

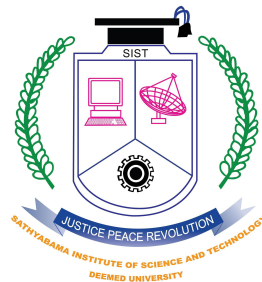
# DESIGN OF A SPECIAL SCHOOL IN WARM AND HUMID CLIMATE

A Thesis

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

by

**NANDHINE J (40890011)**



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

## **SATHYABAMA**

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

**Accredited with Grade "A" by NAAC  
JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600119**

**MAY 2022**



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## DEPARTMENT OF ARCHITECTURE

### BONAFIDE CERTIFICATE

This is to certify that this Report is the bonafide work of **NANDHINE J (40890011)** who carried out the Thesis entitled "**DESIGN OF A SPECIAL SCHOOL IN WARM AND HUMID CLIMATE**" under our supervision from January 2022 to May 2022.

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Submitted for Viva voce Examination held on \_\_\_\_\_

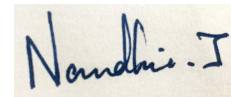
**Internal Examiner**

**External Examiner**

## **DECLARATION**

I **NANDHINE J** hereby declare that the Thesis Report entitled “**STUDY OF NATURAL DAYLIGHTING AND ACOUSTICS IN SPECIAL SCHOOL**” is done by me under the guidance of **Ar.S.Kavitha** (Internal) and **Ar.R.Balamurugan** (External) at Sathyabama Institute of Science and Technology are submitted in partial fulfillment of the requirements for the award of Master of Architecture degree in Sustainable Architecture.

**DATE:**

A rectangular box containing a handwritten signature in blue ink that reads "Nandhini.J".

**PLACE:**

**SIGNATURE OF THE CANDIDATE**





## ACKNOWLEDGEMENT

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

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

## **ABSTRACT**

The aim is to design a special school by incorporating sustainable principles pertaining to warm and humid climatic typology and mainly the design focuses on the energy efficient parameters, strategies and materials that may be incorporated in order to solve the special needs issues in the school. The design will be based on the sensory design theory approach to make the school design more appropriate for the autistic children's. Sensory Design Theory explores the manipulation of the environment to the benefit of autistic people by applying this theory to a treatment facility for people with autism means to design environments with rigorously separate the space into two distinct areas: a high stimulus area which functions as developed public interface with training and conference rooms and a low stimulus area which is destined for treatment activities. The design will incorporate passive design strategies and follow sustainable principles to improve and to encompass a broad spectrum of sensory and to design an user oriented structure. The design is done based on the studying the site study and the preliminary zoning of the blocks are done and then the best orientation for the design is selected followed by the base case model analysis to find out the spaces affected during the critical period and then an design case with the strategies applied to find out the better working design is formulated.



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## LIST OF SYMBOLS AND ABBREVIATIONS

|     |   |                            |
|-----|---|----------------------------|
| ASD | - | Autistic spectrum disorder |
| ADF | - | Average daylighting factor |
| DA  | - | Daylight autonomy          |
| dB  | - | Decibel                    |
| kHz | - | kilohertz                  |

# **CHAPTER 1**

## **INTRODUCTION**

### **1.1 INTRODUCTION**

#### **Special school**

'Special schools' or 'specialist schools' caters for college students who have special educational needs thanks to severe learning difficulties, physical disabilities or behavioral problems.

#### **1.2 AIM:-**

The aim is to design a special school by incorporating sustainable principles pertaining to warm and humid climatic typology.

#### **1.3 OBJECTIVES:-**

1. The main objective of the design is to seek out the energy efficient strategies and materials that may be incorporated in order to solve the special needs issues in the school.
2. The design will be based on the sensory design theory approach to make the school design more appropriate for the autistic children.
3. The design will incorporate passive design strategies and follow sustainable principles to improve and to encompass a broad spectrum of sensory and to design an user oriented structure.

#### **1.4 NEED FOR THE TOPIC:-**

- The need for the topic is to provide a sustainable environment for the special children and improve their conditions.
- The students with mongolism, autism, dyslexia have problems with concentration and by providing an area with better acoustics will help their concentration.
- The design focuses on the major style of special needs children with Developmental - mongolism, autism, dyslexia, processing disorders.

#### **Key Design Issues for Special Needs Environmental Design:**

1. Personal and social space.
2. Daylighting within the interior spaces.
3. Durability of materials.
4. trip rooms.
5. Acoustics and other auditory issues.
6. Colors, patterns and tactile issues.

7. Outdoor spaces, security and independence issues.

- The necessity for the design to specialize in the parameters of natural daylighting and also the acoustics of the materials used is to boost the special school environment in terms of energy efficiency and to enhance the conditions of the special childrens.
- These parameters are important in improving and solving a number of the special needs issues.

#### 1.5 **SCOPE OF THE STUDY:-**

The scope of the project is to design a special school in a sensory design approach through passive strategies, day lighting, energy efficiency and material study.

#### 1.6 **LIMITATION:-**

1. The design is done based on the Warm and Humid climatic zone.
2. The design will follow the sensory design approach of special designing.

#### 1.7 **RESEARCH QUESTIONS:-**

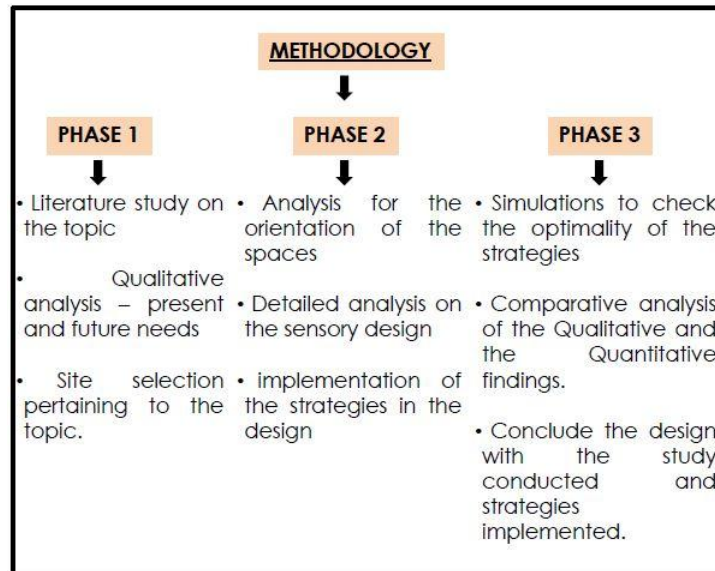
1. How to do spatial analysis and form evolution through a sensory design?
2. What are the passive design strategies that must be adopted in order to eliminate glare, improve acoustics and efficiency?
3. Why is it important to incorporate the passive design strategies in a special school?

#### 1.8 **STANDARDS AND CODES:-**

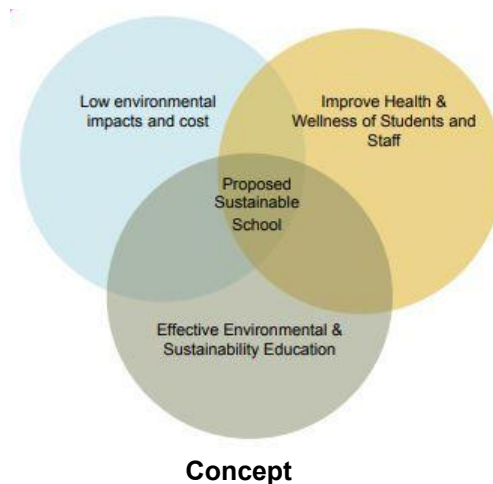
1. IGBC Green Schools rating system addresses green features.
  - Site Selection & Planning
  - Sustainable Water Practices
  - Conserving & Harvesting Energy
  - Eco-Friendly School Material
  - Indoor Environment Quality
  - Health & Hygiene
  - Green Education
2. ECBC
3. NBC standards for the design considerations for special needs.
4. SP41 for the day lighting allowance for the spaces needed.

#### 1.9 **RESEARCH METHODOLOGY:-**

The research methodology utilized in this study is both qualitative and quantitative study done using literature reviews, questionnaire analysis and computer aided softwares.



#### 1.10 Description of the research work:-



The design will incorporate passive design strategies and follow sustainable principles to improve and to encompass a broad spectrum of sensory and to design an user oriented structure. The design is done based on the studying the site study and the preliminary zoning of the blocks are done and then the best orientation for the design is selected followed by the base case model analysis to find out the spaces affected during the critical period and then an design case with the strategies applied to find out the better working design is formulated.

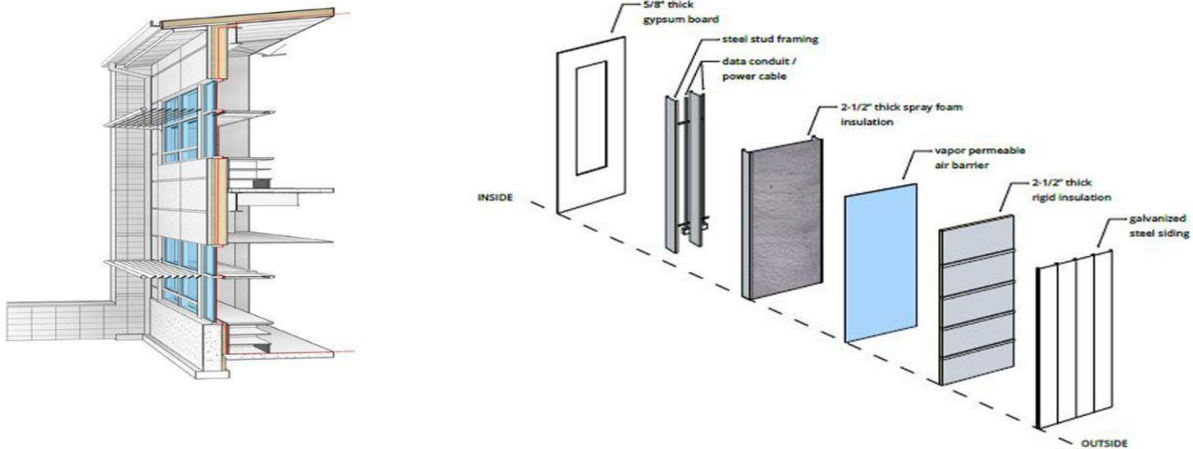
## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 IMPORTANCE OF DAYLIGHTING

- The Clever Classrooms study conducted by the University of Salford, UK, concluded that good daylight helps to make a way of physical and mental comfort, its benefits more far-reaching than merely an aid to sight.
- Several studies have shown that daylight isn't only good for children's overall health and wellbeing, but that it may also significantly improve academic performance. One such study was conducted by the Sorbonne University using SINFONIE Study data, covering 13 European countries with a total of two,387 children participating. It concluded that academic performance can increase by up to fifteen when students add classrooms with larger windows – due both to increased daylight, and a stronger view to the skin world.

#### 2.2 ACOUSTICS IMPORTANCE IN SPECIAL SCHOOL



Insulation cut section. Ref(6)

- Acoustics are among the foremost important factors when designing an education school. the form and surfaces of an area have an instantaneous impact on acoustical comfort and intelligibility.
- While good classroom acoustics benefit all children, they're critical for college students with auditory processing disorders, speech and language delay, or attention issues. Thoughtful material choices and layout can significantly reduce noise distraction, including ground noise, reverberation, and sound transfer throughout the building.

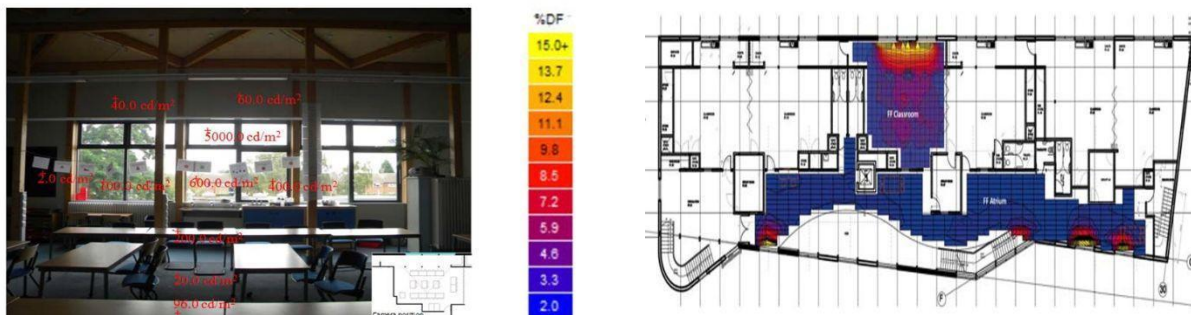
#### 2.3 STUDY ON THE MATERIALS AND COLORS



**Materials.Ref(6)**

- Avoiding bright colors and robust patterns helps to cut back adverse sensory effects for college kids with hyper-sensitivities.
- A spread of touchable and sturdy materials offers options for college students with tactile sensitivities, but should be limited to chosen locations.
- Extremely tactile materials can trigger “stimming” (stereopathy), which is calming but can become excessive and interfere with learning.
- All materials should be non-glare and non-toxic. Students with sensory disorders can perceive glossy flooring as a wet surface and should avoid walking thereon.
- Certain medical conditions might also increase sensitivity to volatile organic compounds and other toxins within the built environment.

## 2.4 Design of daylighting in schools



**Daylight distribution and daylight factor.Ref(1)**

### 2.4.1 Abstract of the study

Daylighting in class buildings has been considered a mutually major aspect over the past few decades. An elegant space should meet appropriate quantitative aspects like illuminance, luminance, and daylight factor together with qualitative aspects like psychological and physiological factors, additionally as time, duration, and directionality of the luminous stimuli. The study aims to grasp the influence and relation between daylight and human productivity within the context of educational buildings.

### 2.4.2 Methodology used in the study



The research procedure is held with two methods of research. The measure has been performed with the pc simulations and on-site measurements, while the analysis has been conducted by observations, survey, performance reports by school and interviews with teachers. The pc simulation is performed through Autodesk Ecotect and Radiance software applications for daylight uniformity distribution and daylight factor.

### 2.4.3 Design Approach for Autism Treatment

#### SENSORY DESIGN APPROACH



- Sensory Design Theory explores the manipulation of the environment to the benefit of autistic people. Developed by Ar. Magda Mostafa.
- Applying this theory to a treatment facility for people with autism means to rigorously separate the space into two distinct areas: a high stimulus area which functions as a developed public interface with training and conference rooms and a low stimulus area which is destined for treatment activities.

#### NEURO-TYPICAL APPROACH



- The Neuro-Typical method focuses on a more direct approach to integration in basic day-to-day circumstances.

- In relation to the therapy, patients are emerging into a highly stimulating environment that should force them to develop a sense of familiarity with the different circumstances that they might observe in normal public spaces.

#### 2.4.4 Understanding Autism Spectrum Disorder (ASD):



Generally prefer to be alone and may avoid eye contact.



Enjoy rotating or spinning objects or lining up objects etc.



Have inappropriate attachments to objects and sustained and repetitive play.



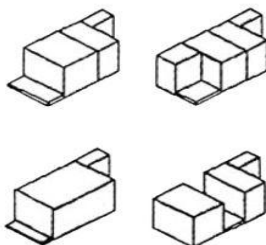
Uneven physical or verbal skills and echo words or phrases and show resistance to change in routines and in surroundings.



Have extreme unusual fears or poor awareness of danger or show insensitivity towards pain.

#### Autism School Design Criteria:

##### 1. Flexible and Adaptable Design.



The ability to modify an environment at a moment's notice to meet the needs of various activities is one of the most important characteristics in Autism Architectural Design. Movable furnishings and spatial arrangements are preferred in such designs.

##### 2. Non – Distracting Space

The spaces should be non-distracting in terms of:

1. Physical clutter and obstruction
2. Odor
3. Visual and aural distractions

### 3. Controllable Environment

The child should be able to control his/her environment in order to feel more attached to the place.

### 4. Predictable

Kids with Autism generally show resistance to change. Therefore, the building should be as legible as possible and the sequencing of spaces should be very much predictable.

### 5. Non – Threatening

As autistic kids have extreme unusual fears and have a high perception of fear, it is advisable to design their environments as non – threatening as possible.

### 6. Sensory Motor Attuned



#### LIGHT

Using adequate amount of natural lighting and ventilation.



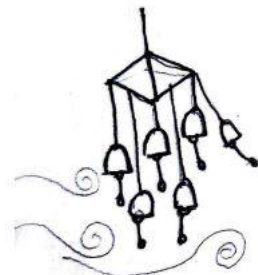
#### SMELL

Incorporating smell also as an sensory stimulation in calssrooms as well as outdoor spaces.



#### TOUCH

Using different elements like water, sand and different textures to incorporate the sensory stimulation of touch



#### SOUND

Using different elements to sensorially stimulate in terms of sound and also use this as learning element for students with learning disabilities.

### 7. Non –Institutional

Feeling really at home in their environment will allow children to relax and learn more. Use of natural light as much as possible and removal of overhead fluorescents, using child-scale furnishings especially in hygiene areas are some of the ways for creating a sense of softness and homeliness.

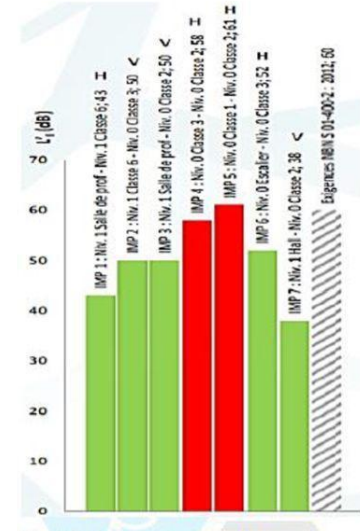
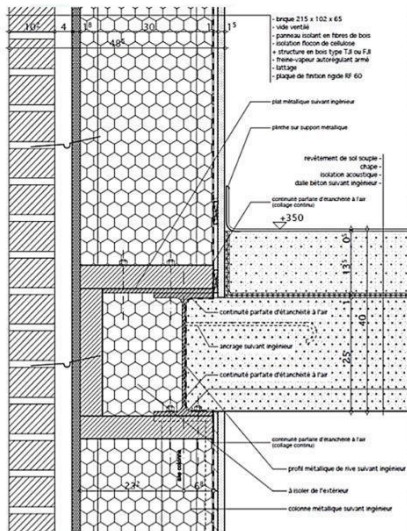
### 8. Safety

Children with autism are often prone to seizures and behaviors like tantrums or stimming , because of which there are chances of injury to themselves or others. So, it is better to avoid breakable surfaces, rough textures etc.

## 2.4.5 Analysis and results from the study

From the results and analysis on glare, it's learnt that there's less discomfort glare from a window given an appropriate content, supporting the investigation and statement by Optimum use of solar shading devices, other design strategies and usage of roof lights may control the incapacity glare and further improves the daylight distribution and uniformity. From the literature review on past research and investigation, it absolutely was understood that students from most day-lit classrooms have performed 20% faster in math tests and 26% in reading tests.

## 2.5 ACOUSTIC IMPROVEMENT IN SCHOOL BUILDINGS



a)Airborne sound insulation b)Insulation to impact noise between classes.Ref(2)

### 2.5.1 Abstract of the study

This paper will analyze the various perspectives and approaches in terms of sound improvement techniques, noise absorption or sound insulation methods that respond differently to noise and supply solutions to certain nuisances.

### 2.5.2 Methodology used in the study

A case study methodology is proposed to review the acoustic conditions of classrooms in the Republic of Korea. The information was collected on-site in previous studies, the lecture rooms for the studies were empty and chosen in keeping with their location and orientation concerning different noise sources.

### 2.5.3 Results from the study

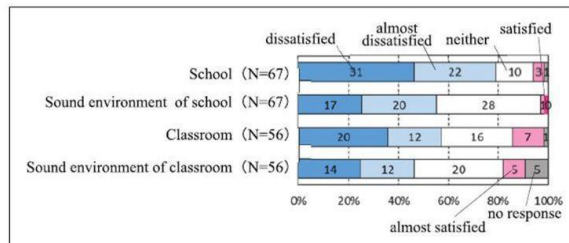
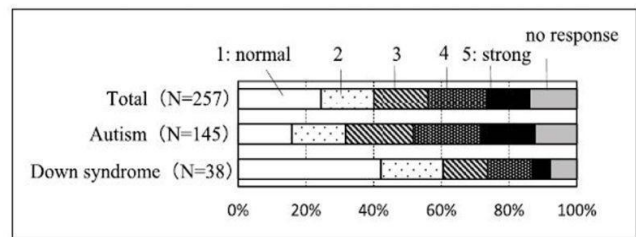
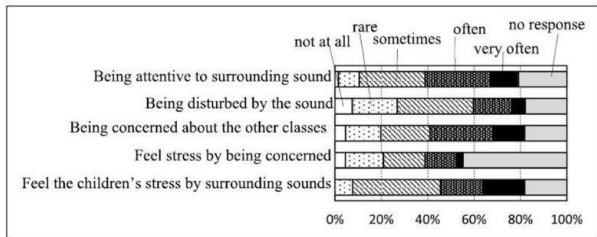
As overall result, for this school the achievements normally are impact sound insulation (L'i) between different local (non-opening separation wall), airborne sound insulation (DA) between classes (non-opening separation wall) and limited performance for airborne sound

insulation (DA) and impact sound insulation (L'I) between classes when the separation wall includes a door (limited door performance, noise transfer opening) and airborne sound insulation (DA) between a hall and a space.

### 2.5.4 Inference from the study

The problems associated with pollution relate to defects in architectural design and materials used for interior spaces. One of the planning errors is the orientation of classrooms and their position in reference to sources of nuisance.

## 2.6 FIELD STUDY ON ACOUSTIC ENVIRONMENT IN SPECIAL SCHOOL

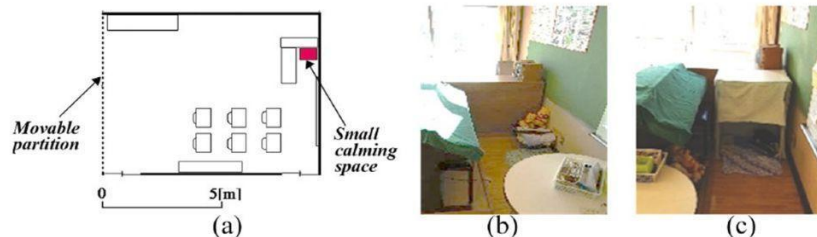


a)Evaluation of sound environment, b)sound sensitivity strength c)satisfaction with school environment.Ref(3)

### 2.6.1 Abstract of the study

A child with a developmental disability, such as autism spectrum disorder, has a high possibility of having typical sensorial characteristics. Indeed, children with autism spectrum disorder often face great difficulties while listening to teachers' instructions in noisy environments. investigated the acoustic problems of schoolrooms for special-needs education and the methods to improve their sound environment.

### 2.6.2 Methodology used in the study

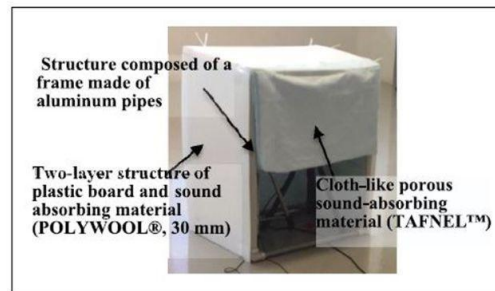




a)Plan, b)before setting and c)after setting.Ref(3)

- A questionnaire survey - special-needs education class, and the children's disorders, hearing properties, and problems caused by the acoustic environment were examined.
- A small space with acoustical properties was built and checked with various noises projected on them.

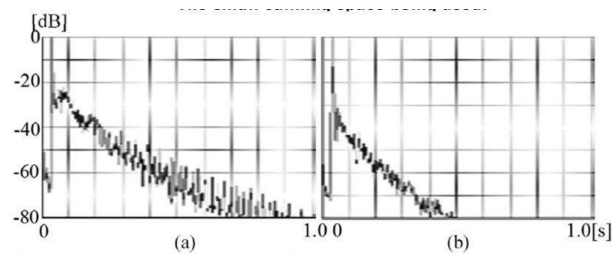
### 2.6.3 Designing a calm space with acoustic



Small calming space.Ref(3)

- To understand the acoustic characteristics of the small calming space, we measured the attenuation performance of the external sound and internal reverberation characteristics. For the measurement, a small calming space of W50 cm × D70 cm × H90 cm was used. The height of the sound source and receiving point was 70 cm.
- The small calming space was installed such that it surrounded the sound receiving point in three directions (front, side, and back), with respect to the sound source.
- The loudspeaker and microphone were installed in the small calming space at a distance of 30 cm. A reverberation decay waveform for each 1/1 octave band was calculated from the measured impulse response.

### 2.6.3 Analysis and results from the design



Reverberation decay curve at 1-kHz octave band.Ref(3)

Evaluation of sounds during class. Results show the resulting answers regarding sounds occurring in classrooms during class. Approximately 40% of faculty members said that the sounds around them are “attentive” “often/very often,” that they are “concerned” about the surrounding classrooms, and that students are affected by the sounds around them.

During panics, he demonstrated self-injurious behavior such as hitting his head against glass, and when a faculty member stopped it, other harmful acts such as hitting the teacher occurred. After the small calming space was constructed, this child entered it before panicking and demonstrated no self-injurious behavior.

## **2.7 IMPORTANCE OF CONTROLLING EXCESSIVE GLARE**

- Glare is created when areas that are too bright are located within the sphere of view, or when the contrast ratio is high. Glare caused by daylight differs from glare caused by bulb sources in terms of the dimensions, complex luminance distribution and acceptance of the users.
- Large expanses of glazing should ideally be facing north, so as to permit diffused daylight to penetrate the foremost amount as possible throughout the day/year.
- Another effective solution for glare control is the installation of easily operable opaque blinds to manage daylight levels.

### **2.7.1 Benefits of fine daylighting**

- Improved sense of vitality.
- Reduced stress and anxiety.
- Shorter hospital stays
- A one-third reduction within the prospect of poor sleep and mood disorders for each additional half-hour we get of daylight.

### **2.7.2 Design considerations**

- Providing access to direct sunlight for a minimum of a selected number of hours day by day.
- Minimizing potential glare through the utilization of effective shading systems which may be controlled by the building users.
- Installing operable windows that may be opened and closed by the building users.
- Pleasant views improve vitality and reduce the chances of self injuries.

## CHAPTER 3 LITERATURE CASE STUDIES

### 3.1 CASE STUDY 1: EKYA EARLY YEARS



View

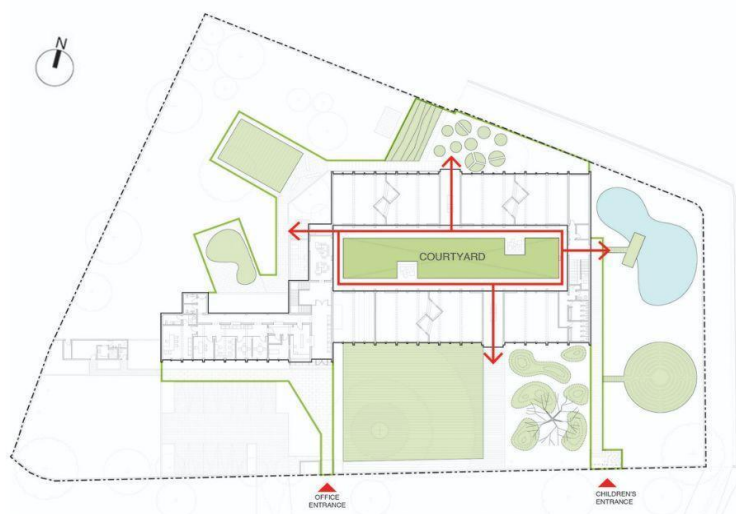
**Architects:** CollectiveProject

**Area:** 25000 ft<sup>2</sup>

**Year:** 2014

**Location:** Bangalore, India

#### 3.1.1 Design and Spatial typology



Site plan



- Designed as an exclusive school for Montessori environments, the new design capitalizes on the sweetness of an old industrial building, repurposing the current shell as a framework for spacious, naturally ventilated and sunlight filled classrooms.
- A design requirement of the Montessori brief, the boundaries are blurred between inside and outdoors with the 13 learning environments (classrooms) accessed from a covered walkway circumnavigating a densely planted central “Jungle” courtyard.

### 3.1.2 Spatial Morphology

- The varsity has an spatial morphology which exactly distinguishes the training environment spaces and thus the open spaces which is incredibly much required for special childrens to urge a noise country within the lecture rooms and a breakout space where they'll relax.
- Conceived in an exceedingly “pinwheel” formation from the courtyard are four controlled access points to the surface recreational and learning landscape.

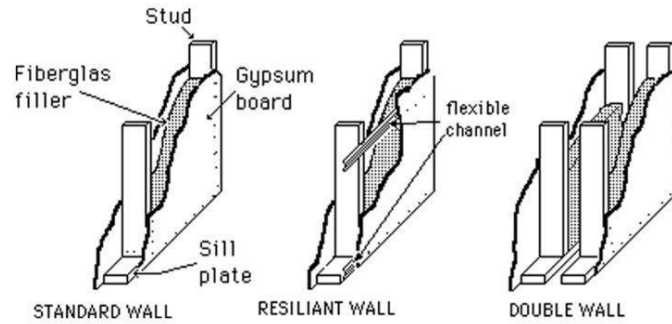
### 3.1.3 Colors and Material analysis



**Classroom - interior view**

- The site has lush greenery with a colorful environment for the childrens.
- Extremely tactile materials can trigger “stimming” (stereopathy), which is calming but can become excessive and interfere with learning.
- All materials utilized during this school are children friendly but the flooring is glossy flooring which isn't a special children material.
- Certain medical conditions may additionally increase sensitivity to volatile organic compounds and other toxins within the built environment.

### 3.1.4 Acoustics analysis

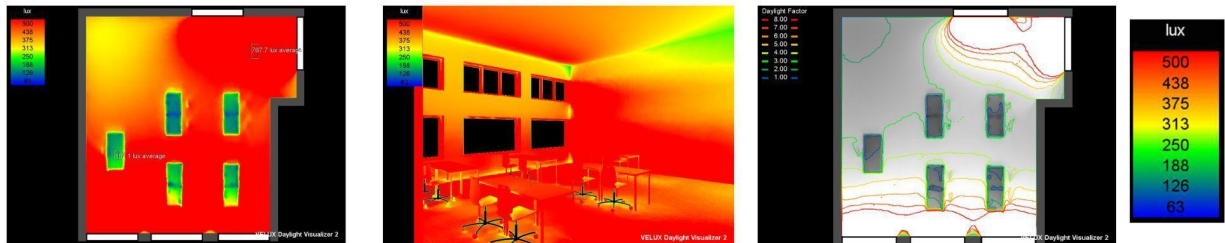


**Cut section detailing**

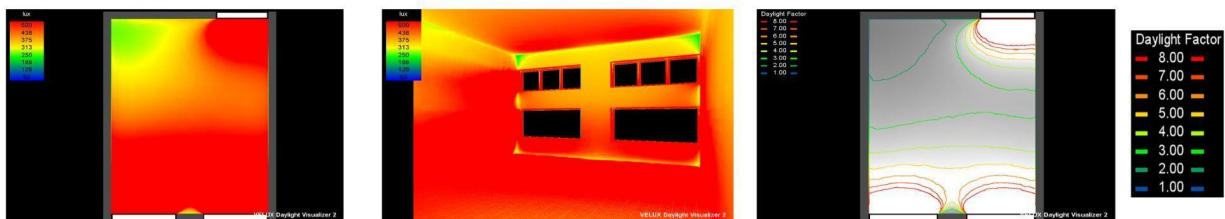
- The classrooms have concrete walls on all the sides and no extra acoustic materials are added to the surface.
- Concrete walls are designed to reflect noise towards the source and absorb a variety of the energy from the undulation. Most of the sound energy isn't traveling through the wall, which is why it provides such a decent noise barrier.
- The sound coefficient of absorption for plain cast concrete is about 0.02, indicating that about 98% of the sound energy is reflected by the surface.

### 3.1.5 Inference

#### DAYLIGHTING ANALYSIS: CLASSROOM TYPOLOGY 1



#### CLASSROOM TYPOLOGY 2



**Velux - simulation.Fig(1.1)**

- Daylighting in class buildings has been considered a major aspect.
- The classrooms have double glazed windows within the lecture rooms and also the lux level achieved within the inside is 500 which is extremely much higher than the standard lux levels 300 for the classroom spaces which reciprocally provides excessive glare that affects the children's eye sight.
- The ADF is 4 that's above the standard minimum ADF 1.5.

### 3.2 CASE STUDY 2: ACTION FOR AUTISM



View

**Orientation:** NE - SW

**Area:** 600 sqm

**Year:** 2006

**Location:** New delhi

#### 3.2.1 Design and Spatial typology



Floor plan

- Designed as an exclusive school for Autistic childrens.
- The four storey structure has 8 classrooms, 5 parent infant intervention rooms, 2 sensory rooms, 2 occupational remedy rooms and a library.

- The spatial typology is done in such a way that the spaces are at easy proximity and every floor consists of all the spaces for easy accessibility.
- The planning is done in such a way that the ventilation and daylighting to the corridor is achieved through the central space towards which the openings are oriented.

### 3.2.2 Spatial Morphology

- The school has the services oriented towards the posterior end of the floor plan and the classrooms and the sensory rooms are oriented towards the frontier space.
- The designing is done very enclosed and private there are no classrooms designed with a breakout space for childrens to relax and lack of connection of interior spaces with the exterior environment.
- The vicinity is very low and the semi open space used grills for safety reasons but they don't connect with the green environment.

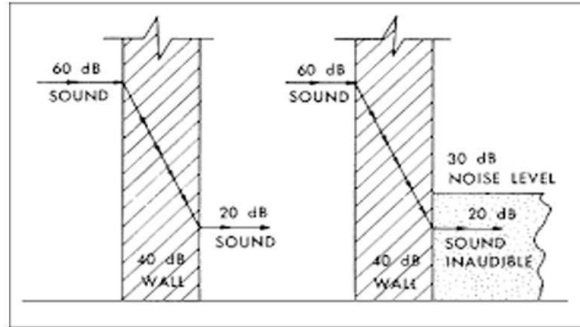
### 3.2.3 Colors and Material analysis



**Classroom - View**

- All partitions are rough textured and coloured white with sensory stimulating objects.
- The surfaces must be more smooth as these childrens tend to hurt themselves so smooth surfaces will be more suitable.
- All materials used in this school are not child friendly and the furniture used also have sharp edges.
- Certain medical conditions may also increase sensitivity to volatile organic compounds and other toxins in the built environment so while choosing materials for the special needs they must be made sure it is not harsh for the childrens.

### 3.2.4 Acoustics analysis

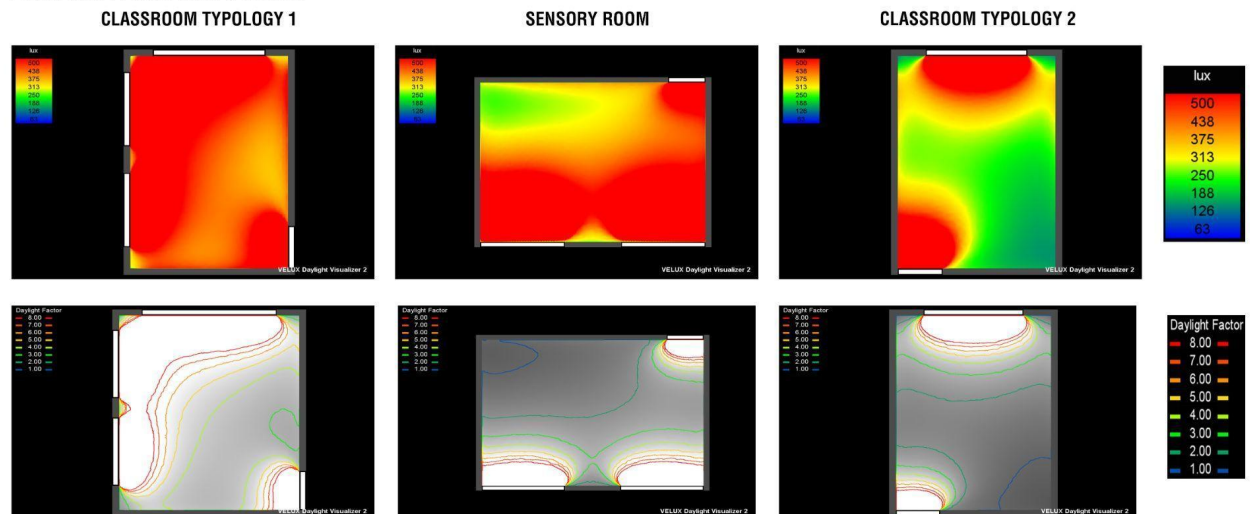


**Decoupling - wall section**

- The rooms have normal brick walls with no acoustics done so the children easily get disturbed from the noise from the outside.
- The decoupling is done for soundproofing to cut the sound wavelength from travelling to the interiors.
- The acoustics have the construction of two walls with a relative gap between them to increase the air gap.
- Soundwaves are trapped within the air gap chambers and will be less likely to penetrate and reach the other part of the wall.

### 3.2.5 Inference

#### DAYLIGHTING ANALYSIS:



**Velux - simulation.Fig(2.1)**

- The LUX levels are 438,375,270 and the DF are 4,2,1.7 for classroom type1,sensory room and type2 respectively only the typology 2 levels fall under standard lux level 300 and the classroom typology 2 and sensory room has achieved minimum standard DF of 1.5-2.
- The illumination near the windows is very high and glare is created. Strategies must be implemented to reduce it.



### 3.3 CASE STUDY 3: CAIRNSFOOT SPECIAL NEEDS SCHOOL



View

**Architect:** The Landscape Studio of NBRS ARCHITECTURE

**Area:** 1000 sqm

**Year:** 2018

**Location:** Australia

#### 3.3.1 Design and Spatial typology



Site plan

- The vision for the project was to make an environment that both shelters and challenges students. Shelter being at the center of human need for safety and challenge being key to a child's development.
- Learning spaces create a way of reassurance, with 'escape spaces', where children who feel overwhelmed can find a sensory haven, yet always maintaining sight lines for teachers.
- The school rooms have spatial orientations of learning environment, breakout space and open space.

### 3.3.2 Spatial Morphology

- The varsity has the services oriented within the middle of the positioning as staff could keep sight on the childrens.
- The morphology of the spaces is exhausted such the simplest way that every learning environment has a breakout space where the stressed children can take rest.
- The vicinity is great because the spatial distribution is finished in such a way that each class has an attached open space to form a way of opening between the inside and therefore the exterior environment.

### 3.3.3 Colors and Material analysis

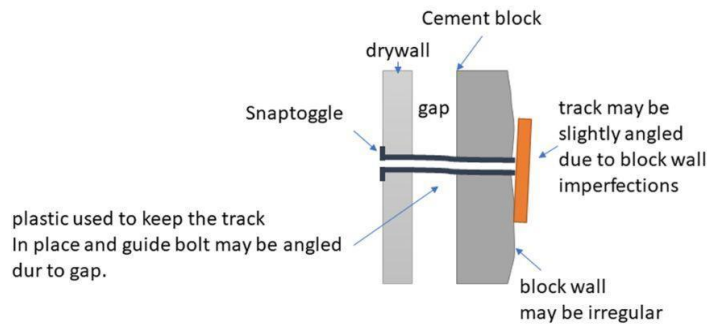


**Classroom - interior view**

- All partitions are smooth textured and colored with sensory stimulating colors.
- The special children friendly surfaces are used and anti slip floorings are used.
- All materials utilized in this school are children friendly and plenty of sensory simulating objects are designed.
- The spaces are okay oriented with combined required spaces at good proximity levels and that they are defined with different colors.
- a spread of finishes and textures like stepping stones, timber balancing logs and textured concrete with stone inlays appeal to students' senses.

### 3.3.4 Acoustics analysis

### SIDE VIEW



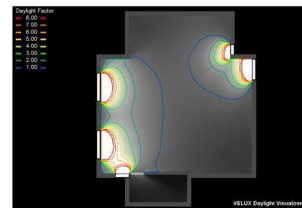
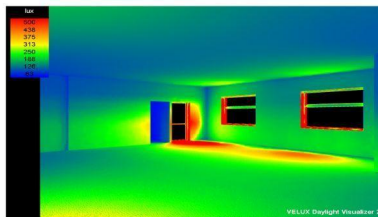
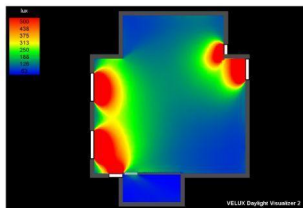
**Drywall - Cut section**

- The rooms have normal concrete walls with no acoustics done therefore the children easily get disturbed from the noise from the surface.
- They need to use a false ceiling for the roof.
- The positioning selection and orientation also contributes to noise levels; they need to be zoned in such the simplest way that the green buffer zones are provided to cut back the noise transmission.
- Fitting a layer of drywall on the already existing wall can go a protracted way in achieving a noiseless living. The concept is cost effective because you don't have to pull your existing wall down.

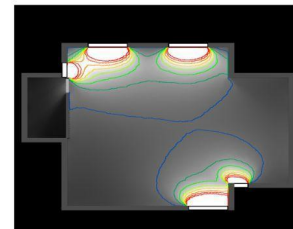
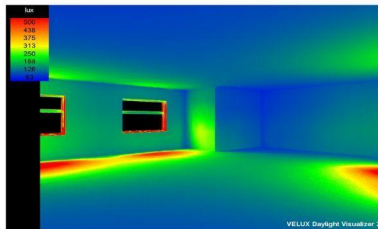
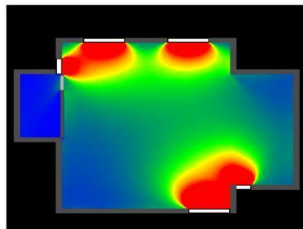
### 3.3.5 Inference

#### DAYLIGHTING ANALYSIS:

##### CLASSROOM TYPOLOGY 1



##### CLASSROOM TYPOLOGY 2



**Velux - simulation.Fig(3.1)**

- Daylighting at school buildings has been considered a major aspect.
- The LUX levels are 250,270 and therefore the DF are 1,1.7 for classroom type1 and kind 2 respectively and both the typologies levels make up standard lux level 300 and type 2 has satisfied the quality DF 1.5-2.



- The illumination near the windows is very high and glare is created. Strategies must be implemented to scale back it.
- The breakout space is incredibly confined and has no natural lighting.

### 3.4 **CASE STUDY 4: SANKALP AUTISM SCHOOL**



**Front view**

**Architect:** Benny Kuriakose and Associates

**Area:** 1625 sqm

**Year:** 1999

**Location:** chennai

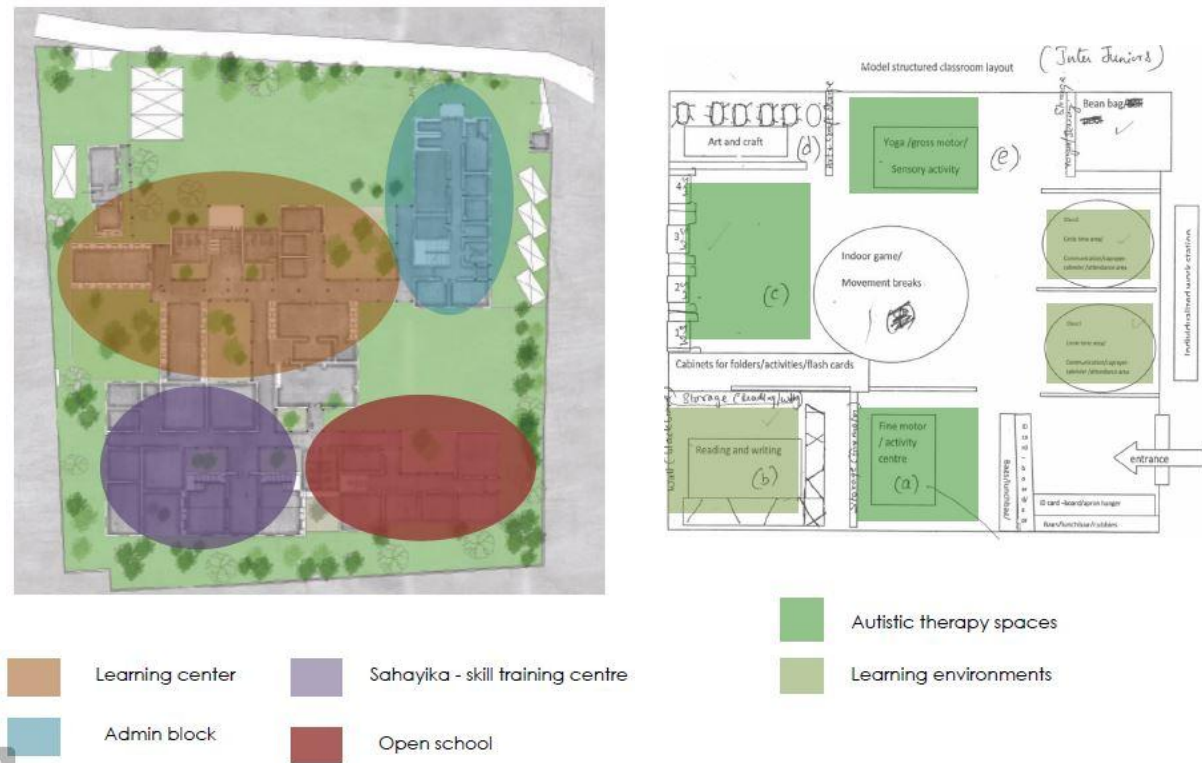
#### 3.4.1 **Design and Spatial typology**



## Site plan

- Designed as an exclusive school for Autistic environments, the design capitalizes on a framework for spacious, naturally ventilated and sunlight filled classrooms.

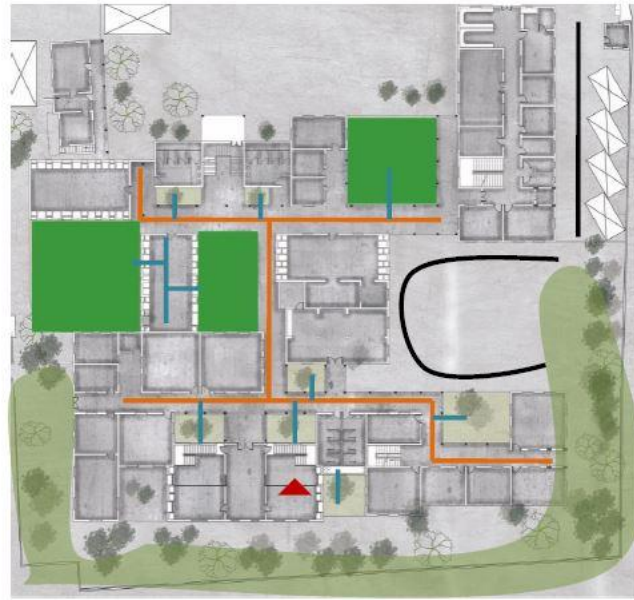
### 3.4.2 Spatial Morphology



## plan view

- The Spatial orientation in the school is done in such a way that the private spaces are oriented on the anterior part of the site and the learning spaces are zoned on the posterior end .
- The learning environments are zoned with elimination spaces designed as sensory gardens which improves the children's skills in a sensory design approach.

### 3.4.3 Accessibility

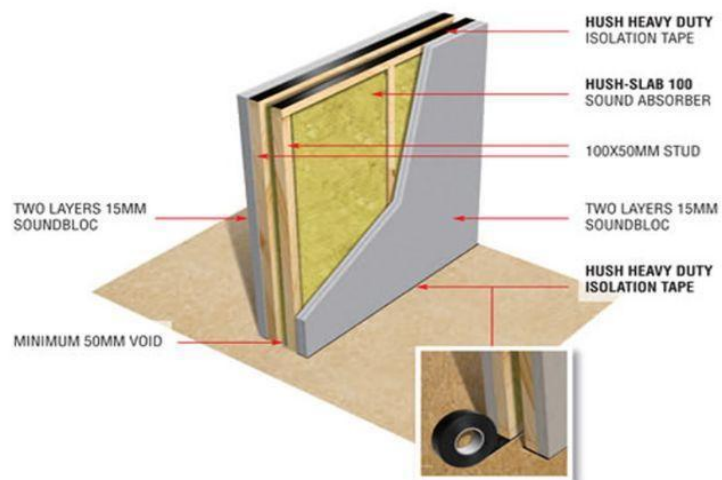


— Formal spaces — Informal spaces — Outdoor spaces

**plan**

- As these kids can sometimes be distracted or agitated at times, they need to break free and let loose to calm themselves. Therefore, courtyards can easily be created based on the way the current building is organized, which can be used as these sensory outlet areas.
- Pathways are provided around the playground so that children can orientate themselves. We have avoided sharp edges and low borders to avoid children getting hurt. For autistic children who might get overwhelmed in a busy playground, a quiet space is provided away from the noise for a child to regroup.

#### 3.4.4 Acoustics analysis



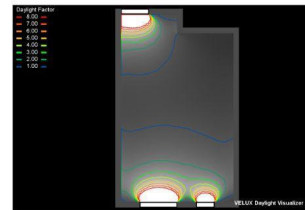
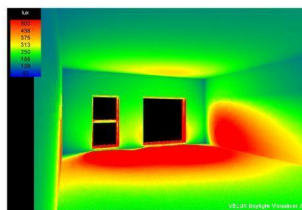
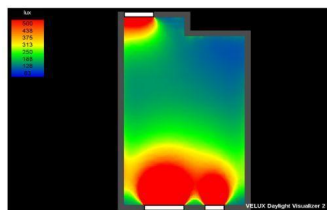
**Acoustics wall cut section**

- The rooms have normal concrete walls with acoustics done therefore the children won't easily get disturbed from the noise from the skin.
- They need to use a false ceiling for the roof.
- The location selection and orientation also contributes to noise levels.
- A double timber acoustics stud wall is employed during this space. Construct two frames of 50x100mm timber stud work then Ensure there's a minimum 50mm clear gap between the 2 stud frames.
- Insulate within the stud frames using the Hush Slab 100 Sound Absorber then Face each stud frame with two layers of 15mm Soundbloc Plasterboards.

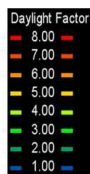
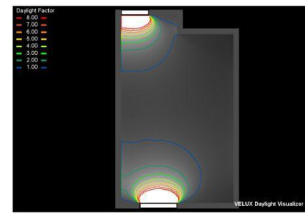
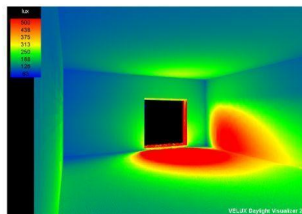
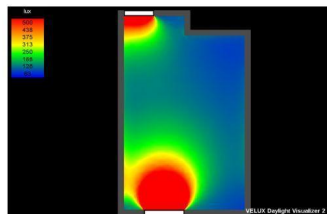
### 3.4.5 Inference

#### DAYLIGHTING ANALYSIS:

##### CLASSROOM TYPOLOGY 1



##### CLASSROOM TYPOLOGY 2



Velux - simulation.Fig(4.1)

- Daylighting at school buildings has been considered jointly a major aspect.
- The LUX levels are 240,270 and therefore the DF are 1,1 for classroom type1 and type2 respectively and both the typologies levels fall into standard lux level 300.
- The illumination near the windows is very high and glare is created. Strategies must be implemented to cut back it.
- As there's no proper shading device the excessive glare is caused within the classroom.

### 3.5 COMPARATIVE ANALYSIS



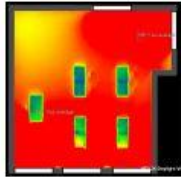
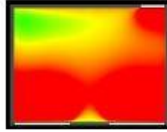
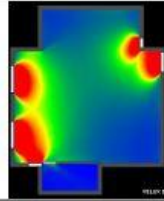
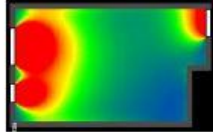
| ASPECTS                                                                                           | CASE STUDY 1                                                                      | CASE STUDY 2                                                                      | CASE STUDY 3                                                                        | CASE STUDY 4                                                                        |
|---------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| Area                                                                                              | 2322 sqm                                                                          | 600 sqm                                                                           | 1000 sqm                                                                            | 1625 sqm                                                                            |
| Orientation                                                                                       | NE - SW                                                                           | NE - SW                                                                           | NE - SW                                                                             | NW - SE                                                                             |
| Spatial Analysis                                                                                  | 13 – Study, 2 – Flex space,<br>1 – Outdoor art, 1- Labyrinth<br>1- courtyard      | 8 – Study, 2 – Flex space,<br>2 – Therapy room,<br>5 – PC intervention            | 15 – Study, 2 – Flex space,<br>1 – Play court,<br>1 – pool, 2 - Courtyard           | 8 – Study, 1– Flex space,<br>4 – Therapy room,<br>4 – Sensory garden, 3- courtyard  |
| Day lighting<br> |  |  |  |  |
| Acoustics                                                                                         | Double Wall Technique<br>Coefficient of<br>sound absorption – 0.02                | decoupling Technique<br>Coefficient of<br>sound absorption – 0.05                 | Dry wall Technique<br>Coefficient of<br>sound absorption – 0.05                     | Stud wall Technique<br>Coefficient of<br>sound absorption – 0.90                    |
| Ventilation                                                                                       | Provision of windows for<br>natural ventilation                                   | Provision of windows for<br>natural ventilation                                   | Provision of Air Conditioner<br>for ventilation                                     | Provision of windows for<br>natural ventilation                                     |
| Visual Comfort                                                                                    | Provision of Colored<br>and designed walls                                        | Provision of simple<br>clean walls                                                | Provision of Colored<br>and designed walls                                          | Provision of simple<br>clean walls                                                  |
| Transition Spaces                                                                                 | Corridors around the<br>courtyard 1.2m                                            | Long N shaped corridor<br>2m                                                      | Long multilinear<br>corridor                                                        | Comb shaped corridor<br>2m                                                          |

Table (1.1)

### 3.5.1 INFERENCES

- The comparative analysis shows the different materials used and the various acoustics strategies that can be implemented in special schools to reduce the noise.
- From the simulations the daylight factor and the lux levels in the structures are noted and analyzed; they are based on the typology and the strategy implemented so the spatial morphology and the window placement in the sensory room has achieved the standard daylight factor and lux levels.

## CHAPTER 4

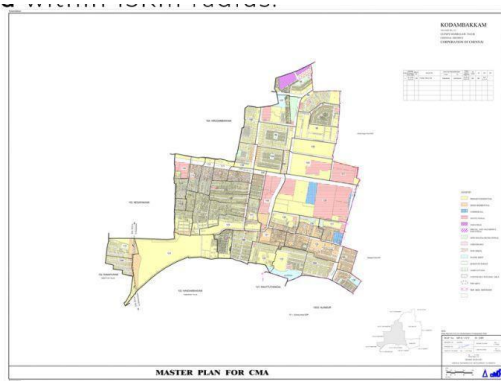
### SITE SELECTION AND CLIMATE STUDY

#### 4.1 **SITE SELECTION**

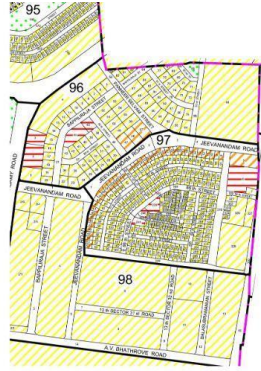
Location - 13.041699, 80.208559 (Kodambakkam)

Land use - Institutional

Neighborhood Land use - Residential



LAND USE MAP



SITE

##### 4.1.1 **Site justification**

- The site is an allocated site for institutional purposes by CMDA.
- The therapy centers are more easily accessible than the previous site.
- The site has a green cover which acts as a natural sound barrier like a buffer zone.
- The site has many Hospitals, Parks, Therapeutic centers within 5km proximity.
- The residential neighborhood has no special schools proposed within 15Km radius.

##### 4.1.2 **Proximity**

###### Hospitals

- ESIC Hospital - 850m - 2min
- K.M.Speciality Hospital - 1.7Km - 5 min
- VHM Hospital - 2 Km - 6min
- Arokya Hospital - 3.1km - 9min

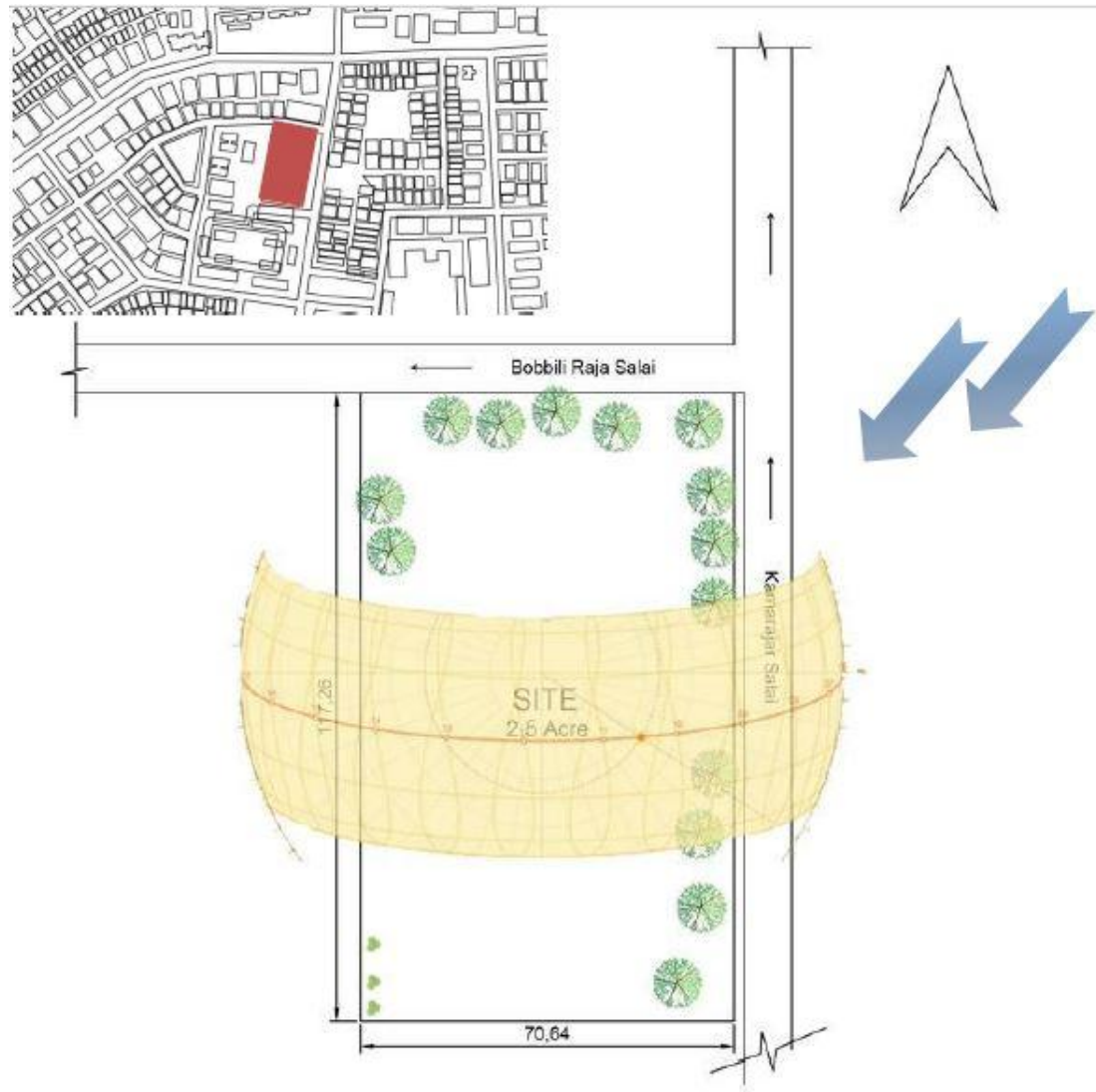
###### Therapeutic centers

- IRIS - 4.9Km - 14min
- direct - 4.7Km - 12min
- care - 7.7Km - 21min
- TALES WITH TAILS 269 - 14Km - 30 min

###### Parks

- Anna park - 3Km - 9min
- Sivan park - 850m - 2min
- Kaveri children's park - 2Km - 6min
- 4th sector park - 1.6Km - 5min

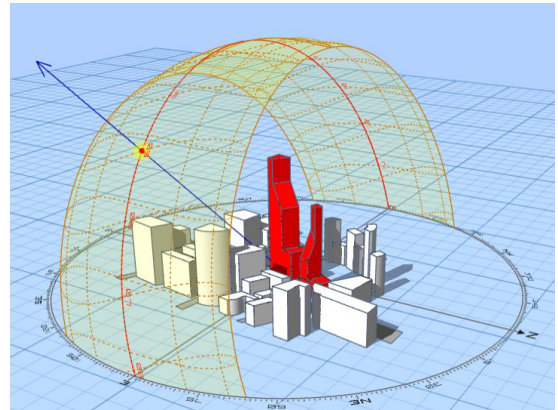
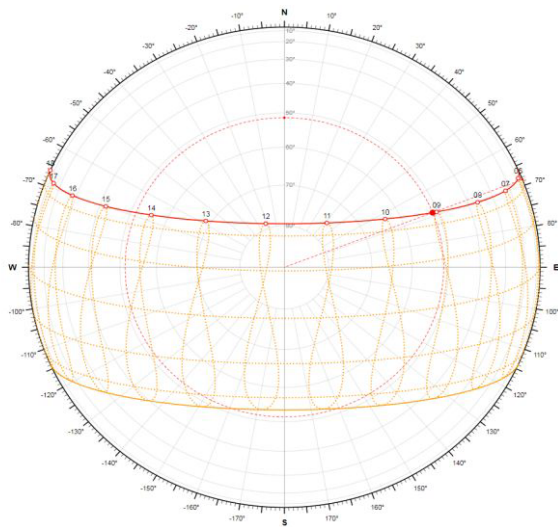
#### 4.1.3 SITE PLAN



## 4.2 CLIMATIC STUDY

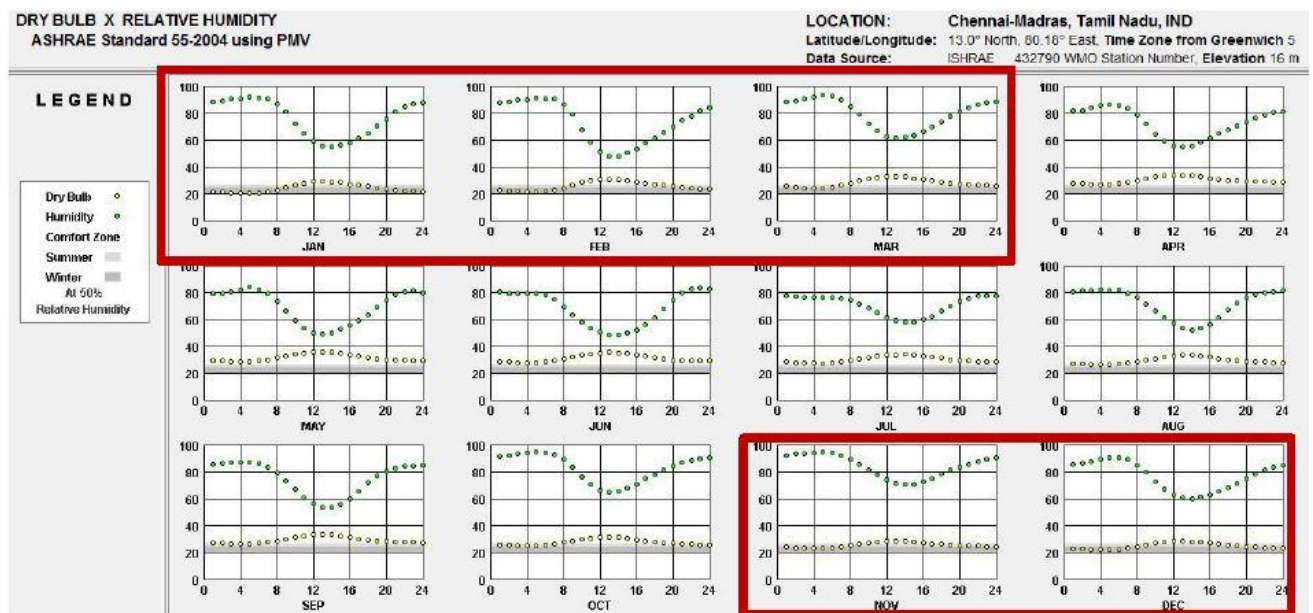
### 4.2.2 Macro climatic analysis

Solar analysis:



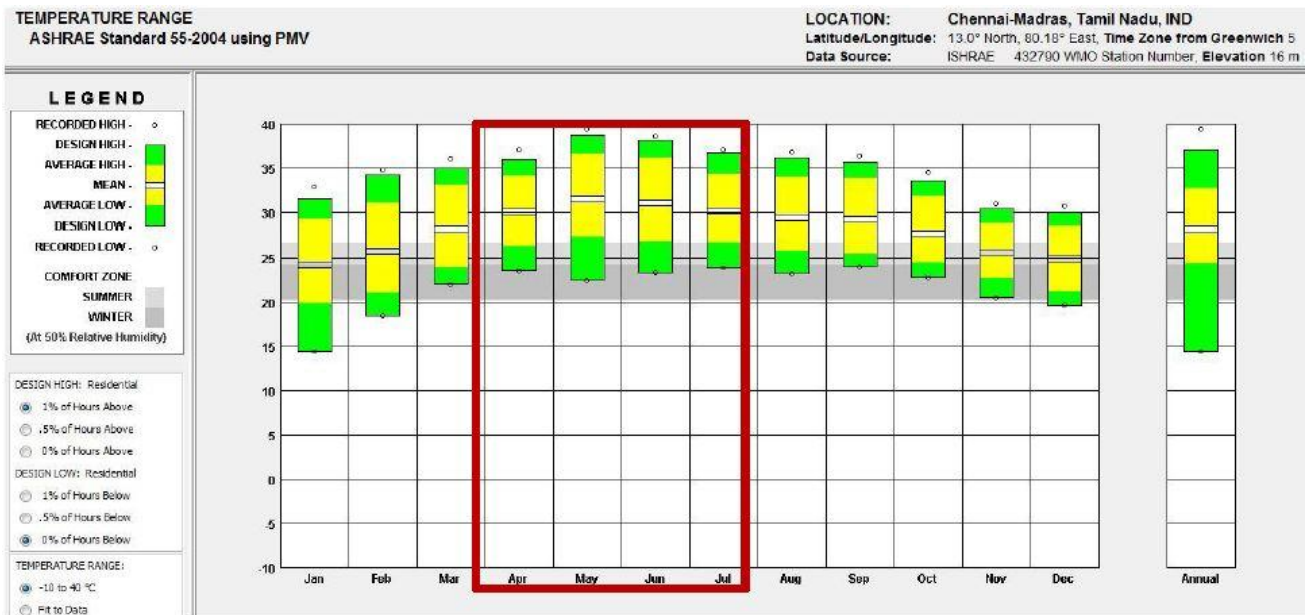
Sun path

Temperature analysis:



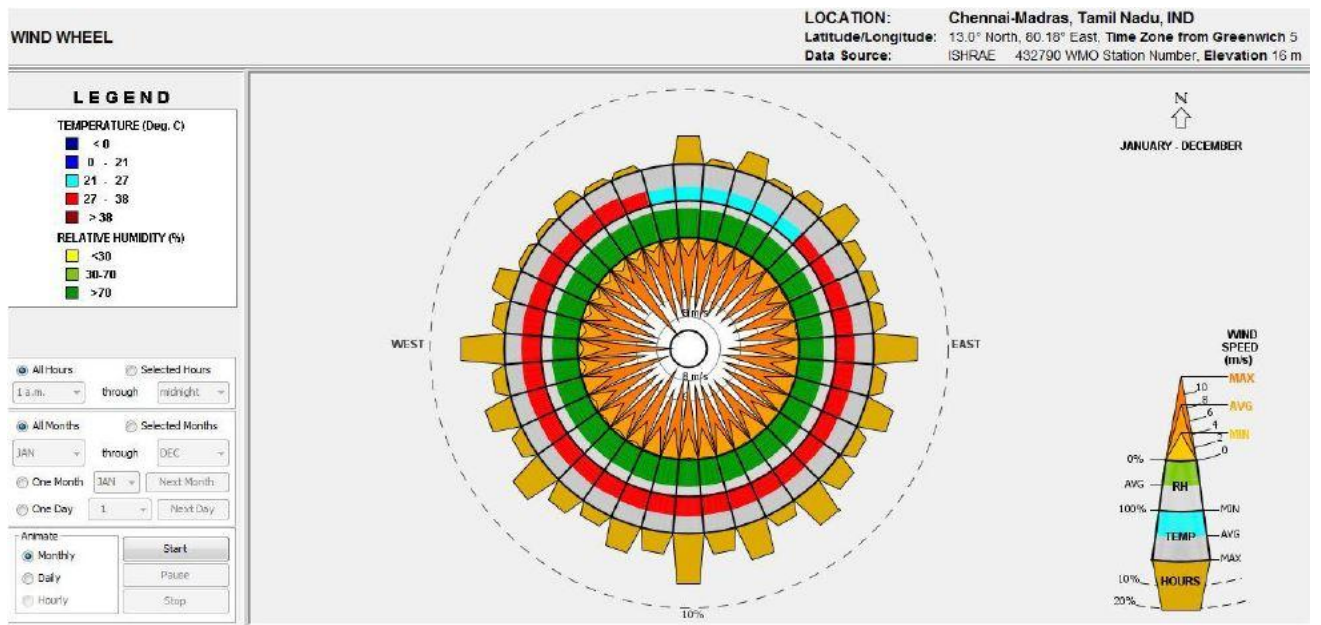
Humidity chart



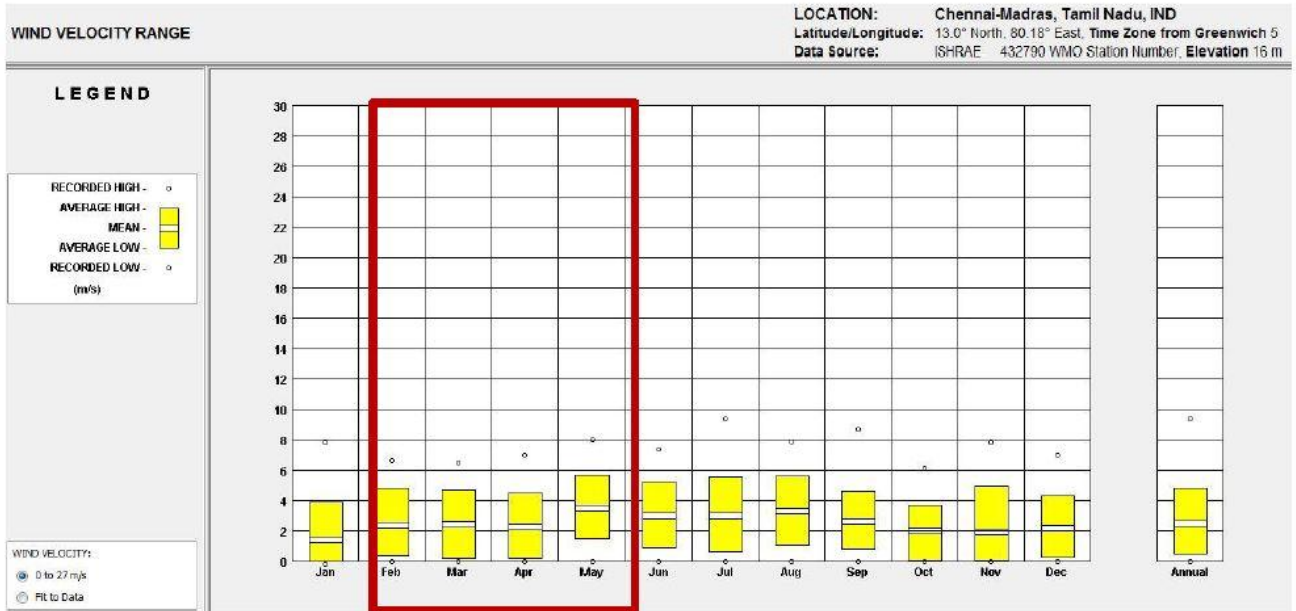


Temperature graph

Wind analysis:



Wind rose diagram

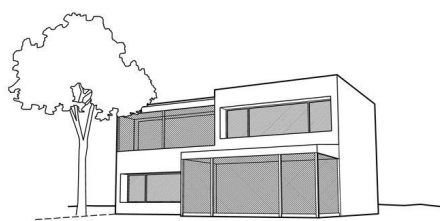


Wind velocity chart

## INFERENCE:

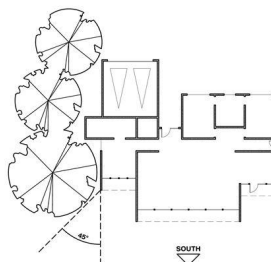
- The site has high relative humidity levels during the months of November to January passive design strategies must be incorporated to maintain the occupants comfort level.
- The site has a natural green cover which acts as a buffer space to reduce the noise from entering the site.
- The temperature is high in the months of April to July so strategies must be implemented.
- The site predominant wind flow with minimum temperature from the NNE direction.
- The prevailing winds flow from the SW direction with high temperature so passive strategies must be incorporated.

## Passive strategies:



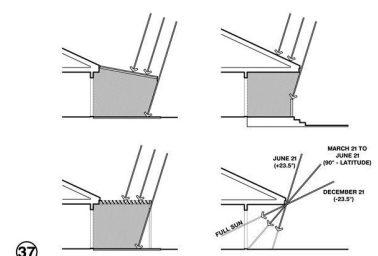
56

Screened porches and patios can provide passive comfort cooling by ventilation in warm weather and can prevent insect problems



17

Use plant materials (bushes, trees, ivy-covered walls) especially on the west to minimize heat gain (if summer rains support native plant growth)



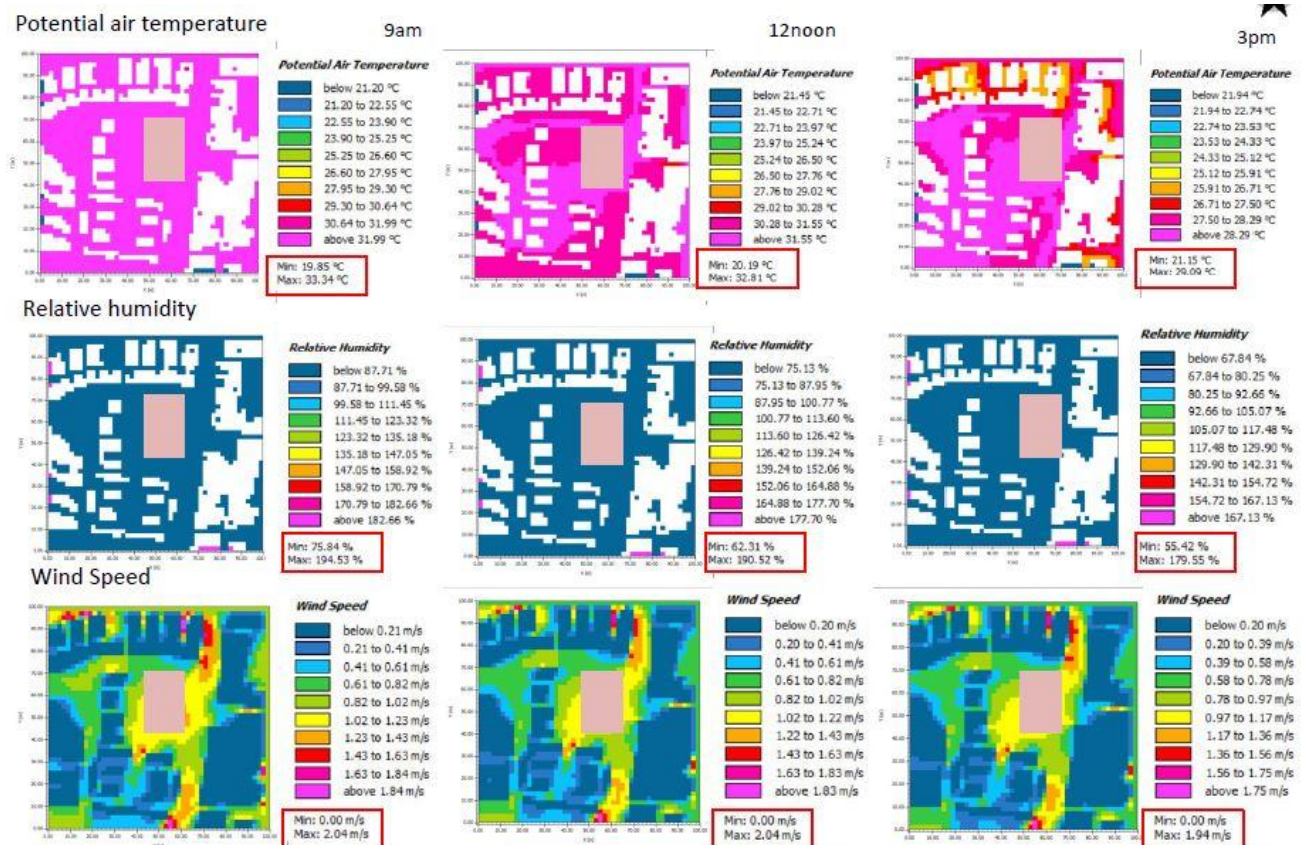
37

Window overhangs (designed for this latitude) or operable sunshades (awnings that extend in summer) can reduce or eliminate air conditioning

### 4.2.3 Micro climatic analysis

| MAHONEY TABLE - CHENNAI  |                                                            |     |      |       |      |      |       |       |       |       |       |       |        |       |  |
|--------------------------|------------------------------------------------------------|-----|------|-------|------|------|-------|-------|-------|-------|-------|-------|--------|-------|--|
| AIR TEMPERATURE:         | JAN                                                        | FEB | MAR  | APRIL | MAY  | JUNE | JULY  | AUG   | SEPT  | OCT   | NOV   | DEC   | HIGH   | AMT   |  |
| Monthly Mean max         | 29                                                         | 31  | 33   | 34.5  | 37   | 37   | 35    | 34.5  | 34    | 32    | 30    | 29    | 37     | 29    |  |
| Monthly Mean min         | 21                                                         | 22  | 24   | 26.5  | 28   | 27.5 | 26    | 26    | 25.5  | 24.5  | 23    | 22    | 21     | 16    |  |
| Monthly Mean range       | 8                                                          | 9   | 9    | 8     | 9    | 9.5  | 9     | 8.5   | 8.5   | 7.5   | 7     | 7     | LOW    | AMR   |  |
| RELATIVE HUMIDITY:       |                                                            |     |      |       |      |      |       |       |       |       |       |       |        |       |  |
| Monthly mean max a.m     | 81                                                         | 80  | 78   | 74    | 67   | 64   | 70    | 73    | 77    | 82    | 83    | 81    |        |       |  |
| Monthly mean min p.m     | 67                                                         | 66  | 67   | 70    | 68   | 63   | 65    | 66    | 71    | 76    | 76    | 71    |        |       |  |
| Average humidity %       | 74                                                         | 73  | 72.5 | 72    | 67.5 | 63.5 | 67.5  | 69.5  | 74    | 79    | 79.5  | 76    |        |       |  |
| Humidity group           | 4                                                          | 4   | 4    | 4     | 3    | 3    | 3     | 3     | 4     | 4     | 4     | 4     |        |       |  |
| WIND DIRECTION:          |                                                            |     |      |       |      |      |       |       |       |       |       |       |        |       |  |
| Wind direction           | NE                                                         | E   | SE   | SSE   | S    | SW   | WSW   | WSW   | SW    | ENE   | NE    | NNE   |        |       |  |
| RAIN FALL:               |                                                            |     |      |       |      |      |       |       |       |       |       |       |        | TOTAL |  |
| Mean total rainfall (mm) | 25.9                                                       | 3.4 | 3.5  | 14.4  | 34.2 | 55.8 | 103.8 | 126.8 | 147.7 | 315.6 | 374.4 | 177.4 | 1382.9 |       |  |
| DIAGNOSIS:               |                                                            |     |      |       |      |      |       |       |       |       |       |       |        |       |  |
| Monthly Mean max         | 29                                                         | 31  | 33   | 34.5  | 37   | 37   | 35    | 34.5  | 34    | 32    | 30    | 29    |        |       |  |
| Day comfort - upper      | 27                                                         | 27  | 27   | 27    | 29   | 29   | 29    | 29    | 27    | 27    | 27    | 27    |        |       |  |
| - Lower                  | 22                                                         | 22  | 22   | 22    | 23   | 23   | 23    | 23    | 22    | 22    | 22    | 22    |        |       |  |
| Monthly Mean min         | 21                                                         | 22  | 24   | 26.5  | 28   | 27.5 | 26    | 26    | 25.5  | 24.5  | 23    | 22    |        |       |  |
| Night comfort - upper    | 21                                                         | 21  | 21   | 21    | 23   | 23   | 23    | 23    | 21    | 21    | 21    | 21    |        |       |  |
| - Lower                  | 17                                                         | 17  | 17   | 17    | 17   | 17   | 17    | 17    | 17    | 17    | 17    | 17    |        |       |  |
| Thermal stress - day     | H                                                          | H   | H    | H     | H    | H    | H     | H     | H     | H     | H     | H     |        |       |  |
| - night                  | O                                                          | H   | H    | H     | H    | H    | H     | H     | H     | H     | H     | H     |        |       |  |
| INDICATORS:              |                                                            |     |      |       |      |      |       |       |       |       |       |       |        | TOTAL |  |
| HUMID - H1               | ✓                                                          | ✓   | ✓    | ✓     | ✓    | ✓    | ✓     | ✓     | ✓     | ✓     | ✓     | ✓     | 12     |       |  |
| - H2                     |                                                            |     |      |       |      |      |       |       |       |       |       |       | 0      |       |  |
| - H3                     |                                                            |     |      |       |      |      |       |       |       | ✓     | ✓     |       | 2      |       |  |
| ARID - A1                |                                                            |     |      |       |      |      |       |       |       |       |       |       | 0      |       |  |
| - A2                     |                                                            |     |      |       |      |      |       |       |       |       |       |       | 0      |       |  |
| - A3                     |                                                            |     |      |       |      |      |       |       |       |       |       |       | 0      |       |  |
| SPECIFICATIONS:          |                                                            |     |      |       |      |      |       |       |       |       |       |       |        |       |  |
| Layout - 1               | Orientation north and south                                |     |      |       |      |      |       |       |       |       |       |       |        |       |  |
| spacing - 3              | Open spacing for breeze penetration.                       |     |      |       |      |      |       |       |       |       |       |       |        |       |  |
| air movement - 6         | Rooms single banked, permanent provision for air movement. |     |      |       |      |      |       |       |       |       |       |       |        |       |  |
| Openings - 9             | Large openings 40-80%                                      |     |      |       |      |      |       |       |       |       |       |       |        |       |  |
| Walls - 12               | Lightwall,Short time-lag                                   |     |      |       |      |      |       |       |       |       |       |       |        |       |  |
| Roofs - 14               | Light,insulation roofs                                     |     |      |       |      |      |       |       |       |       |       |       |        |       |  |

Mahoney table



## Envimet analysis

### Inference:

- orientation of the structure n-s
- spacing between the blocks for air circulation
- large openings inside the spaces for air circulation
- insulated wall and roof design
- provision of elimination space for the special children
- provision of light wells for daylight factor
- learning environment to be provided with sound proofing design
- green cover for the special children's to improve their senses
- design elements to improve comfort levels

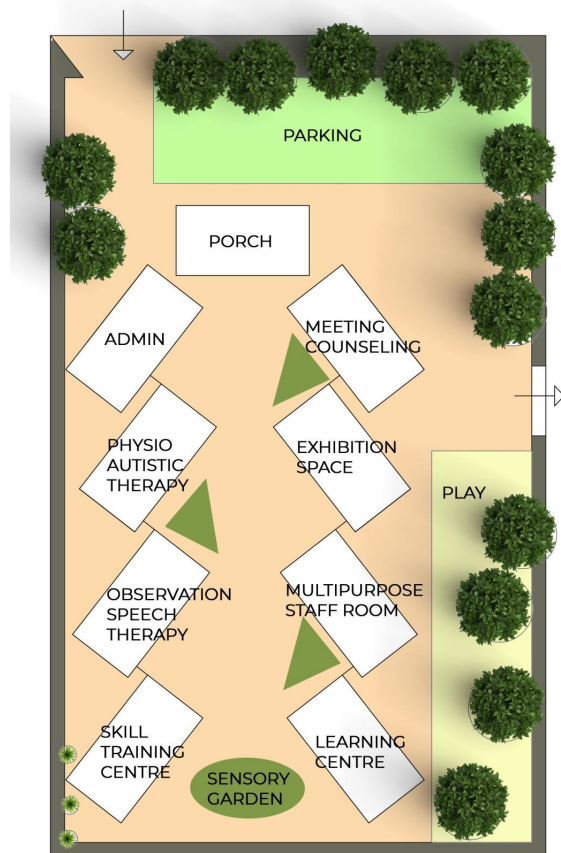


## CHAPTER 5 DESIGN

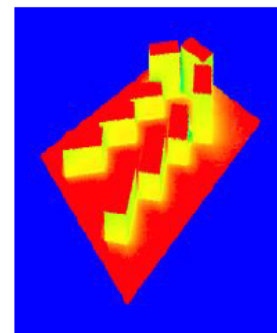
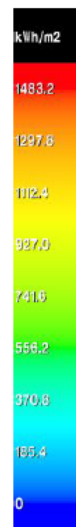
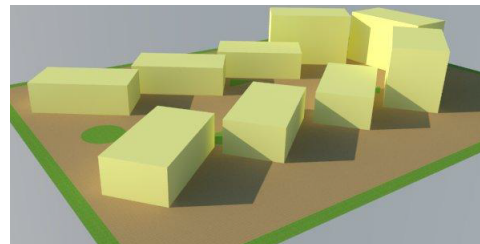
### 5.1 PRELIMINARY SITE ZONING

#### 5.1.1 Site Zoning 1

- The site has a natural green cover which acts as a buffer space to reduce the noise from entering the site so the learning spaces are zoned in that orientation.
- The adjoining learning spaces are provided with a sensory garden which is at easy proximity for the children to access.
- The learning and therapy spaces are zoned with an elimination space.



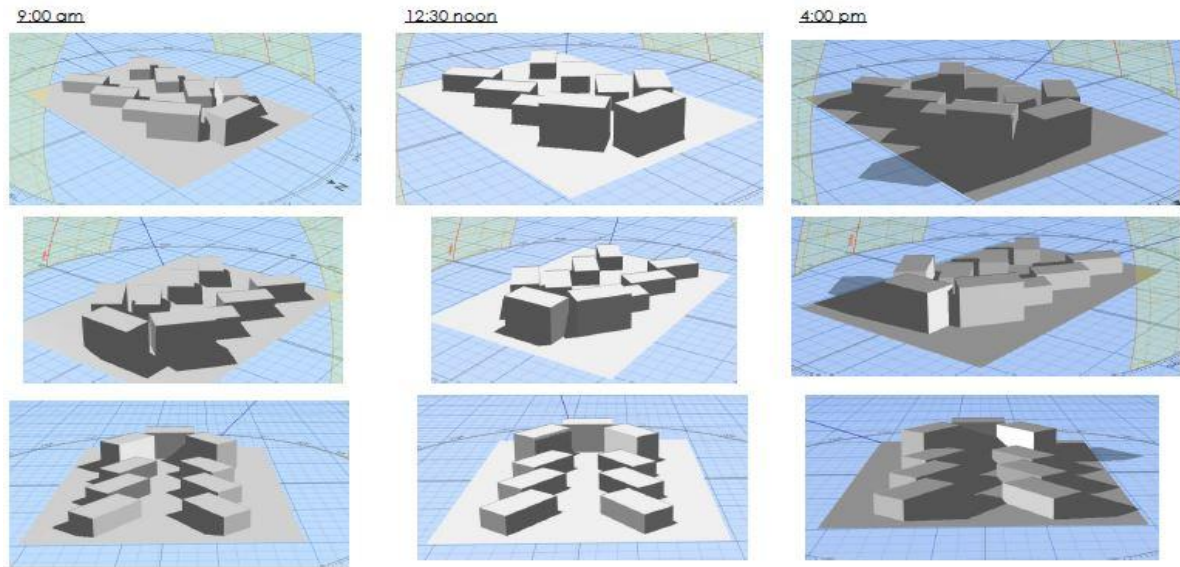
Plan



Avg: 103.4 kWh/m<sup>2</sup>  
Avg/Min: 0.4  
Max: 1,566.1 kWh/m<sup>2</sup>  
Min: 271.1 kWh/m<sup>2</sup>

Total energy mapping

## SHADOW ANALYSIS

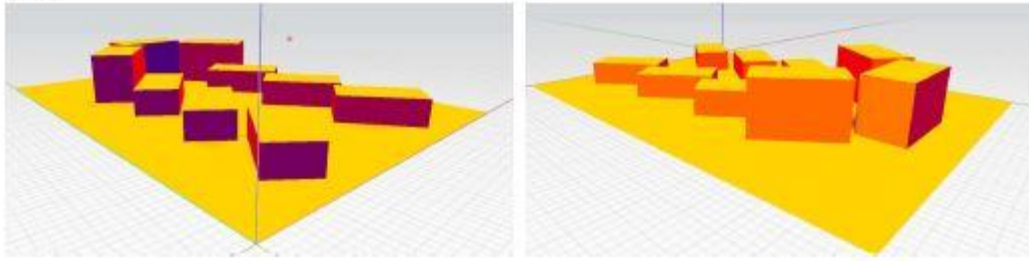


### Inference:

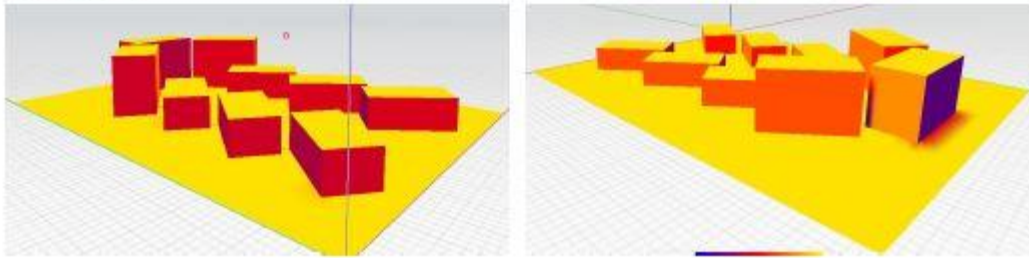
- The block at 9 am the North west and the South east facades are shaded; only the North east facades receive the direct daylight.
- The block at 12 noon almost all the facades are shaded partially so the direct radiation will be in a reduced quantity.
- The block at 4 pm is also partially shaded except the North west facades through which there will be a heat gain.
- The north eastern and the south eastern facades are shaded naturally by the trees present; the NW facades need passive strategies to be implemented.

## RADIATION ANALYSIS

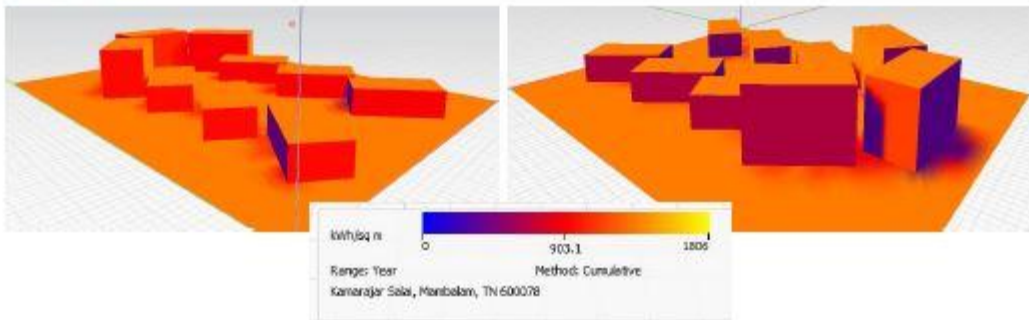
June



September



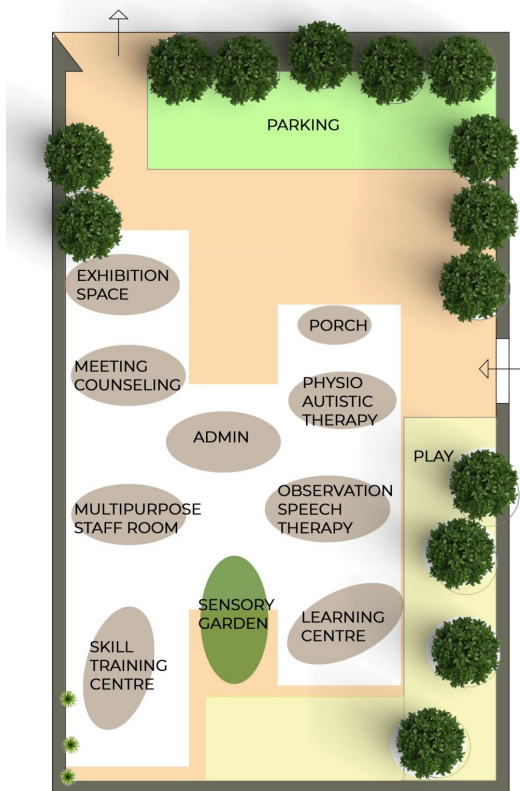
December



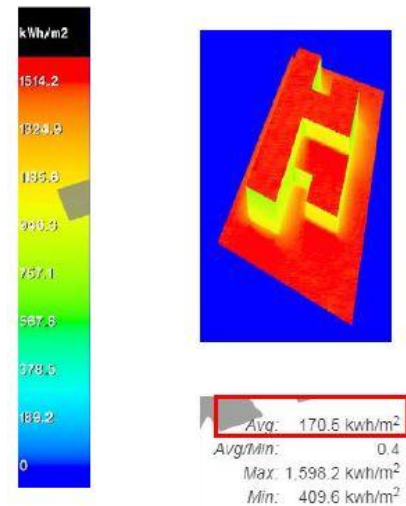
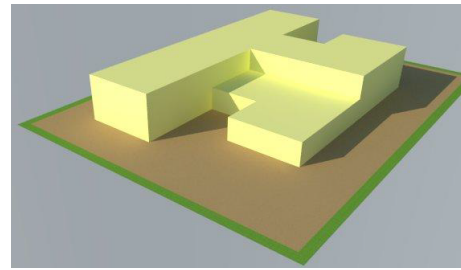
- The critical months of the site are simulated and analyzed to check the facades affected by them.
- The block receives direct radiation on the NE facades.
- The SW facades are shaded by the block orientation and receive less radiation.
- As the exterior walls are zoned with circulation corridors the radiation to the interiors has a larger radiation time lag.

### 5.1.2 Site Zoning 2





plan



Total energy mapping

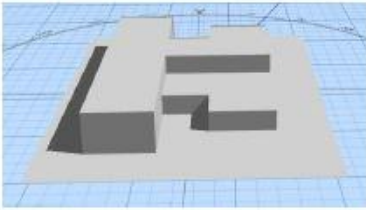
- The site has a natural green cover which acts as a buffer space to reduce the noise from entering the site so the learning spaces are zoned in that orientation.
- The adjoining learning spaces are provided with a sensory garden which is at easy proximity for the children to access.
- The learning spaces and the public and semi public zones like exhibition, multipurpose are zoned Conceptual View separately to provide a calm space.

### Shadow analysis:

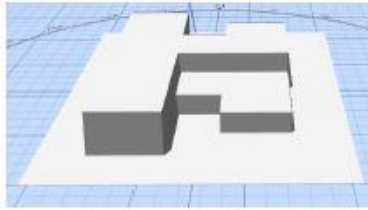
- The block at 9 am the North east and the west facades are shaded only the South east facades receive the direct daylight.
- The block at 12 noon almost all the facades are shaded partially so but the southern facade has heat gain.
- The block at 4 pm is also partially shaded except the North west facades through which there will be a heat gain.
- The South eastern and the NW facades need passive strategies to be implemented.

### **SHADOW ANALYSIS**

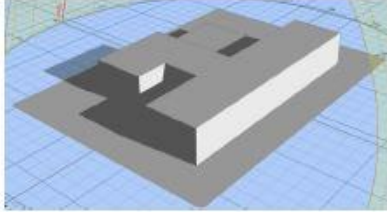
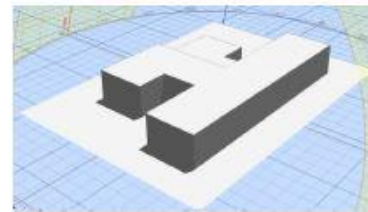
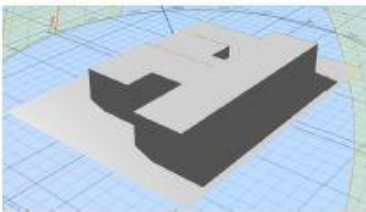
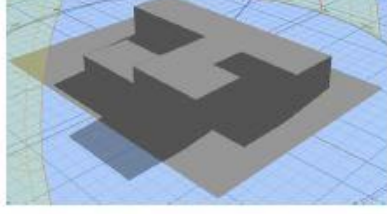
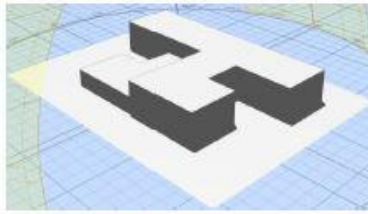
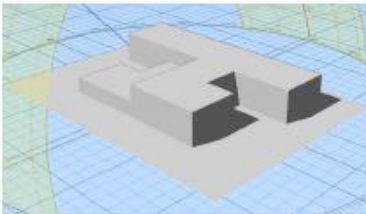
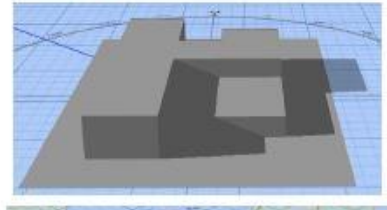
9:00 am



12:30 noon



4:00 pm

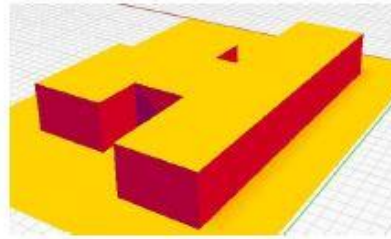
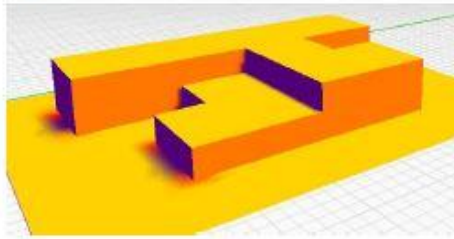


### **Radiation analysis:**

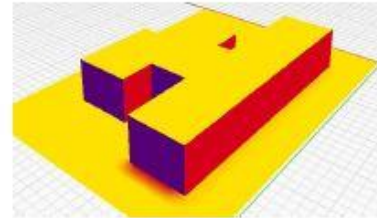
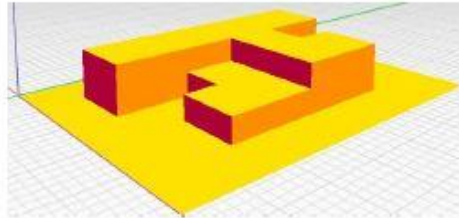
- The critical months of the site is simulated and analyzed to check the facades affected by them.
- The block receives direct radiation on the NE facades in the month of June.
- The SW facades are shaded by the block orientation and receive less radiation.
- Passive strategies must be implemented for the South eastern façade to reduce the direct radiation.

## RADIATION ANALYSIS

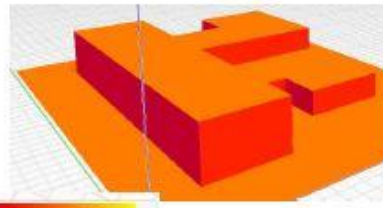
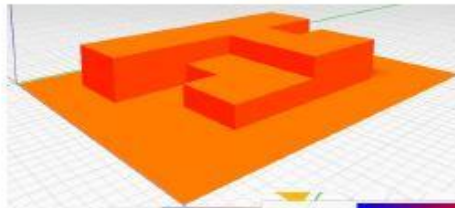
June



September



December

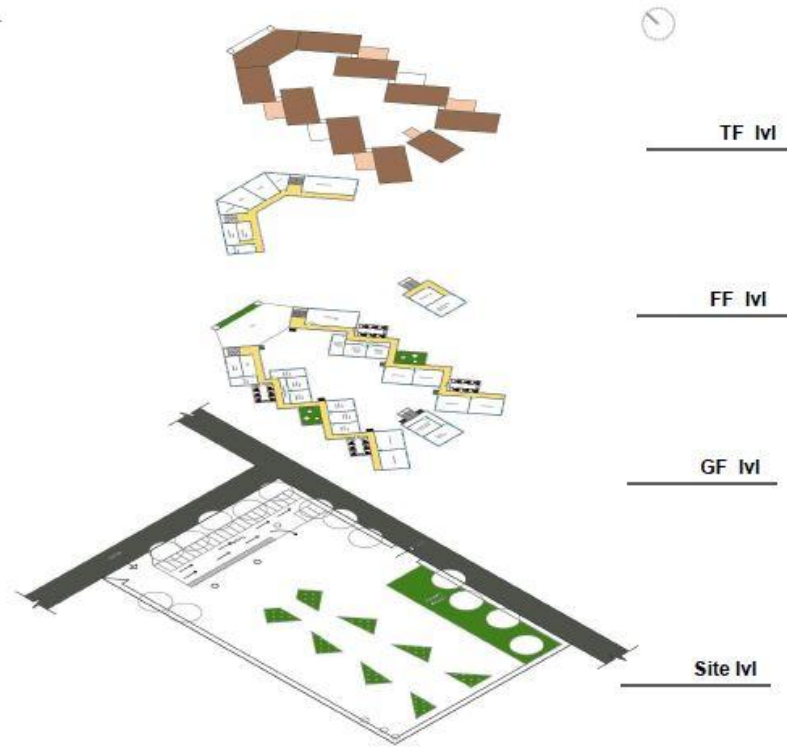
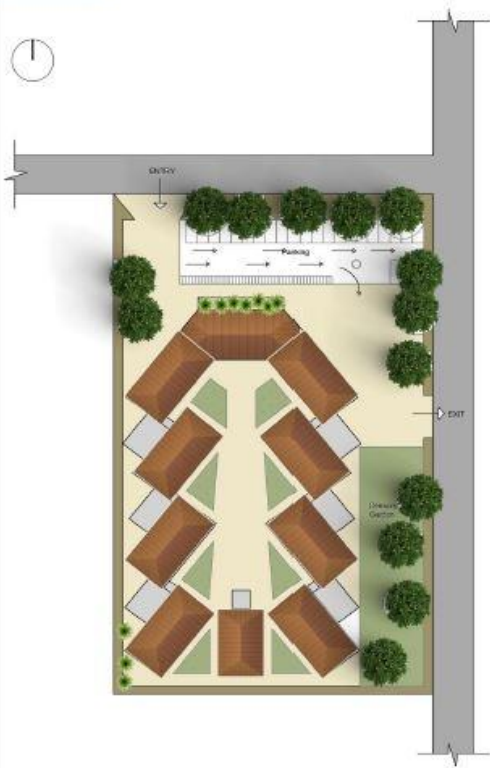


### 5.1.3 COMPARATIVE ANALYSIS:

|                 | <u>SHADOW ANALYSIS</u>                                                                                                                              | <u>RADIATION ANALYSIS</u>                                                                                                                  | <u>SOLAR ENERGY ANALYSIS</u>    | <u>INFERENCE</u>                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <u>ZONING 1</u> | The north eastern and the south eastern facades are shaded naturally by the trees present the NW facades need passive strategies to be implemented. | The block receives direct radiation on the NE facades and the SW facades are shaded by the blocks orientation and receives less radiation. | The Average energy 103.4 kwh/m2 | <ul style="list-style-type: none"> <li>The critical months analysed are from April to December.</li> <li>The zoning done for the site needs passive strategies applied on the SW facade to reduce the radiation.</li> <li>The roof receives radiation of 1036btu through the year so passive strategies must be given to reduce the radiation.</li> <li>The sensory garden zoned on the southern side needs an shading strategy to reduce the direct heat gain.</li> </ul> |
| <u>ZONING 2</u> | The South eastern and the NW facades need passive strategies to be implemented.                                                                     | The block receives direct radiation on the NE facades on the month of June and The SE facades receives high radiation in year cumulating.  | The Average energy 170.5 kwh/m2 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |

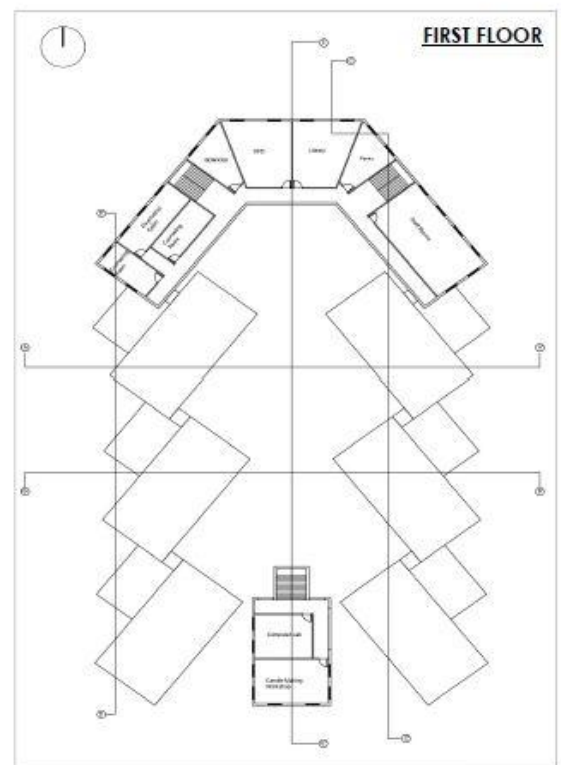
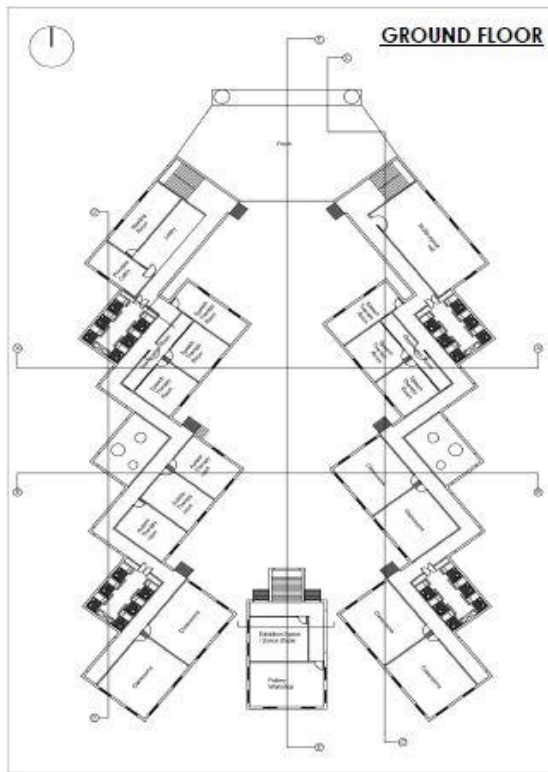
### 5.2 SITE PLANNING:

## SITE PLAN



## FLOOR PLAN

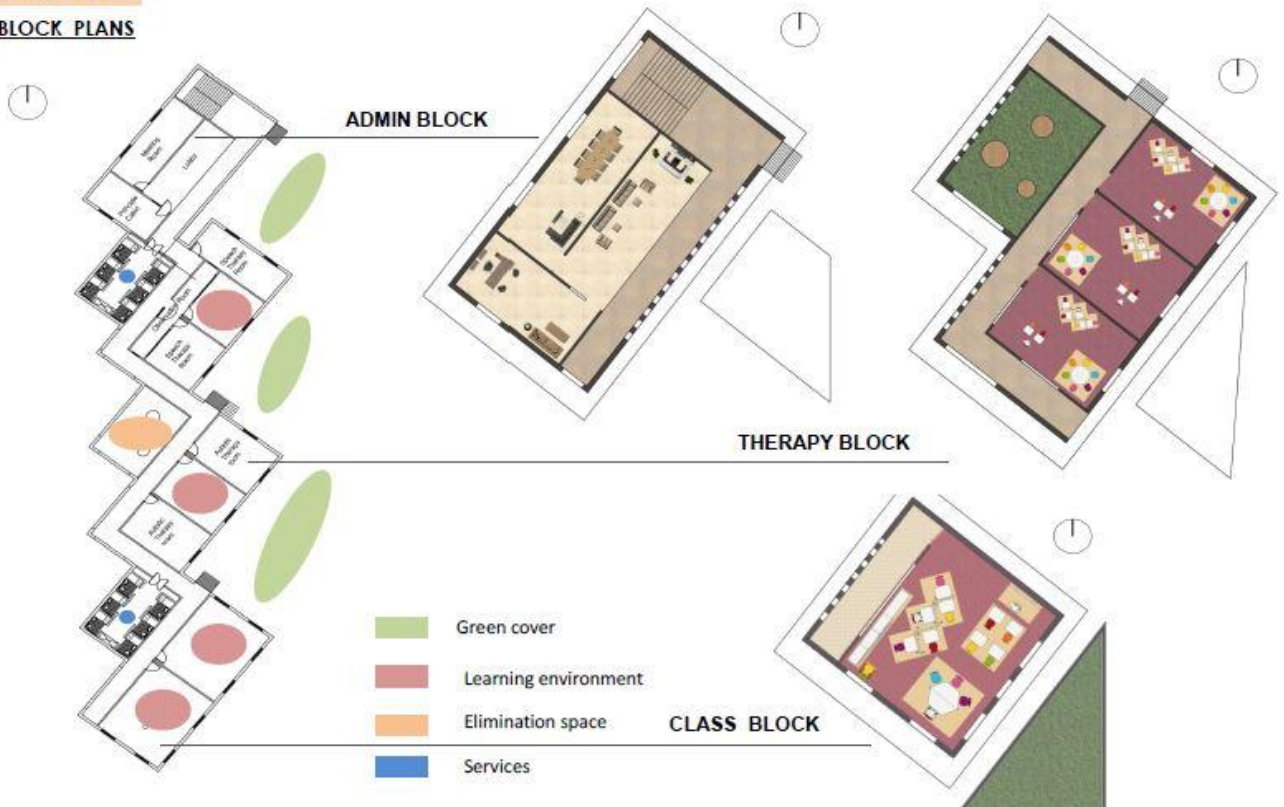
### PLANS





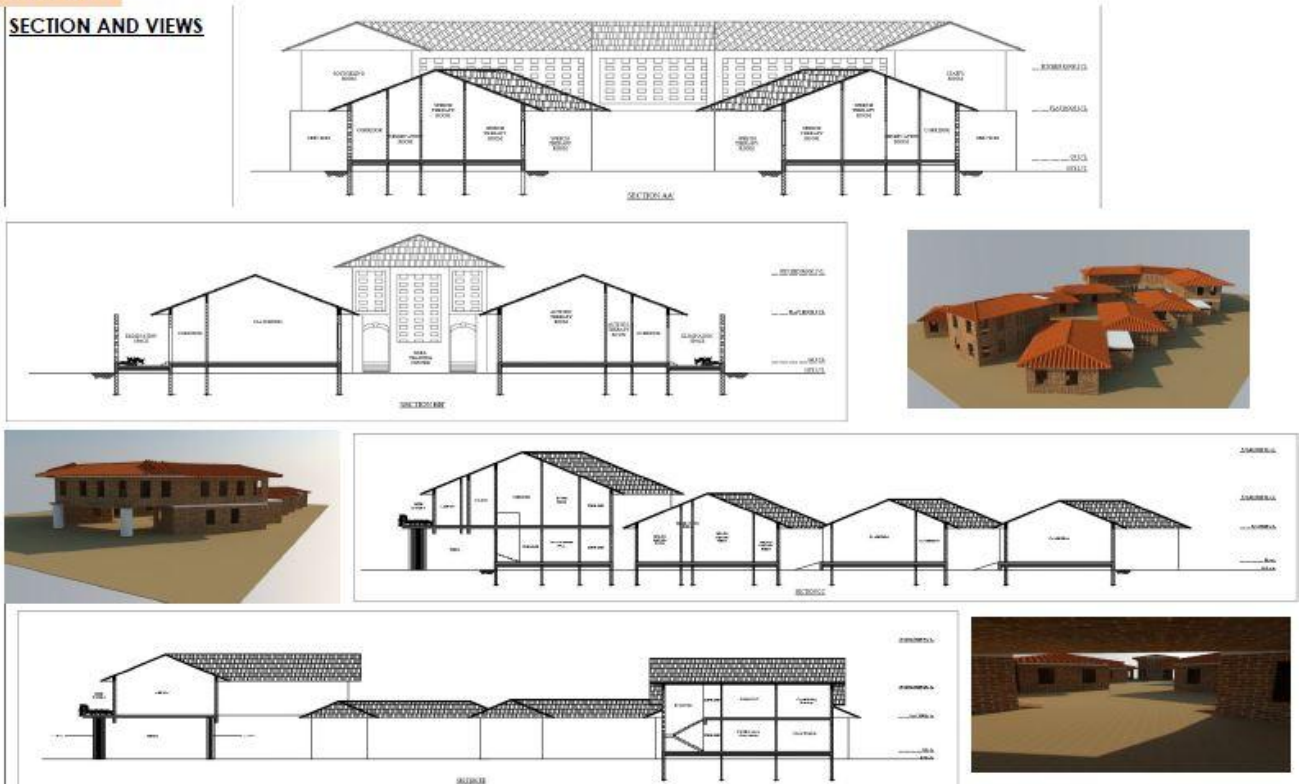
## FLOOR PLAN

### BLOCK PLANS



## SITE PLAN

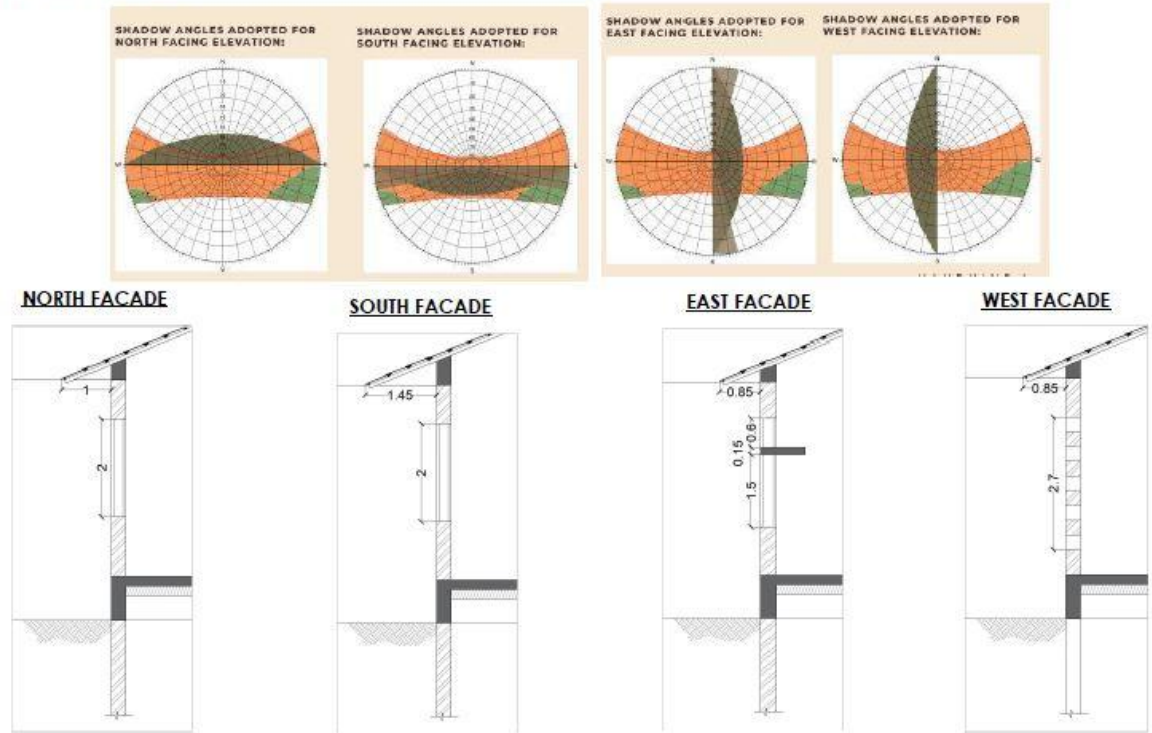
### SECTION AND VIEWS



## 5.2.1 SHADOW ANALYSIS:

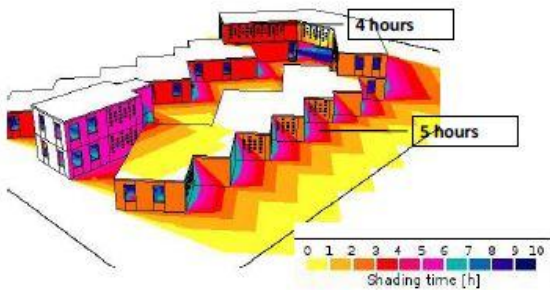
### ANALYSIS

#### SHADING DEVICE ANALYSIS

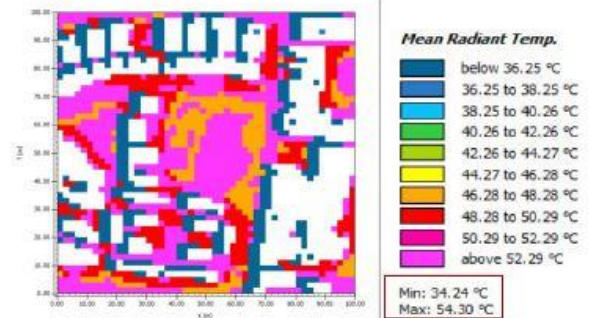


### SHADOW ANALYSIS

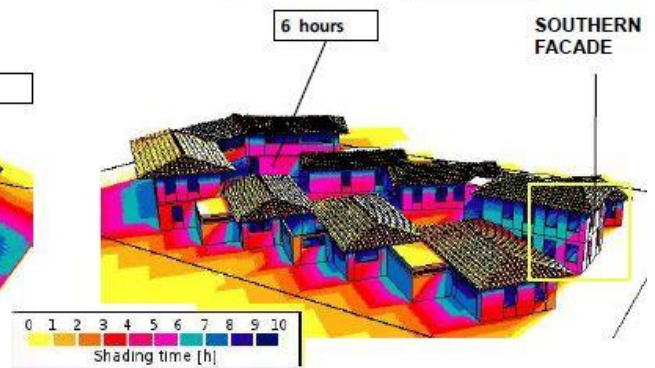
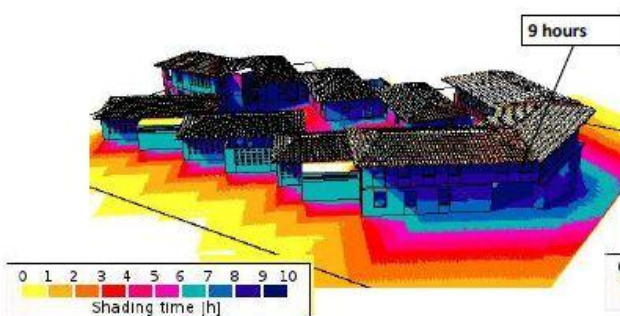
#### BASE CASE ANALYSIS



#### RADIANT TEMPERATURE



#### PROPOSED CASE ANALYSIS





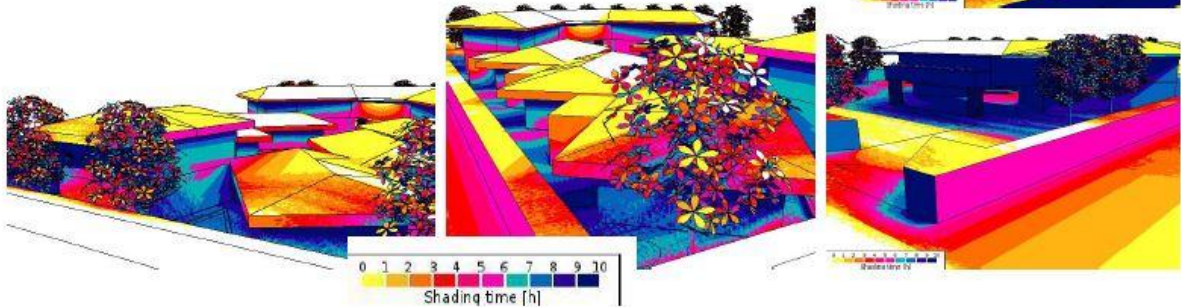
## SHADOW ANALYSIS

### SOUTHERN FACADE



Minimize or eliminate west facing glazing to reduce summer and fall afternoon heat gain

### PROPOSED CASE ANALYSIS



### INFERENCE

- The block receives direct radiation on the NE facade are shaded by the blocks orientation and receives less radiation by self shading by adjoining blocks.
- The southern facade received shading hours less than 1 so the proposal of trees on the southern facade along with the existing shows an improved shading hours as mentioned as a strategy for warm and humid climate.

## 5.2.2 RADIATION ANALYSIS:

### RADIATION ANALYSIS

#### BASE CASE ANALYSIS

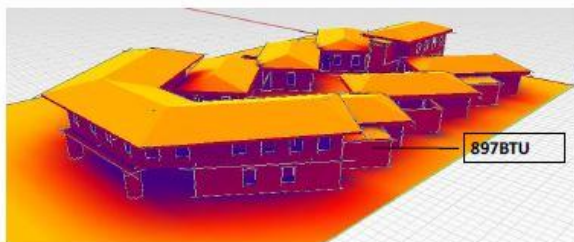


7548BTU

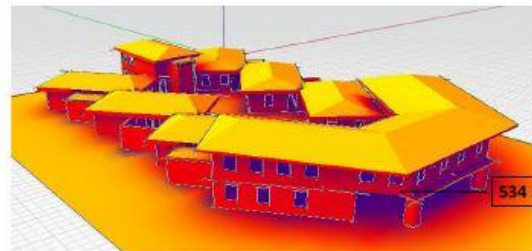


8978BTU

#### PROPOSED CASE ANALYSIS



8978BTU



534 BTU

### INFERENCE

- From the analysis the provision of strategies with 1.45m shading device with jali walls on the western facade perform better.
- The overall study shows that the roof has high thermal radiation throughout the occupancy period so the pitched roof implementation reduces the direct radiation on the roof.

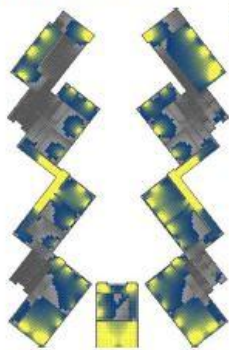


## 5.2.3 DAYLIGHT ANALYSIS:

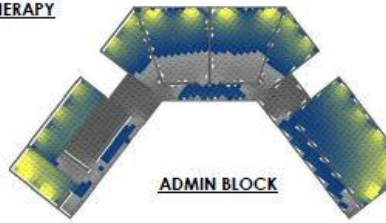


## DAYLIGHT ANALYSIS

### BASE CASE ANALYSIS

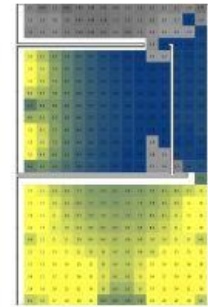


**EARNING/ THERAPY  
BLOCK**



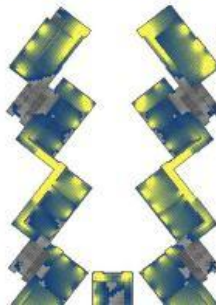
**ADMIN BLOCK**

Avg: 3.8 %  
Avg/Min: ∞  
Max: 33.5 %  
Min: 0.0 %

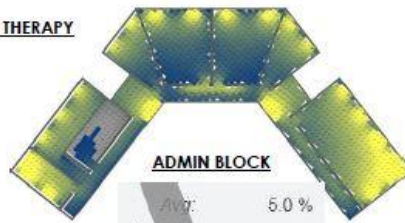


**SKILL TRAINING  
BLOCK**

### PROPOSED CASE ANALYSIS

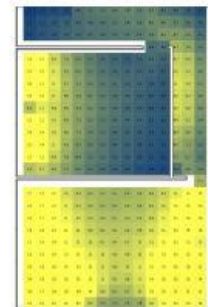


**EARNING/ THERAPY  
BLOCK**



**ADMIN BLOCK**

Avg: 5.0 %  
Avg/Min: ∞  
Max: 33.6 %  
Min: 0.0 %



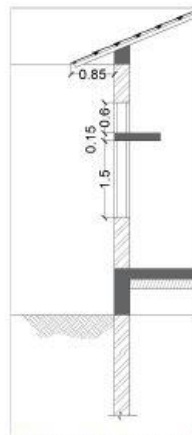
**SKILL TRAINING  
BLOCK**

## DAYLIGHT ANALYSIS

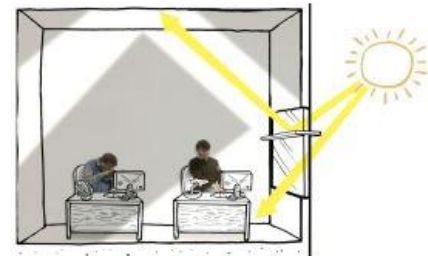
### LIGHT SHELF DESIGN



**VIEWS OF THE LIGHT SHELF  
DESIGN**



**WALL CUT SECTION**



**CONCEPT OF LIGHT  
SHELF**

### INFERENCE

- From the analysis the daylight inside the classroom, therapy, services and admin corridor spaces are inferred to be low and the daylight is not spread uniformly.
- The provision of the light shelves in the critical spaces inferred from the base case analysis has shown improved indoor daylight and uniform spread of lighting.
- The services area still has low levels of daylighting so strategies must be incorporated to improve daylighting.
- The corridor space have enhanced daylighting with reduced glare by the provision of ali walls.

## 5.2.4 VENTILATION ANALYSIS:

## VENTILATION ANALYSIS

SP-41 (SRT)-1987

TABLE 1 DESIRABLE WIND SPEEDS FOR THERMAL COMFORT CONDITIONS

(Clause 4.3.3)

| Dry Bulb Temperature<br>°C | Relative Humidity (Percent) |      |      |      |      |      |      |
|----------------------------|-----------------------------|------|------|------|------|------|------|
|                            | 30                          | 40   | 50   | 60   | 70   | 80   | 90   |
|                            | Wind Speed, m/s             |      |      |      |      |      |      |
| 28                         | *                           | *    | *    | *    | *    | 0.06 | *    |
| 29                         | *                           | *    | *    | *    | *    | 0.06 | *    |
| 30                         | *                           | *    | *    | 0.04 | 0.24 | 0.53 | 0.85 |
| 31                         | *                           | 0.06 | 0.24 | 0.53 | 1.04 | 1.47 | 2.10 |
| 32                         | 0.30                        | 0.44 | 0.64 | 1.54 | 2.26 | 3.04 | +    |
| 33                         | 0.71                        | 1.46 | 2.12 | 4    | +    | +    | +    |
| 34                         | 1.85                        | 2.72 | 4    | +    | +    | +    | +    |
| 35                         | 3.2                         | +    | +    | +    | +    | +    | +    |

\*None  
+Higher than those acceptable in practice.

TABLE 2 MINIMUM WIND SPEEDS FOR JUST ACCEPTABLE WARM CONDITIONS

(Clause 4.3.3)

| Dry Bulb Temperature<br>°C | Relative Humidity (Percent) |      |      |      |      |      |      |
|----------------------------|-----------------------------|------|------|------|------|------|------|
|                            | 30                          | 40   | 50   | 60   | 70   | 80   | 90   |
|                            | Wind Speed, m/s             |      |      |      |      |      |      |
| 28                         | *                           | *    | *    | *    | *    | *    | *    |
| 29                         | *                           | *    | *    | *    | *    | *    | *    |
| 30                         | *                           | *    | *    | *    | *    | 0.06 | *    |
| 31                         | *                           | *    | *    | *    | *    | 0.06 | 0.23 |
| 32                         | *                           | *    | *    | 6.09 | 0.19 | 0.66 | 0.94 |
| 33                         | *                           | 0.04 | 0.24 | 6.60 | 1.94 | 1.81 | 2.10 |
| 34                         | 0.15                        | 0.46 | 0.94 | 1.80 | 2.16 | 3.03 | +    |
| 35                         | 0.68                        | 1.36 | 2.19 | 3.05 | +    | +    | +    |
| 36                         | 1.12                        | 2.70 | +    | +    | +    | +    | +    |

| Months    | Months Avg Temp | Monthly Avg Humidity | Wind direction | Wind speed | Wind speed for thermal comfort | Indoor wind speed Achieved 30% | Indoor wind speed Achieved 40% |
|-----------|-----------------|----------------------|----------------|------------|--------------------------------|--------------------------------|--------------------------------|
| January   | 24.3            | 74%                  | East           | 9.3 m/s    | *                              | 2.79                           | 3.72 m/s                       |
| February  | 25.3            | 73%                  | East           | 8.6 m/s    | *                              | 2.54 m/s                       | 3.44 m/s                       |
| March     | 27.4            | 72%                  | South          | 9.4 m/s    | *                              | 2.8 m/s                        | 3.76 m/s                       |
| April     | 29.6            | 73%                  | South          | 10.9 m/s   | *                              | 3.12 m/s                       | 4.3 m/s                        |
| May       | 31.3            | 66%                  | South          | 11.6 m/s   | 0.53                           | 3.4 m/s                        | 4.6 m/s                        |
| June      | 30.8            | 62%                  | South          | 11.8 m/s   | 0.06                           | 3.54 m/s                       | 4.7 m/s                        |
| July      | 30              | 63%                  | West           | 11.3 m/s   | 0.06                           | 3.3 m/s                        | 4.5 m/s                        |
| August    | 29.2            | 68%                  | West           | 10.5 m/s   | *                              | 3.1 m/s                        | 4.2 m/s                        |
| September | 28.7            | 73%                  | South          | 8.8 m/s    | *                              | 2.6 m/s                        | 3.5 m/s                        |
| October   | 27.3            | 80%                  | South west     | 8.5 m/s    | *                              | 2.5 m/s                        | 3.4 m/s                        |
| November  | 25.7            | 80%                  | East           | 10.9 m/s   | *                              | 3.27 m/s                       | 4.36 m/s                       |
| December  | 24.6            | 77%                  | East           | 11.2 m/s   | *                              | 3.36 m/s                       | 4.48 m/s                       |

## VENTILATION ANALYSIS

### VENTILATION CALCULATION

| SPACES                  | FLOOR AREA | Opening - 1 | Opening - 2 | Opening - 3 | Opening - 4 | TOTAL | OPENING % OF FLOOR AREA |
|-------------------------|------------|-------------|-------------|-------------|-------------|-------|-------------------------|
| <b>LEFT WING</b>        |            |             |             |             |             |       |                         |
| Meeting room            | 42 sq.m    | 6           | 6           |             |             | 12    | 28                      |
| Principal cabin         | 30 sq.m    | 4           | 4           |             |             | 8     | 26                      |
| Speech Therapy room 1   | 38 sq.m    | 4           | 4           |             |             | 8     | 21                      |
| Speech Therapy room 2   | 38sq.m     | 8           |             |             |             | 6     | 21                      |
| Speech Therapy room 3   | 34 sq.m    | 8           |             |             |             | 8     | 23                      |
| Autistic Therapy room 1 | 43 sq.m    | 6           | 4           |             |             | 10    | 23                      |
| Autistic Therapy room 2 | 44 sq.m    | 6           | 4           |             |             | 10    | 22                      |
| Autistic Therapy room 3 | 42 sq.m    | 6           | 4           |             |             | 10    | 24                      |
| Class room 1            | 73 sq.m    | 4           | 4           | 4           | 4           | 16    | 21                      |
| Class room 2            | 73 sq.m    | 4           | 4           | 4           | 4           | 16    | 21                      |
| <b>RIGHT WING</b>       |            |             |             |             |             |       |                         |
| Multipurpose hall       | 116 sq.m   | 6           | 6           | 6           | 6           | 24    | 21                      |
| Speech Therapy room 1   | 38 sq.m    | 6           | 4           |             |             | 10    | 26                      |
| Speech Therapy room 2   | 38 sq.m    | 6           | 4           |             |             | 10    | 26                      |
| Speech Therapy room 3   | 36 sq.m    | 4           | 4           |             |             | 8     | 22                      |
| Class room 1            | 65 sq.m    | 4           | 4           | 4           | 4           | 16    | 25                      |
| Class room 2            | 65sq.m     | 4           | 4           | 4           | 4           | 16    | 25                      |
| Class room 3            | 74 sq.m    | 6           | 6           |             |             | 12    | 16                      |
| Class room 4            | 74 sq.m    | 4           | 4           | 4           | 4           | 16    | 22                      |
| <b>FIRST FLOOR</b>      |            |             |             |             |             |       |                         |
| OPD                     | 71 sq.m    | 6           | 6           | 4           |             | 16    | 23                      |
| Library                 | 71 sq.m    | 6           | 6           | 4           |             | 16    | 23                      |
| Psychiatrist cabin      | 40.7 sq.m  | 4           | 4           | 2           |             | 12    | 25                      |
| Counselling room 1      | 34 sq.m    | 2           | 2           | 4           |             | 8     | 24                      |
| Counselling room 2      | 30 sq.m    | 2           | 2           | 4           |             | 8     |                         |
| Staff Room              | 116 sq.m   | 6           | 6           | 6           | 6           | 21    | 21                      |
| Pantry                  | 33.7 sq.m  | 4           | 4           |             |             | 8     | 24                      |
| Computer lab            | 48.6 sq.m  | 6           | 6           |             |             | 12    |                         |
| Candle making workshop  | 62.7 sq.m  | 6           | 6           | 4           |             | 16    | 25                      |

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

### INFERENCE

- From the calculations done referring to SP-41 for the ventilation shows that the calculation for the spaces with the % of openings provided satisfies the criteria.
- The criteria mentioned in the codes is the % of the opening provided for the total floor area must be ranging between 20 - 30 % to achieve 30% of wind velocity.

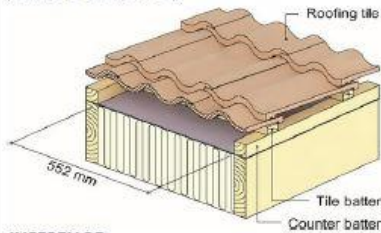
## 5.2.5 MATERIAL ANALYSIS:

## MATERIAL ANALYSIS

### U value of the wall

| U-Value of Wall                                                             |                         |  |
|-----------------------------------------------------------------------------|-------------------------|--|
| Thermal Conductivity of brick work $K_b$                                    | 1.6 W/mK                |  |
| Thermal Conductivity of mineral wool $K_m$                                  | 0.035 W/mK              |  |
| Thermal Conductivity of timber $K_t$                                        | 0.14 W/mK               |  |
| Thermal Conductivity of plasterboard $K_p$                                  | 0.182 W/mK              |  |
| Interior heat transfer coefficient $h_i$                                    | 8.3 W/m <sup>2</sup> K  |  |
| Exterior heat transfer coefficient $h_o$                                    | 22.7 W/m <sup>2</sup> K |  |
| <b>Calculations</b>                                                         |                         |  |
| $U = 1/R$                                                                   |                         |  |
| $R = 1/h_i + 1/h_o + t_1/k_1 + t_2/k_2 + t_3/k_3 + t_4/k_4$                 |                         |  |
| $R = 1/8.3 + 1/22.7 + 0.01/1.6 + 0.2/0.035 + 0.01/0.14 + 0.2/0.182 = 7.053$ |                         |  |
| $U = 1/7.053 = 0.141 \text{ W/m}^2\text{K}$                                 |                         |  |

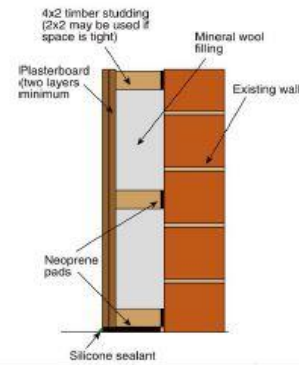
### U value of the roof



Cut section of the roof

### INFERENCE

- The U-Value of the wall is calculated along with the soundproof design for the interiors which is 0.141W/m<sup>2</sup>k that is low so the insulation performance is better.
- The U-Value of the roof is calculated for the design which is 0.122W/m<sup>2</sup>k that is low so the insulation performance is better.
- The decoupling is done for soundproofing to cut the sound wavelength from travelling to the interiors and it has an sound absorption – 0.05.



Cut section of the wall

| U-Value of Roof                                      |                         |  |
|------------------------------------------------------|-------------------------|--|
| Thermal Conductivity of terracotta tile $K_t$        | 0.31 W/m.K              |  |
| Thermal Conductivity of extruded polystyrene $K_e$   | 0.025 W/mK              |  |
| Interior heat transfer coefficient $h_i$             | 8.3 W/m <sup>2</sup> K  |  |
| Exterior heat transfer coefficient $h_o$             | 22.7 W/m <sup>2</sup> K |  |
| <b>Calculations</b>                                  |                         |  |
| $U = 1/R$                                            |                         |  |
| $R = 1/h_i + 1/h_o + t_1/k_1 + t_2/k_2$              |                         |  |
| $R = 1/8.3 + 1/22.7 + 0.01/0.31 + 0.2/0.025 = 8.196$ |                         |  |
| $U = 1/7.053 = 0.122 \text{ W/m}^2\text{K}$          |                         |  |

## 5.2.6 RAINWATER HARVESTING ANALYSIS:

### RAIN WATER HARVESTING ANALYSIS



KEY PLAN



| ONEDAY RAINFALL CALCULATION |      |                  |                |                       |                  |
|-----------------------------|------|------------------|----------------|-----------------------|------------------|
| LOCATION                    |      |                  | Chennai        |                       |                  |
| LOCATION                    | YEAR | PEAK RAINY MONTH | TOTAL RAINFALL | Average peak rainfall | One day rainfall |
| Chennai                     | 2016 | September        | 275.30         | 380.96                | 53.33            |
|                             | 2017 | November         | 583.80         |                       |                  |
|                             | 2018 | August           | 197.70         |                       |                  |
|                             | 2019 | October          | 277.60         |                       |                  |
|                             | 2020 | November         | 570.40         |                       |                  |
| One - day Rainfall/day (mm) |      |                  |                |                       | 53.33            |
| One - day Rainfall/day (m)  |      |                  |                |                       | 0.053            |

| RAINWATER HARVESTING BOREWELL CALCULATION |         |                |                                                                      |
|-------------------------------------------|---------|----------------|----------------------------------------------------------------------|
| Parameters                                | Value   | Unit           | Comments                                                             |
| Injection Recharge rate                   | 10      | lps            | Value from CGWB Chennai                                              |
| Number of Days                            | 1       | day            |                                                                      |
| Quantity of Recharge                      | 864     | m <sup>3</sup> | lps to m <sup>3</sup> conversion as per CGWB calculation methodology |
| Number of Borewell                        | 6.00    |                |                                                                      |
| Total Quantity Recharge                   | 5184.00 | m <sup>3</sup> |                                                                      |



### TOTAL HARVESTING CAPACITY

| POST CONSTRUCTION RUN OFF                      |                |                      |                          |                        |                            |
|------------------------------------------------|----------------|----------------------|--------------------------|------------------------|----------------------------|
| Sl. NO                                         | SURFACE TYPE   | RUN OFF CO-EFFICIENT | AVERAGE RAINFALL (m/day) | AREA (m <sup>2</sup> ) | VOLUME OF CAPTURED RUN OFF |
| 1                                              | Roof Area      | 0.9                  | 0.053                    | 2342.00                | 112.42                     |
| 2                                              | Non roof Area  | 0.95                 | 0.053                    | 5940.00                | 300.97                     |
| 3                                              | Landscape Area | 0.1                  | 0.053                    | 1157.00                | 6.17                       |
| Total roof & non roof run off volume (Cum/day) |                |                      |                          |                        | 419.56                     |
| Total Harvesting Capacity (cum/day)            |                |                      |                          |                        | 5184.00                    |
| Total Storage Capacity (cum/day)               |                |                      |                          |                        | 22.50                      |
| % of Rain Water Capacity                       |                |                      |                          |                        | 1240.96%                   |

### INFERENCE

- The slope of the site is towards the SE direction so the bore well pits are zoned there for proper catchment of rainwater.
- The total harvesting capacity calculated for the design is 5184 cum per day.



## 5.2.7 COMPARATIVE ANALYSIS:

### COMPARATIVE ANALYSIS

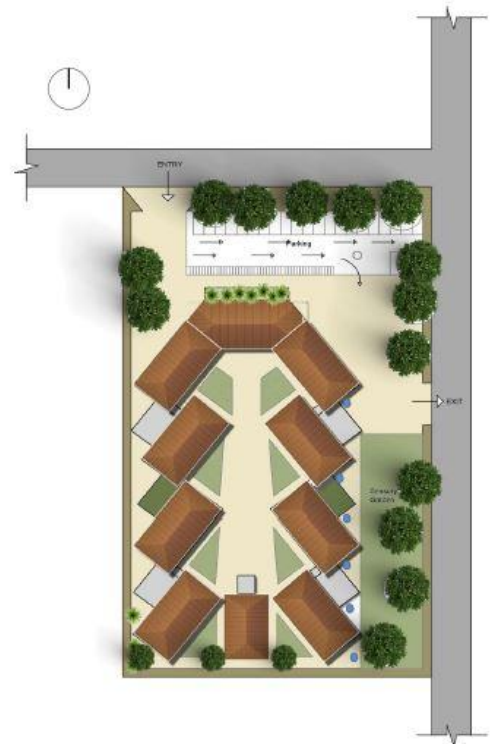
|                      | <u>SHADOW ANALYSIS</u>                                                                                                                                                                                                           | <u>RADIATION ANALYSIS</u>                                                                                                                                 | <u>DAYLIGHTING ANALYSIS</u>                                                                                                                                                                                                                      | <u>VENTILATION ANALYSIS</u>                                                                                                                               |
|----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| <u>BASE CASE</u>     | The north eastern and the south eastern facades are shaded naturally by the trees present the NW and southern facades need passive strategies to be implemented.                                                                 | The overall study shows that the roof has high thermal radiation throughout the occupancy period.<br><br>The NW and southern facade had direct radiation. | The analysis the daylight inside the classroom, therapy, services and admin corridor spaces are inferred to be low and the daylight is not spread uniformly.                                                                                     | The wind analysis for the site flows from the SW with the predominant wind direction and NE with seasonal wind direction.                                 |
| <u>PROPOSED CASE</u> | the NE facade are shaded by the blocks orientation and receives less radiation by self shading by adjoining blocks.<br><br>The proposal of trees on the southern facade along with the existing shows an improved shading hours. | The pitched roof with extended canopy design, the trees proposed reduces the direct radiation on the roof as well as cuts off direct radiation.           | The provision of the light shelves in the critical spaces has shown improved indoor daylight and uniform spread of lighting but The services area still has low levels of daylighting so strategies must be incorporated to improve daylighting. | The jali pattern and the % of opening calculations has a better wind velocity ranging from 2.2 to 3.0 m/s throughout the space on an average for an year. |

## 5.3 CONCLUSION:

### CONCLUSION

#### PARAMETERS CONSIDERED - DESIGN

- ORIENTATION OF THE STRUCTURE N-S
- ADJOINING SPACING BETWEEN THE BLOCKS FOR AIR CIRCULATION
- PROVISION OF WINDOWS AND JALI WALLS FOR AIR CIRCULATION
- BRICK WALL WITH PLASTERING AND PITCHED ROOF DESIGN
- PROVISION OF COMMON ELIMINATION SPACE
- PROVISION OF COURTYARD AND LIGHT SHELVES WHICH PROVIDES BETTER DAYLIGHTING
- CLASSROOMS DESIGNED WITH DECOUPLING DESIGN
- SENSORY GARDEN PROVISION FOR THE SPECIAL CHILDREN'S
- THE BLOCKS ARE ARRANGED IN AN 52 degrees TO ELIMINATE DIRECT RADIATION AND TO PROVIDE SELF SHADING FACTOR.
- THE SOUTHERN FACADE WHEN PROPOSED WITH THE TREES SHOWS IMPROVED SADING HOURS IN FROM SUMMER SUN.
- DESIGN OF PITCHED ROOF WITH APPROPRIATE SHADIND PROJECTION TO PROVIDE BETTER SHADIND ON THE NE AND NW FACADES.
- ITERATION OF DIFFERENT WALL COMBINATIONS TO CHECK EFFICIENCY.



## REFERENCE

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