INTEGRATING VERNACULAR ARCHITECTURE INTO CONTEMPORARY FORM

A Thesis

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

by

ARKIP STELIN D (39890002)

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

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BONAFIDE CERTIFICATE

This is to certify that this Report is the bonafide work of **ARKIP STELIN D (39890002)** who carried out the Thesis entitled "**INTEGRATING VERNACULAR ARCHITECTURE INTO CONTEMPORARY ARCHITECTURE"** under our supervision from January 2021 to May 2021.

Sheetal. A.

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Submitted for Viva voce Examination held on ____________________

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Internal Examiner **External Examiner**

DECLARATION

I **ARKIP STELIN D (39890002)** hereby declare that the Thesis Report entitled "**INTEGRATING VERNACULAR ARCHITECTURE INTO CONTEMPORARY ARCHITECTURE**" done by me under the guidance of **Ar. SANGAVI** (Internal) and **Ar. BALAMURUGAN RAJKUMAR, Principal Architect -Proton Ateliers** (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: 06-05-2021

SIGNATURE OF THE CANDIDATE

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

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I would like to express my sincere and deep sense of gratitude to my Project Guide **Ar.SANGAVI** for her valuable guidance, suggestions and constant encouragement which paved way for the successful completion of my 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

The purpose of this study is to design the integration of vernacular architecture into modern contemporary architecture to achive thermal comfort in warm and humid climate(kerala). because of fast developing of urbanization the kerala traditional architecture rapidly reduced that extends to losing its culture and function of the traditional forms and designs .lack of using vernacular consideration led to poor nature contexts and creating discomfort to the occupants. and the main intend is to bring back the vernacular stratagies and the sociocultural which reflects by adopting and considering the local environment planning principles ,forms ,aesthetics, built forms . methodology of this study is by finding architectural context of the kerala vernacular stratagies that been played effectively as passive stratagy with detail analysis and research and identifying the available linkages that can be easily adopted without eleminating the components of traditional buildings and interpreted into modern architecture .the study on this paper shows that detail analysis on vernacular passive stratagies in kerala that can be adopted which can also create more comfortable for the occupants.

TABLE OF CONTENTS

LIST OF SYMBOLS AND ABBREVIATIONS

T_a	-	Air Temperature
T_{mrt}	-	Mean Radiant Temperature
V	-	Wind Speed
RH	-	Relative humidity
PET	-	Physiological equivalent temperature
SVF	-	Sky view factor
U value	-	Thermal Transmittance
R value	-	Thermal Resistance
CSEB	-	Compressed Stabilized Earth Blocks

CHAPTER 1

INTRODUCTION 1.1

INTRODUCTION

Currently building technology and sustainable design facing lack of consideration in environmental and neglects the passive cooling stratagies because of growing field of contemporary architecture. In kerala vernacular architecture plays a major role in environmental friendly and in sustainable way. this study is to bring back the vernacular stratagies and traditional architecture used in kerala by integrating it into contemporary architecture.so it is important tohave the understand toward the vernacular architecture and utilized them as a model in contemporary architecture due to its reflection of climaticadoption in warm and humid climate.integration of vernacular featuresin contemporary design promotes energy efficient building designs in warm and humid regions for sustainable future.

1.2 AIM

Detailed study of traditional built forms and vernacular strategies and adaptation of identified linkages, in the design of drug de-addiction center, using architecture as a tool to enhance the comfort, physical and mental health of the patient.

1.3 NEED FOR THE STUDY

The objective of the study is to find patterns and sources of settlement, buildings, living cultures and local indigenous knowledge. Using the understanding of vernacular architecture, the categorization of types are assessed with aspects such as culture, social aspects and geography to interpret from it possible factors that espouse the conceptualization of forms, spaces and the living culture.

1.4 SCOPE AND LIMITATIONS FOR THE STUDY

Identify To study the context, vernacular architecture and passive strategies that are adopted and its relevance to the drug deaddiction center addressed through the scope of sustainable architecture.

Design Designing sustainable and contemporary built form by adopting the vernacular architecture.

1.5 RESEARCH QUESTIONS

Main: why it is needed to design towards contemporary vernacular architecture in relation to achieve human comfort.

1) What are the design consideration in warm and humid climate?

2) What are the kerala vernacular features used to achieve human comfort? 3) Why and how the features are adopted in the design?

4) Why is integration needed and how does integration improves the living condition?

Why de-addiction center?

Drug addiction is becoming a major health problem in India with some estimates indicating that as many as is million people in India could become addicts by the end of 2015.

1 out of 20 people aged between 15 and 64 years uses drugs or other narcotics substances.

Alcohol consumption affects virtually every organ of your body, namely kidneys, lungs, heart, liver etc. which in turn will ruin up your entire life.

Gradually an individual will be emotionally, physically and personally muddled up. Similar is the case of smoking and drug abuse.

The number of beds is limited to 100 beds (OPD & IPD)

The Treatment include- detoxification vocational training psychiatric therapy family meetings and games only

Why kerala(Thiruvananthapuram)?

NATION, CURRENT AFFAIRS

Thiruvananthapuram: Lack of de-addiction centres hits rehab of youth

DECCAN CHRONICLE. | SHAINU MOHAN

Published Aug 22, 2019, 3:03 am IST Updated Aug 22, 2019, 3:03 am IST

Kerala stands second in drug abuse; one out of three teens has used drugs at least once.

As per the Childline Trivandrum survey, 28.7 per cent of the students in the district have used drugs at least once.

Thiruvananthapuram: Lack of exclusive de-addiction centres is hindering the proper rehabilitation of youngsters and children who are into drug abuse in the state.

According to records, Kerala stands second when it comes to drug a Surveys show that one out of three children aged between 13 and 18 has used drugs at least once during their school years.

Tobacco, cocaine, marijuana, injectable drugs, synthetic drugs, mushrooms and psychiatric pills and other medicines are used widely by children.

As per the Childline Trivandrum survey, 28.7 per cent of the students in the district have used drugs at least once.

It also found that the relatives or friends of 68.9 per cent of the students use drugs, and 39.8 per cent of the students wish to try drugs.

With cases rising, the psychiatric wing under the Thiruvananthapuram Medical College has proposed setting up of de-addiction centre

Why rehab needs natural environment with vernacular architecture?

the environment can have a powerful impact on a person’s well-being and their sense of self The idea behind ecotherapy deeply connected to the environment surrounding us.Our physical, emotional and spiritual state can benefit from being closer to nature and feeling connected to the earth.The interaction between people and the environment is something that needs to be addressed for better mental health.

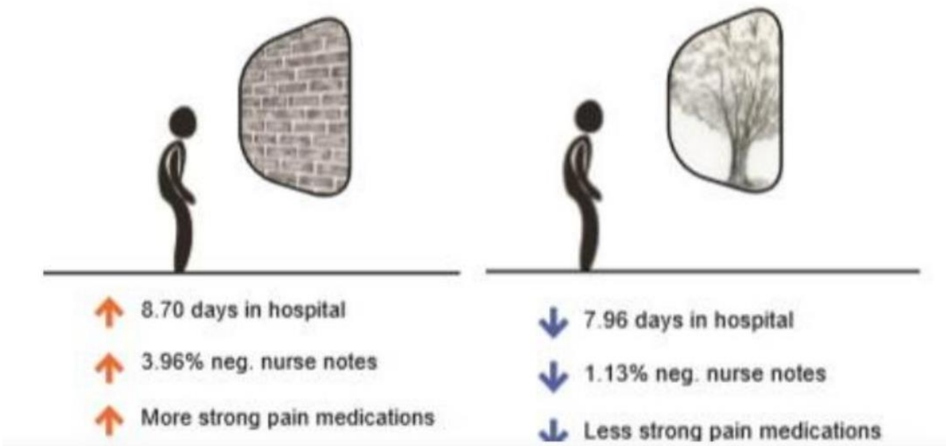
How the Environment Affects Mental Health?

Research has shown that being in a natural place tends to have a more positive impact on a person’s emotions.Those who walked through nature had significantly lower levels of anger and more positive emotions than the ones who had different activities.A rehab center that designed with natural environment can help patients heal in a way that they may not be able to in a more urban setting.

OHE-Optimal Healing Environment

Wellness Achieving wholeness and balance In body, mind and spirit Efficiency Providing quick accessible and care Sustainability Environmentally friendly architecture

Optimal Healing Environment (OHE) framework is described as "the social, psychological, physical, spiritual, and behavioral components of healthcare support and stimulate the body's innate capacity to heal itself”



Healing environment or healing architecture

Healing environment for healthcare centre describes a physical environment that supports patients and families through the stresses that develop as a result of illness.

The physical healthcare environment i.e. physically healthy and psychologically appropriate can make a difference in patients recovery.

The physical aspects (i.e. day lighting, window design thermal conditions) should be designed without compromising the functionality of hospital building.

The goal of healing architecture

The goal is to engage patients in the process of healing and recovery. As a result, spaces should be designed to reduce patient and family stress.

Healing through architecture aims to Eliminate environmental stresses, such as noise, lack of privacy, poor air quality and Connect patients to nature glare.

Enhance the patient's feeling by offering options and choices e.g.- privacy versus socialization, type of music etc.

Encourage opportunities for social support.

Inspire feelings of peace, hope, reflection and spiritual connection.

LITERATURE REVIEW

2.1 WHAT IS VERNACULAR ARCHITECTURE

Vernacular architecture is architecture characterised by the use of local materials and knowledge, usually without the supervision of professional architects. Vernacular architecture represents the majority of buildings and settlements created in pre-industrial societies and includes a very wide range of buildings, building traditions, and methods of construction.

[1] Vernacular buildings are typically simple and practical, whether residential houses or built for other purposes.

2.2 VERNACULAR ARCHITECTURE IN KERALA

Building Materials The common building materials used for vernacular construction in Kerala The masterful joinery and skillful carvings are common in olden are mud, laterite and granite stone blocks, lime mortar, wood, bamboo, clay roofing tile and coconut palm leaves. Broadly speaking, however, vernacular architecture of a region is primarily influenced by the following characteristics:-

1) Climate.

2) Locally available building materials.

3) Indigenous Construction Techniques.

4) Local customs and Social Traditions also influence and mould vernacular architecture of a region. Thus there is a need to study social and cultural influence on built form.

Case study

PROJECT NAME : Karunashraya -Bangalore Hospice Trust, Bengaluru.Site Area: 5 acre Location : Lakshminarayana Pura, Kundatahalli , Marathahalli, Bengaluru.

PROJECT DISCREPTION:

Clustered organisation relies on physical proximity to relate its spaces to one another.Often consists of repetitive, cellular spaces having similar functions & share a common visual trait such as a shape or orientation

(Figure 138) Site Plan


Site Section

Observation

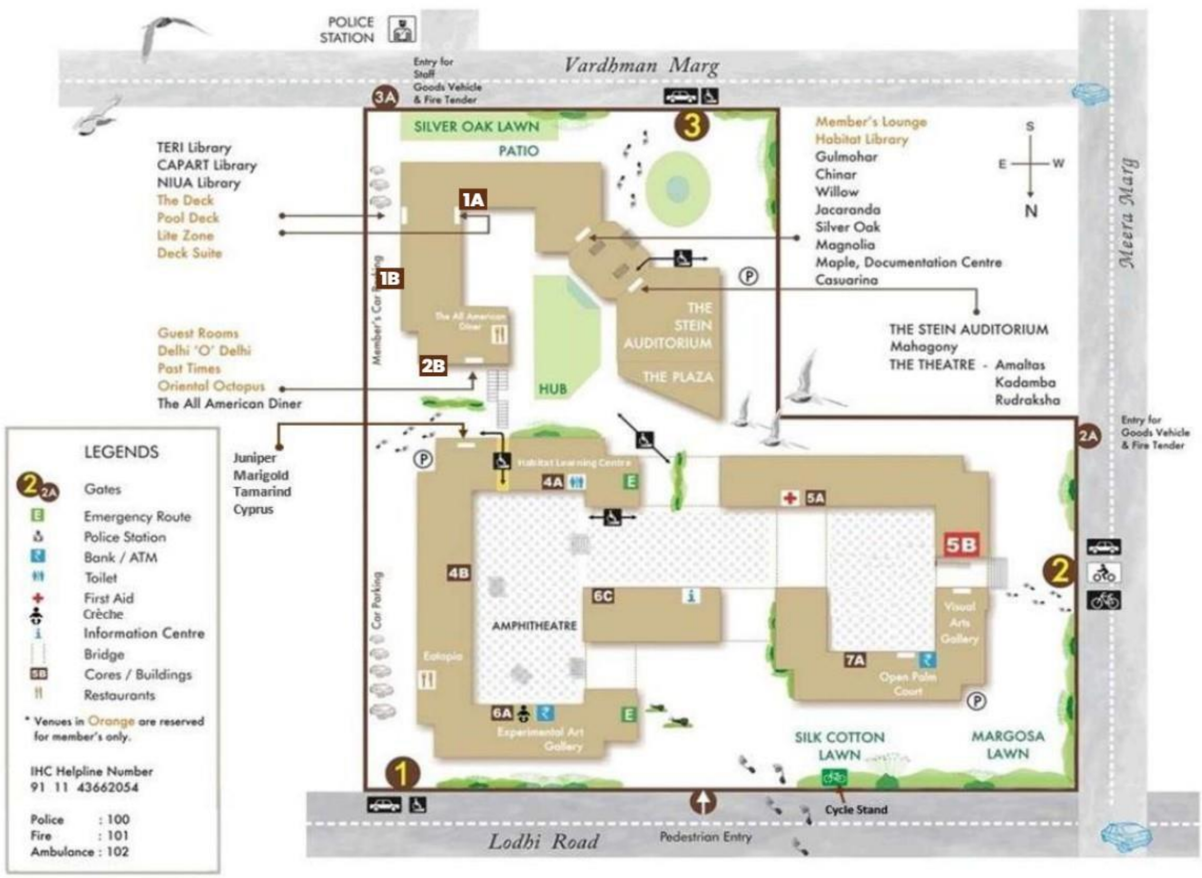
Open Spaces are merged with whole composition. Activities surrounding focused with the open space in between body and courtyards.Open Spaces are providing an experience of pleasant stay, mental & physical relief to the user & also a place for gathering.

Karunashraya as 5 wards & each ward as 12 beds. Each ward is arranged in such a way that it gets the view of water bodyPrayer room is placed in the center so that both entry & exit of patient can be passed through it. The design makes extensive use of landscape elements such as fountain , pond, rockeries greenery & pavers to the facility is shrouded with heavily shaded trees to the right of entrance.The materials used is stone, which allows the structure to naturally merge with the green and also prevents heat transfer. At every zone in the premise, one has the sense of being connected to nature, be it through the chirping birds, the swimming fish or the rustling leaves.

The wards are surrounded by water bodies and greenery. They are designed in a way such that all the wards receive natural lighting and ventilation. The patients can relax with a view of greenery on one side and water on the other of their ward.The all-around ambiance is kept simple and green without any loud colors for the psychological comfort of the patients. The water body plays a pivotal role in offering serenity. Use of natural materials as building elements Presence of a therapeutic environment .Catering to all needs - physical, social, emotional Barrier-free design. Horizontally spread out design The water seems murky due to inefficient maintenance

2.INDIAN HABITAT CENTER

Lodhi road,delhi



Climate Responsiveness

In order to reduce solar heat gain, the building volumes are organised around shaded courtyards. These courtyards are covered by sun-screen pergolas suspended from a space frame structure . The sun-screen pergolas contain angled panels designed to block the summer sun while letting in the winter sun. As a result, the courtyards have acquired a unique microclimate which is conducive for repose. Moreover, the pergolas shade not only the courtyards below but also the inner façades of the building volumes.Other passive climate-control measures include projecting out the top two floors for self-shading, use of cavity walls and a controlled use of glass

Local materials and construction

Stein had left the concrete structural frames exposed.Stein had originally envisioned the cladding in brushed stone aggregate plaster, but had to later switch to brick as the client felt that brick better symbolised ‘habitat’, which was central to the theme of the Centre

2.2.1 CLIMATE

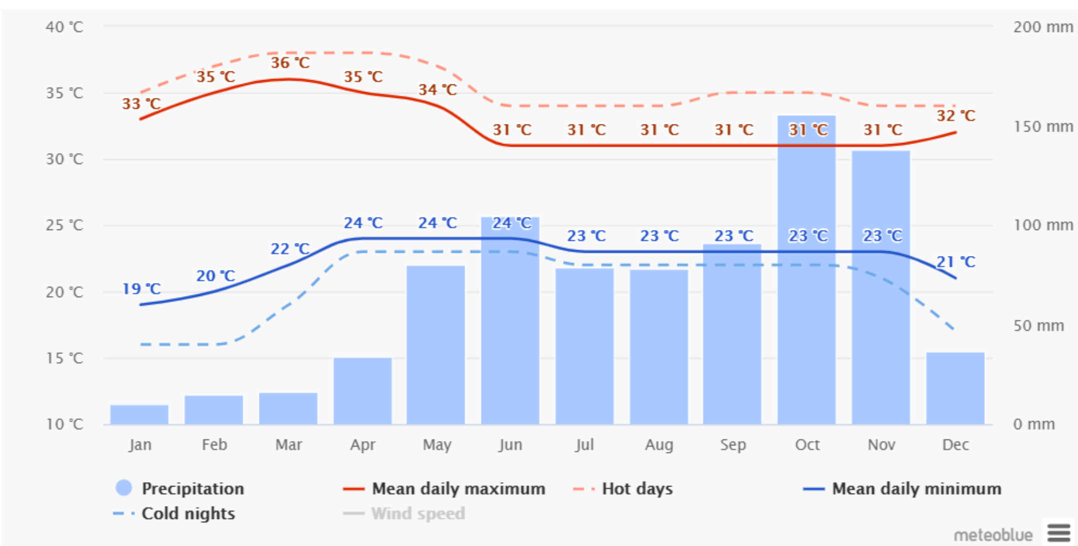
Through the years, amazing skill has been shown by primitive builders in dealing with climatic problems, and their ability to use minimum resources for maximum comfort. One is repeatedly struck by the knowledge and discrimination of such builders in selection of sites and materials suitable to the specific local microclimate. The traditional requirements for placement on site and form which may sometimes have a climatic rationale often become too rigid, not allowing for adjustments of the model for specific local requirements.

Figure 1: Location of Kerala in India. (Source: www.mapsofindia.com)

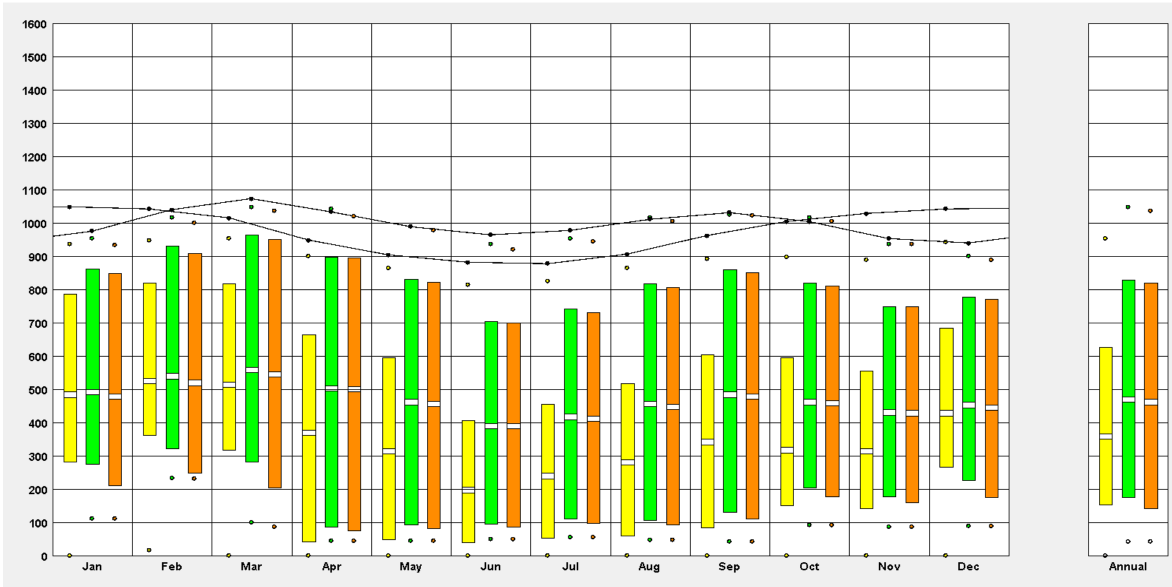
Kerala is situated at the south most tip of India between latitudes 8°.17‟30”N and 12°.47‟.40”N in the northern hemisphere and longitudes 74°.27‟47”East and 77°.37‟.12”East. (Fig 1)The mean daily temperature fluctuates from 26 to 27.5 degree Celsius over the course of a year. The mean daily maximum temperature ranges from 29 to 32.5 degree Celsius. Humidity fluctuates through a considerable range. For the same day humidity may range from 70-80%at 9 am and 50-60% at 6 pm. Thereby, humidity plays a major role in determining the strategies for achieving comfort. The tropical heat and humidity are the main guiding factors behind the climate-responsive design of vernacular dwellings.

TEMPERATURE RANGE

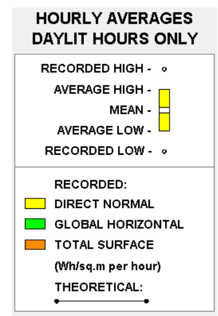
TEMPERATURE AND PRECIPITATON

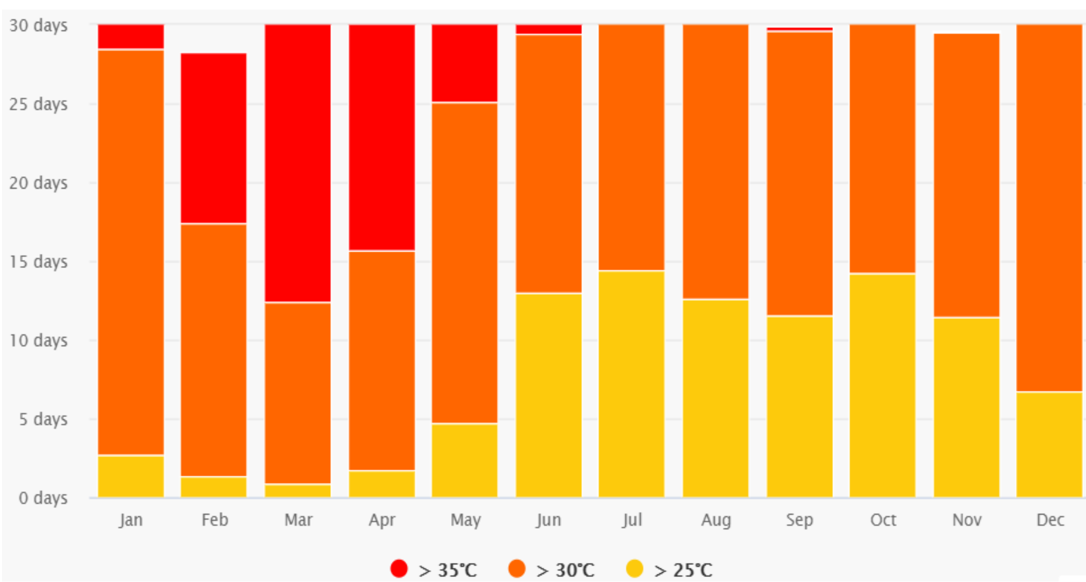


RADIATION RANGE

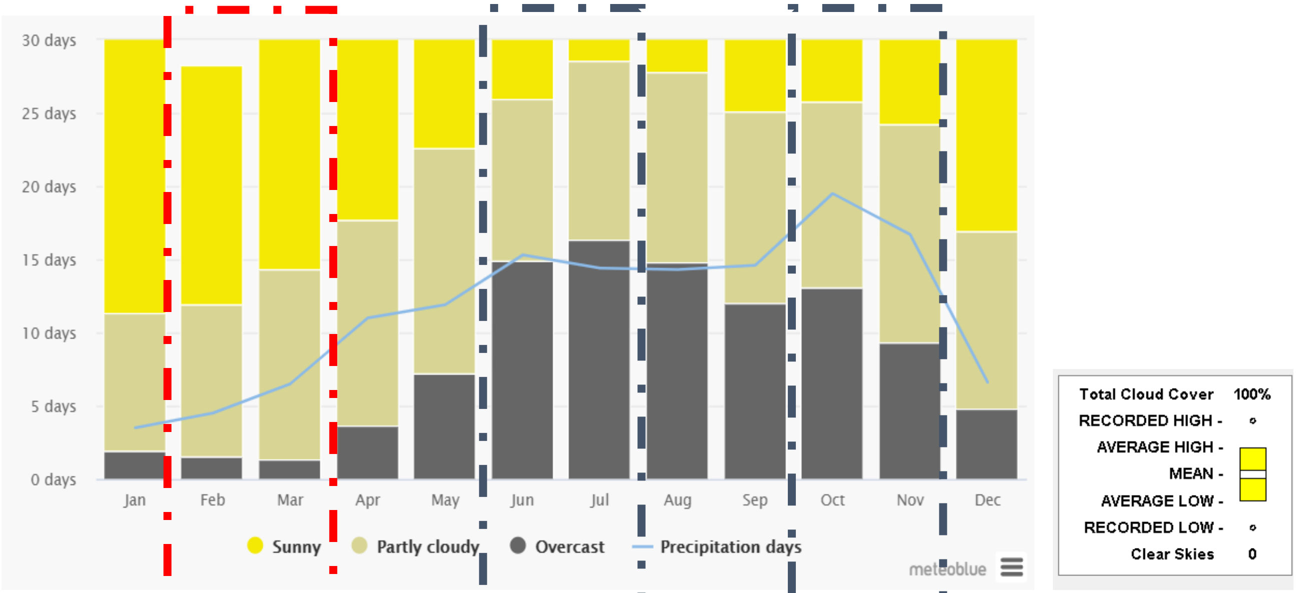


MONTHLY MAXIMUM TEMPERATURE

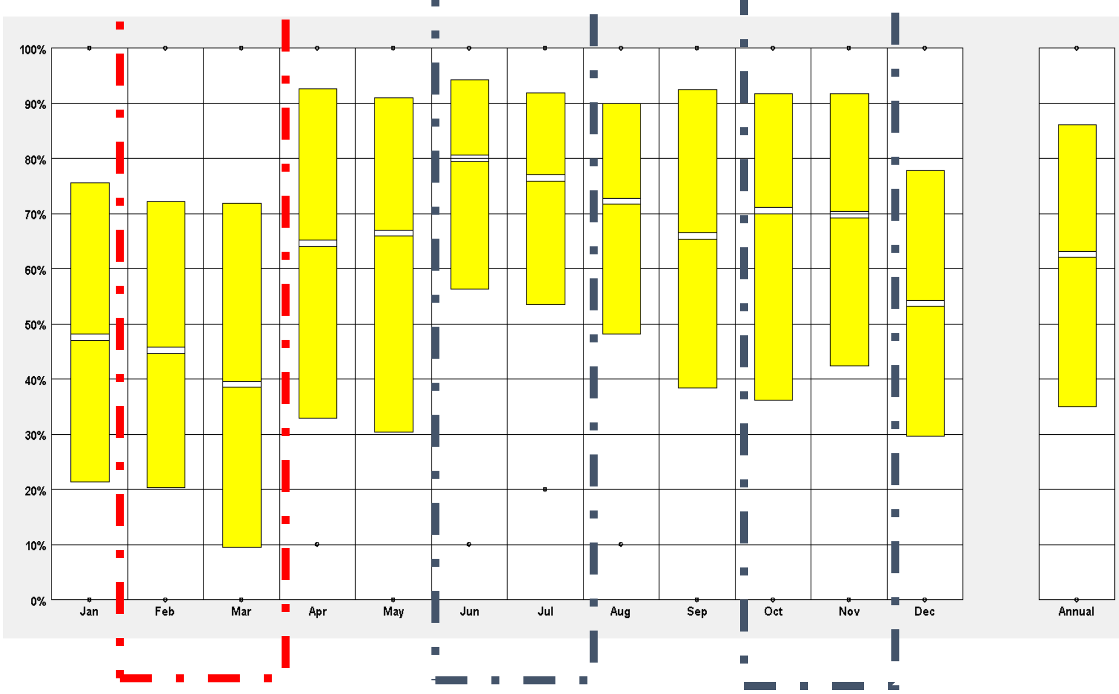




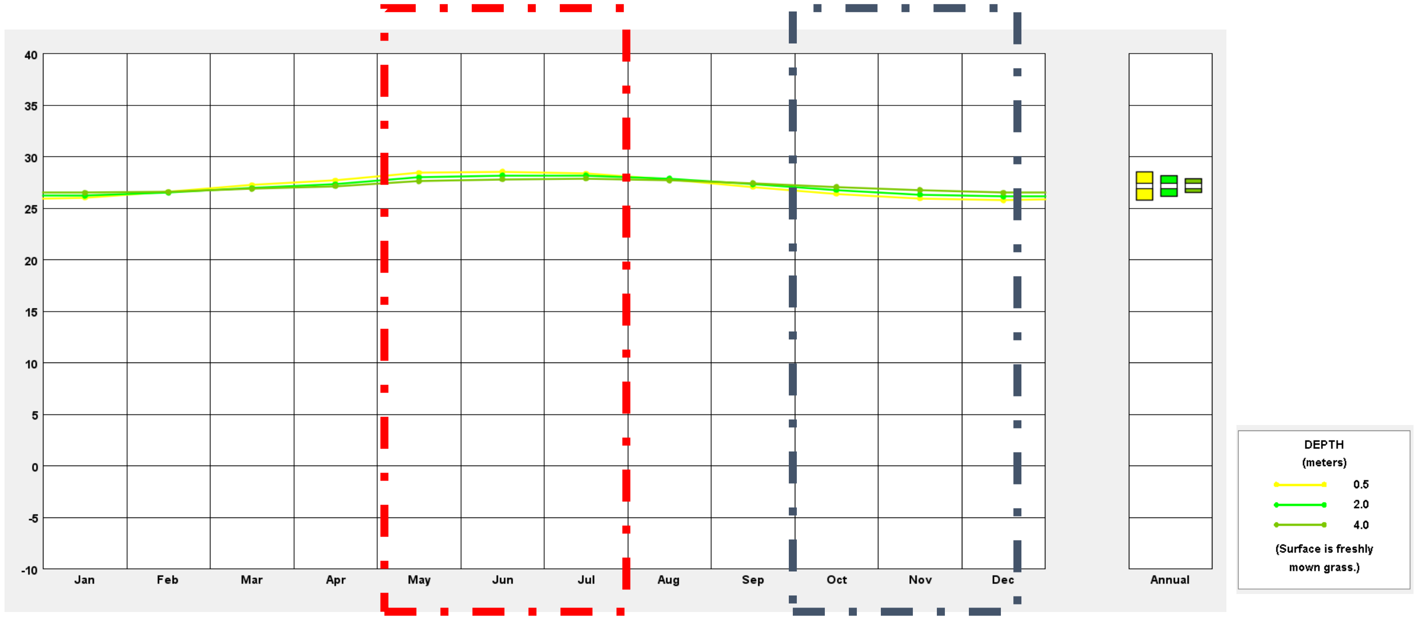
CLOUDY, SUNNY, AND PRECIPITATION DAYS



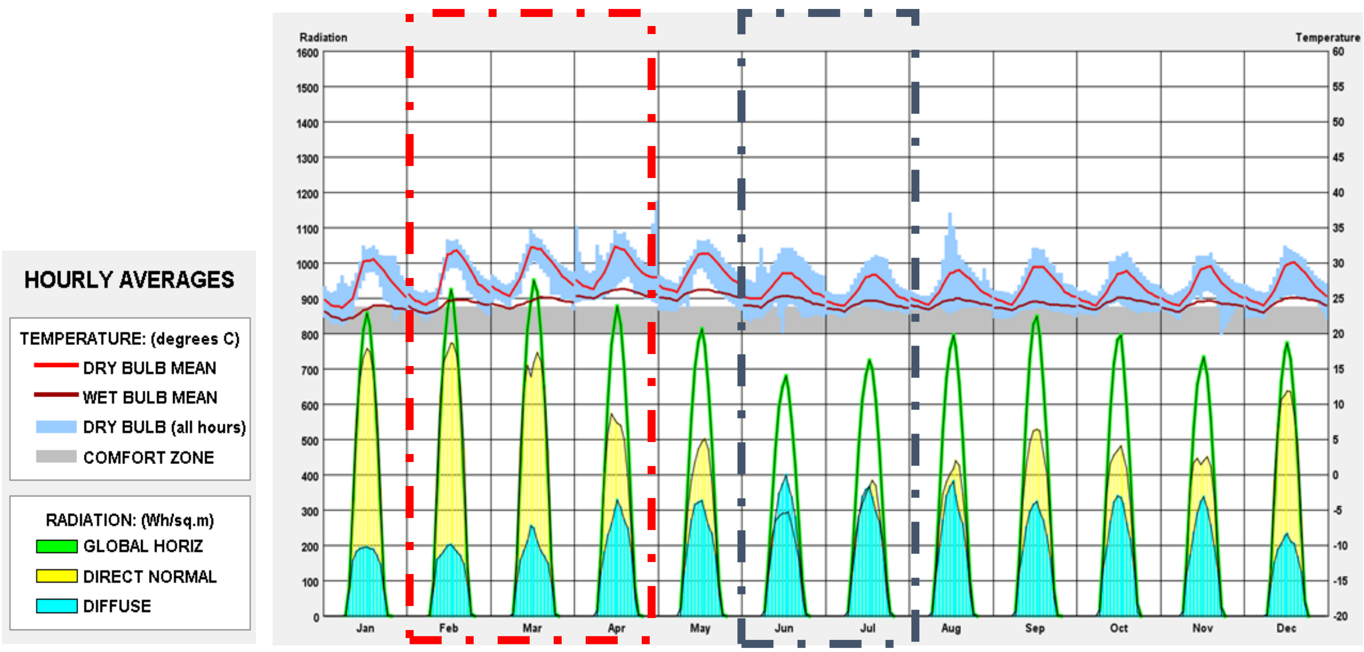
SKY COVER RANGE



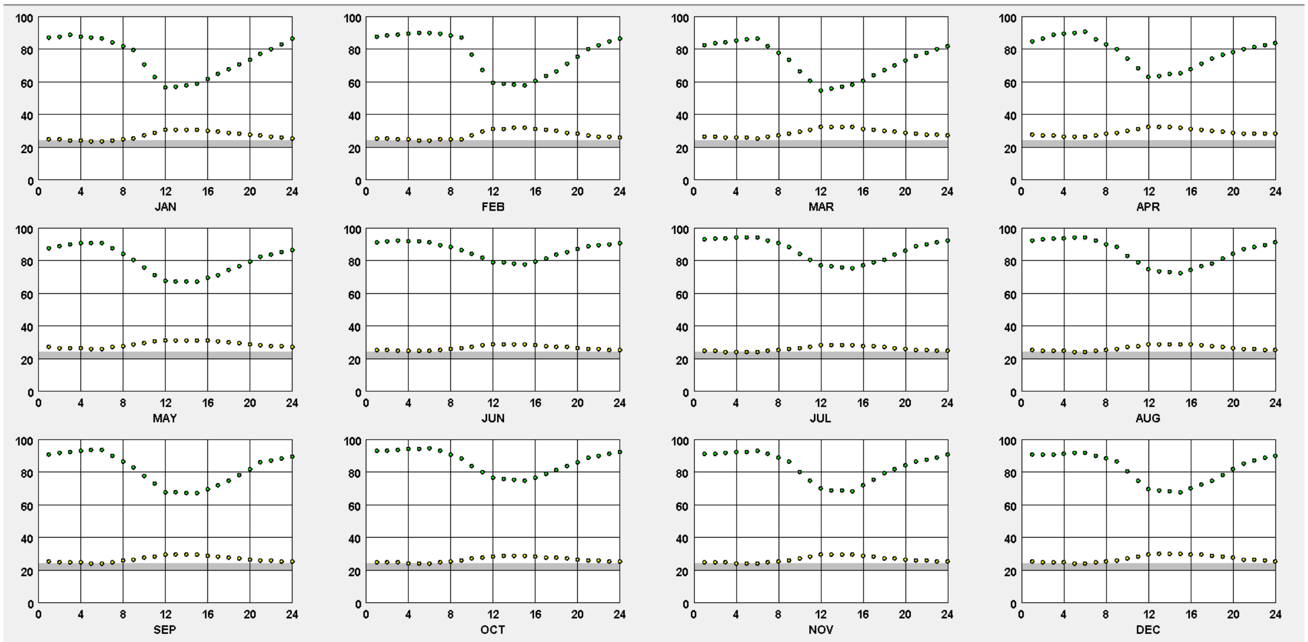
GROUND TEMPERATURE



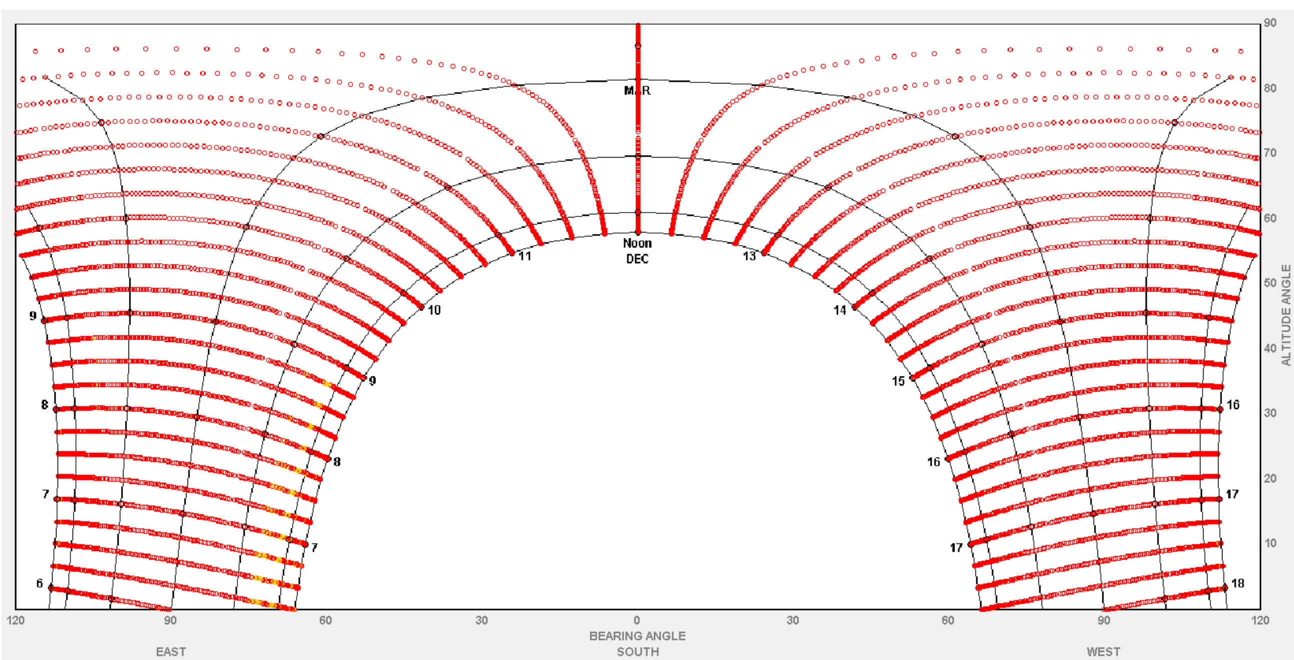
MONTHLY DIURNAL AVERAGE



DRY BULB X RELATIVE HUMIDITY



SUN SHADING CHART



COMFORT BAND

MONTHS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
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7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
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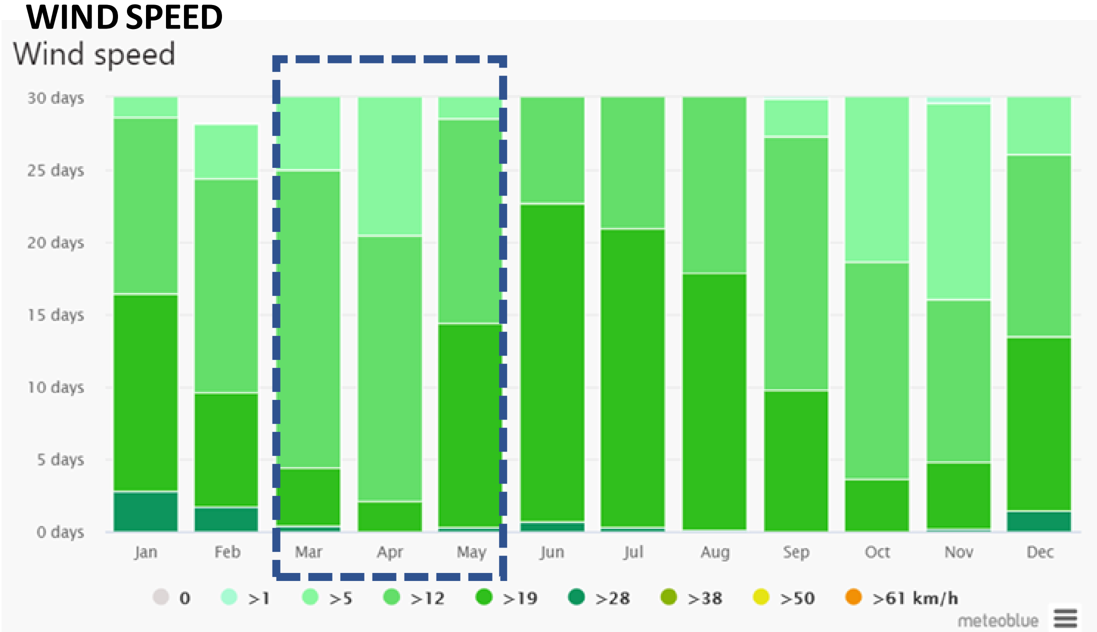
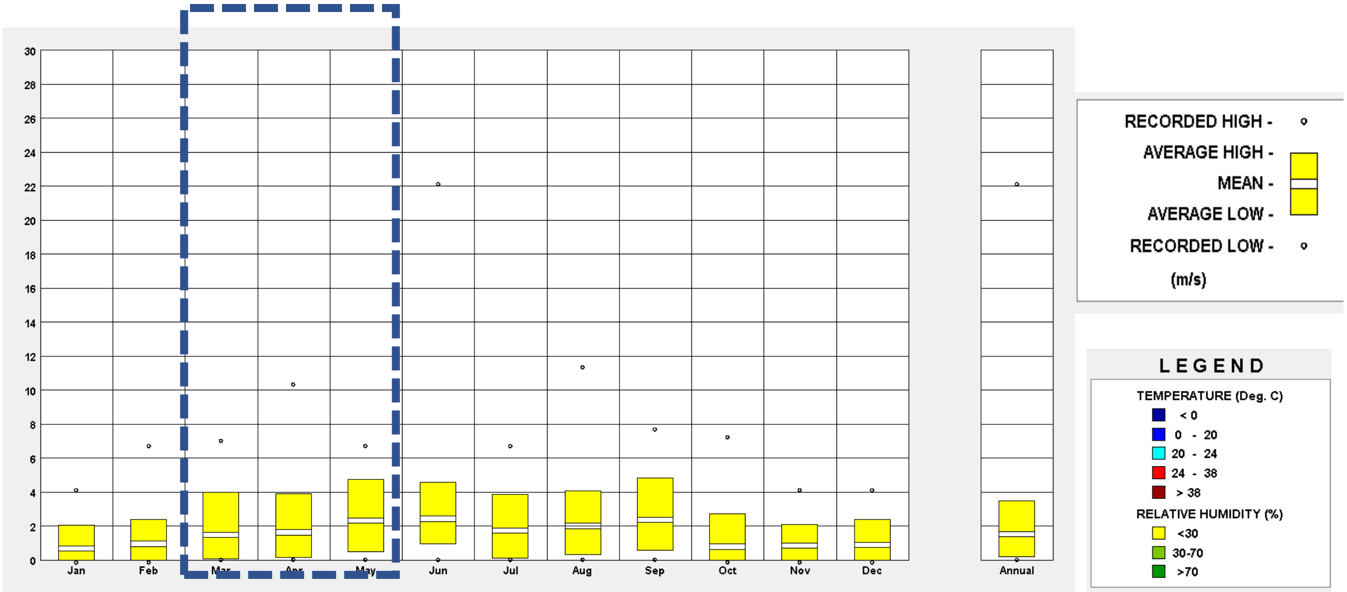
10	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2
11	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	2	2	2	2	2	2	2	2
12	2	2	2	2	2	2	2	2	2	2	2	1	1	1	2	2	2	2	2	2	2	2	2	2

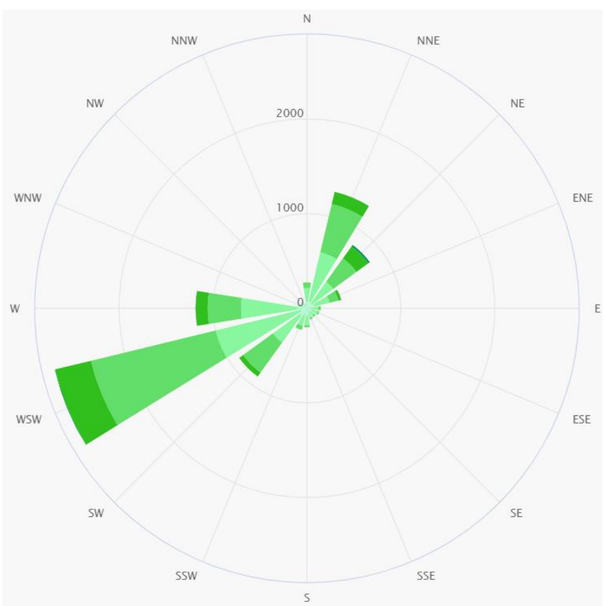
WIND SPEED

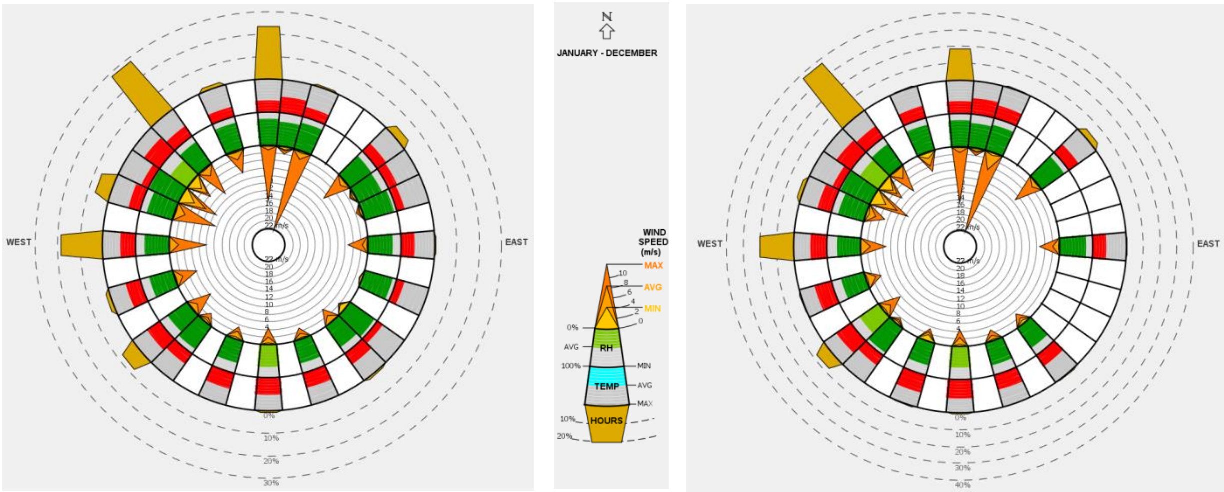


WIND VELOCITY RANGE

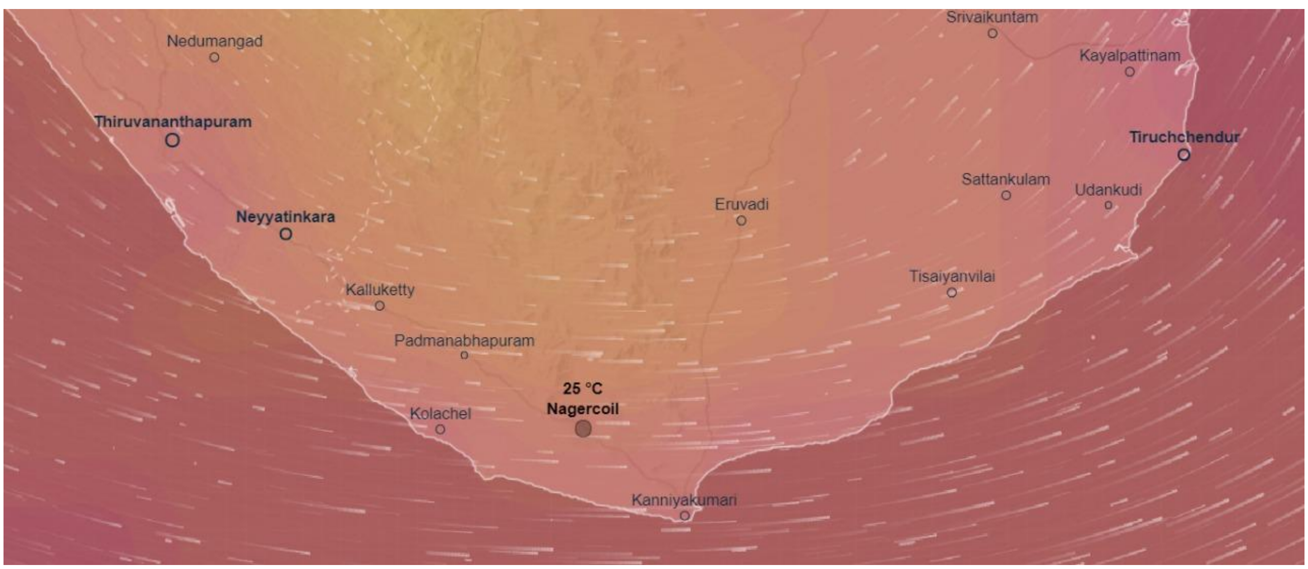


WIND ROSE





WIND MOVEMENT



2.2.2 LOCAL BUILDING MATERIALS

Vernacular builders are able to conserve their materials because they have detailed and precise knowledge of the behavior and characteristics of materials, not just in terms of climatic response and construction, but also in regard to weathering- how the materials and building fabric will stand up to the ravages of time and weather. Vernacular builders always use materials most conveniently available and often the nature of local materials determines form.

The availability of granite -a strong and durable building stone is restricted mainly to the highlands and marginally to some hilly zones. Accordingly, the skill in quarrying, dressing and sculpturing of stone is scarce in Kerala. Laterite stone however, is abundantly found Soft laterite available at shallow depth can be easily cut, dressed and used as building blocks.

It is a local stone that gets stronger and durable with exposure to the atmosphere. Block of this stone may be bonded in mortars of shell lime, the classic binding material used in traditional buildings. Lime mortar can be improved in strength and performance by admixtures of vegetable juices. Such enriched mortars were utilised for plastering and low relief work.

Figure 2: Varied typologies of traditional vernacular dwellings in Kerala. (Source: https://en.wikipedia.org/wiki/Architecture_of_Kerala.)

Timber remains the prime structural material abundantly available in Kerala, in many varieties - from bamboo to teak and rosewood. The skill full choice of timber, artful assembly and delicate carving of wood work for columns, walls and roofs frames are the unique characteristics of Kerala architecture, using accurate fit of joints. Clay was used in many forms - for walling, in filling the timber floors and making bricks and tiles after firing in kilns, tempered with admixtures. Palm leaves are still used effectively for thatching the roofs and for making partition walls and along with mud. Clay was used in many forms for walling, in filling the timber floors and making bricks and tiles after firing in kilns, tempered with admixtures. Palm leaves are still used effectively for thatching the roofs and for making partition walls. Along with mud walls it is still the poor mans construction material.

2.2.3 ROOFING SYSTEM

Structurally the roof frame was supported on the pillars on walls erected on a plinth raised from the ground for protection against dampness and insects in the tropical climate. The roof frame consisted of the wall plate which supported lower ends of the rafters, the upper ends being connected to the ridge. The ridged roof pitched at angles between 30degree to 40degree. The roof with intricately carved gables protruding from the roof with overhangs supported by wooden brackets. No nails are used. The roof is kept in position by interlocking with the hole in the rafters.

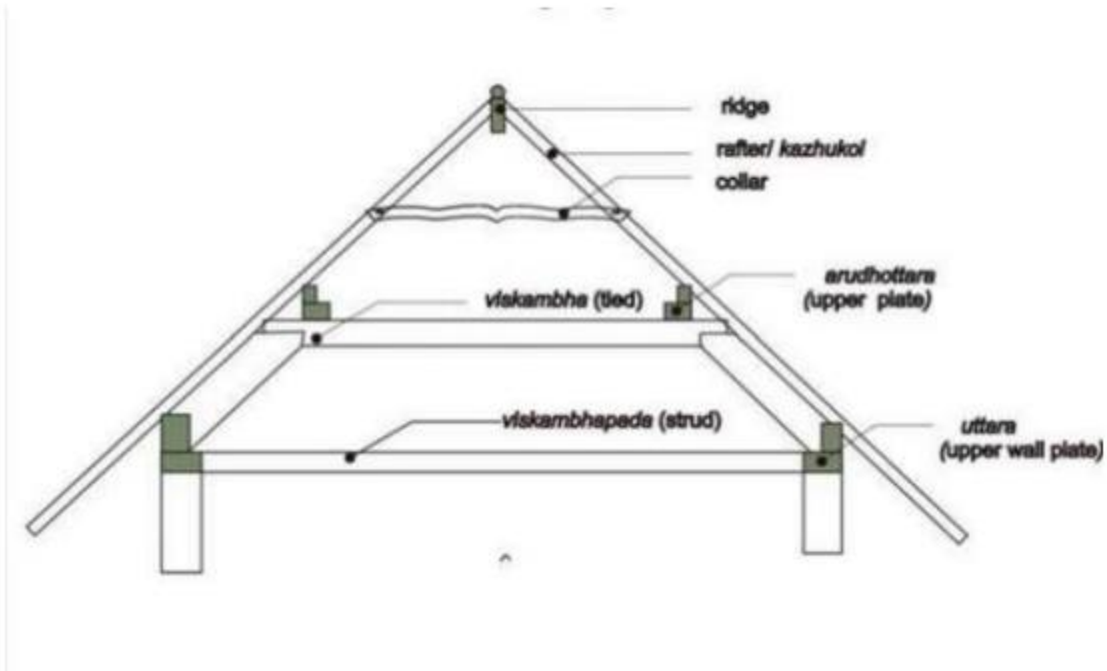


Figure 3: pitched roof ofkerala(source:https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.slideshare.net%2Ffaseehun%2Fkerala architecture&psig=AOvVaw2zgnOficjdK9EdzzgdAHtp&ust=1605443063715000&source=im ages&cd=vfe&ved=0CAIQjRxqFwoTCMDCys-Dgu0CFQAAAAAdAAAAABAE)

2.2.4 Typology of Structure

According to structural and spatial arrangements, there are five general types of residential forms (veedu) in Kerala notably:

1. Rectangular hall (I-Shape) type shelter, belonging to ordinary folk and some tribal people (adivasis). They don't necessarily follow any formal treatise.

2. Rectangular single-hall building (I-shape) type, with structural type of: ekasala; and ekasala with extension.

3. Traditional courtyard house, nalukettu ; and their derivative types, e.g.: Great mansion of ettuketu (Malayalam terms for double nalukettu), patinjarukettu (Malayalam terms for double ettukettu). They are characterized by consistency in complying with the prescription of regional vaastushastra.

4. Vernacular courtyard house: kuttikettu (Malayalam term for ekasala with courtyard-like extension). They are practically veedu with small courtyard and their structure contained many exceptions from the regional vaastushastra; Nalukettu with small courtyard and the Muslim's Veedu.

The five general types and their variants could be related to one another with regard to sequential establishment from rectangular hut, rectangular house, and rectangular house with extension, courtyard house and multi-courtyard house.

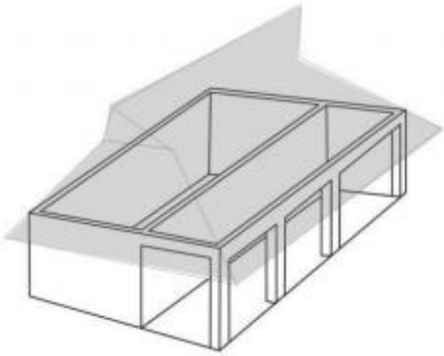


Fig 4. Basic Core-Veranda Structure of Ekasala (Source: Widiastuti, 2004)

Fig 5. A Veedu at Chengganur Source: Widiastuti, 2004

2.3 TRADITIONAL SPACES IN THE ARCHITECTURAL OF KERALA

Unlike in European cities ,where large public spaces are built into the city road networks, kerala does not have many open spaces for public interaction. Spaces for interaction were restricted to domestic and religious architecture.two such spaces of interaction may be studied here in courtyard of agraharam.

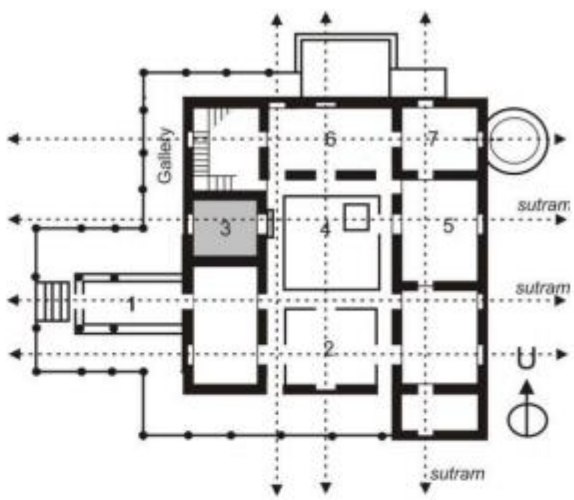


Fig 6. A Manna in Pallipuram, not to scale Source: Widiastuti, 2004

2.3.1 Nadumuttam(courtyard)

The courtyard of the nalukattu houses of kerala are the heart of the homes. Apart from serving from functional activities like drying rice having a water cistern garden or children playground. The space comes to life during festivals and domestic celebrations. However many cases of the courtyard house do not strictly obey the canonical principle of Vaastu. Some local varieties of nalukettu appear. There is another variation of nalukettu structure that performs more or less open lay-out space around a small courtyard. See Fig.6

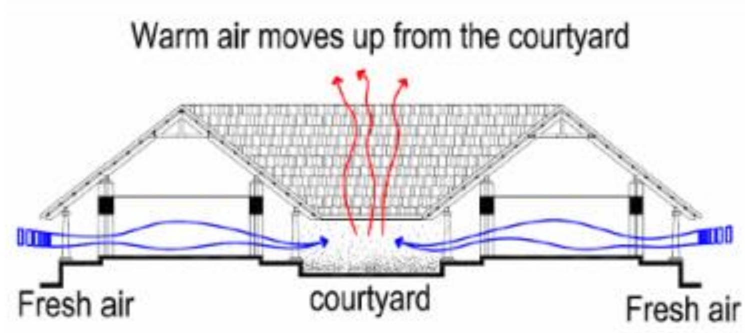


Fig 7: The influence of internal courtyard of Kerala traditional residential buildings in providing a comfortable indoor environment. Source: Dili, A.S., Naseer,M.A., Varghese Z.(2010).

The courtyard could be so small that it works better as water cistern. The domestic activities are not necessarily confined inside segmented rooms but mix together in an open layout spaces around the courtyard (nadumutham).

Nalukettu of this type could be so small that it only requires single wall-plate (uttaram) to bind the whole structures on which one continuous encircling roof structure rest. The construction of nalukettus of this type is built entirely from wooden structure with fewer openings. This type is found mostly in southern Kerala. In Kanyakumari district there is structure of courtyard Nayar landlord house of this description and it is locally termed as arapura

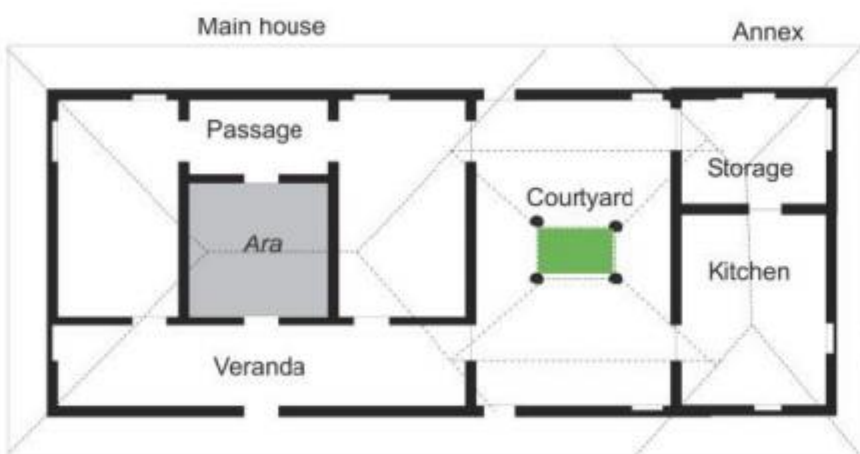
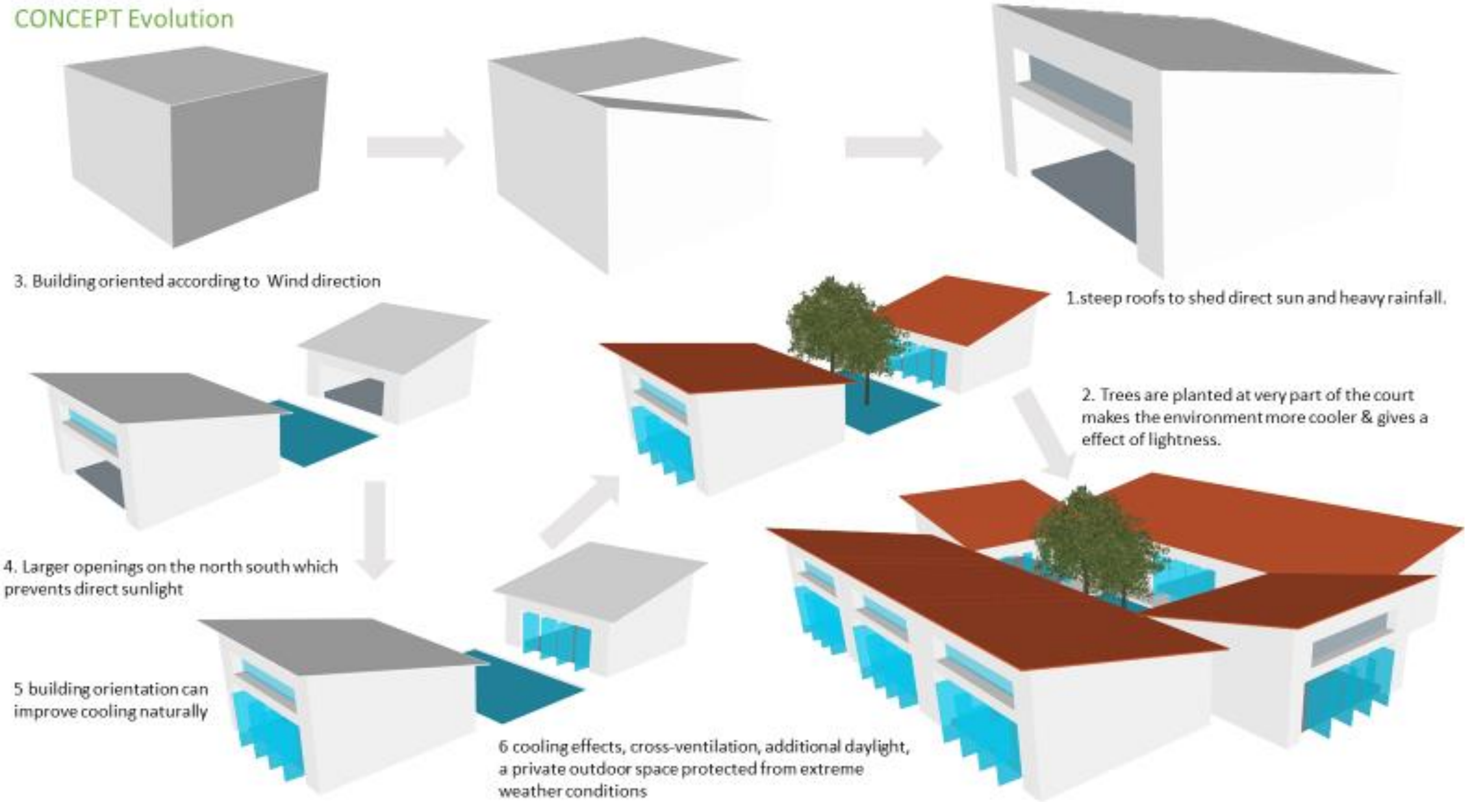
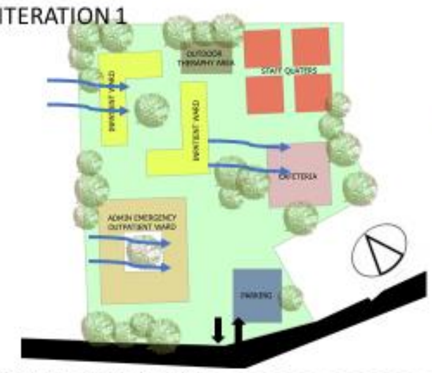


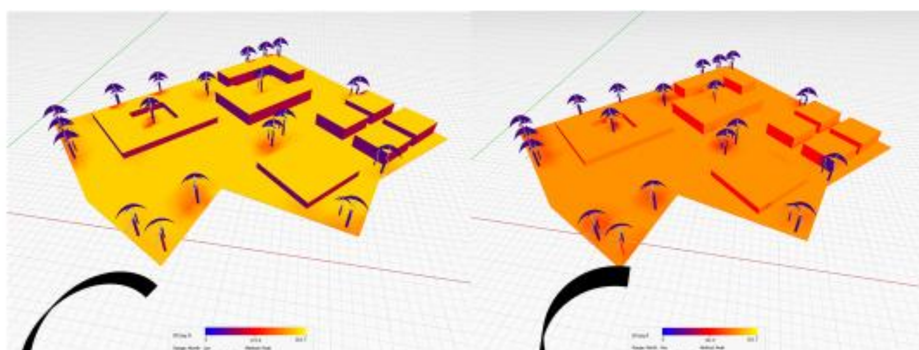
Fig 7. Christian Syrian House, not to scale Source: Widiastuti, 2004

CONCEPT Evolution



ITERATION 1



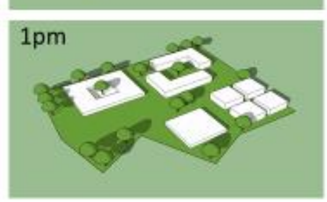


SUMMER SOLSTICE

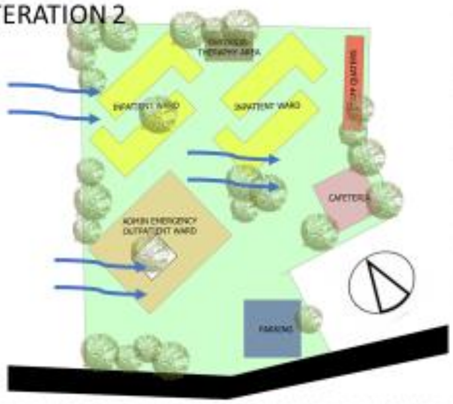
Orientation of wards and admin block longer side towards east and west makes over heat during summer. During 4pm experience high amount of radiation from sun.

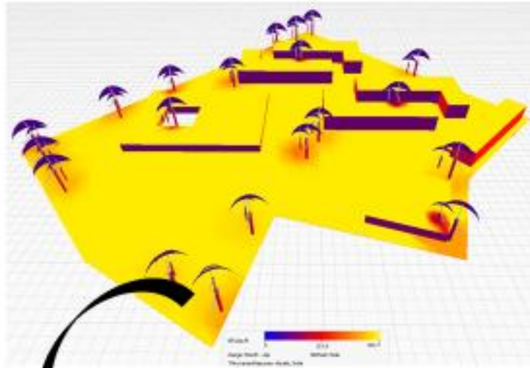
WINTER SOLSTICE

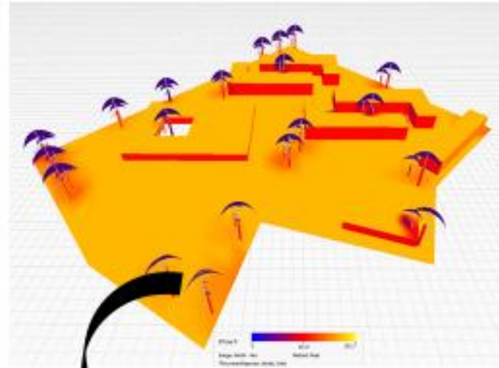
During winter the spaces experiences more mutual shading during 8am and 5pm, hence this makes site even colder during winter.



ITERATION 2







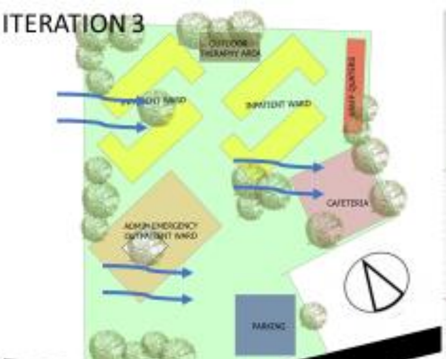
SUMMER SOLSTICE

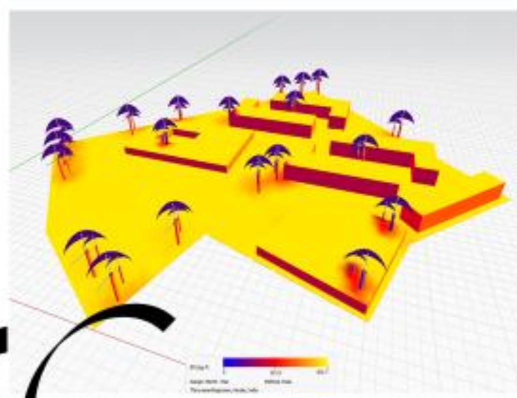
During morning time the shade of the inpatient ward blocks helps to in mutual shading. Since the admin is square shaped hence it makes longer walls in the west and east.

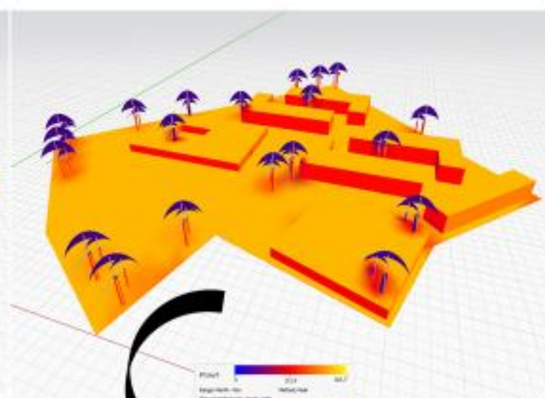
WINTER SOLSTICE

During winter time the spaces need maximum sun radiation but due to shaped Block Mutual shading happens hence the site experience extreme cold during winter time.

ITERATION 3





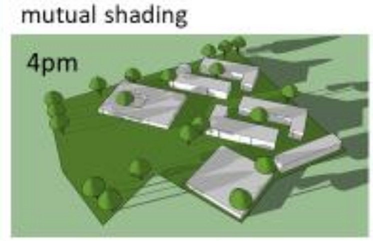


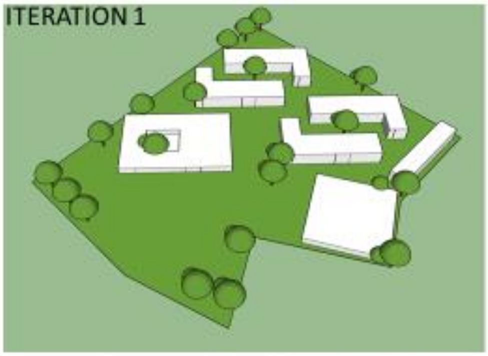
SUMMER SOLSTICE

Blocks are tilted towards the longer wall side on the north south direction. And the space between the wards increased so that it works like an wind catcher

WINTER SOLSTICE

During winter time the block experience maximum radiation from sun and helps in maintaining thermal comfort inside the block by mutual shading





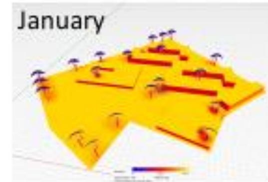
PROS

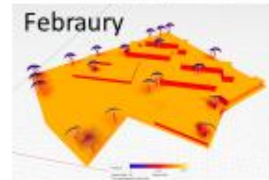
•The longer axis of the block is along north east - south west

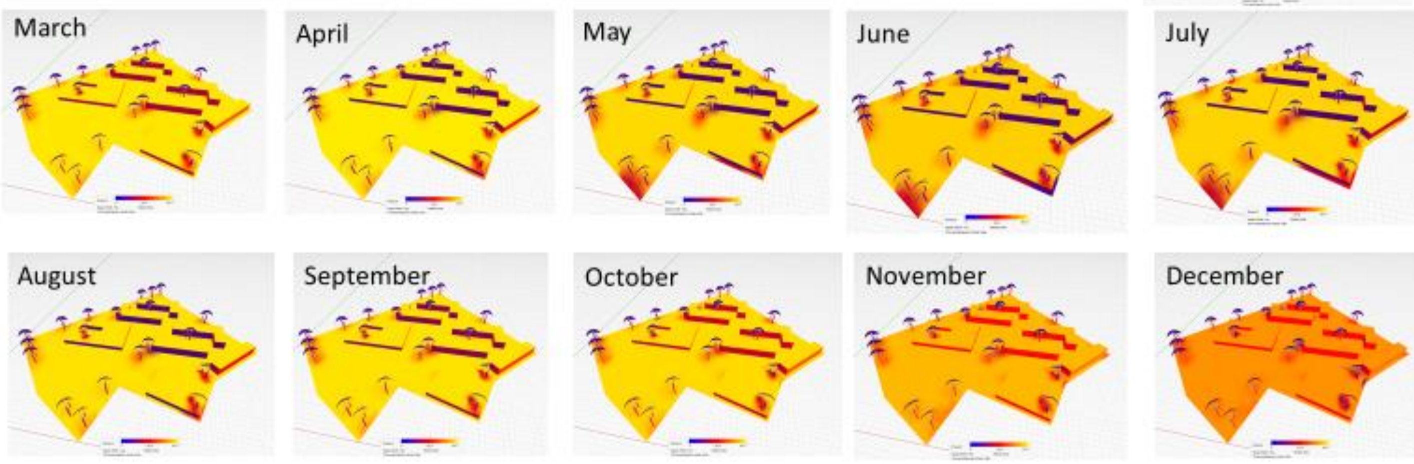
•Block is tilted to allow the wind from both east and west to allow wind to flow through.

CONS

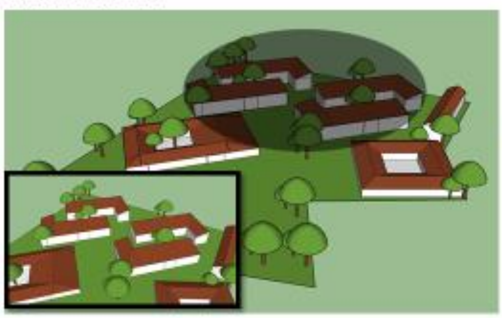
Sun radiation will be high and temperature inside the block is increased due to flat roof.







ITERATION 2

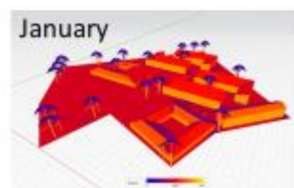


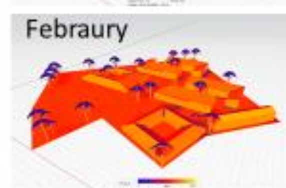
PROS

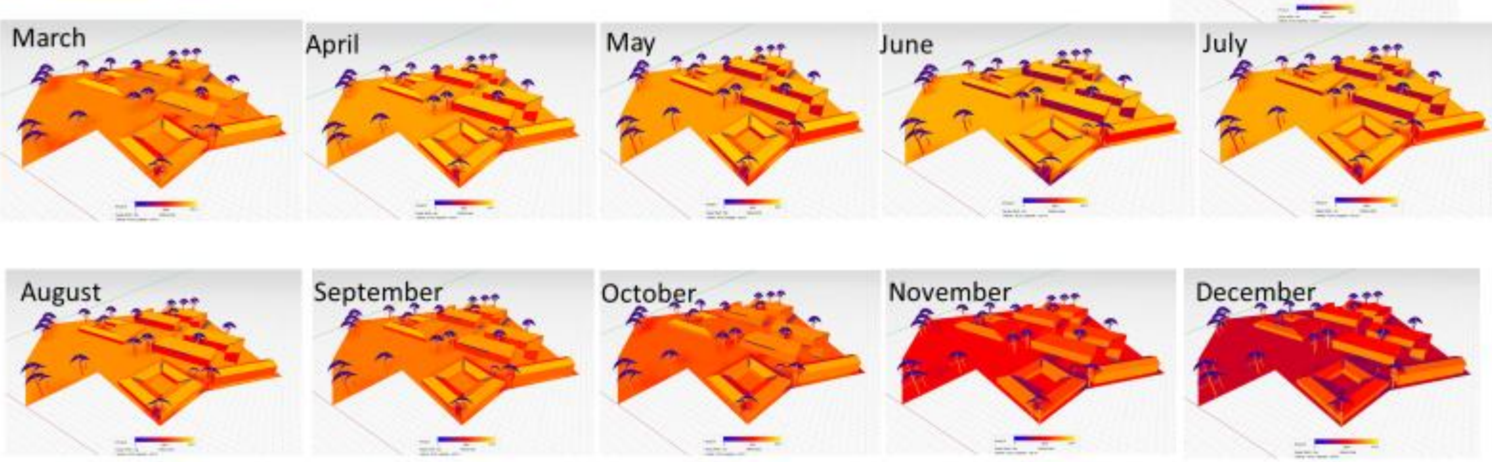
•The longer axis of the block is along north east - south west

•Block is placed in a way it allows eastern and western wind to flow through.

Sun radiation will be high and temperature inside the block is increased due to less opening in the block. Due to continuous air flow the heat inside the block is reduced.







ITERATION 3

PROS

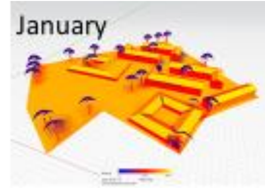
•The longer axis of the block is along north east - south west

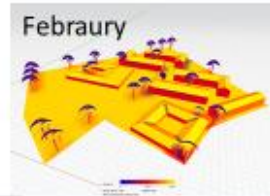
•Block is tilted to allow the wind from both east and west to allow wind to flow through.

•Pitched roof is provided for every block which reflects the solar heat by half

CONS

Sun radiation will be high and temperature inside the block is increased due to flat roof.


January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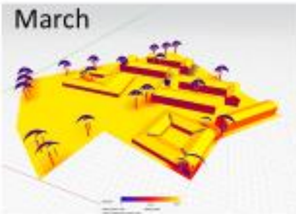
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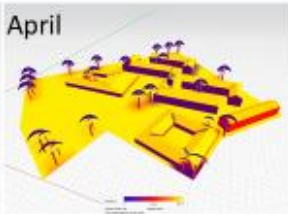
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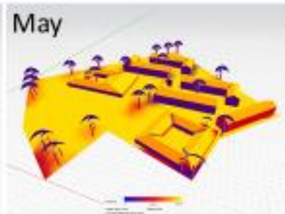
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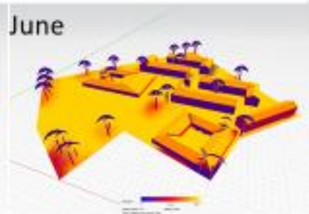
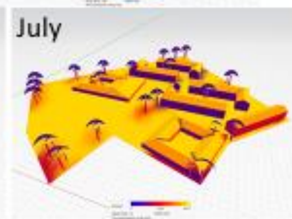

June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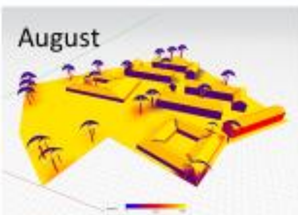
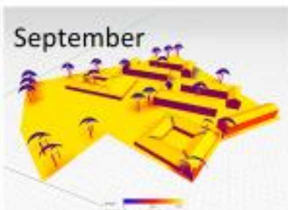
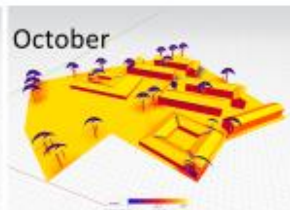
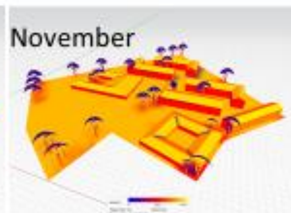
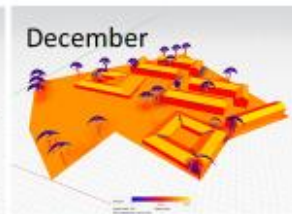

August


September


October


November


December

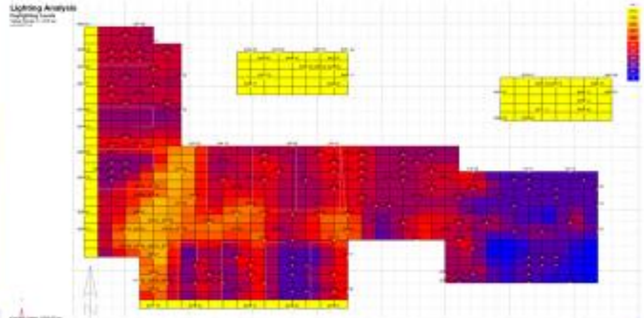
INFERENCE FOR ITERATION 1	INFERENCE FOR ITERATION 3
Since thiruvananthapuram is warm and humid climate the space need equal amount of cool during different climatic conditions.	Since thiruvananthapuram is warm and humid climate the space need equal amount of cool during different climatic conditions.
JUNE - Due the block spatial arrangements the heat or radiation from sun can be reduced with the help of shading devices.	JUNE - Due the block spatial arrangements the heat or radiation from sun is cut off with help of pitched roof shading device and openings according to wind direction maintains comfortable temperature inside the building.
DEC –due to space arrangement the surface of blocks experience direct heat , placement of jaali courtyard can trap radiation inside the building during day and it can use in night.	DEC –due to space arrangement the surface of blocks don't experience any direct sun radiation because of the angled planning and steep roof and gives shade inside the courtyard. Wind can captured by operable windows.
Thus this arrangement helps very well in summer but not in winter.	Thus this arrangement helps both in winter and summer by maintaining temperature inside the block.

Base case iteration (wards)

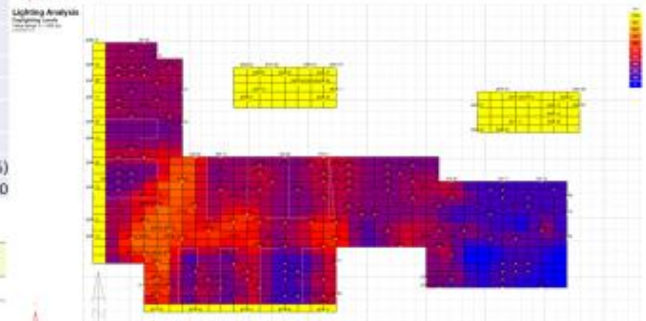
Report: Grid Analysis				
Description: Percentage of nodes by contour band.				
Model:				
Daylighting Levels				
Contour Band	Within		Above	
(from-to)	Pts	(%)	Pts	(%)
0-810	686	64.67	840	100

Building Category	Percentage of above grade floor area meeting the UDI requirement		
	ECBC	ECBC+	SuperECBC
Business, Educational	40%	50%	60%
No Star Hotel Star Hotel Healthcare	30%	40%	50%
Resort	45%	55%	65%
Shopping Complex	10%	15%	20%
Assembly*	Exempted		

*and other buildings where daylighting will interfere with the functions or processes of 50% (or more) of the building floor area



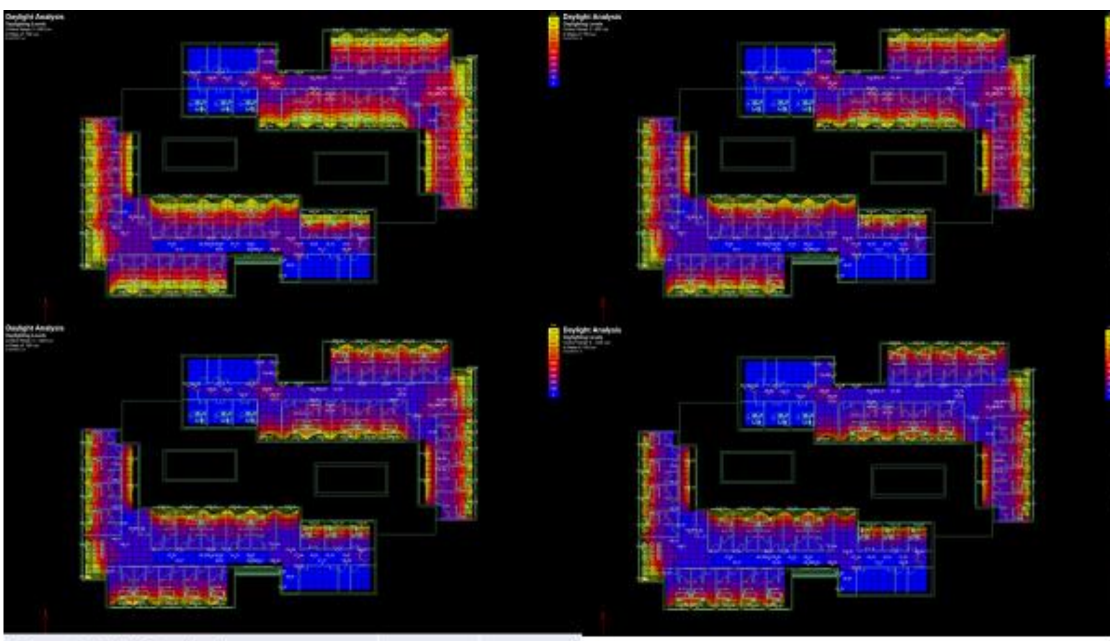
GROUND FLOOR:
The **openings** on the side of **shops** helps achieve **max usage of daylight** but the **corridor space** experience less amount of **light comparatively.**

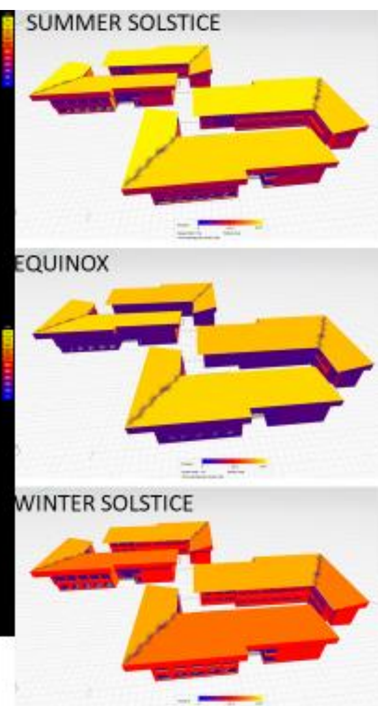


TYPICAL FLOORS:
In this floor both **courtyard and wards** are sufficiently lit by solar and **opening in the centre helps light enter** the space acts as light shelf

Inference

Average lux level of 686 is achieved through almost 64.67% of the indoor spaces in the site. The wards on the sides experience mim amount of light during day.

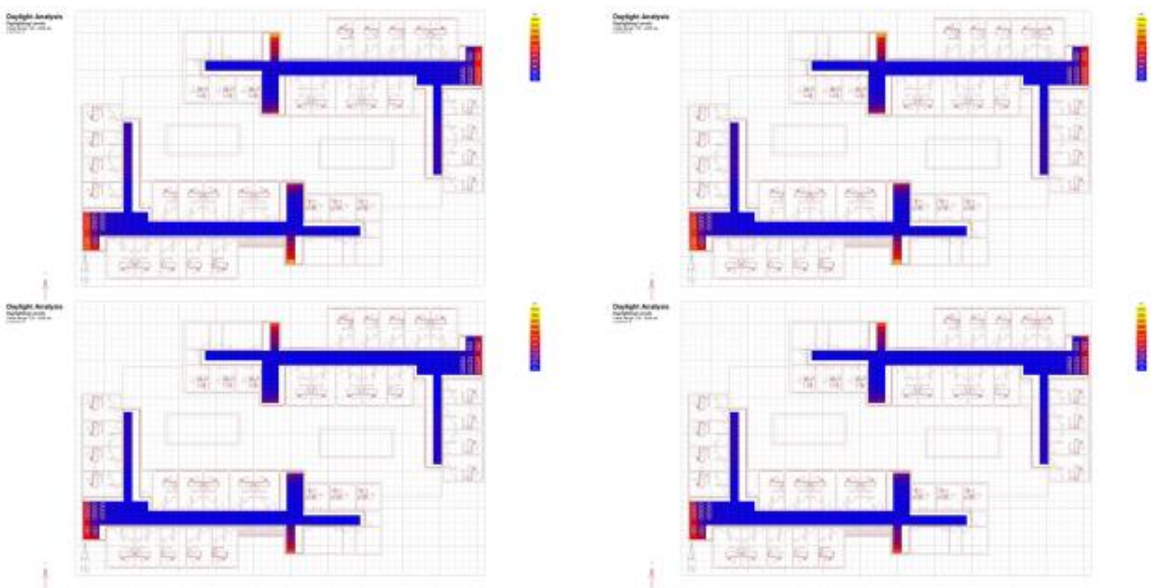




Report: Grid Analysis				
Description: Percentage of nodes by contour band.				
Model:				
Daylighting Levels				
Contour Band	Within		Above	
(from-to)	Pts	(%)	Pts	(%)
0-810	523	43.7	830	100

Inference

Average lux level of 120pts is achieved through almost 43.7% of the indoor spaces in the site. The wards on the sides experience min amount of light during day.
Still some spaces found not enough day light .and during summer solictice solar radiation less impact inside the courtyard spaces



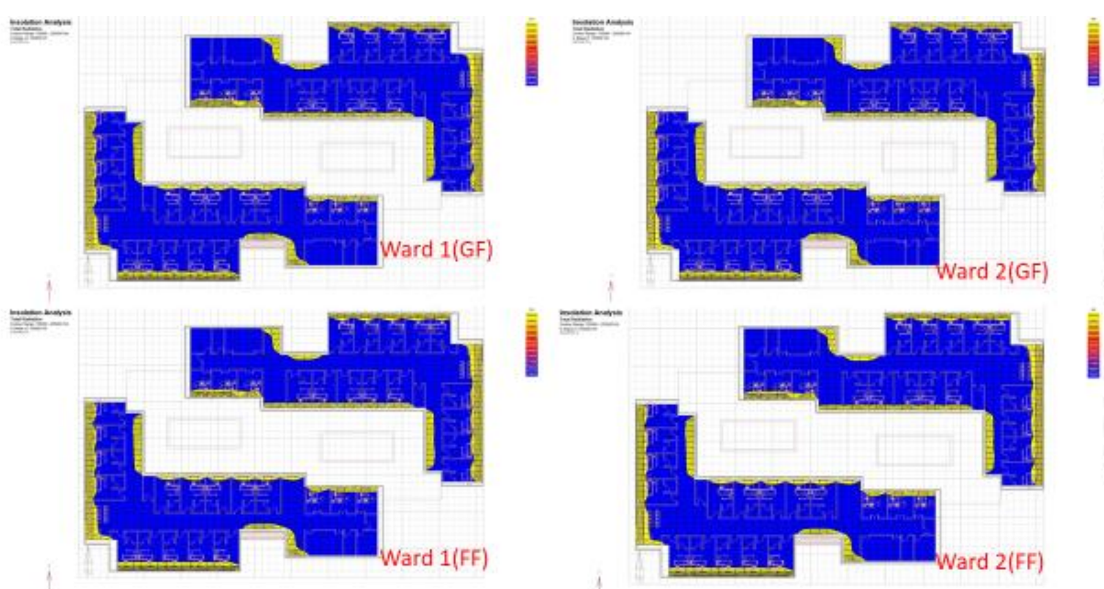
Report: Grid Analysis

Daylighting Levels

Contour Band (from-to)	Within Pts	(%)	Above Pts	(%)
100-810	1080	42	903	100

Inference

Average lux level of 128pts is achieved through almost 42% of the indoor corridor spaces in the site. In the wards on the corridors experience min amount of light during day. Still some spaces found not enough day light .



Insolation analysis

Incoming **solar radiation** (**insolation**) received from the sun is the primary energy source that drives many of the earth's physical and biological processes. ... The resultant outputs can be easily integrated with other GIS data and can help model physical and biological processes as they are affected by the sun.

Report: Selected Objects

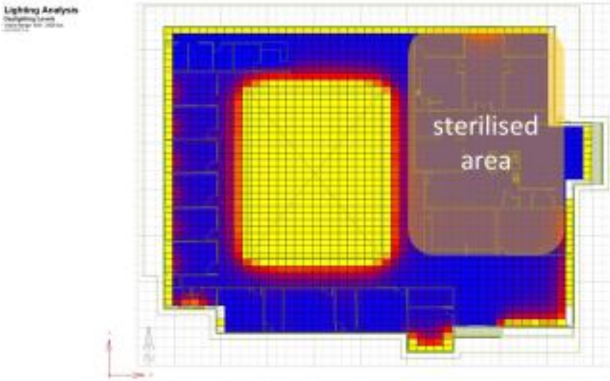
Selected Objects

Object ID #	Object Type	Surface Area (m2)	Exposed Area (m2)	Under Ground (m2)	Azimuth Angle (°)	Altitude Angle (°)
Zone: base.dxf						
27556	Floor	530.263	98.22	0	0	
27574	Floor	530.426	108.47	0	0	
TOTAL		1060.689	1060.689	0		

Inference

Exposed area of solar radiation about 98.22m2 from 530.263m2 and in first floor 108 by 520 pts is achieved through almost 28% of the indoor spaces. And found more heat near the openings because of direct sun light during the sunny days and noon times that results heat gain inside the space.

Admin block



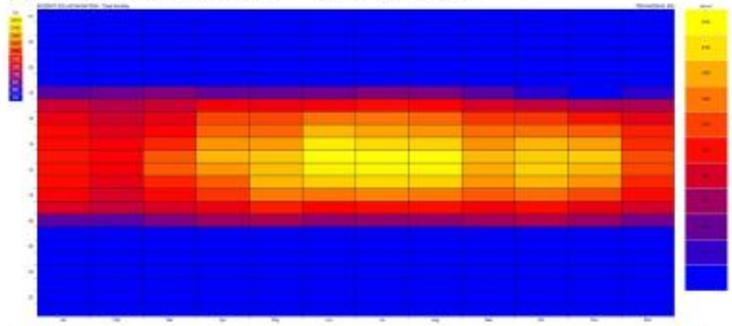
Report: Grid Analysis				
Daylighting Levels				
Contour Band	Within		Above	
(from-to)	Pts	(%)	Pts	(%)
400-1260	1435	65.17	2201	99.95
1260-2120	136	6.18	766	34.79
2120-2980	70	3.18	630	28.61

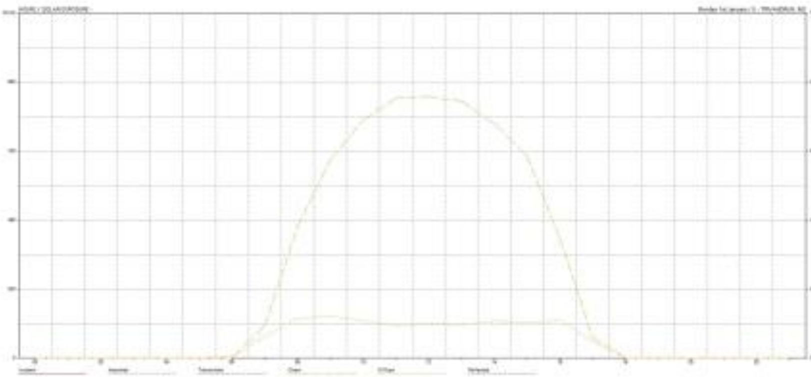
Inference

During **winter** season the high **radiation on the walls** helps maintain thermal comfort inside the building.

Operable windows helps free air flow during summer seasons

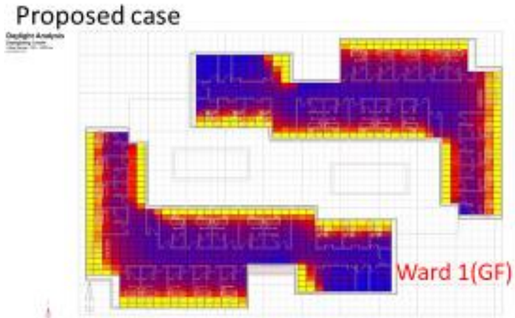
Incident solar radiation – total monthly

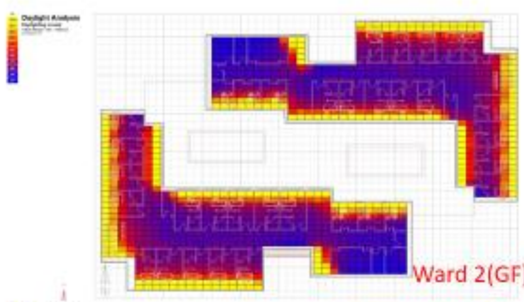


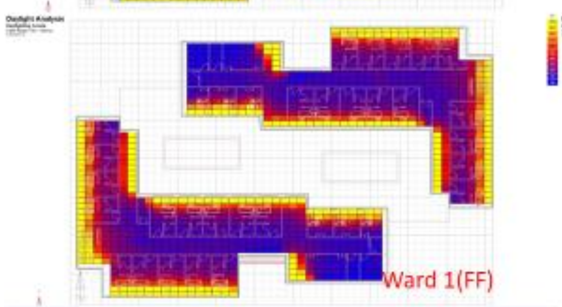


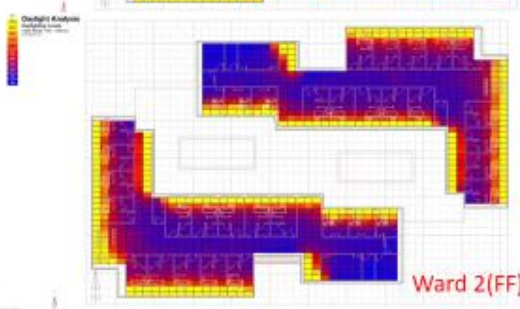
Experiencing high solar radiation above 2400w/m2 between June July august months.

Proposed case









Increase in width can increase the **effect of courtyard in design**.

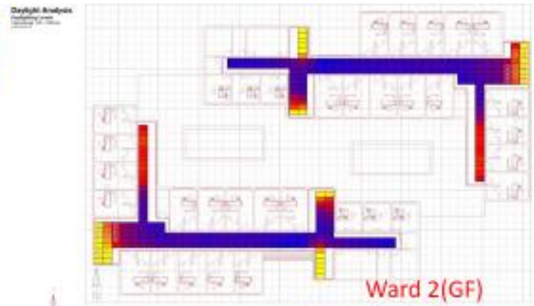
And also increased the window size so that day light enters into the space easily. also provided jaalis works in the waiting lobby and indoor theraphy area which gives more daylight.

Report: Grid Analysis				
Description: Percentage of nodes by contour band.				
Model:				
Daylighting Levels				
Contour Band	Within		Above	
(from-to)	Pts	(%)	Pts	(%)
0-810	654	66.7	830	100

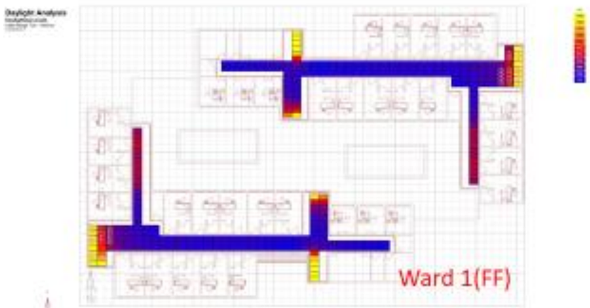
Inference

Average lux level of 480pts is achieved through almost 66.7% of the indoor spaces in the site. The wards on the sides experience min amount of light during day.

Still some spaces found not enough day light .and during summer solictice solar radiation less impact inside the courtyard spaces



Day light in corridor achieved by providing light wells along the corridor top . which results day light during noon imes.



Report: Grid Analysis

Daylighting Levels

Contour Band	Within		Above	
(from-to)	Pts	(%)	Pts	(%)
100-810	1080	68	903	100

Inference

Average lux level of 370pts is achieved through almost 68% of the indoor corridor spaces in the site. In the wards on the corridors experience needed amount of light during day.

Increase in **courtyard size** also **increases air flow** inside the spaces Increase in size of the courtyard helps increasing wind flow.

Placing jaali on the western and eastern side **helps increase wind flow** thus maintain comfort temperature inside the block.

Radiation can reduce by using movable window

Report: Selected Objects

Selected Objects

Object ID #	Object Type	Surface Area (m2)	Exposed Area (m2)	Under Ground (m2)	Azimuth Angle (°)	Altitude Angle (°)
Zone: base.dxf						
27556	Floor	530.263	78.22	0	0	
27574	Floor	530.426	89.47	0	0	
TOTAL		1060.689	1060.689	0		

Inference

Exposed area of solar radiation about 98.22m2 from 530.263m2 and in first floor 108 by 520 pts is achieved through almost 28% of the indoor spaces. And found more heat near the openings because of direct sun light during the sunny days and noon times that results heat gain inside the space.

The **oat space connects** with all the other space acts as **centre element** and that also helps in circulation of people inside the site.

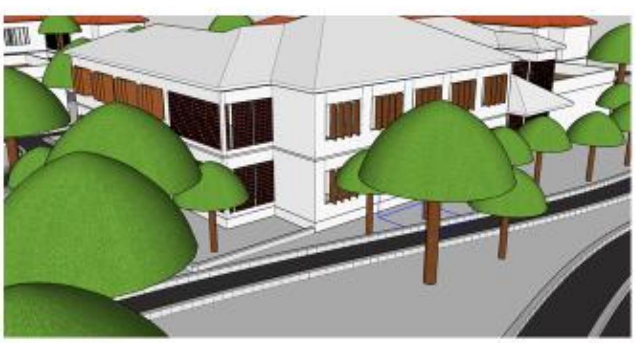
Lots of **open spaces** helps people to **experience outdoor environment called outdoor theraphy area.**

This also **helps in air moveme**nt inside the space.

Since kerala has warm and humid **climate trees helps** in maintaining **comfortability and helps in reducing humidity level and keeps environment cool**

Tress helps in stops direct sun sunlight and helps in providing diffused light And helps to reduce the humidity in micro level

The courtyard provides visual connection for the ward of the first pavilion



roofing tiles, like natural slate, are extremely tough, waterproof and fire-resistant.

Shaped as a triangle, they are stable, stronger and ensure perfect water drainage.

Pitched roofs are built to withstand snow, ice, water and wind.

Buildings with pitched roofs are roughly 10-15% more compact than those with a flat roof.

Thermal insulation

- This gives higher thermal insulation by simply limiting the size of the surface exposed to the exterior.

RAINWATER CALCULATION

ROOF TOP RAIN WATER HARVESTING

PLAN

LEGEND

Rooftop draining area from blocks.

ROOF TOP DRAINING AREA CALCULATION

Rain water harvesting from roof = Area of roof x coefficient x annual rainfall (in mm)

Area of the Total roof = **4343 sqm**

Coefficient of runoff = **0.8**

Annual Rainfall of Bangalore = 2197 **mm**

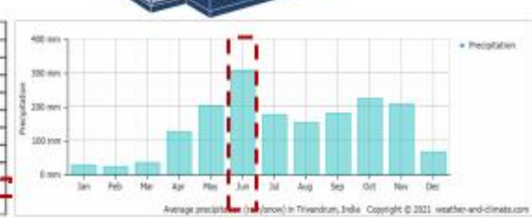
Rain water harvesting from roof = 7,633,256 litres annually.

For the month of June (highest rainfall of 300mm) = 1,042,320litres.

Pitched roof catchment of rainwater

REFERENCE.

Type of surface or land use	Runoff coefficient C
Forest	0.1 - 0.3
Turf or meadow	0.1 - 0.4
Cultivated field	0.2 - 0.4
Bare earth	0.2 - 0.9
Pavement, concrete or asphalt	0.8 - 0.9
Flat residential, about 30% impervious	0.4
Flat residential, about 60% impervious	0.55
Sloping residential, about 50% impervious	0.65
Sloping, built-up, about 70% impervious	0.8
Flat commercial, about 90% impervious	0.8



STORMWATER RUNOFF CALCULATION

PLAN

- Water collected from roof is stored in different tank placed close to retail block.
- In order to reduce usage of pipes to reuse the water in buildings.

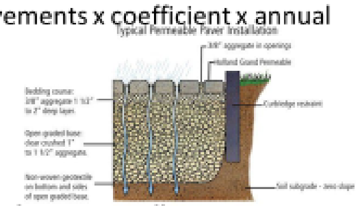
STORM WATER RUN OFF AREA CALCULATION

Storm water runoff from pavements = Area of pavements x coefficient x annual rainfall (in mm)

Area of the pavements = **4893 sqm**

Coefficient of runoff = **0.8**

Annual Rainfall of Bangalore =2197 **mm**



Storm water run off from pavements= 8,599,936.8litres annually.

For the month of September (highest rainfall) = 1,174,320litres.

REQUIRED TANK CAPACITY

For the month of june(highest rainfall 300mm)

Total collected litres from **roof top = litres**

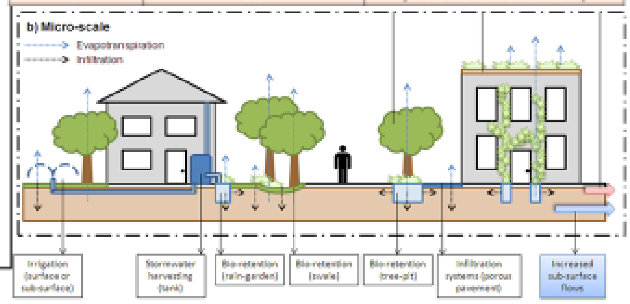
Total collected litres from **pavements = 1,174,320litres**

Total collected water = 12,49,103 litres

TANK CAPACITY -

12mx12mx10m = 1440cum x 1000litres= 14,40,000litres

STORM WATER RUN - OFF CALCULATIONS (PAVEMENT AREA)		
Qt =	C * It * A	
Qt: runoff rate for a T-year storm, in liters/second C: runoff coefficient, nondimensional IT: rainfall intensity for a T-year storm at a storm duration t, in liters/(second*hectare) A: area of the catchment area, in hectares		
C	0.8	(With the ref. to the table)



SOLAR PANEL CALCULATION

PLAN

TRANSFORMER

LEGEND

Allotted Roof space for solar panel.

SOLAR ENERGY FROM EACH BLOCK

WARD BLOCK

Roof Area –**2120 sqm**

No of panels –**1098 nos**

Energy produced –**549,000wh/day**

ADMIN

Roof Area – **975 sqm**

No of panels –**505 nos**

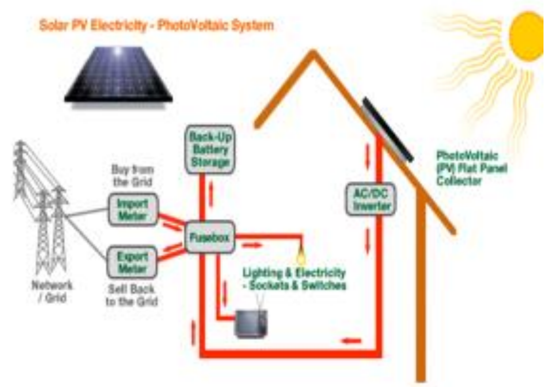
Energy produced –**252,500wh/day**

CAFÉ, STAFF QUATERS

Roof Area –**438sqm**

No of panels –**226 nos**

Energy produced –**113,000wh/day**



SOLAR PANEL CALCULATIONS		
Dimension of single solar panel (standards for commercial purpose)	77" x 39" - 30030 sq.inch	1.93 sq.m
Electricity produced by a single solar panel	500 Wh/ day	
Total roof area	3533 sq m	
NO. of solar panels to be installed - Roof area / Area of single solar panel	3533/1.93	3321 panels
Total generation of electricity in the site through solar panels -Electricity produced by a single solar panel * NO. of solar panels to be installed	116,566	**Wh/day**

WASTE WATER CALCULATION

PLAN

LEGEND

Toilet

WASTE WATER

- **WC** = **1.28**gallons per flush
- **Wash basin** = **2 gallon/min** for 20seconds= 0.67 gallons
- **Urinals** =**1**gallons per flush
- **kitchen sink** = **2.2**gallons per minute

SPACES	WC	WASH BASIN	URINALS	TOTAL WATER/USAGE
ADMIN	16	8	4	40.48
WARDS	6	4	3	17.68
CAFE	8	6	4	26.24
STAFF QUATERS	8	6	4	26.24
TOTAL WATER CONSUMPTION				115.04 Gallons

Assuming 1000 persons/day
•1,15,040 gallons of waste water/day.
•Providing the maximum capacity so that it does not overflow.

Waste water tank capacity:
•(Length X width X depth in feet)/ 0.1337 = gallons
•(40 X 30 X 20) / 0.1337 = 1,79,506.3 gallons
•12m X 9m X 6m is the **capacity of sewage tank** on the site.
•Utilizing the **natural slope** on the site for the **drain of waste water.**

Table 7.3.1: Interior Lighting Power - Building Area Method

Building Area Type	LPD (W/m²)	Building Area Type	LPD (W/m²)
Automotive Facility	9.7	Multifamily Residential	7.5
Convention Center	12.9	Museum	11.8
Dining: Bar Lounge/Leisure	14.0	Office	10.8
Dining: Cafeteria/Fast Food	15.1	Parking Garage	3.2
Dining: Family	17.2	Performing Arts Theater	17.2
Dormitory/Hostel	10.8	Police/Fire Station	10.8
Gymnasium	11.8	Post Office/Town Hall/	11.8
Healthcare-Clinic	10.8	Religious Building	14.0
Hospital/Health Care	12.9	Retail/Mall	16.1
Hotel	10.8	School/University	12.9
Library	14.0	Sports Arena	11.8
Manufacturing Facility	14.0	Transportation	10.8
Motel	10.8	Warehouse	8.6
Motion Picture Theater	12.9	Workshop	15.1

General Lighting	100 lux
Nursing Stations	150-300 lux
Night Lighting	1 lux
Examination Lighting	1000 lux

Ref. : Lighting Design Strategies For ECBC Compliant Buildings

Calculation for lighting in a single ward
Area of a single ward 90 sq m
Watt required per sq m 16.1 LPD
Total Light Power Density Area of a single ward x
Watt required per sq m
-90 x 16.1
-1449 W requirement for artificial lighting Jan
Dec Due to less amount of daylight
Min requirement May Due to sufficient
daylight

Area	Illuminance in Lux	Limiting glare index	Minimum colour rendering
General lighting	100	19	80
Waiting rooms	200	22	80
Corridors: during the day	200	22	80
Corridors: at night	50	22	80
Day rooms	200	22	80
Staff office	500	19	80
Staff rooms	300	19	80
Reading lighting	300	19	80
Simple examinations	300	19	80
Examination and Treatment wards	1000	19	80