

SUSTAINABLE SCHOOL OF ARCHITECTURE BASED ON BUILDING DESIGN PARAMETERS FOR AUGUMENTING INDOOR COMFORT

A Thesis

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

by

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

SATHYABAMA

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

Accredited with Grade "A" by NAAC

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MAY 2022



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BONAFIDE CERTIFICATE

This is to certify that this Report is the bonafide work of **S.MANASWINI DEVI (40890009)** who carried out the Thesis entitled "**SUSTAINABLE SCHOOL OF ARCHITECTURE BASED ON BUILDING DESIGN PARAMETERS FOR AUGMENTING INDOOR COMFORT**" under our supervision from January 2022 to May 2022.

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ABSTRACT

Study on the role of Building parameters to augment Indoor comfort for a Naturally ventilated university building. The Architecture studio classes are strenuous and involves a lot of minute precision works with scope of innovation. The mental impact of the quality of the space and the design of the learning space is profound on the future architects who can design the future buildings of the new generations. A scope of understanding through experience can be provided to have a lifelong impact. The study involves in improving the quality of the learning space based on the Indoor Comfort for an Architectural university by evaluation of the base case scenario of an existing institution building. This helps to understand the need for effective planning of the building space to promote Indoor comfort. Indoor comfort involves study of Both Visual and Thermal comfort simultaneously as the factors are interlinked. A particular case study is analyzed with the simulation method and the space designed with passive strategies proved to be in comfort. Except from mid-April to September 3 to 4 deg higher than the maximum acceptable temperature. Mechanical fans can help with a reduction of 2 deg C. Temperature of 3 to 4 deg C can still be acceptable by the criteria 3 as described by the IESVE Software manual. The design parameters analyzed for a comparative study to understand the efficiency of Passive strategies to improve efficiency of Indoor comfort. Three Case studies was evaluated to understand the efficiency of Passive Strategies Implemented in the Case studies. Based on the design the Thermal and Visual Comfort Analysis was performed and evaluated. It was noted that placing the transition spaces effectively helps improve thermal and visual Comfort. The temperature noted is 2 to 3 deg Higher than Max Acceptable Temperature as per IESVE Adaptive Manual in the Transition spaces of the Case studies.

The design was based on 3 main Design Parameters Spatial Planning, Building Envelope and Open and Transition spaces. By focusing on the placement of transition spaces to improve the Comfort condition the design was evolved. Further Detailed Iterations was carried out for the shading of the Transition spaces to achieve the optimum comfort conditions requires. The Transition spaces thus planned are within the comfort of 2 deg C (Higher than Max Acceptable Temperature) for Central Transition space and 3 deg C (Higher than Max Acceptable Temperature) for Art Court East and West throughout the year. Placement of the Buffer of 1.5 m or 0.75 m on both sides helps reduce glare and increase the thermal comfort of the studio Spaces. Validation of the design is done through Lightstanzza for Daylight and IESVE for Thermal Comfort Analysis.

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LIST OF SYMBOLS AND ABBREVIATIONS

ET	-	Effective Temperature
TSI	-	Tropical Summer Index
Top	-	Operative Temperature
SDGs	-	Sustainable Development Goals
NV	-	Naturally Ventilated
SDA	-	Spatial Daylight Autonomy
UDI	-	Useful Daylight Index
DF	-	Daylight Factor
Tn	-	Thermal Neutrality
Trm	-	Running Mean Temperature
ASE	-	Annual Solar Exposure

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

A student spends about 1/3 of the daily time in the campus and is a very important learning phase. Considering an Architectural University building each space based on the functionality such as the Studio, Materials lab, Display Lab, Review Room and Common areas- all have different needs and usage patterns according to which the Indoor comfort and occupant well-being level varies. Day lighting and Thermal comfort are important environmental factors that affect the health, emotions and academic performance of the students as well as the energy consumption of the educational buildings. In educational building windows are considered as the main fenestrations to provide proper daylight and natural ventilation for Indoor comfort.

1.2 AIM

To design a Sustainable School of Architecture Building focusing on the Impact of the Design Parameters on the Indoor Comfort.

1.3 OBJECTIVE

1. To Understand the Impact of the Design parameters in Case studies for the Optimal comfort of the Indoor spaces in the existing design.
2. To Evaluate schematic models for the design case based on the existing Inferences.
3. To optimize the space usage and activity periods during the occupancy hours based on comfort models for the Indoor spaces with focus on designed Transition spaces.
4. To Identify the effectiveness ratio of various design parameters for the Indoor comfort (Thermal and Visual).
5. To derive a equilibrium between the interdependency of Thermal and Visual Comfort.

1.4 RESEARCH QUESTIONS

1. What is the impact of space planning based on orientation of the buildings in the Indoor comfort?
2. Is there a change in Thermal and visual impact due to various Depth of Transition spaces and Window geometry (all Parameters) ?
3. Evaluate the impact of buffer spaces (Adjacent to the built space – corridor or Indoor Transition spaces) placement and its impact on the Indoor environmental quality?
4. What is point of equilibrium between the Visual and Thermal factors for various defined design parameters?
5. What is the Ratio of impact for the identified parameters on the Indoor Comfort based on occupancy and usage pattern for effective learning and social interactions for the students?

1.5 NEED OF THE STUDY

The building design based on its design features can have an impact on the Indoor comfort. The comfort is dependent on visual and thermal comfort. Absence of daylighting can cause may cause tiresome and exhausting after a time period. On the other hand, provision of direct solar radiation through apertures in addition to daylight may cause overheating, resulting in thermal discomfort, which not only fails to provide a stimulating environment for better teaching-learning process, but also at the same time creates pressure on the overall national energy demand due to need for mechanical ventilation and cooling to obtain Indoor Comfort. Enhancing the Indoor comfort through design parameters is the best solution for Naturally ventilated Buildings.

1.6 NEED FOR SCHOOL OF PLANNING AND ARCHITECTURE

- Rise in economic indicators like GDP, per capita incomes and Human Development Index, there would be improvement in lifestyles which would result in a higher demand for better housing, workplaces and commercial buildings, and therefore for more architects.
- The latest figures (Sept. 2018) for Human Development Index shows that while India still ranks quite low at 130 out of 189 countries in the UNDP rankings, there has been substantial progress over a period of last two decades and it is now in the medium human development category
- To meet the huge demand in a short period of time there will be a need for state of art construction technologies, for building almost 10 million houses by 2022. The emphasis would be on innovative technologies and achieving the Sustainable Development Goals (SDGs) as laid out by the United Nations (UN).

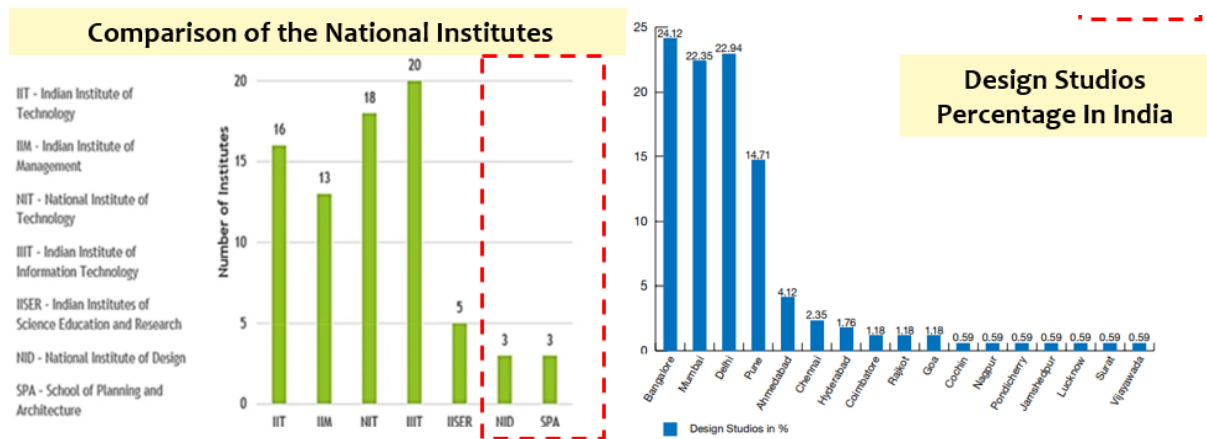


Fig 1.1 Need of the SPA Design

1.7 LIMITATIONS

1. Study is limited to Warm and Humid climatic Conditions and for a selected Context.
2. Indoor comfort parameters like acoustical comfort, Air quality and Ergonomic comfort are not included in the current study.

3. Study of the Entire campus is not included.
4. Limited Iterations are considered based on Inferences of the Literature Reviews and Codes.

1.8 METHODOLOGY

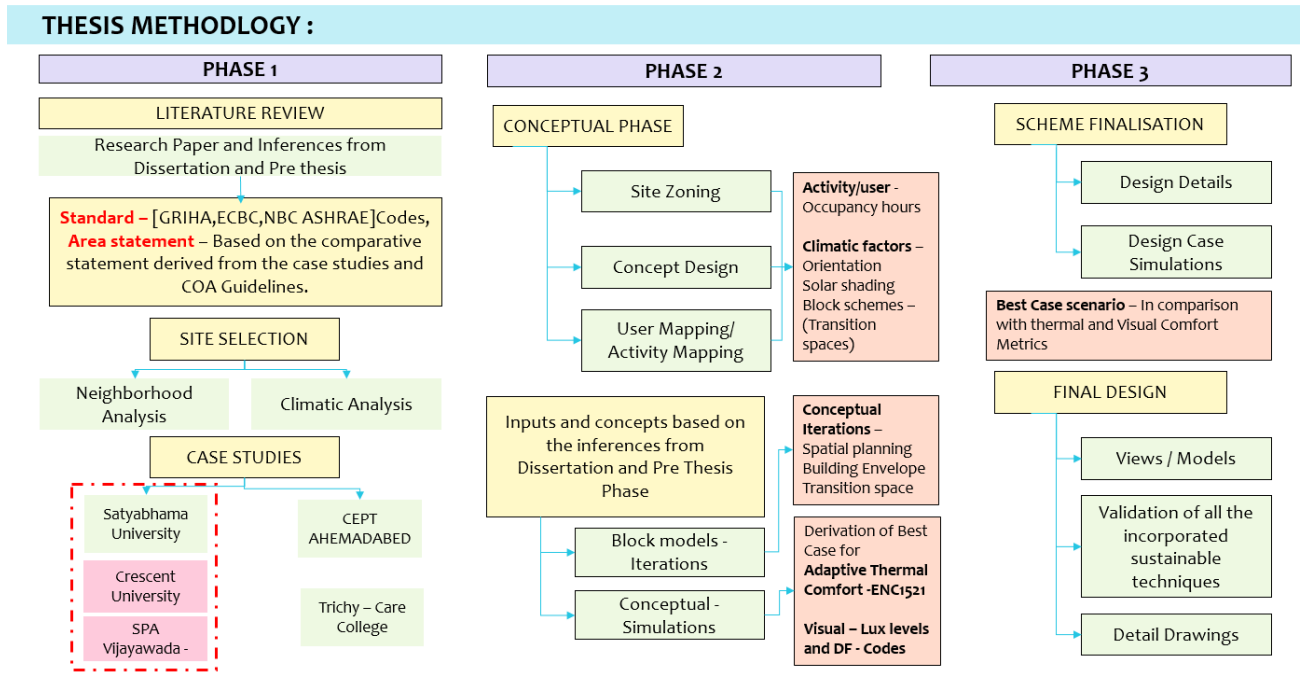


Fig 1.2 Methodology

CHAPTER 2 LITERATURE REVIEW

2.1 INTRODUCTION

Research Study focus is mainly on the Visual and thermal comfort analysis. The parameters involved Thermal comfort – Air Temperature, Humidity Radiant, Temperature, Wind Clothing, Activity Age and Gender. Visual comfort parameters include the Optimum lighting levels (lux), Quality View, Absence of Glare. The parameters are Further evaluated based on the Research Papers Review. The Papers are selected to understand the impact of Thermal comfort of Indoor space based on either field analysis or Simulated analysis along with Iterative case for efficient strategy. The same method is done for the study of the Visual Comfort as a parameter. Both parameters have to be studied simultaneously to avoid overheating due to excessive lighting causing both visual and thermal discomfort.

Table 2.1 Research paper Study Summary

S.NO	Research Paper & Author	Research paper thrust area	Methodology	Limitations	Inference
1	Analyzing The Effect Of Building Orientation, Varied WWR And Building Height On Solar Heat Gain And Internal Temperature Of University Building Located In Composite Climate Of India Raj. R. Nair, Ankit Shukla, Siddharth Shelkar, Abhishek Jatav	The aim of this research work is to control the solar heat gain and internal air temperature of the building thereby improving the thermal comfort. 3 EEM (Energy efficient measures) have been used - varying the orientation of building, window-wall ratio (WWR), and building height	The field measurements air temperature was noted down and compared with simulated results by Mean bias Error method (MBE) . The simulated model iterations are done and final best EEM is noted.	The WWR ratio was the only parameter noted down while the window geometry and window position is not noted down. Also other factors like daylighting and ventilation is not studied.	Combined effect i.e. implementing all the best effects, which we got from three EEMs, into the single building - solar heat gain a reduction of 39 – 40% is achieved and in case of air temperature a decrement of 2-3% is achieved .
2	Performance Evaluation Of Different Window Configurations To Enhance Effective Daylighting In Architecture Design Studios In Dhaka Jayedi Aman ¹ , and Md Ashikur Rahman Joarder ²	Research aims to identify window features of existing architectural design studios, located in Dhaka, that affect the studio lighting and analyze the effectiveness of different window configurations to enhance the quality of luminous environment of design studios. Visual comfort is most important aspect for the design studios where extensive design work is carried out.	Daylight and simulation tools for architectural studios is described in the first part. The second part focuses on iterative simulation study . Finally, the third part presents the findings of simulation results with conclusion	Given the limited time and scope of this research, this study has concentrated solely on lighting issues, through the thermal aspects of a space may also be affected by these options.	For a specific time frame (overcast condition), 'full height windows' were found efficient, while 'segregated viewing windows' were the most feasible option considering the most types of sky conditions.
3	An Analysis of Thermal Environment in Architectural School Classrooms of Warm and Humid Climate in Tiruchirappalli, India S. Niveditha , Dr. D. Kannammaz	This paper aims to investigate the thermal environment in classrooms as well as identifying the best and least performing spaces, concerning both environmental and personal variables by using IMAC (Indian Model for Adaptive thermal Comfort).	The study employed subjective assessments through questionnaires, physical measurements, and simulation study to observe thermal comfort for the whole year.	The study is limited only for its impact on the Thermal comfort of the space and 3 EEM measures are seen with no iterations. Further study can involve visual comfort also.	The result shows the comfort hours are increasing three times than the present case by incorporating the night ventilation technique. Adding of insulating materials is creating a reverse effect in the indoor thermal comfort environment because of the high thermal mass of surface material.
4	North-South vs East-West: The Impact of Orientation in Daylighting Design for Educational Buildings in Bangladesh Dipa Saha , Szadik Ahmed, Abu Towab Md. Shahrar, S. M. Naeem Hossain Mithun.	The study examines the impact of lighting distribution of the same prototype windows in different wall orientation. This study also shows how different window's shapes, sizes, geometries and positions in different orientation respond to lighting distribution. This study can be used to build sustainable education buildings that are highly efficient with low running cost.	Examining the existing lighting condition for windows in all wall orientation. Compare the performance of existing window and a window without shading by using an experimental computer modelling system for effective day lighting in a classroom.	The result may vary from current one if Windows having different configuration, size, position, glazing and shading are used. Also the impact on other parameters like Thermal and ventilation is not studied .	This analysis shows that window with shading works well for north and south. But for east and west window without shading is best. Special attention should be given for west orientation.
5	Thermal Comfort in Architecture Jury Rooms in Presence of Vertical and Horizontal Apertures for Daylighting Display Walls. Jayedi Aman* and Md Ashikur Rahman Joarder ²	This research aims to study the thermal comfort in architecture jury rooms in presence of vertical (slit vertical window) and horizontal (skylight) apertures used to enhance the visibility of design displays hanging on the wall round a year, specially in summer period. Dynamic daylighting and thermal results were combined to find out the most effective aperture configuration ensuring effective daylight on display wall.	One jury room is selected as case room .Based on the existing model 6 different window geometry is considered and simulated. The results are compared to identify the effective ratio for thermal and visual comfort.	Through visual performance during study period, aesthetics, sound transmission, economics, glare control, ventilation, safety, security and subjective concerns of privacy and view of a space may be affected.	Vertical windows performed much better for both visual and thermal comfort. The East and West windows have better lighting and thermal comfort respectively. Overall the PPD value doesn't lie in acceptable range.
S.NO	Research Paper & Author	Research paper thrust area	Methodology	Limitations	Inference
6	A passive design solution to enhance thermal comfort in an educational building in the warm humid climatic zone of Madurai S. Subhashinia,* , K. Thirumaranb	The main aim of the current study is to evaluate thermal comfort sensation of occupants in NV classrooms of an educational building in Madurai and come out with a passive design solution to overcome the thermal discomfort during the hot weather conditions – Shading Devices.	Evaluation of the external and internal parameters through field survey and also a qualitative survey was carried out. The final phase the evaluation of the impact of shading device is carried out.	The was carried out in the month of March and April and only based on field survey and manual methods (calculation & Graphical) the analysis was carried out.	The results showed that there was a considerable decrease of about 2.5–4.5 °C due to solar shading alone. Further modification with insulation and controlled air exchange rate showed a decrease of 4.4–6.8 °C in room temperature.
7	Analysis Of Daylighting Using Daylight Factor And Luminance For Different Room Scenarios Badri Narayan Mohapatra, M. Ravi Kumar, Sushant K. Mandal	Daylight factor and illuminance distribution corresponding to different room scenarios and various window configurations are analyzed	The analysis was carried out by simulation method for 3 cases of 3m , 4m and 5m room depth. The window sizes were varied for 6 iterative cases and the final conclusion is noted.	The study focuses only of lighting and no other parameters are considered . The WWR and shading effect is also not analyzed.	Simulation results also indicate that strip windows provide more comfort as compared to punched window. The use of full width windows does not increase the daylight penetration substantially.
8	The effect of window configuration on daylight performance in classrooms: A field and simulation study Z.S. Zomorodian , S.S. Korsavi, M. Tahsildoost	This paper aims to investigate the effect of window configuration on daylight performance through parametric analysis. Different window configurations such as WWR, incorporating light shelves and roof monitors have been analyzed on a typical south-east facing classroom	The research methodology conducted in this study includes three steps: literature review For various standards of Green rating tools , software validation and iterative parametric analysis for various proposed cases.	Students preferences, satisfaction expectations can be more precisely addressed by subjective measurements and questionnaires. dynamic metrics like SDA and UDI can be applied in studies	Results show that by increasing the window-wall-ratio to 35, 40 and 50% and by installing a roof monitor, the daylight credits of the BREEAM and LEED could be achieved respectively. Combination of installing monitor roof and light shelves and increasing WWR may result in enhanced daylight levels.

2.2 THERMAL COMFORT INDICES

Thermal comfort is that condition of thermal environment under which a person can maintain a body heat balance at normal body temperature and without perceptible sweating. Limits of comfort vary considerably according to studies carried out in India and abroad. The thermal indices which find applications for Indian climate are as follows:

- a) Effective temperature (ET),
- b) Tropical summer index (TSI), and
- c) Adaptive thermal comfort.

2.2.1 Effective Temperature (ET)

Effective temperature (ET) Effective temperature is defined as the temperature of still, saturated air which has the same general effect upon comfort as the atmosphere under investigation. Combinations of temperature, humidity and wind velocity producing the same thermal sensation in an individual are taken to have the same effective temperature. Bedford (1946) proposed the use of globe temperature reading instead of the air temperature reading to make allowance for the radiant heat. This scale is known as the corrected effective temperature (CET) scale. No allowance, however, was made for the different rates of energy expenditure. The scale was compiled only for men either seated or engaged in light activity.

2.2.2 Tropical summer index (TSI)

The TSI is defined as the temperature of calm air, at 50 percent relative humidity which imparts the same thermal sensation as the given environment. The 50 percent level of relative humidity is chosen for this index as it is a reasonable intermediate value for the prevailing humidity conditions.

Mathematically,

$$TSI = 0.745t_g + 0.308t_w - 2.06\sqrt{v + 0.841}$$

where

t_w = wet bulb temperature, in °C;

t_g = globe temperature, in °C; and

V = air speed, in m/s.

Fig 2.1 Tropical Summer Index Formulae

The thermal comfort of a person lies between TSI values of 25°C and 30°C with optimum condition at 27.5°C. Air movement is necessary in hot and humid weather for body cooling.

Sl. No.	Dry Bulb Temperature °C	Relative Humidity Percent						
		30	40	50	60	70	80	90
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
i)	28	¹⁾	¹⁾	¹⁾	¹⁾	¹⁾	¹⁾	¹⁾
ii)	29	¹⁾	¹⁾	¹⁾	¹⁾	¹⁾	0.06	0.19
iii)	30	¹⁾	¹⁾	¹⁾	0.06	0.24	0.53	0.85
iv)	31	¹⁾	0.06	0.24	0.53	1.04	1.47	2.10
v)	32	0.20	0.46	0.94	1.59	2.26	3.04	²⁾
vi)	33	0.77	1.36	2.12	3.00	²⁾	²⁾	²⁾
vii)	34	1.85	2.72	²⁾	²⁾	²⁾	²⁾	²⁾
viii)	35	3.20	²⁾	²⁾	²⁾	²⁾	²⁾	²⁾

¹⁾ None.
²⁾ Higher than those acceptable in practice.

Fig 2.2 TSI Comfort standards for Warm Conditions.

2.2.3 Adaptive thermal comfort

1. Thermal comfort needs depend on their past and present context
2. Get accustomed to variable indoor thermal conditions that reflect local patterns of daily and seasonal climate changes.
3. It allows buildings to operate within broader temperature bands

This tool of Adaptive Thermal Comfort evaluation is taken for further analysis in this Research study so detailed explained in 2.3 of this chapter.

2.3 ADAPTIVE THERMAL COMFORT

The Adaptive Approach that characterized building creation and created life styles is not a new concept. That was in fact the concept that ruled before the advent of modern air conditioning. The comfort temperature becomes a bargain (interaction) between the occupant and the environment. With ability for the occupant to meddle with the adaptive variables themselves, the wide range of temperature can be even “Wider Range of Temperatures”

Table 2.2 Existing Study done for the Adaptive Thermal Comfort

Free-running buildings	Climate		
	hd	hh	Temp
Athens, Greece			6
Baghdad, Iraq	1		
Bangkok, Thailand		3	
Bay Area CA, USA			3
Birkenhead, UK			1
Brisbane, Australia			5
Calcutta, India		1	
Darwin, Australia		2	
Delhi, India	3		
Garston, UK			5
Islamabad, Pakistan	13		
Jakarta, Indonesia		2	
Karachi, Pakistan		6	
London, UK			2
Mapoon		1	
Melbourne, Australia			3
Merseyside, UK			4
Multan, Pakistan	11		
Oxford, UK			3
Peshawar, Pakistan	2		
Port Harcourt		1	
Port Moresby		4	
Quetta, Pakistan	9		
Rio, Brazil		2	
Saidu Sharif, Pakistan			12
Singapore		3	
Sydney, Australia			4
USSR (South)	1		
TOTALS	40	25	48

The sites are from the ASHRAE database [14] the Humphreys database [13] and the Pakistan database [11]. The table shows the number of separate field studies from each site. Climates are characterised as hot-dry (hd) hot-humid (hh) or temperate (temp).

2.3.1 A meta-analysis of field studies

21,000 sets of raw data compiled from field surveys in 160 buildings. Buildings located in 4 continents in a variety of climatic zones Buildings include both (centralized) HVACR buildings and NV (Naturally Ventilated) buildings

2.3.2 Nicol and Humphreys, 2007, European standard, EN15251

Free-running: $T_{comf} = 0.33T_{rm} + 18.8$

For free-running operation,

upper margin: $T_{comf} = 0.33T_{rm} + 20.8$

lower margin: $T_{comf} = 0.33T_{rm} + 16.8$

People can be comfortable in a 'zone' of temperatures no more than 2C from the comfort temperature (Nicol and Humphreys, 2007)

2.3.3 TERI 3rd Regional Conference & Exhibition, "Innovations in Sustainable Habitats – The GRIHA Approach" – 2012 and ASHRAE standard 55

Calculate t_n (temperature corresponding to Thermal Neutrality) from

$$t_n = 17.8 + 0.31.t_m$$

where t_m = Outdoor mean temperature

Fig 2.3 GRIHA Adaptive Comfort Formulae

2.4 COMPARITIVE STUDY OF ADAPTIVE THERMAL COMFORT

Comparative study between CEN EN15251 and ASHRAE standard 55

Table 2.3 Comparative study of Adaptive Standards

CEN EN15251	ASHRAE standard 55
Trm is the exponentially weighted running mean of the daily outdoor temperature, approximated using the previous week's temperatures	Tm is the monthly average of the daily average outdoor dry bulb temperatures
$T_{rm} = (T-1 + 0.8T-2 + 0.6T-3 + 0.5T-4 + 0.4T-5 + 0.3T-6 + 0.2T-7)/3.8$	$T_{avg} = (T_{max} + T_{min})/2$

2.5 ADAPTIVE APPROACH IN INDIAN CONTEXT

2.5.1 Test Methodology Schematic and Critical Overview

1. Methodology detailed in EN15251 proves to be more effective and better in comparison with both ASHRAE Standard 55 and Indian adaptive comfort model, both of which assumes 'running mean temperature' only, whereas EN15251 uses 'exponentially weighted running mean temperature'.
2. Due shift in the domain of comfort temperature towards higher temperature range with EN15251, the load design scope corresponding to damping the higher temperature ranges is reduced which in W&H climate is of major concern, unlike lower temperature range in winters.
3. EN15251 results approximately 50% reduction in Degree Discomfort Hours in comparison with ASHRAE Standard 55 (2010) comfort model.

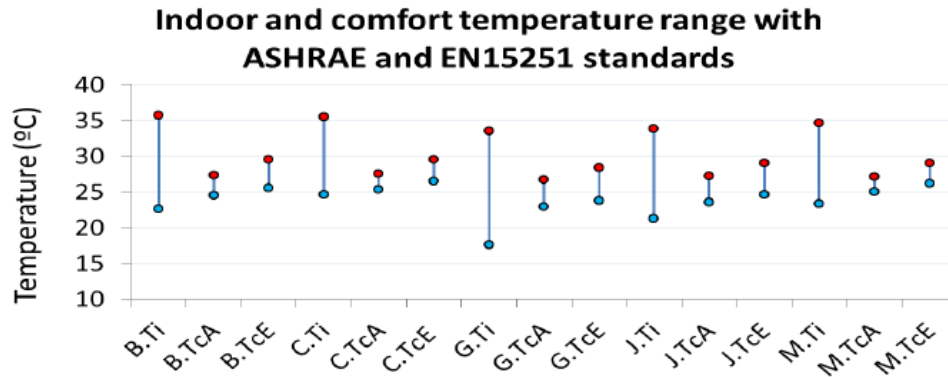


Fig. 5. Indoor and comfort temperature range with ASHRAE Standard 55 (2010) and EN15251 standards.
 * B.Ti: Indoor temperature of Bhubaneswar;
 B.Tca: Comfort temperature as per ASHRAE Standard 55 (2010);
 B.Tce: Comfort temperature as per EN15251, likewise, C: Chennai, G: Guwahati, J: Jamnagar and M: Mumbai

Fig 2.4 Indoor comfort in Indian context comparison

2.5.2 NBC Standards for Comfort band

Sl No.	Mode of Operation →	Naturally Ventilated	
	Approach →	Operative Temperature	
	City ↓	°C	
		90 Percent Upper Band	90 Percent Lower Band
(1)	(2)	(3)	(4)
11)	Bhubaneswar	32.0-26.6	27.2-21.8
12)	Bhuj	32.0-25.4	27.2-20.6
13)	Bikaner	32.0-22.3	27.2-17.5
14)	Chennai	32.0-28.7	27.2-23.9
15)	Chitradurga	31.2-27.2	26.4-22.4
16)	Dehradun	31.0-22.3	26.2-17.5

Fig 2.5 NBC Adaptive Thermal Comfort Band

2.5.3 GRIHA 2016 Standards for Comfort Band

Table 2.4 GRIHA Standards for Comfort in Chennai.

Months	Chennai			
	NV	MM	AC.air.tem	AC.std.eftv
January	28.8	28.4	26.7	25.9
	24	21.4	23.7	23.9
February	29.4	28.7	26.8	25.9
	24.7	21.4	23.8	23.9
March	30.3	29.2	26.9	25.9
	25.6	22.2	23.9	23.9
April	31.4	29.7	27.1	25.9
	26.6	22.8	24.1	23.9
May	32.6	30.3	27.3	26
	27.8	23.4	24.3	24
June	32.9	30.5	27.3	26
	28.1	23.6	24.3	24
July	31.9	30	27.2	26
	27.1	23.1	24.2	24
August	31.5	29.8	27.1	26
	26.7	22.8	24.1	24
September	31.3	29.7	27.1	25.9
	26.5	22.7	24.1	23.9
October	30.8	29.4	27	25.9
	26	22.5	24	23.9
November	30	29	26.9	25.9
	25.3	22.1	23.9	23.9
December	29.2	28.6	26.8	25.9
	24.5	21.7	23.8	23.9

2.6 INDOOR OPERATIVE TEMPERATURE

The operative temperature (Top) is an index that combines the air temperature and the mean radiant temperature into a single value to express their joint effect. It is a weighted average of the two, the weights depending on the heat transfer coefficients by convection (hc) and by radiation (hr) .Thus in both the ASHRAE 55 and the CEN EN15251 standard the comfort temperature in the adaptive section is expressed in terms of the operative temperature. Operative temperature is more suitable index to measure thermal comfort in the building having low indoor air velocities, since the index also accounts for impact of building surface temperatures (radiant temperatures) on human comfort.

Operative temperature

$$= (t_r + (t_a \times \sqrt{10v})) / (1 + \sqrt{10v})$$

Where,

t_a = air temperature

t_r = mean radiant temperature

v = air speed (m/s)

(OR)

Operative temperature

$$t_o = \frac{(h_r t_{mr} + h_c t_a)}{h_r + h_c}$$

where,

h_c = convective heat transfer coefficient

h_r = linear radiative heat transfer coefficient

t_a = air temperature

t_{mr} = mean radiant temperature

Fig 2.6 Operative Temperature Formulae

2.7 IESVE SOFTWARE ALGORITHM FOR ADAPTIVE COMFORT EVALUATION

STEP 1: Evaluating the T_{op} and T_{max} . Both values are calculated by the software from the Input of EPW files and Building envelope parameters. T_{max} is calculated using the maximum acceptable temperature based on the running outdoor mean. T_{op} is calculated from the operative temperature formulae.

STEP 2: Evaluation based on the Building Category selection. The CIBSE suggestion is that designers should aim to remain within the Category II limits.

Table 2.5 Building Categories from IESVE

Category	Explanation	Suggested acceptable range (K)
Category I	High level of expectation only used for spaces occupied by very sensitive and fragile persons	2
Category II	Normal expectation (for new buildings and renovations)	3
Category III	A moderate expectation (used for existing buildings)	4

STEP 3 : Degrees > Max. adaptive temp.

This processed variable uses the following formula to address Criteria 1 and 3:

Data Value $\Delta T = (T_{op} - T_{max})$

Equation 3 – Degrees > Max. adaptive temp.

Criteria 1 Difference in operative temperature minus the maximum acceptable temperature ΔT is greater than or equal to 1 Deg C.

Criteria 2 When ΔT is lesser than 6 Deg C

Criteria 3 This displays the maximum ΔT for the space. This space fails if it is greater than or equal to 4 Deg C.

For the allowable temperatures ΔT it can be done with the help of mechanical fans and other techniques which help in increasing wind velocity

2.8 VISUAL COMFORT – DAYLIGHTING ANALYSIS

In Architecture Studio visual task is most important and prolonged for long studio hours. Optimal lighting levels have to be considered to provide required illuminance at the desk level. Glare creates difficulty in performing a visual task by showing physical symptoms.

2.8.1 DAYLIGHTING METRICS

Metrics for particular Time

- Daylight Factor – Overcast period (Based on the $E_i/E_o \times 100$)
- Point in time illuminance – Mostly for particular time analysis – Done for equinox days and solstices

Annual Metrics

- Daylight Autonomy
- Spatial Daylight Autonomy
- Continuous Daylight Autonomy
- Annual Solar Exposure
- Useful Daylight Illuminance

2.8.2 STANDARDS

TABLE 2.6 STANDARDS BASED ON NBC CODE for Educational Buildings

EDUCATION	
Assembly Halls	
General	200-300-500
Platform and stage	
Teaching Spaces	
General	200-300-500
Lecture Theatres	
General	200-300-500
Demonstration benches	300-500-750
Seminar Rooms	300 500 750
Art Rooms	300-500-750
Needlework Rooms	300-500-750
Laboratories	300-500-750
Libraries	200-300-500
Music Rooms	200-300-500
Sports Halls	200-300-500
Workshops	200-300-500

Lower limit for the Studios and other functional space is 200 lux and upper limit can range between 500 -750 lux

TABLE 2.7 STANDARDS BASED ON SP41 for Educational Buildings

Schools and colleges

Assembly halls:

General	150
When used for examination:	300
Platforms	300

Class and lecture rooms:

Desks	300
Blackboards	200 to 300 †
Embroidery and sewing rooms:	700
Art rooms	450 ‡
Laboratories	300

Libraries:

Shelves, stacks	70 to 100 †
Reading tables	300

Manual training: *See appropriate trade*

Offices	300
Staff rooms, common room:	150
Corridors	70
Stairs	100

Recommended illumination level for the functionality of schools and colleges is given from 200 to 450 lux and 700 for high precision works

2.8.3 Quality Views

95% of the floor area in each relevant building areas is within 7m of a wall which has a window or permanent opening that provides an adequate view out.

CHAPTER 3 CASE STUDY METHODOLOGY

3.1 INTRODUCTION

Based on the Parameters identified for the study like the Spatial Planning, Building Envelope and Impact of Open and Transition spaces the spaces of the Case study are analysed theoretically for the Net case study and simulation analysis is done for the Live Case study. 3 Case studies are selected in the same typology of the Thesis project to understand efficient strategies which promote to induce Thermal and Visual comfort to the Interior spaces. Detailed analysis is carried out based on the following parameters –

- Orientation
- Building Geometry
- Connectivity and Placement
- Opaque envelope – Wall
- Fenestration – Window
- Shading elements

- Placement of Transition spaces
- Shading due to Transition spaces

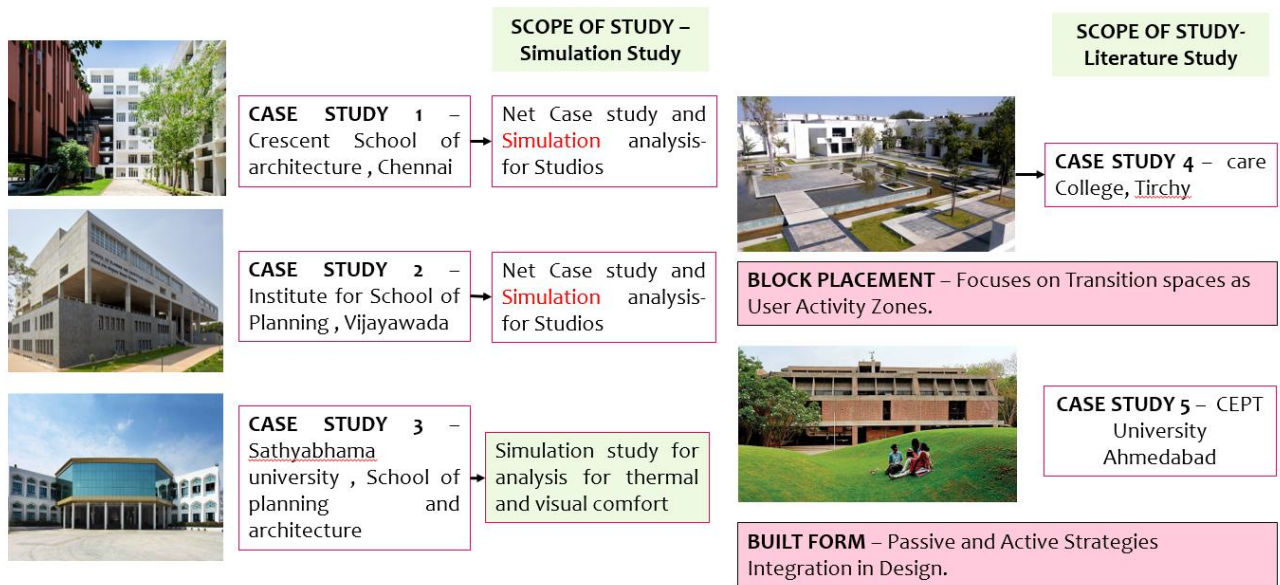


Fig 3.1 CASE STUDY METHODOLOGY

CHAPTER 4 CASE STUDY ANALYSIS

4.1 CASE STUDY 1 - Crescent School of Architecture

Distinctly identifiable by its stepped terraces and red striated facade, the Crescent School of Architecture occupies a relatively small lot of the 60-acre university campus, in Vandalur Chennai. The project brief envisioned studio spaces along with lecture halls and administration areas – which we chose to augment with necessary ‘de-programmed’ spaces for collective working and gathering. This allowed for the exploration of redefining not only the nature of spaces found in an architecture school but also offering us the possibility to inform the future pedagogic program that it could accommodate. Typically, a school would house endless corridors with rooms on either side. Spaces offering opportunity for discussions and chance encounter is severely limited, which in turn confines its users to following a dreary routine.

Overturning this notion of conventional space-making in an institution by replacing it with spaces that can have transformative pedagogical implications becomes imperative; wherein collective creation is encouraged within the institution’s pedagogic program, by explicitly offering spaces that urge for learning outside of the confines of the classroom. With a program that is two-fold in nature, both extroverted and introverted, any architecture school requires spaces that allow its users to work in multiple ways. The ideal school should allow

for an open-ended program. Through means of an unconventional spatial method, our architecture school presents its users with various options for inhabitation and use.



Fig 4.1 : Conceptual Evolution (Building Geometry)

An additional 'new ground' is thus created at every floor level within the building – that stretches the piazza and the open stilt / free plinth upwards into the building volume. This continuous, stepped void created acts as a diagonal courtyard – offering, in this case, exhilarating vistas across the terraced-landscape-like formation, besides becoming the key congregational and social space for the school. These voids – in addition to making the building mass lighter, also perform the important task of creating an 'outdoors-like' experience – with the wind blowing through, the sun traversing across the spaces during the day, and the shaded spaces feeling connected to the elements and the campus (to which the building forms and urban edge) – with views across the reserved forest on the west side and the campus towards the east and south.

Each studio space opens onto its adjoining double-height terrace (shaded by the overhanging floors) through a set of large sliding folding doors – offering the possibility of open studio/workshop spaces and/or open exhibition and review spaces – that can be viewed together diagonally across, during 'open-house' days and common review days. Design studios that are placed adjacent to one another may be transformed into one large space hosting shared classes or studios between two different sections, avoiding complete isolation. Each design studio also accommodates a mezzanine level that houses its respective lecture hall.

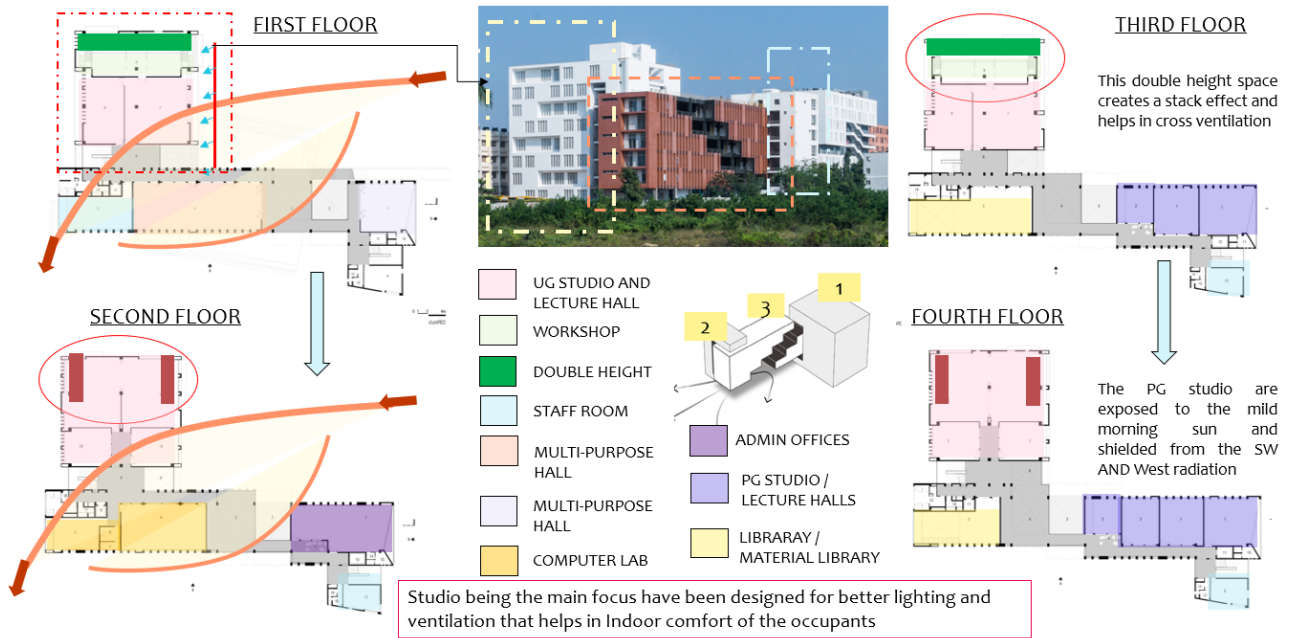


Fig 4.2: Connectivity and Placement

4.1.1 HIGHLIGHTS OF PLANNING

- The plan is oriented towards 45deg tilt from North-south axis, according to Chennai solar exposure N-S long axis is 1st preferred and next is tilted axis.
- The studio being the main focus of an Architecture college is places in the North – Northeast corner to take advantage of the North lighting.
- The Open to sky spaces acts as light wells to promote daylight into Transition spaces but cuts off direct radiation
- Double height space with combined workshop for 3 studios is created in every alternate floors which promotes stack effect.
- The Block in Zone 2 has alternating corridors which helps in spatial connectivity
- The corridor towards the south from Third floor helps to shade the space from the Direct heat gain from the South-West side.
- The temporary occupancy zones like the library and the material museum have been located on the west, SW direction.

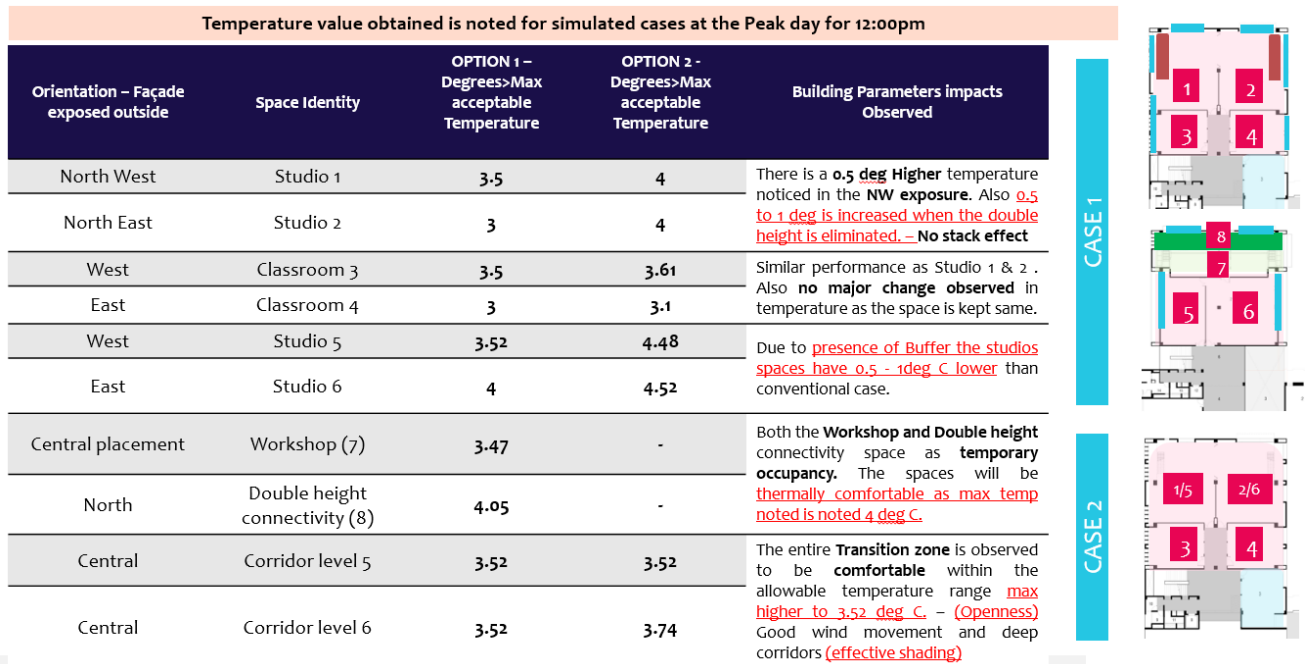


Fig 4.3: Thermal Comfort Analysis CS1

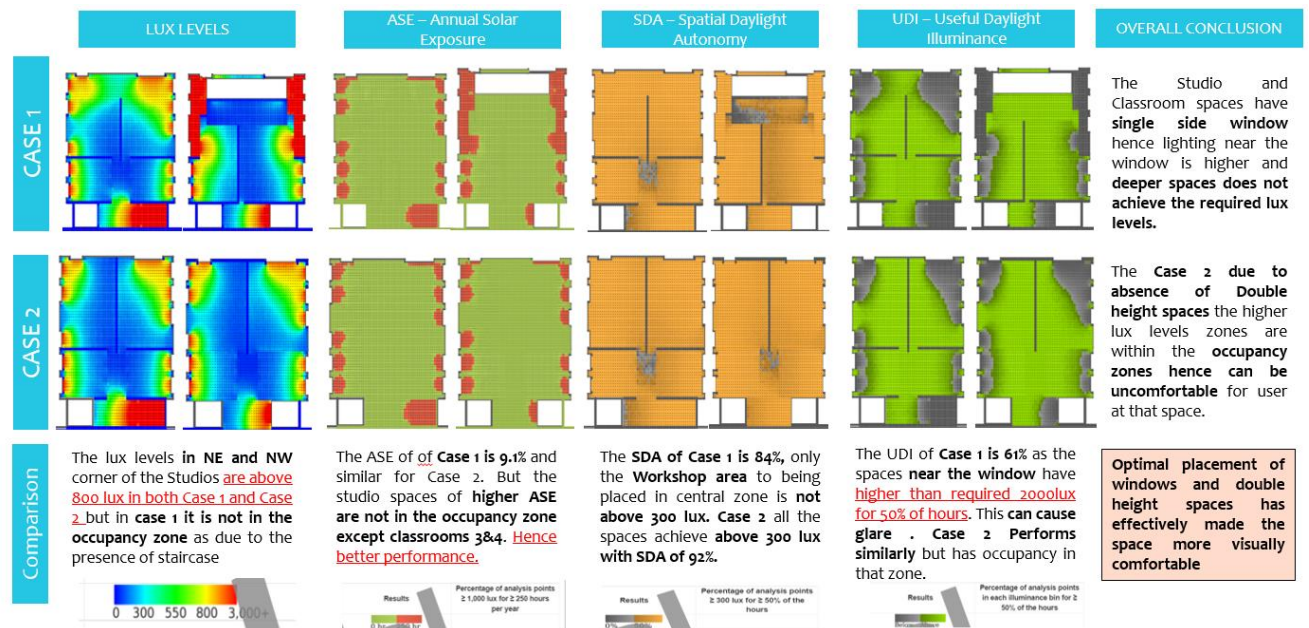
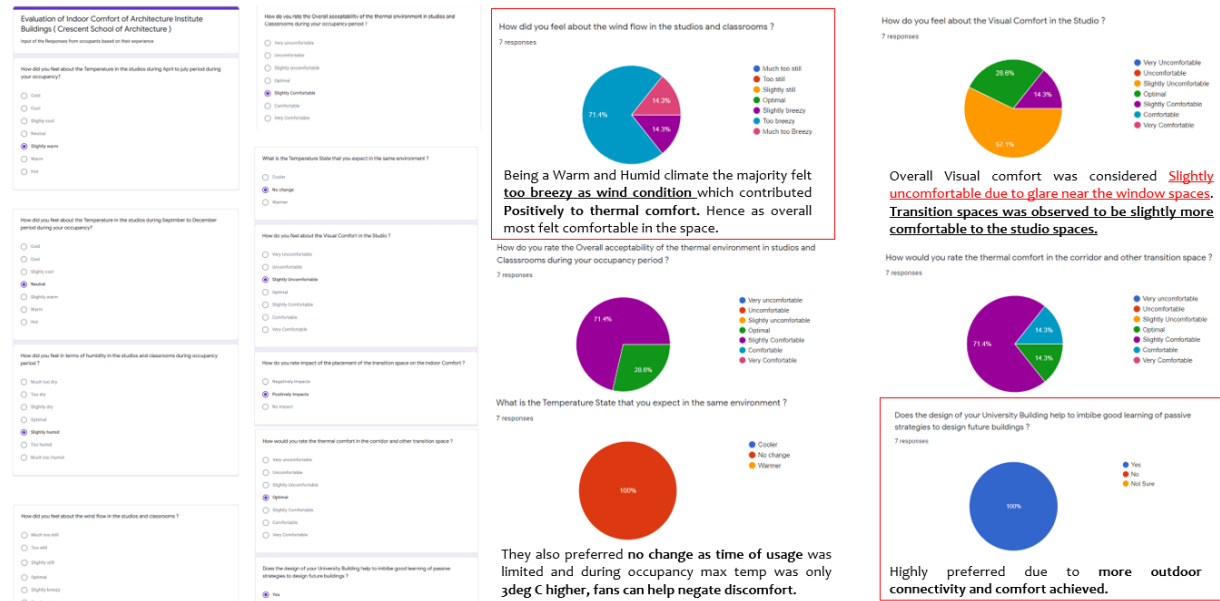


Fig 4.4: Visual Comfort Analysis CS1



4.2 CASE STUDY 2 - Institute at School of Planning and Architecture, Vijayawada

The School of Planning and Architecture, Vijayawada, attempts to make the campus an institutional center in the city of Vijayawada. The institutional building is a platform for debate, exchange and dissemination and becomes a deep gateway and an interface to the entire campus. The Institute draws on the austere ideologies from Brutalism as a form of expression as a response to the extreme climate, and positions it contextually in Vijayawada. The design demonstrates a scale akin to a public building on the outside and the inside explores the didactic nature of space by creating a humane scale apt for an engaged student community. The large volume is punctured by voids, creating a rhythmic play of light and shadows which allows the building to respire; thus yielding spatial patterns that perform as a scaling device. The design focuses on the diversity of individuals and the vastness of a community and creates Interdependent programs that offer a multitude of interactive spaces that would be beneficial for a community experience. Our ideas stem from an interest in developing inter relationships in which students would participate in a non-hierarchical nature of exchange.

The relationships between three sections -The Parasol, Concourse and the Platform have been structured into a three-dimensional constellation that is informed by movement and varying levels of privacy of diverse programs. PARASOL- The top most section of the building houses the morning programs of the learning curriculum such as classrooms and studios. It also acts as a volumetric parasol roof for the lower floors creating a shaded environment below. CONCOURSE - The middle section of the building is a 'Stilted Platform' that allows for student activity.

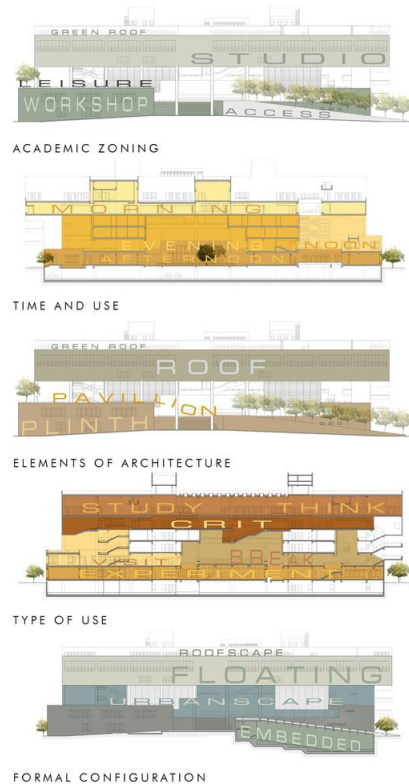


Fig 4.6: Conceptual Spatial distribution

This zone is a reminder of the traditional courtyard that anchors common public and community programs. It behaves as a concourse to the entire building as it filters and mediates the movement of people. Smaller courtyards work as three-dimensional light wells which offer visual connectivity through the layers above and below. This 'Universal zone' is occupied by faculty, students, administrators and visitors enabling non-programmed exchange. The PLATFORM-The bottom most section becomes a heavy base to a floating canopy. The base houses the afternoon programs of the learning curriculum such as workshops and Laboratories and is clad with local Tandur stone which increases the 'Time Lag' for solar- heat gain. This solid platform is punctuated with voids that allow for hot air to dissipate.

The materials are stripped to their raw form, with the fair-faced concrete, local tandur stone, Corten Steel and fly ash bricks ascribing a natural character to the building. Passive energy systems are incorporated into the design via courtyards that funnel winds through the building and enable cross-ventilation, thus regulating the diurnal temperatures; the volumetric parasol that provides thermal comfort below and measures to reduce active solar heat gain such as utilizing North lights while blocking harsh solar radiation from the South. The building intends to create an interactive community learning environment nestled within its cultural context with a keen focus on environmental sensitivity.

4.2.1 HIGHLIGHTS OF PLANNING

- The form of the building is a direct response to the hot and humid climate of Vijayawada, which enables shading and cross ventilation. North-light sections for studios along with insulation of the roof and landscaping create Climate responsive configurations.
- Passive energy systems are incorporated into the design via courtyards that funnel winds through the building and enable cross-ventilation, thus regulating the diurnal temperatures.
- The volumetric parasol that provides thermal comfort below and measures to reduce active solar heat gain
- Utilizing North lights while blocking harsh solar radiation from the South.
- The building intends to create an interactive community learning environment nestled within its cultural context with a keen focus on environmental sensitivity.

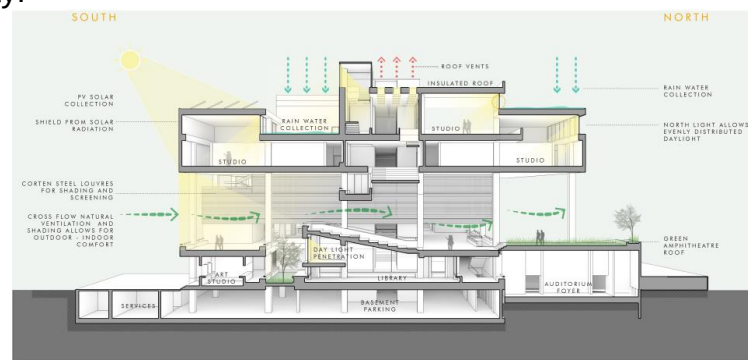


Fig 4.7 Passive Strategies

Temperature value obtained is noted for simulated cases at the Peak day for 12:00pm				
Orientation	Space Identity	OPTION 1 - Degrees>Max acceptable Temperature	OPTION 2 - Degrees>Max acceptable Temperature	Building Parameters impacts Observed
North	Studio 1	6	5.52	Studio 1 has higher temperature range due to lack of sufficient <u>WFRop</u> - Affects the <u>ventilation rate impacts on Thermal Comfort</u>
North	Studio 1 DH	5.48	-	
North	Studio 2	4	5.56	Comparatively, <u>Lower than Studio 1 due Higher WFRop</u> and hence better thermal comfort
North	Studio 2 DH	4	-	
North	Studio 5	4.52	5.52	Due to <u>presence of Buffer the studios spaces have 1deg C lower</u> than conventional case.
North	Studio 6	4.56	5.52	
South	Studio 3	5	5.52	South façade though having a higher heat gain. The is <u>Studio space is within acceptable range of Criteria 2 possibility of optimum comfort</u> within only mechanical Usage.
South	Studio 3 DH	4	-	
South	Studio 4	5	5.52	
South	Studio 4 DH	4	-	
Central	Corridor 4 th Floor	3	3.2	The Transition spaces to <u>no direct exposure to outside</u> is thermally constant and <u>comfortable by criteria 2</u>
Central	Corridor 5 th Floor	4	4.52	



Fig 4.8: Thermal Comfort Analysis CS2

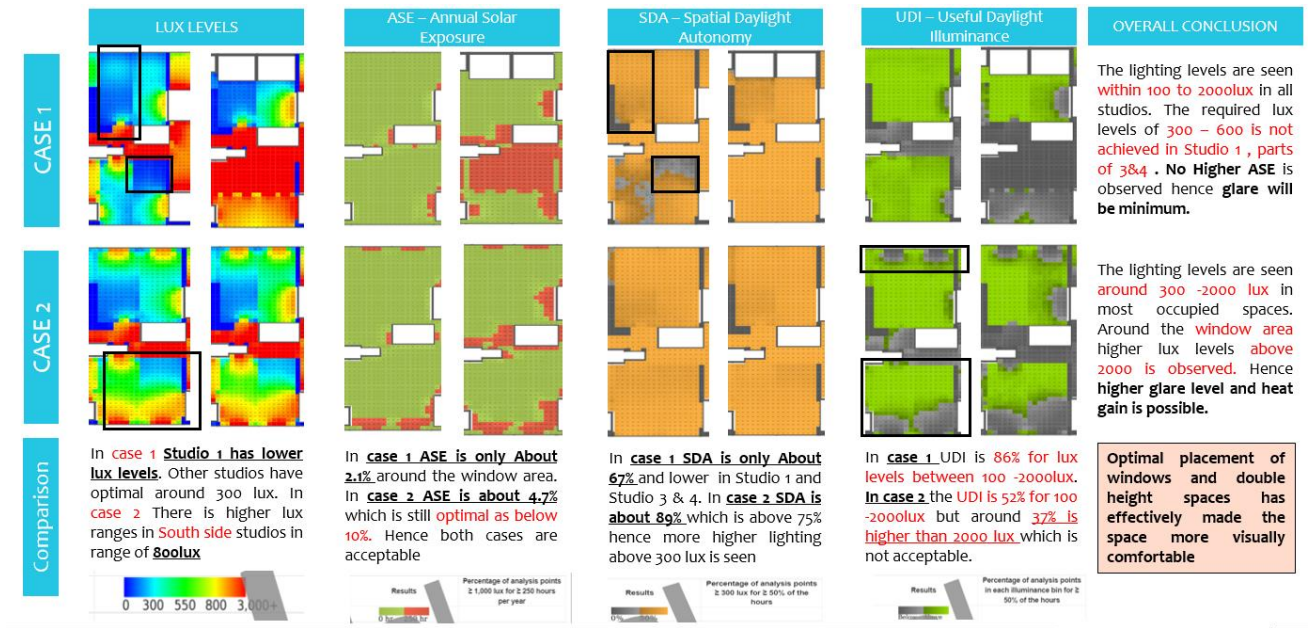


Fig 4.9: Visual Comfort Analysis CS2

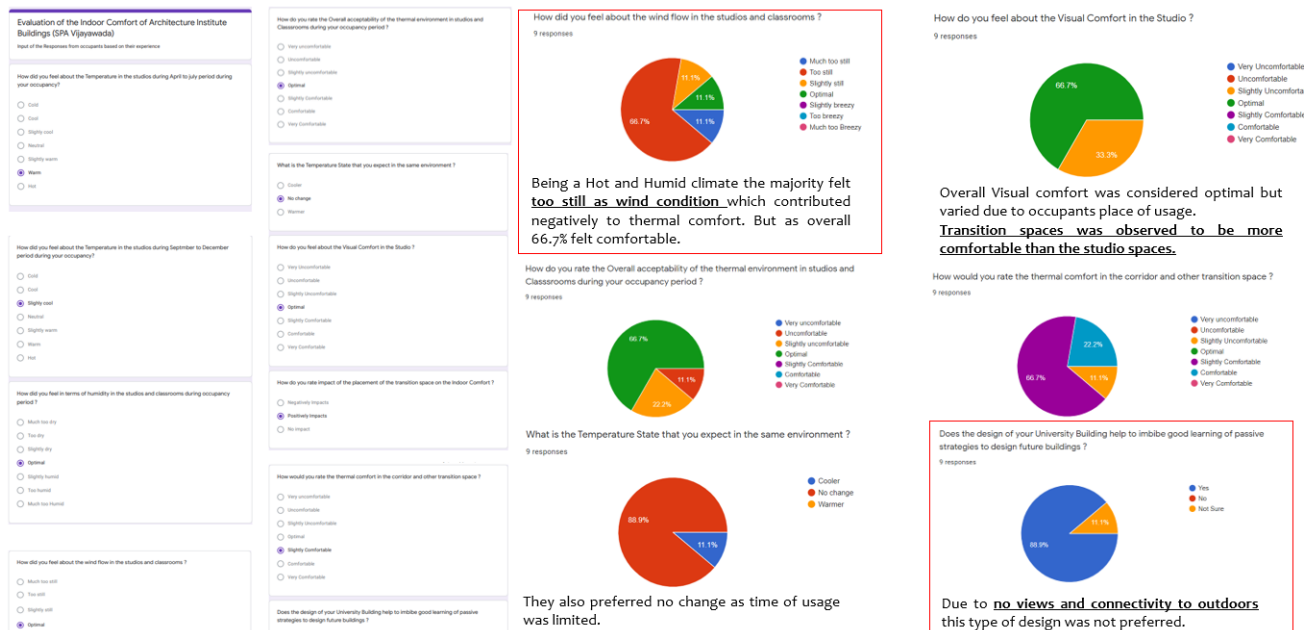


Fig 4.10: Occupancy Comfort Analysis CS2

4.3 CASE STUDY 3 – Satyabhama School of Architecture, Chennai

The main planning strategy of the space is placement of the central spaces and 4 spines having the studios at 45deg angle. The courtyard provides the necessary lighting levels to the central rooms. The transition spaces are wide and helps to provide the climatic buffer between the indoor and the outdoor environment.

4.3.1 Central Room Thermal Comfort analysis

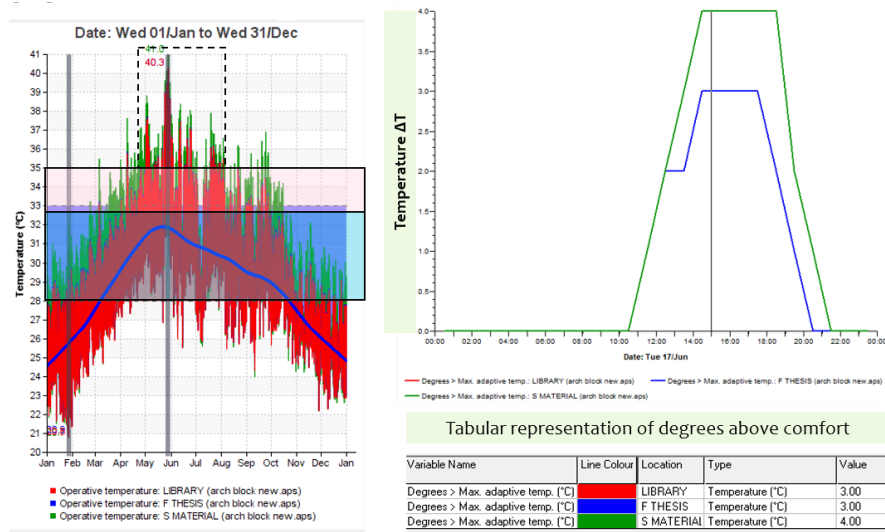


Fig 4.11 Thermal Comfort of Central Room Analysis

The Central space is well shaded due to presence of the adjacent blocks and Transition space. Hence in comfort during occupied hours. The space has adequate no of windows to promote cross ventilation.

4.3.2 Studio Wing 1 Thermal Comfort Analysis

The Studio 1 wing has acceptable range for the Ground floor alone but the higher have 0.5 deg C and 1 deg C higher than acceptable range Since it is in the SE corner the summer radiation is lower in the room space.

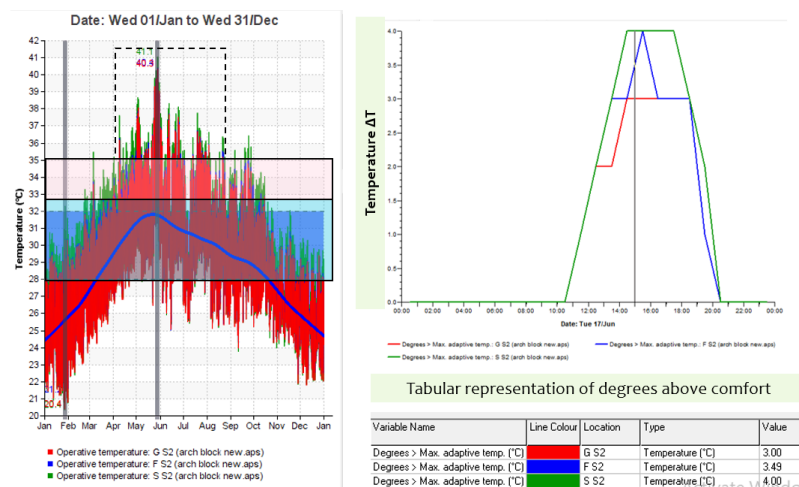


Fig 4.12 Thermal Comfort of Studio Wing 1 Analysis

4.3.3 Studio Wing 2 Thermal Comfort Analysis

The Studio wing 2 has 3.5 to 4 deg according to criteria 3 it can be 4 deg above the acceptable range. Hence in peak summer with the help of mechanical fans which promote 2 deg increase in comfort band the space can be in comfort levels.

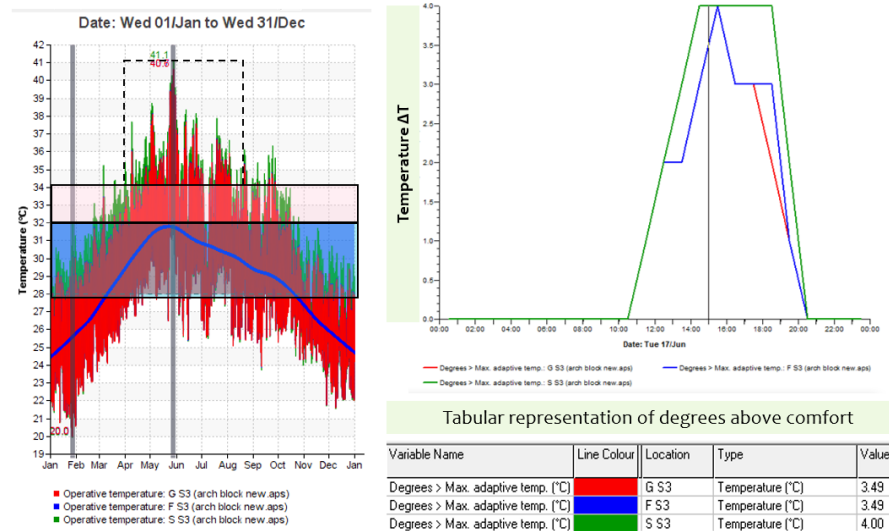


Fig 4.13 Thermal Comfort of Studio Wing 2 Analysis

4.3.4 Studio Wing 3 Thermal Comfort Analysis

In the studio wing 3 in NW position has highest radiation in summer hence even the ground floor level has prolonged heat gain. But still the space lies in comfort during the peak hours with the provision of fans which increase 2 deg in the comfort band

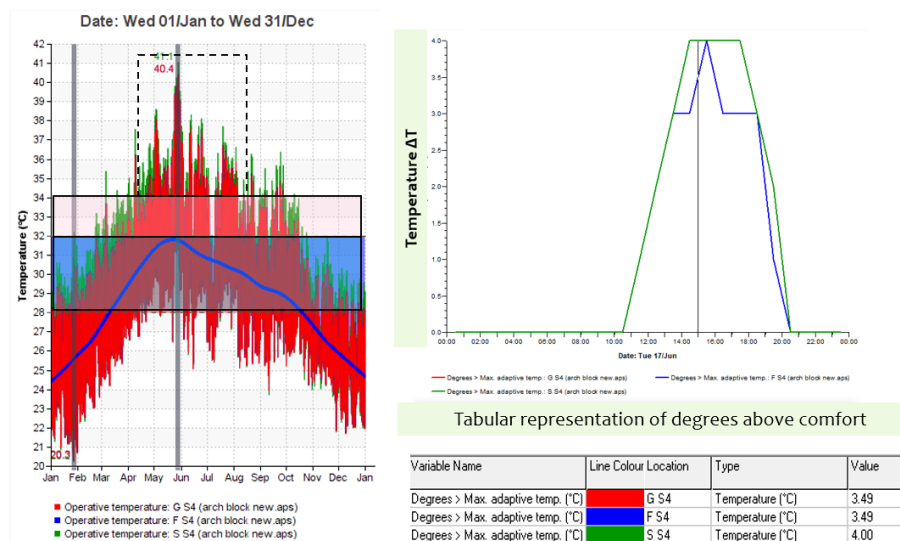


Fig 4.14 Thermal Comfort of Studio Wing 3 Analysis

4.3.5 Studio Wing 4 Thermal Comfort Analysis

As this Studio wing 4 lies in the NE corner the increase in the acceptable temperature is 3.5 to 4. The drop is also very fast as the orientation of the suns position changes and hence decrease in the direct radiation to the interior space.

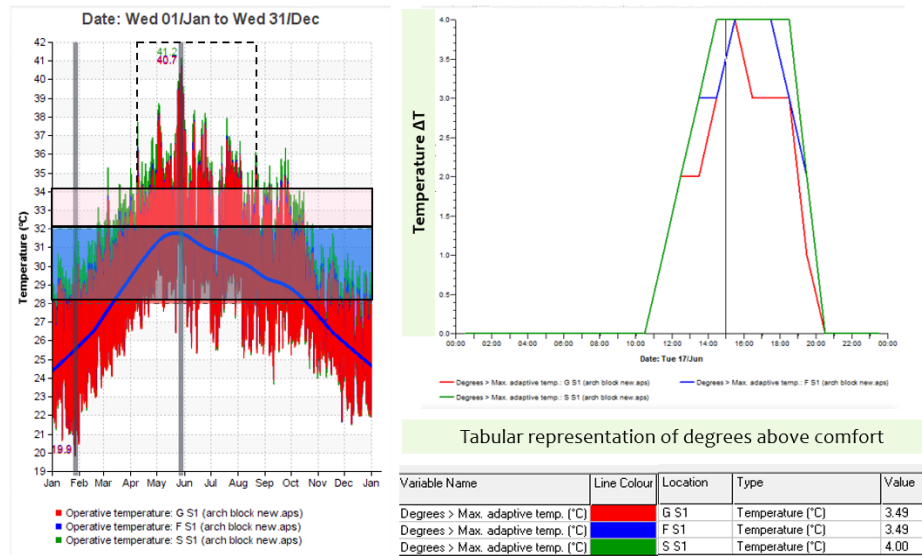


Fig 4.15 Thermal Comfort of Studio Wing 4 Analysis

4.3.6 Lighting Analysis

The ground floor level has the most optimum lighting levels based on all metrics. The front open portico has high lighting levels. The First floor has optimum lighting in all studios. Only the computer lab has lower lighting levels due to presence of shading element. The second floor level has higher DF above 2% but still it can be acceptable till 5% as the task performed requires higher lux level up to 600 lux.

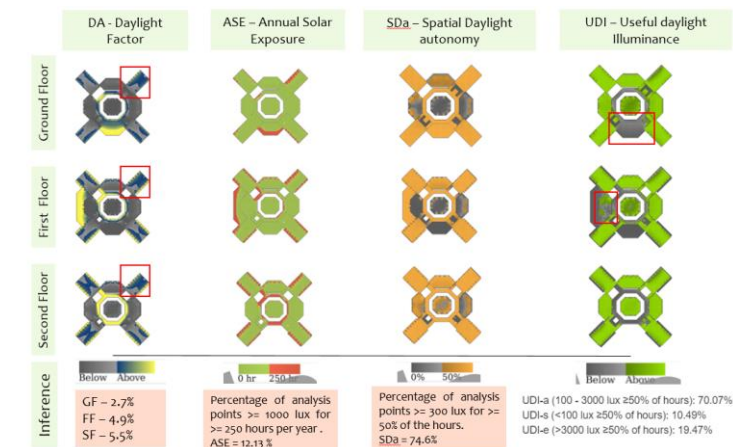


Fig 4.16 Visual Comfort Analysis

CHAPTER 5 SUMMARY AND COMPARITIVE ANALYSIS

5.1 CASE STUDY 1 & 2 COMPARITIVE ANALYSIS

Table 5.1 – Case study 1 & 2 comparison study

Building Parameters	School of planning and Architecture, Vijayawada	Crescent School of Architecture, Chennai
Orientation	30 deg Tilted from North. Only North lighting was allowed – Window placement.	30 Deg Tilted from North. Studio and Classrooms placed in the NE and NW corner of the block.
Building Geometry	Introvert planning spaces are designed based on shadow analysis with no direct solar exposure.	Extrovert Planning to connect indoor to outdoor. Buffer spaces and shading to reduce heat gain.
Connectivity and Placement	Design of Voids and Concourse level provided the necessary connectivity for the fully enclosed façade.	The entire Transition Block provides the shaded connectivity space between the studios , Old Block and informal spaces.
Opaque element –Wall	The wall is made of AAC Block and clad with <u>Tandur Stone</u> hence heat gain is reduced	AAC wall with White paint is used to increase reflectivity on the façade to reduce heat gain.
Window fenestration & Shading design	Window fenestration are oriented only to take in North lighting and diffused light from voids	The space between the columns are recessed to 600 mm with regular intervals forms as vertical shades and horizontal shading device is also provided in the North façade.
Transition spaces placement and its comfort level	The transition spaces are used as Jury spaces at times. It is found through simulation analysis to be within 3 – 4 deg higher than max acceptable temperature , allowed by criteria 3	The Transition space has of 3 to 3.5 deg C higher than max acceptable Temperature, more comfortable due to ample ventilation and openness.

1. The **North Lighting** should be considered as priority in optimization of the fenestration design.
2. Transition spaces should **involve landscape, connectivity to outdoors and Vistas** which has a physiological impact of freedom on the students.
3. **Wall and Fenestration material** should be designed for the **necessary time lag** within the usage period.
4. **Spaces can be zoned** based on **time and activity periods** for different functions.
5. **Double height** space can help for **diffuse lighting** as well as **stack effect for better thermal Comfort.**

5.2 CASE STUDY 3 COMPARITIVE ANALYSIS

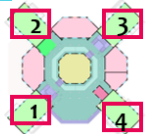
Table 5.2 – Case study 3 comparison study

	CENTRAL ROOM	STUDIO WING - 1	STUDIO WING - 2	STUDIO WING - 3	STUDIO WING - 4	INFERENCE
THERMAL COMFORT	The space is in comfort all year. From May to July end the comfort level above the acceptable range by max 3 deg C	The space is above acceptable comfort condition by 3 to 4 deg C. From Apr to August mid. SE radiation is lowest in summer	The space is above acceptable comfort condition by 3.5 to 4 deg C. From Apr to August mid. SW orientation	The space is above acceptable comfort condition by 3.5 to 4 deg C. From Apr to August mid. NW hence prolonged radiation levels	The space is above acceptable comfort condition by 3.5 to 4 deg C. From Apr to August mid. NE hence faster drop in temperature	Overall by the addition of mechanical fans the space comfort can be increased by 2 deg C which can help the Indoor comfort
VISUAL COMFORT	The central space has only minimum 100 – 300 lux of lighting and No visual discomfort is felt.	The space is comfort. There is higher DF observed in the second floor as due to Sun's position	Similar to the Wing 1 as it is affected by the south direction of sun path. DF factor is higher to 5.5	This orientation is affected during the peak summer months hence high level of DF is observed and ASE	Wing 4 is most comfortable for visual comfort. No higher ASE also required DF is seen	Overall the visual comfort lies in the optimum level for all the spaces on an annual basis. Higher courtyard aspect ratio is required

Ranking done by annual comparison of the spaces for both parameters combined


 Most comfortable spaces by rank order 2nd order preferred comfortable space

POSSIBLE INTERVENTIONS – Focus on building material to reduce conductive heat gain



5.3 COMPARITIVE CASE STUDY ANALYSIS

Table 5.3 – Case studies Comparative Analysis

	Crescent School of Architecture, Vandalur - Chennai	Institute at School of Planning and Architecture, Vijayawada	Sathyabama School of Architecture, Chennai
ORIENTATION	Oriented 45 deg towards west from North. This orientation is followed due to the site constraint. The advantage of diagonal planning is the ease of wind flow movement which is very important in Warm and humid conditions	The orientation is also 45 deg towards west from North but here it was planned so due to the shadow analysis which helps in self shading any one part throughout the year.	The studios are tiled 45 deg to the cardinal directions. To promote ease of ventilation and reduction in the direct radiation for prolonged periods. Noted to be working effectively by the analysis
BUILDING GEOMETRY	L- Shaped building – Extrovert in planning. Includes transition spaces to connect the outdoor to indoor in the main block. The studio block has just studios with double height space as square element	The building is introverted and heavy mass. Rectangular shaped building with interconnected courts and corridors inside. There is a 1 level hollow space to promote breeze penetration.	The building is planned with a concept of Central octagon and 4 rectangular diagonal wings for studios. This planning give the optimum required comfort for the different functions as placed.
CONNECTIVITY AND PLACEMENT	The connectivity spaces are linear and the corridor are singly loaded. This helps promote cross ventilation. Also there is effective transmission of daylight	The transition spaces are interplay of courts and corridors in the central spine. The entire planning was based on the 1 st floor plate which is the space for progressive learning	The courtyard and the surrounding corridor becomes the main focus of connectivity. Since it is well shaded it is also comfortable during the occupant hours.

	Crescent School of Architecture, Vandalur - Chennai	Institute at School of Planning and Architecture, Vijayawada	Sathyabama School of Architecture , Chennai
OPAQUE ELEMENT - WALL	Conventional building materials are used for the building. The type of paint which is white is the major strategy to reflect the heat and reduce heat gain. Transition spaces are used as buffer elements to eliminate direct heat gain	As due to concept of brutalism Raw flyash brick finish is done. Cladded with local Tandur stone which increases the 'Time Lag' for solar- heat gain, So the space remains comfortable in occupant hours	Conventional building materials are used for the building. The entire university is painted white which helps in reflectivity of the heat and hence lowers the rate of heat gain.
FENESTRATION – WINDOW and SHADING DEVICE	Fenestration is of 3 types based on the functional use. The main strip window is used for common facilities. Casement window with top fixed panel used in the Studios . Full height glass adjacent to the South balcony	The Fenestration is special design focus with aluminum framework and Steel louvers. Boxed type windows if no louvers. Corten steel louvers helps in shading of the windows	The windows are 3 panels for studios . Bottom fixed glass . Middle casement window. And top fixed glass panel. Plastering projection of the same wall color helps in shading
PLACEMENT OF TRANSITION SPACES	Transition space is designed In a stepped form to promote interaction and allow the breeze penetration. Buffer spaces are provided near the end of studios as double height workshops to reduce direct heat gain to the studio.	The transition spaces are located as central spine with various sub corridors to connect the spaces. The light wells and double height voids help in the connectivity. The entire level 1 is dedicated to the informal activities.	The main courtyard between the central space and the studio act as the climatic buffer and helps in stack ventilation to induce cooler air into the space. Also the stair core and the landscape are located aptly for social connectivity
COMFORT IN TRANSITION SPACES	The depth of the transition space helps to create a comfortable space due to complete cut off of direct solar radiation. Promotes space for social interaction	The transition spaces have an interplay of light and shadow but is well shaded from direct solar exposure. The wind movement helps mitigate discomfort.	The corridors deep with 3.5 m width and the courtyard has smaller aspect ratio hence increase breeze and lesser radiation helps in comfort

5.3 CONCLUSION

Introducing passive strategies with well-planned design elements helps augment the Indoor comfort in a positive way. Also the Transition spaces play a major role to act as climatic buffer and also social interaction spaces for the students.

CHAPTER 6 SITE SELECTION

6.1 SITE SELECTION

MHRD has approved setting up of National School of Planning & Architecture.

UT of Puducherry stood first in challenge mode competition. A National Institute like NIT, JIPMER. Project cost Rs.338 Cr. - 50 Acres of land to be demarcated in Pondicherry University Campus Forth institute after Delhi, Bhopal and Vijayawada

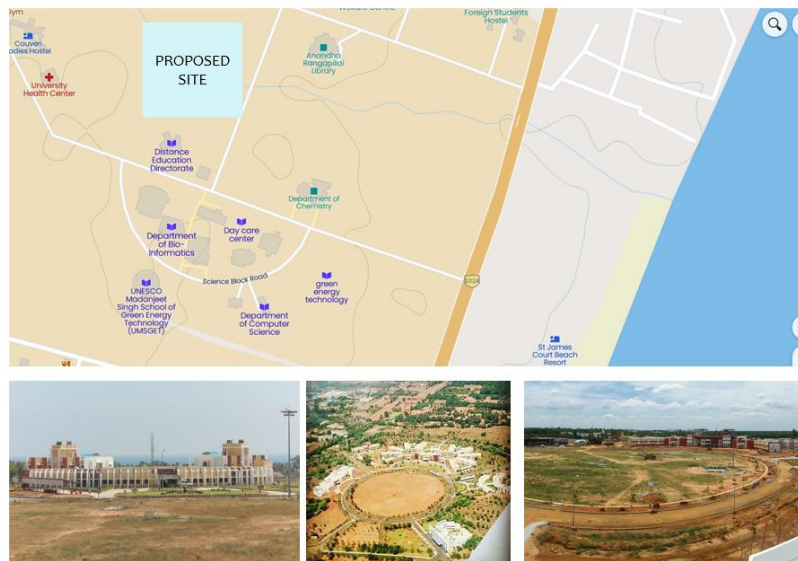
Currently there are only 3 SPA's In India. SPA is considered as premium education institute for Architecture studies in India as it is government based. The Cost of study is lower in case of SPA as compared to other private Institutes. Provides opportunity through merit based and hence well qualified Architects will graduate the institute. More exposure for the southern Part of India for better research scope through a national level university.

The proposal in SPA Puducherry stood first in the challenge Mode competition. Majorly due to CAE norms and its good existing facilities. Opportunity to promote inside an existing campus Can become the 2nd SPA in South India.

6.1.1 COA Guidelines for Architecture Education

Number of Practicing Architects in the region. – Minimum 200 architects must be in active practice within one hour travelling distance of proposed institution for each 40 seats intake. Priority will be given for state/ central non-private universities to establish constituent college of architecture and colleges/institutions to be started by Union/ State government, irrespective of location (Category). Any new institution will be granted initial intake of 40. Only after the first batch completes three years, application for additional intake will be considered provided.

6.1.2 Current Land-use Pattern



The main campus of the University on East Coast road is spread in an area of 800 acres with a 100 acres barren land placed within this

1. Transit Distances

Airport – 9 Kms

Puducherry Bus terminus – 12.9

Kms

Kalepet Bus depot – 1km

2. MAJOR Cities

Puducherry – Main CBD 10 Kms

Auroville – 5Kms

Chennai – 150 Kms

Bengaluru – 366 Kms

Fig 6.1 Site Selection

6.2 NEED FOR SPA IN PONDICHERRY

Currently there are only 3 SPA's In India. SPA is considered as premium education institute for Architecture studies in India as it is government based. The Cost of study is lower in case of SPA as compared to other private Institutes. Provides opportunity through merit based and hence well qualified Architects will graduate the institute. More exposure for the southern Part of India for better research scope through a national level university.

Government of India has proposed 18 SPA's and NITs to promote improved access and quality of education for higher Studies. The proposal in SPA Puducherry stood first in the challenge Mode competition. Majorly due to CAE norms and its good existing facilities. Opportunity to promote inside an existing campus Can become the 2nd SPA in South India.

The Public & Semi-Public land use contribution in Oulgaret Municipality is 22.89 % of the total area and it is around 7.91 sq.km. Puducherry University occupies a large chunk of land

in Kalapet Village. Other major public and semi-public use within the Oulgaret Municipality is JIPMER which is located on western side of NH-66 in Thattanchavady village.

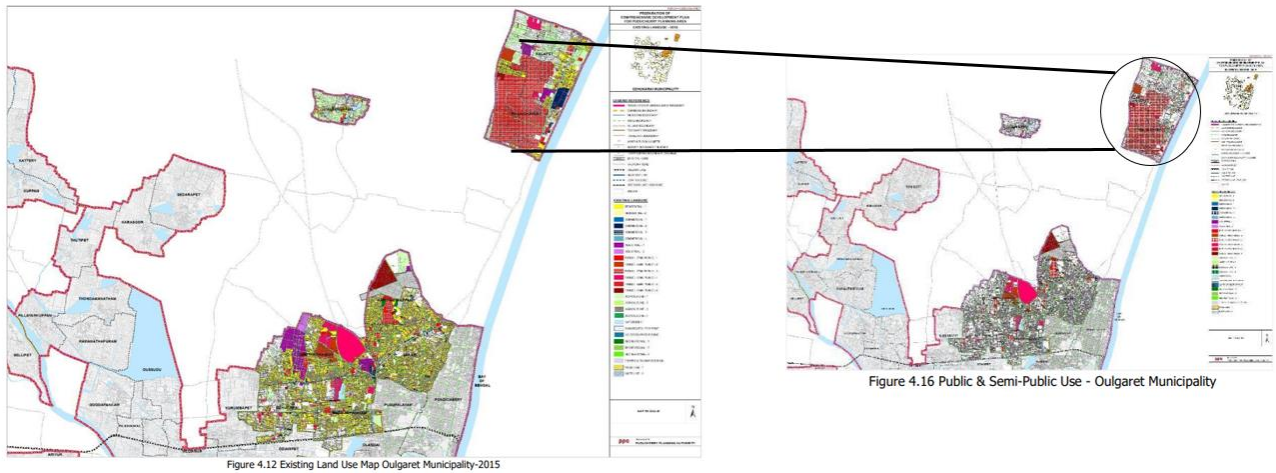


Fig 6.2 Current Land Use Pattern

6.3 COA GUIDELINES

Number of Practicing Architects in the region. – Minimum 200 architects must be in active practice within one hour travelling distance of proposed institution for each 40 seats intake. Priority will be given for state/ central non-private universities to establish constituent college of architecture and colleges/institutions to be started by Union/ State government, irrespective of location (Category).

The main campus of the University on East Coast road is spread in an area of 800 acres with a 100 acres barren land placed within this.

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Chennai – 150 Kms

Bengaluru – 366 Kms

All Campus Facilities Like Health care , Canteen , Student hostels and Sports center are available within the Campus.

6.3 SWOT ANALYSIS



STRENGTH	WEAKNESS
1. All Facilities for students are available in Campus. 2. Located near to Auroville and major cities like Chennai & Bangalore 3. Better facilities for Professionals in field to visit the SPA. 4. Public Transit nearby.	1. Located near in the isolated Village of Kalepet hence, Night travel is unsafe. 2. No Day scholar facilities possible as not located in Tier – 1 city. 3. Located near the ECR within 2.3 km hence possible effects of sea breeze and saline intrusion.
OPPURTUNITES	THREAT
1. As located near Auroville could in future become a center for sustainable and Earth Architecture. 2. Located in campus Green Energy Technology could help Architecture students exposure in Alternate Construction facilities.	1. Due to Coast line nearby sea breeze and its impact on the building 2. During heavy rains and Cyclones the impact on the University Buildings would be High. 3. High Humidity levels possible for increased discomfort levels Indoors

Fig 6.3 SWOT Analysis

6.4 DETAILED SITE SELECTED AREA WITH DIMENSIONS

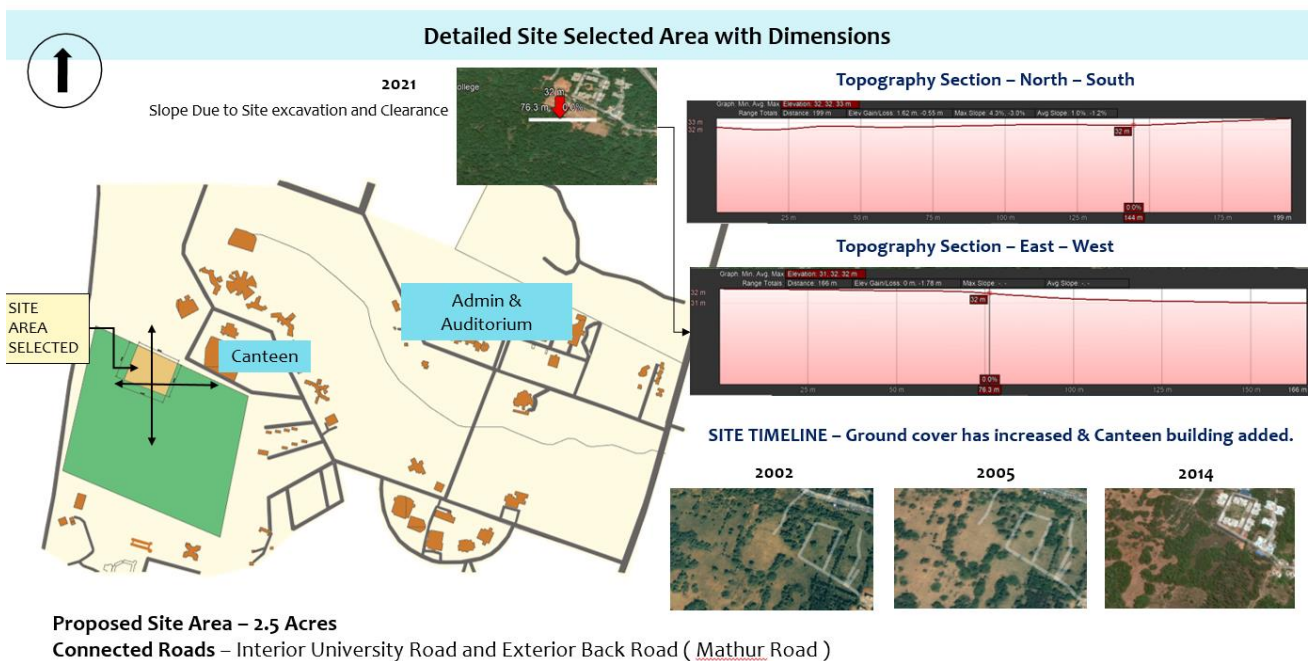


Fig 6.3 Site Selection and Topography Slope

CHAPTER 7 CLIMATE ANALYSIS

7.1 PONDICHERY CLIMATE ANALYSIS – MACRO LEVEL

Climate of the city is characterized by hot, tropical maritime type having small daily range of temperature, humid weather and moderate annual rainfall. Average annual Maximum Temp. is 33.3 C. Mean Maximum Temp. of Hottest Month (May) is 37.0 C. Mean Maximum Temp. of Coldest Month (Jan) is 29.8 C. Average annual Minimum Temp. is 24.2 C. Mean Minimum Temp. of Hottest Month (May) is 26.9 C. Mean Minimum Temp. of Coldest Month (Jan) is 20.6 C.

RAINFALL DATA ANALYSIS - Average Annual Rainfall is 135.5 cm. Average annual Rainy days are 55 nos. Mean monthly highest rainfall observed in November is 37.8 cm. Mean monthly lowest rainfall observed in April is 1.0 cm.

HUMIDITY DATA ANALYSIS - Relative humidity is generally high throughout the year. It ranges from 70% to 89% in the morning and 66% to 79% in the afternoon. During the period June to December the skies are generally heavily clouded to overcast. Rest of the year skies are clear or lightly clouded

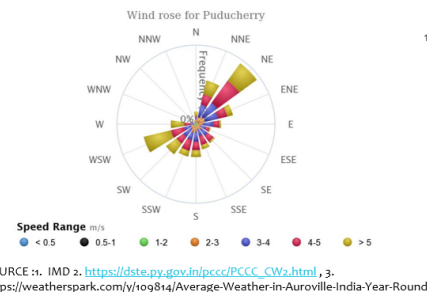
	January	February	March	April	May	June	July	August	September	October	November	December
Avg. Temperature °C (°F)	24.8 °C (76.7) °F	25.7 °C (78.3) °F	27.4 °C (81.4) °F	29.2 °C (84.6) °F	30.4 °C (86.8) °F	30.2 °C (86.4) °F	29.8 °C (85.6) °F	29.2 °C (84.5) °F	28.8 °C (83.8) °F	27.4 °C (81.4) °F	25.9 °C (78.7) °F	25 °C (77.1) °F
Min. Temperature °C (°F)	22.4 °C (72.2) °F	22.8 °C (73.1) °F	24.5 °C (76) °F	26.9 °C (80.5) °F	28.1 °C (82.6) °F	27.8 °C (82.1) °F	27.4 °C (81.3) °F	26.9 °C (80.3) °F	26.5 °C (79.7) °F	25.3 °C (77.6) °F	24 °C (75.2) °F	22.9 °C (73.3) °F
Max. Temperature °C (°F)	27.3 °C (81.1) °F	28.5 °C (83.3) °F	30.3 °C (86.6) °F	32 °C (89.5) °F	33.4 °C (92) °F	33.3 °C (91.9) °F	33 °C (91.3) °F	32.2 °C (90) °F	31.7 °C (89) °F	29.9 °C (85.8) °F	28 °C (82.3) °F	27.1 °C (80.8) °F
Precipitation / Rainfall mm (in)	23 (0.9)	13 (0.5)	22 (0.9)	34 (1.3)	48 (1.9)	48 (1.9)	60 (2.4)	93 (3.7)	104 (4.1)	228 (9)	259 (10.2)	132 (5.2)
Humidity(%)	74%	74%	74%	76%	71%	67%	66%	70%	74%	79%	80%	77%
Rainy days (d)	4	2	3	4	5	7	8	10	11	15	14	8
avg. Sun hours (hours)	7.6	8.4	9.0	9.8	11.0	11.2	10.9	10.7	10.3	8.8	7.4	7.0

Fig 7.1 Pondicherry Climate Data

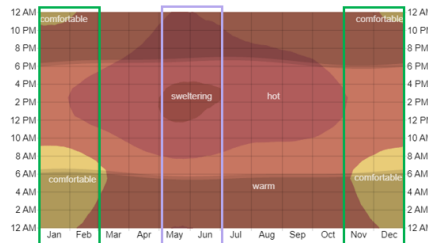
WIND SPEED ANALYSIS

During Southwest monsoon period, wind blows predominantly from **West-South-West direction, some times from Southwest and West directions.**

During the **Northeast monsoon season**, wind blow predominantly from north and sometime from **North-North-West and North-North-East directions.**

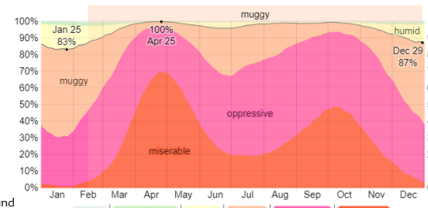


Average Hourly Temperature in Auroville



Since the climatic condition is **warm and humid** it mostly in the **hot and warm condition except may and June** where the sweltering weather is seen in afternoons. **Comfort is observed during Nov, Dec, Jan & Feb**

Humidity Comfort Levels in Auroville



Experiences a high humidity throughout the year. **During Day time, humidity is in the range of 80- 85 %**, coming down to **75-80% in the evenings.**

Fig 7.2 Macro Level Analysis

7.2 SITE MICROCLIMATE ANALYSIS

Due to the Presence of Trees the entire campus has positive Influence of Reduction of Temperature which helps better Comfort Levels for the Building Forms Inside the Campus. Being near the Coast the Wind Speeds Range up to 7m/s but the effect to vegetation slows down this wind speed to acceptable range within 5m/s for outdoor conditions.

7.3 PASSIVE STRATEGIES TO BE INCORPORATED

REDUCE HEAT GAIN – North – South Façade Orientation preferred. MAXIMIZE OUTDOOR INTERACTION - of spaces to improve the Wind movement to mitigate the negative impact created due to high humidity levels. TRANSITION SPACES – Mid level to create comfortable environment – shaded throughout – minimum exposure to direct outside. IMPROVE WIND MOVEMENT – through form facilitate wind to be induced inside the Building mass.

7.4 SITE ANALYSIS

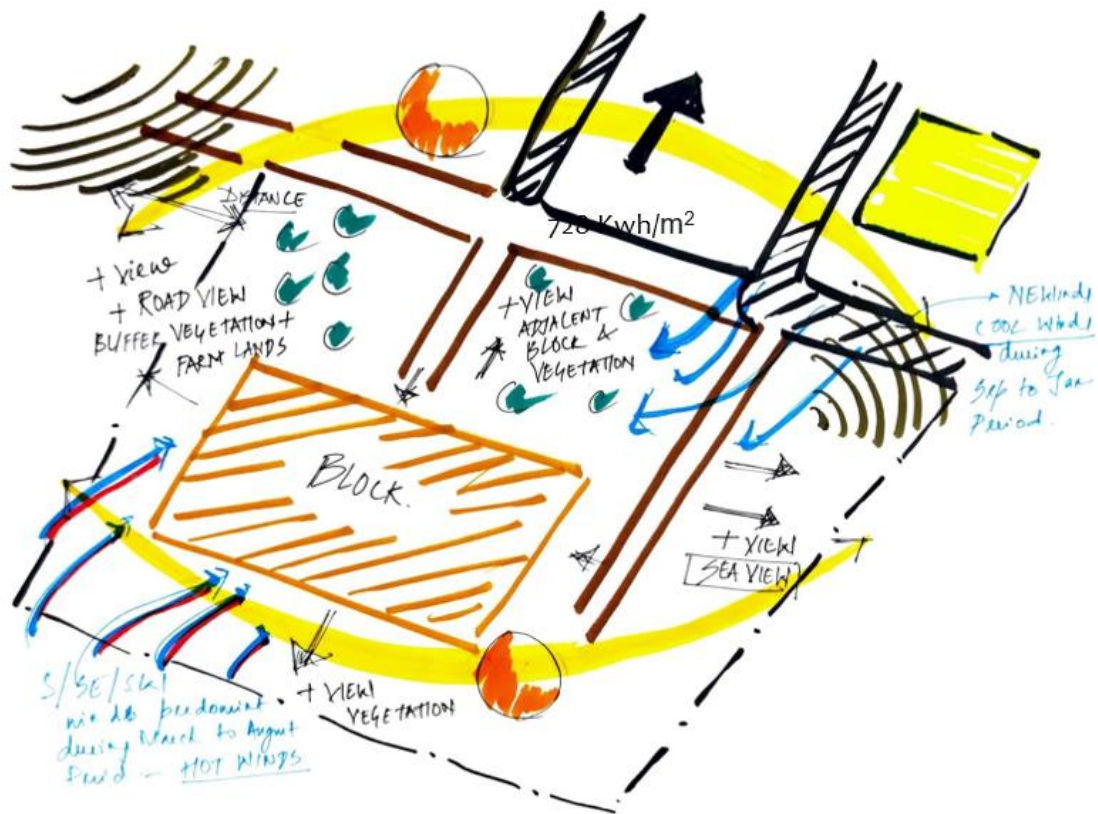


Fig 7.3 Site Analysis

CHAPTER 8 BUILT FORM PARAMETERS AND AREA STATEMENT

8.1 BUILT FORM PARAMETERS CONSIDERED FOR EVALUATION

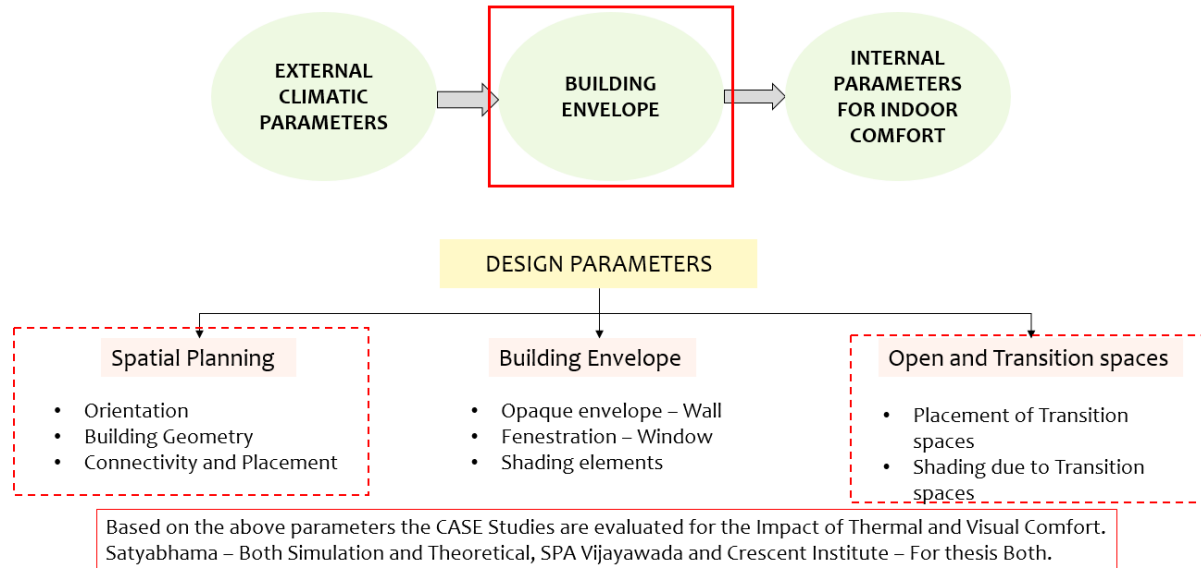


Fig 8.1 Built Form Parameters

8.2 AREA REQUIREMENTS FOR SPA

A. ADMINISTRATION AREA:

Administration area must have common facilities which is shared by all office staff and principal and non-teaching staff

It should be accessible to all the workers of administration area and visitors can access the reception area directly.

All data of institution should be available here and it will be enclosed to administration head office.

Cashier space and locker should be isolated and not accessible to all except the office worker.

B. STUDIO AND CLASSROOM

Different type of studios for different departments

The studio must have enough working space, storage area, display area and area for interaction.

The studio must have intake of fresh air and north light.

Studio size may vary according to number of user and department.

C. LIBRARY

Reading area which is permanently lit with the daylight.

Reference area should be accessible to librarian and under his/he' supervision students and faculty should refer the data.

Cloak room should be outside the library.

I. CANTEEN and other circulation spaces.

34

CHAPTER 9 DESIGN EVOLUTION

9.1 ACTIVITY MAPPING

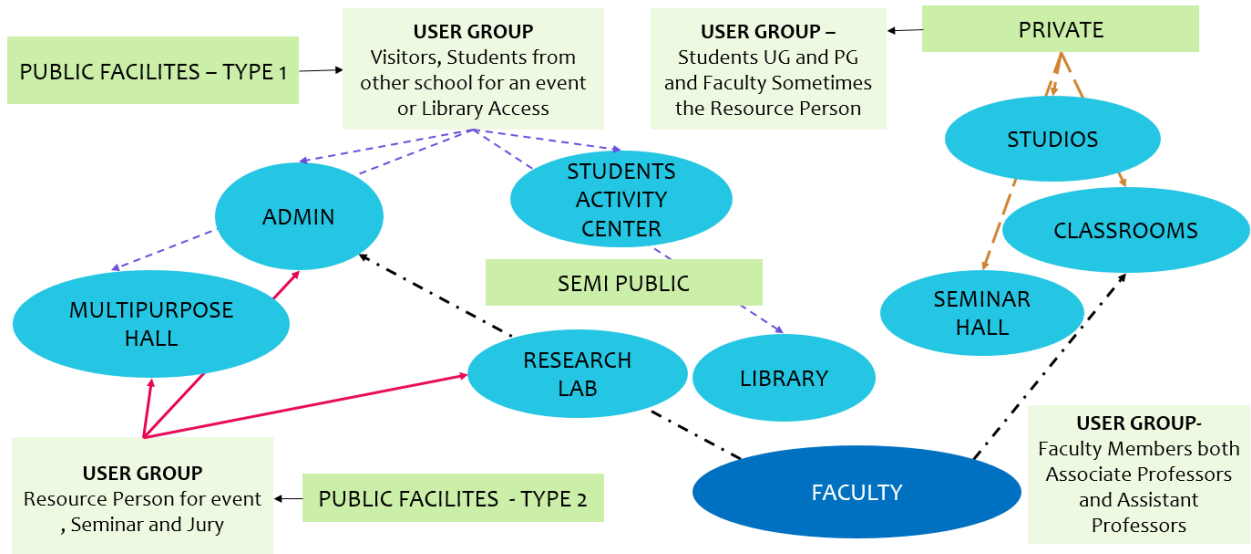


Fig 9.1 Activity Mapping

9.2 FORM EVOLUTION SCHEME 1

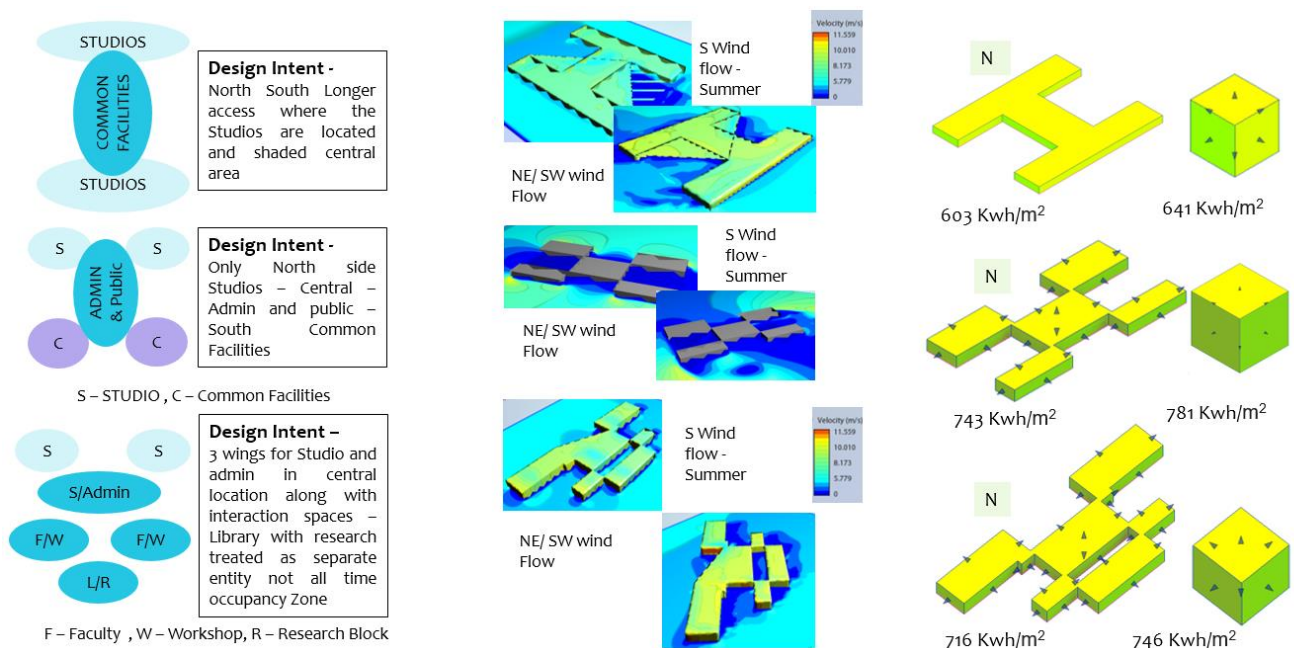


Fig 9.2 Form Evolution Scheme 1

9.2.1 VERTICAL FLOW OF SPACES AND PASSIVE DESIGN CONCEPTS

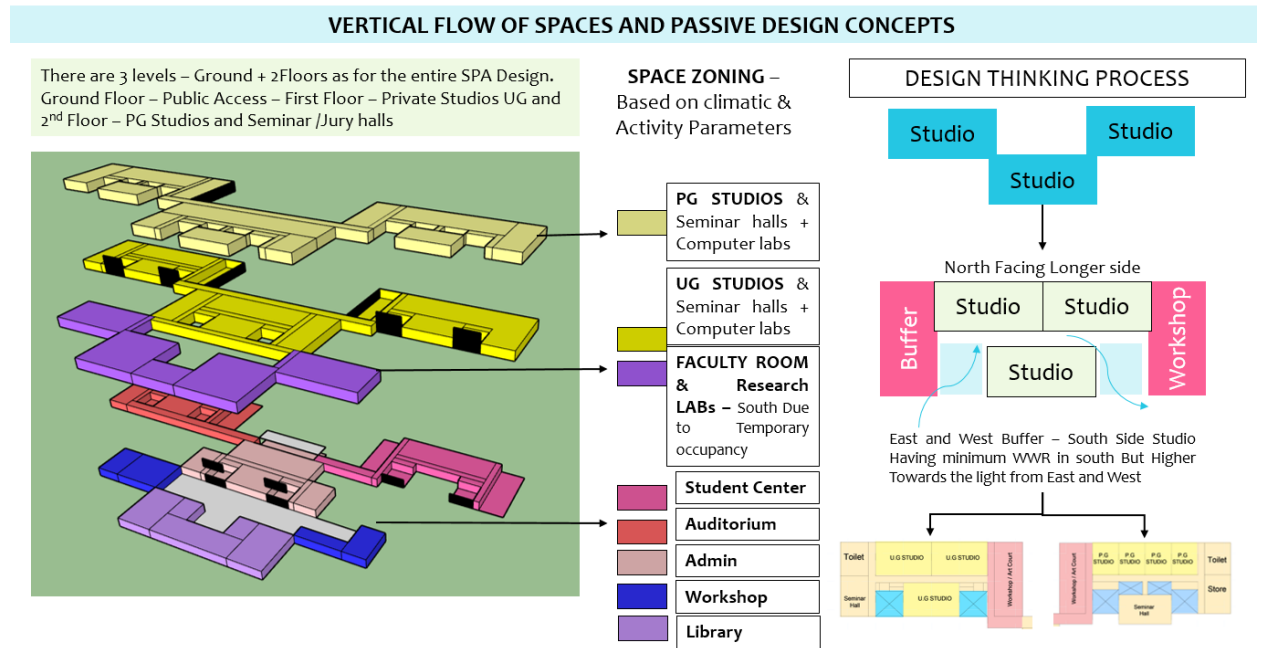


Fig 9.3 vertical flow of spaces and passive design concepts

9.2.2 CONCEPTUAL ZONING

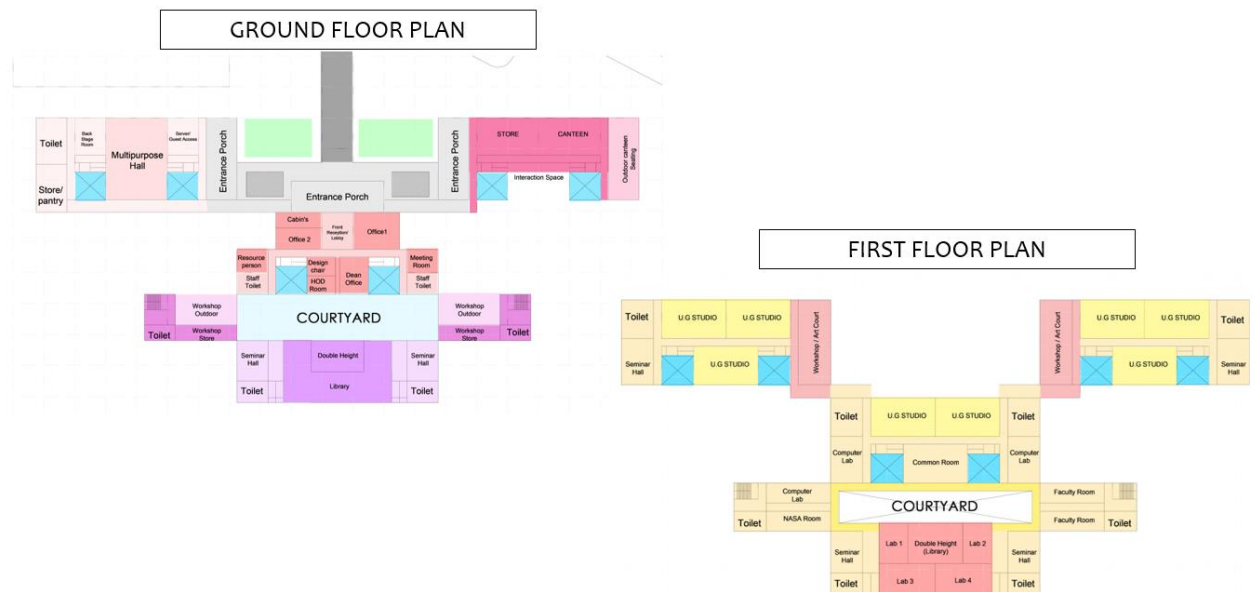


Fig 9.4 Scheme 1 Conceptual Zoning

9.3 FORM EVOULUTION SCHEME 2

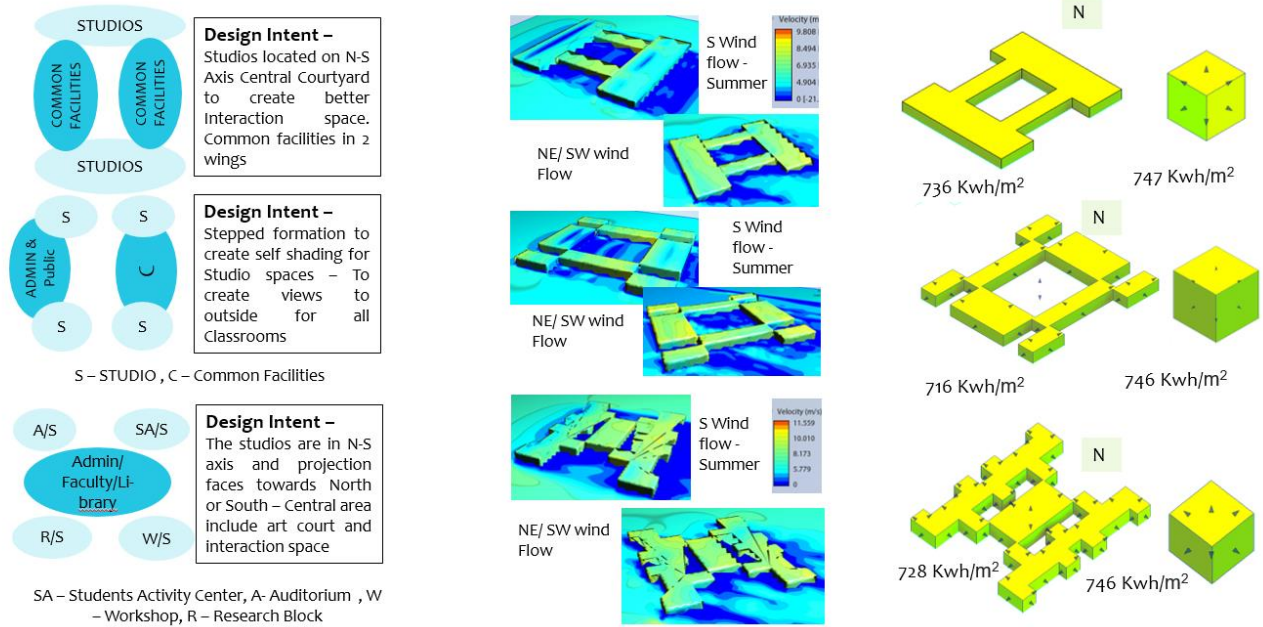


Fig 9.5 Form Evolution Scheme 2

9.3.1 VERTICAL FLOW OF SPACES AND PASSIVE DESIGN CONCEPTS

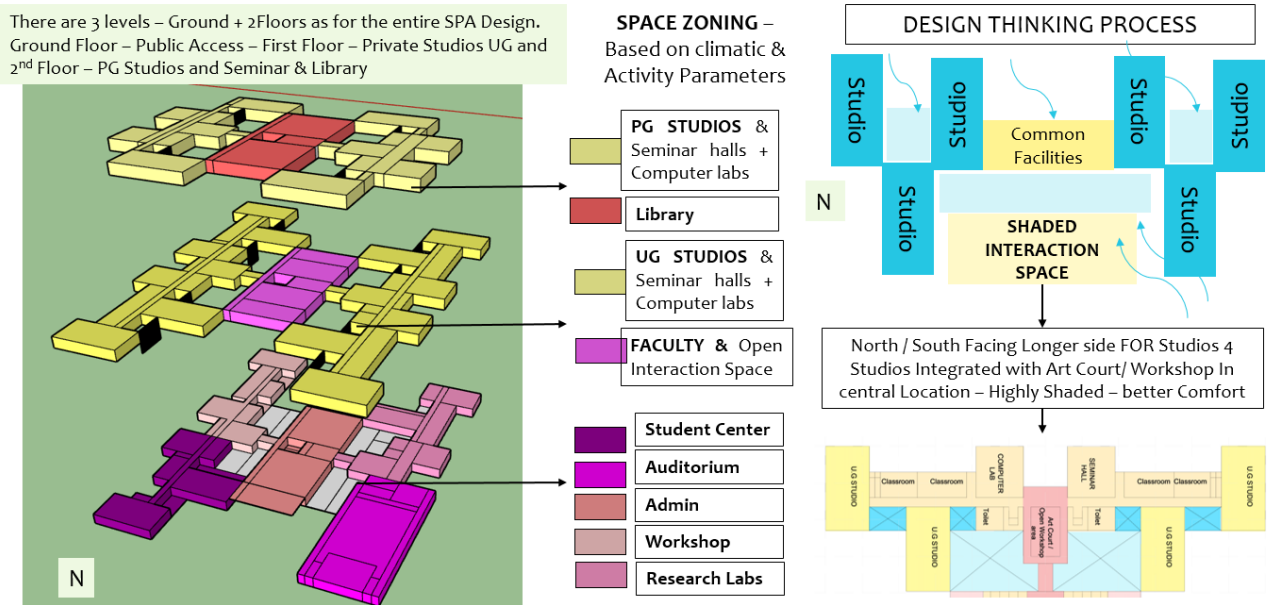
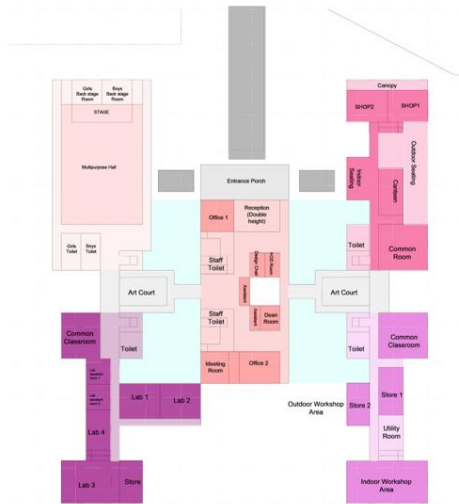


Fig 9.6 vertical flow of spaces and passive design concepts

9.3.2 CONCEPTUAL ZONING

GROUND FLOOR PLAN



FIRST FLOOR PLAN

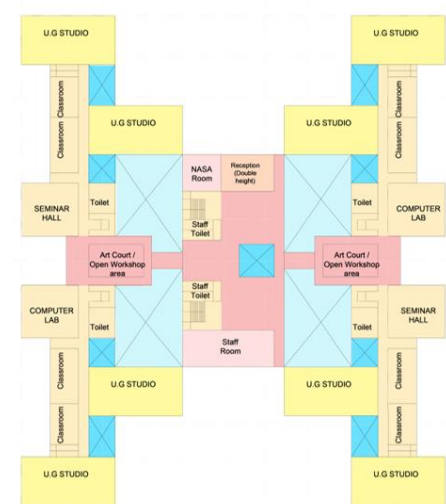


Fig 9.7 Scheme 2 Conceptual Zoning

9.4 FORM EVOLUTION SCHEME 3

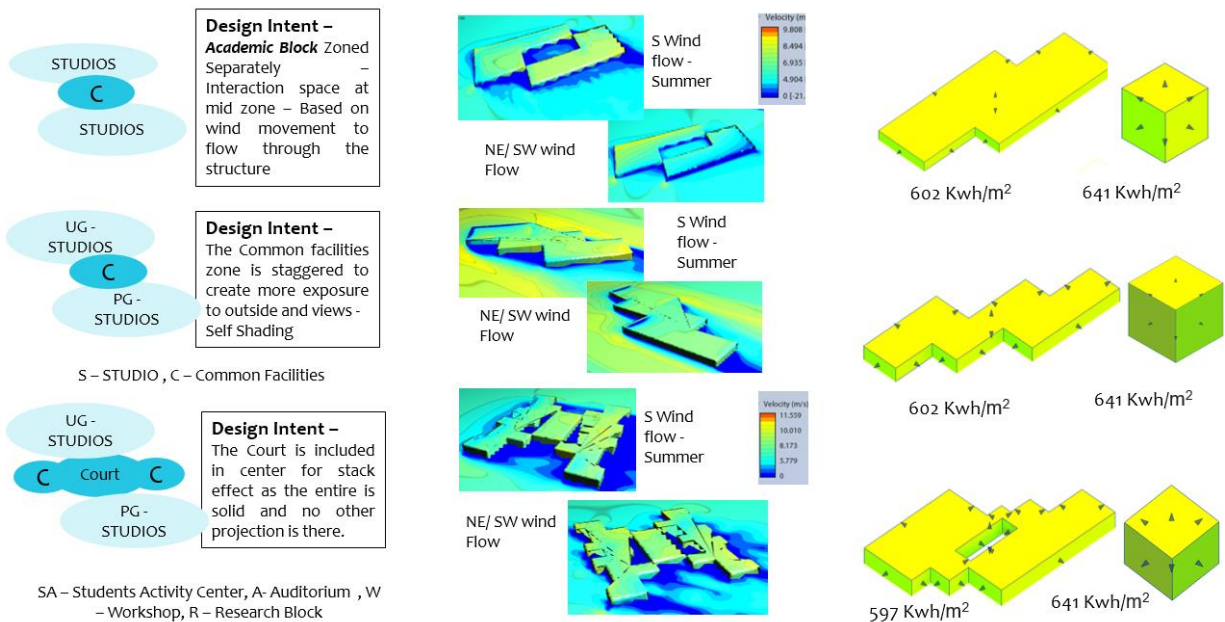


Fig 9.8 Form Evolution Scheme 2

9.4.1 CONCEPTUAL ZONING



Fig 9.9 Scheme 3 Conceptual Zoning

CHAPTER 10 SPA PROPOSED DESIGN PLANS

10.1 WEST WING 15 Deg TILT

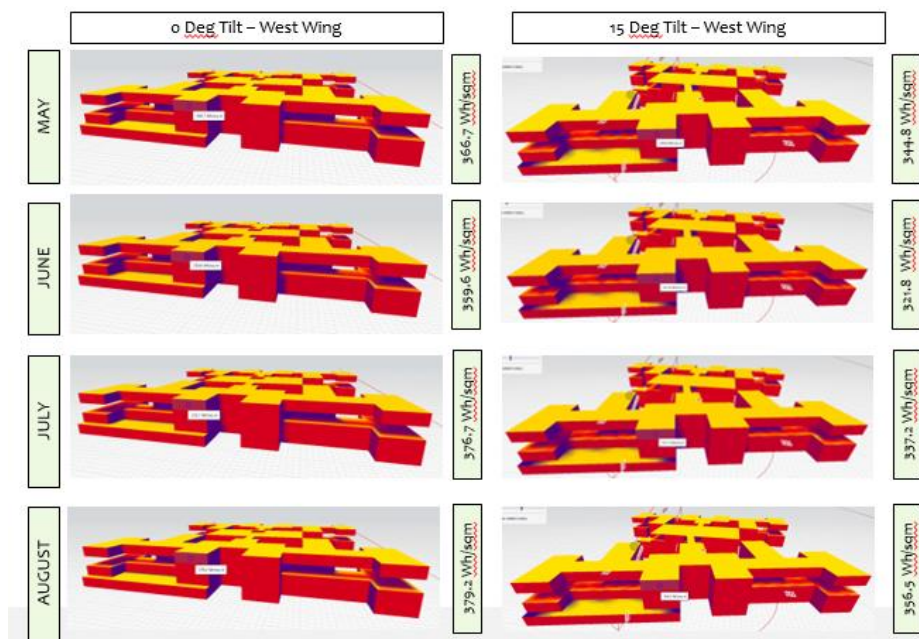


Fig 10.1 15 deg West wing Tilt Analysis

WHY WEST WING ?

The peak RADITION and Thermal discomfort period is noted post afternoon in most conditions. West wing would be directly exposed to radiation during peak time. Hence to reduce the direct radiation the 15 deg tilt was adopted. From the Radiation Analysis we can observe that the 15 Deg Tilt for the west has positively impacted to a decrease of about 30 to 40 wh/sqm. Being a Naturally Ventilated Building Small reduction in incident solar Radiation could also have a huge impact of the thermal Comfort.

10.2 SITE PLAN

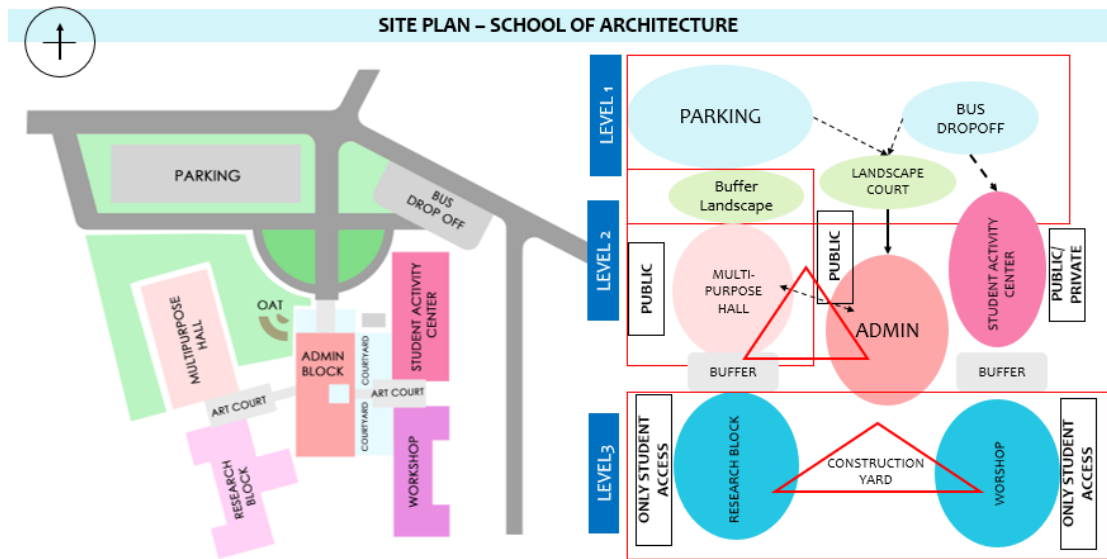


Fig 10.2 Site Plan

10.3 GROUND FLOOR PLAN

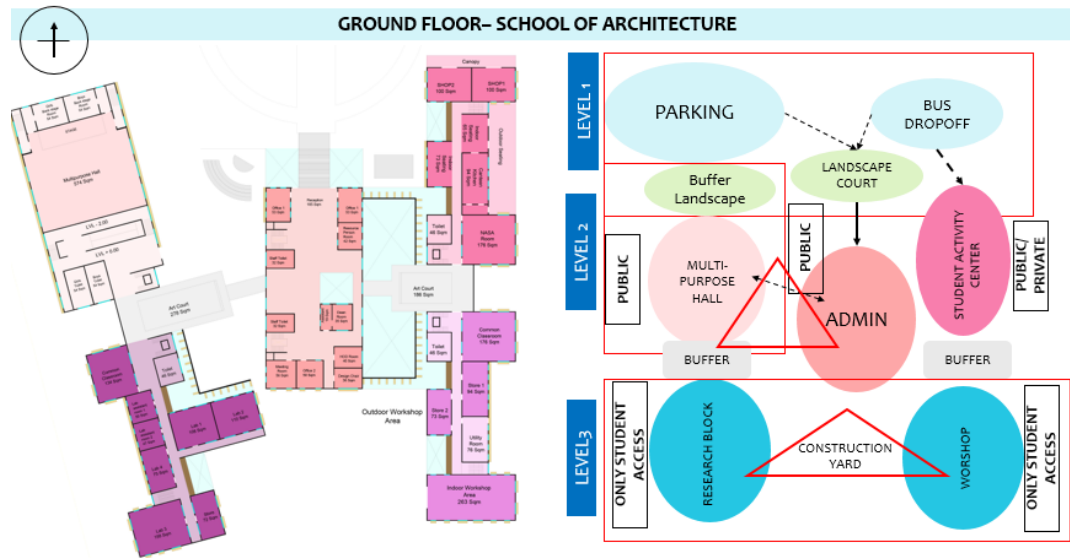


Fig 10.3 Ground Floor Plan

10.4 FIRST AND SECOND FLOOR PLANS

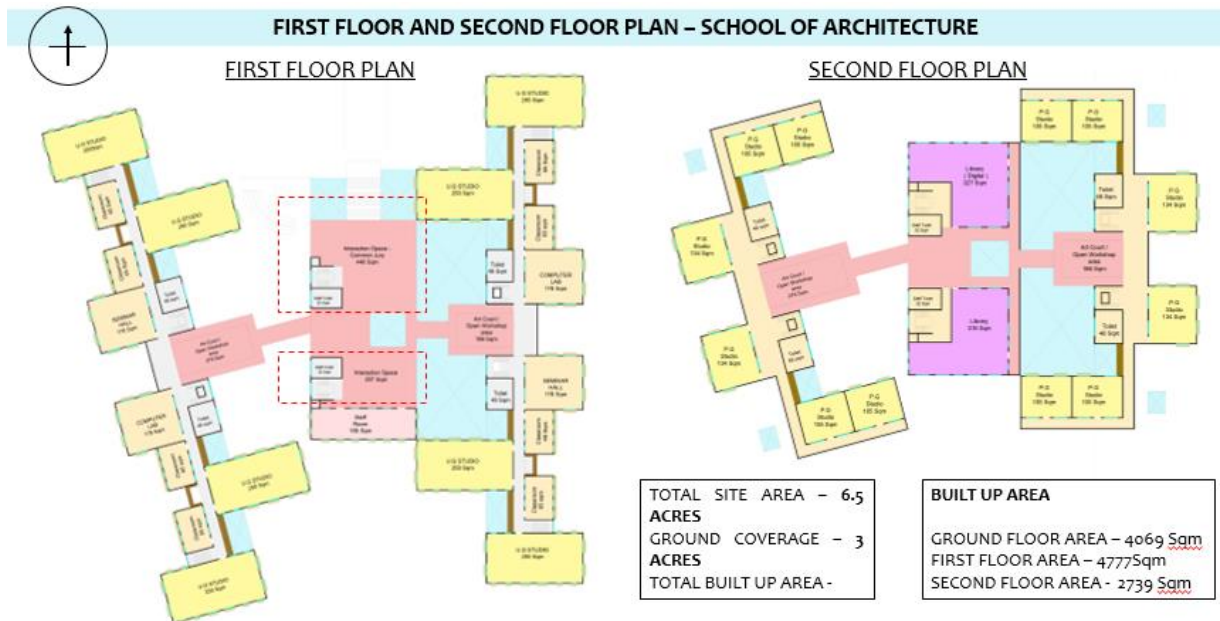


Fig 10.4 First and Second Floor Plan

10.5 TRANSITION SPACES IDENTIFICATION

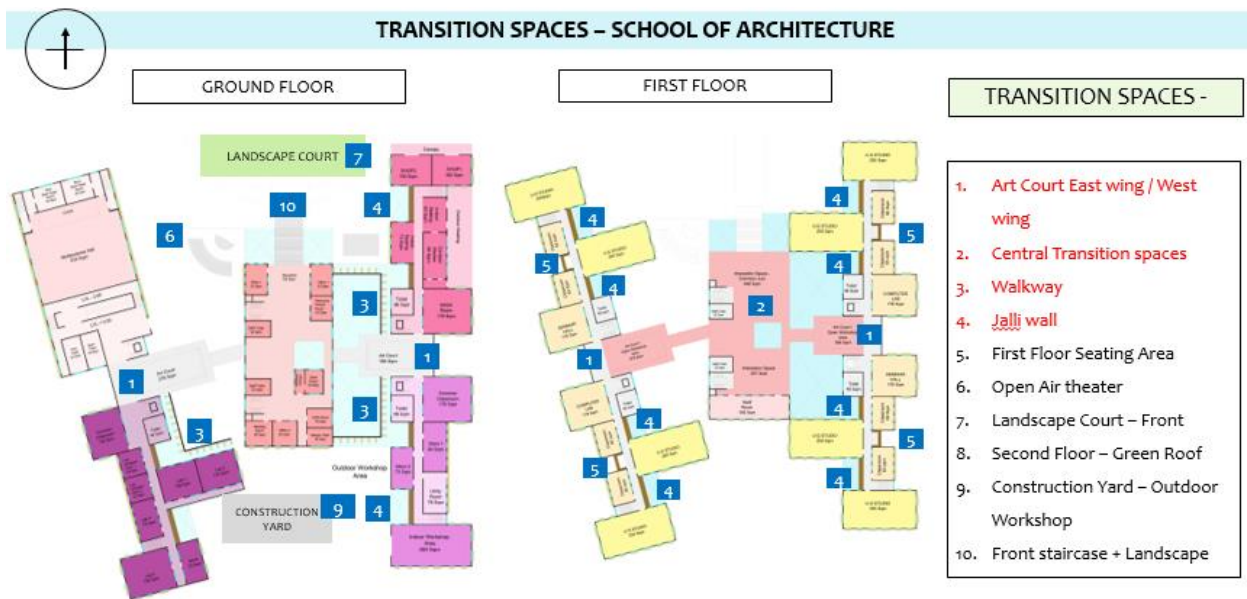


Fig 10.5 Transition spaces Identification

CHAPTER 11 TRANSITION SPACES

11.1 ART COURT AND CENTRAL TRANSITION SPACE

ART COURT - Smaller group of a class for Workshop or hands on work etc and Jury
CENTRAL TRANSITION AREA – Larger group (More than a single class) – Students
General interaction, Mainly open Jury.

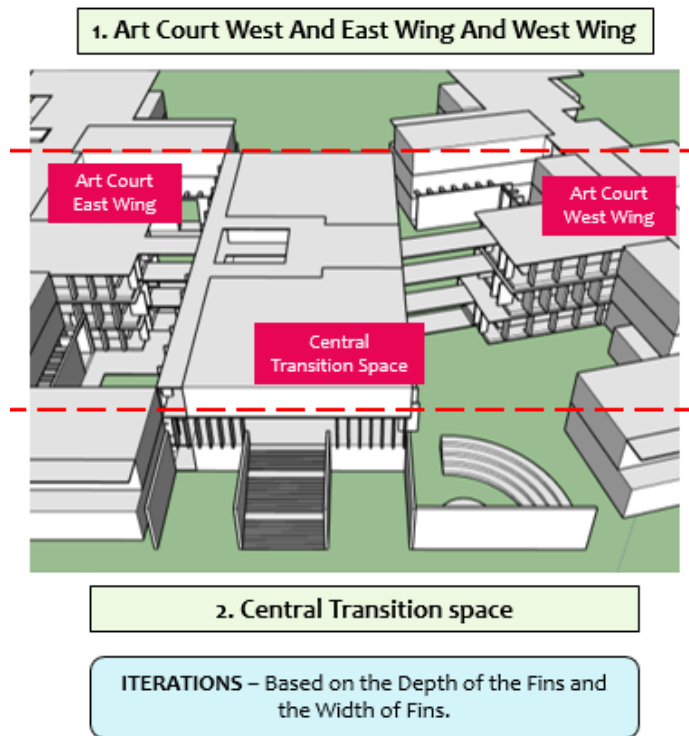


Fig 11.1 Art Court and Central Transition Space

11.2 SKY COURT WALKWAY GROUND FLOOR

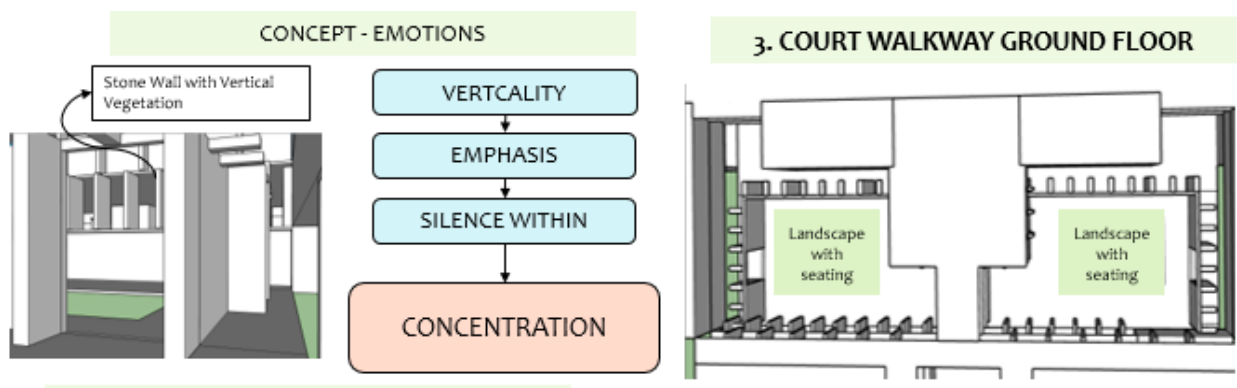


Fig 11.2 Sky Court Walkway

COURT WALKWAY GROUND FLOOR – Larger group (More than a single class)

Students General interaction, Casual discussion. Landscape element , Shaded space in Ground Level.

11.3 JALLI WALL CORRIDOR SEATING AREA

JALLI WALL – CORRIDOR SEATING AREA – Smaller Group, After Class Discussions, 10 to 15 members maximum capacity

Spillover space across the entire corridor helps in breeze penetration and views promotion along with interaction space.

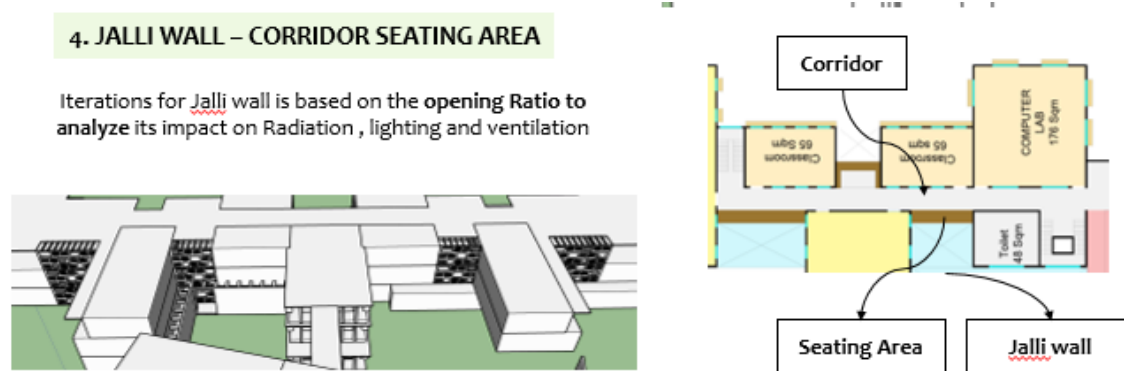


Fig 11.3 Jalli Wall

11.4 FIRST FLOOR SEATING, OPEN-AIR THEATRE AND LANDSCAPE COURT

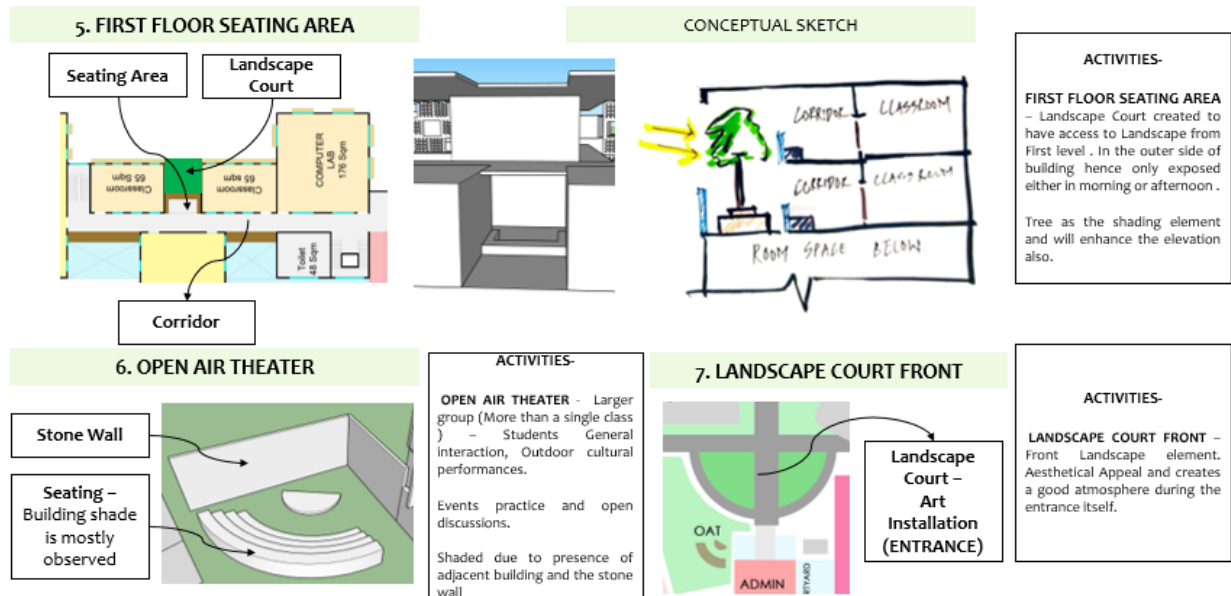


Fig 11.4 First Floor Seating, OAT and Landscape Court

11.5 GREEN ROOF, CONSTRUCTION YARD, AND FRONT LANDSCAPE

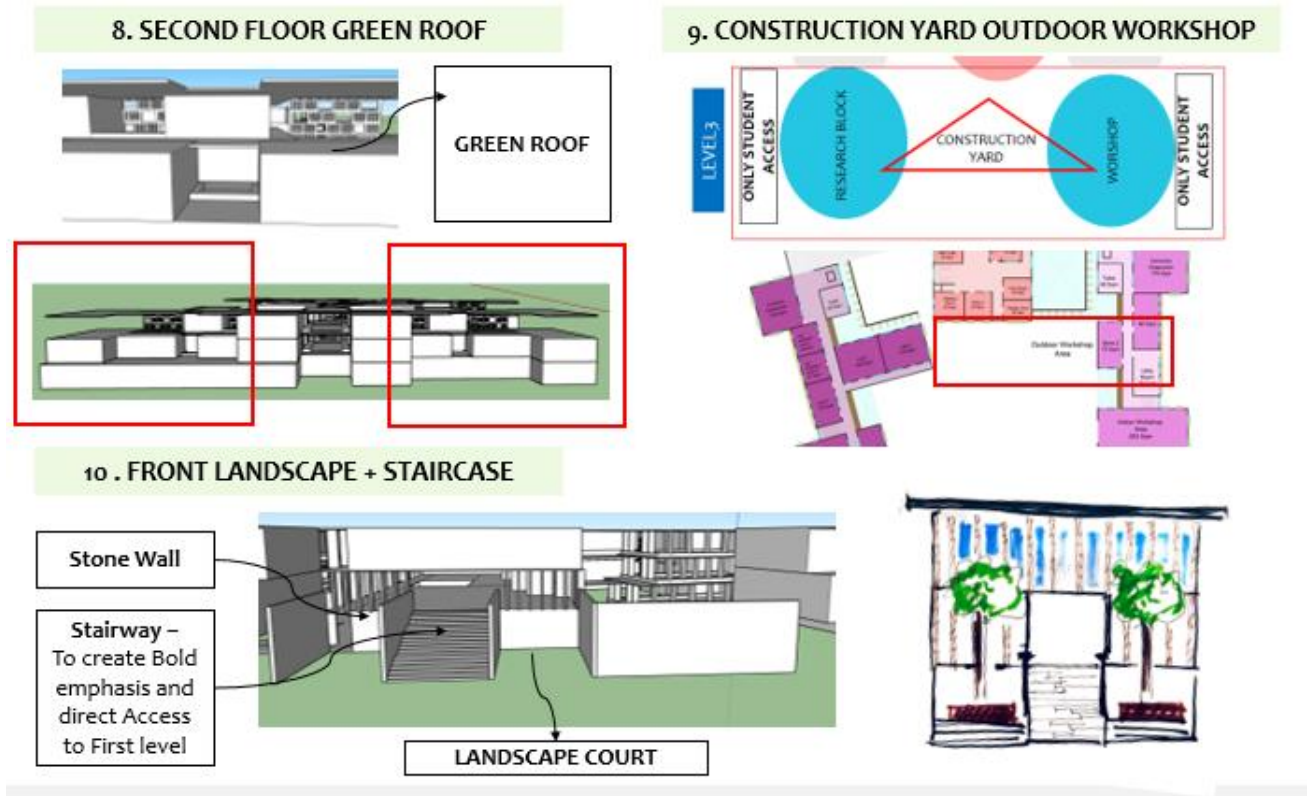


Fig 11.5 Green Roof, Construction Yard, and Front Landscape

CONSTRUCTION YARD OUTDOOR WORKSHOP - Workshop or hands-on work, a Larger group (More than a single class) – Students General Technical Interaction space. Connected with the Outdoor Workshop and Indoor Workshop and Research Block.

FRONT LANDSCAPE + STAIRCASE –Emphasis on the entry with the Massive Stone walls and Grand Staircase. Vertical Fins will be continued from the First floor and Second Floor.

CHAPTER 12 VERTICAL LOUVERS ITERATIONS

12.1 ITERATION 1 - 2m Width and 1m Projection

RADIATION ANALYSIS - VERTICAL LOUVERS – 2m Width and 1m Projection

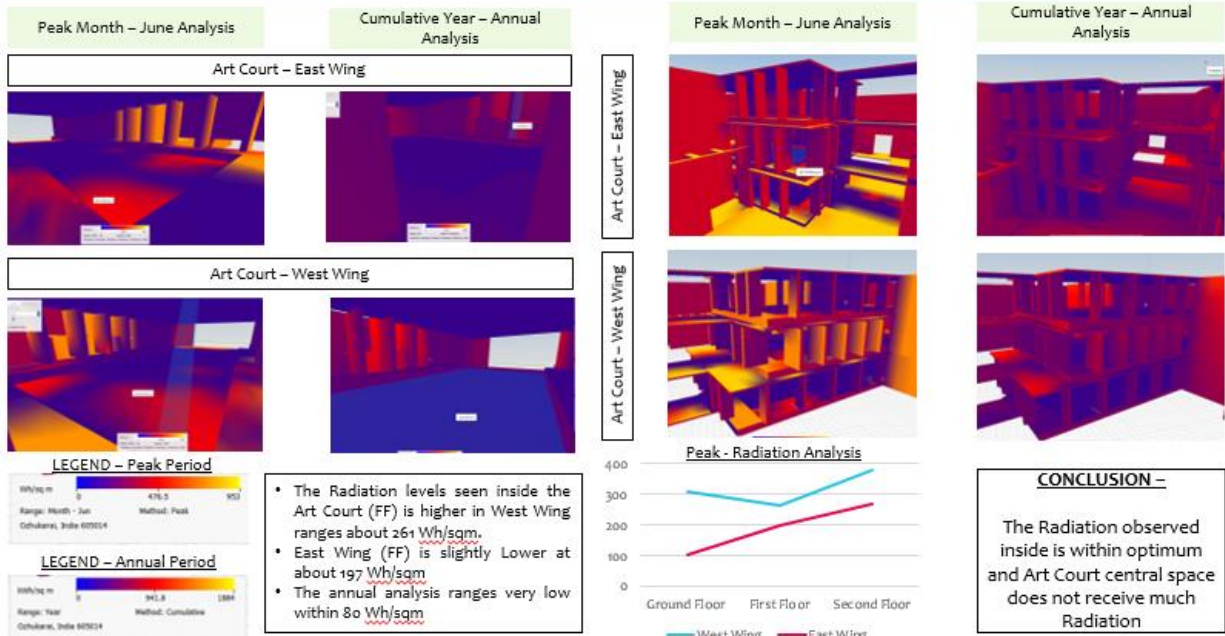


Fig 12.1 Iteration 1 Radiation Analysis

WIND & LIGHTING ANALYSIS - VERTICAL LOUVERS – 2m Width and 1m Projection

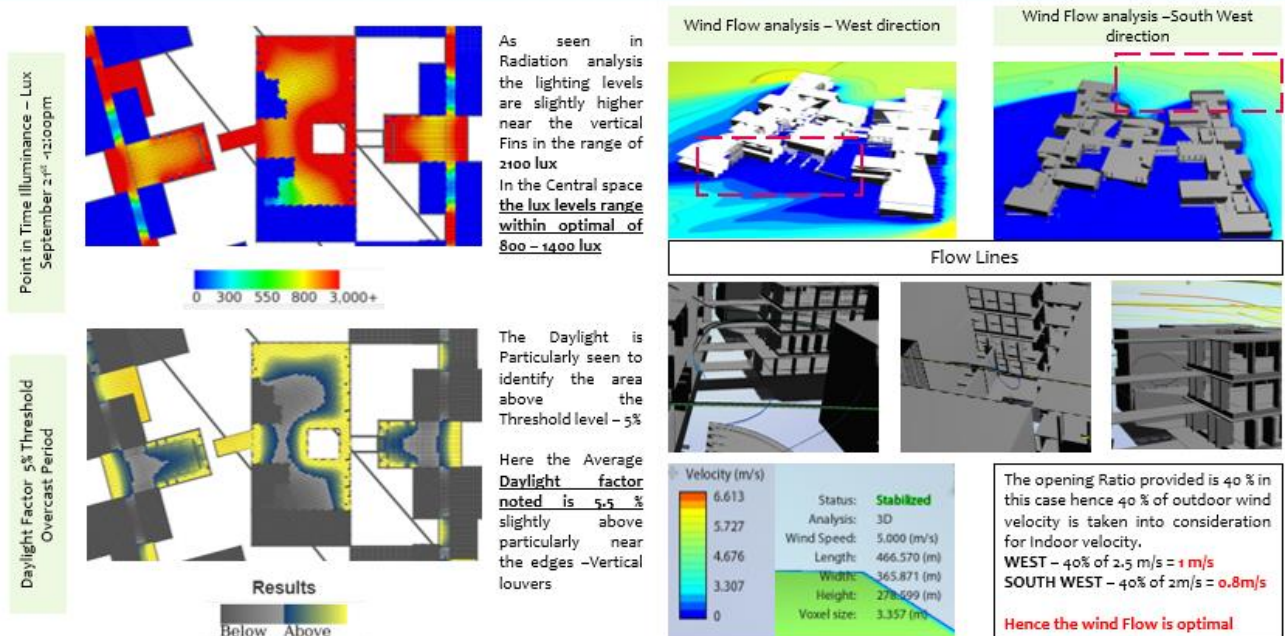


Fig 12.2 Iteration 1 Lighting and Wind Analysis

12.2 ITERATION 2 - 2m Width and 0.5m Projection

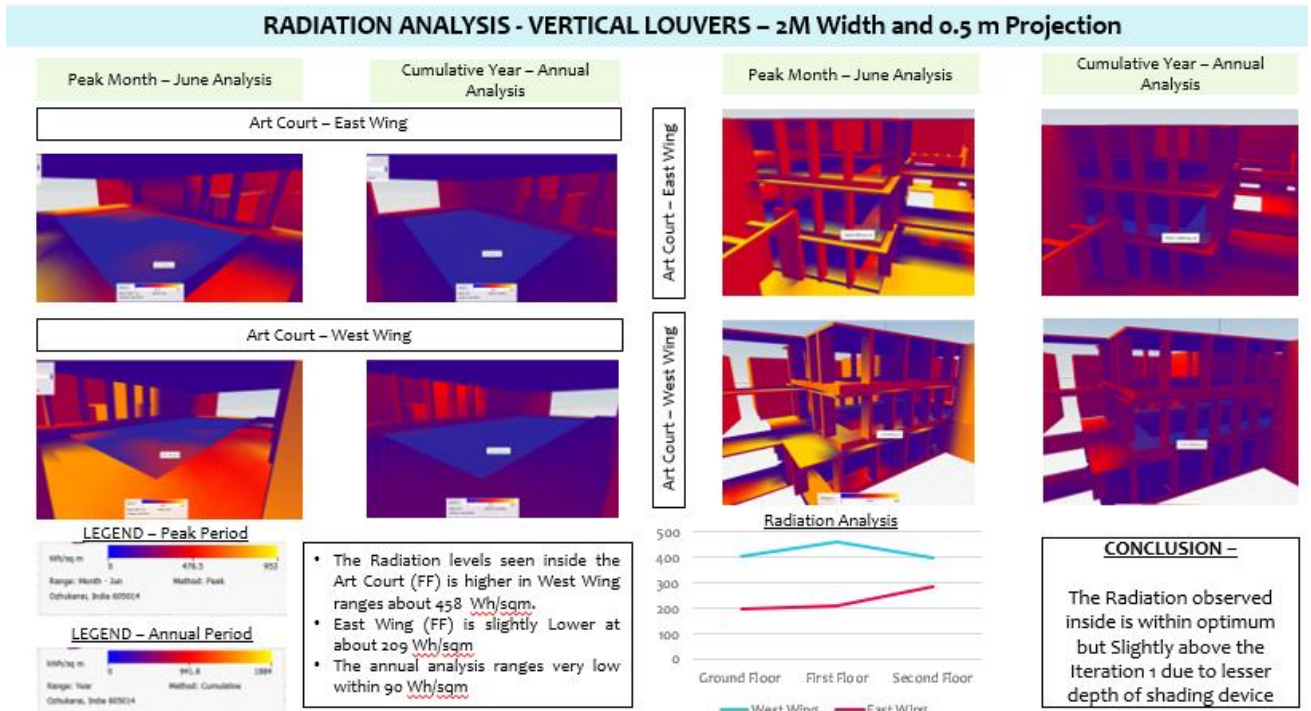


Fig 12.3 Iteration 2 Radiation Analysis

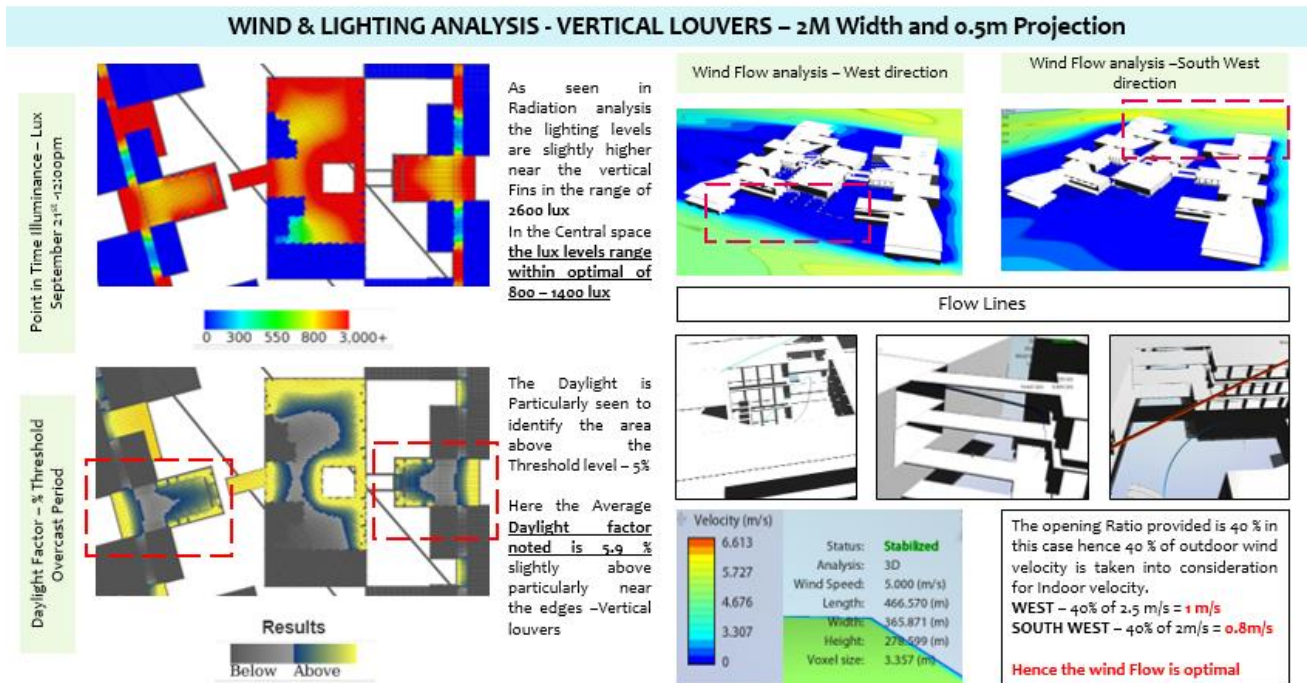


Fig 12.4 Iteration 2 Lighting and Wind Analysis

12.3 ITERATION 3 - 3m Width and 1m Projection

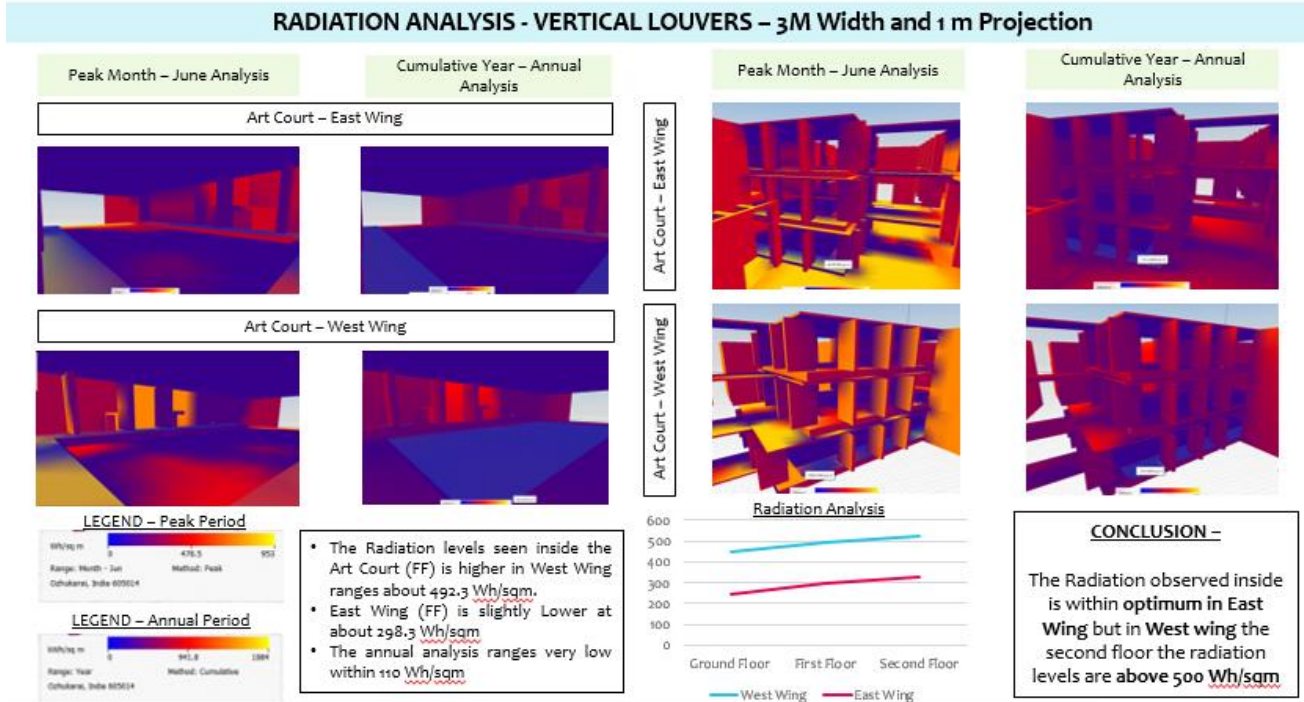


Fig 12.5 Iteration 3 Radiation Analysis

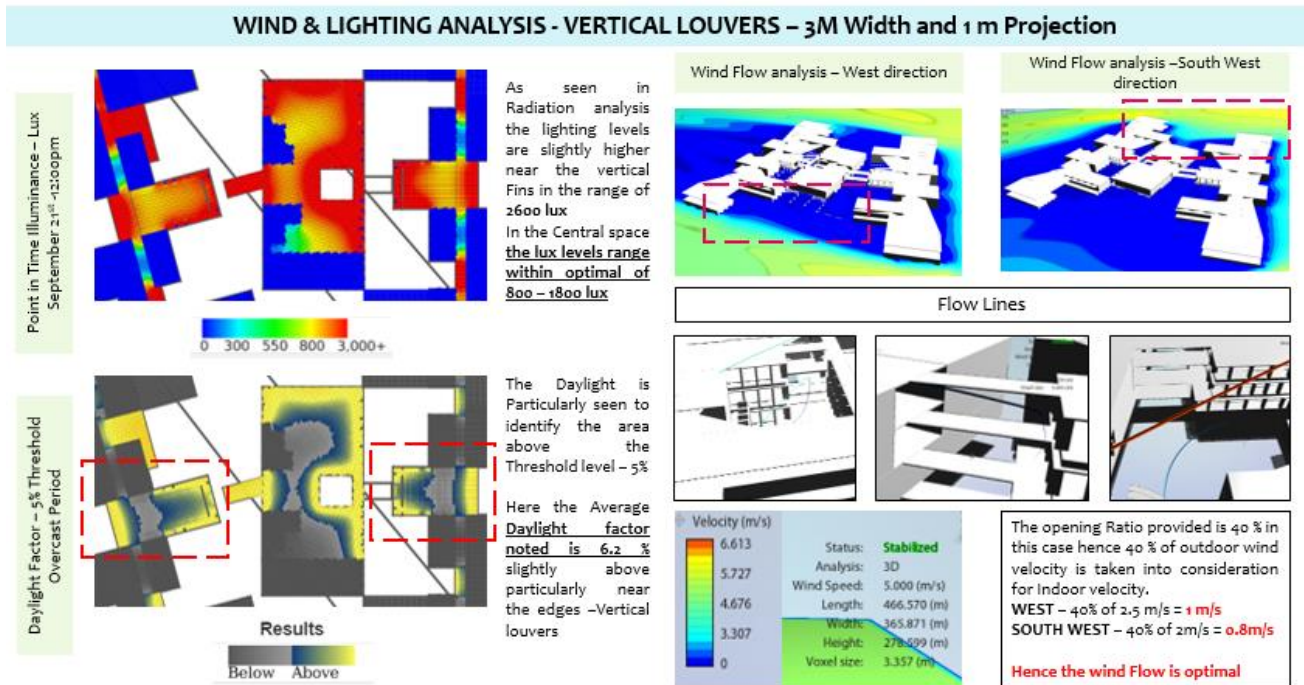


Fig 12.6 Iteration 3 Lighting and Wind Analysis

12.4 ITERATION 4 - 3m Width and 0.5m Projection

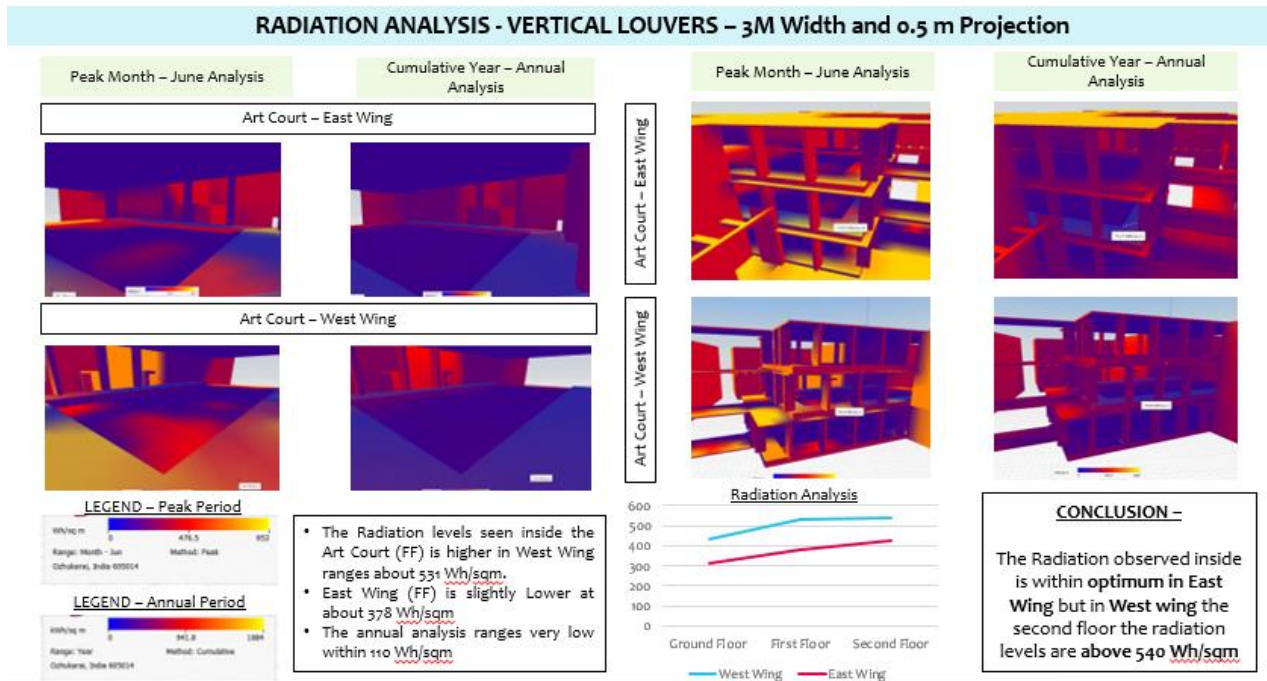


Fig 12.7 Iteration 4 Radiation Analysis

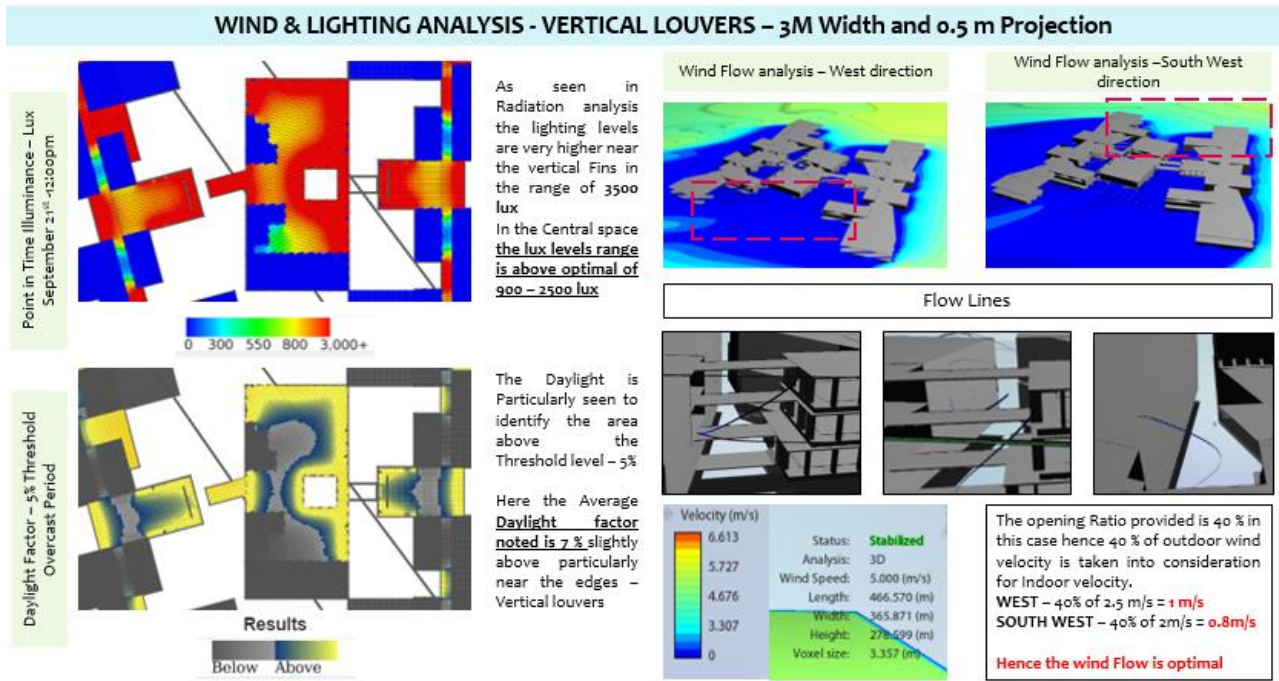


Fig 12.8 Iteration 4 Lighting and Wind Analysis

12.5 ITERATION 5 – 5 m Width and 1m Projection

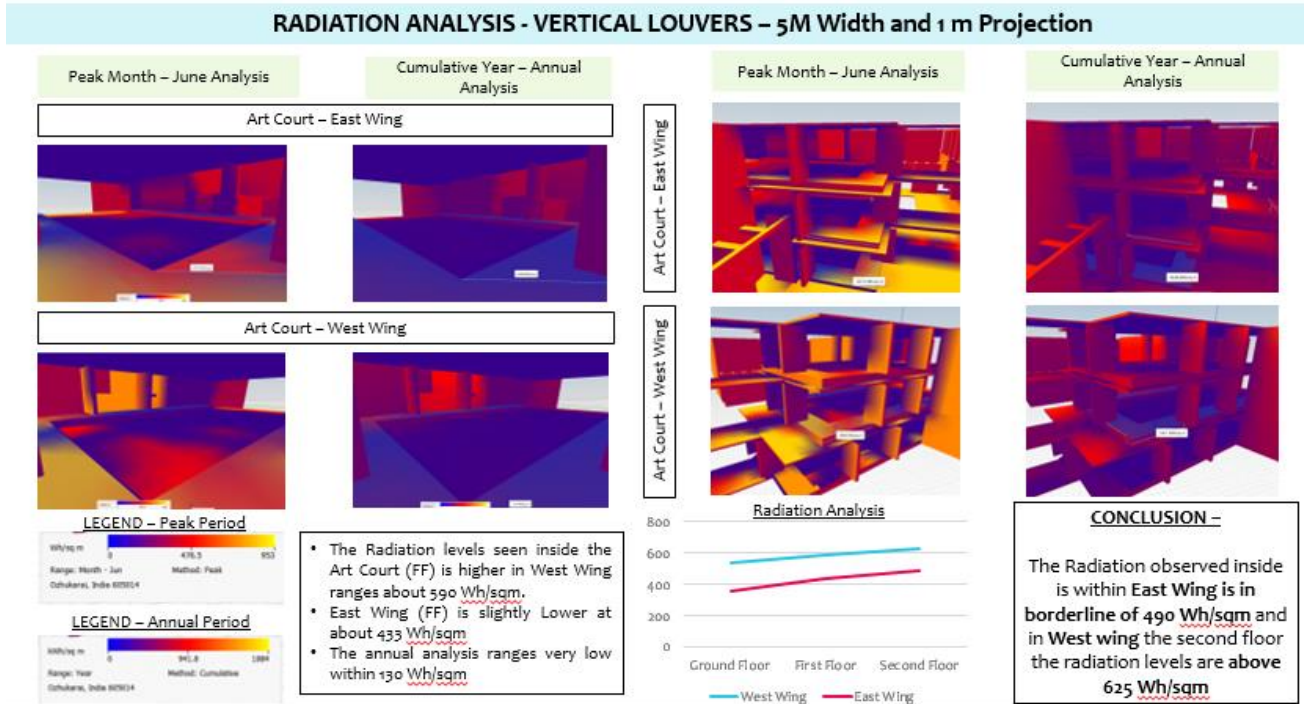


Fig 12.9 Iteration 5 Radiation Analysis

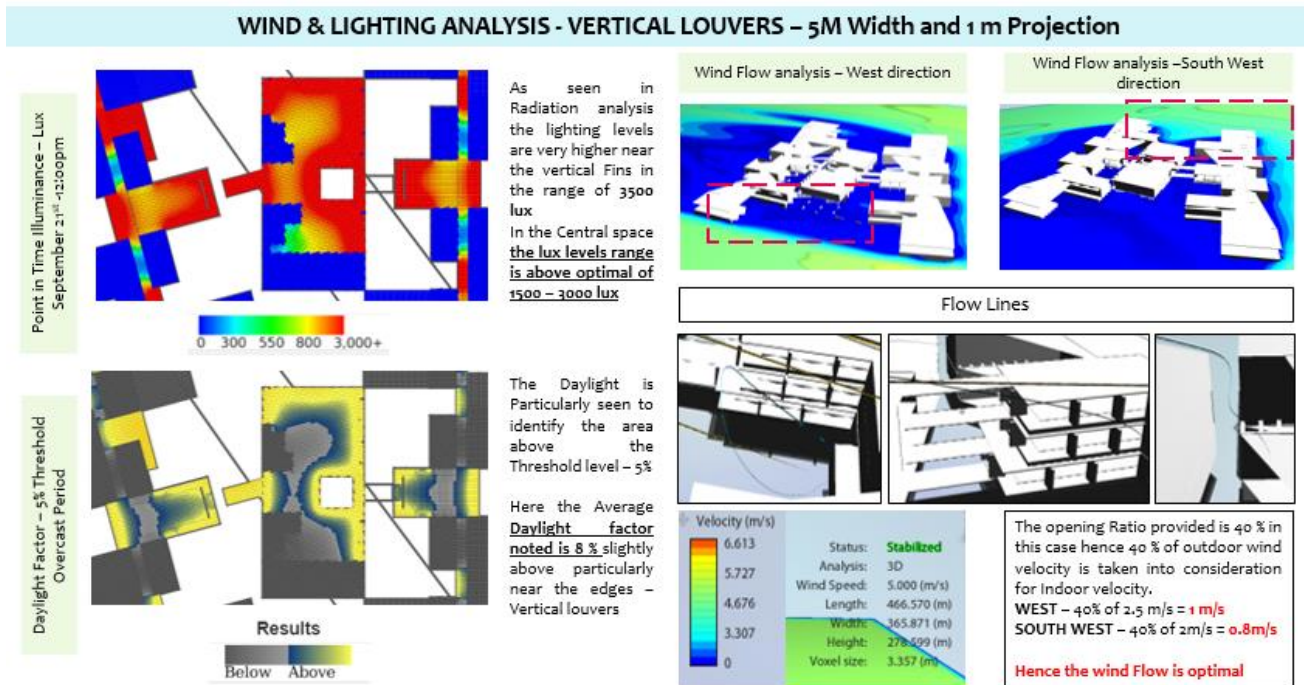


Fig 12.10 Iteration 5 Lighting and Wind Analysis

12.6 ITERATION 6 – 5 m Width and 0.5 m Projection

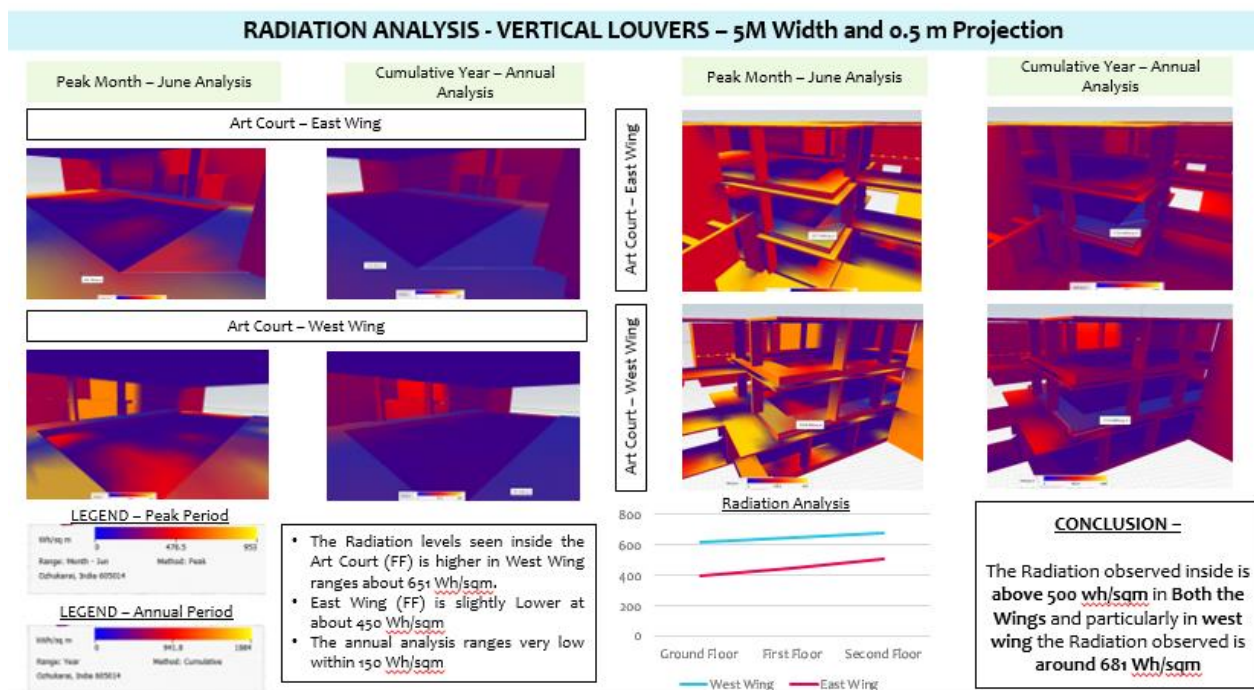


Fig 12.11 Iteration 6 Radiation Analysis

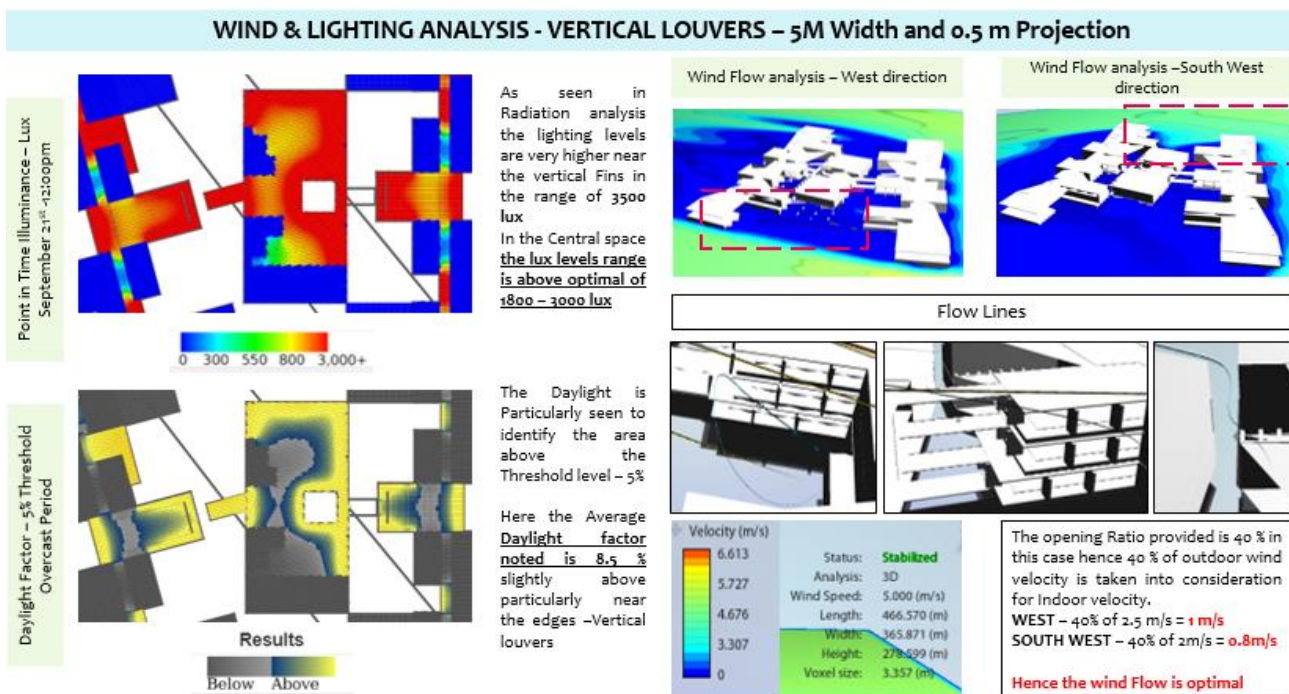
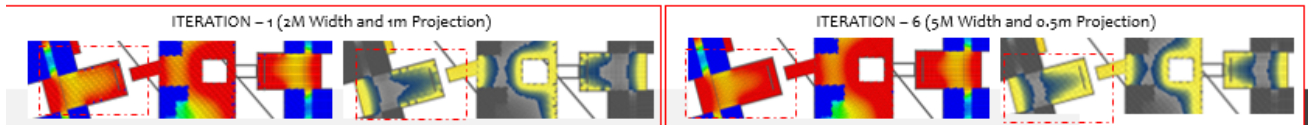


Fig 12.12 Iteration 6 Radiation Analysis

12.7 COMPARITIVE TABLE VERTICAL FINIS

Table 12.1 Vertical Fins Comparative Table

TYPE	RADIATION	RADIATION RANKING	LIGHTING	LIGHTING RANKING	VENTILATION
ITERATION -1	The Radiation observed inside is within optimum and Art Court central space does not receive much Radiation	1	Lighting levels in the Range of 2100 lux. Central space the lux levels range within optimal of 800 - 1400 lux. Average DF is 5.5%	1	The opening Ratio provided is above 40 % in all cases hence 40 % of outdoor wind velocity is taken into consideration for Indoor velocity. WEST - 40% of 2.5 m/s = 1 m/s SOUTH WEST - 40% of 2m/s = 0.8m/s Within the required 0.6m/s to 1.6 m/s Hence the wind Flow is optimal
ITERATION -2	The Radiation observed inside is within optimum but Slightly above the Iteration 1 due to lesser depth of shading device	2	Lighting levels in the Range of 2600 lux. Central space the lux levels range within optimal of 800 - 1400 lux. Average DF is 5.9%	2	
ITERATION-3	The Radiation observed inside is within optimum in East Wing but in West wing the second floor the radiation levels are above 500 Wh/sqm	3	Lighting levels in the Range of 2600 lux. Central space the lux levels range within optimal of 800 - 1800 lux. Average DF is 6.2%	3	
ITERATION-4	The Radiation observed inside is within optimum in East Wing but in West wing the second floor the radiation levels are above 540 Wh/sqm	4	Lighting levels in the Range of 3500 lux. Central space the lux levels range within optimal of 900 - 2500 lux. Average DF is 7%	4	
ITERATION-5	The Radiation observed inside is within East Wing is in borderline of 490 Wh/sqm and in West wing the second floor the radiation levels are above 625 Wh/sqm	5	Lighting levels in the Range of 3500 lux. Central space the lux levels range within optimal of 1500 - 3000 lux. Average DF is 8%	5	
ITERATION-6	The Radiation observed inside is above 500 wh/sqm in Both the Wings and particularly in west wing the Radiation observed is around 681 Wh/sqm	6	Lighting levels in the Range of 3500 lux. Central space the lux levels range within optimal of 1800 - 3000 lux. Average DF is 8.5%	6	



12.8 CENTRAL TRANSITION SPACE ANALYSIS

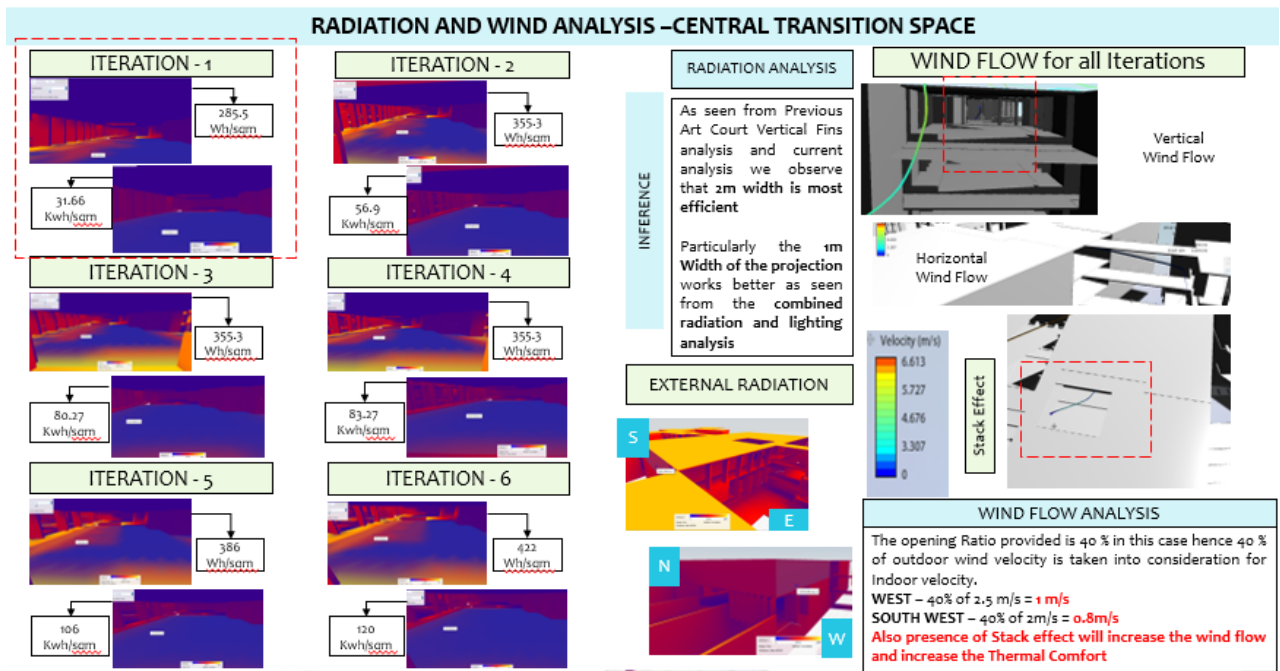


Fig 12.13 Central Transition space Analysis

CHAPTER 13 JALLI WALL ITERATIONS

13.1 SKY COURT ROOF OPENING

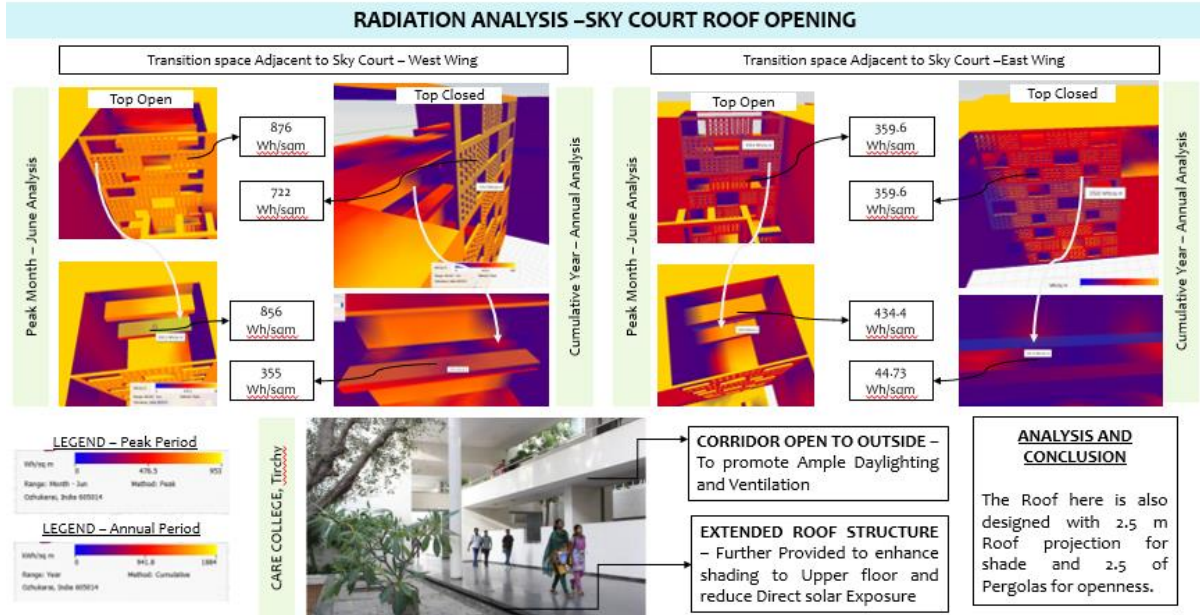


Fig 13.1 Sky Court Top Opening

13.2 ITERATION 1 JALLI ANALYSIS

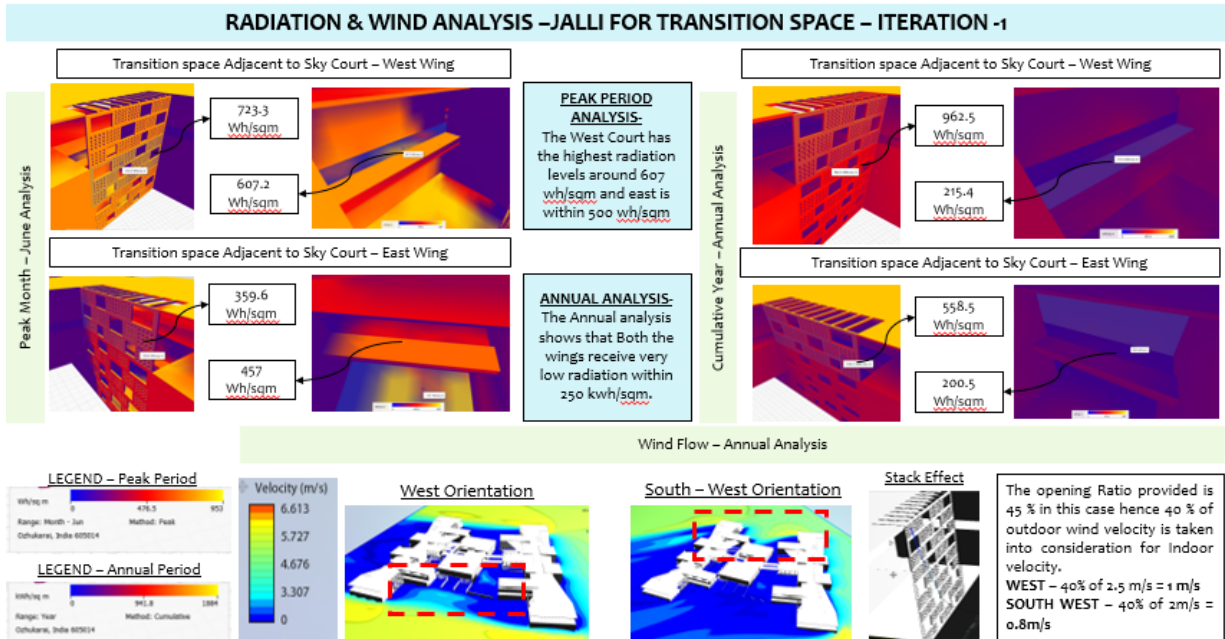


Fig 13.2 Iteration 1 Jalli Analysis

13.3 ITERATION 2 JALLI ANALYSIS

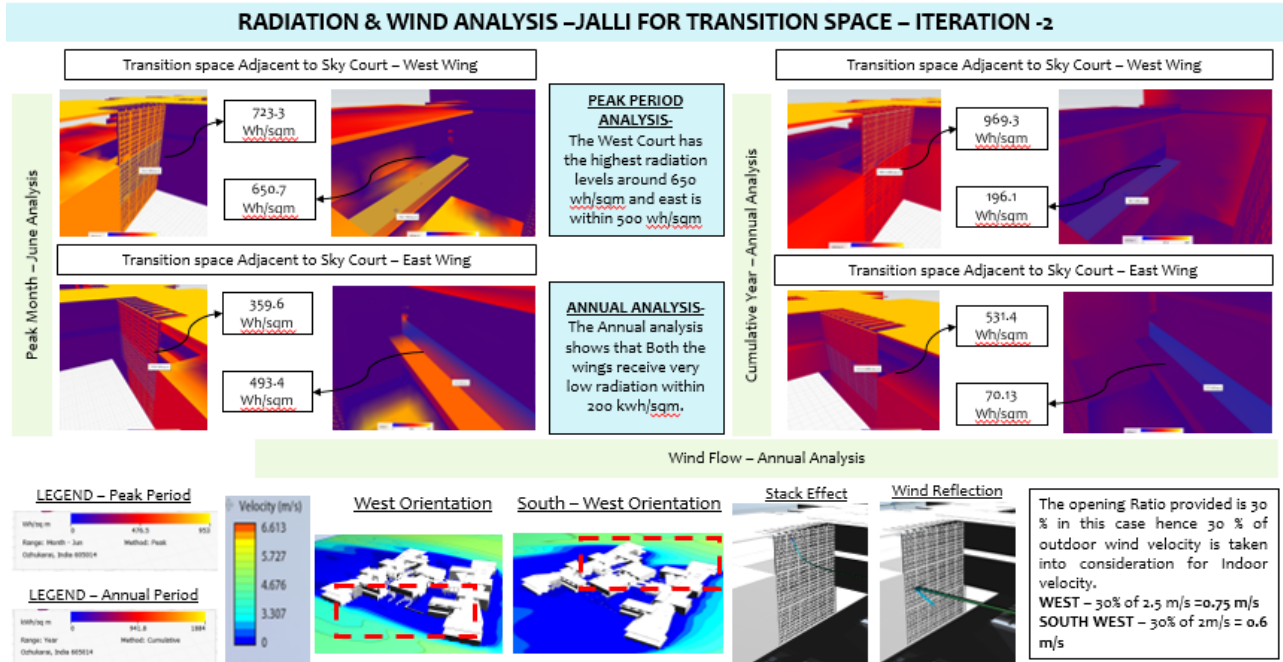


Fig 13.3 Iteration 2 Jalli Analysis

13.4 ITERATION 3 JALLI ANALYSIS

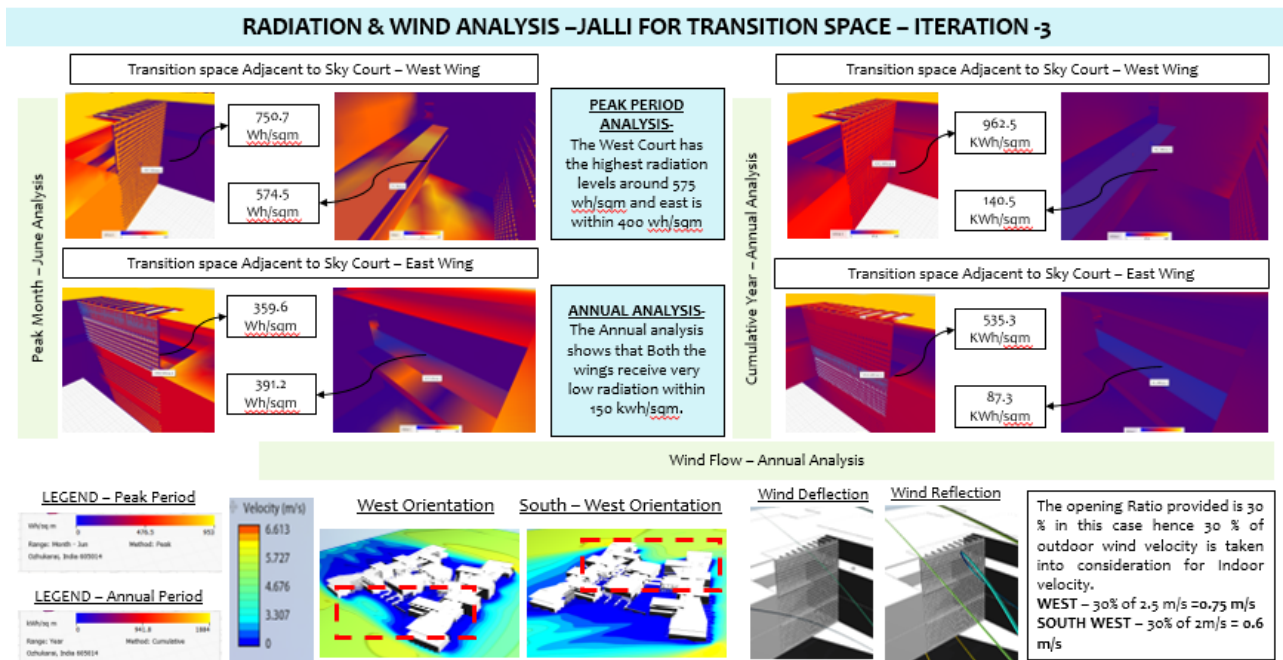


Fig 13.4 Iteration 2 Jalli Analysis

13.5 LIGHTING ANALYSIS – JALLI WALL

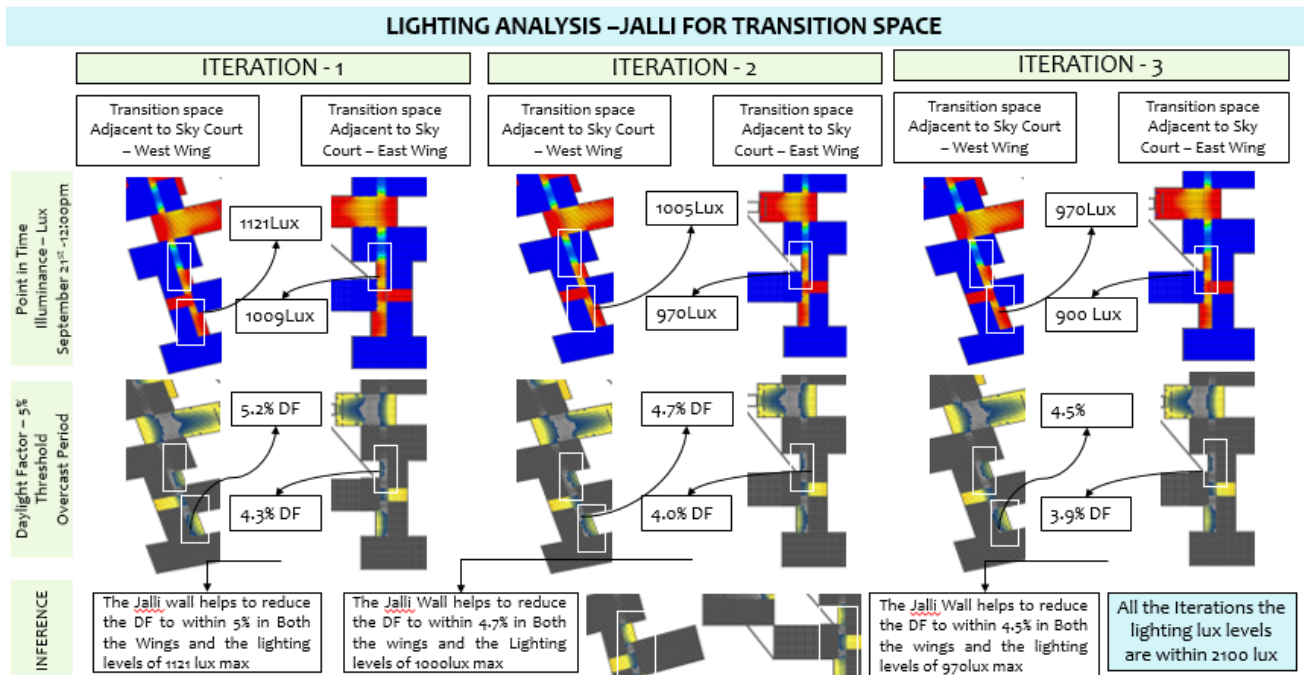


Fig 13.5 Lighting analysis Jalli Wall

13.6 COMPARATIVE ANALYSIS - JALLI WALL

Table 13.1 Comparative analysis – Jalli Wall

TYPE	RADIATION	RADIATION RANKING	LIGHTING	LIGHTING RANKING	VENTILATION	VENTILATION RANKING	ASTHETICAL APPEAL AND PROMOTION OF VIEWS
ITERATION -1	Peak period Analysis - The West Court has the highest radiation levels around 607 $\frac{wh}{sqm}$ and east is within 500 $\frac{wh}{sqm}$. Annual analysis shows that Both the wings receive very low radiation within 250 $\frac{kwh}{sqm}$.	3	The Jalli wall helps to reduce the DF to within 5% in Both the Wings and the Lighting levels of 1121 lux max	Not much variation is seen . All iterations are within the 2100 lux hence no Glare	The opening Ratio provided is 45 % in this case hence 40 % of outdoor wind velocity is taken into consideration for Indoor velocity. WEST – 40% of 2.5 m/s = 1 m/s SOUTH WEST – 40% of 2m/s = 0.8m/s	1	High Aesthetical Appeal and larger Opening helps in view to the outdoor.
ITERATION -2	Peak period Analysis - The West Court has the highest radiation levels around 650 $\frac{wh}{sqm}$ and east is within 500 $\frac{wh}{sqm}$. Annual analysis shows that Both the wings receive very low radiation within 200 $\frac{kwh}{sqm}$.	2	The Jalli Wall helps to reduce the DF to within 4.7% in Both the wings and the Lighting levels of 1000lux max		The opening Ratio provided is 30 % in this case hence 30 % of outdoor wind velocity is taken into consideration for Indoor velocity. WEST – 30% of 2.5 m/s = 0.75 m/s SOUTH WEST – 30% of 2m/s = 0.6 m/s	2	Medium Aesthetical Appeal and Smaller Opening hinders the views
ITERATION-3	Peak period Analysis - The West Court has the highest radiation levels around 575 $\frac{wh}{sqm}$ and east is within 400 $\frac{wh}{sqm}$. Annual analysis shows that Both the wings receive very low radiation within 150 $\frac{kwh}{sqm}$.	1	The Jalli Wall helps to reduce the DF to within 4.5% in Both the wings and the lighting levels of 970lux max		The opening Ratio provided is 30 % in this case hence 30 % of outdoor wind velocity is taken into consideration for Indoor velocity. WEST – 30% of 2.5 m/s = 0.75 m/s SOUTH WEST – 30% of 2m/s = 0.6 m/s	2	Low Aesthetical Appeal and Smaller Opening hinders the views

CHAPTER 14 GROUND FLOOR WALKWAY ANALYSIS

14.1 WALKWAY ANALYSIS

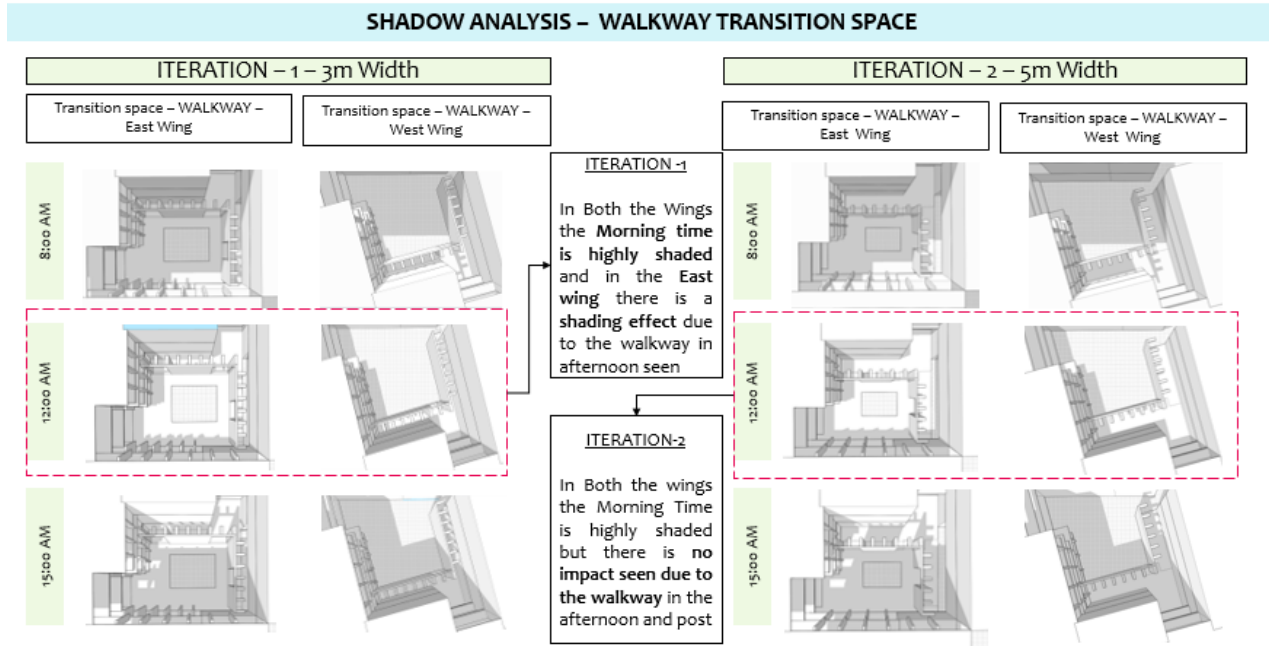


Fig 14.1 Shadow Analysis

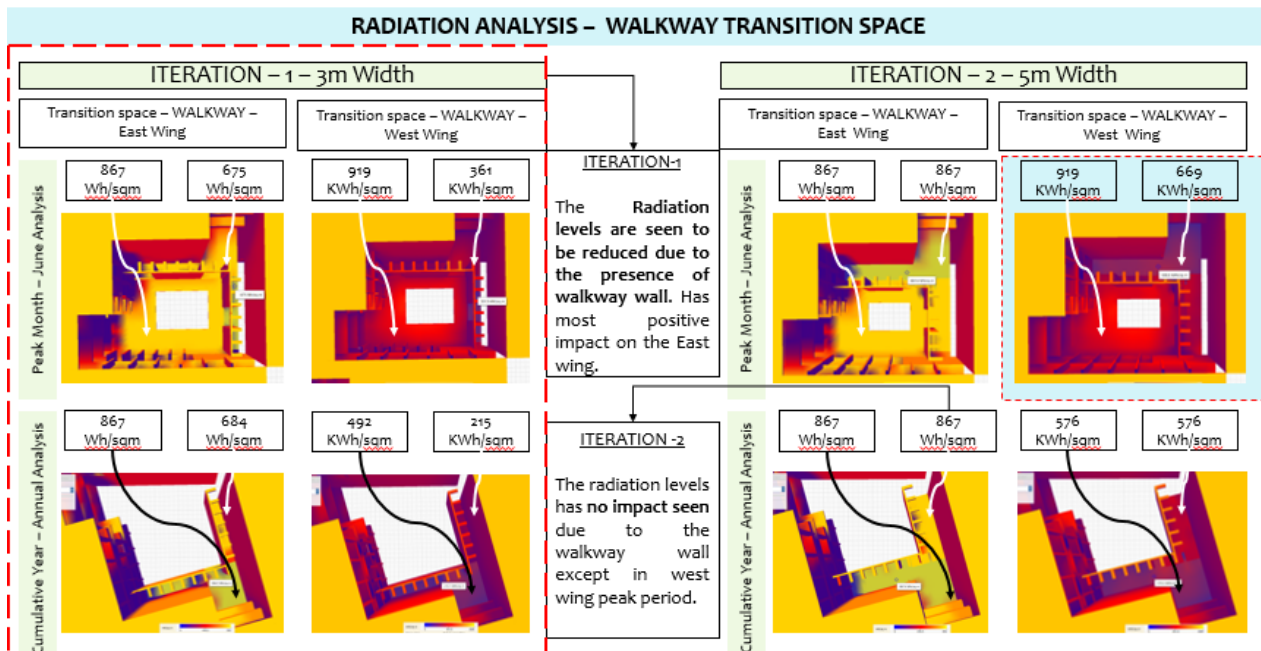


Fig 14.2 Radiation Analysis

CHAPTER 15 TRANSITION SPACES COMFORT ANALYSIS

15.1 TRANSITION SPACES COMFORT ANALYSIS

COMFORT ANALYSIS – TRANSITION SPACES

Jan

Chart Date/Time: Thu, 14/Jan 12:01:11

Variable Name	Line Colour	File Name	Location	Type	Value	Lock
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art c west	Temperature (°C)	0.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art court east	Temperature (°C)	0.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	center	Temperature (°C)	0.00	

Chart Date/Time: Wed, 17/Feb 12:01:10

Variable Name	Line Colour	File Name	Location	Type	Value	Lock
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Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art court east	Temperature (°C)	2.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	center	Temperature (°C)	0.00	

Chart Date/Time: Tue, 16/Mar 12:01:10

Variable Name	Line Colour	File Name	Location	Type	Value	Lock
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Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art court east	Temperature (°C)	2.48	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	center	Temperature (°C)	1.00	

Chart Date/Time: Sat, 17/Apr 12:01:10

Variable Name	Line Colour	File Name	Location	Type	Value	Lock
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Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art court east	Temperature (°C)	2.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	center	Temperature (°C)	2.00	

Chart Date/Time: Fri, 14/May 12:01:10

Variable Name	Line Colour	File Name	Location	Type	Value	Lock
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Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art court east	Temperature (°C)	3.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	center	Temperature (°C)	2.00	

Chart Date/Time: Tue, 15/Jun 12:01:10

Variable Name	Line Colour	File Name	Location	Type	Value	Lock
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art c west	Temperature (°C)	1.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art court east	Temperature (°C)	1.52	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	center	Temperature (°C)	0.00	

Jul

Chart Date/Time: Thu, 15/Jul 12:01:10

Variable Name	Line Colour	File Name	Location	Type	Value	Lock
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art c west	Temperature (°C)	2.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art court east	Temperature (°C)	3.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	center	Temperature (°C)	1.00	

Chart Date/Time: Thu, 15/Aug 12:01:10

Variable Name	Line Colour	File Name	Location	Type	Value	Lock
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Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art court east	Temperature (°C)	3.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	center	Temperature (°C)	2.00	

Chart Date/Time: Sat, 18/Sep 12:01:10

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Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art court east	Temperature (°C)	0.52	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	center	Temperature (°C)	0.52	

Chart Date/Time: Wed, 20/Oct 12:01:10

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Chart Date/Time: Tue, 16/Nov 12:01:11

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Chart Date/Time: Sat, 18/Dec 12:01:11

Variable Name	Line Colour	File Name	Location	Type	Value	Lock
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Aug

Chart Date/Time: Thu, 15/Jul 12:01:10

Variable Name	Line Colour	File Name	Location	Type	Value	Lock
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Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art court east	Temperature (°C)	3.00	
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Chart Date/Time: Thu, 15/Aug 12:01:10

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Chart Date/Time: Sat, 18/Sep 12:01:10

Variable Name	Line Colour	File Name	Location	Type	Value	Lock
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Chart Date/Time: Wed, 20/Oct 12:01:10

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Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art court east	Temperature (°C)	2.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	center	Temperature (°C)	0.00	

Chart Date/Time: Tue, 16/Nov 12:01:11

Variable Name	Line Colour	File Name	Location	Type	Value	Lock
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Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art court east	Temperature (°C)	1.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	center	Temperature (°C)	0.00	

Chart Date/Time: Sat, 18/Dec 12:01:11

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Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art court east	Temperature (°C)	0.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	center	Temperature (°C)	0.00	

Sep

Chart Date/Time: Thu, 15/Jul 12:01:10

Variable Name	Line Colour	File Name	Location	Type	Value	Lock
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Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art court east	Temperature (°C)	3.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	center	Temperature (°C)	1.00	

Chart Date/Time: Thu, 15/Aug 12:01:10

Variable Name	Line Colour	File Name	Location	Type	Value	Lock
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Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art court east	Temperature (°C)	3.00	
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Chart Date/Time: Sat, 18/Sep 12:01:10

Variable Name	Line Colour	File Name	Location	Type	Value	Lock
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Chart Date/Time: Wed, 20/Oct 12:01:10

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Chart Date/Time: Tue, 16/Nov 12:01:11

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Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art court east	Temperature (°C)	0.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	center	Temperature (°C)	0.00	

Oct

Chart Date/Time: Thu, 15/Jul 12:01:10

Variable Name	Line Colour	File Name	Location	Type	Value	Lock
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art c west	Temperature (°C)	2.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art court east	Temperature (°C)	3.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	center	Temperature (°C)	1.00	

Chart Date/Time: Thu, 15/Aug 12:01:10

Variable Name	Line Colour	File Name	Location	Type	Value	Lock
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art c west	Temperature (°C)	3.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art court east	Temperature (°C)	3.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	center	Temperature (°C)	2.00	

Chart Date/Time: Sat, 18/Sep 12:01:10

Variable Name	Line Colour	File Name	Location	Type	Value	Lock
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art c west	Temperature (°C)	0.52	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art court east	Temperature (°C)	0.52	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	center	Temperature (°C)	0.52	

Chart Date/Time: Wed, 20/Oct 12:01:10

Variable Name	Line Colour	File Name	Location	Type	Value	Lock
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art c west	Temperature (°C)	1.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art court east	Temperature (°C)	2.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	center	Temperature (°C)	0.00	

Chart Date/Time: Tue, 16/Nov 12:01:11

Variable Name	Line Colour	File Name	Location	Type	Value	Lock
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art c west	Temperature (°C)	0.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art court east	Temperature (°C)	1.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	center	Temperature (°C)	0.00	

Chart Date/Time: Sat, 18/Dec 12:01:11

Variable Name	Line Colour	File Name	Location	Type	Value	Lock
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Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art court east	Temperature (°C)	0.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	center	Temperature (°C)	0.00	

Nov

Chart Date/Time: Thu, 15/Jul 12:01:10

Variable Name	Line Colour	File Name	Location	Type	Value	Lock
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art c west	Temperature (°C)	2.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art court east	Temperature (°C)	3.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	center	Temperature (°C)	1.00	

Chart Date/Time: Thu, 15/Aug 12:01:10

Variable Name	Line Colour	File Name	Location	Type	Value	Lock
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art c west	Temperature (°C)	3.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art court east	Temperature (°C)	3.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	center	Temperature (°C)	2.00	

Chart Date/Time: Sat, 18/Sep 12:01:10

Variable Name	Line Colour	File Name	Location	Type	Value	Lock
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art c west	Temperature (°C)	0.52	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art court east	Temperature (°C)	0.52	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	center	Temperature (°C)	0.52	

Chart Date/Time: Wed, 20/Oct 12:01:10

Variable Name	Line Colour	File Name	Location	Type	Value	Lock
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art c west	Temperature (°C)	1.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art court east	Temperature (°C)	2.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	center	Temperature (°C)	0.00	

Chart Date/Time: Tue, 16/Nov 12:01:11

Variable Name	Line Colour	File Name	Location	Type	Value	Lock
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art c west	Temperature (°C)	0.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art court east	Temperature (°C)	1.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	center	Temperature (°C)	0.00	

Chart Date/Time: Sat, 18/Dec 12:01:11

Variable Name	Line Colour	File Name	Location	Type	Value	Lock
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art c west	Temperature (°C)	0.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art court east	Temperature (°C)	0.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	center	Temperature (°C)	0.00	

Dec

Chart Date/Time: Thu, 15/Jul 12:01:10

Variable Name	Line Colour	File Name	Location	Type	Value	Lock
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art c west	Temperature (°C)	2.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art court east	Temperature (°C)	3.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	center	Temperature (°C)	1.00	

Chart Date/Time: Thu, 15/Aug 12:01:10

Variable Name	Line Colour	File Name	Location	Type	Value	Lock
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art c west	Temperature (°C)	3.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art court east	Temperature (°C)	3.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	center	Temperature (°C)	2.00	

Chart Date/Time: Sat, 18/Sep 12:01:10

Variable Name	Line Colour	File Name	Location	Type	Value	Lock
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art c west	Temperature (°C)	0.52	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art court east	Temperature (°C)	0.52	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	center	Temperature (°C)	0.52	

Chart Date/Time: Wed, 20/Oct 12:01:10

Variable Name	Line Colour	File Name	Location	Type	Value	Lock
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art c west	Temperature (°C)	1.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art court east	Temperature (°C)	2.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	center	Temperature (°C)	0.00	

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Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art c west	Temperature (°C)	0.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art court east	Temperature (°C)	1.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	center	Temperature (°C)	0.00	

Chart Date/Time: Sat, 18/Dec 12:01:11

Variable Name	Line Colour	File Name	Location	Type	Value	Lock
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art c west	Temperature (°C)	0.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	art court east	Temperature (°C)	0.00	
Degrees > Max. adaptive temp. (°C)		Thrd review IES.aps	center	Temperature (°C)	0.00	

Fig 15.1 Annual Analysis Output

Table 15.1 Comfort Analysis Comparison

COMFORT ANALYSIS – TRANSITION SPACES				
MONTH	SPACE	Max Deg C > Acceptable Temperature	INFERENCE	
April	Art Court – West Wing	2	- The Spaces are within comfort by Criteria 3 throughout the year IESVE . - In the peak Summer months also we see only 2 deg C higher than 32.5deg C (Max Acceptable Temperature) in the Central Transition space . This states that the spaces are highly comfortable. - Max Temperature Noted higher than acceptable range is 3 DegC: Art Court - At Afternoon we see Art court west wing performs better than East wing and Post afternoon west wing has slightly higher range. - All other months expect mentioned here are having only max of 2 to 0 Deg C higher than the Acceptable Range. Jan , Feb, Nov and Dec are completely within the Range .	
	Central Transition space	2		
	Art Court – East Wing	2		
May	Art Court – West Wing	3		
	Central Transition space	2		
	Art Court – East Wing	3		
June	Art Court – West Wing	1		
	Central Transition space	1		
	Art Court – East Wing	1.52		
July	Art Court – West Wing	2		
	Central Transition space	1		
	Art Court – East Wing	3		
August	Art Court – West Wing	3		
	Central Transition space	2		
	Art Court – East Wing	3		

CHAPTER 16 MATERIAL STUDY

16.1 WALL MATERIAL ANALYSIS

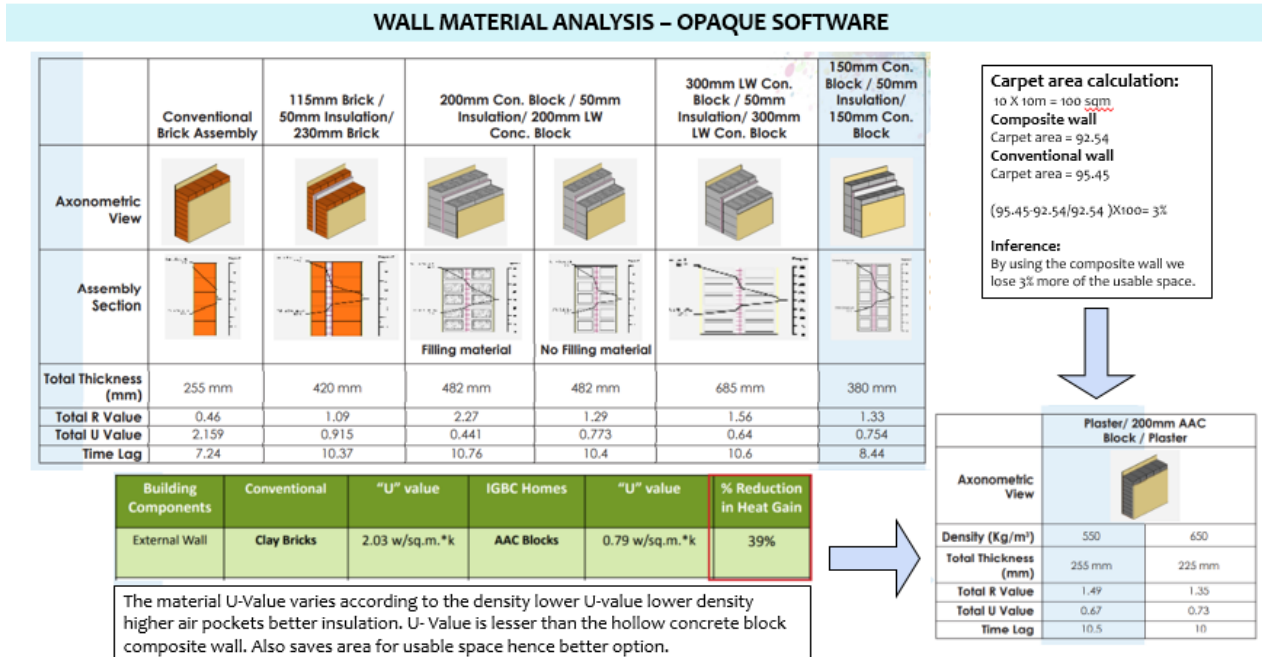


Fig 16.1 Wall Materials

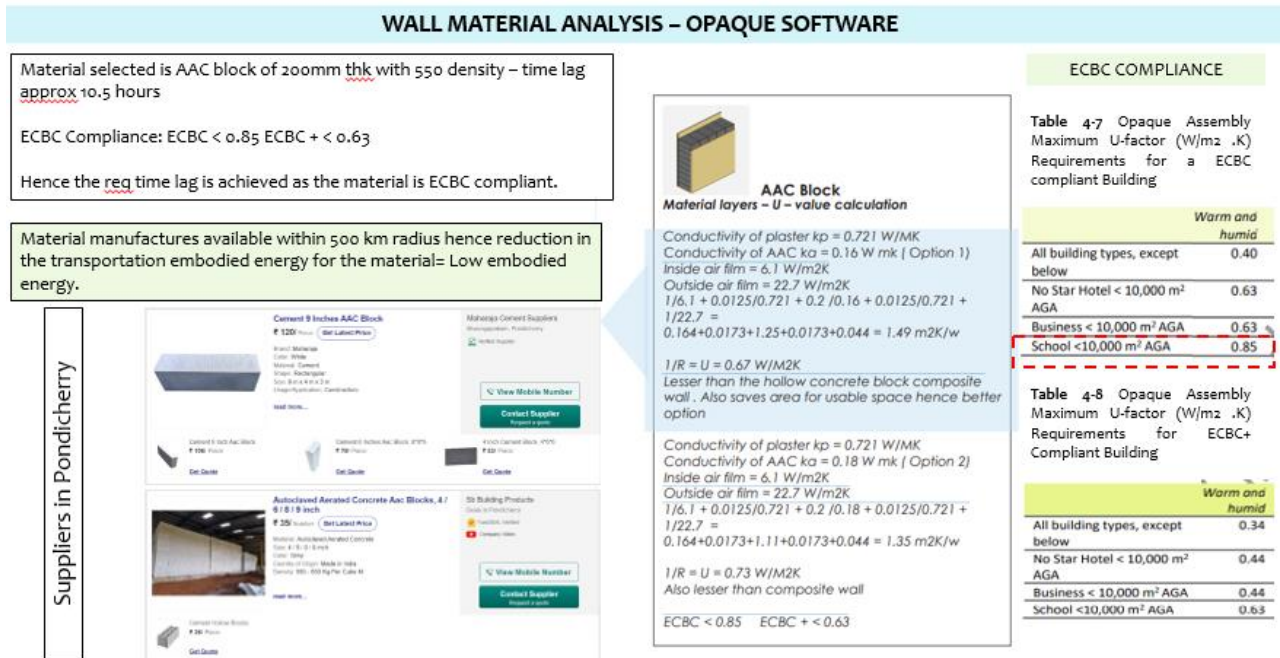


Fig 16.2 AAC Thermal Calculations

16.2 ROOF MATERIAL ANALYSIS

ROOF MATERIAL ANALYSIS – GREEN ROOF & COOL ROOF

The Table Shows Values for Conventional Roof Materials – 150mm thk concrete Roof

Material	U-value (Wim ² K)	Thickness (mm)
RCC Walls	1.95	225
AAC Blocks	0.67	230
Concrete Roof	2.5 – 3.0	150

THERMAL RESISTANCE OF ROOF FOR COOL ROOF

Material Layer	Thickness t (m)	Thermal Conductivity, k (W/m.K)	Thermal Resistance of material R=t/k/ (sqm.K/W)
Broken Glazed China mosaic tiles	0.008	1.5	0.005
Cement Mortar	0.05	0.71	0.070
Hollow clay tiles	0.1	0.78	0.128
Cement Mortar	0.05	0.71	0.070
Concrete	0.05	1.74	0.029
Polyurethane Foam (PUF)	0.04	0.02	1.739
Cement screed	0.02	0.72	0.028
RCC slab	0.15	1.58	0.095
Internal Plaster	0.02	0.72	0.021
Sum of all material thermal resistance			2.186



Broken	Glazed
China	Mosaic Tiles,
acts as	reflective
material	

Hollow clay Tiles
Indoor temp
difference of 3deg
in comparison to
untreated roof

Inverted Earthen
Pots, Indoor Temp
Difference of 1.5deg
in comparison to
untreated roof

Total Thermal Resistance $R_{\text{total}} = R_{\text{se}} + R_{\text{sf}} + R_1 + R_2 + R_3 + \dots = 0.17 + 0.04 + 2.186 = 2.396 \text{ m}^2\text{K/W}$
Thermal Transmittance of Roof, $U_{\text{roof}} = 1/R_{\text{total}} = 0.42 \text{ W/m}^2\text{K}$
This is less than the Maximum U roof Value of $0.47 \text{ W/m}^2\text{K}$ for Warm and Humid as per ECBC. Hence it complies with the requirement.
The Thermal Transmittance of Untreated Roof is $2.5 - 3 \text{ W/m}^2\text{K}$ reduced by about approximately 2.58 than the untreated Roof.

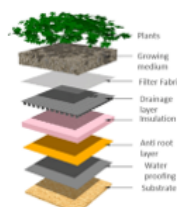
Table 4-4 Roof Assembly U-factor ($W/m^2.K$) Requirements for ECBC Compliant Building

	Composite	Hot and dry	Warm and humid	Temperate	Cold
All building types, except below	0.33	0.33	0.33	0.33	0.28
School <10,000 m ² AGA	0.47	0.47	0.47	0.47	0.33
Hospitality > 10,000 m ² AGA	0.20	0.20	0.20	0.20	0.20

THERMAL RESISTANCE OF ROOF FOR GREEN ROOF

Material Layer	Thickness t (m)	Thermal Conductivity, k (W/m.K)	Thermal Resistance of material R=t/k (sqm.K/W)
Soil	0.1	1.16	0.09
Gravel	0.15	0.7	0.21
Permeable Geotextile	0.02	0.1	0.20
Drainage layer	0.02	0.27	0.07
Insulation	0.3	0.04	7.50
Anti root layer	0.01	0.7	0.01
Waterproofing	0.01	0.17	0.06
RCC slab	0.15	1.58	0.09
Internal Plaster	0.02	0.72	0.02
Sum of all material thermal resistance			8.26

Green Roofs Reduce Rainwater Surface run-off and the ambient Temperature.
Indoor Temperature Difference is 2 Deg C Compared to untreated roof.



Total Thermal Resistance $R_t = R_{si} + R_{se} + R_1 + R_2 + R_3 + \dots = 0.17 + 0.04 + 8.263 = 8.473 \text{ m}^2\text{K/W}$
Thermal Transmittance of Roof, $U_{\text{roof}} = 1/R_t = 0.12 \text{ W/m}^2\text{K}$
This is less than the Maximum U_{roof} Value of Super ECBC $0.2 \text{ W/m}^2\text{K}$ and $0.47 \text{ W/m}^2\text{K}$ for Warm and Humid as per ECBC. Hence it complies with the requirement.
The Thermal Transmittance of Green Roof is less than that of the cool roofs by $0.3 \text{ W/m}^2\text{K}$

Fig 16.3 Roof Material Analysis

16.3 WINDOW GLAZING MATERIAL SELECTION

WINDOW GLAZING MATERIAL SELECTION

SGG ANTELIO PLUS

Solar Control Glass Providing Abundant Daylight to the Interiors.
SG Antello Plus is an advanced coated glass manufactured by state of art magnetron sputtering process under vacuum conditions. It blocks the incoming heat radiation from the sun, while allowing the natural light to filter in.
It is available in soothing neutral, green, blue and bronze shades and can be used in single and double glazing applications.

- Higher light transmission
- Solar control
- UV protection
- Subtle reflections
- Soothing colours
- Makes the building look very elegant

SINGLE GLAZING

Product	Visual Comfort				Thermal Comfort			
ISO Ambient Light (lx)	Visual Light Transmittance (%)	External Reflector (%)	Internal Reflector (%)	Solar Factor (ISO 15093)	Shading Coefficient (SC)	U-value (W/m²K)	Swirl (%)	ISO comfort (°C)
Sparking Box (ISO 15093)	87	19	19	0.66	0.76	7.4	0.39	41
External Glass (ISO 15093)	95	54	54	0.5	0.57	9.5	0.1	35
Star Box	92	59	59	0.52	0.6	8.1	0.41	19

DOUBLE GLAZING

Product	Visual Comfort				Thermal Comfort					
	Visual Light (foot-candles)	External Reflection (%)	Internal Reflection (%)	Color Fidelity (CRI)	Shading coefficient (SC)	U-value (W/m²K)	Indoor Air Quality (IAQ)	Acoustics	Health	CO ₂ concentration (ppm)
SmartWindow (SW-100)	90	72	75	94	0.65	0.8	1.00	95	90	400
SmartWindow (SW-200)	85	70	73	93	0.70	0.9	1.00	92	88	450
SmartWindow (SW-300)	80	68	71	92	0.75	1.0	1.00	90	85	500
SmartWindow (SW-400)	75	65	69	91	0.80	1.1	1.00	88	82	550
SmartWindow (SW-500)	70	63	67	90	0.85	1.2	1.00	85	80	600

ECBC Prescriptive Compliance

Table 4-10 Vertical Fenestration Assembly U-factor and SHGC Requirements for ECBC Buildings

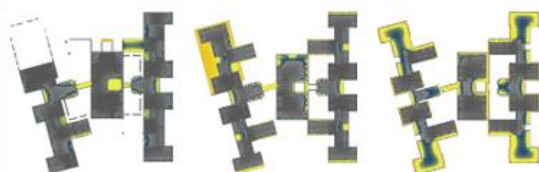
	Composite	Hot and dry	Warm and humid	Temperate	Cold
Maximum U-factor (W/m ² .K)	3.00	3.00	3.00	3.00	3.00
Maximum SHGC Non-North	0.27	0.27	0.27	0.27	0.62
Maximum SHGC North for latitude $\pm 15^{\circ}$ N	0.50	0.50	0.50	0.50	0.62
Maximum SHGC North	0.27	0.27	0.27	0.27	0.62

See Appendix A for default values of unrated fenestration.

Table 3: Minimum daylight factor

Type of space	Daylight factor (%)
Art studios, galleries	4-6
Factories, laboratories	3-5
Offices, classrooms, gymnasiums, kitchens	2
Lobbies, lounges, living rooms, churches	1
Corridors, basements	0.5

Daylight Factor Analysis
with Double Glazing
Window and THRESHOLD
OF 5%



- The Studio are Within the Threshold of 5% DF
- Only near the periphery of the Central Transition space DF above 5% is observed

Average Daylight Factor

Table -2: Average daylight factor

Average DF	Appearance	Energy implications
< 2%	room looks gloomy	Electric lighting needed most of the day
2% to 5%	Predominantly day lit appearance-but supplementary artificial lighting is needed.	Good balance between lighting and thermal aspects
> 5%	Room appears strongly day lit	At Daytime electric lighting is rarely needed but potential for thermal problems due to overheating in summer and heat losses in winter

Fig 16.4 Window Glazing Material Selection

16.4 LANDSCAPE MATERIAL ANALYSIS

LANDSCAPE VEGETATION SELECTION AND MATERIALS

Selection of Vegetation for Warm and Humid Conditions

First Floor Access
Landscape court


Nyctanthes Arbor Tristis


Plumeria Alba

Smaller Root system. Can grow in warm and humid conditions. Height - 3-5 m Max

Sky Court - Ground Floor


Saraca Indica


Bamboo

Smaller Root system. Can grow in warm and humid conditions. Height - 6-10m Max

Studio space - shading element


Rangoon Creeper


Star Jasmine

Creepers can be used to help shade the Walkway area and First Level Windows.

Landscape elements Materials

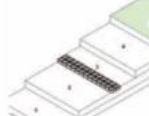
Turf Pave: A New Age Solution for Landscaped Parking

1



Turf Pave is a **light weight robust plastic grid structure**, specially designed to stabilize and support turf, grass or decorative gravels used for landscape. It provides an environment friendly and practical alternative to impermeable surfaces like concrete and asphalt. **20 yrs**

2



Permeable Pavers with grass helps in rainwater harvesting reducing surface runoff as shown in detail (Right)

Positioned under a grass landscape, Turf Pave distributes load from pedestrian and vehicular traffic to the base course below, minimizing grass and root compaction. The interconnected plastic cells allow roots to develop with minimal restriction, resulting in a durable and stable grass surface.

CASE STUDY - The CPWD first used Turf Pave in the Jawaharlal Nehru Bhawan Project in New Delhi. 1582Rs /Sqm

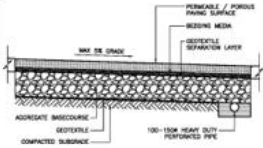


Fig 16.5 Landscape Material Analysis

CHAPTER 17 WWR, WFR, AND SHADING DEVICE CALCULATIONS

17.1 WWR AND WFR CALCULATIONS

WWR and WFR Calculations

Window to Wall –WWR Max Allowable as Per ECBC

4.3.3 Vertical Fenestration

For all climatic zones, vertical fenestration compliance requirements for all three incremental energy efficiency levels, i.e. ECBC, ECBC+, and SuperECBC, shall comply with the following:

(a) **Maximum allowable Window Wall Ratio (WWR) is 40%** (applicable to buildings showing compliance using the Prescriptive Method, including Building Envelope Trade-off Method)

(b) Minimum allowable Visual Light Transmittance (VLT) is 0.27

Window to Floor Area –WFR Max Allowable as Per NBC

TABLE 1 Minimum requirement of window-to-floor area ratio (WFR_g)

Climatic zone	Minimum WFR _g (%)
Composite	12.50
Hot-Dry	10.00
Warm-Humid	16.66
Temperate	12.50
Cold	8.33

SOURCE Adapted from Bureau of Indian Standards (BIS). 2016. National Building Code of India 2016. New Delhi: BIS.

Studio space window opening according to prescriptive standards

1.5m X 2 m

STUDIO
229 Sqm

3 m X 1 m

Seminar Hall window opening according to prescriptive standards

1.5m X 2 m

SEMINAR HALL
176 Sqm

3 m X 1.25 m

WWR CALCULATION

1.5 X 2 X 7 = 21 Sqm, Total = 21 Sqm
 10.10 X 4 X 2 = 80.8, 6.6 X 4 X 2 = 52.8, Total = 133.6 Sqm
 Total Opaque Area = 133.6 – 21 = 112.6 Sqm
 Total Openable Area = 21 Sqm
WWR = 18.65 % (within 40%)
 Total Carpet Area = 66.6 Sqm
WFR = 31.5% (Above 16.66%)

WFR CALCULATION

1.5 X 2 X 8 = 24, 2.5 X 2 X 4 = 20, 3 X 1 X 4 = 12, Total = 56 Sqm
 10.10 X 4 X 2 = 80.8, 22.6 X 4 X 2 = 180.8, Total = 261.6 Sqm
 Total Opaque Area = 261.6 – 56 = 205.6 Sqm
 Total Openable Area = 56 Sqm
WWR = 27.23% (within 40%)

WFR CALCULATION

1.25 X 3 X 7 = 26.25, 2 X 3 X 1.5 = 9, Total = 35.25 Sqm
 13.6 X 4 X 2 = 108.8, 12.6 X 4 X 2 = 100.8 Sqm, Total = 209.6 Sqm
 Total Opaque Area = 209.6 – 35.25 = 174.35 Sqm
 Total Openable Area = 35.25 Sqm
WWR = 20.21% (within 40%)

WFR CALCULATION

Total Carpet Area = 171.36 Sqm
 Total Openable Area = 32.25 Sqm
WFR = 18.82% (Above 16.66%)

Fig 17.1 WWR , WFR and shading device calculations

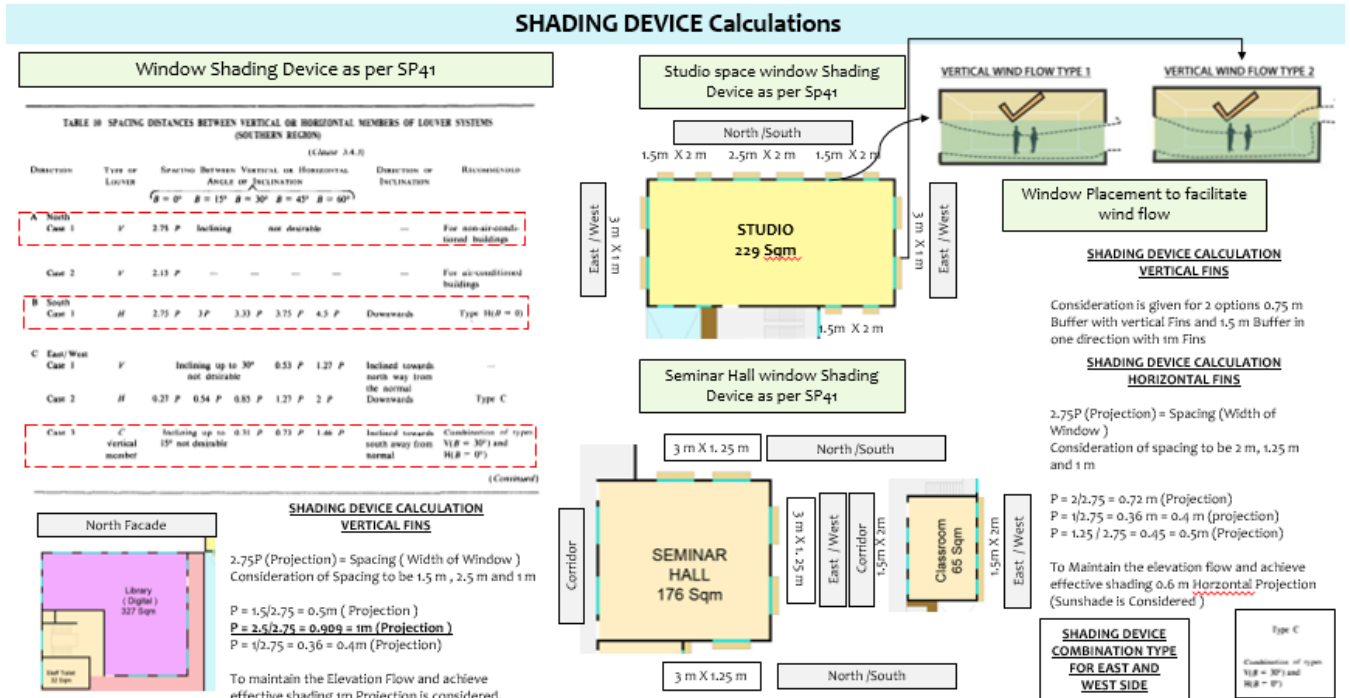


Fig 17.2 Shading Device Calculations

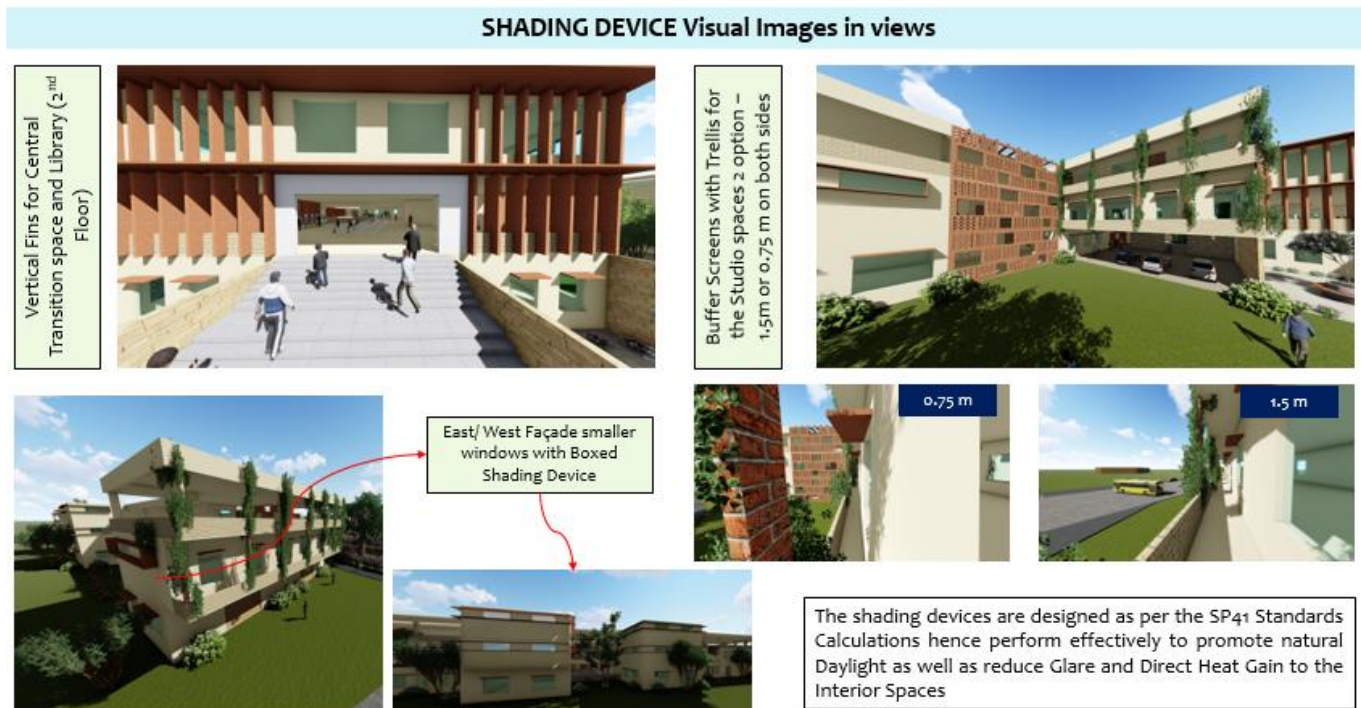


Fig 17.3 Shading Device Views

CHAPTER 18 THERMAL COMFORT ANALYSIS

Table 18.1 West Wing Comfort Analysis

COMFORT ANALYSIS – STUDIO SPACES (West Wing) – First Floor Level

Studio No	April	May	June	July	August	Conclusion
	Max Deg C > Acceptable Temperature					
Studio -1 (West)	2	3.48	4	2.48	3	- The Comfort Analysis is done according to EN1521 Standards from IESVE Adaptive Comfort Manual. - West Wing as seen from the Analysis during the months of April it is only 2 deg C above max Acceptable Range - May and June is higher in the range of 3.5 to 4.5 deg C. - Particularly June is above 4 degC hence does not Satisfy the Comfort Standards by Criteria 3 from IESVE Manual (ENS 1521) - BUT This Period is generally the Summer Break hence the space would remain unoccupied. - All other months Satisfy the Comfort Range as prescribed.
Studio -2 (West)	2	3.52	4	2.52	3	
Studio -3 (West)	2	3.36	4.48	2.52	3	
Studio -4 (West)	2	3.52	4	2	3	
Corridor (West wing)	2	3.48	4.52	2	3	

First Floor Studios Comfort Analysis – KEY PLAN

Passive Strategies Implemented

- Buffer Space Provided for Studios as 1.5m if outside and 0.75m on both sides if located inside
- The Vertical Fins as shading device for the Art Court and central transition spaces
- Proper shading Device as per SP41.
- Selection of Opaque wall material with low U-Value .
- Window Thermal performance as per ECBC.
- 15deg TILT to reduce direct solar exposure Post Afternoon

Difference in Studio 3 & Studio 4

Consideration is given for 2 options for STUDIO 0.75 m Buffer in both sides with vertical Fins and 1.5 m Buffer in one direction with 1m Fins

Table 18.2 East Wing Comfort Analysis

COMFORT ANALYSIS – STUDIO SPACES (East Wing) – First Floor Level

Studio No	April	May	June	July	August	Conclusion
	Max <u>Deg C</u> > Acceptable Temperature					
Studio -1 (East)	2	3.52	4	2	2.52	- The Comfort Analysis is done according to ENS1521 Standards from IESVE Adaptive Comfort Manual. - The month of April, July and August is 2 or Max 2.5 <u>deg C</u> higher than Max acceptable temperature. This range is within the acceptable range by Criteria 2 of ENS1521 - May and June has higher ranges of about 3.5 to 4 <u>deg C</u> higher than Max acceptable range. This is just below the Max range upper value of 4 <u>deg C</u> hence within Criteria 3. - June month can be avoided as the space would remain unoccupied as per the college working days. - East wing Comparatively perform much better than west wing
Studio -2 (East)	2	3.52	4	2.52	2	
Studio -3 (East)	2	3.52	4	2.52	2	
Studio -4 (East)	2	3	4	2	2.52	
Corridor (East wing)	2	3.52	4	2	3	

First Floor Studios Comfort Analysis – KEY PLAN

Passive Strategies Implemented

- Buffer Space Provided for Studios as 1.5m if outside and 0.75m on both sides if located inside
- The Vertical Fins as shading device for the Art Court and central transition spaces
- Proper shading Device as per SP41.
- Selection of Opaque wall material with low U-Value .
- Window Thermal performance as per ECBC.

CHAPTER 19 VISUAL COMFORT ANALYSIS

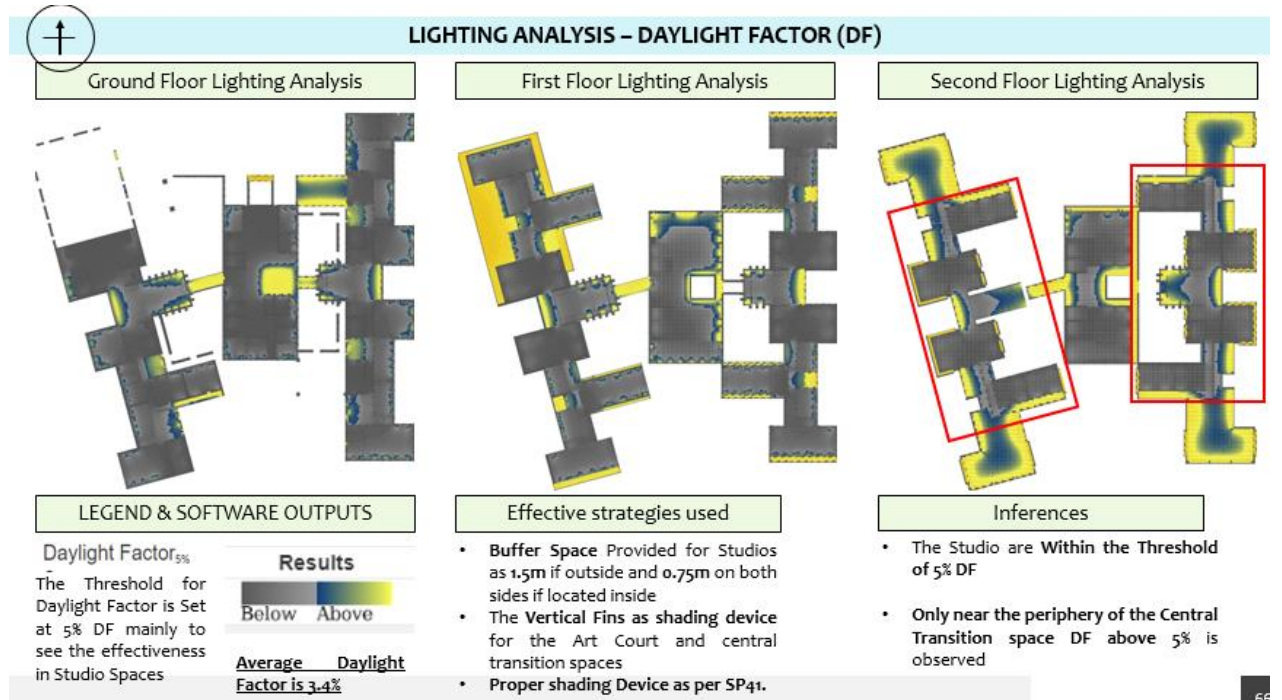


Fig 19.1 Daylight Factor

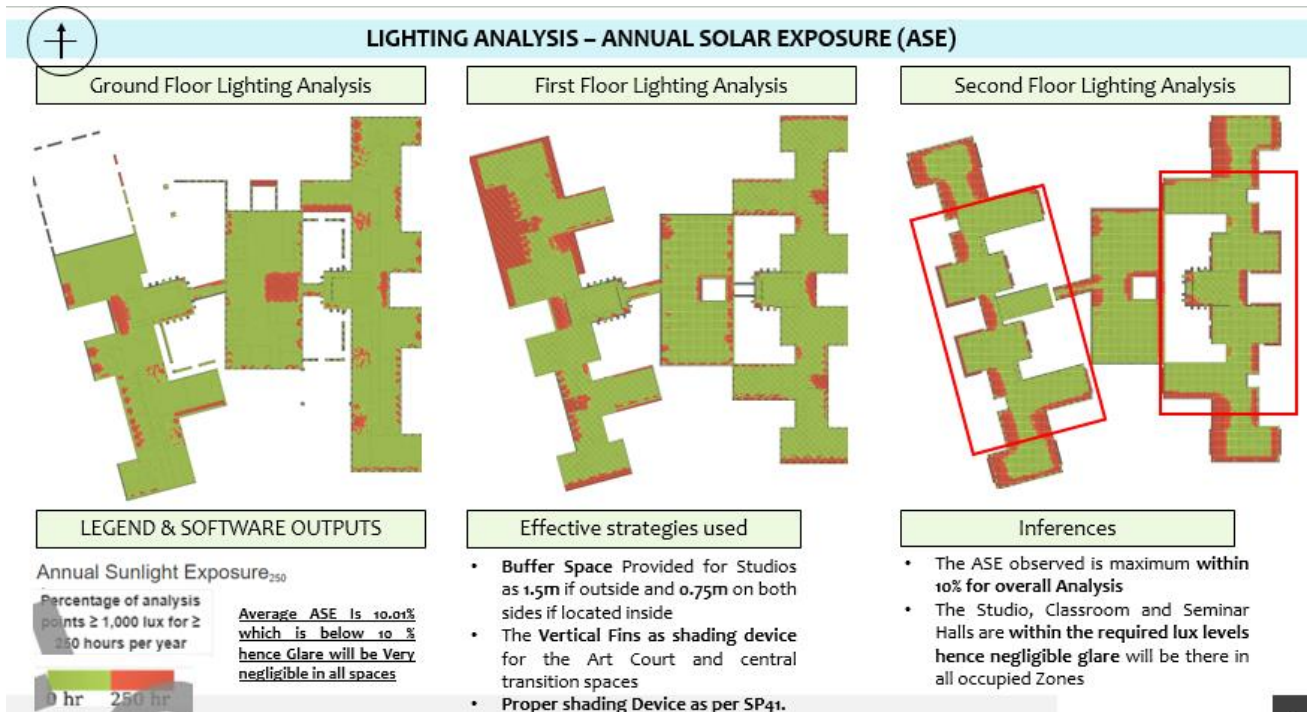


Fig 19.2 Annual Solar Exposure

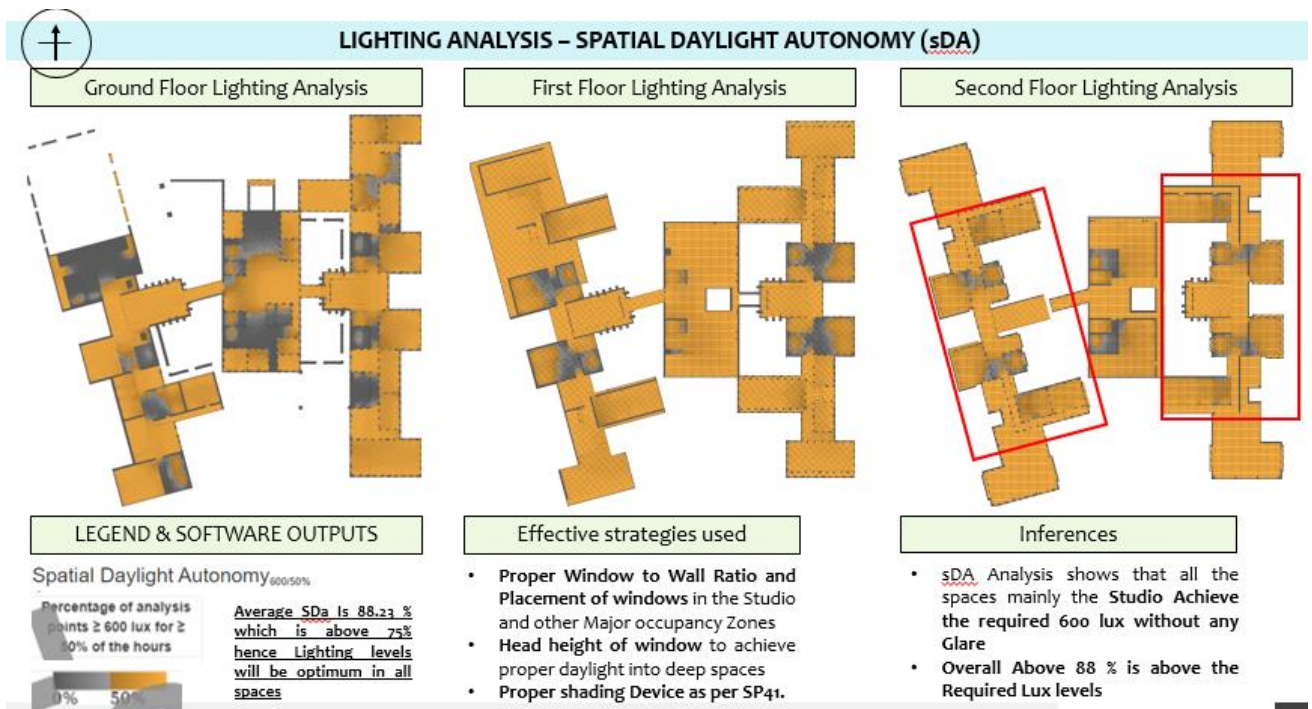


Fig 19.3 Spatial Daylight Autonomy

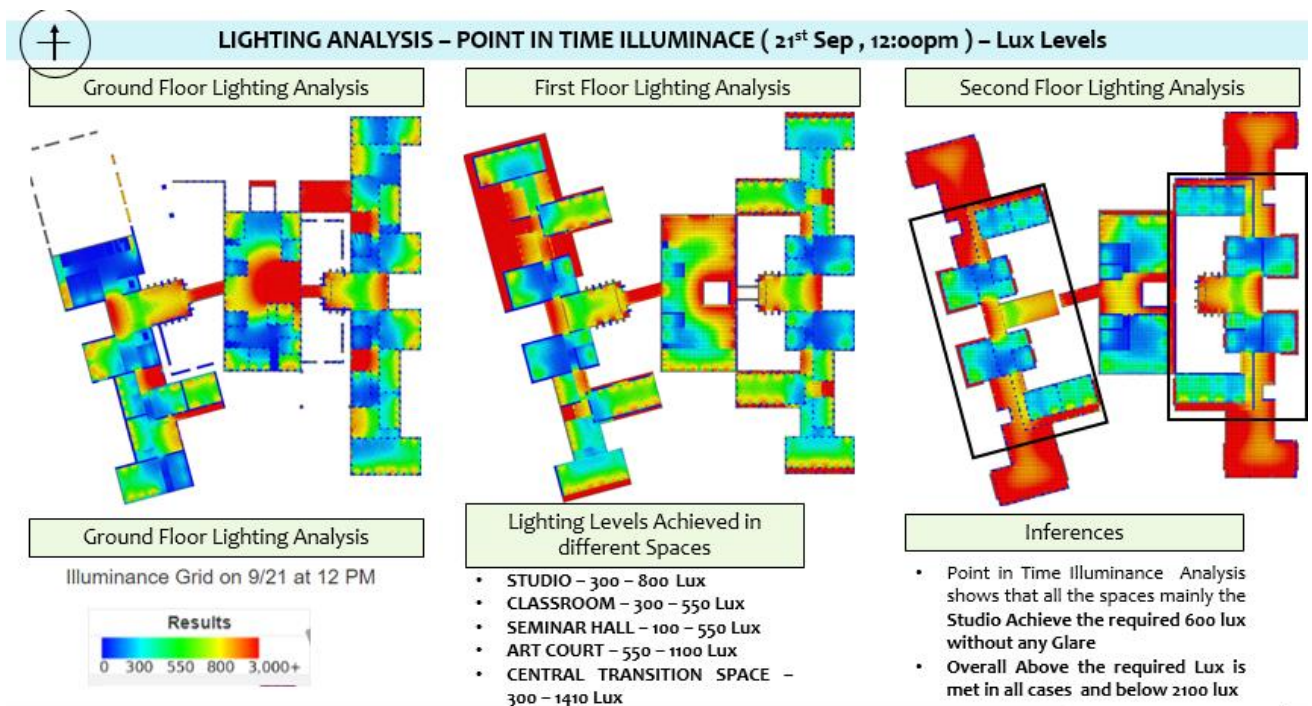


Fig 19.4 Point in Time Illuminance

CHAPTER 20

SCHOOL OF PLANNING AND ARCHITECTURE VIEWS

SCHOOL OF PLANNING AND ARCHITECTURE - VIEWS



Front Elevation view –
NORTH FAÇADE

Passive strategies
incorporated seen in this
view

- Vertical Louvers
- Buffer Screens for Studio spaces
- Entrance Landscape Court
- Jalli walls as Buffer Screens

Fig 20.1 North Façade



Front Elevation view –
NORTH WEST FAÇADE

Passive strategies
incorporated seen in this
view

- Vertical Louvers
- Buffer Screens for Studio spaces
- Combination Type Shading Device for East/ West façade
- Jalli walls as Buffer Screens

Fig 20.2 North West Façade



Side Elevation view –
WEST FAÇADE

Passive strategies
incorporated seen in this
view

- Landscape Adjacent to Art Court to reduce Direct heat gain
- Smaller window sizes for Seminar Hall and Computer hall
- Combination Type Shading Device for East/ West façade
- Connectivity between Art Court(East and West) Through the Central transition Space

Fig 20.3 West Façade

SCHOOL OF PLANNING AND ARCHITECTURE - VIEWS



Fig 20.4 Aerial view

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