NATIONAL INSTITUTE OF TECHNOLOGY, ROURKELA
GANDHI INSTITUTE OF TECHNOLOGY AND MANAGEMENT,
SCHOOL OF ARCHITECTURE, VISHAKHAPATNAM

PRELIMINARY REPORT – OCTOBER 2023

TEAM ZERO GRID

MULTI – FAMILY HOUSING

PROJECT PARTNER –
NATIONAL INSTITUTE OF TECHNOLOGY, ROURKELA

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REVIEWER 1		
SECTION	REVIEWER'S COMMENT	RESPONSE
Team summary	You have a good mix of disciplines in the team but it could be improved. Add more engineering students if possible. In your document, the text under team photos is hard to read. You have a good collection of faculty advisors - please mention their expertise areas. Approach needs to be articulated better in terms of approach to net-zero building design with such a large team. How will you meet, argue, make decisions? How will you use the expertise of your faculty advisors, how often you will meet the project partner, and what do you expect from your industry partners?	We've added one more civil engineering student. The mandatory requirement of having multidisciplinary team with at least one architecture and one engineering student has been fulfilled.
Project summary	You need to revise your EPI goal of 33 kWh/m2. Is that the best you can do? Will it get you to an NZE project? Average household size of 3 persons seems low. What is the justification this? There seems to be some problem with your PV calculations. An area of 2520 m2 with 70% PV coverage will not be able to generate more than 2,30,000 kWh. Also what about staircase and lift pop-ups in the terrace? Will those reduce your PV coverage? Will they cause shadows on the PV arrays? Mention the overall project timeline, not just its current stage.	The average household has been taken 4, as per NBC 2016.The PV calculations has been revised accordingly. The partial shading impact has been addressed. Each wing generates 1,75,000 kWh/yr where as the entire project consisting of 6 wings, generates 10,50,000 kWh/yr.
Case studies	It is not clear which aspects of the cases that you studied are applicable to your building type or your climate and context. Therefore it is not clear if you have learned anything useful from the case studies.	
Context Analysis	Good context analysis, you have covered the right aspects in this. You have identified fly-ash as a local resource. How will you use it on your project?	We'll be utilizing fly-ash in structural application for sustainable construction under the specialized guidance in this field from Prof.Pradip Sarkar, one of our faculty advisor.
Goals	Very nicely written, clear and concise goals. Please rethink your strategies. E.g. if your thermal mass strategy releases heat at night, will it not make the dwellings uncomfortable at night? Your climate does not have cold nights and hot days. So how will thermal mass work? Are you planning to incorporate radiant cooling in your housing? Who will operate the cooling plant?	Not yet addressed
Building Area Programme	The building area programme is poorly written up. It is not clear how many total dwelling units you will have. Some rows in the table do not have descriptions (numbers like 42.6 and 71.6). Please redo this. At this point it is not clear that your project meets the Division requirements and if it does not meet the requirements, your team will be disqualified in D2. Also, classification of spaces for conditioned and unconditioned areas has not been provided.	This has been revised.
Findings from pre-design analysis	Climate analysis.: Incomplete. It is not clear that your team understands the climate. Site analysis: much of what you have provided belongs in the context analysis. Preliminary energy and thermal analysis was limited to radiation analysis. Overall, the pre-design analysis is incomplete and minimal.	Finding from Pre-Design analysis has been revised and updated, the inferences have been added based on the analysis done. Both the climate analysis & the site

		analysis has been completed.
REVIEWER 2		
SECTION	REVIEWER'S COMMENT	RESPONSE
Team summary	Make your team graphic bigger, the smaller text is pixelated and hard to read. Add one more engineer to your team from an HVAC or MEP background to help with your HVAC design. Try to have each member be involved in 2 or more contest areas with one person leading the contest area. This will help the team brainstorm and discuss the ideas and make a much more informed decision. Add more people to your resilience contest area.	We've added one more civil engineering student. The mandatory requirement of having multidisciplinary team with at least one architecture and one engineering student has been fulfilled.
Project summary	1) You have set your goal for the EPI as per GRIHA, however, you need to reach the Net-zero goal. Is the GRIHA benchmark allowing your project to achieve Net-Zero? 2) You should report your preliminary construction budget in Rs per sq.m 3) You should give a proposed timeline for your project.	Not yet completed
Case studies	You should mention the key findings and key takeaways from your case study. What learnings from the case studies will you apply while designing your project?	Not yet addressed
Context Analysis	You should also list the problems faced by your target user. This will help you set the stage to solve your innovation contest area.	Not yet addressed
Goals	You need to refine your goals a little further. Additionally, you need not mention strategies at this point in the competition. The goal for your Affordability contest area is the same as the Architectural design contest area. This needs to be changed and refined for the next deliverable.	Not yet addressed
Building Area Programme	Mention the conditioned and unconditioned areas of your project. How many units have you calculated per floor?	This has been revised.
Findings from pre-design analysis	Only the observations, inferences and key takeaways of your climate study are important at this point. The strategies you have suggested may or may not be useful in your design depending on which of the strategies you will be implementing. Are you implementing all of them? Give justification and evidence as to why you are doing a particular strategy.	Not yet completed

1. TEAM SUMMARY

1.1. TEAM NAME - ZeroGrid

1.2. INSTITUTION(S) NAME- National Institute Of Technology, Rourkela
Gandhi Institute Of Technology And Management, College Of Architecture, Vishakhapatnam

1.3. DIVISION - Multi-Family Housing

1.4. TEAM MEMBERS

1.5. APPROACH:

Team ZeroGrid is a multidisciplinary group of students from the Gandhi Institute of Technology and Management College of Architecture in Vishakhapatnam, as well as the National Institute of Technology in Rourkela, the lead institution. Self-evaluation and acknowledgment of individual interests are key components of the team organization strategy. Flexible assignment of roles and tasks was done while considering the ten contests. The goal of the plan was to construct affordable, energy-efficient, and sustainably designed multifamily housing that is also net zero. To encourage open communication and decision-making, team meetings are planned. These gatherings provide as spaces for group problem-solving, brainstorming, and problem-solving strategies. Faculty meetings offer a forum for comprehensive conversations, constructive criticism sessions, and direction. Their observations help the team overcome obstacles and improve design solutions. meetings with the project partner to keep the objectives and expectations of the project aligned. These gatherings provide a forum for talking about project updates and overcoming obstacles. Working together with project partner to gain access to technical know-how for multifamily housing that aims to achieve net-zero standards. Seek assistance from industry partners to gain access to resources, such as cutting-edge technologies, energy-efficient systems, and sustainable materials.

Our collaborative approach combines effective team organization, communication strategies, faculty advisor engagement, and industry collaboration to create a sustainable, cost-effective, and energy-efficient net-zero multi-family housing design. This approach ensures a holistic and innovative solution that aligns with the project's overarching goals.

1.6. BACKGROUND OF THE INSTITUTIONS

National Institute Technology Rourkela (Lead Institute): NIT Rourkela is one of the premier national level institutions for technical education in the country and is funded by the Government of India. The Department of Planning and Architecture (PA), established in 2013 with the objective of amalgamating the aesthetics and technology together, now has a NIRF rank 8th in 2023. With a NIRF Engg. rank 16th, the institute offers various undergraduate and graduate studies.

Gandhi Institute of Technology and Management: located on the shores of the Rushikonda beach, the Visakhapatnam campus was established in 1980. The Architecture programmes at GITAM train students in contemporary practice and cultural aspects of building. The programme responds to the challenges of sustainability, urbanisation, and climate change through design of cost-effective portable modules.

1.7. FACULTY LEAD

Dr. Roshmi Sen
Assistant Professor,
Department of Planning and Architecture, NIT Rourkela
Areas of Interest: Climate responsive architecture and urban planning, Slum

upgrading and inclusive development, District cooling in
Indian cities

1.8. FACULTY ADVISORS

1.8.1. NIT ROURKELA

Dr. Pradip Sarkar, Professor, Dept. of Civil Engineering, Dean PD (Dean Planning and Development), NIT Rourkela
Areas Of Interest:
Earthquake Structural Engineering, Sustainable building materials

Dr. B. Kiran Naik, Assistant Professor, Dept. of Mechanical Engineering,
Areas Of Interest:
Energy and Buildings , Energy-Water Nexus , Thermo-chemical energy conversion and storage

Dr. Deepanjan Saha, Assistant Professor, Dept. of Planning & Architecture
Areas Of Interest:
Neighbourhood planning, Architectural Design

Dr. Nabanita Saha, Assistant Professor, Dept. of Planning & Architecture
Areas Of Interest:
Vulnerability Assessment, Building byelaws, Urban and landscape design

Prof. Ankur Baghel, Assistant Professor, Dept. of Planning & Architecture
Areas of Interest:
Neighbourhood Planning, Building materials and construction

Prof. N. Nizamuddin, Assistant Professor, Dept. of Planning & Architecture
Areas of Interest:
Building Sciences, Healthcare Architecture, Climate Responsive Architecture

Prof. Simantini Behera, Assistant Professor, Dept. of Planning & Architecture
Areas of Interest:
Vulnerability Assessment, Neighbourhood Planning, Building Sciences

1.8.2. GITAM SCHOOL OF ARCHITECTURE

Prof. Krishna Kasi, Associate Professor, School of Architecture
Areas of Interest:
Sustainable Architecture

2. PROJECT SUMMARY

2.1. PROJECT NAME: Multi-Family Staff Housing Inside Nit Rourkela Campus

2.2. PROJECT PARTNER

National Institute of Technology Rourkela

National Institute of Technology Rourkela provided us the Project details of the upcoming campus project, 144 No's Staff Quarters to be carried by the contractor Central Public Works Department (CPWD).

2.3. PROJECT DESCRIPTION

Brief description of project:

- Location: National Institute of Technology, Rourkela
- Coordinates: 22.24 N, 84.89 E
- Altitude: 218m MSL
- Climate Zone: Warm & Humid
- Typology: Multi-Family
- Current Stage: Not started yet
- Hours of Operation: 24 hrs

2.4. SITE DETAILS

- Site Location: Rourkela, Odisha
- Site Area: 12,000 sq. M
- FAR: 1.5
- Setbacks: 7 m on all sides
- Permissible built-up area – 18,000 sq. m
- Permissible Ground Coverage (30%) - 3600 sq. m
- Total Built-up Area (Each Block): 2946.30 sq. M
- Total No. of Blocks: 6

2.5. ENERGY PERFORMANCE INDEX

Goal for Energy Performance Index (EPI) 33 kWh/m^2 per year.as prescribed by GRIHA.

2.6. ON-SITE RENEWABLE ENERGY GENERATION POTENTIAL

Solar Water Heater

Required for each Person = 0.75 sq. m

As mentioned in SDI's SLM, hot water consumed per person = 50 LPCD

As per NBC 2016, no. of occupants per 1 BHK = 4

Total no. of occupants = 4*144 dwellings = 576 occupants

Total Area Required = 0.75*576 = 432 sq. m

Total Hot Water Required = 50*576 = 28,800 litres

Renewable energy generated by solar panels:

Electricity generated by 1kw solar panel = 1400 kwh/year

Carpet area of roof per wing = 295 sq. m

Total carpet area of roof (all 6 wings) = 295*6 = 1,770 sq. m

432 sq. m consumed for solar water heater; thus 1,338 sq. m is left for solar panels on the roof.

Total area for solar panels considering the partial shading impact (reducing 30%) = 1,338 – 402 = 936 sq. m
Size of the solar panel = 1.6*0.89 = 1.42 sq. m
Total no. of units = 936/1.42 = 660 units (Therefore, 660/6 = 110 units per wing)
Total electricity generated = 660*1400 = 9,24,000 kwh/yr.
(Therefore, 9,24,000/6 = 1,54,000 kW/yr per wing)

1.1. **PRELIMINARY CONSTRUCTION BUDGET:** 65,81,25,000/-

Table 1 Preliminary Estimate of Overall Construction Budget

DESCRIPTION OF WORK	**AMOUNT (Rs.)**			
	CIVIL	**ELECTRICAL**	**TOTAL**	
Building portion	421798775.00	116769435.00		538568210.00
Development of site	38537495.00	0.00		38537495.00
Total (A)	**460336270.00**	**116769435.00**		**577105705.00**
Adding effect of enhanced GST rate implemented w.e.f. 18th July, 2022 (From 12% to 18% = Multiplying factor of 1.0633)	29139286.00	7391505.00		36530791.00
Total (B)	**489475556.00**	**124160940.00**		**613636496.00**
Adding EPF & ESI charges @4.25% on (B)	20802711.00	5276840.00		26079551.00
Adding contingencies @3% on (B)	14684267.00	3724828.00		18409095.00
Grand Total	**524962534.00**	**133162608.00**		**658125142.00**
		Approx.		**65,81,25,200.00**

1.2. **TIMELINE:** The project is at infant stage.
1.3. **SPECIAL REQUIREMENTS:** To follow the CPWD manual for construction methodology

3. SUMMARY OF CASE STUDIES

3.1. CASE STUDY 1: ATAL AKSHAYA URJA BHAVAN

Location: New Delhi
Climate: Composite
Building type: Office building

- Functional spaces with continuous double-glass unit (DGU) glazing on the eastern side allow light in while preventing heat.
- A solar wall on the southern boundary of the building not only contributes to its energy sources but also shelters the structure from incident radiation.
- Western side covered **GFRC** jaails, bringing cooling breezes into the building for cross-ventilation.
- Using **PEX pipes** placed in the ceiling, water-cooled screw-chilling machines have been employed to construct a **radiant cooling system** that uniformly lowers the surface temperature.

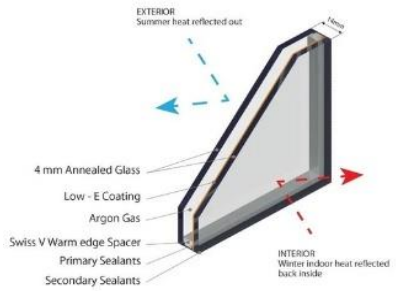


Figure 1: Double glass unit

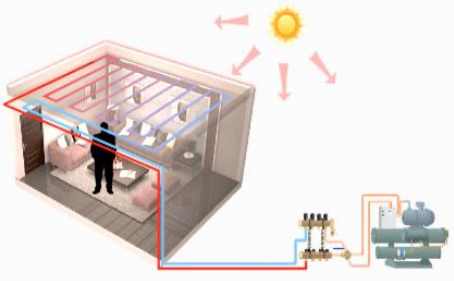


Figure 2 Radiant heating system of roofs

3.2. CASE STUDY 2: 303 BATTERY

Location: Washington
Climate: Humid Temperate
Building type: Multi-family housing

- The building is powered by solar panels distributed across the building's roof, exterior walls, and balconies.
- Onsite battery storage used to cover nighttime power use and power outages.
- Underfloor radiant heating and cooling in units providing efficient temperature interiors.
- **Regenerative gear elevators and daylight sensors** that will reduce power use throughout the building.
- A grey water system and space for urban agriculture for future tenants with gardens

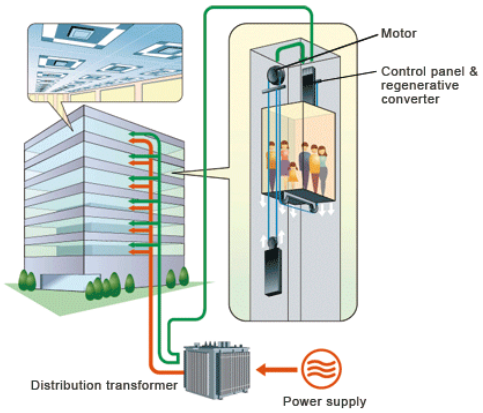


Figure 3 Regenerative Lifts

3.3. CASE STUDY 3: SHREE AUROBINDO ASHRAM

Location: New Delhi
Climate: Composite
Building type: Institutional

- Rainwater harvesting System is incorporated, and rainwater is collected from roof tops, surface runoffs and open areas, the rooftop rainwater is collected through a network of pipes and chambers then diverted to a dry open well of 15 m depth and 2m dia. The rainwater is passed through a distilling chamber before it is diverted to the well.
- Building layout planned along with hexagonal courtyards for good ventilation.
- Openable shutters to control the amount of sunlight in the rooms.
- The sill is low height to get good airflow even at the level of the bed.
- Load bearing structure reduces embodied energy by reducing the consumption of concrete and steel.
- Permanent rough white finish for high emissivity and poor absorptivity.

Figure 4 Finishes and openings

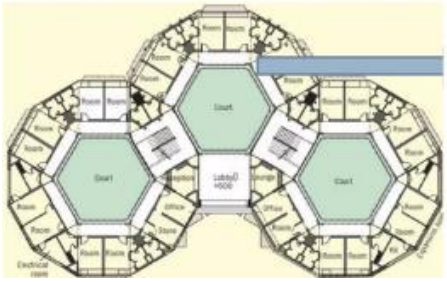


Figure 5 Courtyard Layout

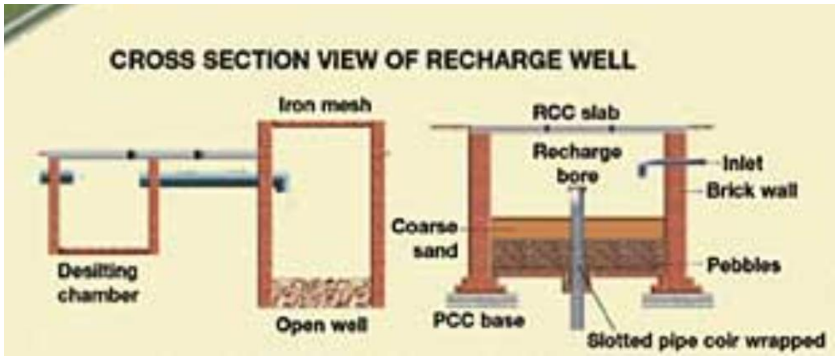


Figure 6 Cross sectional view of recharge well

4. CONTEXT ANALYSIS

4.1. LOCATION AND SITE:

Rourkela is the India's largest steel plant city, the largest city of Sundargarh district with five ultramodern, self-contained administrative zones, each with its own municipal corporation. Rourkela, located in the eastern Indian state of Odisha, is a vibrant and rapidly growing city. With a population of over 3.5 lakh people, it is a diverse and culturally rich urban centre. Known for its thriving steel industry and educational institutions, Rourkela is a significant industrial hub in the region. The city boasts a blend of traditional and modern lifestyles, making it an intriguing place to explore.

The NIT campus is situated in Rourkela, Odisha, and covers 1200 acres of land. The Staff Quarters project site is located within the campus, adjacent to Water Treatment Plant in the south-west corner of the campus.

4.2. CAMPUS ENVIRONMENT:

The institute is bordered by small mountains on the south which are sometimes used as a picnic spot by students.

4.3. ACCESSIBILITY:

The city of Rourkela came into prominence in the year 1954-55, with the decision of the Government of India to set up the first Public Sector Steel Plant in this locality in collaboration with the then West Germany. The city is a medium-sized metropolis connected with all parts of the country by railway and road. The population of the city is about 6 lakhs.

4.4. INFRASTRUCTURE AND UTILITIES:

The campus of the Institute consisting of the Institute buildings, halls of residence and staff colony is situated at the eastern end of Rourkela steel city, beyond Sector-1 over a land provided by the Government of Orissa. It is a residential campus offering accommodation to faculty, staff and students. The campus has all the amenities for developing personal, social and academic skills of the student community.

4.5. ELECTRICITY & SEWAGE:

Receives current from the OPTCL Chhend Grid to the Main-Receiving Sub-station further connected with the ring main system in the campus connecting with 12 substations of 33KVA. Proposed Central Sewage Treatment Plant.

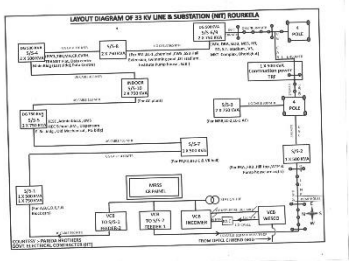


Figure 7 Power grid distribution System at NIT Rourkela

4.6. CAMPUS GROWTH AND FUTURE NEEDS:

The campus is expanding rapidly, and the future upcoming project complex includes the 500-seater Girls Hostel, 1000-seater Boys Hostel, Kendriya Vidyalaya and the 144 no's Multi-Family Housing Staff Quarters.

4.7. STAKEHOLDER NEEDS:

To provide convenient and secure housing for their employees and providing a comfortable living arrangement close to their workplace, reducing commute times and improving overall work-life balance.

4.8. REGIONALLY AVAILABLE MARKET:

Fly ash continues to be treated as a waste product, which contributes nearly 85% of the fly ash generated in India. So, fly ash is easily available material.

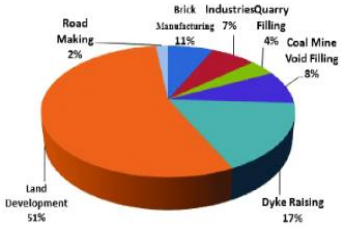


Figure 8 Various Usages of Flyash

5. GOALS

5.1. ENERGY PERFORMANCE:

Goal: To attain EPI < 33 kWh/yr/m2

5.2. STRATEGY:

Thermal Mass: Incorporate thermal mass materials (e.g., concrete or masonry) to store heat during the day and release it at night, providing passive temperature control. Installing solar panels or other renewable energy systems to offset electricity consumption. Optimize building orientation to minimize direct sun exposure during hot months and maximize it during cold months Radiant cooling systems are often more energy-efficient than traditional forced-air cooling systems, such as air conditioning, as they can operate at higher chilled water temperatures, reducing the energy required for cooling.

5.3. WATER MANAGEMENT:

Goal: Target per capita water consumption: 70 LPCD.

Strategy: Using recharge borewells Using water-efficient fixtures and appliances, irrigation equipment, sustainable landscape design solutions, enhanced operation and maintenance of water systems. Reducing the storm water runoff by installing rain gardens, permeable pavements, green roofs, infiltration planters, rainwater harvesting systems, etc so that it. can help storm water to infiltrate the original water source. Water sub-metering and smart water metres for apartments.

5.4. WASTE MANAGEMENT:

Goal: To generate 40000-litre biogas from wet waste production kg/day and generate revenue from MRF for Dry waste.

Strategy: Using techniques like MRF, composting and biogas generation which helps with building autonomy and revenue generation. Efficient housekeeping system infused with app to encourage people towards better waste management and minimize product of waste. To create an efficient and stable waste management and segregation system so the further process becomes simpler.

5.5. ARCHITECTURAL DESIGN:

Goal: Dealing with the harsh winters and summers by using adaptive design strategies to extend internal comfort hours while simultaneously maintaining comfort in the outside environment.

Strategy: Employing double glass glazing to restrict the flow of external heat in the summer and retain internal warmth in the winter. Radiant heating and cooling systems to keep the building's interior at a comfortable temperature throughout the year. Operable facade systems maintaining better wind flow and cross-ventilation

5.6. AFFORDABILITY:

5.6.1. GOAL:

Dealing with the harsh winters and summers by using adaptive design strategies to extend internal comfort hours while simultaneously maintaining comfort in the outside environment.

5.6.2. STRATEGY:

Employing double glass glazing to restrict the flow of external heat in the summer and retain internal warmth in the winter. Radiant heating and cooling systems to keep the building's interior at a comfortable temperature throughout the year. Operable facade systems maintaining better wind flow and cross-ventilation

6. BUILDING AREA PROGRAMME

6.1. AREA CALCULATIONS

Site area: **12,000 sq. m**
Total no. of dwellings = **144 units**
Total no. of wings = 6 wings (A, B, C, D, E, F)
Total no. of dwellings per wing = 144/6 = 24 dwellings
Each wing will have **stilt + 6 floors.**
Therefore, no. of dwellings per floor in a wing = 24/6 = 4 dwellings
Built-up area per wing = floor area*no. Of floors = 420*6 = **2520 sq. m**
Total built-up area of all the wings = 2520*6 = **15,120 sq. m**
Landscape area = Site area – Ground coverage = 12,000 – 2520 = 9,480 sq. m

6.2. LIST OF SPACES

Table 2 List of Spaces in a Typical Dwelling Unit

SPACES	SUB-SPACES	AREA(SQ.M)	USER PER UNIT	TOTAL AREA PER FLOOR	CONDITIONING
DWELLING UNIT	BEDROOM	12	4	188	UNCONDITIONED
	TOILET	3			
	LIVING ROOM	15			
	KITCHEN	9			
	UTILITY BALCONY	4			
	BALCONY	6			
	TOTAL AREA PER DWELLING	**49**			
SERVICES	STAIRCASE	25		73	UNCONDITIONED
	FIRE STAIRCASE	20			
	LIFTS AND LOBBY	28			
TOTAL AREA WITHOUT CIRCULATION				**261**	
25% CIRCULATION				**65**	
TOTAL BUILT AREA				**326**	

7. FINDINGS FROM PRE-DESIGN ANALYSIS

7.1. CLIMATE ANALYSIS:

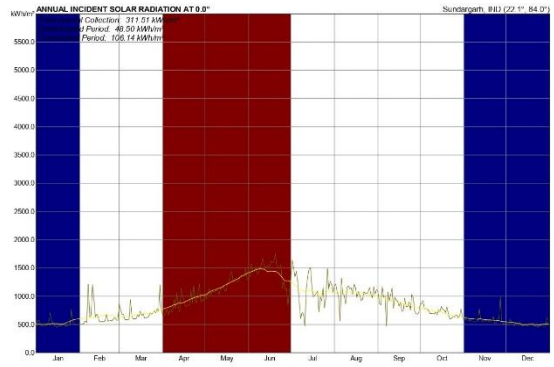
Rourkela comes under warm-humid climate zone under Koppen climate classification. The site is in Sundargarh District which falls under the Warm and Humid Climate Zone as per ECBC 2017.

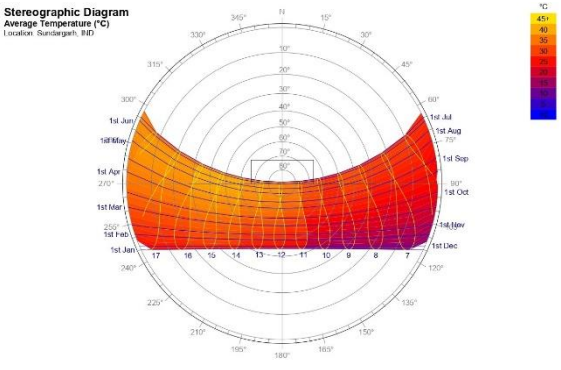
Experiences high temperatures, especially during the summer months. Daytime temperatures often exceed 40 degrees Celsius. Winters are relatively mild, with daytime temperatures typically ranging from 15 to 25 degrees Celsius.

Has high humidity levels throughout the year, particularly during the monsoon season. Relative humidity can often exceed 80%, leading to a muggy and uncomfortable environment.

Experiences a significant monsoon season from June to September, bringing heavy rainfall. The southwest monsoon winds bring intense downpours, contributing to a lush and green landscape. The heavy monsoon rains can lead to localized flooding, and proper drainage infrastructure is crucial for managing rainwater.

The peak summer design hours are in the month of May and June. The stereographic diagram of the average temperature denotes that the peak design hours in the summer season is approximately between 11am and 5pm. The average annual wind chart shows that the prominent wind direction from the east direction. The summer wind chart shows that the harsh summer wind from the south-west and west should be tackled efficiently.





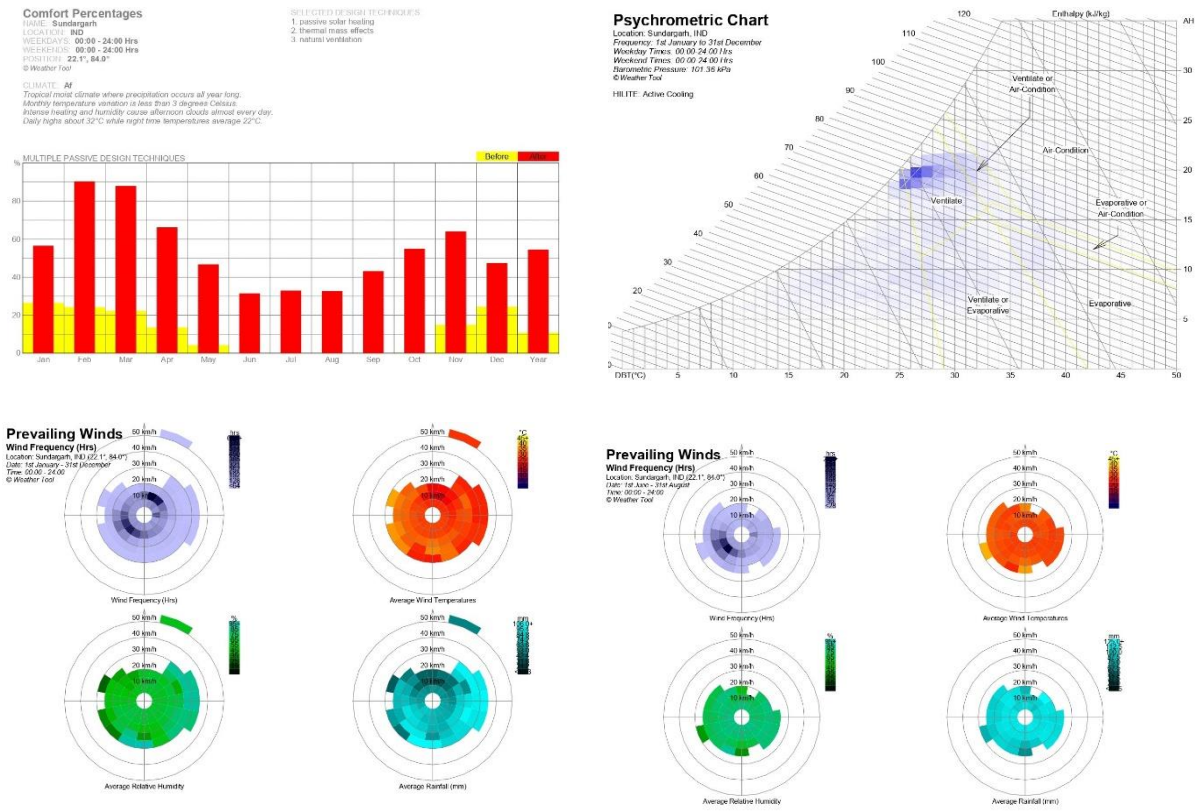


Figure 9 Climate-analysis conducted in Ecotect

The peak summer design hours are in the month of May and June. The stereographic diagram of the average temperature denotes that the peak design hours in the summer season is approximately between 11am and 5pm. The average annual wind chart shows that the prominent wind direction from the east direction. The summer wind chart shows that the harsh summer wind from the south-west and west should be tackled efficiently.

INFERENCES:

- trees and greenery can contribute to cooling effects and improve outdoor comfort
- passive cooling strategies, such as natural ventilation, shading devices, and thermal mass, to enhance indoor comfort.
- rainwater harvesting and drainage solutions, are essential due to the significant rainfall during the monsoon.
- longer sides of the apartment building along the north-south axis to minimize direct exposure to the east and west sun.
- natural cross-ventilation
- use of materials with high thermal mass & use glazing with lower SHGC
- roof insulation and wall insulation

7.2. SITE ANALYSIS:

The site lies inside the NIT Rourkela campus, surrounded by mountains on the south and west sides and a rich green landscape on the west. The major entrance to the site is from the north side via the southern avenue road, and it has NITR residential quarters on the opposite side and a water treatment plant on the eastern side.

Strength

- Dense vegetation on 3 sides providing buffer and views
- Mountain range on the south side provide good views
- An electric connection is already provided at the site

Weakness

- No central STP present in campus
- contours

Opportunity

- Water treatment plant near site providing easy water supply

Threat

- In monsoons water logging can create issues as the site is situated near mountain ranges

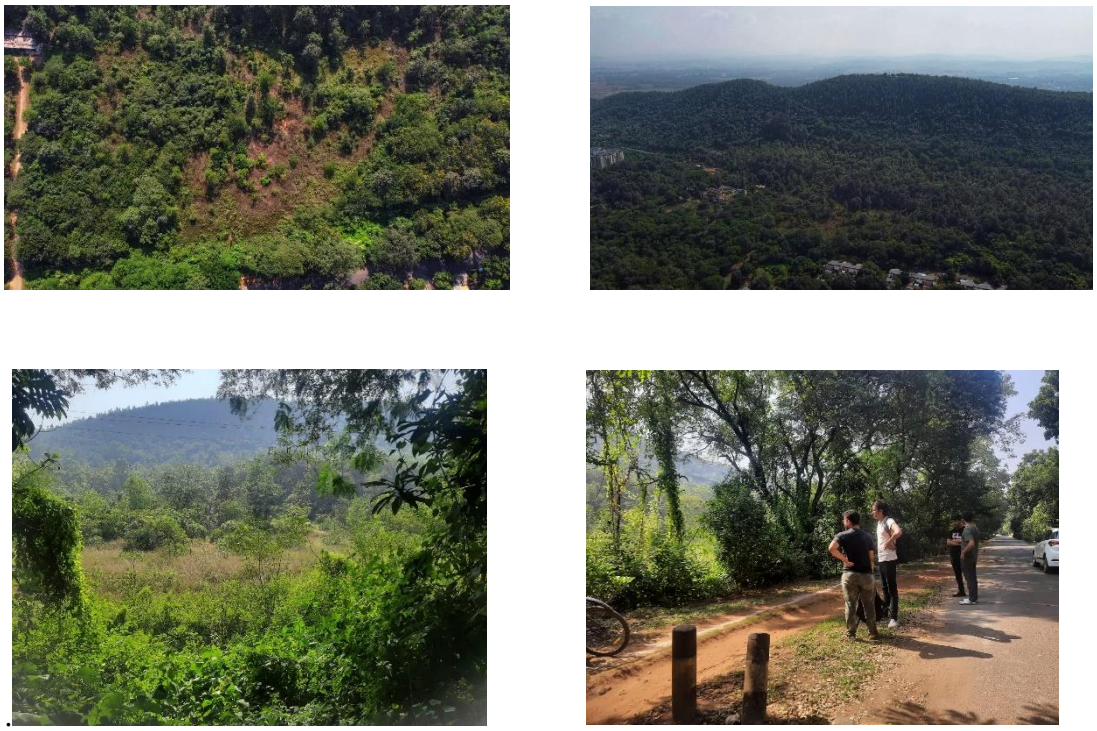
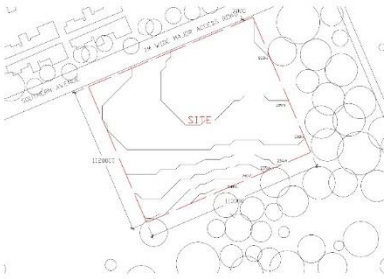
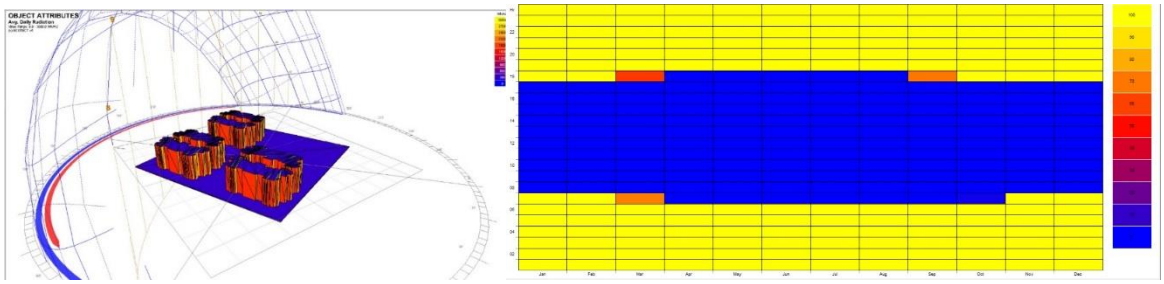
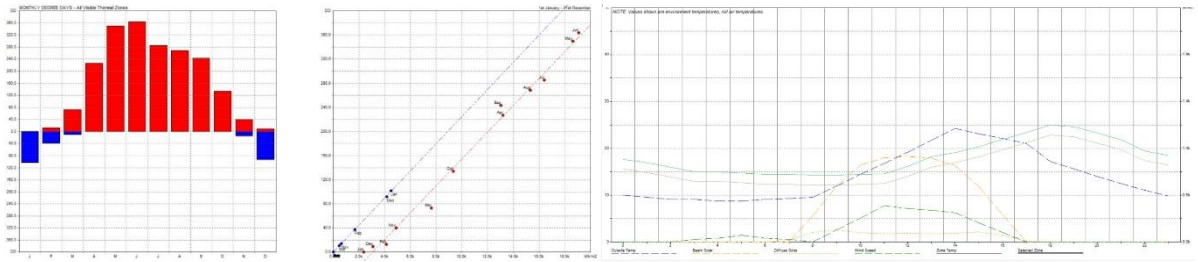


Figure 10 Views of the Site



7.3. PRELIMINARY ENERGY AND THERMAL ANALYSIS USING SIMPLE BOX MODELS:





The above following is analysis done using Autodesk Ecotect Analysis using block model. The above images show the surface radiation analysis on vertical and horizontal surfaces of the building irrespective of the construction material.

These analyses are performed on simple model to understand the overall radiation in the entire year from 8am to 6pm.Since Roof area is almost covered by solar panels and type of roof, we are using is cool-type roof.

1.Solar radiation on the horizontal surface (roof of the building) is almost equal throughout the year.

2.solar radiation maximum spread over north-east and south-east faces. To avoid, that amount of radiation, we are using shading devices fenestration on those surfaces.

3. And the rest of directional sides, we can use for more and regularly occupied spaces.

8. RESILIENCE

8.1. MEASURES:

- **Climate-Resilient Design:** Since the location is close to mountain ranges, water logging might occur during the monsoon season. Utilising contours and locating the building above flood level will help us tackle the problem. We can use the wet flood proofing technique in this case. Wet floodproofing involves controlled and safe passage of floodwater through lower levels of the house.
- **Building Materials and Construction:** Use durable and weather-resistant materials that can withstand the local climate's challenges. This includes materials with high resistance to moisture, corrosion, and degradation due to exposure to heat and sunlight. Implement construction practices and designs that are resilient to high wind speeds. This includes proper anchoring of roofing materials and exterior elements to withstand strong gusts during storms.
- **Emergency Preparedness:** Considering the planning of secure escape routes and locations for emergency gatherings. Install emergency power backup devices, such solar-powered backup or generators, to guarantee that critical services continue to run in the case of a power loss, which can happen under extreme weather conditions.
- **Community Resilience:** Foster a sense of community resilience by engaging residents in disaster preparedness and response. Develop community initiatives that promote cooperation and mutual support during emergencies. Integrate local resources and traditional building practices that have proven resilience to the climate. This may involve incorporating vernacular architecture principles that have stood the test of time in the region.
- **Regulatory Compliance:** Ensure that the design complies with local building codes and standards related to resilience and disaster preparedness. This may include specific requirements for flood-resistant construction, wind load resistance, and other safety measures.
- **Continuous Monitoring and Maintenance:** Implement a regular inspection and maintenance schedule to assess the condition of the building and address any wear and tear promptly. This helps ensure that the structure remains resilient over time.
- **Integration of Smart Technologies:** Incorporate smart building technologies that enable real-time monitoring of various parameters, such as weather conditions, structural integrity, and energy consumption. This facilitates proactive responses to changing circumstances.

9. ENERGY AND WATER CALCULATIONS

9.1. ELECTRICAL LOAD:

Electrical load = Lighting load + Plug load + HVAC load + Equipment load

Lighting Load

As per ECBC, lighting power density for residential building is 7.5W/sq. m

Total Lighting Load = Built-up area * LPD * 0.001 = 15,120 * 7.5 * 0.001 = 113.4 kW

Maximum Demand = Connected load * Diversity factor = 113.4 * 0.9 = 102.06 kW

Plug Load

Plug load density for residential building is 10W/sq. m

Total Plug Load = Built-up area * PLD * 0.001 = 15,120 * 10 * 0.001 = 151.2 kW

Maximum Demand = Connected load * Diversity factor = 151.2 * 0.9 = 136.08 kW

HVAC Load

For residential building = 65% of the built-up area

AC area = 0.65 * 15,120 = 9,828 sq. m / 1,05,787.7 sq. ft

Since, sq. Ft/tr for residential building is 280.

Total HVAC Load = [AC area / (sq. ft/tr)] * 1.2 = [1,05,787.7 / 280] * 1.2 = 453.38 kW

Maximum Demand = Connected load * Diversity factor = 453.38 * 0.9 = 408.006 kW

Equipment Load

Load factor for residential building is 20 W/sq. m

Total Equipment Load = Built-up area * Load factor * 0.001 = 15,120 * 20 * 0.001 = 302.4kW

Maximum Demand = Connected load * Diversity factor = 302.4 * 0.75 = 226.8 kW

Total Electrical Demand Load = 102.06 + 136.08 + 408.006 + 226.8 = 872.95 kW

10. APPENDIX-I (Letter from Project Partner)

राष्ट्रीय प्रौद्योगिकी संस्थान
NATIONAL INSTITUTE OF TECHNOLOGY
राउरकेला ROURKELA - 769008, ओडिशा ODISHA

RIGHT TO INFORMATION

No. NITR/DN/2023/L/0162

Date: October 04, 2023

To
The Director
Solar Decathlon India

Dear Sir,

This is to inform you that our organization National Institute of Technology Rourkela has provided information about 'multifamily staff housing at NIT Rourkela campus' project to the participating team led by National Institute of Technology Rourkela, so that their team ZeroGrid may use this information for their Solar Decathlon India 2023-24 Challenge entry.

As a Project Partner to this team for the Solar Decathlon India 2023-24 competition, we are interested in seeing the Net-Zero-Energy, Net-Zero-Water, resilient and affordable solution this student team proposes and the innovation that results from this.

We would like to have a representative from our organization attend the Design Challenge Finals event in April/May, if this team is selected for the finals.

We would like our organization's logo to be displayed on the Solar Decathlon India website, recognizing us as one of the Project Partners for the 2023-24 Challenge.

We would like our contact information to be shared with DesignBuilder Australia who provides energy simulation software to our team during the Solar Decathlon India Challenge.

With warm regards,

(PRADIP SARKAR)

Name of Representative: Prof. Pradip Sarkar
Designation: Dean of Planning and Development
Email: dean-pd@nitrkl.ac.in
Phone: 0661-246-2013

11. References

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