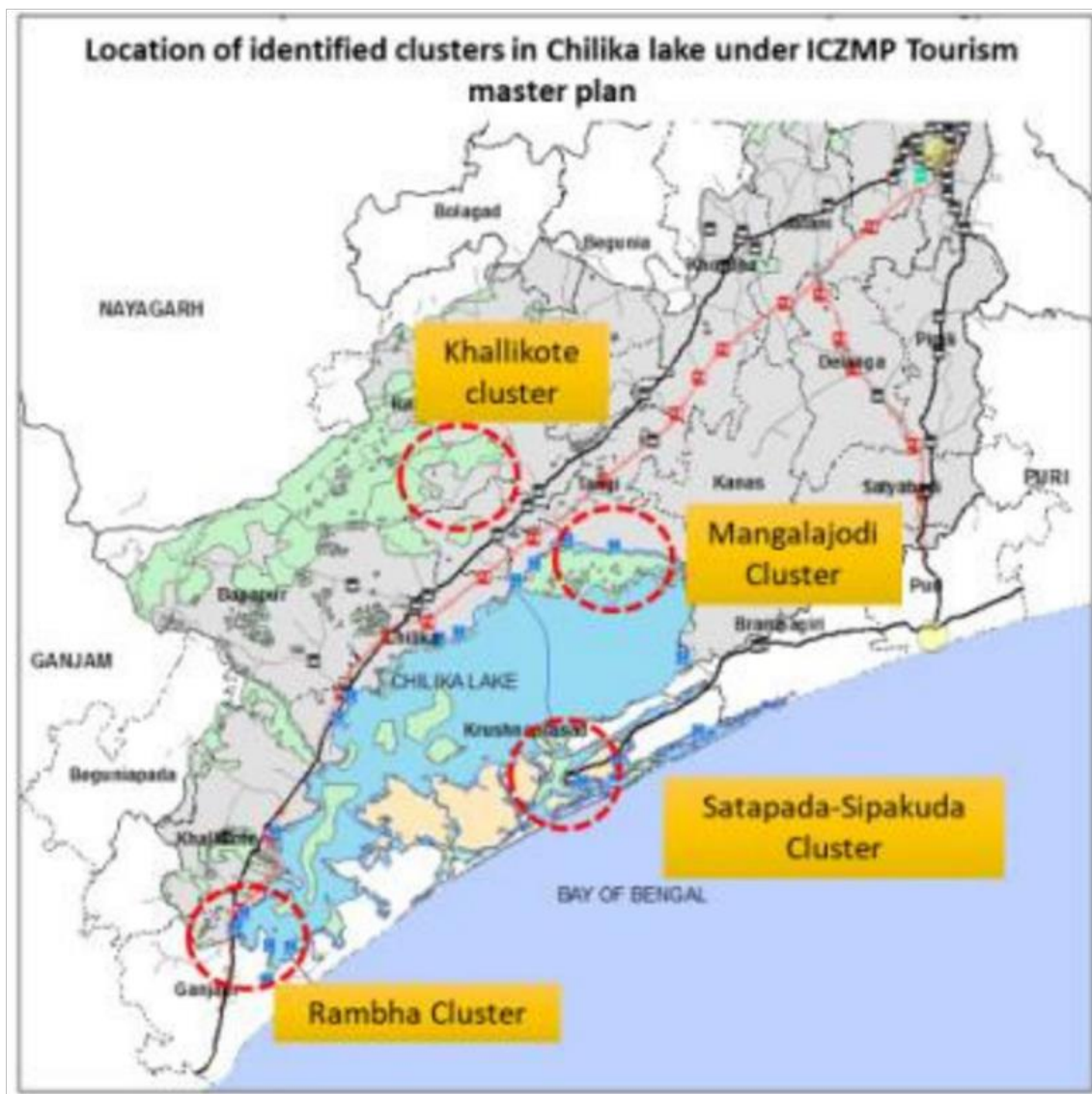


Fig 4.1 Location of identified clusters in Chilika lake

4.3 PROPOSED TOURISM MASTER PLAN AREA AT RAMBHA CLUSTER

Chilika Tourism Masterplan (under ICZMP) recommends following 4 priority projects in Rambha Cluster:

- a. Tourism Node (Rambha Panthanivas)
- b. Luxury eco resort Convention centre ar Sabilia
- c. Eco-village (Poribeso gramo) at Breakfast island
- d. Water Sports operations

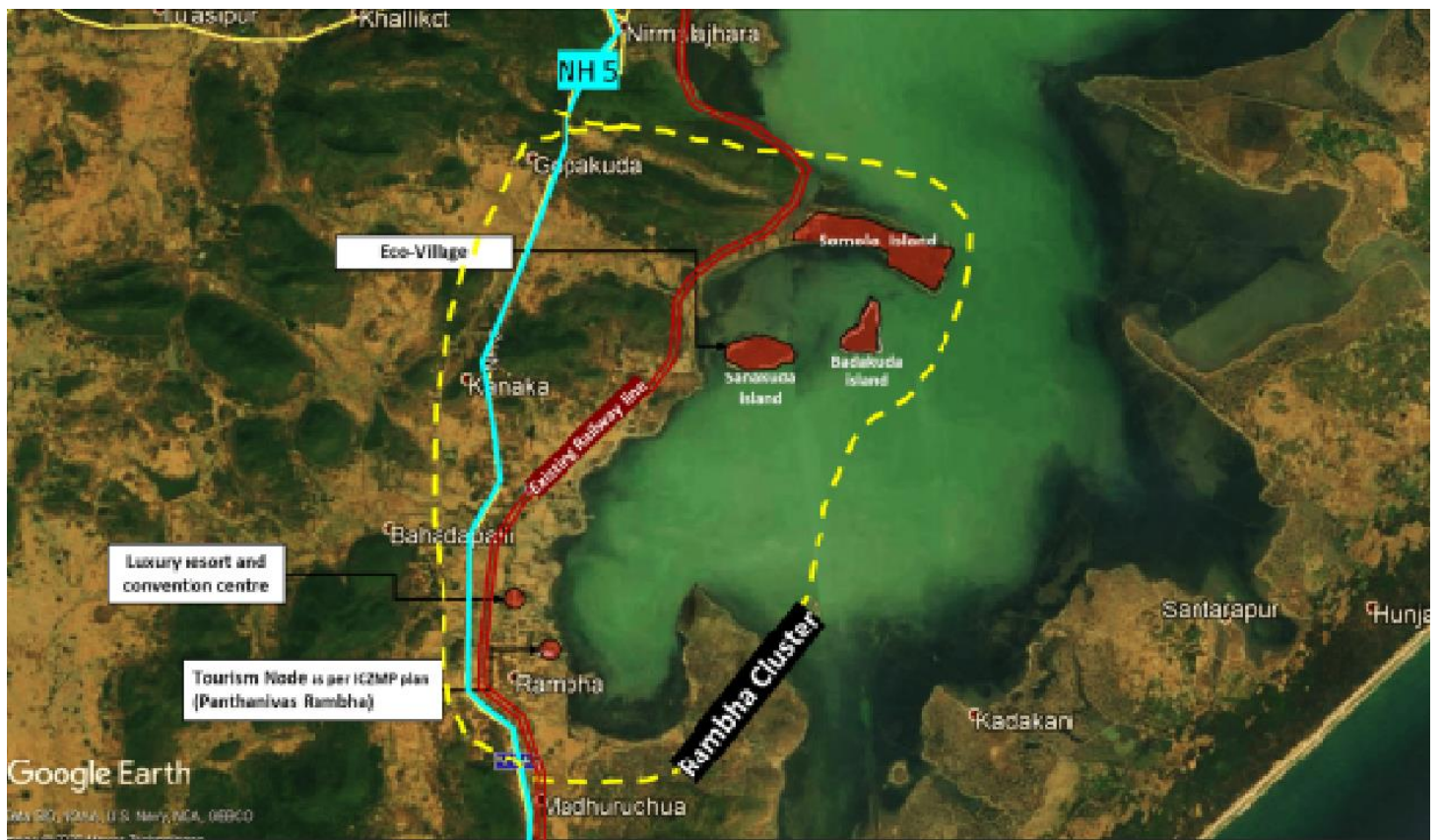


Fig 4.2 Location of identified for development at Rambha Cluster

4.4 SITE SELECTION AND JUSTIFICATION

This piece of land is selected for the development of the eco resort by the department of tourism, Odisha. Due to following reasons this site is selected.

- a. This eco resort project is an extension to the Rambha Panthanivas which is presently not effectively serving the tourists as there is always a lack of availability of accommodation.
- b. Rambha Chilika Lake Point is one of the tourist interests from where the site is very near.
- c. Rambha palace is also an attraction due to which the site is selected.

The Site Area: 6.13392 Acre or 24823.120 Sqm

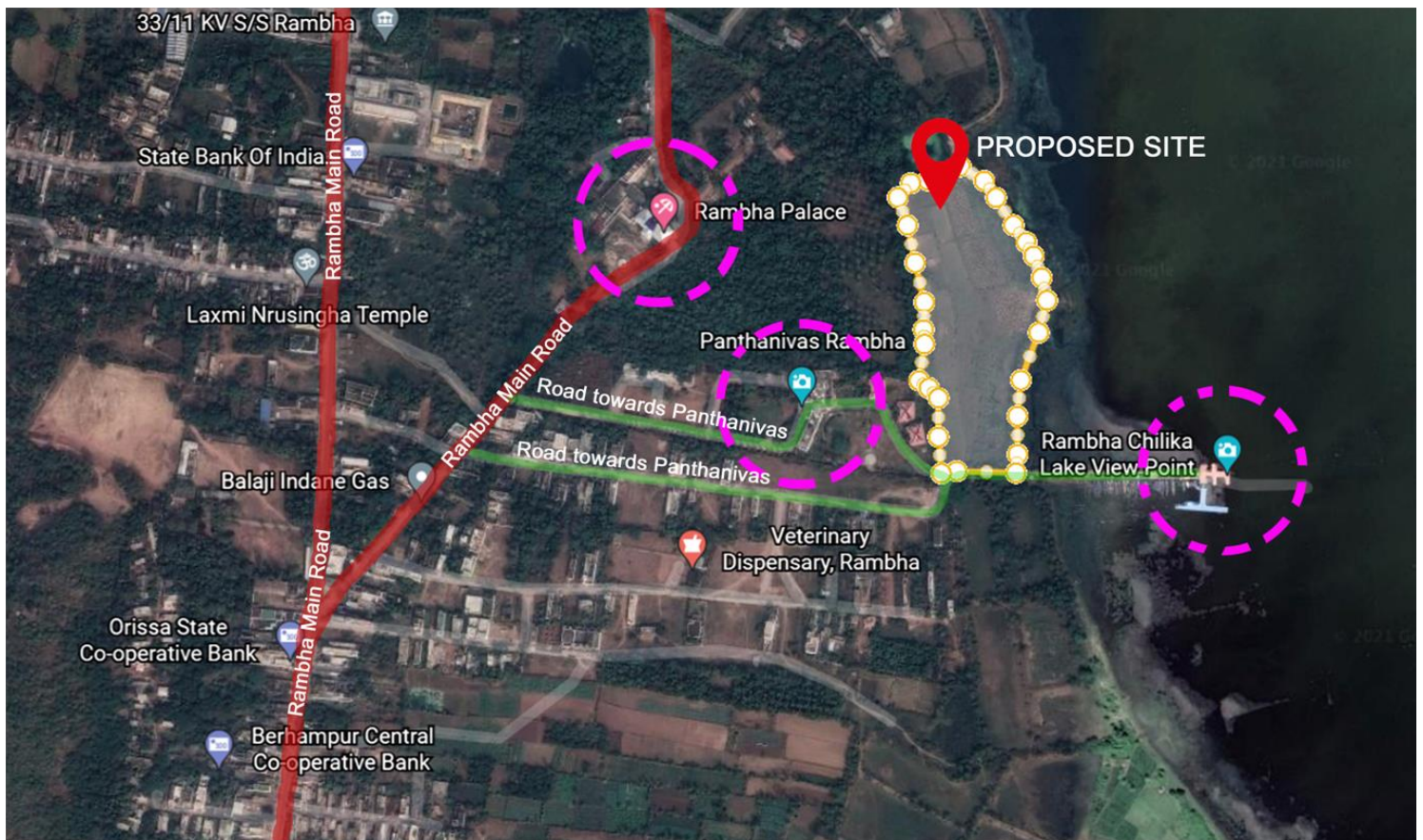


Fig 4.3 Demarcation of Proposed site

4.5 PROXIMITY OF THE SITE FROM THE RAMBHA BIRDSANCTUARY

The site is approximately 5.1Km away from the Rambha bird sanctuary. There is no such impact on the Rambha bird's sanctuary due to construction at the site.

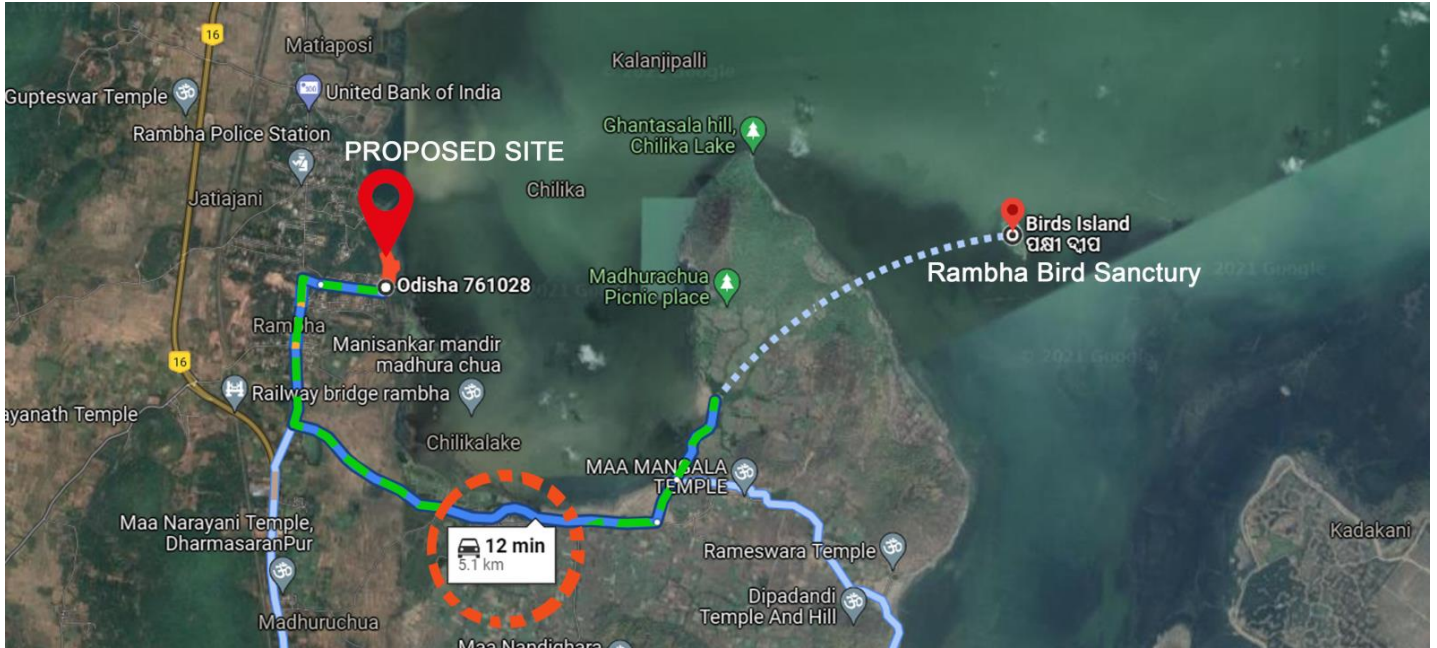


Fig 4.4 Proximity of the site from Rambha bird sanctuary

CHAPTER 05

5.1 LANDUSE SURROUNDING THE PROPOSED SITE

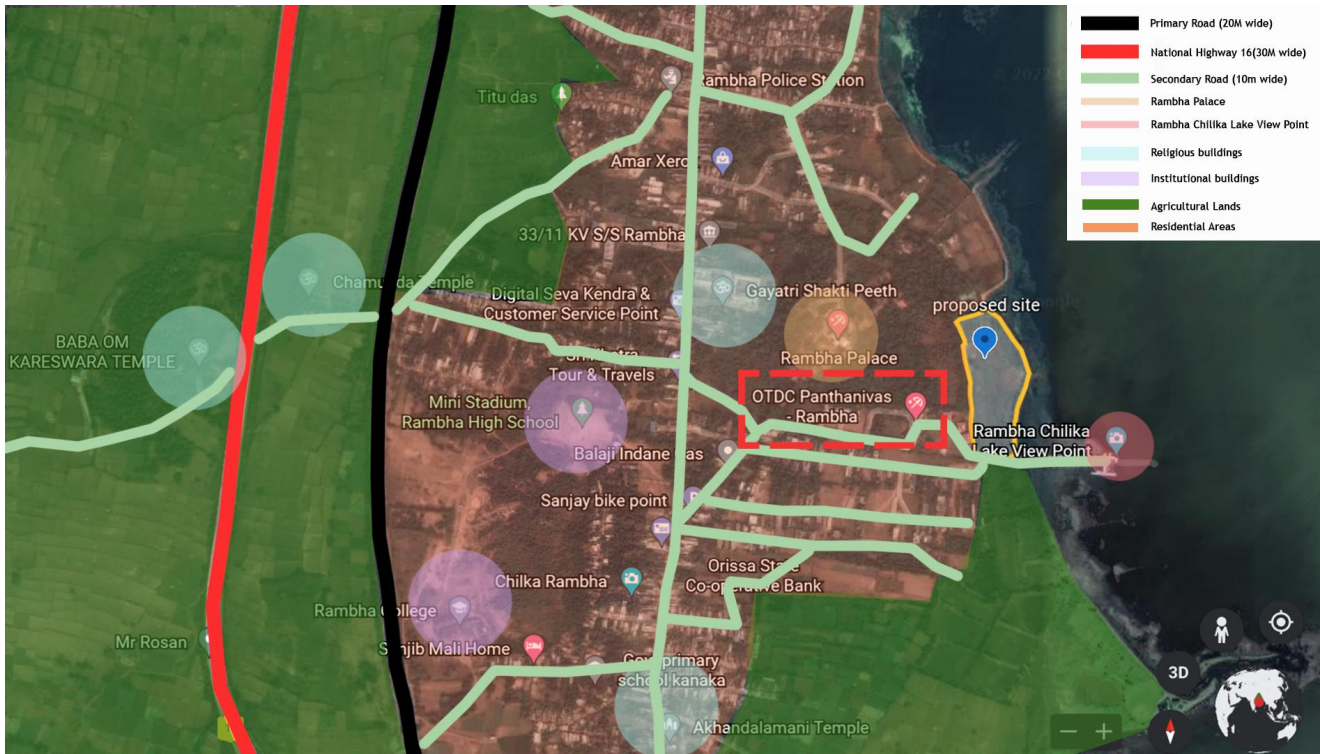


Fig 5.1 Land use pattern surrounding the proposed site

5.2 MACRO CLIMATE ANALYSIS OF THE SITE

The proposed site is situated under tropical savanna climate type. Nearby weather station is Bhubaneswar which is located 90 kms. far from the proposed site.

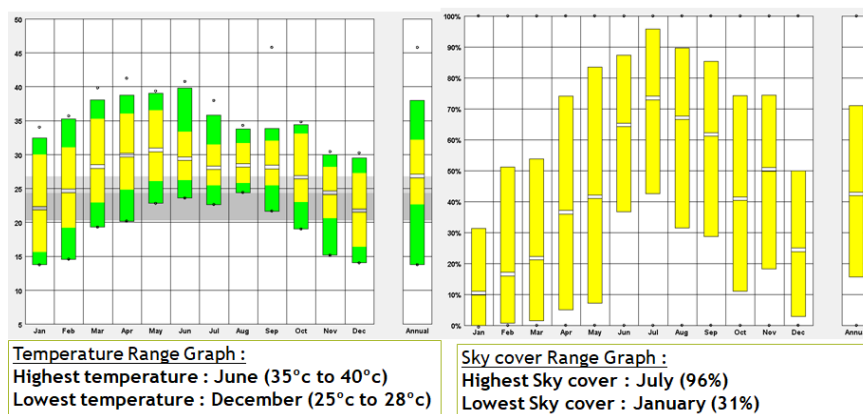


Fig 5.2 Temperature and sky cover range graph

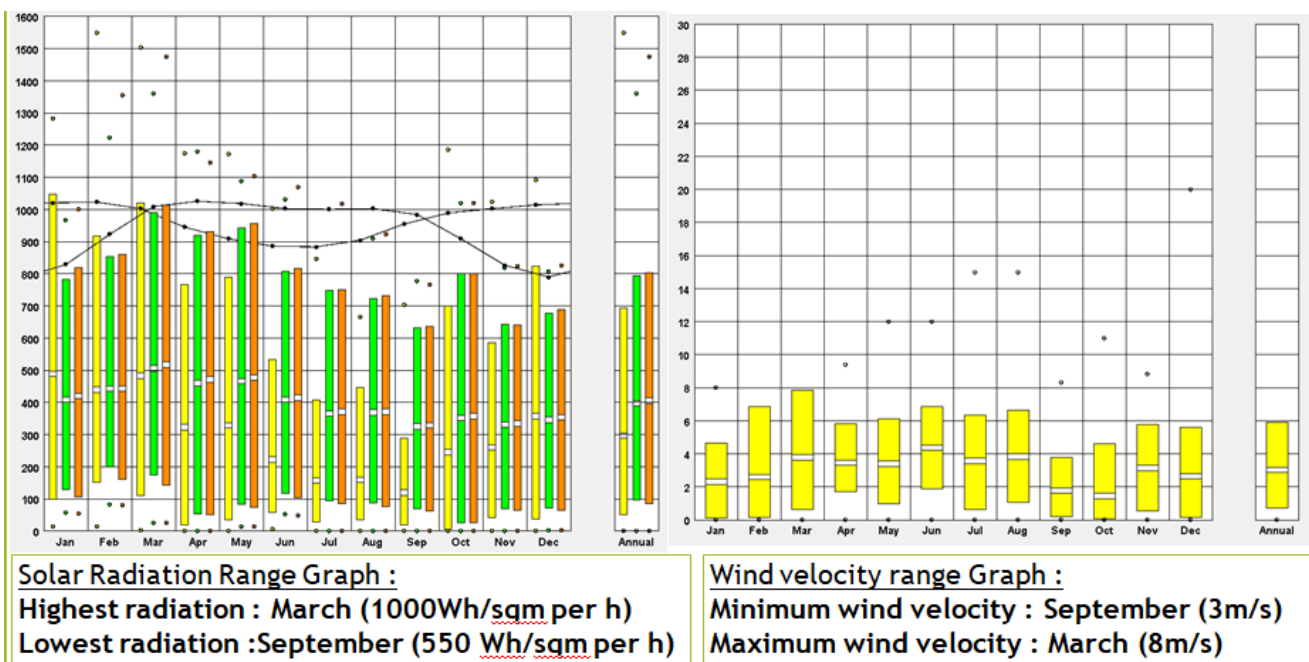


Fig 5.3 Solar radiation and wind velocity graph

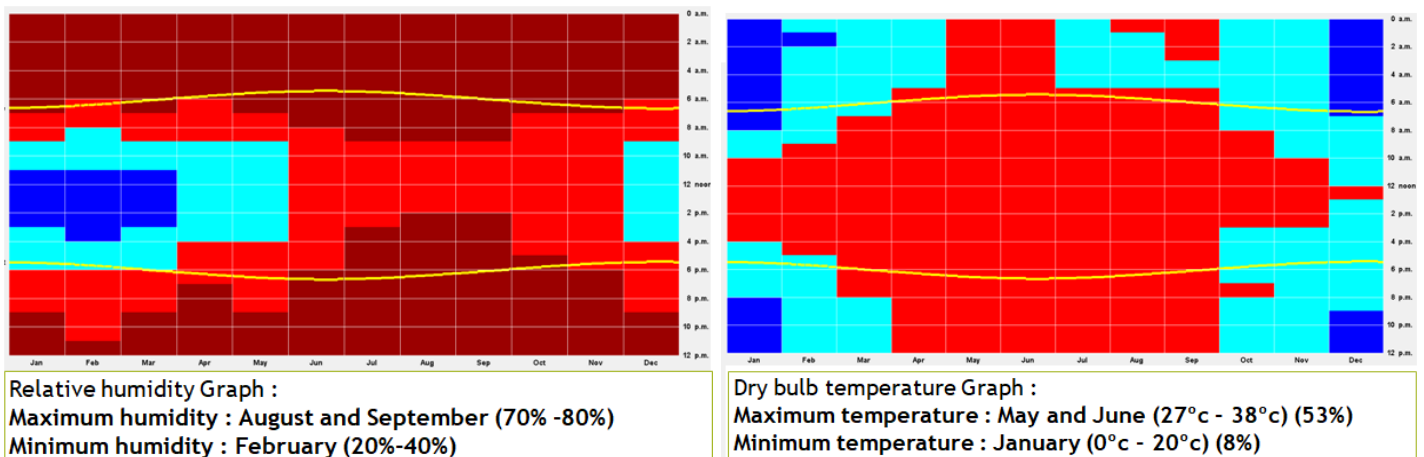


Fig 5.4 Relative humidity and Dry bulb temperature graph

5.3 SITE ACCESSIBILITY AND PROXIMITY ANALYSIS

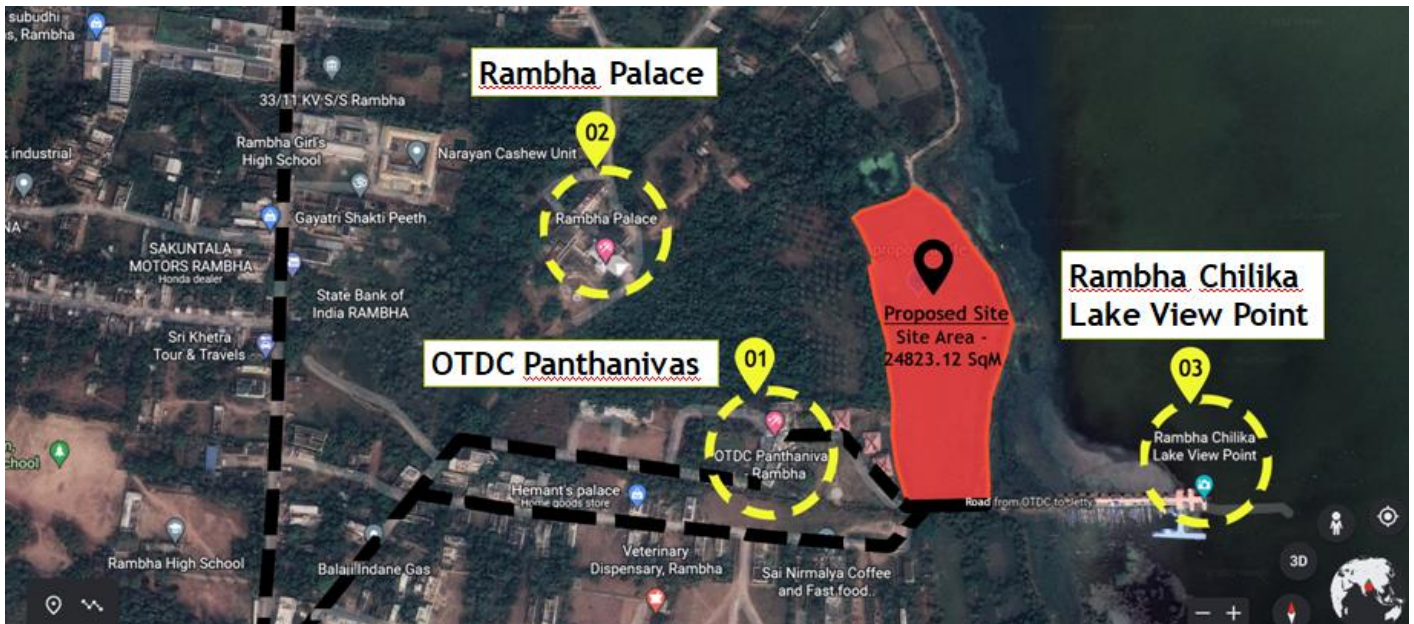


Fig 5.5 Locating important structures nearby proposed site



Fig 5.6 Photographs of important structures nearby proposed site

5.4 SITE PROXIMITY ANALYSIS

Access Road: 11.7M wide road laid from OTDC Panthanivas towards Rambha Chilika Lake view point Jetty.

Nearby Bus stop: Chatrapur bus stop (25.2 Kilomtres)

Nearby Railway Station: Chatrapur railway station (26.2 Kilometres)

Nearby Airport: Biju Pattanaik Airport park, Bhubaneswar (126 KM)

Nearby health care facilities: Rambha Government hospital (1.5 KM)

5.5 SITE CONTOUR ANALYSIS

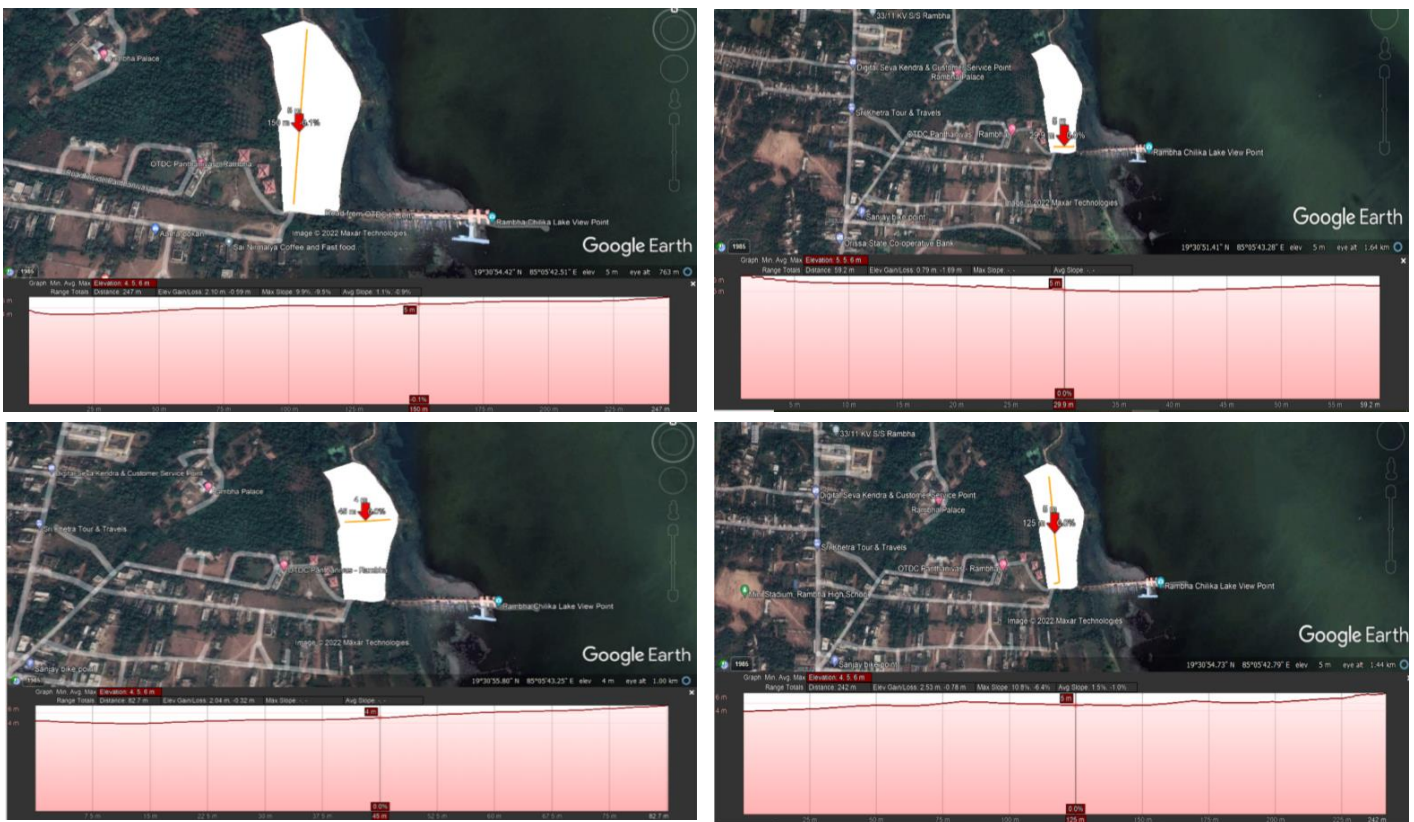


Fig 5.7 Contour maps of proposed site

5.6 3D IMAGES OF THE PROPOSED SITE

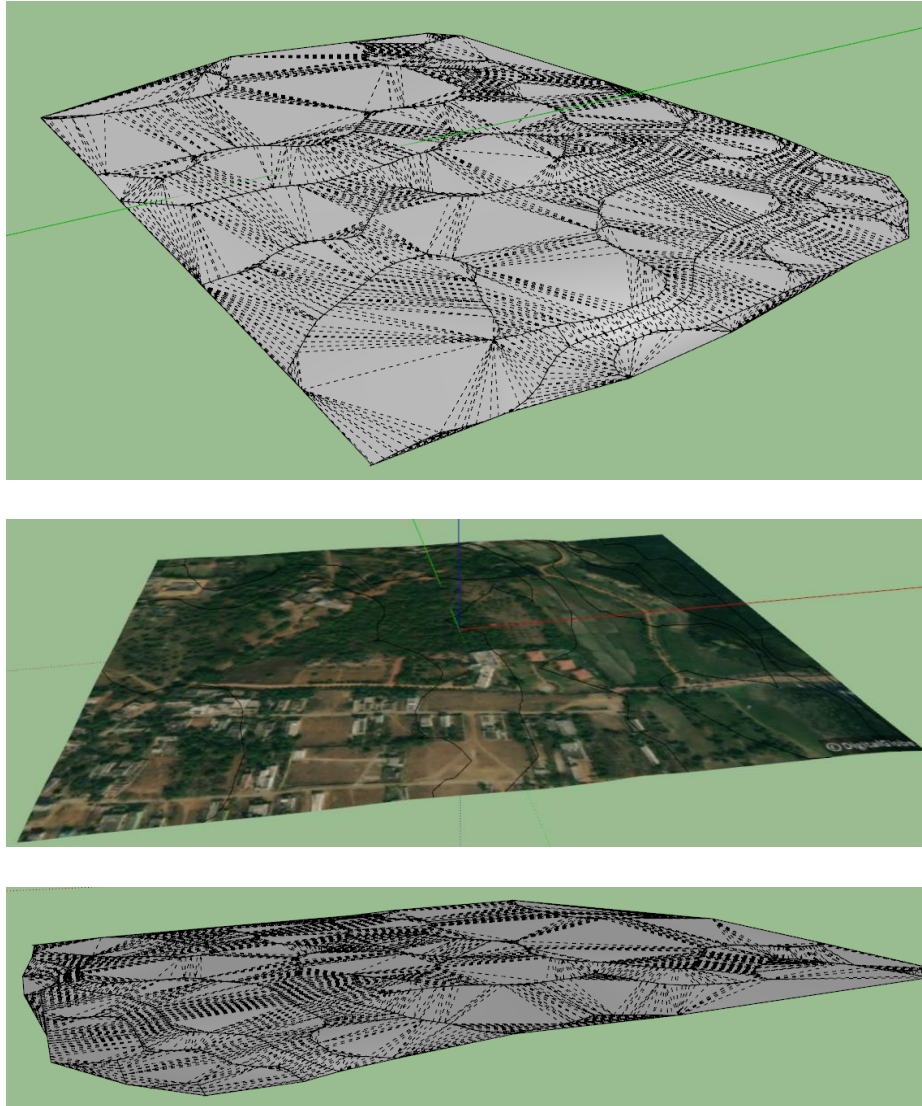


Fig 5.8 3D views of the proposed site

The site is a flat land with gradual difference in the terrain ranging from 6m elevation in the North to 5m at the centre of the site and 4m at the southern end. The slight variation is visible from the edges of the site to the centre of the site.

INFERENCE:

The natural slope of the site can be utilized for site draining and storm water collection.

5.7 SWOT ANALYSIS

STRENGTH OF THE SITE -

- a. Site is closer to National Highway 16.
- b. There is proper road connectivity.
- c. Close proximity to major amenities.
- d. Appropriate location for development of an eco resort due to prevailing natural beauty.

WEAKNESS OF THE SITE –

- a. Loose soil in the site may cause difficulties during construction.
- b. There are no adjacent buildings present for self shading of the building.
- c. Strategies should be adopted to achieve thermal comfort in summer.

OPPORTUNITIES OF THE SITE -

- a. Lake present nearby the site will help to modulate the microclimate of the site.
- b. Existing trees on the site can be helpful for shading.
- c. We can use the natural resources to create an energy efficient structure.
- d. Use of natural slope for site drainage system.
- e. Site is located in a calm spot away from the city which is suitable for visitors.

THREATS ASSOCIATED OF THE SITE –

- a. There is a possibility of Chilika Lake to overflow during monsoon season.

5.8 LOCALLY AVAILABLE MATERIALS NEAR TO SITE

5.8.1 LOCALLY AVAILABLE STONES IN ODISHA



Fig 5.9 Locally available stones in Odisha

5.8.2 LOCALLY AVAILABLE TIMBERS IN ODISHA



Fig 5.10 Locally available timbers in Odisha

5.8.3 SOIL TYPE ANALYSIS AT RAMBHA CLUSTER OF CHILIKA LAKE

The proposed site is located in Ganjam district where soil consists of Sandy loam, Loam Costal alluvium and Saline soil in few patches in coastal plains in eastern parts. Helical piers or helical piles or helical anchors are best suitable foundation for this type of sandy soil.

5.9 SITE SUN PATH DIAGRAM, PREVAILING WIND DIRECTION ANALYSIS

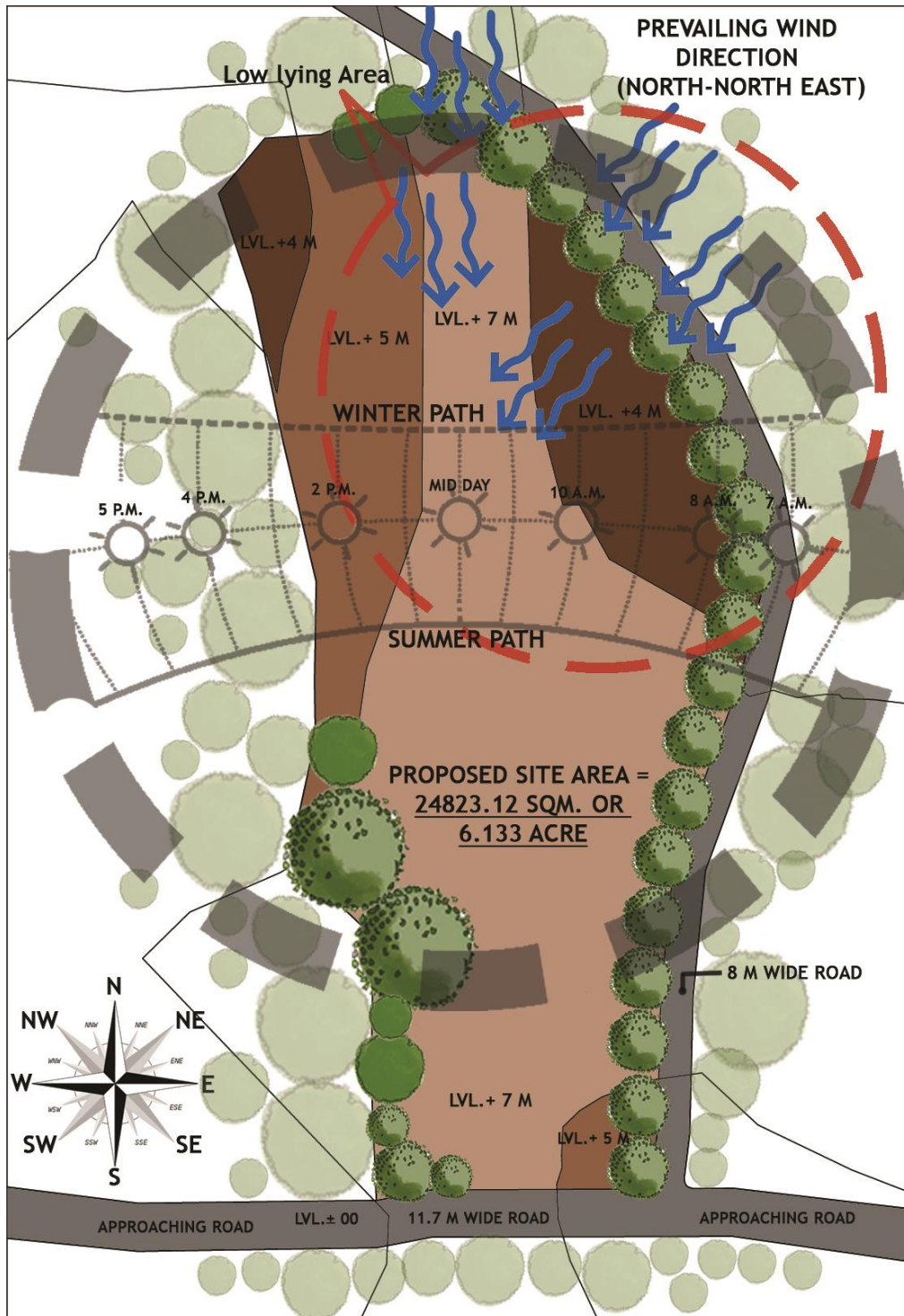


Fig 5.11 Sun path diagram and prevailing wind direction at site level

5.10 MICRO CLIMATE ANALYSIS OF THE SITE

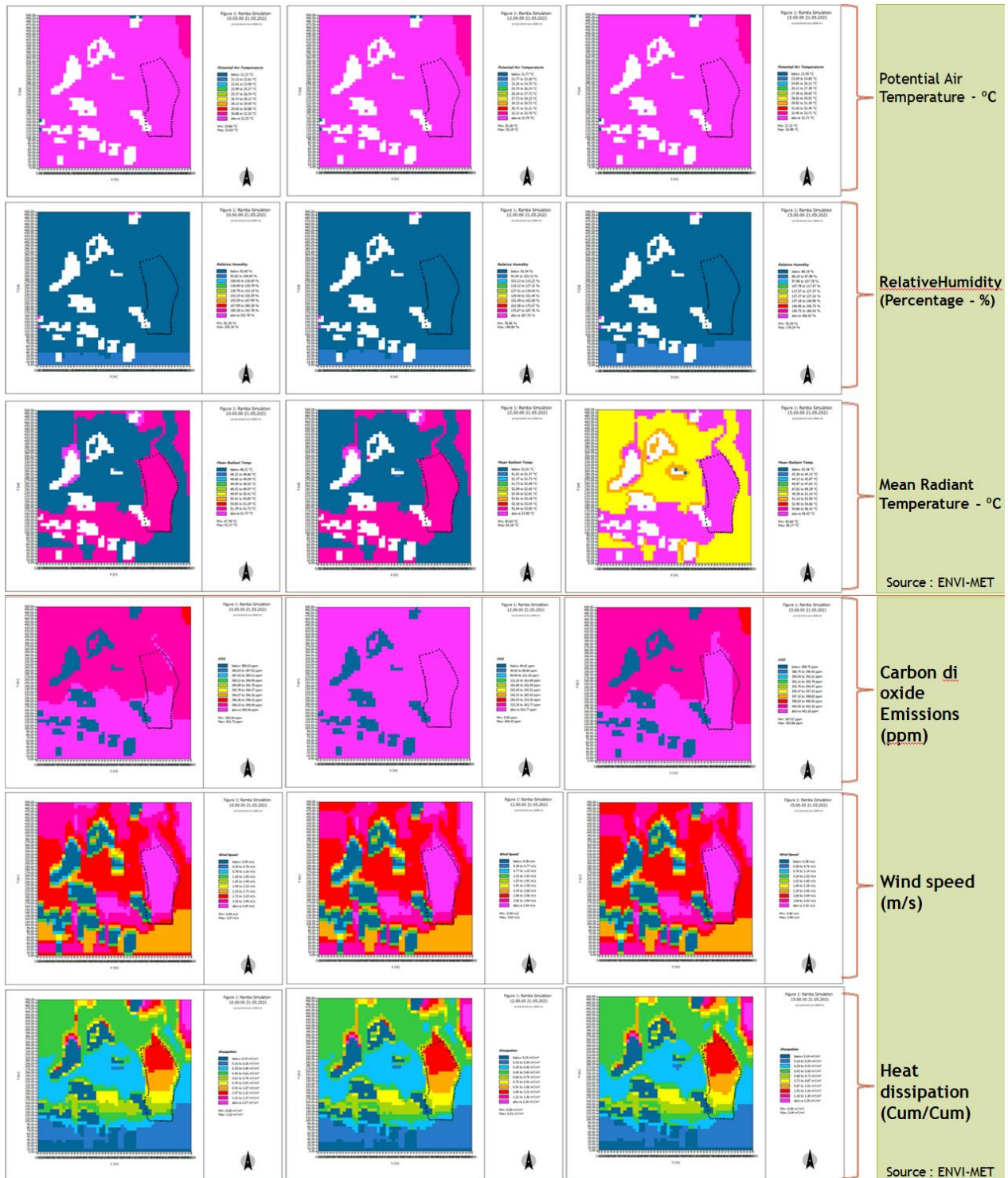
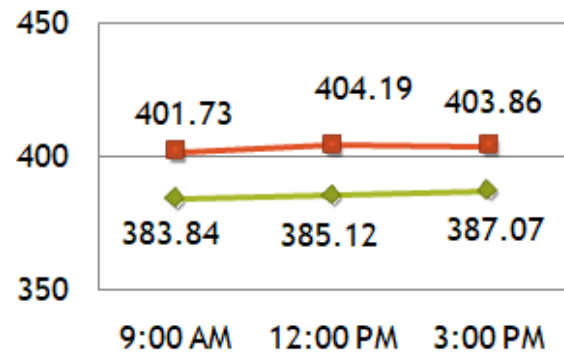
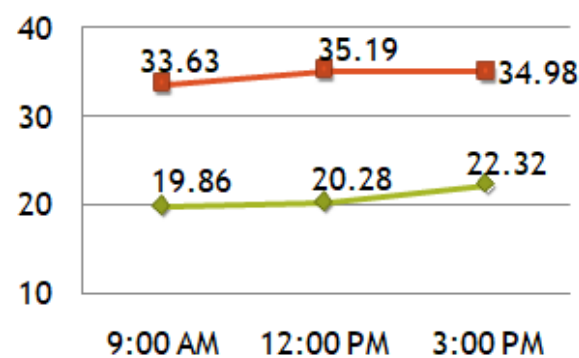
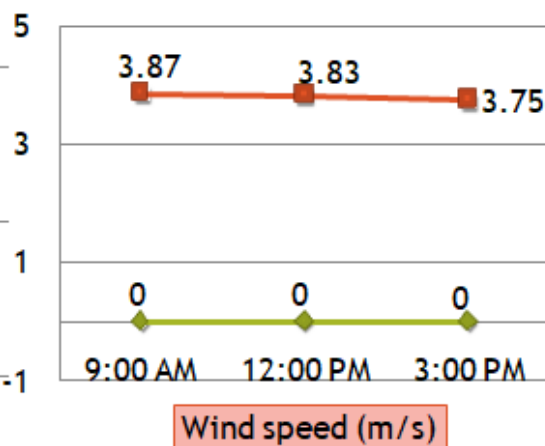
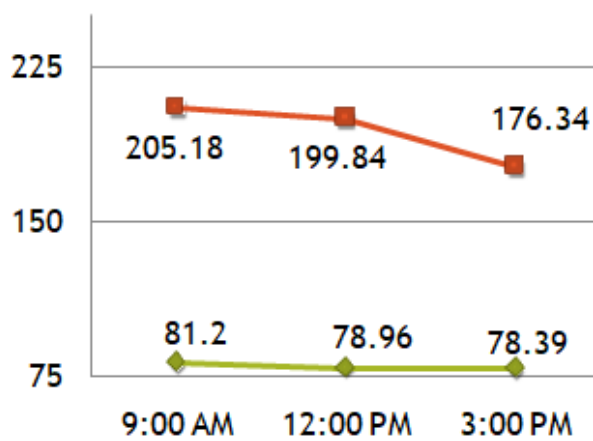


Fig 5.12 Showing ENVI-MET software results regarding various physical parameters



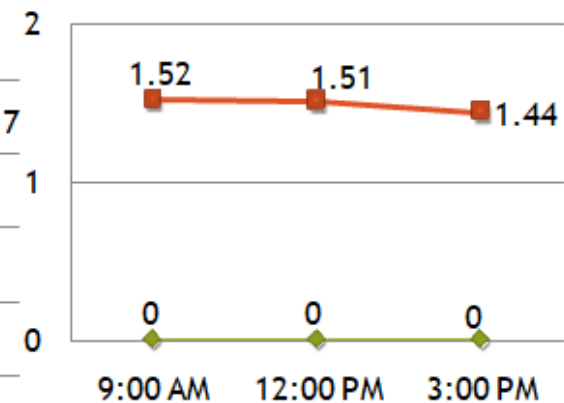
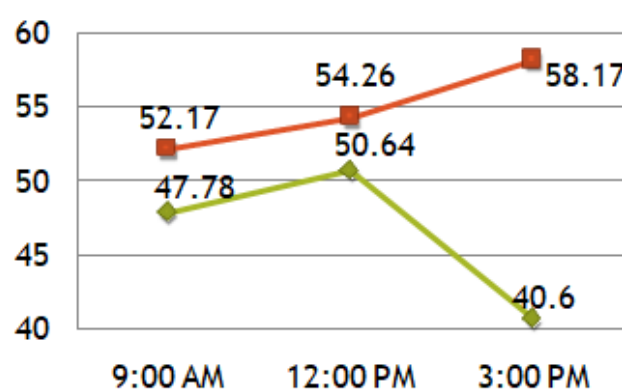
Potential air temperature graph (°C)

Carbon di oxide Emission graph (ppm)



Relative Humidity graph (%)

Wind speed (m/s)



Mean radiant temperature graph (°C)

Heat dissipation (Cum/Cum)

Fig 5.13 Graphical representation of ENVI-MET software results regarding various physical parameters

Parameters	Inference achieved
Potential air temperature (°C)	At 9 am, the temperature is 33.63°C on all the areas, <u>whereas at 12 pm, it is the highest. The maximum temperature is 35.19°C.</u> At 3 pm, recorded temperature is 34.98°C.
Relative Humidity (%)	At 9 am, relative humidity is 205.18%. At 12pm, relative humidity is 199.84%. At 3 pm, relative humidity is 176.35%. <u>Highest relative humidity is observed at 9 am.</u>
Mean radiant Temperature (°C)	<u>The temperature is highest at 3 pm which is around 58.17°C.</u> We can see increase in temperature with respect to increase in time.
Carbon di Oxide Emission (ppm)	During daytime around 12pm, the whole area is experiencing <u>maximum Carbon-di-oxide emission</u> which is about 404.19 ppm.
Wind Speed (m/s)	Wind speed is highest inside the site during <u>morning 9 am which is 3.87m/s.</u> We can see lowest wind speed at 3pm.
Heat dissipation (Cum/Cum)	<u>Highest heat dissipation is observed at 9 am</u> which is 1.52 Cum/Cum. Heat dissipation reduces with time.

TABLE 5.1 Study of design parameters derived from case study

5.11 FUNCTIONAL SPACE REQUIREMENT ANALYSIS

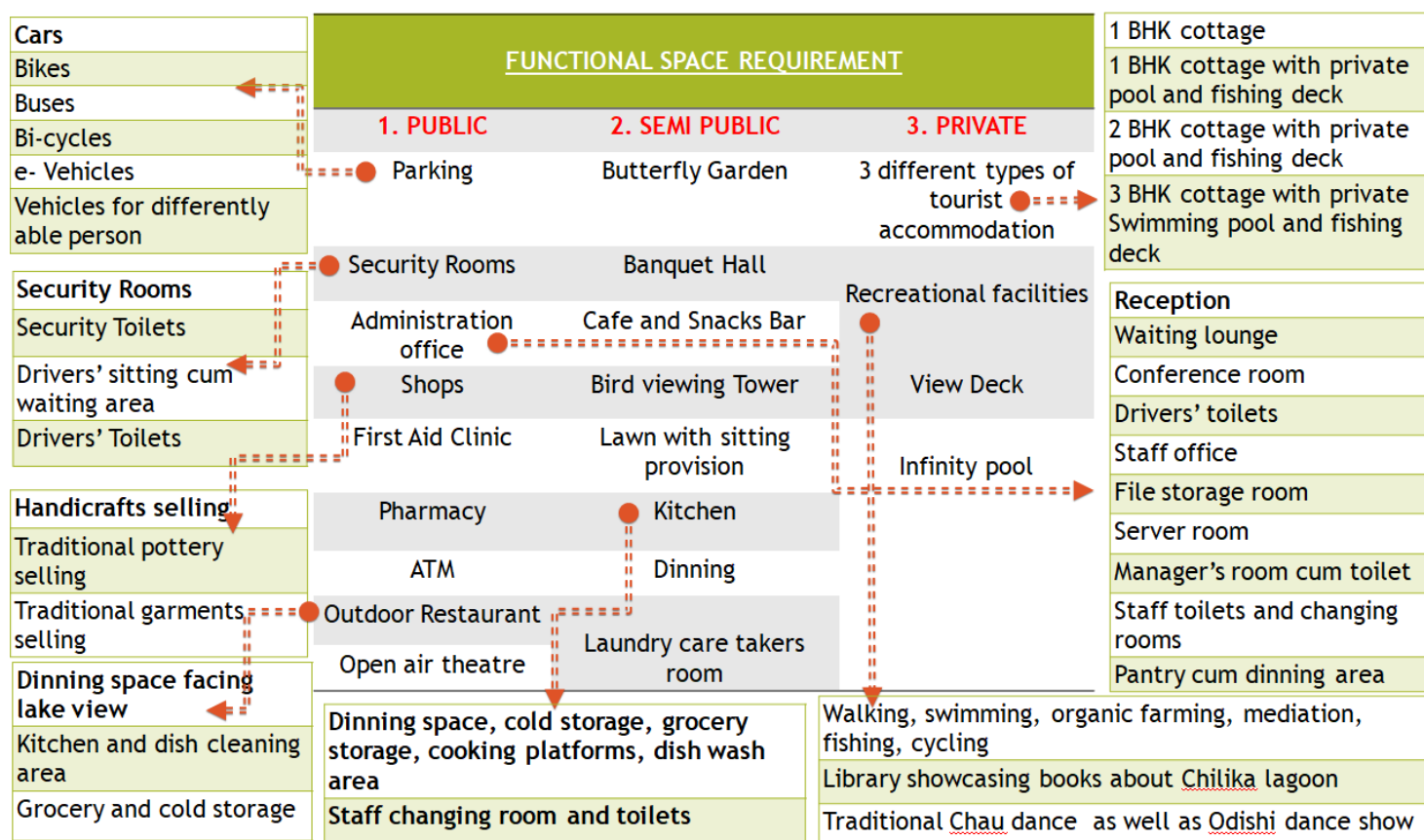


TABLE 5.2 Study of various functional space requirements

5.12 CODES AND STANDARDS TO BE FOLLOWED

Serial No.	Name	Parameters to be considered
01	Odisha development Authorities Act (ODA) Bylaws	Minimum road width, Minimum setback width, FAR calculations, Provisions for differently able, Parking requirements, Driveway and aisle width, corridor and verandah width, staircase width etc.
02	Odisha tourism Policy -2020	Promotion of eco tourism, Promotion of ethical responsibilities and behavior of tourists towards natural environment etc.
03	ICZM regulations by Odisha Tourism Development Corporation (OTDC)	Preservation of local ecosystem, recognition of intrinsic values of the tourism related resources, better management of valuable regions, consideration of on site experience plus offsite long lasting benefits etc.
04	Chilika development Authority guidelines	Guidelines pertaining to Chilika lake birds sanctuary would be checked.
05	CRZ regulations	CRZ maps and graphs would be followed.
06	National building code (NBC)	Lighting, ventilation and building services will be followed.
07	ECBC	WFR, VLT, Thermal transmittance of roof, REVT calculation for building envelope, Thermal transmittance of building envelope.
08	Architectural Standards	Time saver standards for planning requirements are referred.
09	Passive strategies implemented	Relevant research papers and case studies will be referred.

TABLE 5.3 Study of Codes and Standards to be followed

5.13 GUIDELINES AND REGULATIONS TO BE FOLLOWED

- a. Proposed site area = 24823.12 Sqm.
- b. Approaching road width = 11.8 m
- c. Permissible FAR (Floor area ratio) = 2.00
- d. Maximum permissible ground coverage allowed = 20% = 4,964.624 Sqm.
- e. Maximum height allowed = 7m
- f. Vegetation -
- g. Minimum percentage of vegetation covering the whole site = 50%
- h. Setbacks -
- i. For road width in between 9 m to 18 m :
- j. Minimum frontal set back = 4.5 m
- k. Minimum other sides set back = 3 m
- l. Parking -
- m. Minimum percentage of car parking = 50% of total permissible built up area
- n. 15% of the total parking should be allotted for two wheeler parking.
- o. Barrier free access for the physically challenged differently able person, elderly and children.
- p. Recharging of ground water is mandatory for all types of buildings having a plot area more than 300 square meters.
- q. For the plot area of 300 square meters and above, minimum generation capacity of 5% of the connected load should be provided with rooftop
- r. Solar energy installation.

CHAPTER 06

6.1 FORM FACTOR ANALYSIS

Form factor analysis describes the relationship between external surface area and the internal treated floor area. This allows useful comparisons of the efficiency of the building form relative to the useful floor area. We all know heat will enter through the building gradually throughout the day. Compact buildings (reduced surface area) will have less heat entering inside it. Achieving a heat loss form factors of less than or equal to 3 is a useful benchmark guide for designing small passive buildings.

FORM FACTOR (FF) = BUILDING ENVELOPE AREA / GROSS FLOOR AREA

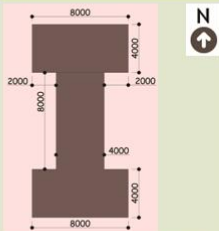
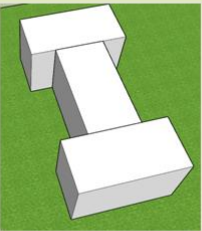
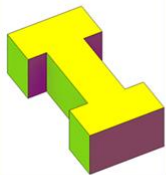
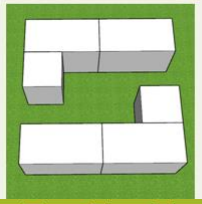
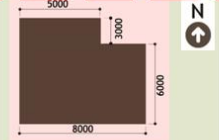
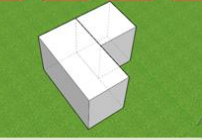
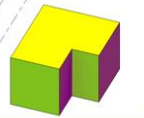
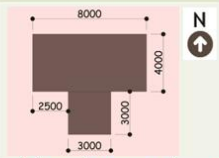
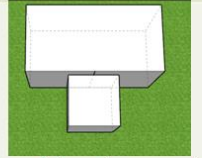
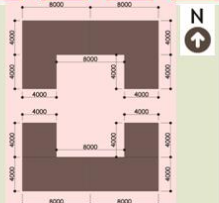
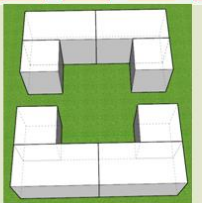
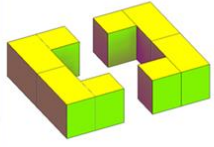
Sl. NO.	2D FORM	3D MODEL	GROSS FLOOR AREA	ENVELOPE AREA	FORM FACTOR	CUMULATIVE SOLAR INSOLATION (KWh/sqm) Source : REVIT (Solar Analysis)
FORM 01			96 Sam	280 Sam	2.916	Cumulative solar insolation = 1254 Kwh/sqm. 
FORM 02			160 Sam	480 Sam	3	Cumulative solar insolation = 1906 Kwh/sqm. 
FORM 03			73 Sam	218 Sam	2.98	Cumulative solar insolation = 616 Kwh/sqm. 
FORM 04			41 Sam	117 Sam	2.953	Cumulative solar insolation = 554 Kwh/sqm. 
FORM 05			128 Sam	480 Sam	3.75	Cumulative solar insolation = 1753 Kwh/sqm. 

TABLE 6.1 Form factor analysis

INFERENCE –

From the above simulation results, it is clearly visible that FORM 04 is receiving minimum solar insolation of 554 kwh/sqm whereas FORM 03 is also performing better by receiving 916 kwh/sqm. FORM 03 and FORM 04 have form factor 2.98 and 2.953 respectively which are less than 3 which is recommended for small passive house design.

6.2 ZONING ITERATION 01

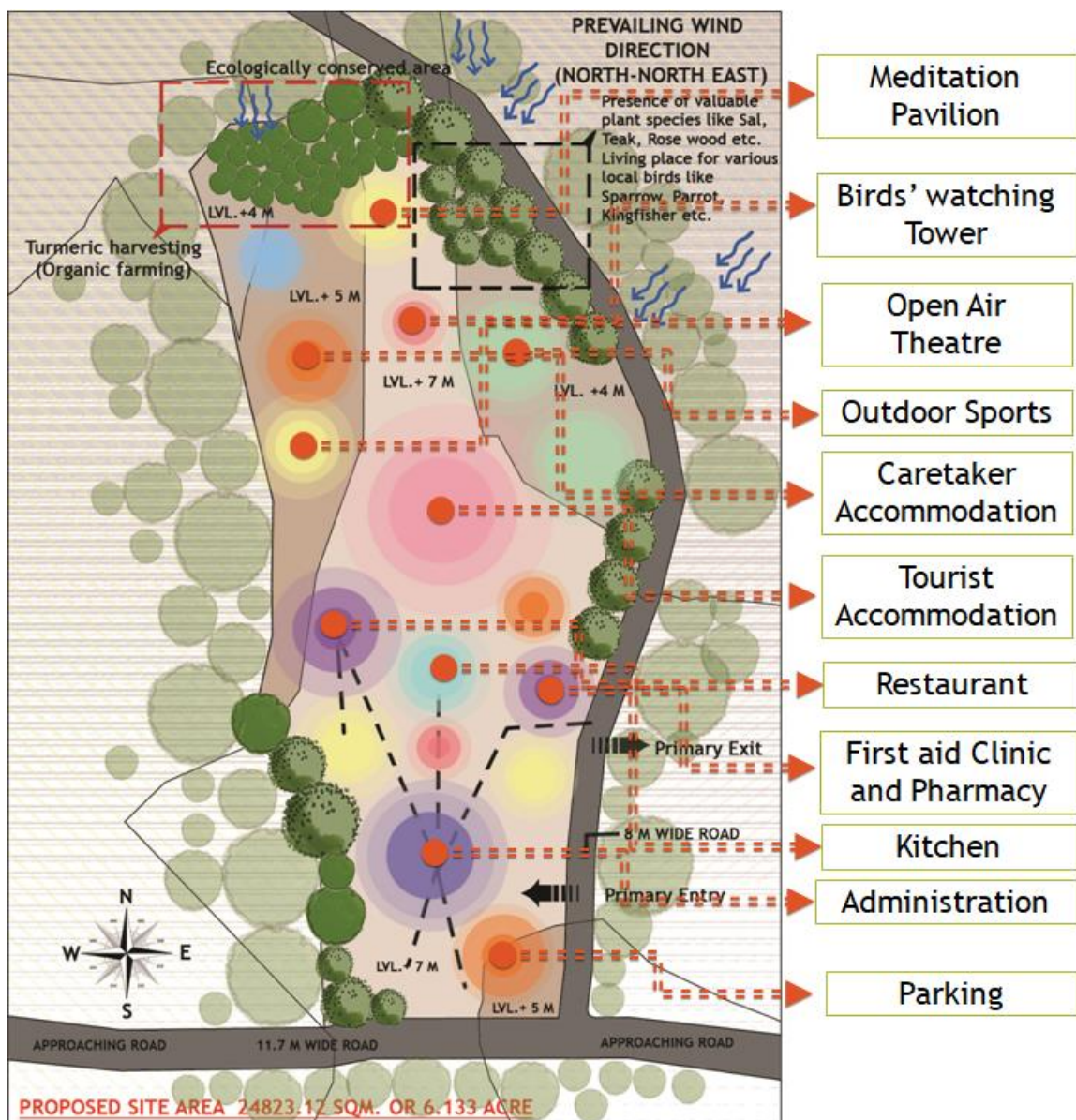


Fig 6.1 Showing Site zoning iteration 01

6.2.1 POSITIVE ASPECT:

- a. The primary entry and exit is positioned along 8 m wide road.
- b. Administration block is placed at the entrance of the site for better ease of communication.
- c. Shops are also placed at the entrance of the site so that it will encourage tourist as well as outsiders to purchase local handicrafts.
- d. First-Aid Clinic and Pharmacy are also located near primary exit for any kind of emergency.

6.2.2 NEGATIVE ASPECT:

- a. Private zones like tourist accommodation are surrounded by public activities which may create increase in noise level.
- b. There is no provision for service entry and exit in this zoning iteration.
- c. Outdoor amenities are located near to the ecologically sensitive zone in this zoning iteration which is not suitable.
- d. There is no segregation between public, semi public, semi private and private spaces which can hamper entire site.
- e. Placement of Open air theatre near to the tourist accommodation can cause privacy issues.
- f. Caretaker accommodation must be located near to the tourist accommodation for easy maintenance.
- g. Main entry and exit must be placed through 12m wide road which is advisable.

6.3 ZONING ITERATION 02

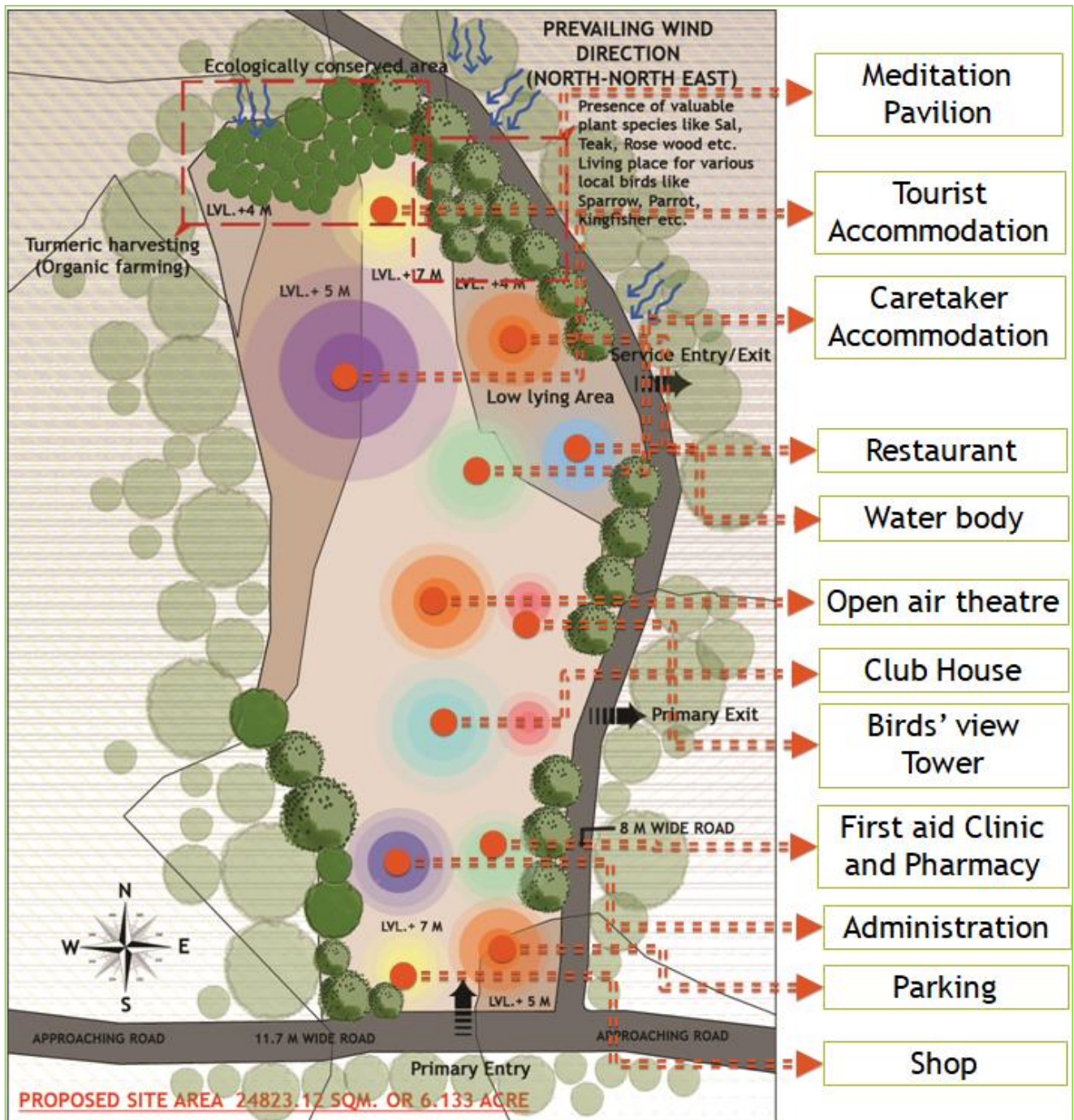


Fig 6.2 Showing Site zoning iteration 02

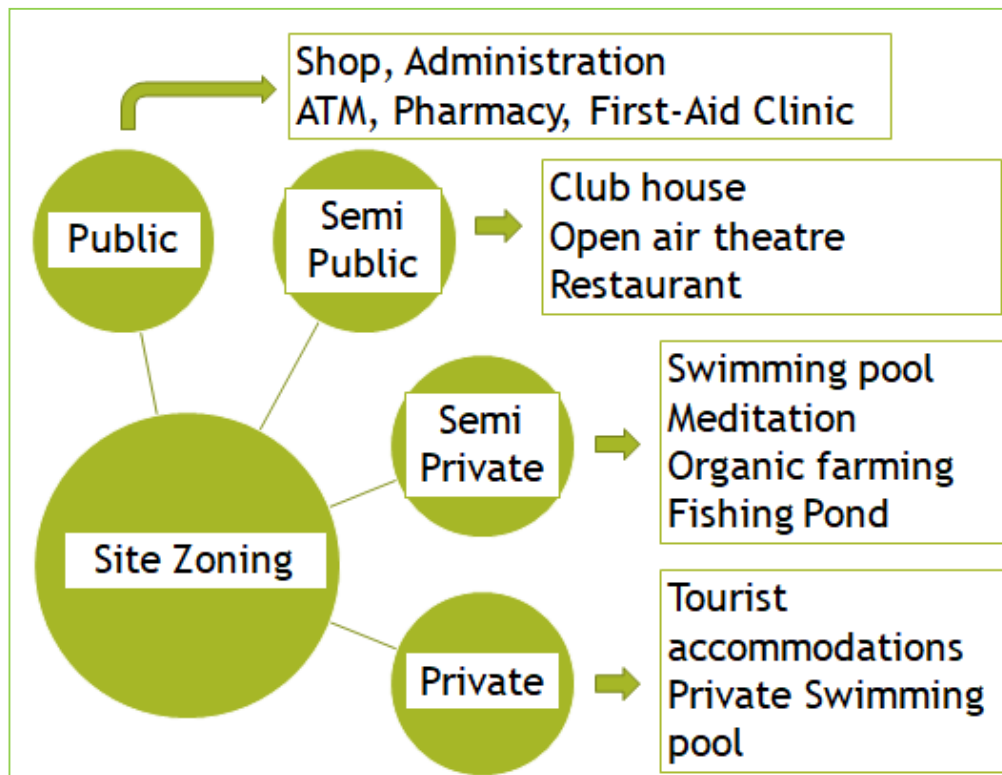


Fig 6.3 Site zoning bubble diagram

6.3.1 POSITIVE ASPECT:

- The primary entry and exit is positioned along 12 m wide road.
- Administration block is placed at the entrance of the site for better ease of communication.
- Shops are also placed at the entrance of the site so that it will encourage tourist as well as outsiders to purchase local handicrafts.
- First-Aid Clinic and Pharmacy are also located near primary exit for any kind of emergency.
- Provision for service entry and exit is incorporated.
- There is proper demarcation of public, semi public and private zones.

6.4 ARRIVAL OF PUBLIC, SEMI PUBLIC, PRIVATE, SEMI PRIVATE ZONES

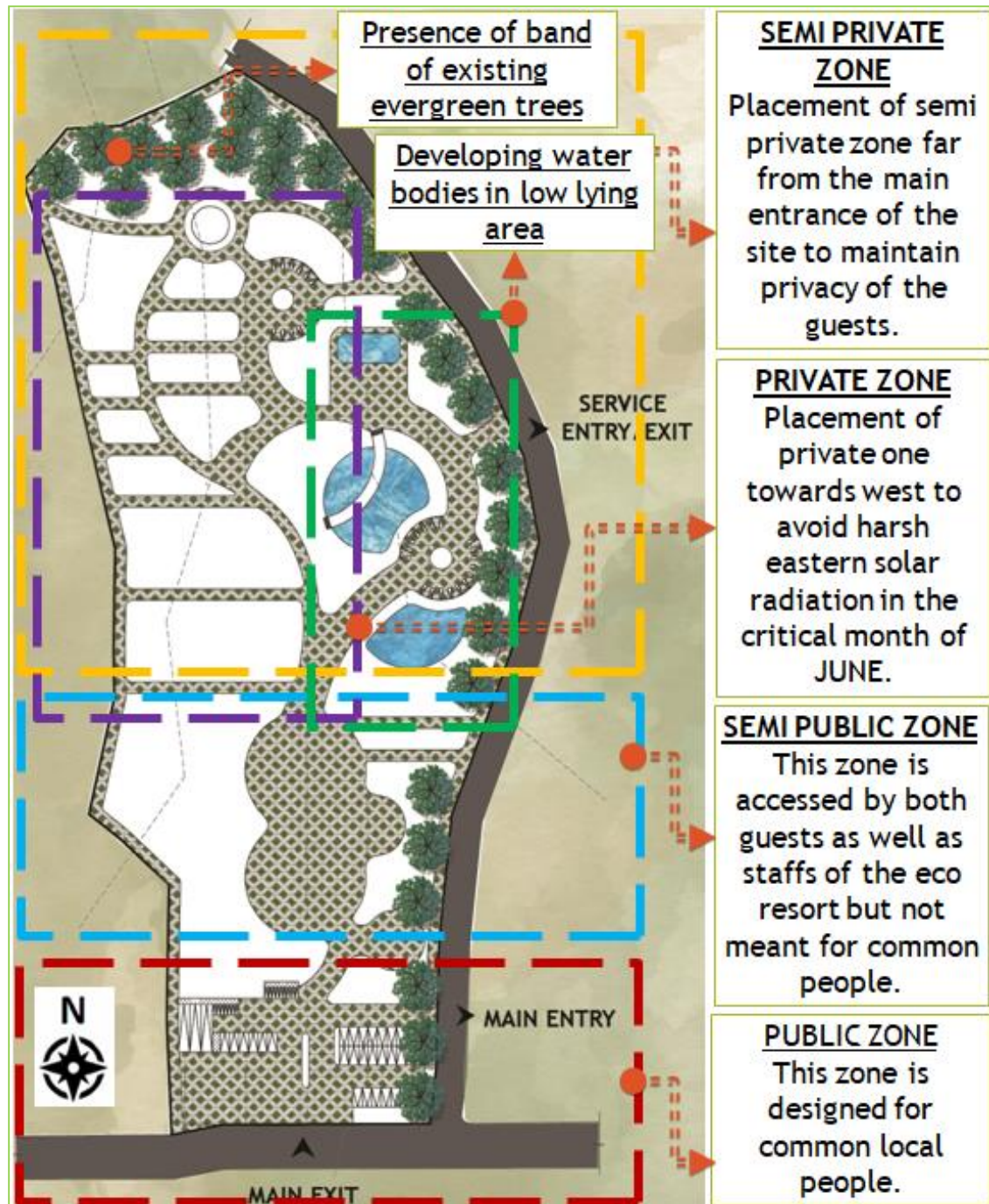


Fig 6.4 Demarcations of different zones in site layout

6.5 ESSENTIAL STRATEGIES THOSE WILL BE INCORPORATED AT SITE LEVEL

- a. Orientation – The longer facade of the building should orient towards North and South direction. Length of eastern and western facade should be kept minimum.
- b. Shading – There is already a band of existing local shading trees in the eastern side of the site which will be beneficial to avoid direct solar heat. Apart from this, through native shading plants, bushes and trees shading of walkways can be increased.
- c. Ventilation – Placement of maximum number of larger inlet windows in the north facade and placement of small outlet windows in southern facade will encourage more wind flow inside the building. For releasing warm air from the interior of the building, we can go for placement of skylights as well as vents at higher level.
- d. Humidity control – Efficient use of prevailing wind can control humidity as there will be presence of higher humidity due to lake near to site.
- e. Other strategies – Design strategy must involve various building components like roofs with higher solar reflective index, solar radiation reduction with composite wall. Compact structures must be preferred to reduce exposed surface. Use of local material with lower embodied energy and lower carbon emission will make the structure sustainable. The lowest point on the site must be converted into water harvesting pond.

CHAPTER 07

7.1 BLOCK ORIENTATION ANALYSIS WITH RESPECT TO SOLAR RADIATION

7.1.1 ORIENTING BUILT FORM AT 0°

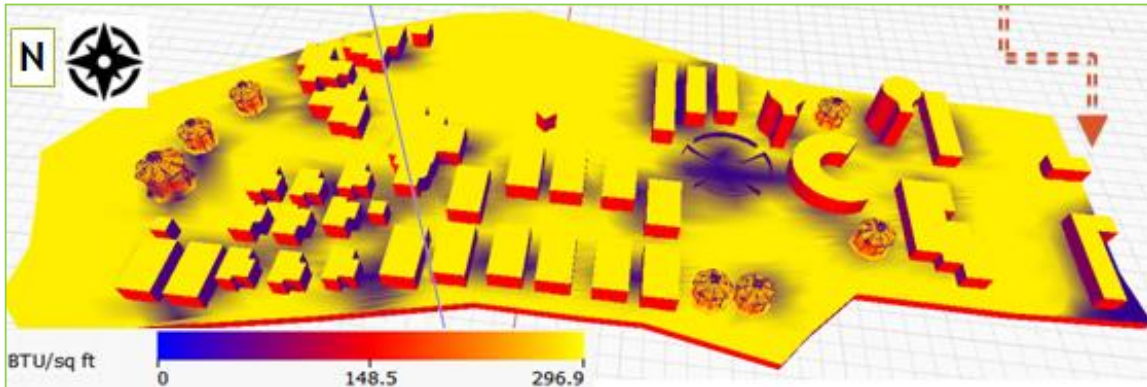


Fig 7.1 Orientation at 0° with respect to solar radiation

7.1.2 ORIENTING BUILT FORM AT 15°

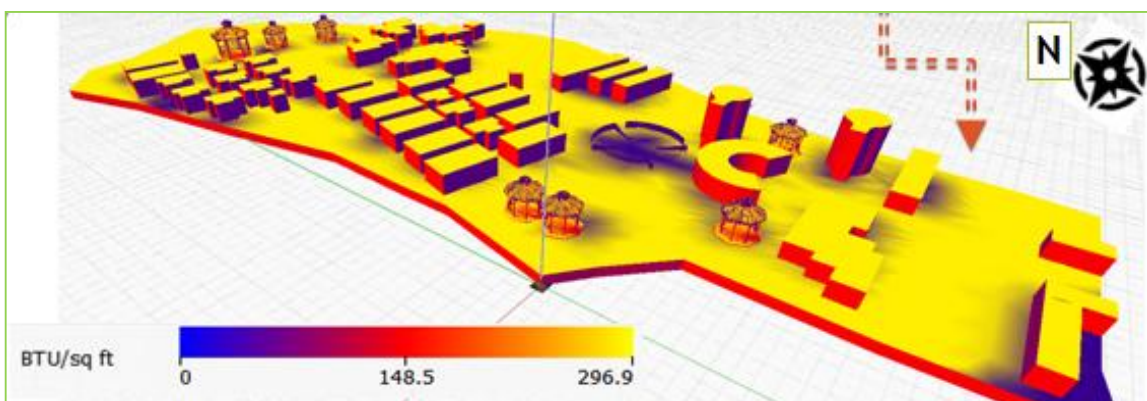


Fig 7.2 Orientation at 15° with respect to solar radiation

7.1.3 ORIENTING BUILT FORM AT 30°

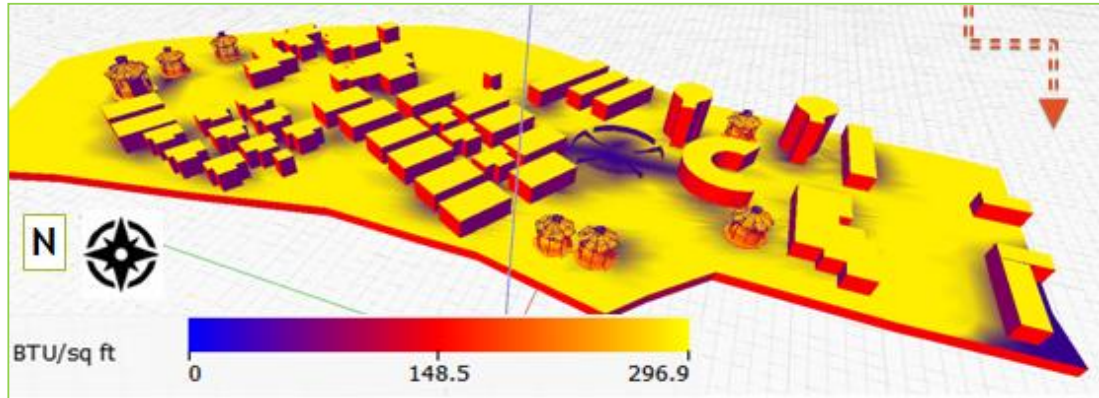


Fig 7.3 Orientation at 30° with respect to solar radiation

7.1.4 ORIENTING BUILT FORM AT 45°

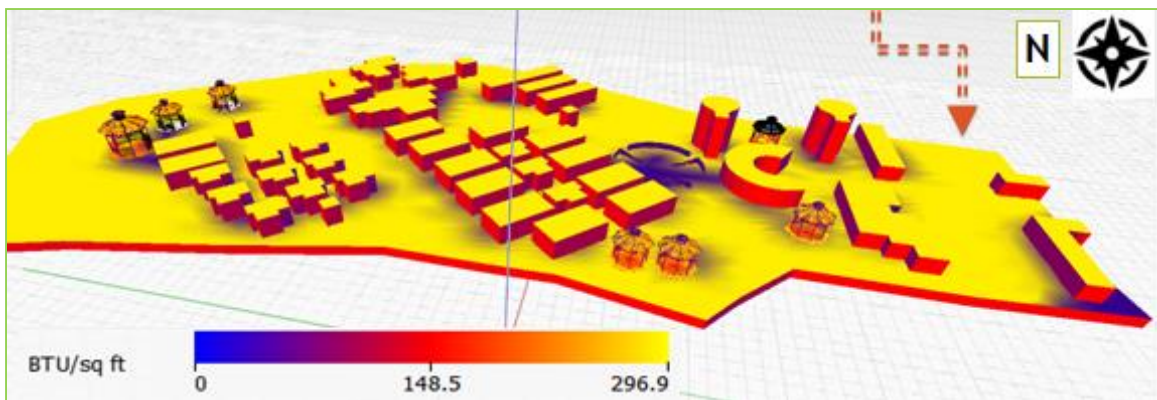


Fig 7.4 Orientation at 45° with respect to solar radiation

7.1.5 ORIENTING BUILT FORM AT 60°

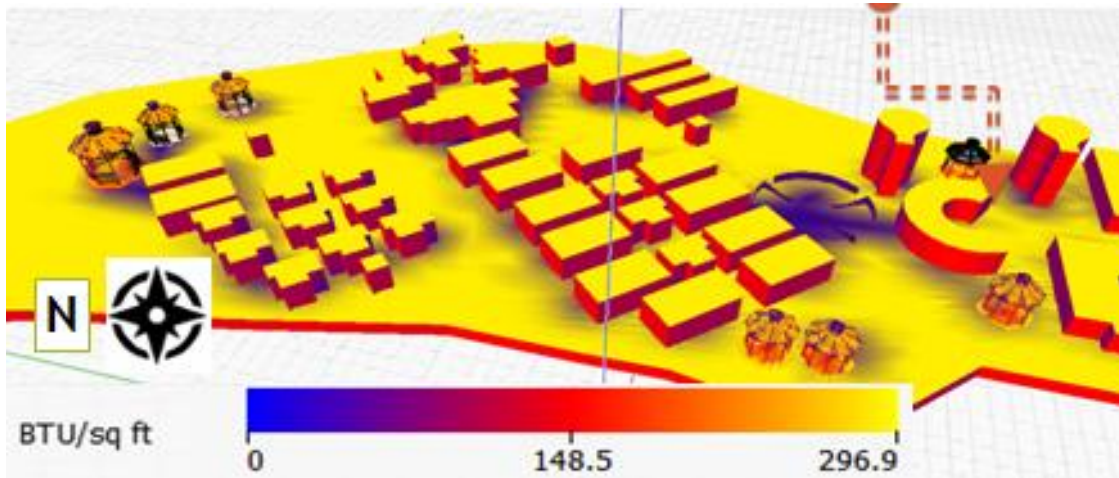


Fig 7.5 Orientation at 60° with respect to solar radiation

ORIENTATION	NORTH	SOUTH	EAST	WEST	ROOF	CUMULATIVE RADIATION
0 degree	51.35	15.86	194	145.4	287	693.61
15 degree	75.39	17.7	201.6	130.1	287	712.29
30 degree	103.7	53.54	196.4	105.9	287	746.54
45 degree	120.4	68.21	185.4	86.8	287	747.81
60 degree	145.6	141.7	141.1	38.59	287	753.99

TABLE 7.1 CUMULATIVE SOLAR RADIATION CALCULATIONS

INFERENCE - Minimum radiation is visible along Zero degree orientation.

Radiation unit – BTU/Sqft.

7.2 BLOCK ORIENTATION ANALYSIS WITH RESPECT TO WIND SPEED

7.2.1 ORIENTING BUILT FORM AT 90° TOWARDS WIND DIRECTION

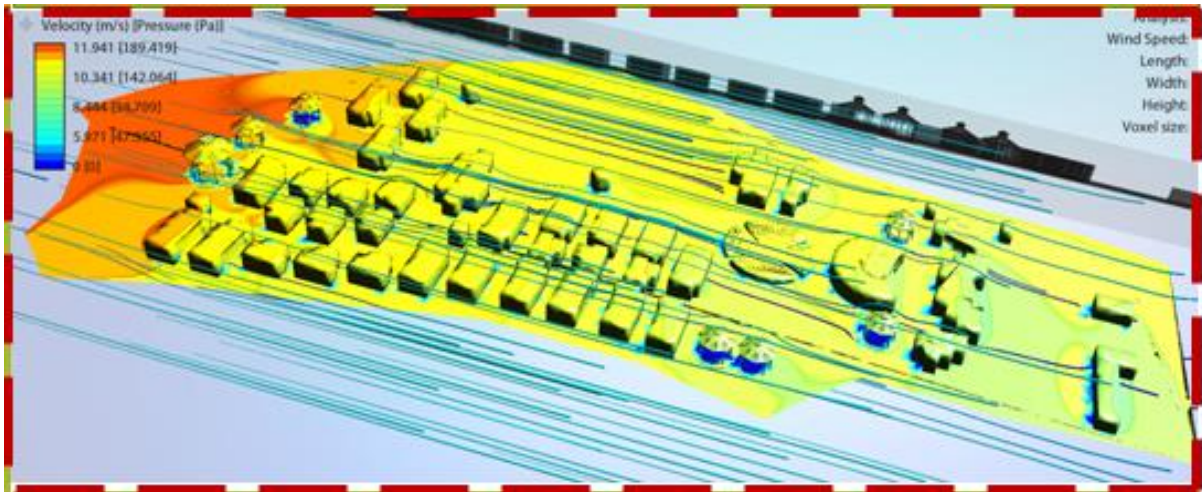


Fig 7.6 Orientation at 90° with respect to wind direction

7.2.2 ORIENTING BUILT FORM AT 60° TOWARDS WIND DIRECTION

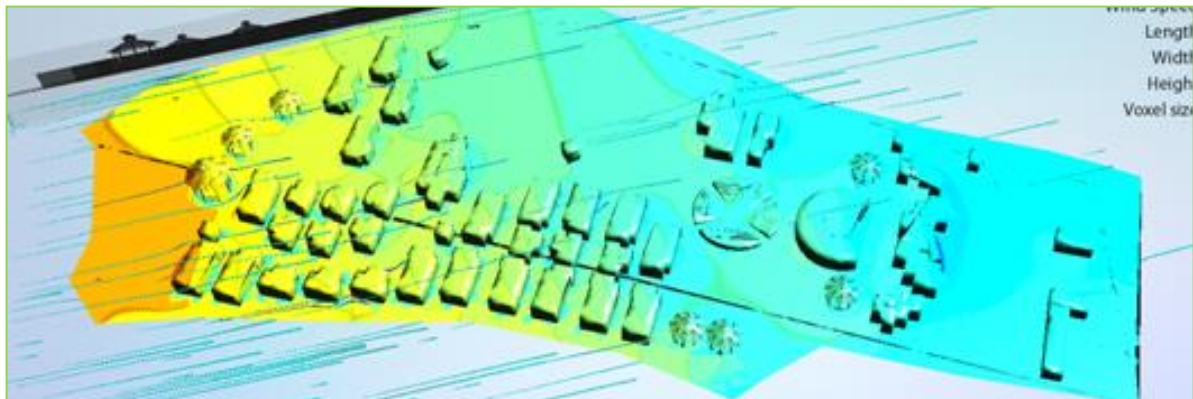


Fig 7.7 Orientation at 60° with respect to wind direction

7.2.3 ORIENTING BUILT FORM AT 45° TOWARDS WIND DIRECTION

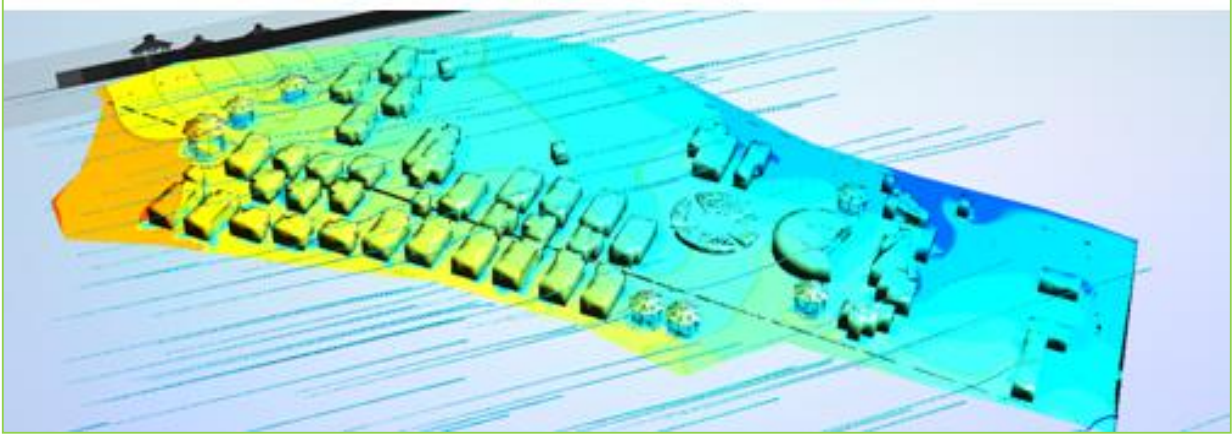


Fig 7.8 Orientation at 45° with respect to wind direction

7.2.4 ORIENTING BUILT FORM AT 30° TOWARDS WIND DIRECTION

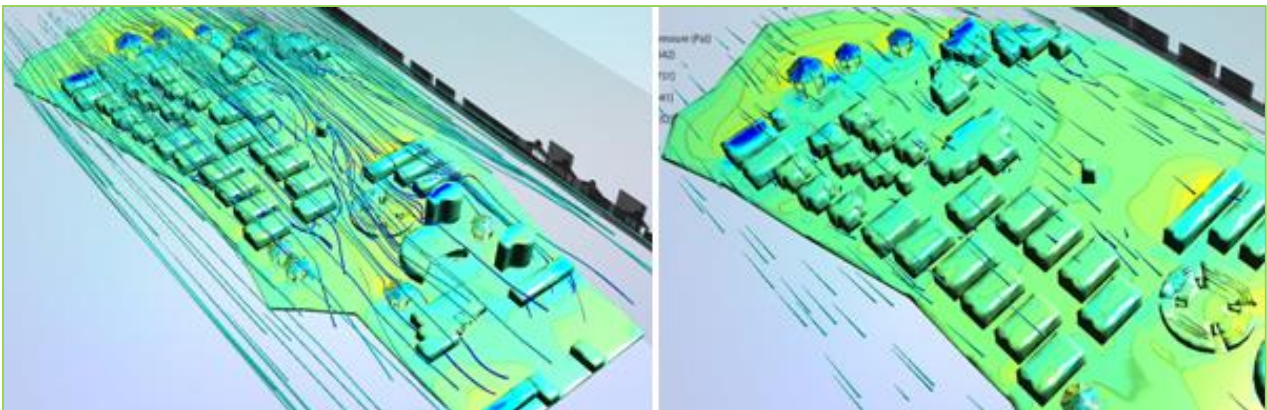


Fig 7.9 Orientation at 30° with respect to wind direction

7.2.5 ORIENTING BUILT FORM AT 15° TOWARDS WIND DIRECTION

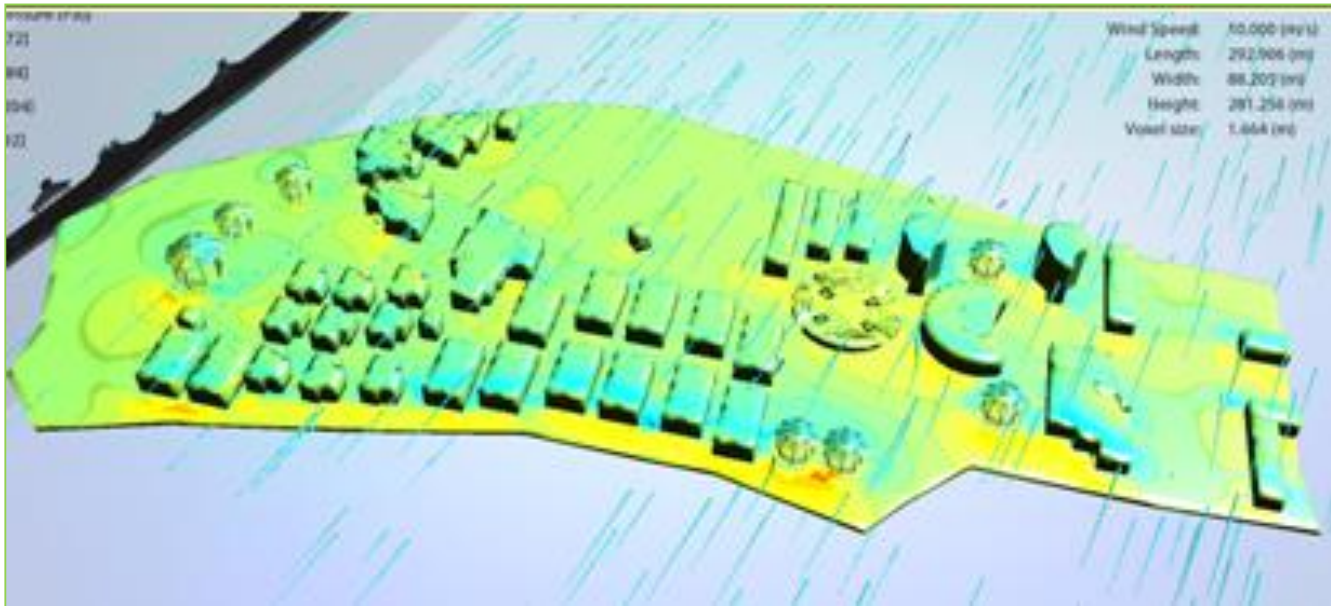
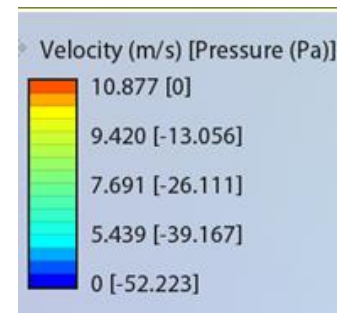


Fig 7.10 Orientation at 15°

Orientation angle towards prevailing wind direction	Air velocity on windward side	Air velocity on leeward side	Inference
15°	10.42	5.12	For orientation angle 90°, the entire site is getting almost similar wind speed i.e. 10 to 11 m/s.
30°	10.20	7.38	
45°	10.32	6.59	
60°	9.36	5.49	
90°	10.26	10.53	

TABLE 7.2 CUMULATIVE WIND SPEED CALCULATIONS

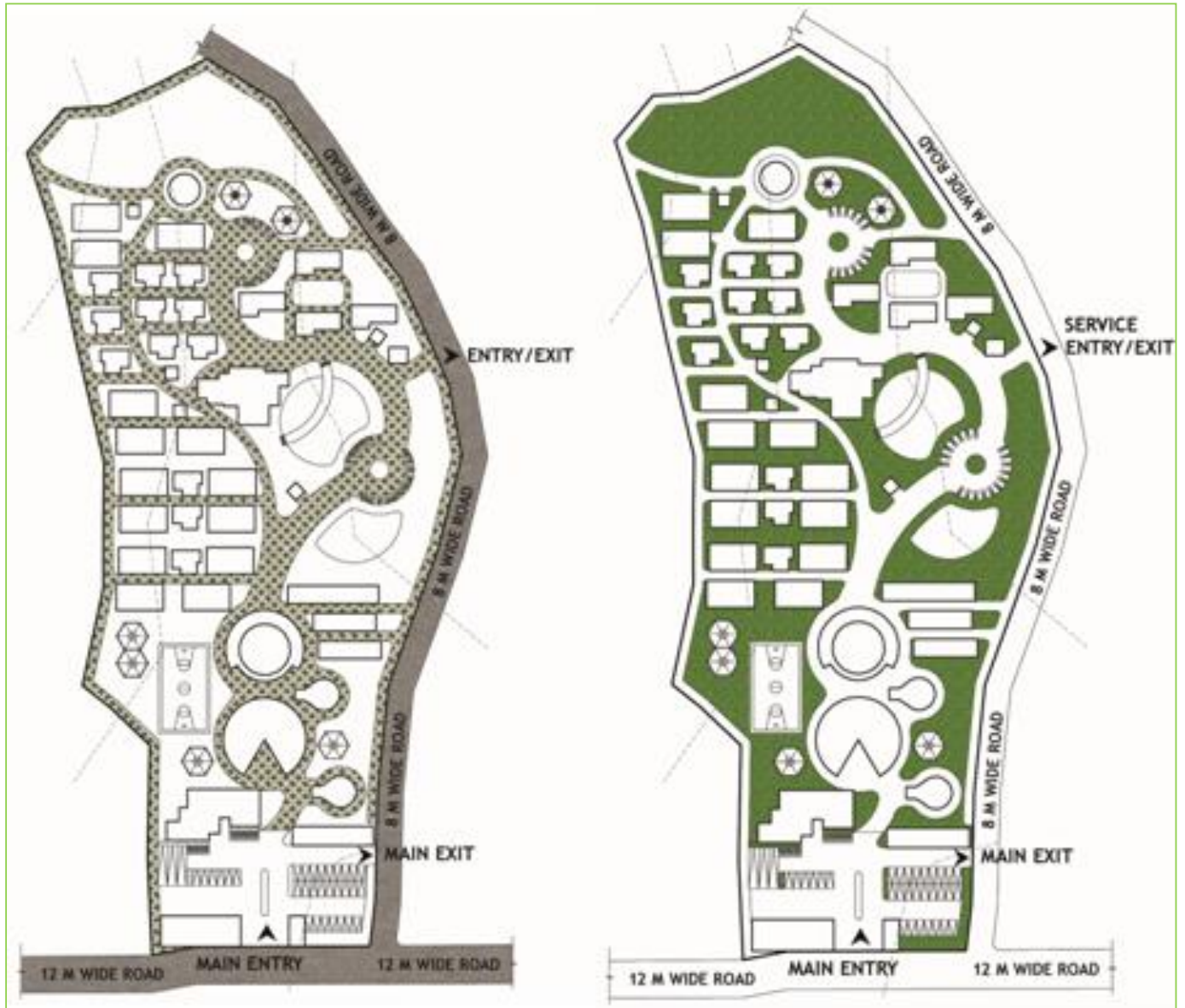


7.3 DETAIL SITE PLANNING



Fig 7.11 Detail Site layout

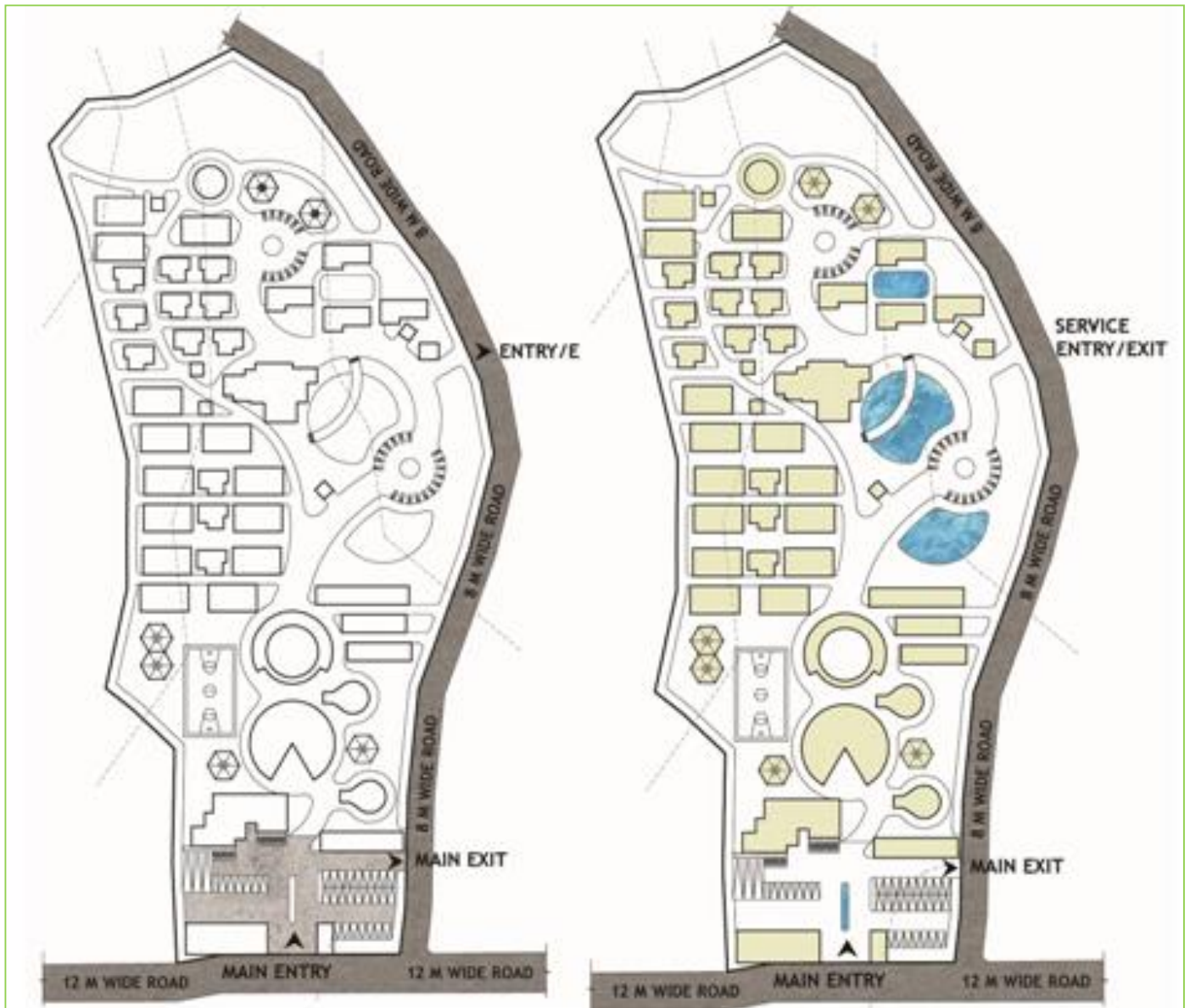
7.4 SITE AREA MAPPING



GREEN PAVERS – 19.42%

GREEN SPACE – 66.62%

Fig 7.12 Site area mapping



CONCRETE –2.1%

BUILT UP AREA – 17.9%

Fig 7.13 Site area mapping

7.5 VARIOUS BUILDING BLOCKS AND THEIR DETAIL PLANS

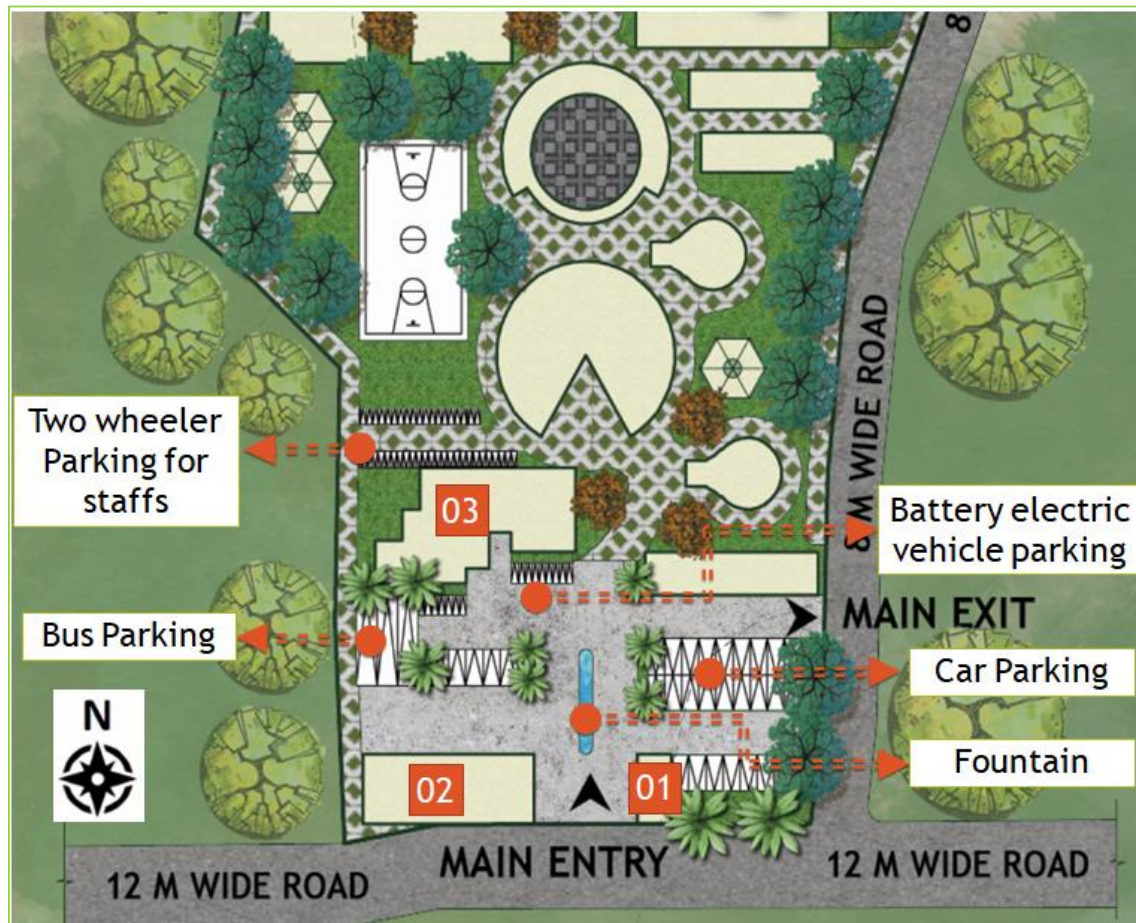


Fig 7.14 Blocks demarcation in site planning

Serial No.	Name of building	Types of spaces provided
01	DRIVERS' WAITING HALL	Waiting lounge for drivers, Toilets
02	SHOPPING ARCADE	Shops, Security space, ATM, Toilets
03	ADMINISTRATION BLOCK	Reception cum waiting lounge, Guests Toilet, Conference, office, Pantry, Changing room, Staff toilet, Server room, Store Room

TABLE 7.3 FUNCTIONAL SPACES PROVIDED IN DIFFERENT BLOCKS



Fig 7.15 Detailed plan of shopping arcade, administration block



Fig 7.16 Blocks demarcation in site planning

Serial No.	Name of building	Types of spaces provided
04	SERVICE BLOCK	Laundry, First Aid clinic, Pharmacy, ATM, security space
05	BIRD WATCHING TOWER	Tower leads to a height of 15 M
06	CLUB HOUSE	SPA, Indoor games, Gymnasium
07	OPEN AIR THEATRE	This space will host local dance performances and other talents as well
08	GAZEBO	This space will provide outdoor seating facilities.

TABLE 7.4 FUNCTIONAL SPACES PROVIDED IN DIFFERENT BLOCKS

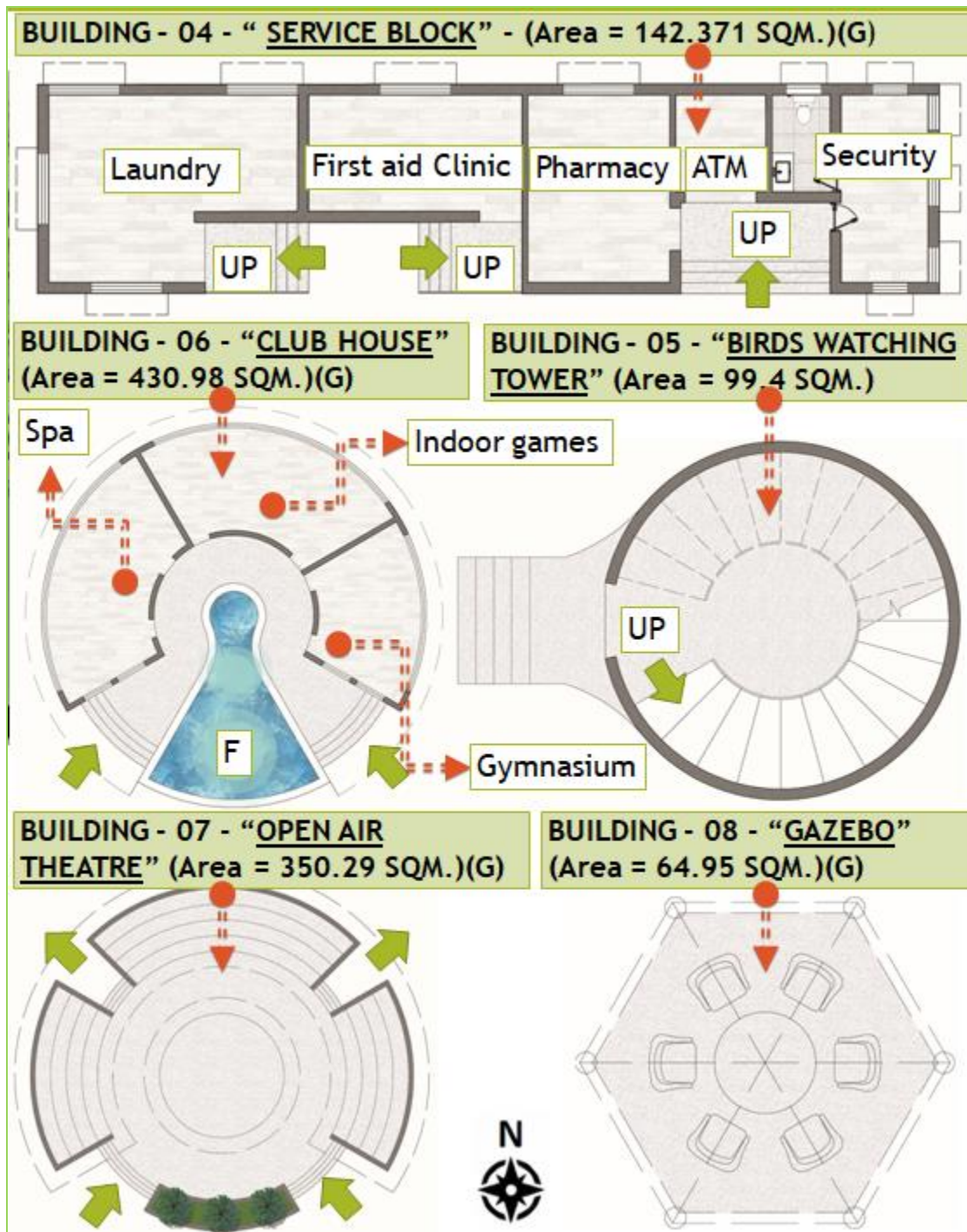


Fig 7.17 Detailed plan of service block, club house, birds watching tower, open air theatre and gazebo

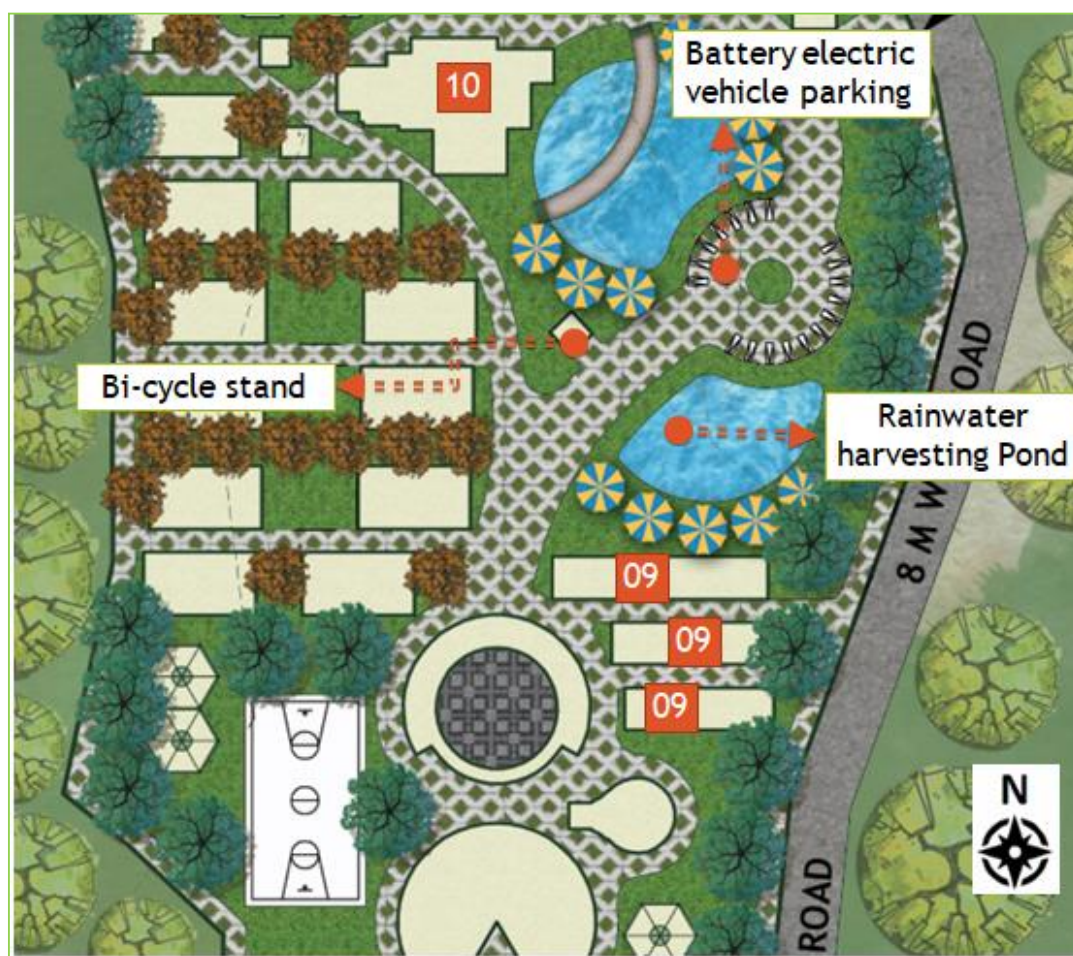


Fig 7.18 Blocks demarcation in site planning

Serial No.	Name of building	Types of spaces provided
09	CARE TAKER ACCOMODATION BLOCK	Provision of bedrooms as well as attached toilets
10	RESTAURANT CUM SNACKS BAR	Indoor dinning, Outdoor snacks bar cum cafeteria, drinking water space, hand wash space, kitchen, changing room, store toilet for staffs

TABLE 7.5 FUNCTIONAL SPACES PROVIDED IN DIFFERENT BLOCKS

BUILDING - 09 - “CARE TAKER ACCOMODATION BLOCK” - (Area = 109.93 SQM.)(G)



BUILDING - 10 - “RESTAURANT CUM SNACKS BAR” - (Area = 328.74 SQM.)(G)

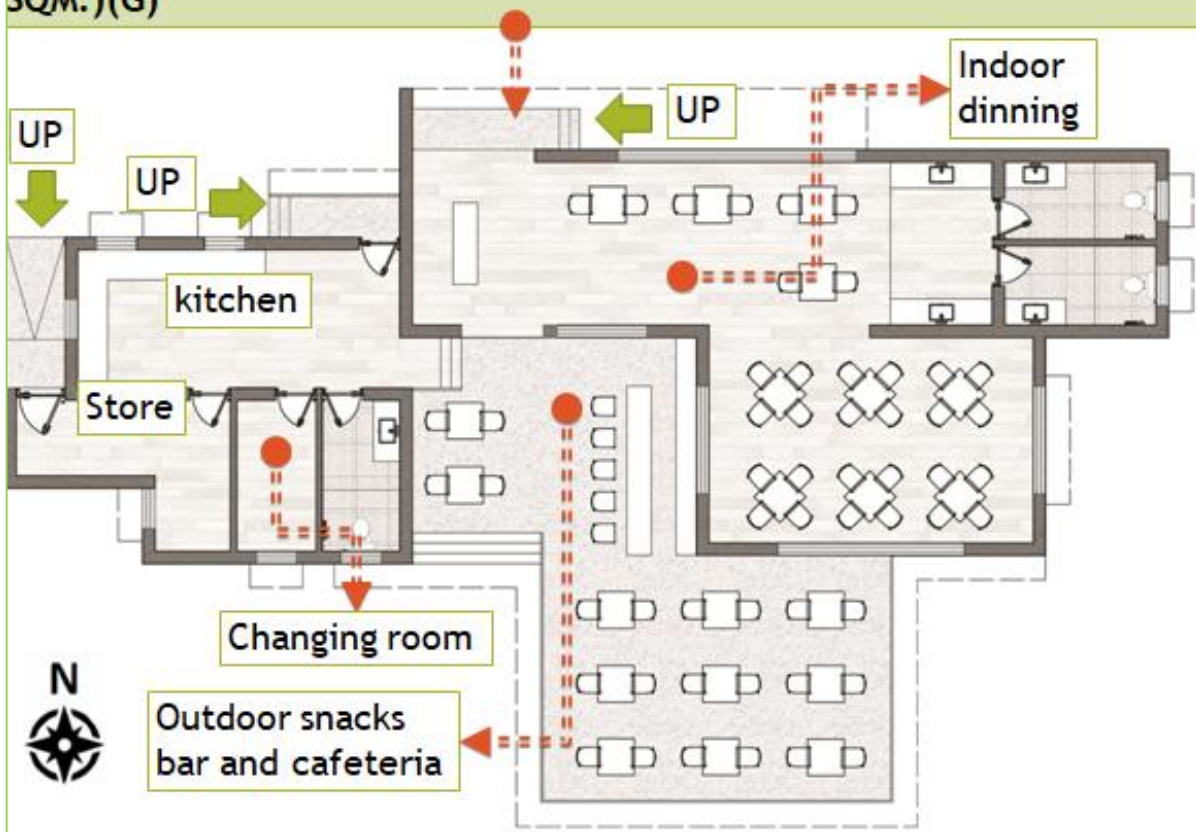


Fig 7.19 Detailed plans of care taker accommodation and restaurant cum snacks bar



Fig 7.20 Blocks demarcation in site planning

7.6 DETAILED AREA STATEMENT

DETAILED AREA STATEMENT			
01	Car Parking	35	437.5
02	Two wheeler Parking	35	87.5
03	Battery electric vehicle parking	30	84
04	Bus Parking	3	112.5
05	Bi cycle stand	5	80
06	ATM	2	12
07	Security	3	21
08	Administration	1	352.25
09	First aid clinic and Pharmacy	1	132
10	Shops	4	225.98
11	Club House (Spa, Gymnasium, Indoor games)	1	430.98
12	Open air theatre	1	350.29
13	Birds view tower	2	200
14	Gazebo	5	324.75
15	Badminton Court	1	450
16	Meditation pavilion	1	150
17	Restaurant cum snacks bar	1	328.74
18	Care taker Accommodation	7	390.6
19	Guest Accommodation (Deluxe cottage)	9	515
20	Guest Accommodation (Presidential cottage)	16	1965
21	Guest Accommodation (Family suite)	3	510
Total built up area			4468.16
Proposed site area = 24823.12 <u>Sqm.</u>			
Permissible FAR (Floor area ratio) = 2.00			
Maximum permissible ground coverage allowed = 20% = 4,964.624 <u>Sqm.</u>			
Maximum height allowed = 7m, Proposed FAR = 4468/24823.12 = 0.179			
(Open space - 82 %, Built up space - 17.9 %)			

TABLE 7.6 DETAIL AREA STATEMENTS

7.7 DETAIL PLAN – “PRESIDENTIAL COTTAGE

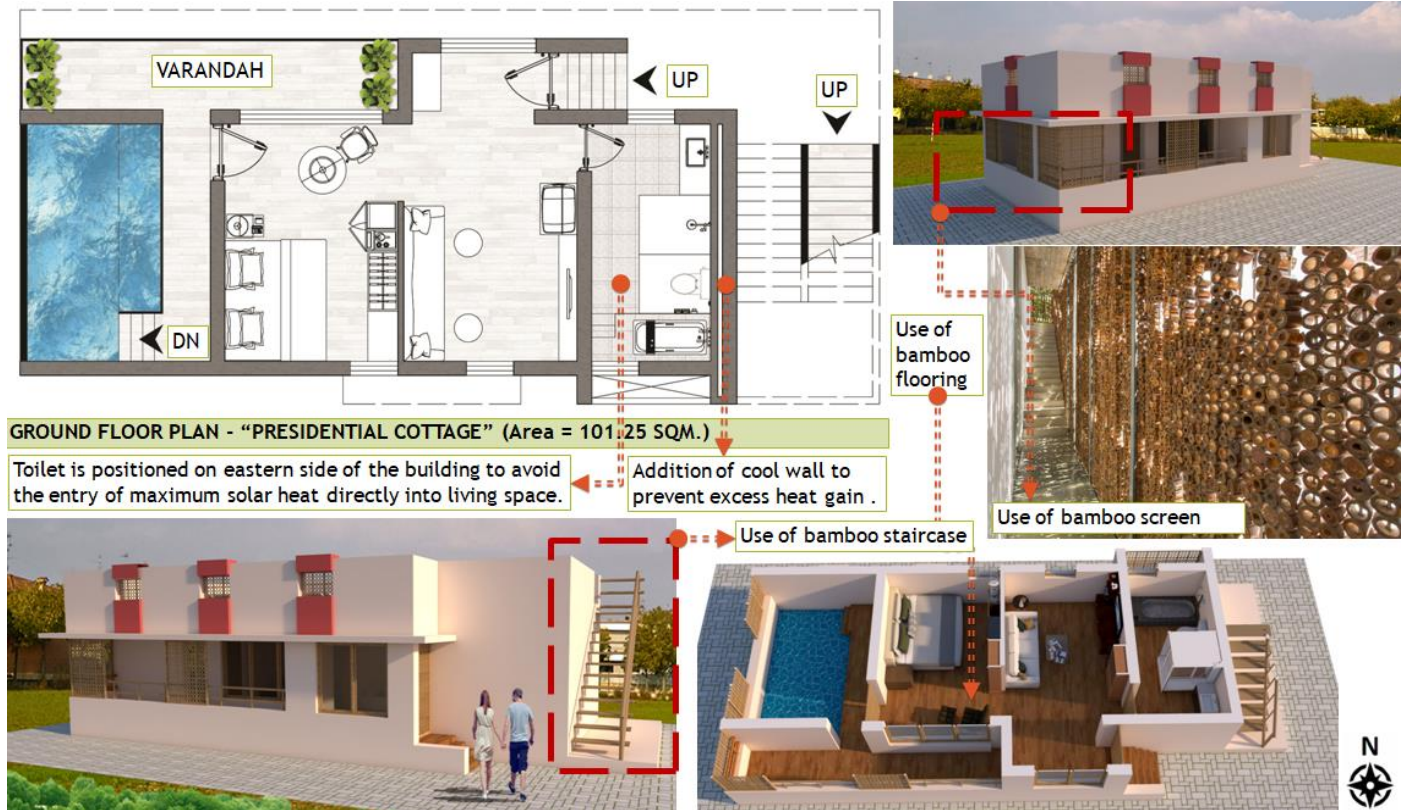


Fig 7.21 Detail plan – Presidential cottage

7.7.1 SOLAR RADIATION ANALYSIS – “PRESIDENTIAL COTTAGE”

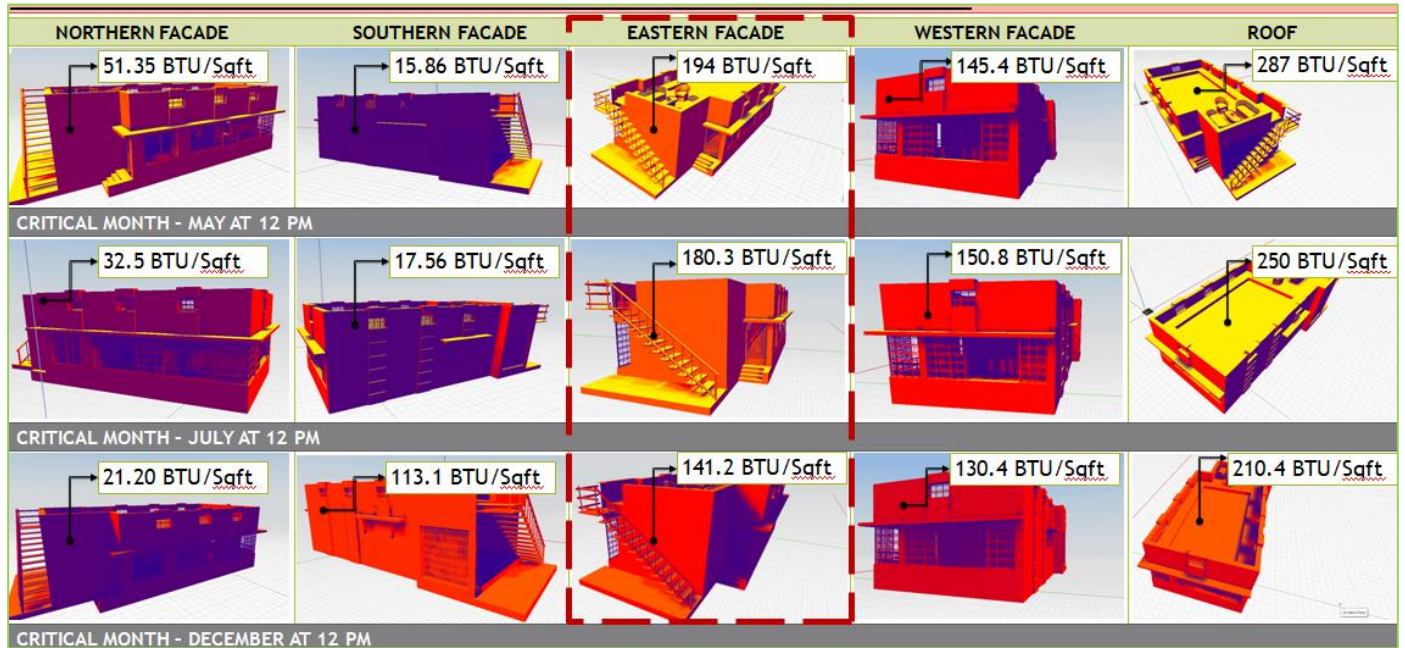
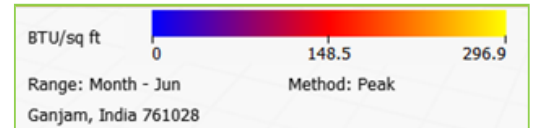


Fig 7.22 Solar radiation analysis - Presidential cottage



MONTH	NORTH	SOUTH	EAST	WEST	ROOF	CUMULATIVE RADIATION
MAY	51.35	15.86	194	145.4	287	693.61
JULY	32.5	17.56	180.3	150.8	250	631.16
DEC	21.20	113.1	141.2	130.4	210.4	616.3

TABLE 7.7 CUMULATIVE RADIATION CALCULATIONS - Presidential cottage

INFERENCE –

From the above simulation result we can see, maximum solar radiation is seen on EASTERN facade. Maximum radiation is visible during the month of JUNE which is around 693.61 BTU per sqft. Strategies must be adopted to cut down the excess heat on EASTERN facade of the building.

7.7.2 DAYLIGHTING ANALYSIS – “PRESIDENTIAL COTTAGE”

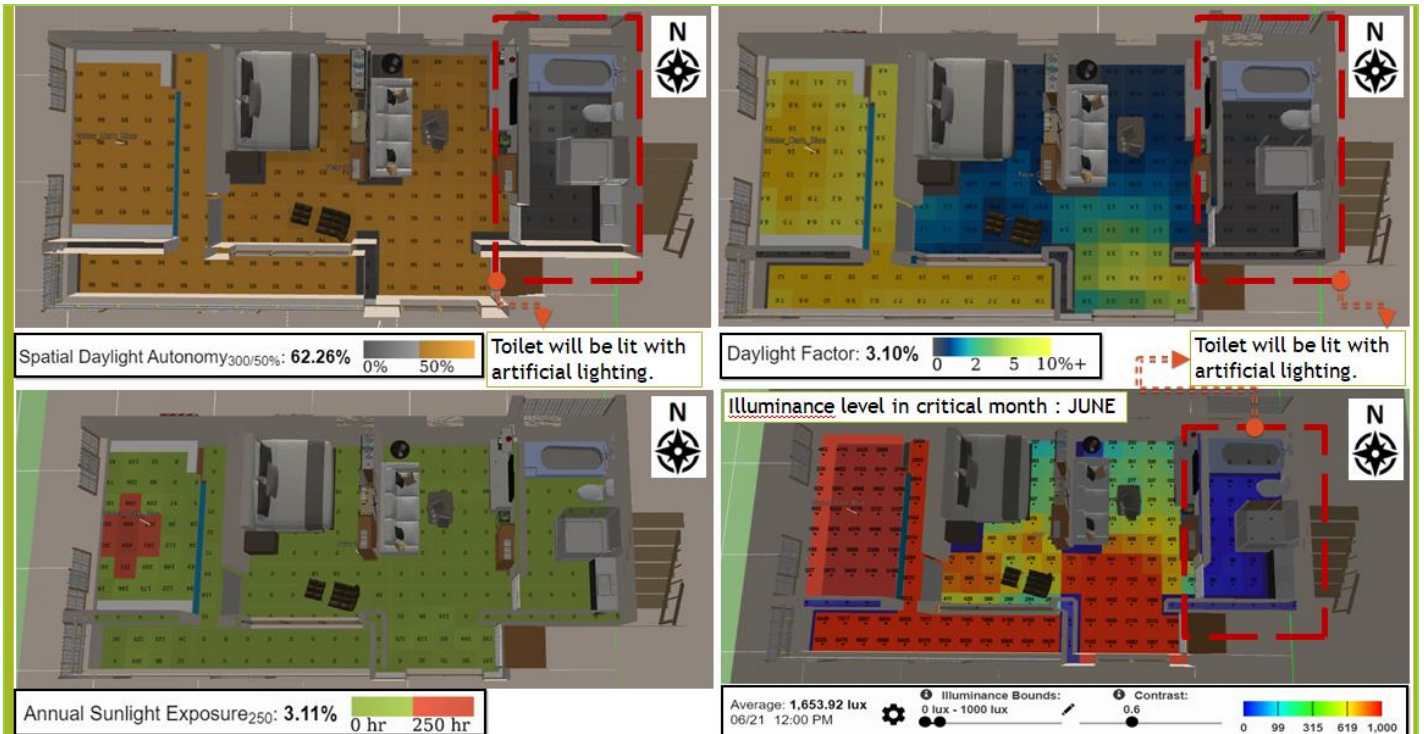


Fig 7.23 Day lighting analysis - Presidential cottage

INFERENCE – From the above simulation result it is seen that, SDA = 62.26% which satisfies required criteria. (REQUIRED CRITERIA - Minimum 55% of regularly occupied floor area must meet SDA 300+ lux for 2 CREDITS of LEED VERSION 4.0) and ASE = 3.11% (REQUIRED CRITERIA – ASE percentage value must not exceed 10%). This building is maintaining the minimum required values with respect to natural day lighting aspect.

7.7.3 WIND FLOW ANALYSIS – “PRESIDENTIAL COTTAGE”

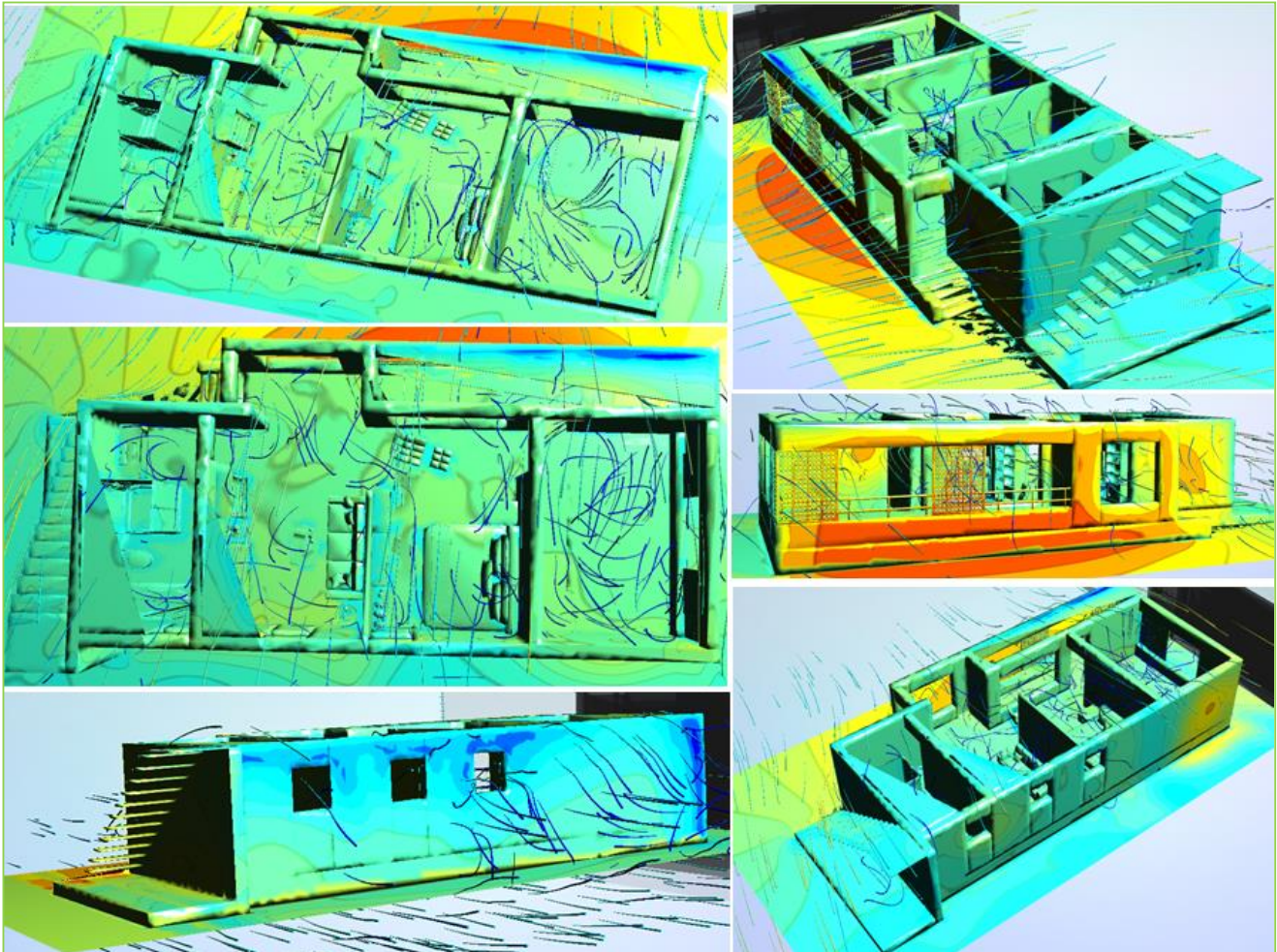


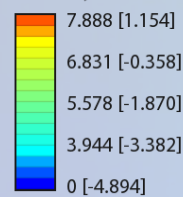
Fig 7.24 Wind flow analysis - Presidential cottage

VENTILATION CALCULATION – SP41

5.3.6 For a total area of openings (inlet and outlet) of 20 to 30 percent of floor area, the average indoor wind velocity is around 30 percent of outdoor velocity. Further increase in window size increases the available velocity but not in the same proportion. In fact, even under most favourable conditions, the maximum average indoor wind speed does not exceed 40 percent of outdoor velocity.

Source :SP41 (5.3.6)

✦ Velocity (m/s) [Pressure (Pa)]



INFERENCE – From the above simulation result, it is visible that entire building is well ventilated and there is no obstruction in wind flow inside. The outdoor wind velocity is 3 to 5 m/s. As per SP41, average indoor wind velocity is around 30% of outdoor velocity. The Indoor wind velocity is 0.9 to 1.5 m/s.

7.8 DETAIL PLAN – “DELUXE COTTAGE”

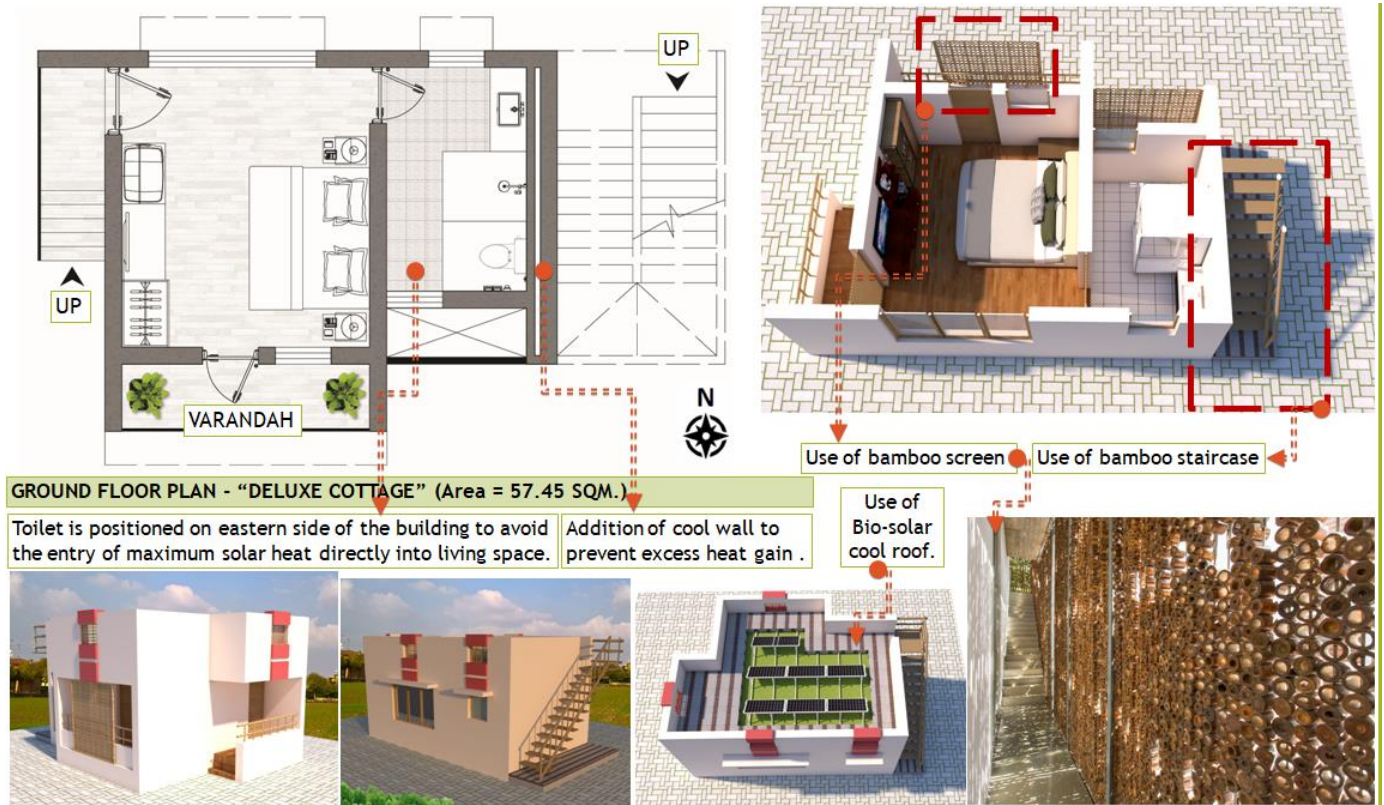


Fig 7.25 Detail plan – Deluxe cottage

7.8.1 SOLAR RADIATION ANALYSIS – “DELUXE COTTAGE”

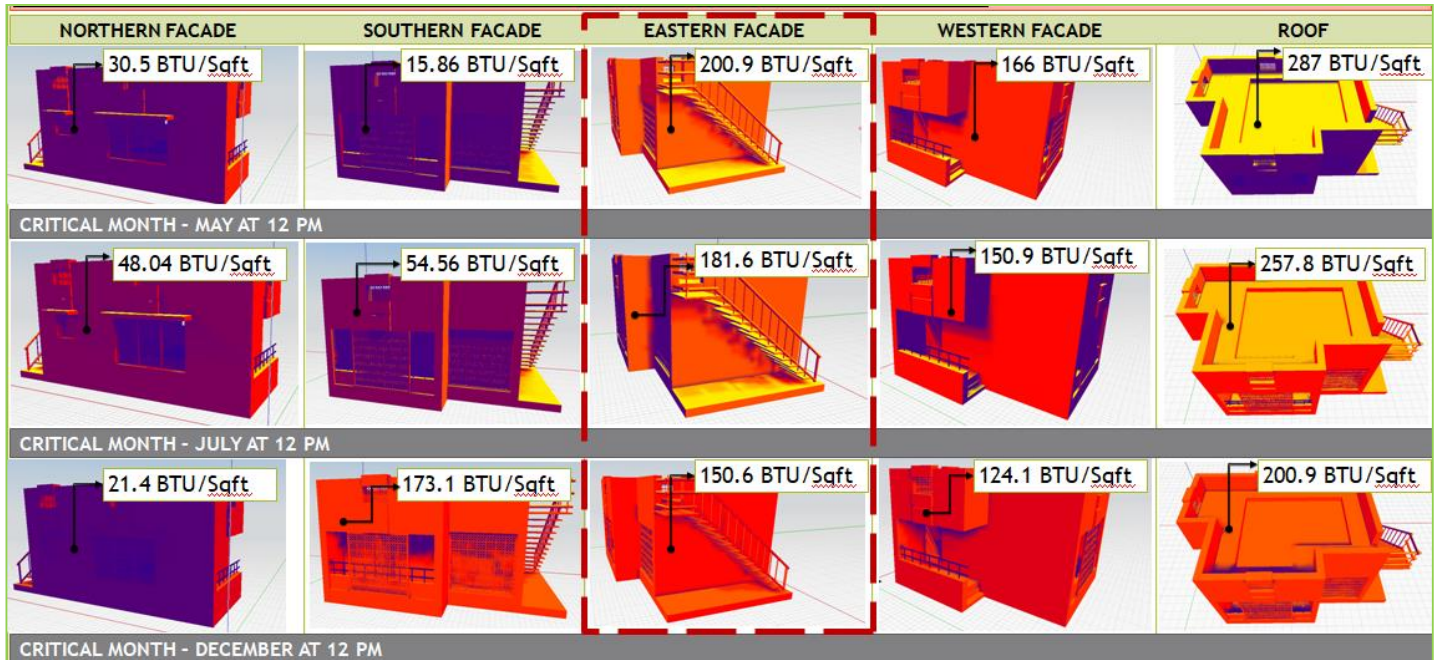
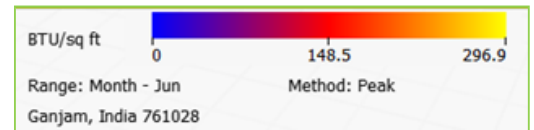


Fig 7.26 Solar radiation analysis – Deluxe cottage



MONTH	NORTH	SOUTH	EAST	WEST	ROOF	CUMULATIVE RADIATION
MAY	30.5	15.86	200.9	166	287	700.26
JULY	48.04	54.56	181.6	150.9	257	692.1
DEC	21.4	173.1	150.6	124.1	200.9	670.1

TABLE 7.8 CUMULATIVE RADIATION CALCULATIONS – DELUXE COTTAGE

INFERENCE – From the above simulation result we can see, maximum solar radiation is seen on EASTERN facade. Maximum radiation is visible during the month of JUNE which is around 693.61 BTU per sqft. Strategies must be adopted to cut down the excess heat on EASTERN facade of the building.

7.8.2 DAYLIGHTING ANALYSIS – “DELUXE COTTAGE”

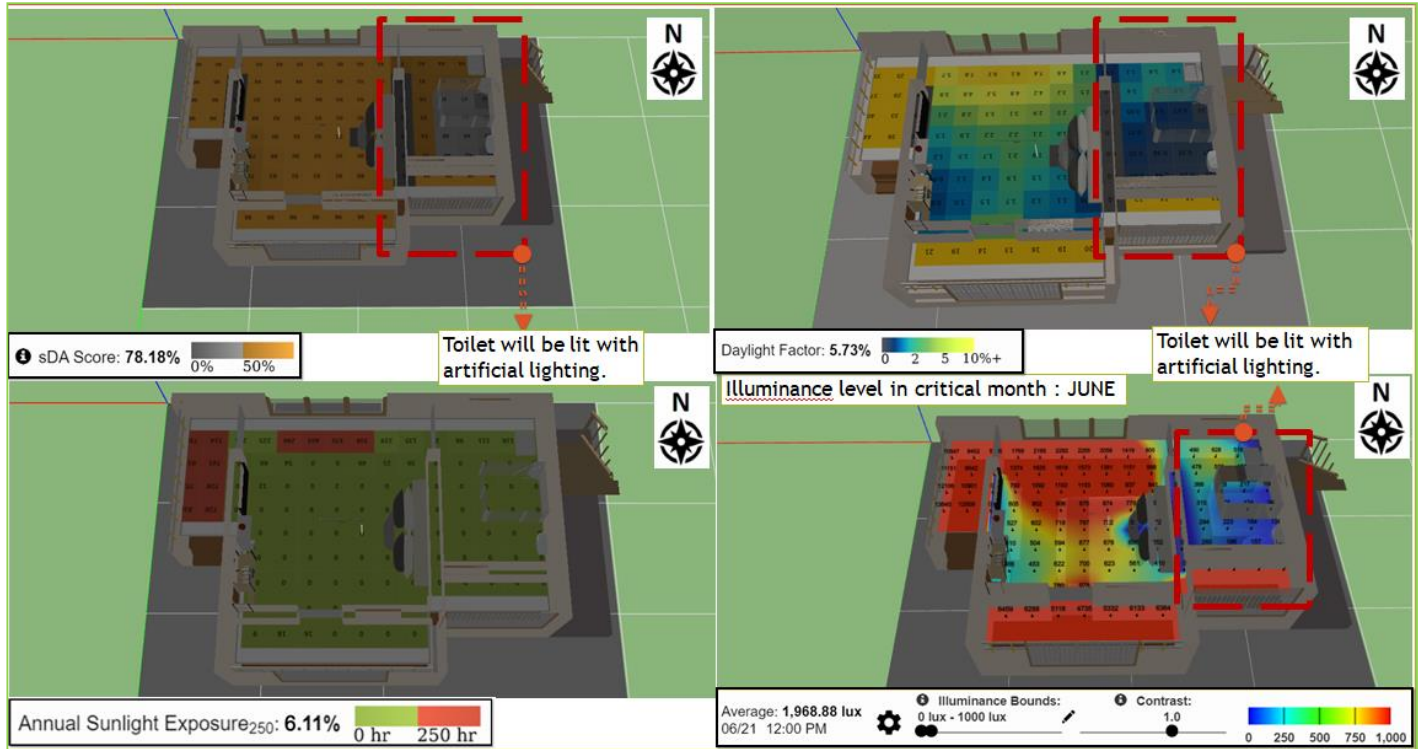


Fig 7.27 Day lighting analysis – Deluxe cottage

INFERENCE – From the above simulation result it is seen that, SDA = 78.18% which satisfies required criteria. (REQUIRED CRITERIA - Minimum 55% of regularly occupied floor area must meet SDA 300+ lux for 2 CREDITS of LEED VERSION 4.0) and ASE = 6.11% (REQUIRED CRITERIA – ASE percentage value must not exceed 10%). This building is maintaining the minimum required values with respect to natural day lighting aspect.

7.8.3 WIND FLOW ANALYSIS – “DELUXE COTTAGE”

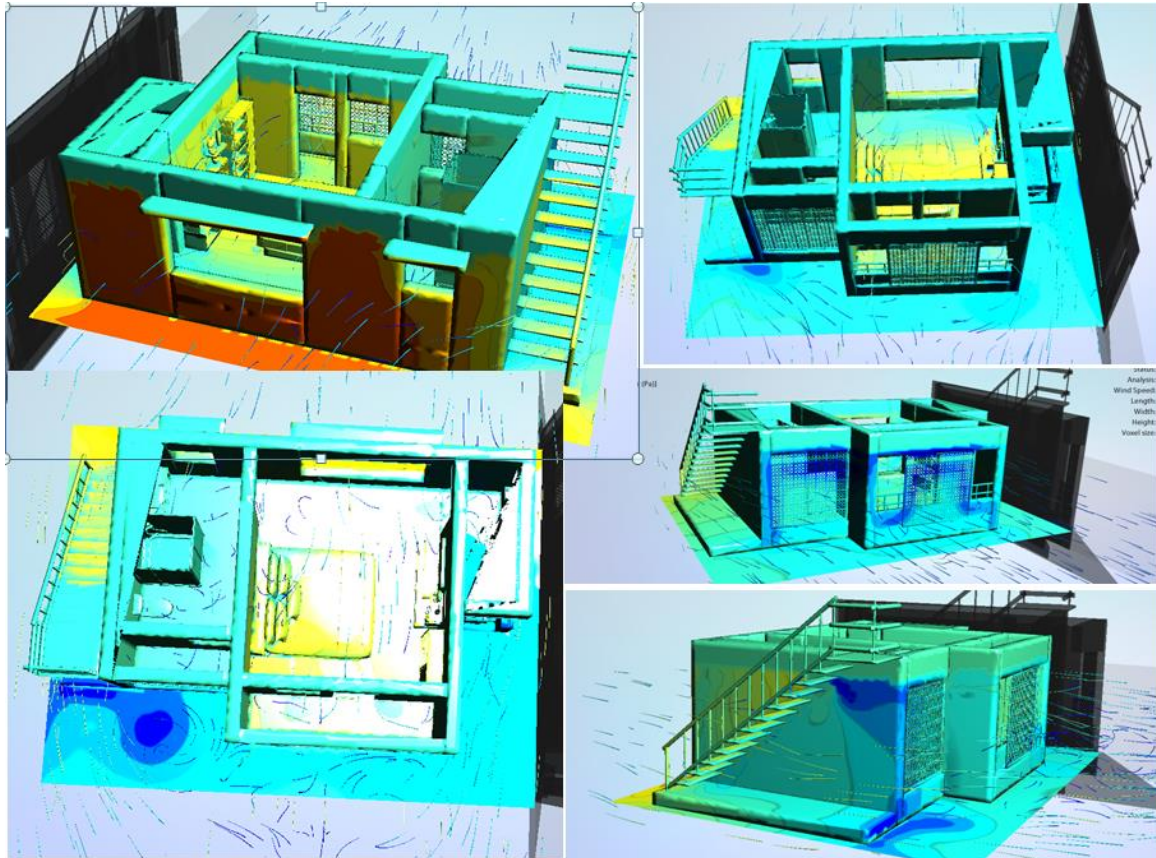


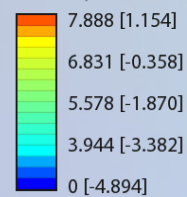
Fig 7.28 Wind flow analysis – Deluxe cottage

VENTILATION CALCULATION – SP41

5.3.6 For a total area of openings (inlet and outlet) of 20 to 30 percent of floor area, the average indoor wind velocity is around 30 percent of outdoor velocity. Further increase in window size increases the available velocity but not in the same proportion. In fact, even under most favourable conditions, the maximum average indoor wind speed does not exceed 40 percent of outdoor velocity.

Source :SP41 (5.3.6)

✦ Velocity (m/s) [Pressure (Pa)]



INFERENCE – From the above simulation result, it is visible that entire building is well ventilated and there is no obstruction in wind flow inside. The outdoor wind velocity is 3 to 5 m/s. As per SP41, average indoor wind velocity is around 30% of outdoor velocity. The Indoor wind velocity is 0.9 to 1.5 m/s.

7.9 DETAIL PLAN – “FAMILY COTTAGE”

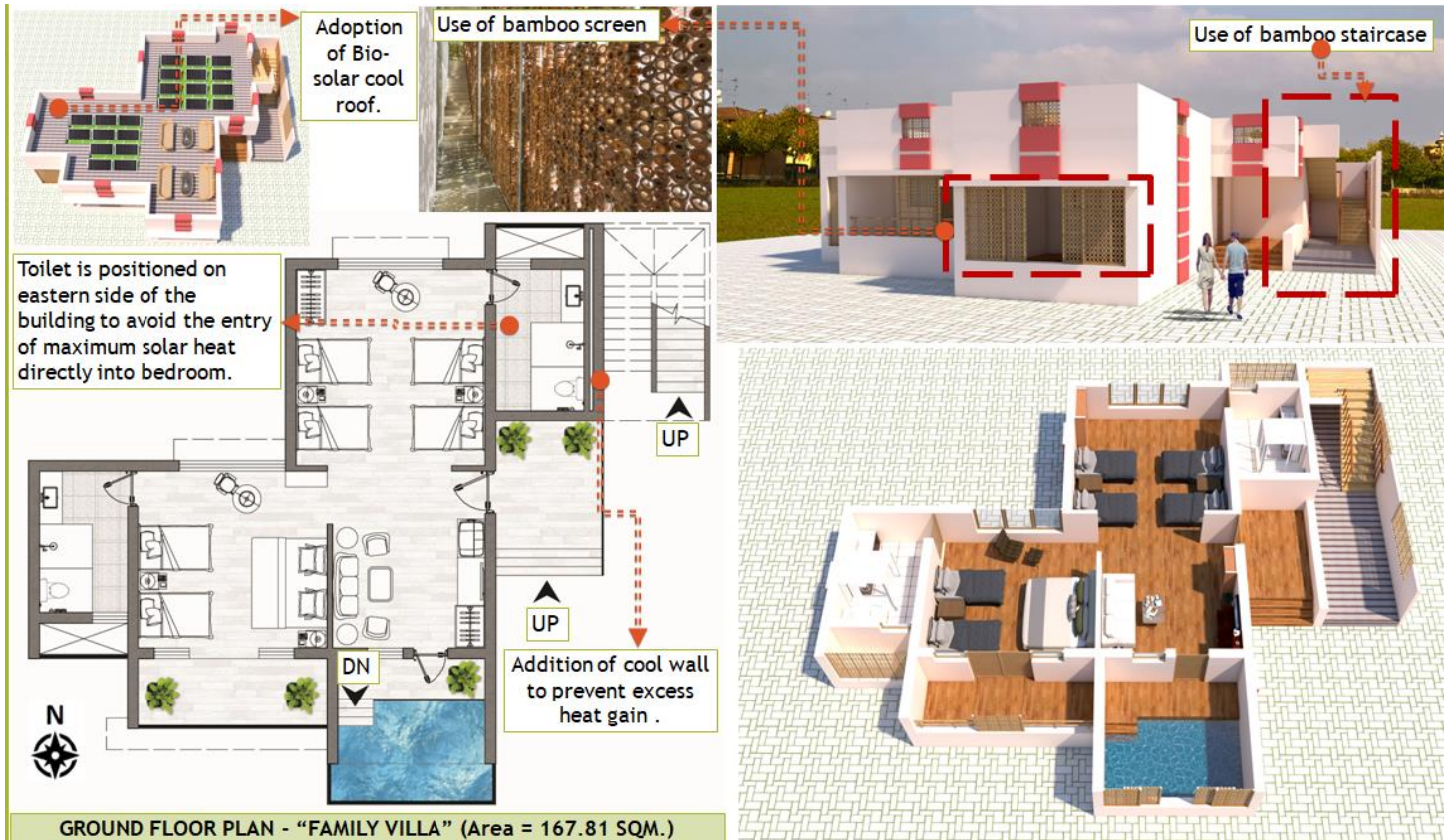


Fig 7.29 Detail plan – Family cottage

7.9.1 SOLAR RADIATION ANALYSIS – “FAMILY COTTAGE”

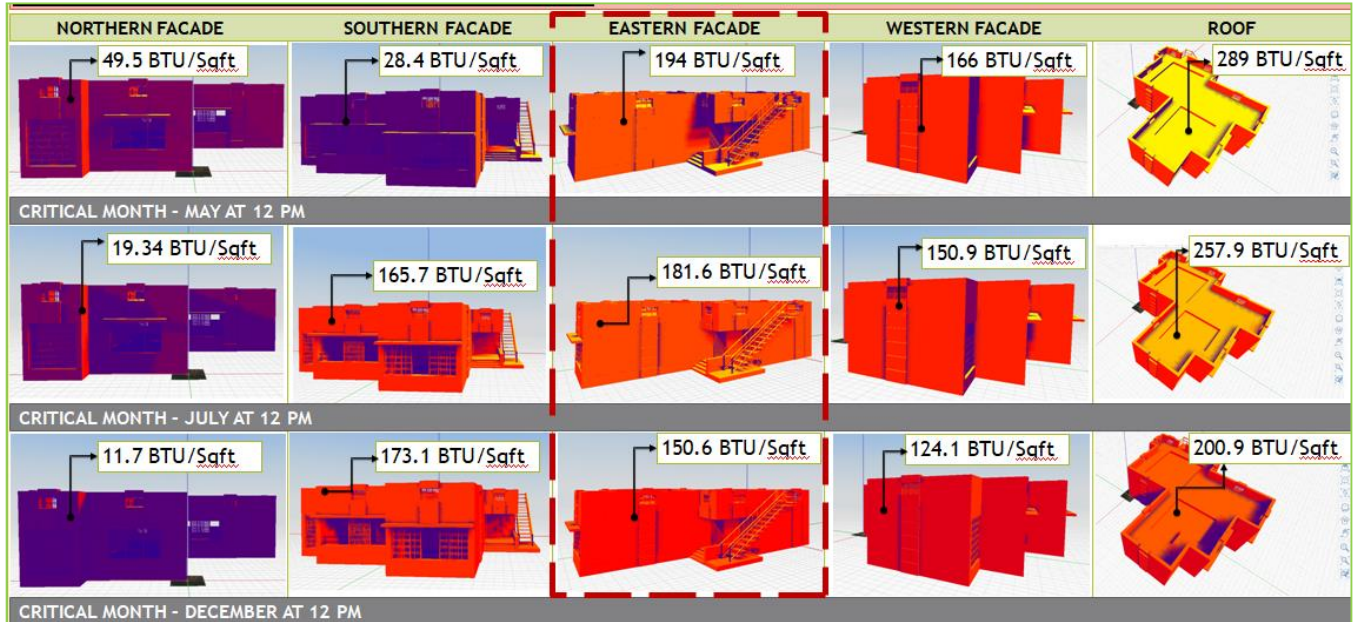
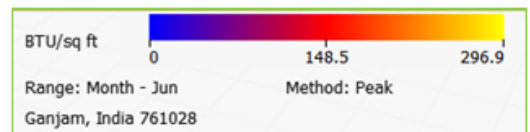


Fig 7.30 Solar radiation analysis – Family cottage



MONTH	NORTH	SOUTH	EAST	WEST	ROOF	CUMULATIVE RADIATION
MAY	49.5	28.4	194	166	289	726.9
JULY	19.34	165.7	181.6	150.9	257	692.1
DEC	11.7	173.1	150.6	124.1	200.9	660.4

TABLE 7.9 CUMULATIVE RADIATION CALCULATIONS – FAMILY COTTAGE

INFERENCE – From the above simulation result we can see, maximum solar radiation is seen on EASTERN facade. Maximum radiation is visible during the month of JUNE which is around 693.61 BTU per sqft. Strategies must be adopted to cut down the excess heat on EASTERN facade of the building.

7.9.2 DAYLIGHTING ANALYSIS – “FAMILY COTTAGE”

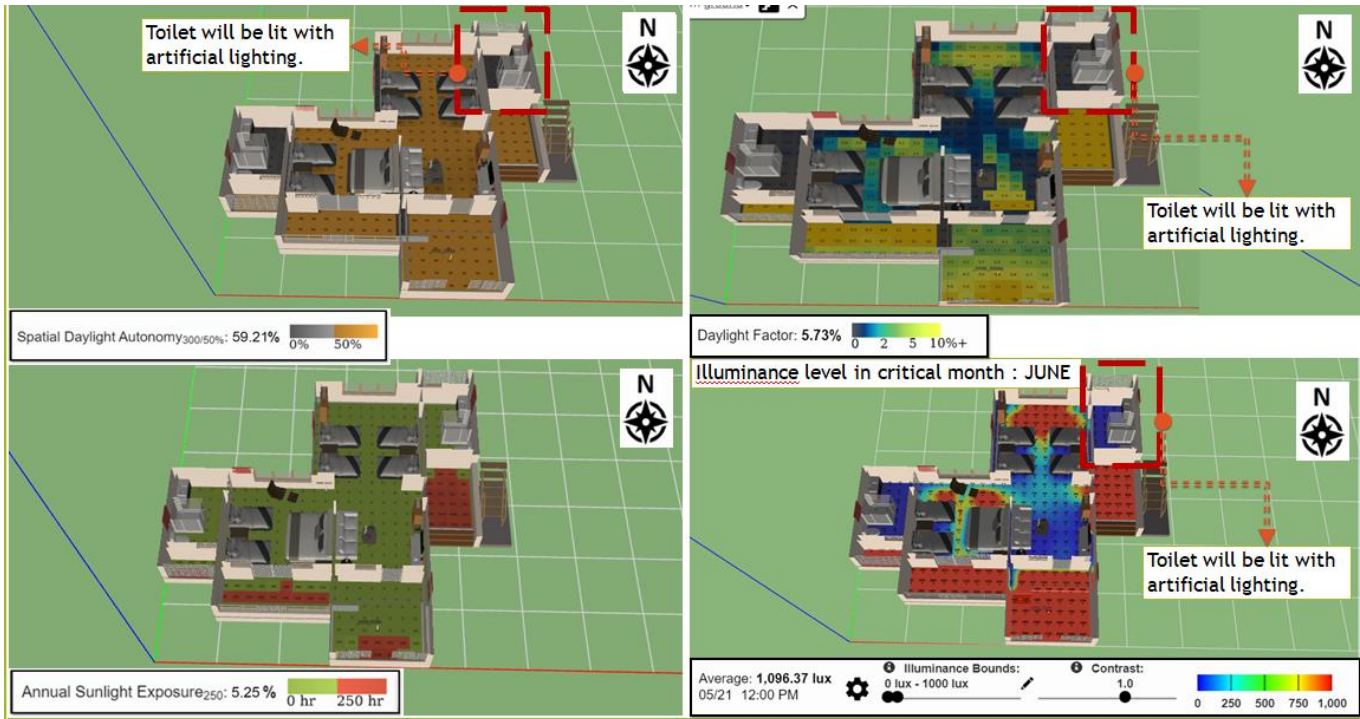


Fig 7.31 Day lighting analysis – Family cottage

INFERENCE – From the above simulation result it is seen that, SDA = 59.21% which satisfies required criteria. (REQUIRED CRITERIA - Minimum 55% of regularly occupied floor area must meet SDA 300+ lux for 2 CREDITS of LEED VERSION 4.0) and ASE = 5.25% (REQUIRED CRITERIA – ASE percentage value must not exceed 10%). This building is maintaining the minimum required values with respect to natural day lighting aspect.

7.9.3 WIND FLOW ANALYSIS – “FAMILY COTTAGE”

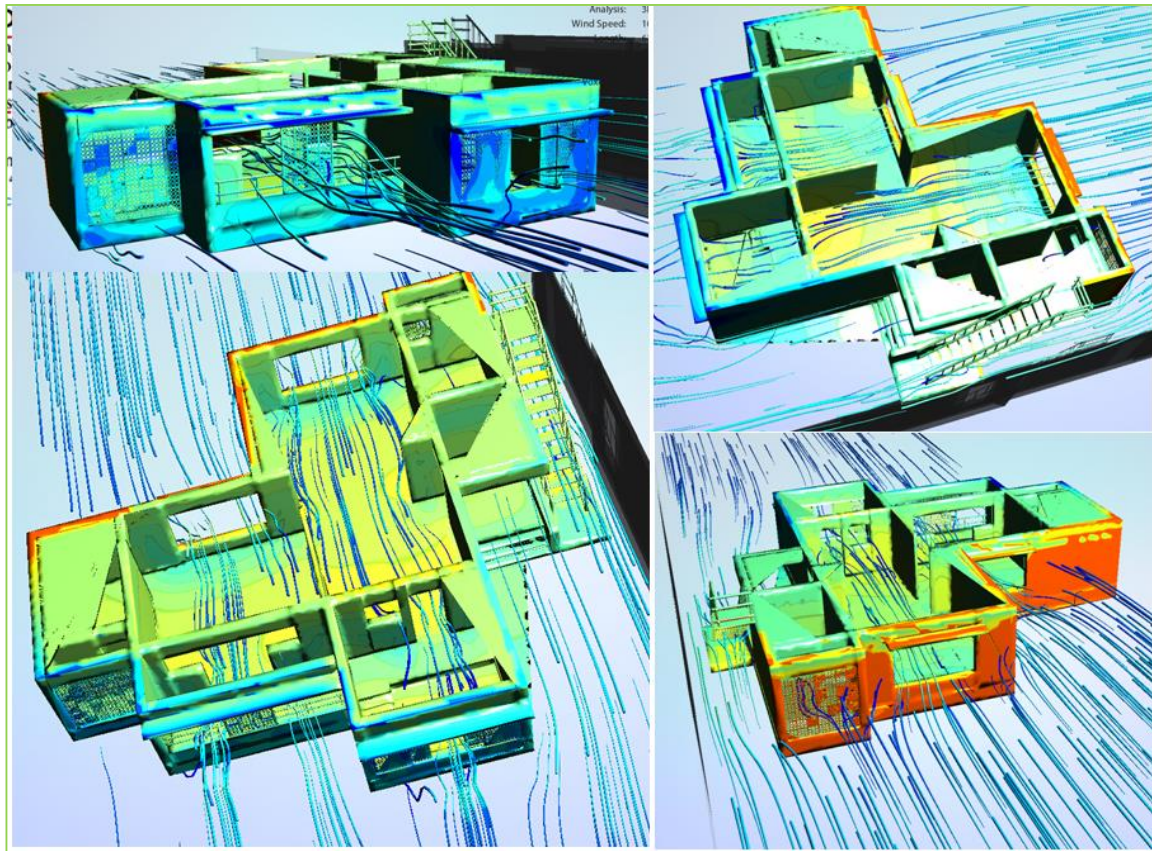


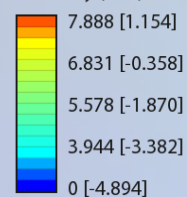
Fig 7.32 Wind flow analysis – Deluxe cottage

VENTILATION CALCULATION – SP41

5.3.6 For a total area of openings (inlet and outlet) of 20 to 30 percent of floor area, the average indoor wind velocity is around 30 percent of outdoor velocity. Further increase in window size increases the available velocity but not in the same proportion. In fact, even under most favourable conditions, the maximum average indoor wind speed does not exceed 40 percent of outdoor velocity.

Source :SP41 (5.3.6)

✦ Velocity (m/s) [Pressure (Pa)]



INFERENCE – From the above simulation result, it is visible that entire building is well ventilated and there is no obstruction in wind flow inside. The outdoor wind velocity is 3 to 5 m/s. As per SP41, average indoor wind velocity is around 30% of outdoor velocity. The Indoor wind velocity is 0.9 to 1.5 m/s.

CHAPTER 08

8.1 RESEARCH PAPER: “SAFE, SIMPLE AND COMFORTABLE HOUSE WITH BAMBOO REINFORCED CONCRETE STRUCTURE” BY NYOMAN SUTARJA

In this research paper, author has conducted analysis of house constructed with bamboo reinforced concrete structure. These houses are resistant to earthquake and wind as well. Following conclusions are made by author as follows:

- (1) compressive strength of concrete, $f_c = 20.75$ MPa and the tensile strength of bamboo, $f_y = 129.17$ Mpa
- (2) The simple house with the bamboo reinforced concrete structure can fulfill the requirement of being safe prevailing in Indonesia.
- (3) It can fulfill the requirement of physical comfort, which includes the temperature, humidity, the wind speed, noise, and illumination.
- (4) Based on the information obtained through the questionnaire, such a house can also make the dweller feel highly safe, comfortable, and satisfied.
- (5) The measured building physical comfort included the temperature, humidity, noise, and the natural illumination. The results of the measurement are presented below.

0.2 Y.S.	Yield strength	Rupture strength	Elongation
(MPa)	(MPa)	(MPa)	(%)
130.67	130.67	180.00	8.865
127.67	127.67	201.00	9.128

Nbr.	Description	Time of measurement			
		06 a.m.	12.00 a.m.	06 p.m.	12.p.m.
1	The temperature within the room (°C)	26	32	31	28
2	Humidity (%)	79	67	77	80
3	Noise (dBA)	41	41.8	44.74	41.47
4	Natural illumination (Lux)	145	255	235	—
5	Speed of wind (m/second)	0.1	0.4	0.25	—

TABLE 8.1 LISTS OF PHYSICAL COMFORT PARAMETERS



Fig 8.1 Construction process of Bamboo reinforcement structure

The tensile strength of the bamboo averaged 129.17 MPa and the rupture strength averaged 191 Mpa. The over strength is 47.86%. The flexibility averages 84 MPa and its elastic modulus is 200.000 MPa.

INFERENCE FROM THE RESEARCH PAPER –

1. The simple house with the bamboo reinforced concrete structure can fulfill the requirement of being safe prevailing in Indonesia.
2. It can fulfill the requirement of physical comfort, which includes the temperature, humidity, the wind speed, noise, and illumination.
3. Based on the information obtained through the questionnaire, such a house can also make the dweller feel highly safe, comfortable, and satisfied.
4. This is suggested that the bamboo reinforced concrete structure should be taken into consideration in case of the simple house construction.

8.2 CURRENT AVAILABILITY OF BAMBOO IN INDIA:

Bamboos are largest members of the grass family represented by 75 genera and 1621 species across the tropics and sub tropics in the Asia, Africa and Pacific. India has 20% of the world's bamboo resources spreading across around 14 million hector of forest land. India has abundant bamboo resources of about 29 genera and 148 species (both wild and cultivated).

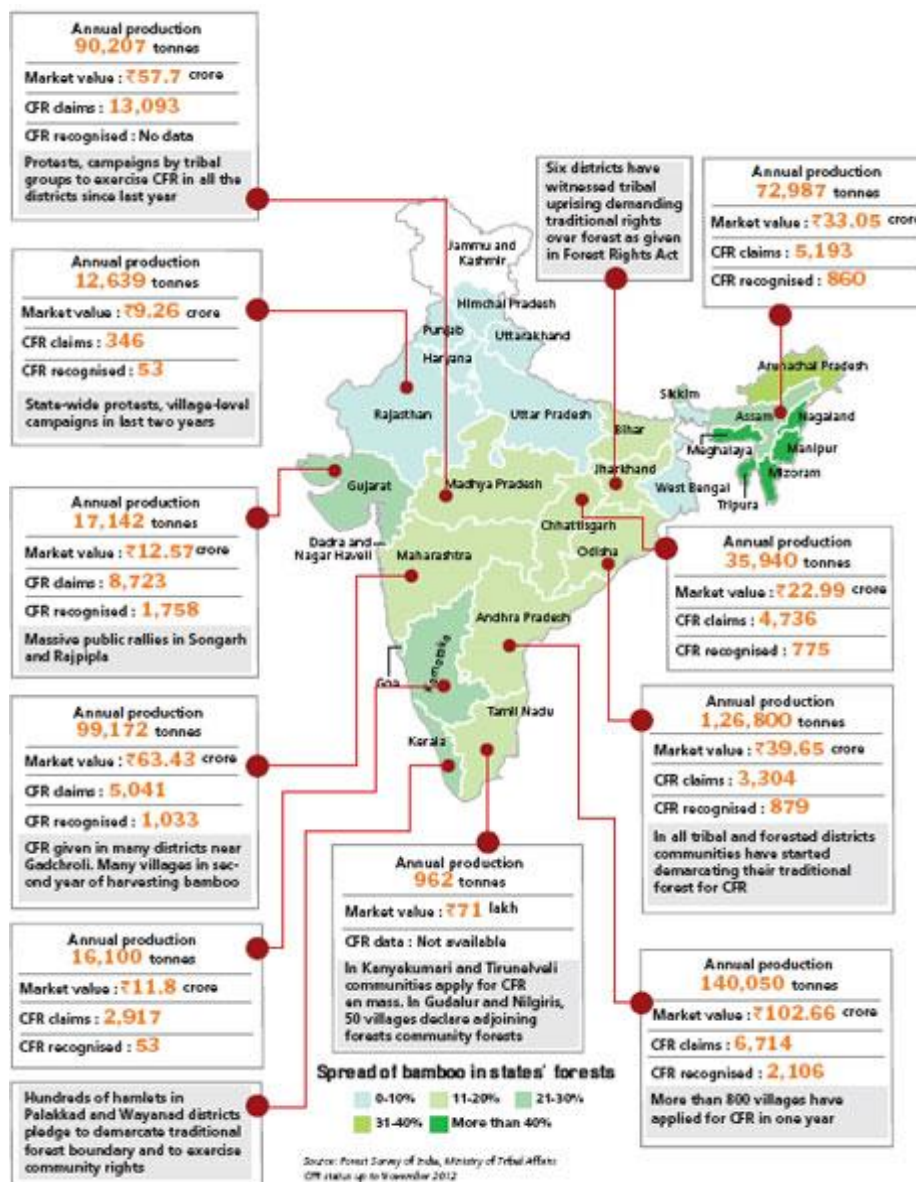


Fig 8.2 Annual Bamboo production in different states of India

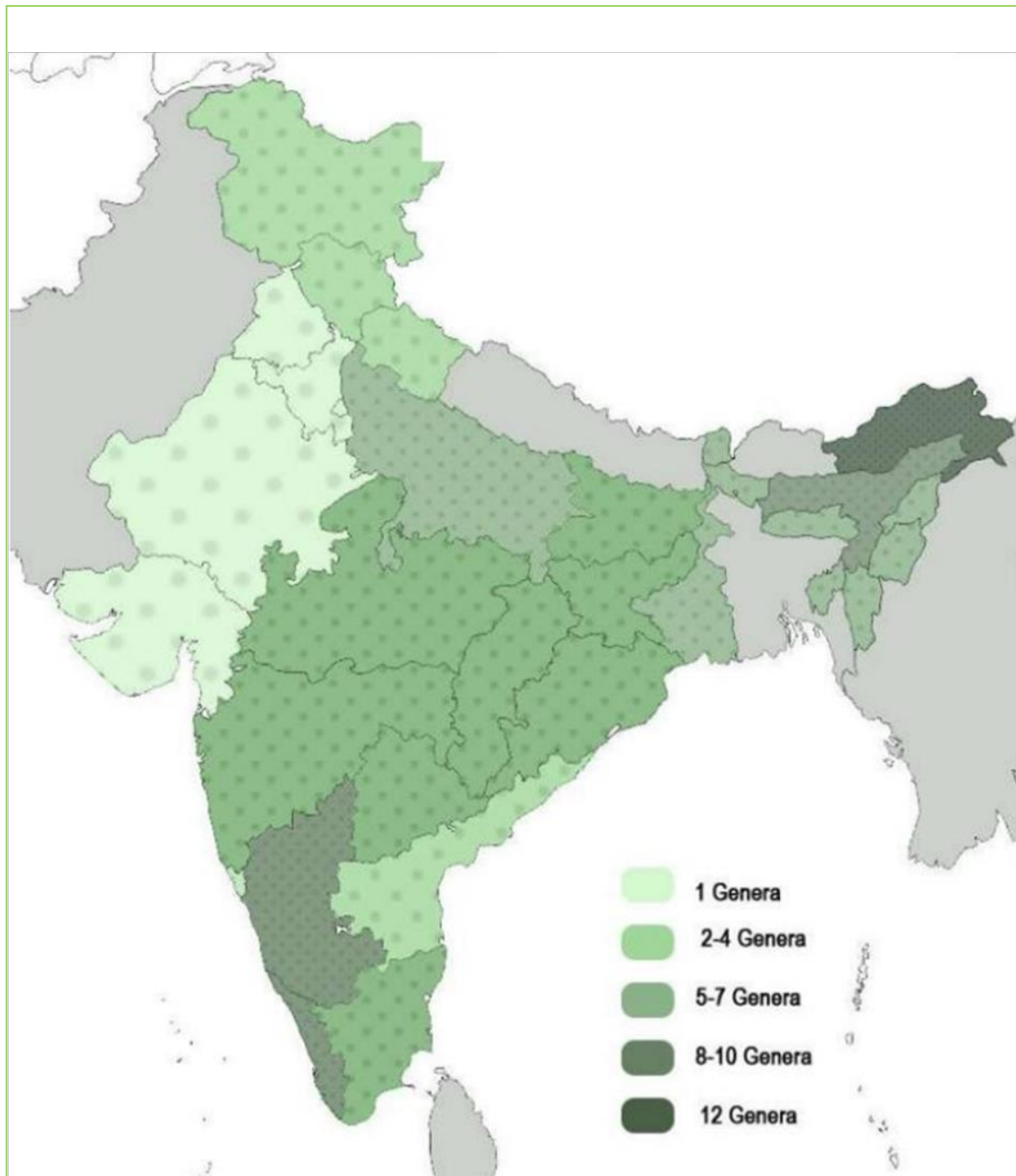


Fig 8.3 Bamboo species production in different states of India

The National Bamboo Mission recognizes 13 commercial bamboo species in India. The multiple uses of bamboo include house construction, bamboo ply, agricultural implements, handicrafts, irrigation, brooms, medicine food, fuel, fodder, paper and pulp and especially bamboo as a perfect substitute for some wood based products.

There are about 1500 documented application of bamboo, which include use as floor boards, bamboo mat corrugated sheets, bamboo mat boards, bamboo ply boards and bamboo particle boards.

S. No	State/ Region	Area %	Growing Stock
1.	North East	28.0	66
2.	Madhya Pradesh	20.3	12
3.	Maharashtra	9.9	5
4.	Orissa	8.7	7
5.	Andhra Pradesh	7.4	2
6.	Karnataka	5.5	3
7.	Others	20.2	5

TABLE 8.2 LISTS OF STATES WITH BAMBOO GROWING STOCK

8.3 CURRENT STATUS OF BAMBOO IN ODISHA:

- Odisha has 9% of the Country's total bamboo forest cover and 7% of total growing stock of Bamboo.
- The bamboo in forest areas of Odisha grows as mixed crop associated with Sal & other species. The mixed bamboo forest area is spread over about 17,795 Sq. Km. and pure bamboo forest (occurring mostly as bamboo brakes) is about 375 Sq.Km.
- There are about 13 species of bamboo available in Odisha of which most commonly found are *Dendrocalamus strictus*.
- (80%), *Bambusa bambos* (10%).
- Cultivated species are *Bambusa vulgaris* & *Bambusa nutans*. *Bambusa tulda*, *Dendrocalamus lorgispathus*, *Schizostachyum pergracile*, *Thyrostachys oliveri* & *Gigantachloa rostrata* are occurring in localized area in different parts of State.

8.3.1 THE BAMBOO SPECIES AVAILABLE IN ODISHA CAN BE BROADLY CLASSIFIED IN TO FOUR DIFFERENT CATEGORIES:

a. Occurring naturally in the forests :

Dendrocalamus strictus (Salia), *Bambusa bambos* (Daba)

b. Cultivated by villagers in their homestead land :

Bamusa vulgaris (Sundarkani), *Bamusa nutans* (Badia)

Year	Yield in lakh \ MT	Royalty received by the State (Rs.in Million)
1980-81	3.48	23.55
1981-82	3.02	26.53
1982-83	2.95	21.59
1983-84	2.63	24.32
1984-85	3.88	30.88
1985-86	2.89	30.90
1986-87	2.15	29.97
1987-88	2.54	30.00
1988-89	2.61	75.93
1989-90	2.39	78.95
1990-91	2.20	74.55
1991-92	2.38	82.56
1992-93	2.45	87.31
1993-94	2.41	101.14
1994-95	2.40	103.50
1995-96	2.18	95.31
1996-97	2.46	90.00
1997-98	2.08	85.00
1998-99	1.20	85.00
1999-2000	1.12	20.00

TABLE 8.3 RECORDED BAMBOO HARVEST IN LAST TWO DECADES

c. Found in small numbers in specific locations either in forests or in village land :

Schizostachyum pergracile (Dangi) *Gigantochloa rostrata* (Pani bans), *Thyrsostachys oliveri* (Nala bans), *B.tulda* (Taleda)

d. Occurring as very few individuals :

Bambusa striata, *Bambusa wamin*, *Dendrocalamus giganteus*, *Thyrsostachys regia*.

8.3.2 THE FOLLOWING ACTIVITIES NEED IMMEDIATE CONSIDERATION FOR IMPROVEMENT OF THE RESOURCE BASE:

- Rehabilitation of degraded bamboo areas.
- Introduction of new bamboo species.
- Study the Culm production in different intensity of felling cycle to prescribe cutting period to meet the requirement of artisans.
- Study the growth and production behavior in different climatic conditions.
- Development of technique for vegetative methods of propagation for mass production of quality planting material.

8.4 WALL MATERIAL ANALYSIS:

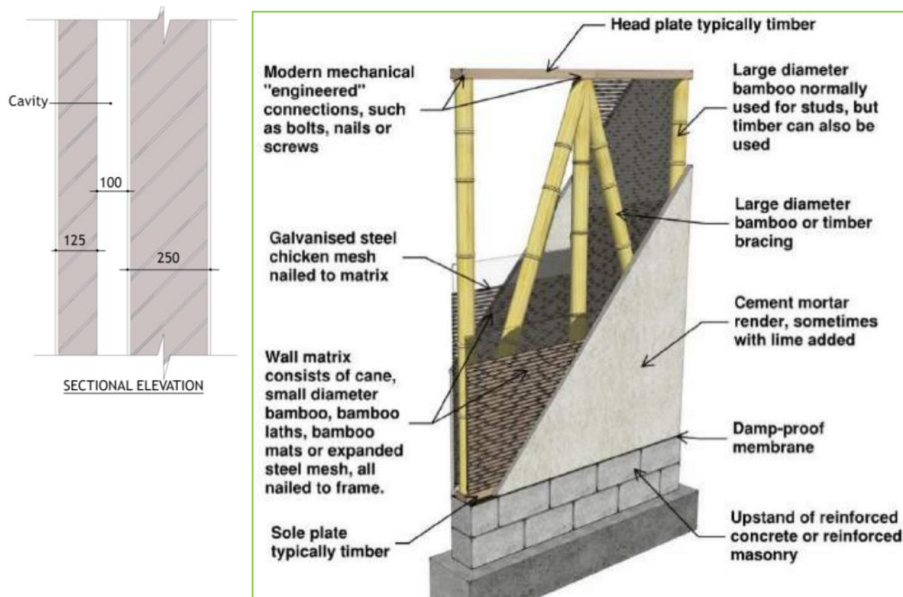


Fig 8.4 Sectional view of bamboo reinforced Concrete

ITERATION 01		
Material layers	Thickness	Time lag (Hours)
Concrete Block	200 mm	5.3 hrs
Air Cavity	25 mm	1 hrs
Polystyrene	10 mm	1.1 hrs
Interior finish	10 mm	0.15 hrs
Time lag		7.55 hrs
Thickness of wall		245 mm

ITERATION 03		
Material layers	Thickness	Time lag (Hours)
Brick	250 mm	8 hrs
Adhesive	10 mm	0.15 hrs
Polystyrene	10 mm	1.1 hrs
Interior finish	10 mm	0.15 hrs
Cement plastering	25 mm	0.26 hrs
Time lag		9.4 hrs
Thickness of wall		310 mm

Name of the material	Thickness	Thermal Conductivity	Thermal Resistance
Bamboo	0.06	0.59	0.72
Cement Mortar	0.02	0.72	0.03
Damp proofing	0.02	0.17	0.09
Reinforced Concrete	0.1	2.25	1.43307
Sum of all material thermal resistance			2.27307

ITERATION 02		
Material layers	Thickness	Time lag (Hours)
Plaster	10	0.104
Concrete	125 mm	2.3125
Air cavity	100 mm	3
Concrete	250 mm	4.625
Plaster	10	0.104
Time lag		10.14 hrs
Thickness of composite wall		475 mm

TABLE 8.4 DIFFERENT TYPES OF WALL MATERIAL ANALYSIS

INFERENCE – $RT = R_{si} + R_{se} + R_1 + R_2 + R_3 + R_4$, $RT = 0.17 + 0.04 + 2.27307 = 2.48307 \text{ mK/W}$. **U-value) of wall = $1/RT = 0.409 \text{ W/mK}$**

8.5 ROOF MATERIAL ANALYSIS:

UNTREATED FLAT ROOF :			
Name of the material	Thickness	Thermal Conductivity	Thermal Resistance
Internal plaster	0.01	0.72	0.03
RCC slab	0.15	1.58	0.10
Cement Screed	0.02	0.72	0.03
Vapor control layer	0.02	0.12	0.17
Water proofing	0.01	0.17	0.09
Thickness of slab = 0.2 m = 200 mm			
Sum of all material thermal resistance =			0.42
$RT = R_{si} + R_{se} + R_1 + R_2 + R_3 + R_4 + R_5$, $RT = 0.17 + 0.04 + 0.42 = 0.63 \text{ mK/W}$ Thermal transmittance (U value) of roof = $1/RT = 1.587 \text{ W/m.K}$ This is more than recommended U value of 1.2 W/m.K			
BIOSOLAR COOL ROOF :			
Name of the material	Thickness	Thermal Conductivity	Thermal Resistance
Soil	0.1	1.16	0.09
Gravel	0.05	0.7	0.21
Drainage	0.02	0.27	0.07
Water proofing	0.01	0.17	0.09
Cement screed	0.02	0.72	0.03
Concrete	0.1	2.25	1.43307
Bamboo	0.05	0.59	0.72
Thickness of slab = 0.3 m = 300 mm			
Sum of all material thermal resistance =			2.643
$RT = R_{si} + R_{se} + R_1 + R_2 + R_3 + R_4$, $RT = 0.17 + 0.04 + 2.643$, $RT = 2.853 \text{ mK/W}$ Thermal transmittance (U value) of roof = $1/RT = 0.350 \text{ W/m.K}$ This is less than the maximum U_{roof} value of 1.2 W/m.K as per ECBC. Hence this sort of slabs can be adopted for better insulation.			

TABLE 8.5 DIFFERENT TYPES OF ROOF MATERIAL ANALYSIS



(a)



(b)



(c)

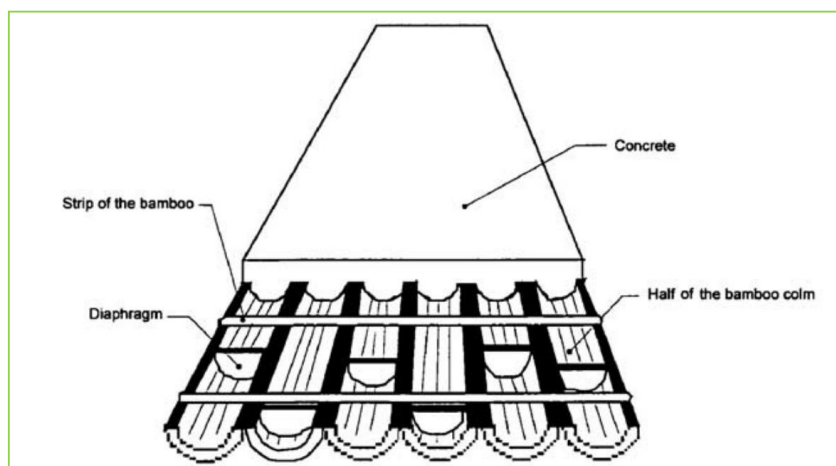


Fig 8.5 Details of Bio-Solar roof

8.6 RESEARCH PAPER: “STRENGTH BEHAVIOR OF BAMBOO-REINFORCED CONCRETE SLABS” BY ROZAINA ISMAIL, YONG CHUA BON, NUR ADIBA

This study support the effort of using “Semantan” bamboo as a sustainable engineering material since it can be used effectively as structural reinforcing bars in concrete.

From the conducted study, it is shown that higher percentage of main reinforcement sample able to cater more loads. It also experienced cracking later than the one with lower percentage of main reinforcement.

Methodology -

- The research work was carried out to determine the load-deflection relationship of bamboo-reinforced concrete slabs subjected to four-point load and its mode of failure.
- Two slab specimens were prepared to test for the flexural capacity. Slab dimension is 1100 mm x 500 mm x 100 mm and were reinforced with main and secondary reinforcements. They are reinforced with Semantan type of bamboo strips with 20 mm wide and 10 mm thick.

Table 3. Maximum load and deflection for one-way bamboo-reinforced concrete slab			
Sample	Maximum Load (kN)	Deflection at Maximum Load (mm)	Load at First Crack (kN)
1	33.77	10.4	14.17
2	40.96	15.0	17.52

Table 4. Experimental and theoretical moment capacity			
Sample	Experimental Moment Capacity, M_{exp} (kNm)	Design Moment Capacity, M_{des} (kNm)	Ratio, M_{exp}/M_{des}
1	6.06	5.69	1.1
2	6.66	8.88	0.75

TABLE 8.6 MAXIMUM LOAD AND DEFLECTION FOR BAMBOO REINFORCED SLAB

Green Roof Type 	 EXTENSIVE	 SEMI-INTENSIVE	 INTENSIVE
Purpose	Stormwater Mitigation	Stormwater Mitigation, Biodiversity	Stormwater Mitigation, Biodiversity, Amenity Space
Vegetation	Moss-Herbs-Grasses	Grass-Herbs-Shrubs	Lawn/Perennials, Shrubs, Trees
Overall Depth	100-200mm 4 to 7 inches	150-250mm 6 to 10 inches	200-750mm + 8 to 30 inches +
Weight Range	100-200 kg/m ² 20-40 Lb/sf	120-300 kg/m ² 25-60 Lb/sf	220-800 kg/m ² + 45-160 Lb/sf +
Ecological Compensation			
Max. Rain Event	50-100mm 2"-4"	75-110mm 3"-4.2"	over 120mm over 4.2"
Cost			
Irrigation System	not recommended	partially	required

TABLE 8.7 TYPES OF BIO SOLAR ROOF

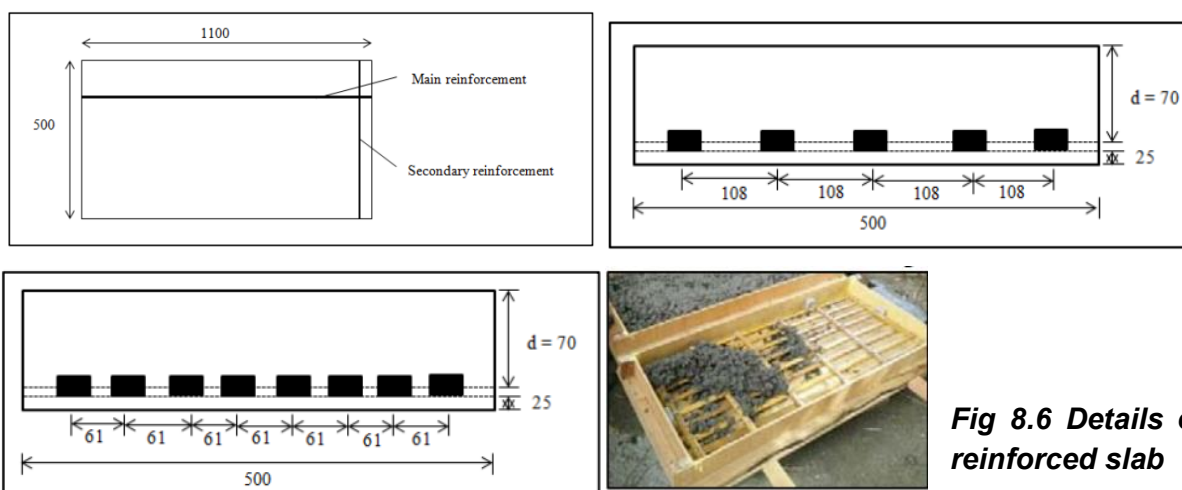


Fig 8.6 Details of bamboo reinforced slab

8.7 WINDOW AND DOOR MATERIALS COMPOSITION:

SELECTED WINDOW TYPE : GAS FILLED DOUBLE GLAZING CASEMENT WINDOW SELECTED DOOR TYPE : BAMBOO DOOR FIXED INSIDE WOODEN FRAME	
SPECIFICATION	Low U value, Low SHGC and high VLT
FRAME SELECTED	WOOD
VALUES As per ECBC, SHGC : 0.27 W/SqmK VLT : 0.27 U value : 3 W/SqmK	PROPERTIES Shading coefficient : 0.1-0.4 W/sqm K U-Value : 1.7-3.0 W/sqm K Visual light transmittance : 40 - 60%
TYPE OF GLAZING	Low emissivity, Spectrally selective and reflective coating, insulated double glazing, heat absorbing

TABLE 8.8 WINDOW MATERIAL COMPOSITIONS

8.8 FOUNDATION ADOPTED:

Isolated footing with RCC of depth 2000 mm until plinth level of the building will be selected as foundation. Ground level beam tie and plinth level beam tie would be 600 mm above ground level. This foundation type would be structurally sufficient as structure height would be 5m (only ground floor).

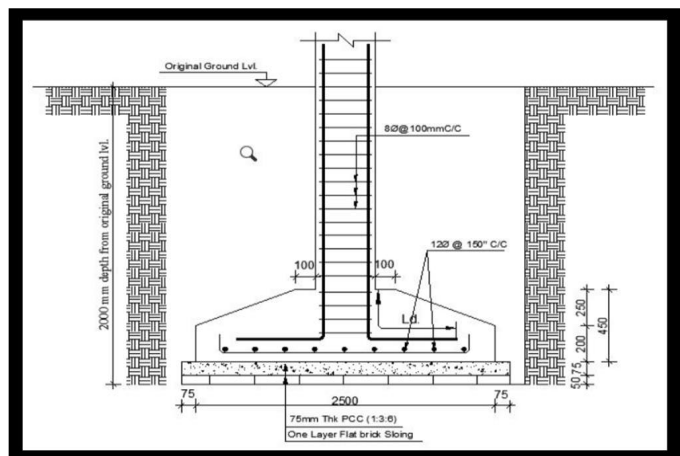


Fig 8.7 Foundation details

8.9 BAMBOO FLOORING

Due to following reasons bamboo flooring is preferred.

- a. Eco-friendly and sustainable flooring option.
- b. Inexpensive choice compared to hardwood flooring.
- c. Strand Woven bamboo is extremely tough and durable – can be used in commercial areas.
- d. Can be used in versatile ways (in conservatories, with under floor heating).
- e. Easy to look after and maintain.



Fig 8.8 Details of Bamboo door and Bamboo curtain

CHAPTER 09

9.1 ANNUAL POWER CONSUMPTION CALCULATION

PRESIDENTIAL COTTAGE					
Monthly power consumption for fan :					
No	Hour	Watts per Hour	Watts per day	Watts per Month	Kilowatt per year
1	24	80	1920	57600	691200
Total nos. of fans = 2					
Total electricity consumption = 691200X2					
13,82,400 Watts or 1382.4 Kilowatts					
Monthly power consumption for LED lights :					
No	Hour	Watts per Hour	Watts per day	Watts per Month	Kilowatt per year
Total no. of LED tube lights = 3					
3	6	36	216	6480	77,760
Total no. of LED bulbs = 7					
7	6	10	60	1800	21600
Total nos. of LED lights = 10					
Total electricity consumption = (77,760X3)+(21600X7) = 384480 Watts					
384480 Watts or 384.48 Kilowatts					
Total power consumption for fan and LED lights : 1382.4 + 384.48 = 1766.88 KW					

DELUXE COTTAGE					
Monthly power consumption for fan :					
No	Hour	Watts per Hour	Watts per day	Watts per Month	Kilowatt per year
1	24	80	1920	57600	691200
Total nos. of fans = 1					
Total electricity consumption = 691200 Watts					
691200 Watts or 691.2 Kilowatts					
Monthly power consumption for LED lights :					
No	Hour	Watts per Hour	Watts per day	Watts per Month	Kilowatt per year
Total no. of LED tube lights = 2					
2	6	36	216	6480	77,760
Total no. of LED bulbs = 7					
5	6	10	60	1800	21600
Total nos. of LED lights = 7					
Total electricity consumption = (77,760X2)+(21600X5) = 263520 Watts					
263520 Watts or 263.520 Kilowatts					
Total power consumption for fan and LED lights : 691.2 + 263.52 = 954.72 KW					

FAMILY SUITE					
Monthly power consumption for fan :					
No	Hour	Watts per Hour	Watts per day	Watts per Month	Kilowatt per year
3	24	80	1920	57600	691200
Total nos. of fans = 3					
Total electricity consumption = 691200X3					
2073600 Watts or 2073.6 Kilowatts					
Monthly power consumption for LED lights :					
No	Hour	Watts per Hour	Watts per day	Watts per Month	Kilowatt per year
Total no. of LED tube lights = 2					
4	6	36	72	2160	25920
Total no. of LED bulbs = 7					
10	6	10	60	1800	21600
Total nos. of LED lights = 7					
Total electricity consumption = (25920X4)+(21600X10) = 319680 Watts					
319680 Watts or 319.68 Kilowatts					
Total power consumption for fan and LED lights : 2073.6 + 319.68 = 2393.28 KW					

TABLE 9.1 ANNUAL POWER CONSUMPTION CALCULATIONS

9.2 ANNUAL SOLAR POWER PRODUCTION CALCULATION

PRESIDENTIAL COTTAGE		DELUXE COTTAGE		FAMILY SUITE	
ANNUAL SOLAR PANEL CALCULATIONS		ANNUAL SOLAR PANEL CALCULATIONS		ANNUAL SOLAR PANEL CALCULATIONS	
Electricity produced by a single panel (Watt per day)	1800	Electricity produced by a single panel (Watt per day)	1800	Electricity produced by a single panel (Watt per day)	1800
Actual performance of solar panel based on climate conditions is 75%		Actual performance of solar panel based on climate conditions is 75%		Actual performance of solar panel based on climate conditions is 75%	
Electricity produced by a single panel (Watt per day)	1350	Electricity produced by a single panel (Watt per day)	1350	Electricity produced by a single panel (Watt per day)	1350
No. of rainy days in a year (Bhubaneswar)	87	No. of rainy days in a year (Bhubaneswar)	87	No. of rainy days in a year (Bhubaneswar)	87
Dimension of single solar panel	1.44 Sqm (1.6m x0.9 m)	Dimension of single solar panel	1.44 Sqm (1.6m x0.9 m)	Dimension of single solar panel	1.44 Sqm (1.6m x0.9 m)
No. of solar panels installed	15	No. of solar panels installed	7	No. of solar panels installed	22
Total power production through solar panels per day-	1350X15 =20250W	Total power production through solar panels per day-	1350X7 =9450W	Total power production through solar panels per day-	1350X22 =29700W
Total power production through solar panels per year	20250X365 = 73,91,250W =7391.25KW	Total power production through solar panels per year	9450X365= 34,49,250 = 3449.25KW	Total power production through solar panels per year	29700X365= 1,08,40,500 = 10840 KW

TABLE 9.2 ANNUAL SOLAR POWER PRODUCTION CALCULATIONS

9.3 LIFE CYCLE COST CALCULATION

INITIAL COST ANALYSIS			
CRITERIA	SPECIFICATIONS	BASE CASE	PROPOSED CASE
CONSTRUCTION	Wall Material	Brick	Bamboo reinforced concrete wall
	Cost including material cost, labor cost and construction time period	(Rs.1500 per <u>sqm</u>) @121.75 <u>sqm</u>	(Rs.1250 per <u>Sam</u>) @121.75 <u>sqm</u>
	Total Cost	Rs 1,82,625	Rs.1,52,187
CRITERIA	SPECIFICATION	BASE CASE	PROPOSED CASE
HEATING	Water heating for domestic use	Geyser - 15 liters (1 nos./Bath)	Solar water heater (1 no./cottage)
	Buying + Installation cost	Rs.12,000	Rs.15,000
	Total Cost	Rs.12,000	Rs.15,000
CRITERIA	SPECIFICATION	BASE CASE	PROPOSED CASE
SPACE COOLING	Cooling Technique	Air conditioning (Split AC unit 1.5 Ton) (1 no. per cottage)	Fans Electricity and solar power (2 nos. per cottage)
		Rs.50,000	Rs.3000
	Total Cost	Rs.50,000	Rs.3,000

TABLE 9.3 LIFE CYCLE COST CALCULATION

INITIAL COST ANALYSIS			
CRITERIA	SPECIFICATIONS	BASE CASE	PROPOSED CASE
LIGHTING	No. of lights	3 Tube lights 7 CFL Bulbs per cottage	3 LED Tube lights 7 LED Bulbs per cottage
	Cost including material cost, labor cost and construction time period	(@ 1 CFL bulb Rs.400 and tube light Rs.275)	(@ 1 LED bulb Rs.250 and LED tube light Rs.350)
	Total Cost	Rs.3625	Rs. 2800
Total initial cost for base case for duration of 30 years			Rs.248250
Total initial cost for proposed case for duration of 30 years			Rs.172987
TOTAL COST SAVINGS			Rs.75,263
MAINTENANCE COST ANALYSIS			
CRITERIA	SPECIFICATIONS	BASE CASE	PROPOSED CASE
CONSTRUCTION COST	Total cost for painting (every 5 years) for a period of 30 years	Brick (Rs.65/sqm) @121.75 sqm	Bamboo reinforced concrete wall (Rs.65/sqm) @121.75 sqm
	Total Cost	Rs. 7913.75	Rs. 7913.75

TABLE 9.4 LIFE CYCLE COST CALCULATION

MAINTENANCE COST ANALYSIS			
CRITERIA	SPECIFICATIONS	BASE CASE	PROPOSED CASE
SPACE COOLING	Cooling Technique	Air Conditioning Split AC 1.5 ton (1 no. per cottage)	Fans (2 fans per cottage)
	Maintenance frequency	(Every year) (Rs. 2000 per unit per year)	Not required
	Total Cost	Rs. 60,000	-
	Replacement frequency	Every 10 years	Every 15 years
	Replacement + Installation Cost	Rs. 1,80,000	Rs.3000
	Total cost for 30 years	Rs.1,80,000	Rs.3000
HEATING COST	Maintenance frequency	Geyser 15 liters (For every 5 years)	Solar water heater (For every 5 years)
	Maintenance cost + Replacement cost	Rs. 2000 per coil	Rs. 1000
	Total Cost for 30 years	Rs. 12000	Rs.6000

TABLE 9.5 LIFE CYCLE COST CALCULATION

MAINTENANCE COST ANALYSIS			
CRITERIA	SPECIFICATIONS	BASE CASE	PROPOSED CASE
	Mode of lighting	Electricity	Solar power
LIGHTING	No. of light fixtures	Tube light =3 CFL bulb = 7 @ 1 tube light = 40W @ 1 CFL bulb = 25W	LED Tube light =3 LED bulb = 7 @ 1 LED tube light = 30 W @ 1 LED bulb = 10W
	Replacement frequency	Every 2 years	Every 5 years
	Replacement cost	Rs.3625	Rs. 2800
	Replacement cost for 30 years	Rs.54,375	Rs. 16,800
Total maintenance cost for base case for duration of 30 years			Rs. 2,54,288
Total maintenance cost for proposed case for duration of 30 years			Rs. 33,713
TOTAL COST SAVINGS			Rs.2,20,575
ENERGY CONSUMPTION COST ANALYSIS @ Rs. 6.00 per KW			
CRITERIA	SPECIFICATIONS	BASE CASE	PROPOSED CASE
HEATING COST	Water heating for domestic use	Geyser- 15 liters @1 no. Geyser per cottage	Solar water heater @ 1 no. per cottage
	Energy consumed per year	480 KW/year	320 KW/year

TABLE 9.6 LIFE CYCLE COST CALCULATION

ENERGY CONSUMPTION COST ANALYSIS @ Rs. 6.00 per KW			
CRITERIA	SPECIFICATIONS	BASE CASE	PROPOSED CASE
HEATING COST	Water heating for domestic use	Geyser- 15 liters @1 no. Geyser per cottage	Solar water heater @ 1 no. per cottage
	Cost per year	Rs. 2880	Rs. 1920
	Total energy consumption for duration of 30 years	14400 KW	9600 KW
	Total cost for duration of 30 years	Rs. 86400	Rs. 57,600
SPACE COOLING	Cooling Technique	Air Conditioning Split AC 1.5 ton (1 no. per cottage)	Fans (2 nos. fans per cottage)
	Energy consumed per hour per unit	1700 Wh per unit	80 Wh per unit
	Energy consumed per year	9928 KW/year	1384 KW/year
	Cost per year	Rs. 59,568	Rs. 8304
	Total energy consumption for duration of 30 years	2,97,840 KW	41,520 KW
	Total cost for duration of 30 years	Rs. 17,87,040	Rs. 2,49,120

TABLE 9.7 LIFE CYCLE COST CALCULATION

ENERGY CONSUMPTION COST ANALYSIS @ Rs. 6.00 per KW			
CRITERIA	SPECIFICATIONS	BASE CASE	PROPOSED CASE
LIGHTING	Mode of lighting	Electricity	Solar power
	No. of light fixtures	Tube light =3 CFL bulb = 7 @ 1 tube light = 40W @ 1 CFL bulb = 25W	LED Tube light =3 LED bulb = 7 @ 1 LED tube light = 30 W @ 1 LED bulb = 10W
	Energy consumed per year	637.2 KW	384.48 KW
	Cost per year	Rs. 3,823.2	Rs. 2,307
	Total energy consumption for duration of 30 years	19,116 KW	11,534.4 KW
	Total cost for duration of 30 years	Rs. 1,14,696	Rs. 69,210
	Total energy consumption cost for base case for duration of 30 years		Rs. 19,88,136
Total energy consumption cost for proposed case for duration of 30 years			Rs. 3,75,930
TOTAL COST SAVINGS			Rs. 16,12,206
INITIAL COST			69.68 %
MAINTENANCE COST			13.25 %
ENERGY CONSUMPTION COST			18.90 %
MAJOR COST REDUCTION IN PROPOSED CASE IS NOTED THROUGH ENERGY CONSUMPTION AND MAINTENANCE COST BY USAGE OF SOLAR POWER AND NATURAL VENTILATION.			

TABLE 9.8 LIFE CYCLE COST CALCULATION

CHAPTER 10

BENEFITS OF SUSTAINABLE TOURISM

Environmental benefits -

1. Promotes conservation of nature.
2. Protects biodiversity.
3. Balances stability of ecosystems.
4. Generates awareness on environmental education.
5. Connects people to the environment.

Economic benefits -

1. Generates economic benefits.
2. Promotes sustainable livelihood.
3. Encourages stable and quality employment growth.
4. Speaks for equitable distribution.

Social benefits -

1. Helps in enrichment of society.
2. Preserves local culture.
3. Preserves local art and regional master crafts.
4. Respects indigenous peoples.
5. Create bridge for cultural exchange among people.

Sustainable tourism is a major economic activity that has developed significantly over the years. Sustainable tourism is deeply interconnected with pillars of sustainability.

Tourism not only benefits the government but also the people that live in the local area by creating business as well as employment opportunities for the local people.

But in reality, local people are excluded from many major grant-aided initiatives and marginalized from earning income directly from tourism. This condition will not be

sustainable in long run. In conclusion, we can say that Government support will be needed to co-ordinate economic activities, so that demand for resources can be met within the limits of local environment's capacity.

The success of sustainable tourism is the participation of local people based on the use of their assets and diversification of their livelihood.

Government should create a mechanism for empowerment of local people as well as development of tourist spots to enable tourists to enjoy their best.

REFERENCES

<https://www.infobloom.com/what-is-an-eco-resort.htm>

https://en.wikipedia.org/wiki/Eco_hotel

<https://www.unescap.org/sites/default/d8files/19.%20FS-Eco-resorts-and-hotels.pdf>

Alho, C., & Pina, J. C. (2013). In direction to sustainable eco resorts. *Green Design, Materials and Manufacturing Processes*, 51.

Zuhairy, D. A., Eweda, N., & El-Shorbagy, A. M. (2020). JEDDAH WEST COAST ISLAND ECO-RESORT. *Journal of Critical Reviews*, 7(8), 404-407.

Magray, N. A. (2018). Ecotourism: an adversity in itself with special reference to Jammu & Kashmir. *International Journal of Global Science Research*, 5(2).

D'souza, L. M., & Sarode, N. G. EXPERIENTIAL MARKETING PRACTICES IN GOA—A CASE STUDY OF AN ECO RESORT.

<https://www.orchidhotel.com/lotus-eco-beach-resort-konark/gallery.html>

<https://en.climate-data.org/asia/india/odisha/puri-2810>

<https://www.thoughtco.com/lighting-levels-by-room-1206643>

https://www.meteoblue.com/en/weather/historyclimate/climatemodelled/konark_india_1266220

<https://www.scribd.com/presentation/206140291/Kumarakom-lake-resort>

<https://www.archdaily.com>

