

ENERGY RESOURCE AND RESEARCH INSTITUTE

THESIS

Submitted in partial fulfilment of the requirements for the award of Bachelor
of Architecture degree

By

SHANTHINI. M 3621069



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

SATHYABAMA

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

**Accredited with Grade "A" by NAAC
JEPPIAAR NAGAR, RAJIV GANDHI SALAI,
CHENNAI - 600 119**

JUNE 2021



**DEPARTMENT OF ARCHITECTURE BONAFIDE
CERTIFICATE**

This is to certify that this Project Report is the bonafide work of **Shanthini. M (3621069)** who carried out the project entitled “**Energy resource and research institute**” under our supervision from January 2021 to June 2021.

Internal Guide

(Ar. Seetha)

Internal Review Member

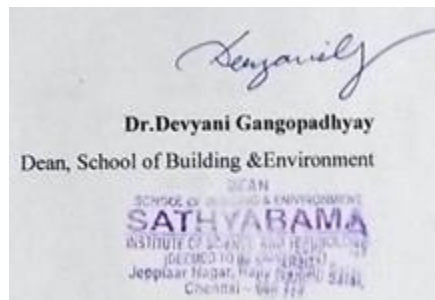
(Ar. Ebin Horrison)

External Guide

(Ar. Diwakar Kowshik)

Dean and Head of the Department

Dr. DEVYANI GANGOPADHYAY



Submitted for Viva voce Examination held on _____

Internal Examiner

External Examiner

DECLARATION

I, **Shanthini. M** hereby declare that the Project Report entitled “**Energy resources and research institute**” done by me under the guidance of **Ar. Seetha** (Internal Guide), **Ar. Ebin Horrison** (Internal Review Member) and **Ar. Diwakar Kowshik** (External Guide). Sathyabama Institute of Science and Technology is submitted in partial fulfilment of the requirements for the award of Bachelor of Architecture Degree.

DATE:

PLACE: Chennai
ACKNOWLEDGEMENT

SIGNATURE OF THE CANDIDATE

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

I convey my thanks to **Dr. Devyani Gangopadhyay**, Dean and Head of the Department, **Dr. Suresh Kuppuswamy**, Design Chair of School of Building and Environment, Department of Architecture and providing me necessary support and details at the right time during the progressive reviews.

I would like to express my sincere and deep sense of gratitude to my Project Internal

Guide **Ar. Seetha**, Internal Review member **Ar. Ebin Horrison** and External Guide **Ar. Diwakar Kowshik** their 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 the project.

ABSTRACT

The Energy Resource and Research Institute is a project which focuses on sustainability and ways to reduce carbon emissions through architecture and other such initiatives. TERI, an independent, multi-dimensional organization whose works focuses on promoting efficient use of resources, to increase access and uptake of sustainable inputs and practices, to reduce the impact on environment and climate. With TERI as a major example, the proposed project has multi-functional spaces which include: an energy resource office, a college space, where students can learn more in-depth about the energy efficient ways and innovative technologies that are practices and also involve in research works, so a research centre is provided along with accommodation. The project will be following passive and active design strategies which promotes effective climate responsive design and a sustainable environment.

CONTENTS

	PAGE NUMBER
<i>Abstract</i>	<i>(i)</i>
<i>Contents</i>	<i>(ii)-(iv)</i>
<i>List of figures</i>	<i>(v)-(vii)</i>
<i>List of plates</i>	<i>(viii)</i>
CHAPTER – 1: INTRODUCTION	1
1.1 About the project	1
1.2 Aim	1
1.3 Objectives	1
1.4 Scope of the project	1
1.5 Limitations of the project	2
1.6 Hypothesis	2
CHAPTER – 2: BACKGROUND STUDY	3
2.1 Carbon footprint	3
2.2 Carbon emissions in Architecture	3
2.3 Ways to reduce emissions	5
2.4 Building industry and Rating systems in India	5
2.4.1 Indian Green Building Council (IGBC)	6
2.4.2 Green Rating for Integrated Habitat Assessment (GRIHA)	6

2.4.3 Bureau of Energy Efficiency (BEE)	6
2.5 GRIHA	6
2.6 TERI	7
CHAPTER – 3: CASE STUDIES	9
3.1 TERI – Retreat, Gurgaon	9
3.1.1 About the project	9
3.1.2 Design Description	9
3.1.3 Materials	10
3.1.4 Design features	11
3.2 TERI – Southern regional centre, Bangalore	18
3.2.1 About the project	18
3.2.2 Design Description	18
3.2.3 Materials	19
3.2.4 Design features	20
3.3 CII Sohrabji godrej green business centre, Hyderabad	23
3.3.1 About the project	24
3.3.2 Design Description	24
3.3.3 Materials	25
3.3.4 Design features	25
3.4 Suzlon One Earth, Pune.	28
3.4.1 About the project	28
3.4.2 Design Description	28

3.4.3 Materials	29
3.4.4 Design features	29
CHAPTER – 4: DESIGN SHEETS	33
4.1 Site Analysis	33
4.2 Requirements	34
4.3 Site Plan	35
4.4 Master plan	36
4.5 College Block	37
4.6 Energy Office and Research Centre	38
4.7 Admin and Gallery	39
4.8 Library and Café	40
4.9 Accommodation	41

LIST OF FIGURES

PAGE NUMBER

CHAPTER – 2: BACKGROUND STUDY **3**

FIG 2.1 Carbon emission cycle of a building 5

FIG 2.2 Evolution of GRIHA 7

CHAPTER – 3: CASE STUDIES **9**

3.1 TERI – Retreat, Gurgaon 9

FIG 3.1.1 Floor plan 10

FIG 3.1.2 Section 10

FIG 3.1.3 Elevation 10

FIG 3.1.4 Solar panels 11

FIG 3.1.5 Earth air tunnel 11

FIG 3.1.6 Ammonia Absorption Chillers 12

FIG 3.1.7 Biomass Gasifier 12

FIG 3.1.8 Biomass Gasifier 12

FIG 3.1.9 Water management System 13

FIG 3.1.10 Membrane Bioreactor 13

FIG 3.1.11 Forestry Research Centre 14

FIG 3.1.12 Renewable Energy Technologies 14

FIG 3.1.13 Micropropagation Technology Park 15

FIG 3.1.14 Deakin and Nano-Biotechnology Centre 15

FIG 3.1.15 Mahindra- TERI COE 16

FIG 3.1.16 Fermentation technology research centre 16

	FIG 3.1.17 TEAM	17
	FIG 3.1.18 ETP	17
3.2	TERI – Southern regional centre, Bangalore	19
	FIG 3.2.1 Floor Plans	19
	FIG 3.2.2 View 1	19
	FIG 3.2.3 View 2	19
	FIG 3.2.4 Solar Panels	21
	FIG 3.2.5 Solar Panels	21
	FIG 3.2.6 Water	21
	FIG 3.2.7 Earth	22
	FIG 3.2.8 Skylight	22
	FIG 3.2.9 Skylight	22
	FIG 3.2.10 Air	23
3.3	CII Sohrabji godrej green business centre, Hyderabad	23
	FIG 3.3.1 Roof Plan	24
	FIG 3.3.2 Aerial View	24
	FIG 3.3.3 View 1	25
	FIG 3.3.4 View 2	25
	FIG 3.3.5 Roof Garden	25
	FIG 3.3.6 Roof Garden Section	25
3.3.7	Jali Walls	26
	FIG 3.3.8 Solar photovoltaic panels	26
	FIG 3.3.9 Solar photovoltaic panels	26

	FIG 3.3.10 Water System	27
	FIG 3.3.11 Wind tower	27
3.4	Suzlon One Earth, Pune.	28
	FIG 3.4.1 Roof plan	29
	FIG 3.4.2 Interior View	29
	FIG 3.4.3 Floor plan	29
	FIG 3.4.4 External View	29
	FIG 3.4.5 Sewage Treatment Plant	32
	FIG 3.4.6 Sewage Treatment Plant	32

LIST OF PLATES

	PAGE NUMBER
CHAPTER – 4: ARCHITECTURAL DRAWINGS	33
4.1 Site Analysis	33

4.2	Requirements	34
4.3	Site Plan	35
4.4	Master plan	36
4.5	College Block	37
4.6	Energy Office and Research Centre	38
4.7	Admin and Gallery	39
4.8	Library and Café	40
4.9	Accommodation	41

CHAPTER - 1

INTRODUCTION

1.1 ABOUT THE PROJECT:

- ✦ Energy Resource and Research Institute is an institutional organization, which promotes efficient use of existing resources by increasing the access and uptake to sustainable aspects and practices which contributes to reducing the impact on climate challenge and our environment.
- ✦ Main parameters include - energy efficiency and optimization, climate change, renewable energy, waste management and social upliftment.

1.2 AIM:

The aim of the project is to design an institutional space and a sustainable environment.

1.3 OBJECTIVE:

- ✦ Incorporating passive design strategies and experimenting with latest engineered techniques.
- ✦ Facilitating efficient use of building materials.
- ✦ Enhancing waste water treatments and waste management.
- ✦ The limitation to the study will be that it is concentrated in micro level building materials, this may reduce the opportunity to study about other materials which are not in use when considering local context.

1.4 SCOPE OF THE PROJECT:

The scope of the project is that the building is designed exclusively for the coastal, warm and humid climate, while the other southern regional centre is designed according to Bangalore's climate.

1.5 LIMITATION OF THE PROJECT:

The limitation to the project is that the building will be proposed for Chennai's context, while the design program is wide and can be accessed by allover India.

1.6 HYPOTHESIS:

The proposal of this project is for a hypothetical situation but is much needed for the current trend of over usage of resources and to educate people.

2.1 CARBON FOOTPRINT:

- Carbon footprint are defined as the emission of greenhouse gases such as carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), due to certain activities by humans or other natural occurring.
- More the carbon emissions, earth is prone to global warming which ultimately causes climate changes. Carbon footprint can be calculated for every other thing that emits carbon including humans, in terms of transportation, food consumption, usage of water, energy usage, and managing the waste.
- Apart from this everything in the world has its inbuilt carbon or overall carbon consumption by it called as Embodied carbon or Embodied Energy. It is the overall cycle associated with that material from extraction, manufacturing, transportation, usage to recycling it, they have overall carbon emission associated with each step which is briefly referred as embodied energy of a material.
- Therefore, calculating a material's carbon footprint is essential and contributes to reducing global carbon emission.

2.2 CARBON EMISSIONS IN ARCHITECTURE:

- ✦ In the field of architecture, the embodied energy of the building materials and carbon emissions from the construction process is the second major contributor. In terms of buildings, starting from usage of land, excavation – usage of machineries, production of materials, transportation of materials, immense use of water, waste management to overall construction process emit carbon.

- ✦ The detailed 5 stages in building industry where there's carbon consumption and emission are as follows,

- [i] Production of materials
- [ii] Construction processes
- [iii] Usage of the building
- [iv] End life of building
- [v] Starting from the scratch

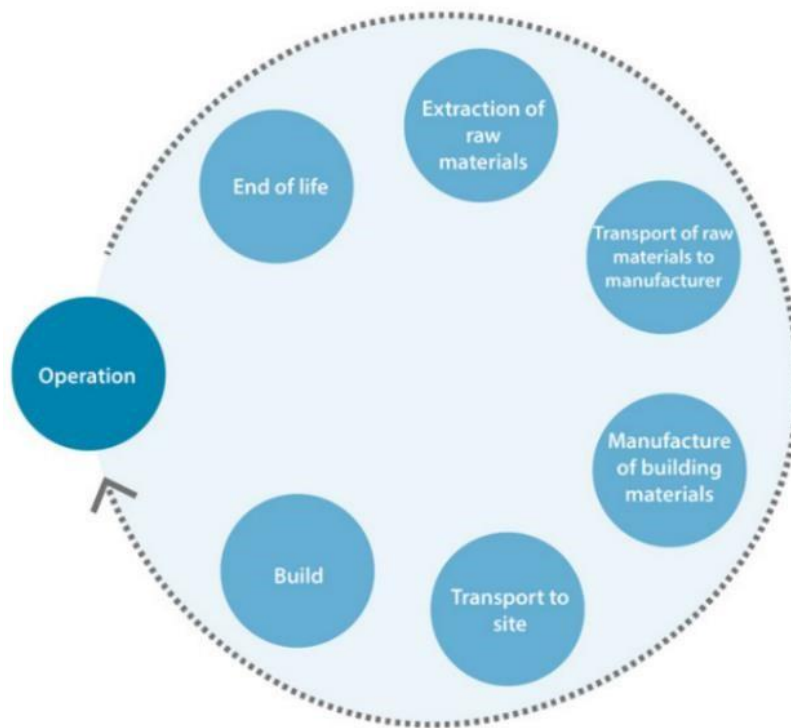


FIG 2.1

2.3 WAYS TO REDUCE EMISSIONS

- Instead of designing new structures, reuse houses. In contrast to designing a new structure, restoration and reuse schemes usually saves up to 50-75% of carbon emissions. This is particularly valid if the foundations and structure are retained, since most of the embodied energy goes there.
- By limiting materials that are carbon intensive.
- By choosing materials with low carbon, and materials with carbon sequestration.
- By reusing materials or using recycled materials.
- By increasing the structural strength, because effective concrete parts and slabs are both efficient ways to optimize performance and minimize material usage using optimal value engineering timber framing methods.
- Using finishing materials for the purpose of aesthetics alone can be avoided.
- Alternative Methods to reduce wastage of materials during construction and in production. Less wastage also can reduce carbon emissions.

2.4 BUILDING INDUSTRY AND RATING SYSTEMS IN INDIA:

- Architecture in India in recent times are adding up to the existing carbon emissions, because earlier Indian architecture was vernacular but due to globalization and need for more westernised structures led the country to fall prey for the carbon emissions in construction industry as well.
- Since the Paris agreement, the country developed various schemes in terms of reducing excessive energy consumption which leads to carbon emissions and also collaborated with other nations as part of (UNFCCC) United Nations Framework Convention on Climate Change.
- India introduced and developed rating systems, which focuses on sustainable construction technologies, material usage and energy-efficient buildings. Some popular green building rating systems in India are as follows,

2.4.1 Indian Green Building Council (IGBC):

The Leadership in Energy & Environmental Design (LEED) is the rating system developed for certifying Green Buildings. LEED is developed by the U.S. Green Building Council (USGBC), the organization promoting sustainability through Green Buildings. It is a framework for assessing building performance against set criteria and standard points of references.

2.4.2 Green Rating for Integrated Habitat Assessment (GRIHA):

Green Rating for Integrated Habitat Assessment (GRIHA) is India's own rating system jointly developed by TERI and the Ministry of New and Renewable Energy, Government of India. It is a green building design evaluation system where buildings are rated in a three-tier process.

2.4.3 Bureau of Energy Efficiency (BEE):

BEE developed its own rating system for the buildings based on a 1 to 5-star scale. More stars mean more energy efficiency. BEE has developed the Energy Performance Index (EPI). The unit of Kilo watt hours per square meter per year is considered for rating the building and especially targets air conditioned and non-airconditioned office buildings.

2.5 GRIHA

- ✦ The GRIHA is a rating tool, that lets people assess the efficiency of their building against certain globally appropriate standards. It holistically assesses a building's environmental efficiency over its entire life cycle, thereby establishing a definitive benchmark on what constitutes a 'green building'.

- ✦ The rating system would aim to strike a balance between existing standards and new ideas, both national and international, on the basis of accepted energy and environmental values.
- ✦ TERI has developed GRIHA (Green Rating for Integrated Habitat Assessment) with over two decades of experience in green and energy efficient buildings, which was adopted by the Government of India in 2007 as the national green building rating system. The Ministry for New and Renewable Energy has adopted this tool. This tool is able to 'rate' a building on the degree of its 'greenness' through its qualitative and quantitative measurement criteria.

FIG 2.2

- TERI is a multi-dimensional yet independent Organization which concentrates in research, policy, consultancy and implementation of the same.
- Their works focusses on
 - Promoting efficient use of resources.

- Increasing the access and uptake of sustainable inputs and practices. ○
Reducing the impact on environment and climate.
- They provide technology products, technical services, as well as policy advisory and outreach.

2.5.1 Mission

Their mission is “to usher transitions to a cleaner and sustainable future through the conservation and efficient use of energy and other resources, and innovative ways of minimizing of reusing waste.

2.5.1 Goals

- Helping a global transition to renewable energy pathways.
- Enhancing energy efficiency, especially in industries, public utilities and buildings.
- Enhancing conservations, utilization and access to water, including watershed management.
- Enabling the planning and governance of environmentally sustainable cities through green buildings and through management of solid waste, sewage, sanitation, mobility and air quality.
- Building resilience to adverse impacts of climate change due to cyclones and variations in hydrology and temperature.

CHAPTER – 3

CASE STUDIES

3.1 TERI – RETREAT, GURGOAN

Building Typology: Institutional

Climate: Composite

Architects: Sanjay Prakash and TERI

Year of Completion: 2000

Client: TERI

Site Area: 36 Hectares

Built-up: 3000sq.m.

3.1.1 About:

TERI developed a **RETREAT** (Resource Efficient TERI Retreat for Environmental Awareness and Training) complex in Gual Pahari which is in Gurgaon, Haryana. This visionary project of TERI is an example of a sustainable habitat. The site chosen was once a swampy, wasteland which now is a lush green habitat because of intense plantation activities by researchers, and scientists.

This model training campus illustrates efficient use of energy, sustainable practices, usage of both natural resources and renewable energy, and effective waste management techniques.

3.1.2 Design Description:

TERI's Gual Pahari campus is intended to represent a sustainable habitat paradigm focused on modern and renewable technology. Thus, it makes good use of the most plentiful source of resources, namely the sun, by tapping in different ways the sun's energy, directly and

indirectly. A part of the building is sunken partially so as to take advantage of the underground space and also stabilizes internal temperature. Landscapes are oriented to facilitate adequate wind supply through the spaces. In spaces like conference hall, Library and recreation hall, natural glare-free sky-lighting is provided. Fenestration and shading devices are designed such that the summer sun is cut-off and lets in winter sun. the deciduous trees are planted in southern side, which protects from summer sun and while in winter the leaves shed bringing in the winter sun.

3.1.3 Materials:

The roof of the structure is insulated by vermiculate concrete and white China mosaic. For walls, Styrofoam insulation is used.

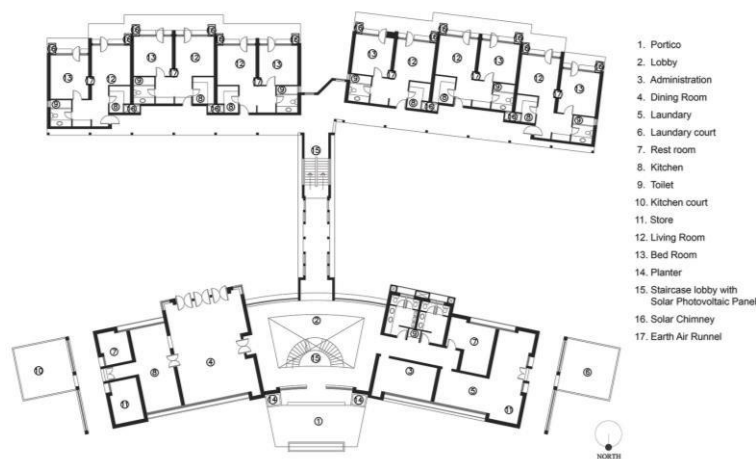


FIG 3.1.1

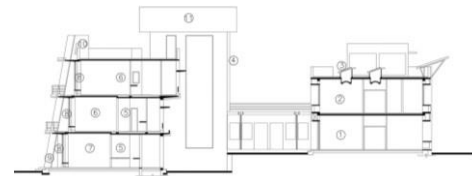


FIG 3.1.2



FIG 3.1.3

3.1.4 Design Features:

SOLAR WATER HEATER is an array of 24 solar water heaters is part of the living quarters' parapet wall. Up to 2000 litres of hot water (at 65 °C) can be supplied every day by the system. In winter, gas extracted from burning twigs, dried leaves, etc., acts as a back-up source to heat the water when the days are low and the sun less strong. In the solar water

heater, as a back-up source, the heat given off while the standby generator is running is also stored and used.



FIG 3.1.4

EARTH AIR TUNNELS (EATs) are provided for the living quarters (the south block) which are kept at comfortable temperatures (about 20 °C to 30 °C) throughout the year, not by traditional air conditioners, but by naturally cooled air circulating, augmented, if necessary, with an absorption chiller system operated by LPG (liquefied petroleum gas). There is a 'solar chimney' in each room in the south block; hot air rises and exits through the chimney, which generates an air current: the cold air from the underground tunnels rushes in to absorb the warm air. The process is intensified by two blowers mounted in the tunnels. During winter, the same mechanism delivers warm air from the tunnel.

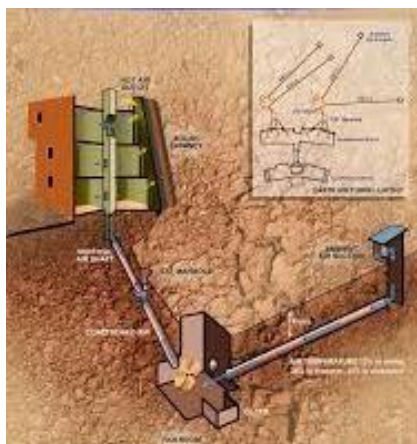


FIG 3.1.5

AMMONIA ABSORPTION CHILLERS, when necessary, a range of eco-friendly chillers, running on LPG and consuming minimal energy, provide extra cooling. As LPG is a nonrenewable energy source, efforts are underway to operate the chillers on producer gas provided by wood-based gasifiers. By means of ammonia-based absorption chilling, the conference room, which accommodates up to 100 participants, is conditioned.



FIG 3.1.6

BIOMASS GASIFIER - The biomass gasifier converts electrical energy from woody biomass and agricultural waste. In a few villages in Odisha and Madhya Pradesh, this technology is currently being used to fuel micro-enterprises, thereby helping to provide poor communities with livelihoods. TERI independently started research work in the mid 1980s on gasifier technology. The gasifier technology has since been customized and widely tested in the field for a variety of direct-heat applications. A few examples of the applications worked on at TERI are silk weaving, large-cardamom drying and gasifier-based crematoria.



FIG 3.1.7

FIG 3.1.8

WATER & WASTE MANAGEMENT SYSTEM - ROOT ZONE - Reed

plants whose roots

function as a filter and help extract several harmful compounds from almost 2000 liters of sewage water every day, which is then used for irrigation, are used in the TERI Gram Root zone.



FIG 3.1.9

MEMBRANE BIOREACTOR (MBR) - The integration of biological treatment with membrane filtration with membrane bioreactors (MBRs) is an advanced treatment technique that is lightweight and can provide high quality treated water. In emerging markets like India, however, commercially available membranes are expensive and therefore not cost-effective. TERI has developed ceramic membranes from waste fly-ash extracted from the combustion of agricultural residues to resolve the issue of high membrane costs.



FIG 3.1.10

FORESTRY RESEARCH CENTRE – NURSERY & VERMICOMPOSTING - Established in 1987, a nursery and research Centre for forest tree varieties, medicinal, herbal and ornamental plants is managed by TERI's Forestry Research Centre. Spread over an area of 2.5 acres and growing more than 40 medicinal plant species, the nursery is equipped with facilities such as mist chambers, shade houses, hedge gardens, clonal orchards, as well as an open area for shifting and grading sapling.

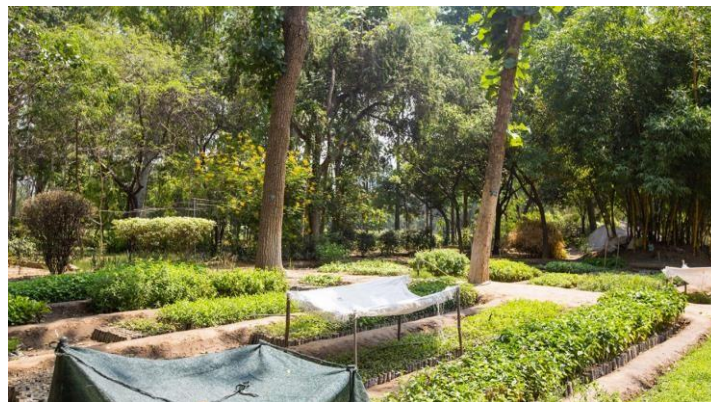


FIG 3.1.11

RENEWABLE ENERGY TECHNOLOGIES - TERI's Green Energy Technology Division has a range of R&D ventures and laboratories under it, including the Solar Lighting Laboratory, which seeks to identify high-quality, efficient and cost-effective solar lighting solutions and the Smart Mini Grid (SMG) i.e. a micro-grid to provide electricity through advanced sensing, connectivity and control techniques at the community level which helps in reducing fossil fuel consumption.



FIG 3.1.12

MICROPROPAGATION TECHNOLOGY PARK - The first ever building to be constructed at TERI GRAM. Earlier it was a tissue culture pilot plant which was later upgraded into a micropropagation technology park (MTP) which by taking tissues from an elite genotype of plants, mass produces economically significant plant species. These plants have been supplied domestically to various forestry departments, agro-based companies, NGOs and private farmers as well, which roughly estimates over 18 million plants.



FIG 3.1.13

TERI - DEAKIN NANO-BIOTECHNOLOGY CENTRE - In 2011, the TERI-Deakin Nanobiotechnology Centre was developed by the Biotechnology and Bioresources Division of TERI in collaboration with Deakin University, Australia, with the mandate to develop creative solutions focused on nanobiotechnology to resolve current challenges in agriculture and the environment. It puts together TERI's complementary skills in agriculture, biotechnology, green energy, bioremediation and nanotechnology and Deakin's expertise in materials research, chemical and physical science.



FIG 3.1.14

MAHINDRA-TERI CENTRE OF EXCELLENCE FOR SUSTAINABLE HABITATS

(MAHINDRA-TERI COE) - In September 2014, the Mahindra-TERI Centre of Excellence for Sustainable Habitats (Mahindra-TERI CoE) was established at TERI Gram. It aims to develop sustainable, energy-efficient solutions for the construction industry, adapted to the local climate in India.



FIG 3.1.15

FERMENTATION TECHNOLOGY RESEARCH CENTRE - The purpose of the Fermentation Technology Research Centre is to help researchers develop new fermentation techniques and strategies that include the environmentally friendly 'oil zapper' - a mixture of bacteria that breaks down the oil into harmless products such as water and carbon dioxide in contaminated soil and therefore helps to clean up hazardous oil spills etc. The TERI Gram facility has bioreactors of varying capacities that can be used to manufacture approximately 15 tonnes of oil zapper in one day.



FIG 3.1.16

TERI'S ENHANCED ACIDIFICATION AND METHANATION (TEAM) - Enhanced Acidification and Methanation (TEAM) by TERI converts food waste into biogas. The RETREAT plant processes almost 25 kg of food waste per day in order to produce 4 m³ of biogas. This was also constructed at, among other sites, the City and Industrial Development Corporation (CIDCO), Mumbai; the Colony of ONGC (Noida); and Numligarh Refineries Limited (Assam).



FIG 3.1.17

EFFLUENT TREATMENT PLANT (ETP) - By using the microbes already present in the water, the effluent treatment plant (ETP) at TERI Gram naturally treats sewage water. These microbes enable the sewage to eliminate organic matter, making it ideal for nonpotable use as well as for appropriate discharge into wastewater or river systems. The TERI Gram plant processes over 25000 liters of sewage water every day.



FIG 3.1.18

3.2 TERI – SOUTHERN REGIONAL CENTRE, BANGALORE

Building Typology: Institutional

Climate: Moderate

Architects: Sanjay Mohe

Year Of Completion: 1990

Client: TERI

Site Area: 18210.85 sq.m.

3.2.1 About:

The Southern Regional Centre was set up in Bengaluru in 1990 with the primary objective of promoting industrial energy efficiency through research, consultancy, training, and information dissemination. Over the years, the Centre has built a reputation not only in energy efficiency services, but also in renewable energy and environmental studies. Other focus areas include sustainable buildings, water resources policy, and development of biodegradable and green plastics. The site is located at Domlur, about 3 km from the Bangalore airport. It is a long and narrow site with roads on the eastern and northern sides, the former being the major road. The western side has an open ground and on the southern

side is an open drain about 9 m wide. The buildings are aligned along the east-west axis and entry into the site is from the road on the northern side which is relatively less busy. The building has been divided into individual and common areas. 75 intimate small spaces are provided for individual work. Common areas refer to the atriums, courts, nodes and corridors meant for wider interaction.

3.2.2 Design Description:

The master plan consists in two parallel four-floor buildings containing a street for pedestrian and vehicles movements along it. The south-facing buildings are segmented into blocks in order to provide maximum natural light to the street and homes located in the second row of buildings. These cavities called “e-zone” are treated as garden for recreation.



FIG 3.2.1

3.2.3 Materials:

Filler Slabs, Soil-Stabilized Blocks, Laterite Blocks.



FIG 3.2.2



FIG 3.2.3

3.2.4 Design Features:

Reducing environmental impact: The proposal addresses not only Thermal comfort but also Visual appeal & environmental issues. Less usage of natural energy by means of promoting the local climatic condition like using Cavity wall in the south. Promoting passive solar & ventilation in the interiors. With green roof is used above the spaces where the AC system is used. Waste is used as in the form manure for the landscapes. Wide of variety of landscape are used to absorb the CO₂ produced in the building. Building with Low embodied energy materials.

Life cycle assessment (LCA): As use of local materials reduces the energy consumed in their transportation, local materials and materials with low embodied energy have been used wherever possible. The operation and maintained cost is considerable high with respective Towards the Human comfort. Disposal or recycling of the waste product is achieved with treatment Plants. Impacts like embodied energy, global warming, resource use, air pollution, water pollution, and waste are taken into account in Promoting the efficiency of the building in various building detailing.

Siting and structure design efficiency: The concept stage is taken into account of deciding the cost and performance of the building. The cost is reduced with the effective use of local materials and with the proper usage of landscaping in heat reduction thus creating thermal comfort in south. In designing environmentally optimal buildings the objective is to minimize the total environmental impact.

Energy efficiency: The elemental forces of earth, wind, fire and water are imperative to the architectural design of the building. It opens towards the northern side facilitating access to glare-free light. A solar wall towards the south (drain side) of the building directs the flow of the breeze over the building, which, in turn, creates a negative pressure and pulls fresh air from the north into the building.

SUN: Photo voltaic cells are used to capture the suns energy thus generating electrical energy for the various stations. These photovoltaic cells have been arranged in line with the primary orbit of the sun the panel are integrated with dynamic truss to optimize the generation of energy. The suns energy is further used in the form of solar heaters which is used to generate all the hot water in the guest house.



FIG 3.2.4



FIG 3.2.5

WATER: An efficient rainwater harvesting system preserves water to the maximum possible extent. Water run-off from the roofs and from the paved area is collected and stored in a collection sump below the Amphitheatre. This water is used for various purposes including landscaping and flushing toilets.

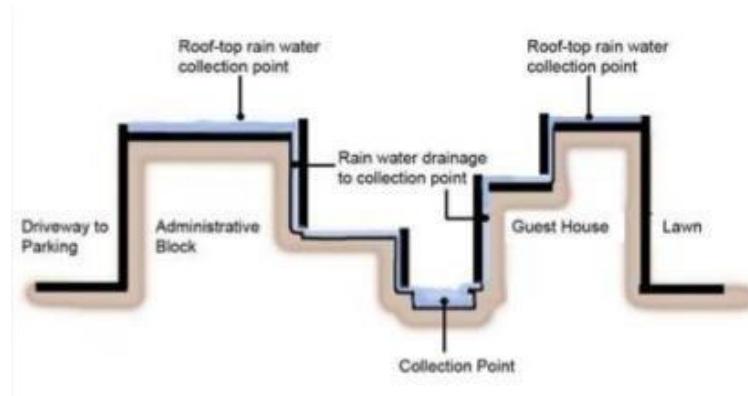


FIG 3.2.6

EARTH: The building has been designed with landscaped courts at various levels these courts help to enliven the working environment as well as enhance the micro climate within the structure. The various level of terraces also have been landscaped which reduces the heat exchanges and heat flow between the structure and the outside environment hence act as good insulation device. having this ground cover on the roof further reduces the impact on the environment through photosynthesis. As thermal capacity of earth is high, daily and annual temperature fluctuations keep decreasing with increasing depth of earth. At depth of 4m below ground, temperature remains constant and equal to annual average temperature.

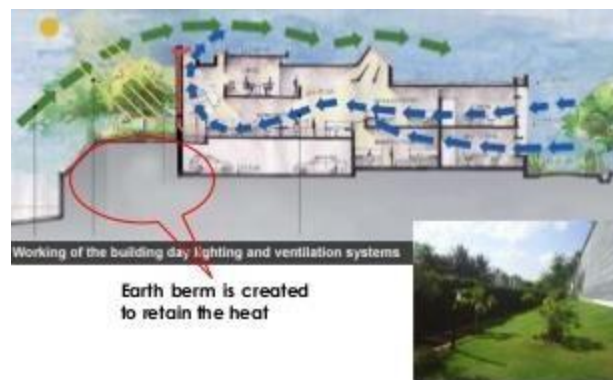


FIG 3.2.7

SKY: Openings have been designed such that requirement of artificial lighting is minimal throughout the day when the building is under maximum usage. Abundant natural light inside due to intelligently designed fenestrations. By creating atrium spaces with skylights,

the section of the building is such that natural light enters into the interiors of the building, considerably reducing the dependence on artificial lighting. Daylight streaming through huge skylights right through to the heart of the building enriches the vibrancy of the “commons”. The entire fenestration has been conceptualized to minimize dependence on artificial lighting during the day.



FIG 3.2.8



FIG 3.2.9

AIR: A blank wall towards the south (facing the drain) allows the breeze to flow over the building. This creates a negative pressure which pulls fresh air from the north into the building. The sections are designed such that hot air rises to the top and make the building breathe. Air in the cavity in the south wall on the south creates negative pressure, thereby enhancing the convection currents in the building. On the south, there is an absorptive double wall with a cavity which provides insulation from the southern sun and heats up the air within.



FIG 3.2.10

3.3 CII SOHRABJI GODREJ GREEN BUSINESS CENTRE, HYDERABAD

Building Typology: Office

Climate: Tropical wet and dry

Architects: Karan Grover and Associates

Year Of Completion: 2003

Client: CII

Built-up Area: 18210.85 sq.m.

Site Area: 4.5 acres

3.3.1 About:

CII-Sohrabji Godrej Green Business Centre (CII-Godrej GBC) was established in the year 2004, as CII's Developmental Institute on Green Practices & Businesses, aimed at offering world class advisory services on conservation of natural resources. The Green Business Centre in Hyderabad is housed in one of the greenest buildings in the world and through Indian Green Building Council (IGBC) is spearheading the Green Building

movement in the country. The Green Business Centre was inaugurated by His Excellency Dr. A. P. J. Abdul Kalam, the then President of India on 14 July 2004. The Services of Green Business Centre include- Energy Management, Green Buildings, Green Companies, Renewable Energy, GHG Inventorization, Green Product Certification, Waste Management and Cleaner Production Process. CII-Godrej GBC works closely with the stakeholders in facilitating India emerge as one of the global leaders in Green Business by the year 2022.

3.3.2 Design Description:

It has a Central courtyard. A Roof Garden, which protects from heat penetration and also cuts down heat-island effect. High performance glazing has been used to let in natural light while minimizing heat penetration. Usage of light glazing and vision glazing. Jali walls are used. Energy saving systems are incorporated like wind towers.

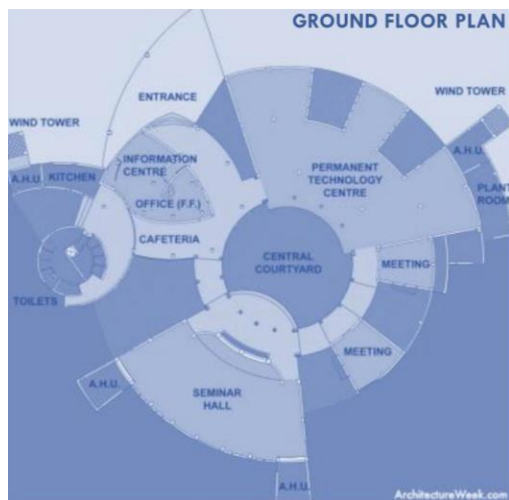


FIG 3.3.1



FIG 3.3.2

3.3.3 Materials:

Recycled fly ash bricks, interlocking pavement blocks, stone slabs, scrap glazed tiles and steel, broken glasses and tiles, recycled aluminium, quarry dust, cellulose fibres.

3.3.4 Design Features:

COURTYARD: The courtyards act as "light wells" illuminating adjacent work areas. When this light is not sufficient, sensors trigger the deployment of efficient electric lights. Dimmers automatically control the illumination levels, turning the lights off when they're unnecessary. Also, occupancy sensors prevent a light from being switched on at an unoccupied workstation.



FIG 3.3.3



FIG 3.3.4

ROOF GARDEN: Absorbing heat and radiating it into the building. This is minimized through the roof gardens covering 55% of the roof area. Rain water harvesting. Seepage into the ground have been installed in pedestrian areas and parking.



FIG 3.3.5

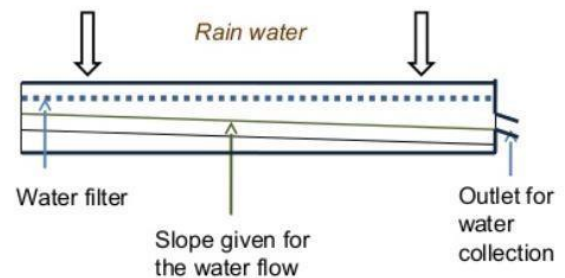


FIG 3.3.6

JALI WALLS: Lattice walls are used to prevent glare and heat gain while ensuring adequate day lighting and views. The Jali, used in many historic buildings such as the Taj Mahal, which gives definition and an aesthetic appeal to a space.

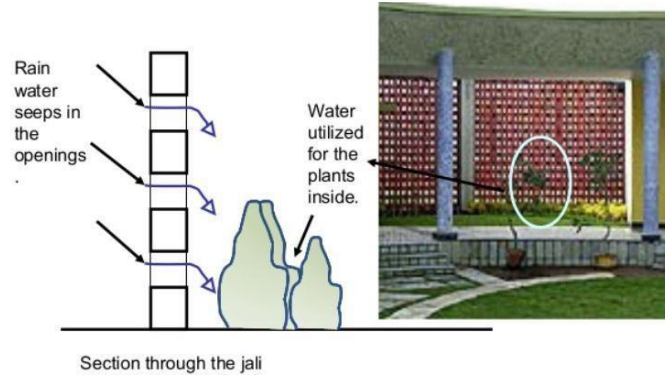


FIG 3.3.7

SOLAR PHOTOVOLTAIC PANELS: 20% of the building. energy requirement is catered to by solar photovoltaic. The Solar PV has an installed capacity of 23.5 KW. Average generation is 100-125 units per day Solar Photovoltaic System. The solar panels are placed on the eastern side and they are sloping which helps production of energy throughout the day and as it is a commercial building more amount of energy is consumed during the working hours [day] compared to the evenings.

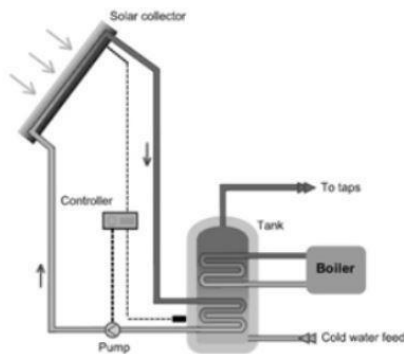


FIG 3.3.8



FIG 3.3.9

WATER SYSTEM: Collect rainwater for external use i.e. garden/washing car. Use water conserving appliances including toilets, shower, taps, washing machine and dish washer

e.g.. Low flow faucets, water saving dual flush tanks. Reduce irrigation and surface water run-off .

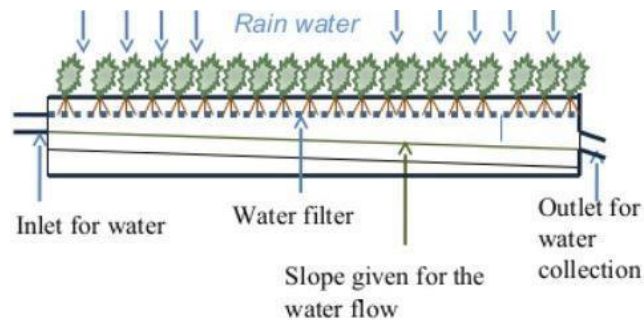


FIG 3.3.10

WIND TOWER WITH EVAPORATIVE COOLING: A combination of sensible cooling in the ground and evaporative cooling with the flow of air induced by the wind tower can be achieved by a configuration as shown. The heat loss from air results in a decreased air temperature, but no change in the water vapor content of the air.

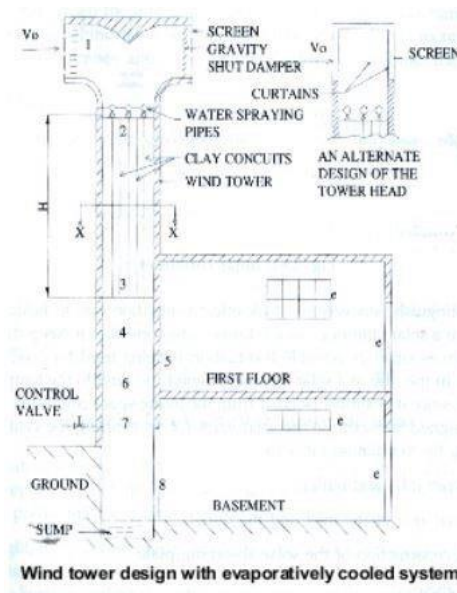


FIG 3.3.11

3.4 SUZLON ONE EARTH, PUNE

Building Typology: Institutional

Climate: hot semi-arid

Architects: Christopher Benninger

Year of Completion: 2009 *Client:*

Suzlon Energy Ltd.

Site Area: 45392 sq.m.

Built-up: 70865sq.m.

3.4.1 About:

An unique corporate headquarters **Suzlon One Earth** is located over 10 acres of land in Hadapsar, Pune, India. The site was designed with a business and functional need to bring under one roof all business verticals and corporate facilities, which, although connected to each other, would be adequately independent to be able to perform according to their respective requirements and needs. With 8 percent of its annual energy generated on site using photovoltaic panels and windmills, it earned LEED Platinum and TERI GRIHA 5 Star certification with a cumulative incremental cost of about 11 percent.

Suzlon one earth is 100% powered by onsite and offsite renewable sources. The campus has 18 hybrid wind turbines that account for 7% of the overall electricity usage, while offsite wind turbines satisfy the majority of the energy demand. The framework is designed to ensure optimum daylight visibility, thus reducing the use of artificial lighting. Inside the campus, the infrastructure is designed to allow water percolation and thereby regulate the drainage of storm water, leading to an increased level of the water table.

3.4.2 Design Description:

From site selection and planning through architecture, building, materials and processes, environmental standards have been scrupulously adhered to. This entails the use of natural plants, mitigating both the effect on the atmosphere and reducing the need for water

1. Main building
2. New building
3. New building
4. New building
5. New building
6. New building
7. New building
8. New building
9. New building

A large, modern interior space, likely a lobby or atrium, featuring a high ceiling with a grid of skylights. The space is characterized by glass walls and a central area with a grid of water features. People are visible walking through the space, and there are various displays and seating areas.

OFFICE BUILDING
LIBRARY
GYMNASIUM
HALLWAY
RESTROOM
ELEVATOR
STAIRWELL
CLOSET
BATHROOM
KITCHEN
DINING HALL
CAFETERIA
RECEPTION AREA
CLASSROOM
LABORATORY
OFFICE BUILDING

3.4.3 Materials:

3.4.4 Design Features:

30

that enables daylight and cross ventilation, aluminum louvers feature. Natural air and ventilation are possible in areas of operable fenestration. These strategies have resulted in lower, lighter and longer building forms that improve the volume-to-fenestration ratio, maximizing natural light and airflow in hot and dry climate conditions. 100% powered by renewable energy on site and off site, including hybrid wind turbines, solar panels and photovoltaic cells. Rainwater harvesting facilities and water storage and disposal services on site. On-site organic waste converter. Design concept of Office in Garden that harvests optimum daylight in work spaces and common areas. Reduction by about 35 percent in running costs due to savings in energy and water costs, an opportunity that is transferred to consumers by increased infrastructure investment.

PASSIVE TECHNIQUES - Majority of the campus façade faces the south side thus, heat gain is avoided by using specially designed louvers and a double glazed with air gap in between, without disturbing the view.

ACOUSTIC MATERIALS - Paper pulp ceiling and recycle carpet tiles are used for acoustical insulation.

FLYASH BLOCKS - Recycled industrial waste transformed into pavements blocks was used in vehicular path.

TOP SOIL WHILE CONSTRUCTION - The top soil taken out for terminus construction was used for plantations in the campus and passed on for public gardens.

UNPOLISHED HARDSCAPE - Unpolished dark coloured granites are used which absorbs sun's radiation and reduce the heating of the site

EROSION CONTROL - Most of the site is covered by plantations and pebbles to reduce soil erosion.

NATURAL LIGHT - All buildings are designed to harvest maximum day light through glass and louvers with almost 90% of the users not required to use artificial lights.

GARDEN WASTE - Wastes like grasses, plants, branches, etc is put into the organic waste converter (OWC) and manure generated is used in its own landscape and excess is sold out to vendors.

Organic Waste Converter - Wastes such as plastic waste, garden waste, office waste are either converted into organic manure or is recycled. The process is as follows:

- Collection of waste and separating bio waste from it.
- Addition of bio-Cullum, malum and saw dust.
- The mixture is grinded and settled in crates.
- After 5 days, the organic manure will be ready to use.

CONSTRUCTION WASTE - The construction waste management in Suzlon One Earth is handled by reduction in waste during construction. Also the leftover materials were returned to the vendors.

SEWAGE TREATMENT PLANT - All the waste water is collected in a storage tank. Separation of slurry from water is done. The slurry is stored in a tank for about a year and then its further dumped to the Municipal Corporation and the waste water is further treated in sewage treatment plant.

The process is as follows,

- The solid waste water is collected from different places are then collected in tanks through drainage lines in pump room.
- The waste collected in the tanks area separated into slurry and waste water, and further waste water is sent to sewage treatment plant for the further process.
- Waste water is passed through sand tanks where the sand layers and the waste in the water is separated and processed water is passed through another line for next process.
- After the process in sand tank, the water is sent in chlorine tank, where the water and chlorine is mixed.

- Then the chlorine water is sent to water softener tank where the hard water is converted soft water.
- The recycled water is used in gardening and HVAC Plant.

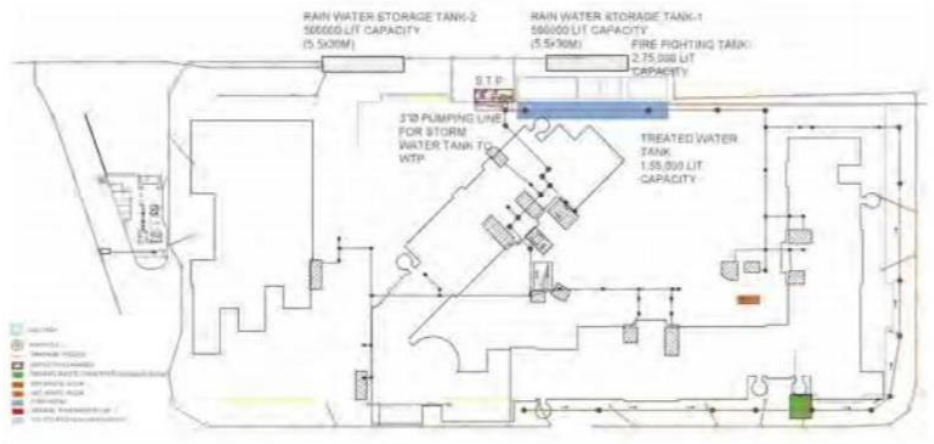
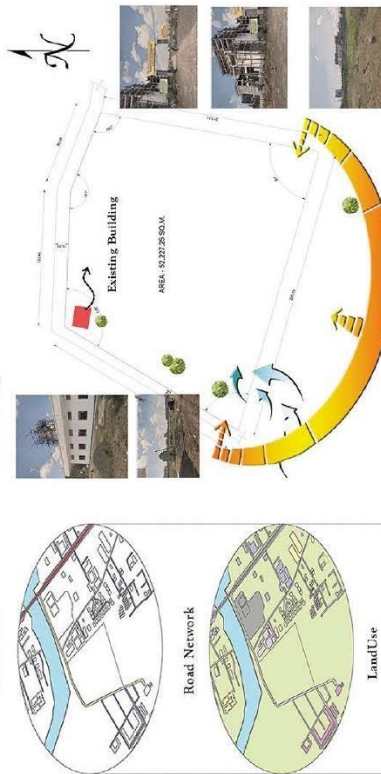
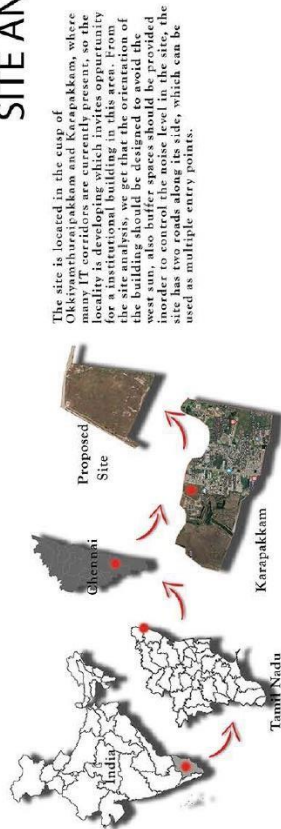


FIG 3.4.5



FIG 3.4.6

SITE ANALYSIS

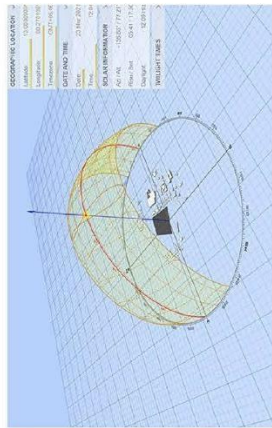


Strength of the site is that its near an Institutional building which will attract students and also helps them socialize.

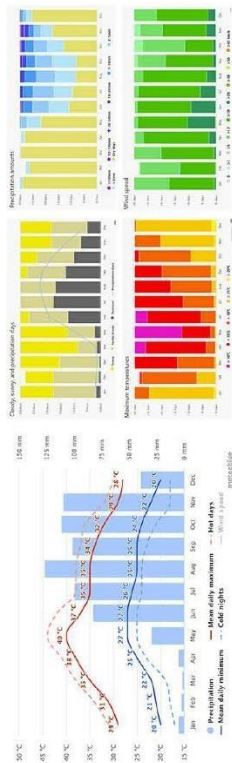
Weakness of the site is, it is not connected directly to a primary road.

Opportunities are wide open for this site because the site is located in a IT corridor and surrounded by many other institutions.

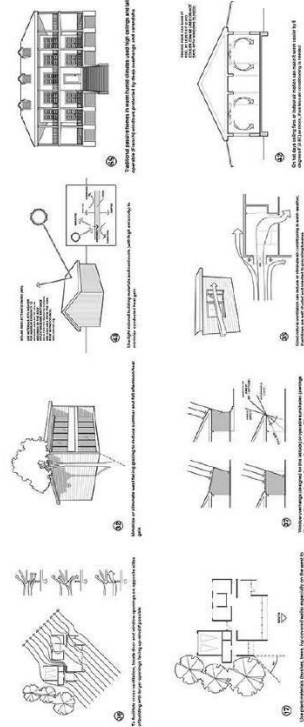
Threat will include water front-site, which makes this site a marshy land.



SOLAR DIAGRAMS suggests that the sunrays will be directly on the site most of the months in a year. From the CLIMATE DATA the location has a warm and humid climate, the passive design strategies should be planned to reduce the heat gain and keep the indoors cool during day.



DESIGN STRATEGIES FOR WARM AND HUMID CLIMATE



Energy Resource and Research Institute

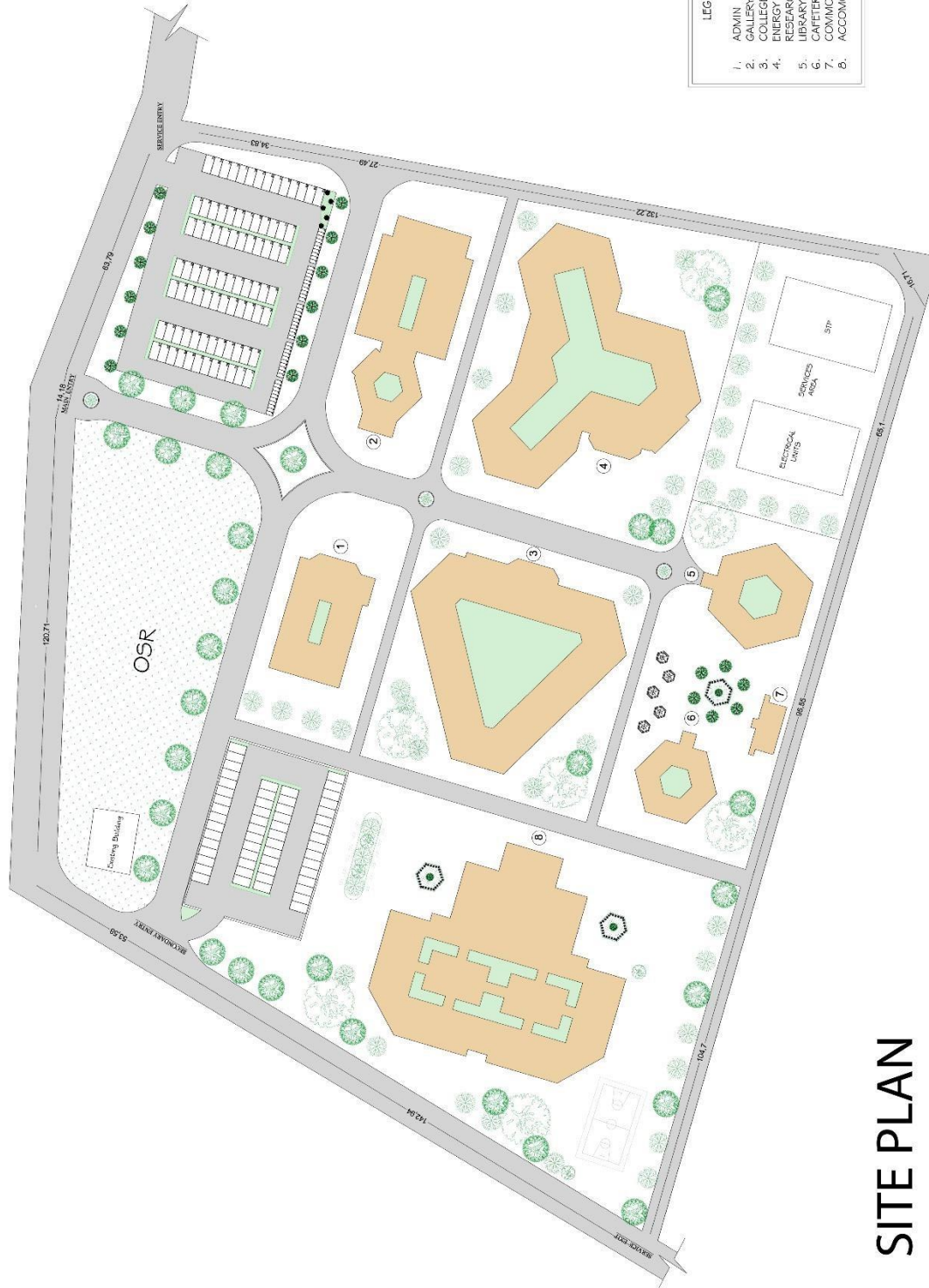
Shanthini M 3621069 Batch 2016-2021 Department of Architecture

REQUIREMENTS AND AREA STATEMENT

Sr.NO.	Name of the Space	No. Of Units	Area of Space	Total Area	COLLEGE BLOCK		
ADMINISTRATION BLOCK							
1	Lobby	1	40 sq.m	40 sq.m	1 Admin	181 sq.m	181 sq.m
2	Waiting area	1	30 sq.m	30 sq.m	2 Lobby	40 sq.m	40 sq.m
3	Reception	1	10 sq.m	10 sq.m	3 Staff rooms	40 sq.m	80 sq.m
4	Office room	3	50 sq.m	150 sq.m	4 HOD room	20 sq.m	20 sq.m
5	Work Station	2	75 sq.m	150 sq.m	5 Master classroom	100 sq.m	1300 sq.m
6	Server Room	1	20 sq.m	20 sq.m	6 Diploma classroom	30 sq.m	300 sq.m
7	Conference Room	2	30 sq.m	60 sq.m	7 Ph.D classroom	30 sq.m	90 sq.m
8	Accounts Room	1	40 sq.m	40 sq.m	8 Laboratories	200 sq.m	800 sq.m
9	Manager's Office	1	20 sq.m	20 sq.m	9 Exam cell	20 sq.m	20 sq.m
10	Controller's Room	1	20 sq.m	20 sq.m	10 Restrooms	25 sq.m	100 sq.m
11	Pro- Chancellor's						
12	Chancellor's Room	1	20 sq.m	20 sq.m	ENERGY RESOURCE OFFICE		
13	Rest Rooms	2	24 sq.m	48 sq.m	1 Admin	24 sq.m	24 sq.m
					2 Head officer rooms	12 sq.m	24 sq.m
					3 Work Stations (5)	25 sq.m	125 sq.m
					4 Conference room	100 sq.m	100 sq.m
					5 Server room	20 sq.m	20 sq.m
					6 Rest rooms	25 sq.m	50 sq.m
RESEARCH BLOCK							
1	Vestibule	1	20 sq.m.	20 sq.m	GALLERY		
2	Lobby	1	30 sq.m.	30 sq.m	1 Admin	30 sq.m	30 sq.m
3	Lounge	1	48 sq.m.	40 sq.m	2 Lounge	20 sq.m	20 sq.m
4	Laboratories	3	50 sq.m.	150 sq.m	3 Exhibition Space	200 sq.m	200 sq.m
5	Work Stations	4	50 sq.m.	200 sq.m	4 Store room	15 sq.m	15 sq.m
6	Seminar Room	1	120 sq.m.	120 sq.m	5 Gathering Space	100 sq.m	100 sq.m
7	Meeting Rooms	2	48 sq.m.	96 sq.m	6 Restrooms	50 sq.m	100 sq.m
8	Storage	1	40 sq.m.	40 sq.m	HOSTEL AND ACCOMODATIONS		
9	Cold storage	1	20 sq.m.	20 sq.m	1 Rooms for women	40 sq.m	2560 sq.m
10	Library	1	300 sq.m.	300 sq.m	2 Rooms for men	40 sq.m	2560 sq.m
11	Cafeteria	1	150 sq.m.	150 sq.m	3 Mess	600 sq.m	600 sq.m
12	Restrooms	3	25 sq.m.	75 sq.m	4 kitchen	120 sq.m	120 sq.m
13	Individual plants	4	150 sq.m.	600 sq.m			

Energy Resource and Research Institute

Shanthini M 3621069 Batch 2016-2021 Department of Architecture



Energy Resource and Research Institute



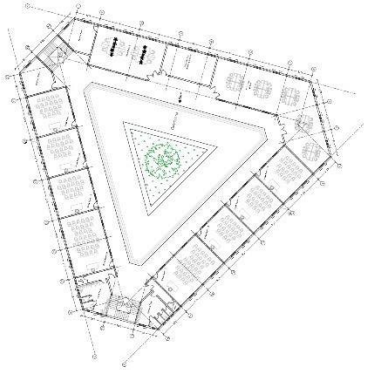
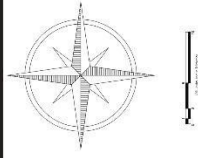
SATHYABAMA
INSTITUTE OF SCIENCE AND TECHNOLOGY



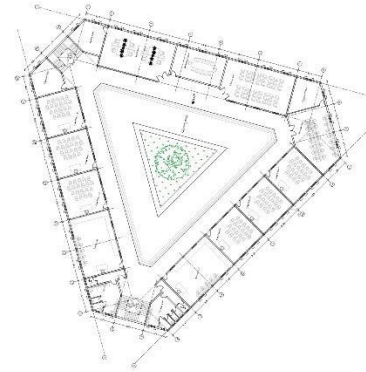
MASTER PLAN

Energy Resource and Research Institute

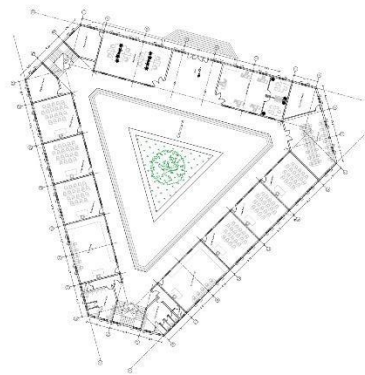
Shanthini M 3621069 Batch 2016-2021 Department of Architecture



SECOND FLOOR PLAN



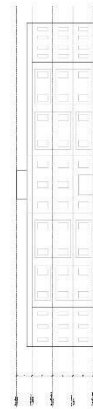
FIRST FLOOR PLAN



GROUND FLOOR PLAN



SECTION AA



FRONT ELEVATION



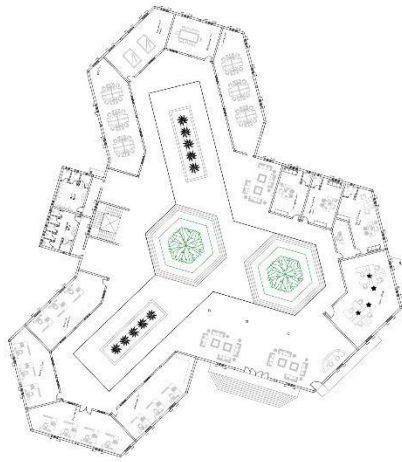
COLLEGE BLOCK



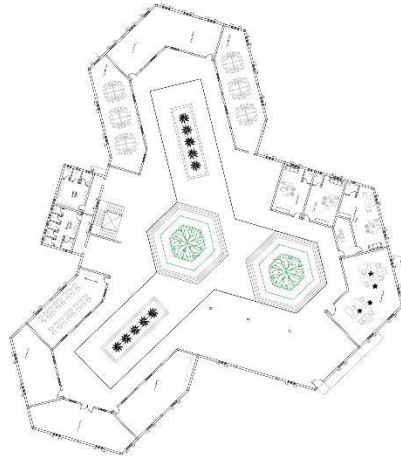
SATHYABAMA
INSTITUTE OF SCIENCE AND TECHNOLOGY

Energy Resource and Research Institute

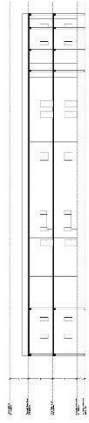
Shanthini M 3621069 Batch 2016-2021 Department of Architecture



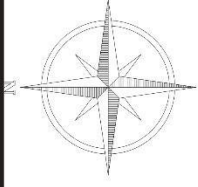
GROUND FLOOR PLAN



FIRST FLOOR PLAN



SECTION BB'



OFFICE AND RESEARCH CENTRE

Energy Resource and Research Institute

Shanthini M

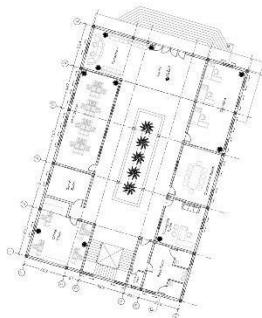
3621069

Batch 2016-2021

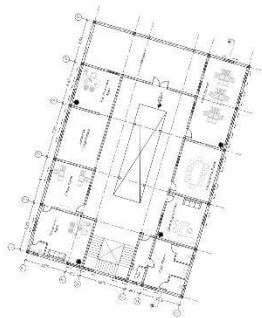
Department of Architecture



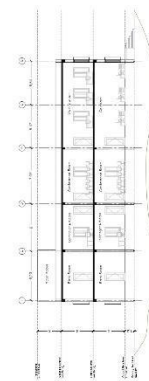
SATHYABAMA
INSTITUTE OF SCIENCE AND TECHNOLOGY



GROUND FLOOR PLAN



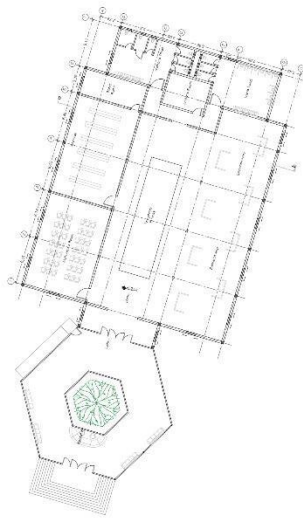
FIRST FLOOR PLAN



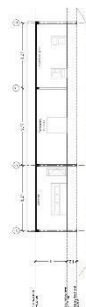
SECTION CC'



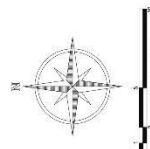
ADMIN AND GALLERY

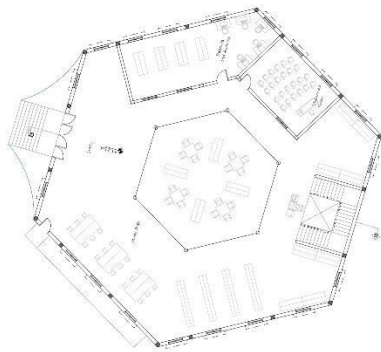


GROUND FLOOR PLAN

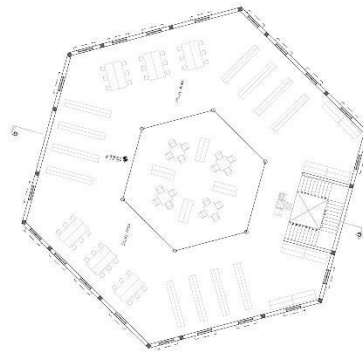


SECTION DD'



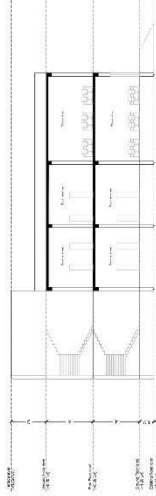


GROUND FLOOR PLAN

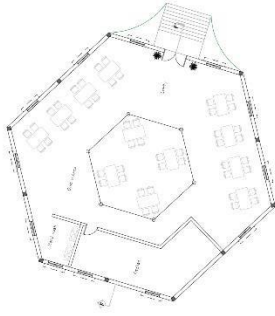


FIRST FLOOR PLAN

LIBRARY



SECTION GG'



GROUND FLOOR PLAN



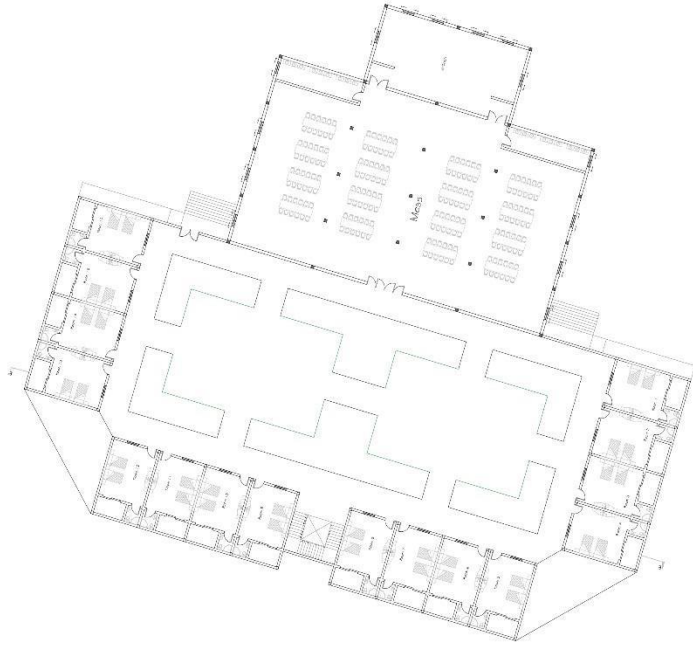
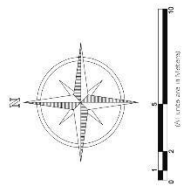
SECTION FF'
CAFETERIA



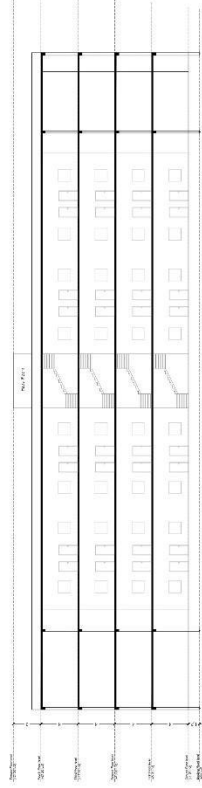
SATHYABAMA
INSTITUTE OF SCIENCE AND TECHNOLOGY

Energy Resource and Research Institute

Shanthini M 3621069 Batch 2016-2021 Department of Architecture



TYPICAL FLOOR PLAN G+4



SECTION EE'



ACCOMMODATION

Energy Resource and Research Institute

Shanthini M 3621069 Batch 2016-2021 Department of Architecture