

Technical Advisory for Climate-Smart Cooling Solutions for Vulnerable Urban Communities in Bhubaneswar

Final Comprehensive Report

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1. Executive Summary

As the temperatures are on the rise, the coastal and riverine regions are particularly susceptible to humid heat, which refers to high temperature combined with high moisture. This exerts considerable physiological strain on the body. In response to this, the body begins to sweat. As this sweat evaporates, it cools down the body. Since the environment is already humid, the evaporation slows down and fails to lower the body temperature. This gives rise to one of the many damaging effects of high heat in the form of heat stroke. Extreme heat also alters how our brain functions, which can lead to neurological side effects, hence adversely affecting decision-making abilities and increasing the likelihood of people taking greater risks¹. This can further marginalize vulnerable populations by making them susceptible to other heat-related health conditions and thereby increasing the burden of escalating healthcare bills, risks to livelihood, and productivity.

To work on this problem, this project seeks to identify, evaluate, and guide the implementation of climate-smart, affordable, and context-appropriate cooling solutions designed for vulnerable urban communities in Bhubaneswar. These high-risk groups include street vendors, micro and small businesses, and public institutions such as Anganwadi centers, primary healthcare centers, and community centers. The project focuses on these vulnerable groups and spaces, as they often lack access to sustainable, efficient, affordable cooling and are disproportionately exposed to heat stress². To protect these high-risk groups from the catastrophe of global warming, proactive interventions before summer and high-temperature months can significantly reduce its impact by improving thermal comfort.

Through this engagement, cBalance will serve as a technical advisor and implementation support partner to the SELCO foundation for eight months, starting from October 2025. The work will focus on both passive and active space and storage cooling. This will improve access to thermal comfort in working, service delivery, and community environments while also supporting livelihoods by protecting perishable and temperature-sensitive goods.

cBalance's approach focuses on co-creating thermal comfort interventions that can be scaled to help more people and on building local skills. Through listening and participatory design workshops, the project will involve key stakeholders in collaborating, contributing insights, and supporting the implementation of sustainable cooling solutions to maximize impact in vulnerable urban communities. This will enable communities in Bhubaneswar to manage, use and maintain these co-created cooling solutions in the long term.

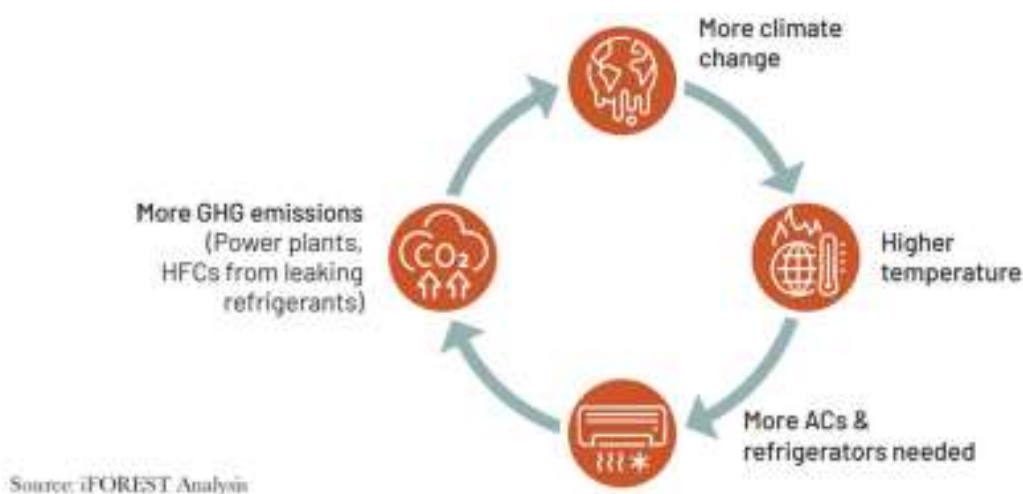
¹<https://bbc.com/future/article/20250731-how-heatwaves-affect-our-brains>

² <https://www.mahilahousingtrust.org/knowledgehub/heat-stress-and-impact-on-communities/>



2. Background and Context

Sleepless summer nights, unbearable daytime temperatures inhibiting household activities, health conditions such as nausea, headaches, heart palpitations, and dizziness are a few of the many heat stress-related issues plaguing the lives of people from marginalized urban settlements. While people in affluent homes seek thermal comfort through climate-polluting and energy-intensive technologies such as air conditioners (a typical one-ton split AC in India consumes as much power as 25 ceiling fans³), especially during peak summers, the marginalized often live and work in cramped, poorly ventilated house structures with scant protection from solar heat. Additionally, the affluent often possess backup power sources (diesel generators, etc) to permit constant energy use during planned power cuts induced by the high demand of energy for indoor cooling, while the urban poor are unable to even operate a ceiling or floor fan (ventilator) to maintain a modicum of comfort during peak summers, increasing their vulnerability to thermal distress. Given the prevailing climate crisis, temperatures are bound to increase in the coming years. Therefore, to alleviate energy burdens and provide affordable indoor cooling to people from marginalized sections, there is a need to resort to retrofitting structures with passive cooling solutions that provide thermal comfort with minimal energy usage.



4

³ <https://thebetterindia.com/300827/heat-stress-waves-kills-indians-but-mud-homes-lattice-buildings-sustainable-architecture-can-help/>

⁴ Acknowledgement- IHCAP- Integrated Heat and Cooling Action Plan Report for Bhubaneshwar by iFOREST published in September 2025, Figure 1.2, Chapter 1

The city of Bhubaneswar is becoming hotter, and the increasing humidity is causing its inhabitants to experience excessive discomfort. The heat stress of the city is projected to grow sevenfold by 2050⁵. The prolonged heat months of summer make it much tougher and more dangerous for people working outdoors.

These conditions place an additional burden on the following typologies, which serves a critical functional role in the community:

- Street vendors operating in exposed vending zones or under temporary structures without shade or ventilation.
- Micro and small businesses, especially those whose working environments are not thermally conducive during work hours.
- Anganwadi centres (government-sponsored childcare and maternal health centers), Primary Health Centres (basic healthcare facilities at the neighborhood level), and community centres that deliver critical services in thermally uncomfortable environments.

As a result, critical public-facing settings experience greater health risks, lower productivity, reduced comfort, increased risks of spoilage, financial losses, and compromised service quality. Standard active cooling solutions, such as conventional air conditioning, are not feasible in these environments as they generate high carbon emissions, add heat to the surroundings, incur high capital and operating costs, rely on unreliable or expensive energy sources, pose structural challenges, and exceed local maintenance capacity. A careful examination of the lifecycle cost of an air conditioner is enough to dispel the myth that it solves the heat issue.

In this context, there is an alarming opportunity to introduce climate smart active passive or low energy cooling solutions such as shading/radiant barrier (materials or structures that reflect sunlight and block heat), insulating materials (building materials that reduce heat transfer), thermal mass improvement (enhancing a building's ability to absorb and slowly release heat), ventilation enhancement (increasing air movement to cool interiors), PCM (Phase Change Material) based cooling (using substances that absorb and release heat during phase changes, such as ice gel packs), and appropriate low energy storage cooling paired with practical installation guidance and basic operation and maintenance support.

⁵ <https://www.newindianexpress.com/cities/bhubaneswar/2025/Sep/03/bhubaneswars-heat-stress-to-grow-sevenfold-by-2050-ihcap-report>

During the preliminary study to understand the problem statement, several difficulties were observed as follows.

- These solutions are not consistently cataloged or evaluated for this specific context.
- Vendors and fabricators may exist, but they are not always visible to end-users or local institutions.
- Communities and frontline service providers are rarely brought into the technical selection process in a structured way.
- There is limited performance documentation in real-use conditions in Bhubaneswar.

SELCO Foundation intends to bridge this gap by piloting and documenting scalable solutions. cBalance will provide technical research, field-aligned methodology, advisory support during implementation, and a monitoring and learning framework to ensure that solutions are both effective and adoptable.

3. Objectives of the Study

This section lists down the objectives of the program. This has been further broken down into detailed actionable points under scope of work section.

- To assess and map passive cooling solutions (Space & Storage), including their technical, financial, and operational characteristics relevant to urban vulnerable settlements.
- To build a database of vendors and solution providers, along with preliminary evaluations to support selection.
- To assist in raising awareness among end-users, e.g., street vendors, micro-businesses, and Institutions on cooling solutions.
- To assist in developing selection criteria for end-users and intervention sites to ensure the suitability, impact, and sustainability of the solutions.
- To recommend tailored cooling solutions for each selected site or user group based on need assessment and market analysis.
- To establish a baseline and monitoring framework for evaluating the performance and effectiveness of implemented solutions over time.
- To assist in implementing the shortlisted solutions and post-implementation training of the shortlisted solutions.
- To document and catalogue the selected cooling interventions, highlighting their technical specifications, use cases, suitability, and relevance to different end-users.
- To synthesize findings and recommendations into a comprehensive final report outlining lessons learned, impacts, and potential scaling.
- Co-design and execution of knowledge sessions with practitioners, including recommendations, briefing of practitioners, and documentation of learnings through the knowledge sessions.



4. Scope of Work

This section outlines the scope of work and provides a brief description of the actionable points to be followed under each listed point. The project will be carried out within the administrative boundary of Bhubaneswar city.

4.1. Solution and vendor market research and mapping

- Identifying, evaluating, and mapping passive cooling solutions suitable for vulnerable urban settlements
- Space and storage cooling solutions to be researched and mapped for micro businesses, Street vendors, and public institutions such as Anganwadi health centres and community centres
- Undertaking market mapping of relevant solution vendors and manufacturers
- Assessment of the solutions based on technical, financial, and operational feasibility
- Undertaking exposure visits to the selected communities to understand the heat impact context of the end user

4.2. Solution awareness and engagement with the target end user

- Providing support to the SELCO Foundation and building awareness among the target user groups about the potential benefits and impacts of the cooling solution.
- Providing content and technical input for awareness materials, which include presentations, brochures, and posters.
- Participating in focus group discussions and awareness events to communicate potential context-based solutions.

4.3. Needs assessment

- Developing methodologies and tools to assess user-specific needs.
- Defining and setting the selection criteria for selecting the pilot implementation sites.
- Coordinating with the SELCO Foundation team and other stakeholders in conducting the needs assessment and selecting suitable intervention sites for implementation of the solutions.



4.4. Finalization of solutions to suit individual user interventions

- Recommending relevant site/user context-specific cooling interventions based on the evaluation of the assessment outcome.
- Visiting identified target sites/areas in order to validate the recommendations and ensure contextual fit of the proposed solution.

4.5. Support and impact evaluation of the implemented sites

- Developing a comprehensive evaluation framework for monitoring the baseline, midline, and endline impacts of the intervention.
- Defining and incorporating evaluation key impact parameters related to thermal comfort and energy efficiency.
- Designing and developing data collection tools that include questionnaires, forms, and templates.

4.6. Create a catalog of solutions

- Solution details product sheets, specifications, and applications..
- Implementation guidelines and best practices to be followed.
- A Step-by-step implementation manual execution guide.
- Dos and don'ts for the implementation and execution process.

4.7. Implementation and post-implementation training

- Identifying and building the capacity of contractors and vendors that are champion implementers for implementation support
- Providing technical assistance during the design and on-site monitoring of the implementation of selected solutions to ensure quality and compliance
- Providing post-implementation training so as to enable the user to adopt, troubleshoot, and maintain their solutions

4.8. Documentation, stakeholder presentations, and reporting

- Preparation of the final comprehensive report that covers the methodology used, activities that were undertaken, results achieved, and lessons learned.
- Reporting, sharing, and presentation of the main insights, learnings, and key findings from the engagement to the stakeholders.



4.9. Knowledge partner support for the knowledge series

- For designing and executing knowledge sharing sessions with stakeholders and practitioners to achieve clearly defined objectives.
- Documentation of insights and disseminating recommendations from these engagements.

5. Research Methodology

This section introduces the research method, steps, and explains the approach that will be followed in the study, based on project requirements. The process combines community engagement aspects through participatory decision-making to absorb and integrate local context-based inputs, thereby supporting the sustainable and scalable implementation of solutions.

5.1. Primary and Secondary Data Collection

5.1.1. Primary Data Sources

- Focus group discussions with end users across the shortlisted sites.
- Structured interviews with street vendors, micro business owners, anganwadi staff, primary healthcare staff, and community center representatives.
- Observation of structural conditions (exposure to sun, ventilation, shading, available energy sources, storage practices, etc.)
- Interactions with solution vendors, manufacturers, and fabricators in the market to understand the supply chain ecosystem, product manufacturing processes, and associated costs.

5.1.2. Secondary Data Sources

- Existing market intelligence on passive and active and low-energy cooling approaches.
- Product and technical specifications from solution providers.
- Any available prior assessments done by industry experts, academia, or partner reports shared by the SELCO Foundation.



5.2. Sampling Outline

Sites: The initial sampling frame comprises five shortlisted locations in the city of Bhubaneswar, based on the vulnerability assessment study conducted by the SELCO Foundation.

- a. Shikhar chandi Slum
- b. Jokalendi Slum
- c. B.R. Ambedkar Vending Zone
- d. Salia Sahi Slum, Tarininagar
- e. Maa Pata Devi Slum

Users: To understand and identify user requirements and their thermal comfort needs, sampling at each location will take into account diverse user groups such as

- a. Street cart vendors, including operators of perishable goods such as vegetables, fruits, fish, etc.
- b. Childcare and health service providers, anganwadi staff, community representatives
- c. Children and youth

Material suppliers, vendors, and fabricators: To assess affordability, adaptability, and scalability potential, the sampling strategy will include the following

- a. Formal or established suppliers
- b. Informal local masons, bamboo artisans, and fabricators
- c. Women's self-help groups that are working to co-create locally sourced and sustainable material supply chains.

5.3. Data Collection Methods

Preliminary structure audit questionnaire to capture quantifiable aspects such as:

- a. Hours of peak heat exposure
- b. Current coping methods
- c. Access to shade, ventilation, and storage cooling
- d. Duration of electricity supply outage
- e. Type of roof structure
- f. No. of users

- A comprehensive structural audit for detailed physical assessment of the structure will be conducted after the shortlisting of structures based on a preliminary structural audit.
- Focus group discussions, in the form of listening and participatory design workshops, will be conducted to gather qualitative insights into user preferences, perceived usefulness, cost, safety considerations, space constraints, user suggestions on the design, its working, maintenance, and practical challenges associated with the thermal discomfort.
- Vendor profiling interviews that document product types, customization ability, after-sales support, indicative price range,



operating physics principle, and applications.

5.4. Analysis and Solution Matching

Comparative analysis of solutions against user site needs and constraints. A mapping matrix that links:

- Site User Needs
- Shortlisted Solutions
- Available Vendors, Fabricators
- Cost
- Operation and maintenance constraints.

The scoring and prioritization process will identify 5 to 6 shortlisted best-fit solutions, followed by the selection of three to four solutions for implementation.

5.5. Monitoring and Evaluation Framework Design

cBalance will develop a monitoring and evaluation framework for use by SELCO Foundation during and after the installation phase. The framework will define baseline, midline, and endline stages.

Key indicators will include

- a. Mean Radiant Temperature
- b. Under Roof Temperature
- c. Dry Bulb Temperature
- d. Humidity

cBalance will also prepare data collection forms tailored for each stage of the monitoring and evaluation process.

5.6. Documentation and Knowledge Transfer

cBalance will prepare a detailed documentation for each intervention, which includes technical specifications, installation procedures, and operating guidelines.

This documentation will feed into

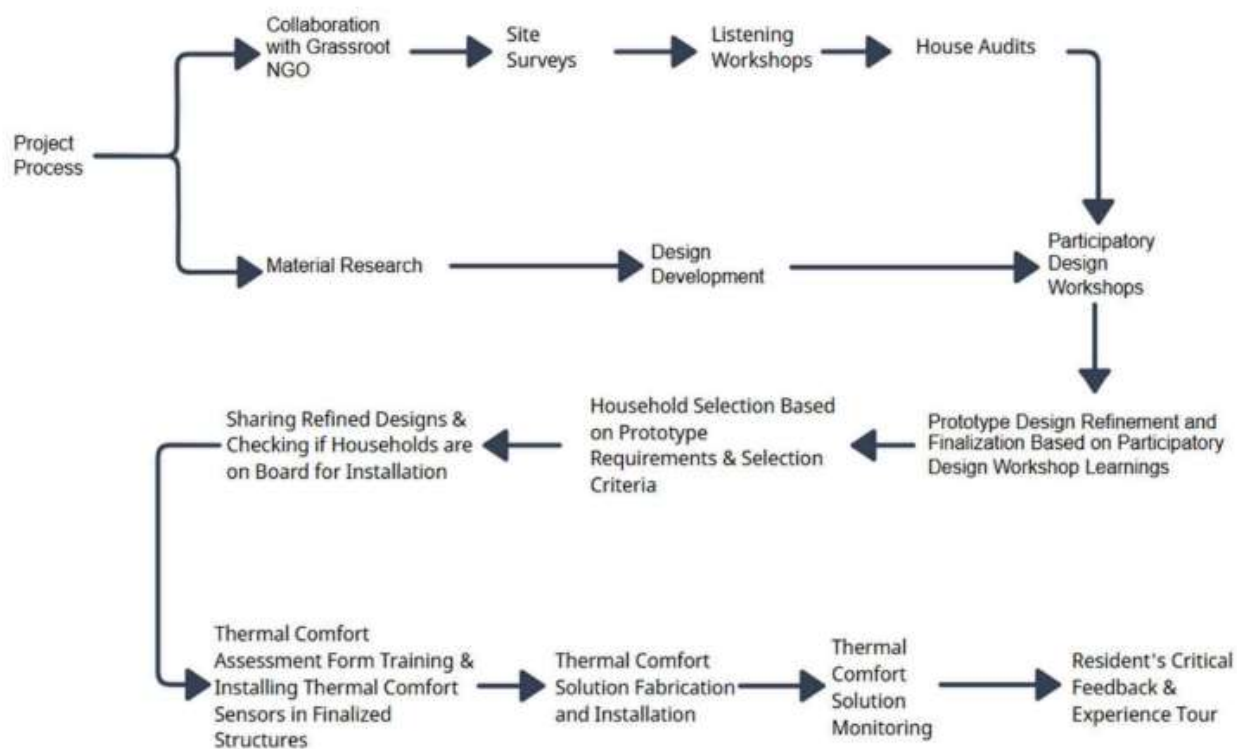
- a. Solutions catalog which contains technical specifications, use cases, dos and don'ts, and step-by-step guidance.
- b. Final report and presentation that will consolidate the methodology, activity results, lessons learned, and critical feedback.

This methodology has been designed taking into consideration our previous thermic learnings and process evolution over the years across different cities of India. The process is open to modification and review during the entire engagement, as and when there is a need to restructure it.



6. Project Process Flow Chart

A brief skeleton overview of the core design and solution implementation process.



7. Overview of Market Research

7.1. Outputs

The primary outputs of this report can be categorised as follows:

- A short list and detailed profile of 48 active and passive solutions.
- 13 domestic solution case studies.
- Database of 33 vendors, manufacturers and solution providers, including vendor profiles with preliminary evaluation.

8. Market Research Methodology

This section explains the methodological framework used to conduct the market research and mapping exercise. It describes the sequential steps followed from literature review to stakeholder consultations and comparative evaluations.

8.1. Research Design

8.1.1. Internet Research

This included product technical specifications, working principle, variant nomenclature, operating and maintenance procedures, durability, cost, vendors in the city of Bhubaneswar, fabricators etc related to the identified cooling solution.

8.1.2. Field Research and Stakeholder Interviews

This included surveys, interviews and field discussions done at the shortlisted sites, interactions with users and vendors.

1. Sites: The initial sampling frame comprised five shortlisted locations in the city of Bhubaneswar, based on the vulnerability assessment study conducted by the SELCO Foundation.
 - a. Shikhar chandi Slum
 - b. Jokalendi Slum
 - c. B.R. Ambedkar Vending Zone
 - d. Salia Sahi Slum, Tarininagar
 - e. Maa Pata Devi Slum
2. The finalized sites as as follows:
 - a. B.R Ambedkar Vending Zone
 - b. Bharatpur
 - c. Shikharchandi
3. Users: To understand and identify user requirements and their thermal comfort needs, sampling at each location was conducted so as to develop a comprehensive database of diverse user groups which included the following:
 - a. Street cart vendors, including operators of perishable goods such as vegetables, fruits, fish, etc.
 - b. Childcare and health service providers, anganwadi staff, community representatives
 - c. Children and youth



4. Material suppliers, vendors, and fabricators: To assess affordability, adaptability, and scalability potential, the sampling strategy included the following:
 - a. Formal or established suppliers
 - b. Informal local masons, bamboo artisans, and fabricators

8.1.3. Comparative Evaluation

This included the performance evaluation of the identified cooling solutions based on the parameters as listed under Section 2.2. Fabricator evaluation parameters are listed under Section 8.1.1.

Vendor Product evaluation parameters are listed under Section 7.

8.2. Evaluation Criteria

This section defines the criteria employed for performing a rigorous technical, cost, operation & maintenance need, scalability, and use-case evaluation for every relevant passive and active cooling solution.

8.2.1. Technical Specifications

Technical Specification parameters used to evaluate the cooling solutions including passive and active cooling are presented in the Table below.

Sr No.	Technical Specifications
1	Cooling Mechanism
2	Compressor Type
3	Construction Material
4	Insulation/Functional Layer
5	Capacity - Min. Value (kg, litres, MT, sq. ft., TR, W)
6	Capacity - Max. Value (kg, litres, MT, sq. ft., TR, W)
7	Power Input (V)
8	Power Input Type (AC/DC)
9	Refrigerant Type (R134a, R290, R600a)
10	Battery Type (Lithium Iron Phosphate (LiFePO ₄), Lead Acid)
11	Max. Ambient Operating Temperature (oC)
12	Max. Ambient Operating RH (%)

Sr No.	Technical Specifications
13	Lifespan (years)
14	Weight (kg)
15	Integrability with Solar (Yes/No)
16	Mobility (Stationary/Portable/Mobile)
17	Installation Time (hrs)
18	Cooling Capacity Range - Low Value (W/liter)
19	Cooling Capacity Range - High Value (W/liter)
20	Internal/Product Temperature Reduction (oC)
21	Air Temperature Reduction (oC)
22	Surface Temperature Reduction (oC)
23	Power Consumption (W/liter, W/TR., W/sq.ft., W/MT)
24	Energy Consumption (kWh/liter/day, kWh/TR/day, kWh/sq.ft./day, Wh/liter/day)

8.2.2. Cost

Sr No.	Cost
1	Capital Cost (INR)
2	Other Capital Cost (INR) (includes auxiliary support items)
3	Operating Cost - Energy (INR/liter/year)
4	Maintenance Cost (INR/year)

8.2.3. Operation And Maintenance

Sr No.	Operation and Maintenance
1	Daily Operation Process
2	Routine Maintenance Process
3	Frequency

Sr No.	Operation and Maintenance
4	Spare Parts & Service Availability - within Locality
5	Spare Parts & Service Availability - within City
6	Spare Parts & Service Availability - within State
8	Skill Level Required - Evaluation

8.2.4. Use Case

Sr No.	Use Case
1	Use Case (Application 1, Application 2, ...n)
2	User Group (Street Vendor, Micro and Small Business, Institution)

8.2.5. Scalability

Sr No.	Scalability
1	Scalability Score - Institutional Buildings (High, Medium, Low)
2	Scalability Score - Micro and Small and Medium Enterprises (High, Medium, Low)
3	Scalability Score - Street Vendors (High, Medium, Low)

9. Typology Analysis

This section details characteristics of users and sites for the following three typologies:

- Street Vendors
- Micro Business
- Institutions (Anganwadis, Urban PHC's etc)

During the site visit, combined with secondary research, these typologies were analysed to understand their needs and constraints related to thermal comfort and cooling storage requirements. The field survey involved interviews with users, photographs of the structures to understand the site's surrounding context and user and climatic conditions, critical heat-stress times during the day, hazards, and the identification of vulnerable groups.

The following points summarize the climatic zone, hazards, and vulnerable groups in the city of Bhubaneswar, based on findings published in IHCAP in September 2025.

- Climate zone: The city is explicitly classified as warm & humid, with high temperatures and humidity from March–October, annual mean temp ~27.5°C, summer max often >35°C and >40°C in May–June⁶.
- Humidity & night-time heat are critical: Night-time Heat Index and humidity push heat stress well into the night, and many days exceed thresholds when night-time heat is included⁷.
- Hazards: The city is exposed to cyclones, strong winds, floods, and heat waves⁸.
- Key vulnerable groups: Outdoor workers and informal occupations, including street vendors, etc., with significant productivity and wage losses due to heat⁹.

9.1. Street Vendors

Along with direct interviews with 8 street vendors to exhaustively identify and investigate categorisation parameters, a photographic survey was conducted across the entire city of Bhubaneswar to capture as many unique street vendor types as possible. This exercise was crucial in identifying the following parameters:

⁶ Chapter 3 – Bhubaneswar's Heat Profile, Section 3.1 "Climate and Weather Profile", IHCAP Report 2025

⁷ Chapter 7, Section 7.1 "Revising Heat Thresholds for Early Warning", IHCAP Report 2025

⁸ Chapter 2 – City Profile, subsection "Governance and Climate Vulnerability", IHCAP Report 2025

⁹ Chapter 2 – City Profile, subsection "Economy & Workforce Trends", IHCAP Report 2025

Sr No.	Categorisation Parameters
1	Vendor Type (Food, Vegetable, Grocery Store, Fish, Salon, Books, Clothes, Poultry, Flowers, Ice cream, Fruit)
2	Mobility (Stationary, Mobile & Parked, On the move)
3	Vehicle Type (Motorised, Manual)
4	Locality (Urban, Slum, Sub-Urban, Market Spaces)
5	Roof Type (Corrugated Tin + Tarpaulin Metal (GI/Tin Sheet) Metal (GI/Tin Sheet) - Flat + Umbrella Metal (GI/Tin Sheet) - Flat + Umbrella + Tarpaulin Metal (GI/Tin Sheet) - Flat Shaped Roof Metal (GI/Tin Sheet) - Flat Shaped Roof + Tarpaulin Metal (GI/Tin Sheet) - Stepped + Tarpaulin Metal (GI/Tin Sheet) - U + Tarpaulin Metal (GI/Tin Sheet) - U + Umbrella Metal (GI/Tin Sheet) - U Shaped Roof Metal (GI/Tin Sheet) - V Shaped Roof No Roof Purlin + Tarpaulin Tarpaulin Tent Thatch + Tarpaulin Umbrella Wood + Metal (GI/Tin Sheet))
6	Enclosure Type (Manual Shutters, Open, Tarpaulin Covered)
7	Floor Type (Pavement Blocks, Concrete, Soil)
8	Surrounding Elements - Top (Tree, Open Sky)
9	Surrounding Elements - Back (Wall, Semi-Wall, Open)
10	Heat source (Induction Gas, Oven, Lighting)

Table: Refer Tab>Street Vendor Categorisation

Link: [ThermIC_SELCO_Project_Management_Tracker](#)

Photographs: Refer Folder> Photos&Videos [Street Vendor Categorization Photos](#)

Summary of Street Vendor Survey

- Heat Impact on different Street Vendor groups**
 Food vendors dominate the sample; 49 of 69 vendors (71%); making them the group with the greatest aggregate heat exposure risk in the city. This matters for two compounding reasons: food vending typically involves standing near additional



heat sources (stoves, hot oil, grills), and food vendors are disproportionately stationary or mobile-and-parked rather than fully itinerant, meaning they spend extended hours in one radiant-heat-exposed spot rather than moving to seek shade opportunistically.

Mobility data (recorded for 68 of the 69 vendors) reinforces this:

Mobility Type	Number of Street Vendors	Percentage
Mobile and Parked	36	53%
Stationary	30	44%
On the move	2	3%

Roughly 97% of vendors with mobility recorded are either fully stationary or parked for extended periods; very few vendors are continuously moving in a way that would let them self-select shaded locations throughout the day. This means that for the large majority of vendors, heat exposure is a function of a fixed microsite's infrastructure (roof, enclosure, tree cover) rather than mobility-based avoidance behaviour.

- **Street Vendor setup types in Bhubaneswar**

Synthesising the modal value across each category, the "typical" vendor is:

1. A food vendor (71% of the sample)
2. Stationary or mobile-and-parked (97% combined, of those with mobility recorded) rather than continuously moving.
3. Sheltered by metal (GI/tin sheet) roofing in some configuration (the modal category overall, 57%)
4. Operating in an open enclosure with no walls or shutters (68% of recorded cases)
5. Most often standing on pavement blocks (47%); though a substantial minority (36%) stand directly on bare soil, with concrete flooring actually the least common surface (17%)
6. Slightly more often positioned under tree cover (57%) than under open sky (43%); a much narrower margin than shade infrastructure alone would suggest
7. Backed by a wall (47%) or no wall at all (39%)

This composite profile is telling: it describes a vendor with only partial passive heat mitigation. Tree shade covers a bare



majority, not the norm; more than a third work directly on unpaved ground; and there is almost no active enclosure or airflow control; an open-sided stall with a conductive metal roof, only inconsistently backed by natural shade.

- **Street Vendor Roofing Material Type**

Individually, "Umbrella" is the single largest named category (16 vendors, 23%). However, when the various metal (GI/tin sheet) configurations are aggregated; flat, V-shaped, U-shaped, stepped, plain, and combined with tarpaulin or umbrella; metal roofing appears in 39 of 69 setups (57%), including corrugated tin. This makes metal/GI tin sheet the dominant roofing material by a wide margin — well over half the vendor population.

Type of Roofing	Number of Street Vendors	Percentage
Metal (GI/Tin Sheet) — any configuration, incl. corrugated tin	39	57%
Umbrella (only)	16	23%
Tarpaulin / Tent / Thatch (only)	11	16%
No Roof	2	3%
Purlin + Tarpaulin	1	1%

- **Street Vendor Roofing Material Photographs**



Fig 9.1-1 : Metal (GI/Tin Sheet) - any configuration, incl. corrugated tin



Fig 9.1-2 : Umbrella (only)



Fig 9.1-3 : Tarpaulin / Tent / Thatch (only)



Fig 9.1-4 : No Roof

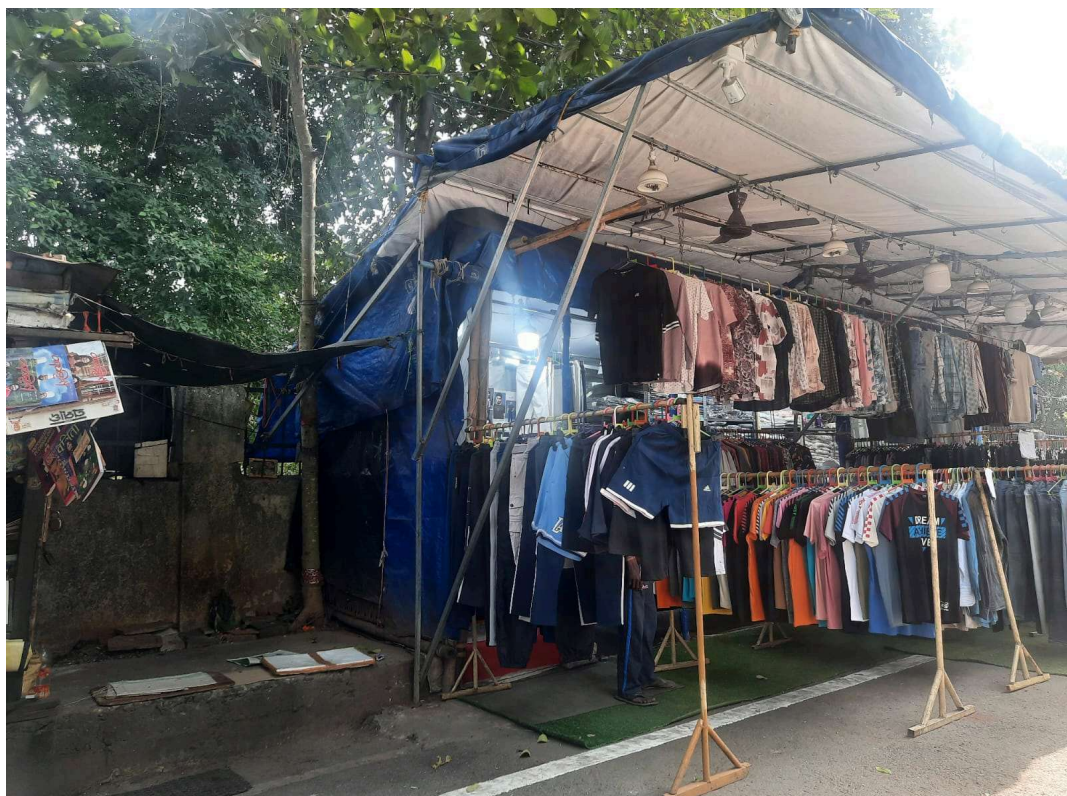


Fig 9.1-5 : Purlin + Tarpaulin

9.2. Small/Micro Businesses

7 Small and Micro Businesses were interviewed; 4 in CRPF BR Ambedkar Vending Zone and 3 in Jhoklandi Basti Bharatpur, Ward no.22 . The structures are general stores, tiffin centres, laundry shops and salons. A survey was conducted to understand the number of staff & beneficiaries using the space, kind of activities done in the space, roof material, structure type, start and end time to use the space, frequency of power cuts etc.

Survey Questionnaire& Results: Refer Tab> Form responses (Institutions and M&S Business) Link:

[ThermIC_SELCO_Project_Management_Tracker](#)

9.3. Institutions

8 Institutions were interviewed,5 in Sikharchandi and 1 each in Niladri Vihar,Bharatpur and Jhoklandi Basti Bharatpur, Ward no.22. The structures are Primary Health Centre, Anganwadi and Youth Center. A survey was conducted to understand the number of staff & beneficiaries using the space, kind of activities done in the space, roof material, structure type, start and end time to use the space, frequency of power cuts etc.

Survey Questionnaire& Results: Refer Tab> Form responses (Institutions and M&S Business)

Link: [ThermIC_SELCO_Project_Management_Tracker](#)

■ Summary of Institutions and Small& Micro Business Survey

- The survey covers 15 locations in Bhubaneswar, comprising eight institutional buildings and seven micro and small businesses. The institutional sites include urban primary health centres, Anganwadis and a youth centre, while the micro and small businesses include food stalls, general stores, a laundry and a salon. The findings below use building materials, operating hours, power supply and water access as indicators of potential heat exposure and provide an assessment of heat vulnerability.
- Institutional buildings serve some of the most heat-sensitive groups, including children, pregnant and lactating women, elderly people, hospital patients and adolescent girls. One primary health centre reports approximately 200-250 patients, indicating that a substantial number of people may be exposed



during hot conditions. Although these buildings have comparatively durable brick walls, flat concrete roofs can absorb solar heat and release it gradually into rooms. This may create uncomfortable conditions during the afternoon, particularly in crowded waiting, teaching or healthcare spaces.

- Cooling reliability is also a concern. Several institutional locations experience power interruptions, ranging from short weekly cuts to outages lasting several hours. Consequently, patients, children and staff may experience reduced comfort when fans or cooling equipment cannot operate.
- Micro and small businesses may face greater direct occupational heat exposure. Five of the seven businesses have tin roofs, and several also use corrugated tin, wood enclosed with tin, acrylic sheeting or tarpaulin as wall materials. These lightweight materials can heat up rapidly under direct sunlight. The risk is greater in businesses that produce additional internal heat, such as:
 - 1) the laundry, where ironing and washing are undertaken;
 - 2) the tiffin centre and restaurant, where food is prepared;
 - 3) the tea and betel shop; and
 - 4) the salon, which is enclosed
- Several businesses operate for long periods, with some open for approximately 14-18 hours a day. This increases workers' cumulative exposure, especially during the hottest afternoon hours.
- Family-run businesses also include women, elderly people and children. Heat exposure at these locations is therefore not only an occupational issue for adult workers but may also affect family members who remain inside or near the business throughout the day.
- The most common roofing material across all institutional building locations is concrete slab.
- Within the micro and small-business category, tin is the dominant roofing material, used by five of the seven businesses, or approximately 71%. These businesses are therefore likely to experience faster heat transfer through the roof than the concrete institutional buildings.
- The findings indicate two distinct forms of heat vulnerability. Institutional buildings have stronger brick-and-concrete

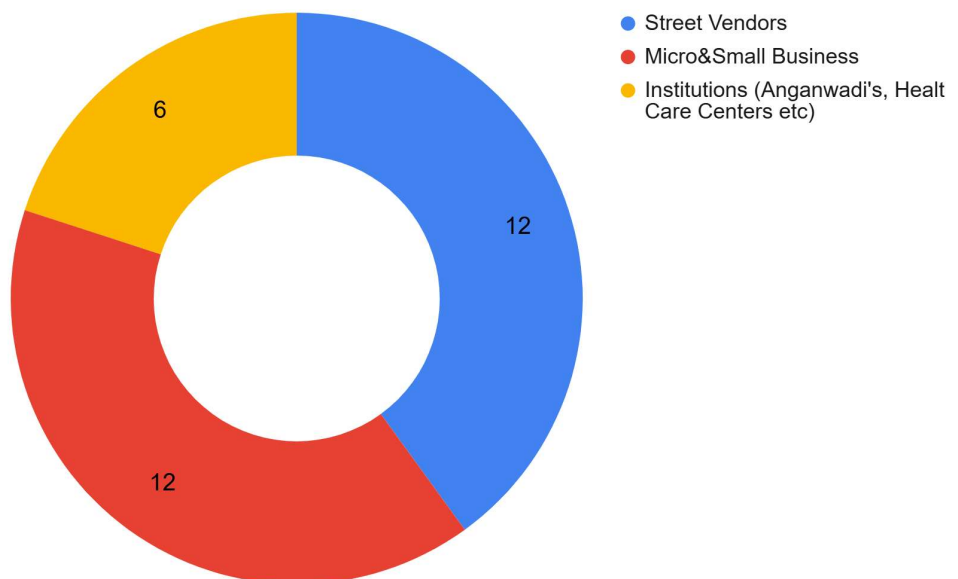


construction and generally better water access, but they accommodate large numbers of vulnerable users, including patients, pregnant women, elderly people and young children. Their heat risk is associated with crowding, flat-roof heat accumulation and interruptions to electrically powered cooling.

- Micro and small businesses accommodate fewer people but appear to face more intense physical exposure. Tin roofs, lightweight walls, long working hours, heat-generating activities, limited water connections and unreliable electricity combine to create potentially severe working conditions. Food businesses, the laundry, tin-enclosed general stores and the tarpaulin-covered restaurant should be considered priority locations for thermal comfort intervention, improved airflow and reliable access to drinking water.

9.4. Implementation Mix Pie Chart Of 30 Interventions

The project planning involves implementation of 30 interventions across three typologies with bifurcation as shown in the Pie chart.



The actual implementation numbers as of June 2026 are as follows:

Street Vendor Installations - 6

Micro& Small Business Installations - 7

10. Cooling Principles

This section explains the cooling principles.

10.1. Active Air Movement

Air movement plays a crucial role in evaporation. When air moves over the surface of a liquid, it removes the air saturated with evaporated molecules, enabling more liquid to evaporate.

10.2. Evaporative Cooling (Direct)

Evaporative Cooling works on the same principle as perspiration on the human body. The direct evaporative cooling process reduces dry bulb temperature while the wet bulb temperature remains constant. It is achieved by natural evaporation of water. Evaporative cooling is most efficient in areas of low humidity.

10.3. Evaporative Cooling (Indirect)

This is similar to Direct Evaporative Cooling in its basic working but differs in its science and engineering principle. Cools air without adding humidity, Dry-Bulb and Wet-Bulb temperature of air drops as a consequence of the evaporative and heat-exchange effect.

10.4. Evaporative Cooling (Passive)

Passive Evaporative Cooling uses porous materials like earthen pots, jute/khadi cloth to achieve cooling through natural evaporation of water.

10.5. Evapotranspiration

Evaporation of water from the soil and foliage produces an adiabatic (evaporative) cooling effect stemming from the significant latent heat of evaporation of water.

10.6. Insulation

The underside of the roof is covered with an insulating material: achieved through affixing compressed biomass-based panels, to reduce conductive heat transfer from the inner roof surface to the air volume within the home. This directly mitigates the solar heat load endured by occupants.

A co-benefit of this is also a reduction of mean radiant temperature stemming from the reduced surface temperature of insulating materials



relative to the exposed underside of metal or cement-asbestos sheet roofs.

10.7. Low Emissivity Surface

Most importantly, the underside of the exo-skeletal 'active' surface is a low-emissivity surface ($e \sim 0.05$): achieved through affixing aluminized layers such as cross-linked polyethylene foam (also known as XLPE) or Multi-Layered-Plastic sheets fabricated from upcycled packaging waste with the 'shiny' surface pointing downwards – in the direction of the roof. This ensures that the roof is shielded from approximately 95% (due to an emissivity ~ 0.05) of the radiant solar heat.

10.8. Mechanical Vapour Compression Refrigeration

In current Air Conditioners, desired cooling is provided by heat removal from the space to be cooled, often termed as "heat rejection". This heat transfer (removal) is facilitated through HVAC systems which consume energy to perform work. The HVAC systems or cooling equipment function on the principle of the conventional refrigeration cycle which is the Vapour Compression Refrigeration Cycle.

10.9. Night Sky Radiation

After sun-down, to promote radiation of internally accumulated heat embedded in the roofing material and re-radiation of ambient heat absorbed during the day, the installed apparatus either folds into a stack of panels in its closed position, or assumes a vertical perpendicular to the roof) position, thereby exposing a majority of the primary roofing material to the cool night sky which facilitates the process of natural cooling through night sky radiation. This diurnal cycle of operation restores thermal comfort conditions within the structure below to acceptable conditions that promotes human wellbeing.

10.10. Phase Change Material

Phase change material (PCM) is defined as an organic or inorganic compound that absorbs and stores large amounts of heat energy during a phase change process, specifically when transitioning between solid and liquid states. During the phase change, PCMs can maintain a constant temperature in their environment by absorbing heat when melting and releasing heat when solidifying.



10.11. Radiant Barrier

The exo-skeletal structure (functioning as an operable 'second' roof) extends over the entire primary roof in its 'open' position, functioning as a radiant barrier that blocks solar radiation during the day time i.e. the roof is 'shaded' through this mechanism in the day time. The 'dynamic' (or operable surface) variant enables a) radiant-barrier benefits during the day-time and b) after sun-down, to promote radiation of internally accumulated heat embedded in the home and radiation of body heat to the cooled roof surface, the installed apparatus folds into a stack in its closed position, thereby exposing the entire roofing material (with lower-than-skin radiant temperature at night) to the internal occupants/warm indoor surfaces and concomitantly to the cool night sky through the natural process of night sky radiation.

10.12. Reflection

When heat falls over an object some of the heat is absorbed by the body and some of the heat is reflected. Reflective coating (white or light-colour paint, or specialized cool-roof coating) applied to roof surface (metal sheet, concrete slab, tiles) to reflect solar radiation and reduce heat absorption.

10.13. Shading

Foliage of the living vegetation shields the roof from direct solar radiation.

10.14. Thermal Mass

Water has the highest specific heat capacity of any commonly available fluid. Specific heat is defined as the amount of heat one gram of a substance must absorb or lose to change its temperature by one degree Celsius. For water, this amount is one calorie, or 4.184 joules. Water can thus absorb a significant amount of heat with a moderate temperature rise. This trait helps it to stabilize temperature in its surroundings. Soil held in diverse physical configurations and containers (e.g. grow-bags) functions as thermal mass, with enhanced efficacy as thermal mass when holding adequate moisture.

10.15. Thermoelectric Refrigeration

Thermoelectric refrigeration involves the use of thermoelectric devices to transfer heat from one side of the device to another, effectively cooling one side while warming the other. It operates on principles



rooted in the thermoelectric effects, particularly the Peltier Effect, which is the basis of its functionality. When an electric current passes through a junction of two different conductors, a temperature differential is created; one junction absorbs heat, while the other dissipates it.

10.16. Ventilation

Ventilation is the process of introducing fresh air and removing stale or polluted air to improve indoor air quality.

11. Identified Cooling Solutions

The Table below delineates the following characteristics of each cooling solution investigated as part of this research effort:

- cooling technology (passive, active, or hybrid)
- primary cooling service (space cooling or storage cooling)
- cooling principle
- technology variant
- social-economic context i.e. user-groups (street vendor, micro & small business, or institutional settings).

To access master database, refer “Cooling Solutions Database” Tab>

[ThermIC_SELCO_Project_Management_Tracker](#)

Identified Cooling Solutions					
Sr No.	Cooling Technology	Cooling Service	Cooling Principle	Variant	User Group
1	Passive	Space	Reduced Thermal Conductivity	Aerogel Insulation	Micro Enterprise, Institutional Building
2	Active	Space	Evaporative Cooling (Direct)	Ambiator	Micro Enterprise, Institutional Building
3	Passive	Space	Reduced Thermal Conductivity, Thermal Mass	Bamboo Corrugated Roofing Sheet	Micro Enterprise, Institutional Building
4	Passive	Space	Insulation, Reduced Thermal Conductivity	Bamboo Mat Board	Micro Enterprise, Institutional Building
5	Passive	Space	Insulation, Low Emissivity Surface, Radiant Barrier	Biomass Panel (MLP Covered)	Micro Enterprise, Institutional Building
6	Passive	Space	Insulation, Reduced Thermal Conductivity	Bison Board	Micro Enterprise, Institutional Building
7	Passive	Space	Thermal Mass, Insulation	Brick Bat Coba	Micro Enterprise, Institutional Building



Identified Cooling Solutions					
Sr No.	Cooling Technology	Cooling Service	Cooling Principle	Variant	User Group
8	Passive	Storage	Evaporative Cooling (Passive)	Clay Pot (Matka) +Wet Cloth Wrap	Street Vendors, Micro Enterprise
9	Passive	Space	Thermal Mass, Reduced Thermal Conductivity	Compressed Stabilized Earth Block	Micro Enterprise, Institutional Building
10	Passive	Space	Radiant Barrier, Shading	Cool Canvas	Street Vendors, Micro Enterprise, Institutional Building
11	Passive	Space	Reflection, Reduced Thermal Conductivity	Cool Roof Paint	Micro Enterprise, Institutional Building
12	Passive	Space	Reflection, Reduced Thermal Conductivity, Insulation	Corrugated Recycled Tetra Pak Sheet (PolyAl roofing sheet)	Micro Enterprise, Institutional Building
13	Active	Storage	Mechanical Vapour Compression Refrigeration	DC Compressor Freezer/Fridge	Street Vendors, Micro Enterprise, Institutional Building
14	Passive	Storage	Insulation	EPS Box Coolers	Street Vendors, Micro Enterprise
15	Active	Storage	Evaporative Cooling (Direct)	Evaporative Cabinets with DC Fan	Street Vendors, Micro Enterprise
16	Passive	Space	Evaporative Cooling (Passive)	Evaporative Cart Canopy	Street Vendors
17	Passive	Space	Insulation	Expanded Polystyrene (EPS)	Micro Enterprise, Institutional Building
18	Passive	Space	Radiant Barrier, Low Emissivity Surface, Night Sky Radiation	External Radiant Barrier	Micro Enterprise, Institutional Building
19	Passive	Space	Reduced Thermal Conductivity	Extruded Polystyrene Insulation Board	Micro Enterprise, Institutional Building
20	Passive	Space	Reduced Thermal Conductivity, Insulation	Fibre Based-Modular Roof panels - 20mm Thick	Micro Enterprise, Institutional Building
21	Passive	Space	Reduced Thermal Conductivity, Insulation	Glass Wool	Micro Enterprise, Institutional Building
22	Passive	Space	Insulation	Gypsum Board	Micro Enterprise, Institutional



Identified Cooling Solutions					
Sr No.	Cooling Technology	Cooling Service	Cooling Principle	Variant	User Group
					Building
23	Passive	Space	Insulation, Thermal Mass	Honeycomb Panels	Micro Enterprise, Institutional Building
24	Passive	Space	Insulation, Thermal Mass	Hourdi Blocks	Micro Enterprise, Institutional Building
25	Active	Storage	Evaporative Cooling (Indirect)	Indirect Evaporative Boxes	Street Vendors, Micro Enterprise
26	Passive	Storage	Insulation	Insulated Ice Chest Box	Street Vendors, Micro Enterprise
27	Passive	Space	Radiant Barrier, Low Emissivity Surface, Night Sky Radiation	Internal Radiant Barrier	Street Vendors, Micro Enterprise, Institutional Building
28	Passive	Space	Evaporative Cooling (Passive), Radiant Barrier, Thermal Mass	Inverted Earthen Pots/ Clay tiles	Micro Enterprise, Institutional Building
29	Active	Storage	Evaporative Cooling (Passive)	Jute/Khadi/Charcoal Swamp Cabinets	Street Vendors, Micro Enterprise
30	Passive	Space	Thermal Mass	Kadapa + Cement Screed	Micro Enterprise, Institutional Building
31	Passive	Space	Shading, Evaporative Cooling (Passive)	Khus Curtains / Blinds	Street Vendors, Micro Enterprise
32	Passive	Space	Reflection, Thermal Mass	Lime Concrete	Micro Enterprise, Institutional Building
33	Active	Space	Active Air Movement	Low Energy / Energy Efficient Ceiling Fans	Micro Enterprise, Institutional Building
34	Active	Space	Active Air Movement	Low Energy / Energy Efficient Exhaust fans	Micro Enterprise, Institutional Building
35	Active	Space	Active Air Movement	Low Energy / Energy Efficient Wall Fans	Micro Enterprise, Institutional Building
36	Active	Space	Evaporative Cooling (Direct)	Low Energy Solar DC Cooler	Micro Enterprise, Institutional Building
37	Passive	Space	Thermal Mass, Insulation	Madras Terrace Roof Slab	Micro Enterprise, Institutional Building
38	Passive	Space	Reduced Thermal Conductivity,	Magra Wool - 20 mm	Micro Enterprise, Institutional Building



Identified Cooling Solutions					
Sr No.	Cooling Technology	Cooling Service	Cooling Principle	Variant	User Group
			Insulation		
39	Passive	Space	Insulation	Mangalore Tiles	Micro Enterprise, Institutional Building
40	Active	Storage	Mechanical Vapour Compression Refrigeration	Micro Cold Room	Micro Enterprise, Institutional Building
41	Passive	Space	Low Emissivity Surface	MLP Tarpaulin	Street Vendors
42	Passive	Space	Low Emissivity Surface	MLP Umbrella	Street Vendors
43	Passive	Space	Insulation	Multiwall Polycarbonate Sheet	Micro Enterprise, Institutional Building
44	Passive	Space	Reduced Thermal Conductivity, Insulation	Onduline Sheet	Micro Enterprise, Institutional Building
45	Passive	Storage	Phase Change Material, Thermal Mass	PCM/ Eutectic box Thermal Battery	Street Vendors
46	Passive	Space	Thermal Mass	PET Bottles - Crate Mounted	Micro Enterprise, Institutional Building
47	Passive	Space	Thermal Mass	PET Bottles - Directly Secured	Street Vendors, Micro Enterprise, Institutional Building
48	Passive	Space	Insulation	Poly Urethane Foam Panel	Micro Enterprise, Institutional Building
49	Passive	Storage	Insulation	PolyUrethane Foam Coolers	Street Vendors, Micro Enterprise
50	Passive	Space	Insulation, Reflection, Reduced Thermal Conductivity	Polyvinyl Chloride Boards (PVC)	Micro Enterprise, Institutional Building
51	Passive	Space	Insulation, Thermal Mass	Porotherm Block Masonry	Micro Enterprise, Institutional Building
52	Passive	Space	Reflection, High Emissivity	Pre-Painted Galvalume Sheet (PPGL)	Micro Enterprise, Institutional Building
53	Passive	Space	Radiant Barrier	Pre-Painted Galvanized Iron Sheet	Micro Enterprise, Institutional Building



Identified Cooling Solutions					
Sr No.	Cooling Technology	Cooling Service	Cooling Principle	Variant	User Group
54	Passive	Space	Thermal Mass, Reduced Thermal Conductivity	Precast Concrete Slabs	Micro Enterprise, Institutional Building
55	Active	Space	Active Air Movement	PV Exhaust Ventilator	Street Vendors, Micro Enterprise, Institutional Building
56	Active	Space	Active Air Movement	PV Powered Fan (DC)	Street Vendors, Micro Enterprise
57	Passive	Space	Reflection, Shading	Reflective Tarpaulin	Street Vendors
58	Passive	Space	Reflection, Shading	Reflective Umbrella	Street Vendors
59	Active	Storage	Mechanical Vapour Compression Refrigeration	Refrigerated E Kart/Tricycle	Street Vendors
60	Passive	Space	Thermal Mass	Reinforced Cement Concrete Slab	Micro Enterprise, Institutional Building
61	Passive	Space	Reflection, Shading	Retractable Awnings – White PVC-Coated Fabric (Solar Reflectivity Index 85-95)	Micro Enterprise, Institutional Building
62	Passive	Space	Reduced Thermal Conductivity, Thermal Mass	Rockwool Slabs - 30mm/50mm	Micro Enterprise, Institutional Building
63	Passive	Space	Shading, Evapotranspiration, Thermal Mass	Roof Top Garden	Micro Enterprise, Institutional Building
64	Passive	Storage	Insulation, Evaporative Cooling (Passive)	Sabjee Cooler - Rukart	Street Vendors, Micro Enterprise, Institutional Building
65	Passive	Space	Active Air Movement, Reduced Surface Heat Gain	Shade Net	Street Vendors, Micro Enterprise, Institutional Building
66	Active	Storage	Mechanical Vapour Compression Refrigeration	Solar Direct Drive (SDD) Freezer/Fridge	Street Vendors, Micro Enterprise, Institutional Building
67	Passive	Space	Reduced Thermal Conductivity,	Spray Foam	Micro Enterprise, Institutional Building



Identified Cooling Solutions					
Sr No.	Cooling Technology	Cooling Service	Cooling Principle	Variant	User Group
			Insulation		
68	Passive	Space	Radiant Barrier, Low Emissivity Surface	Static Alufoil	Street Vendors, Micro Enterprise, Institutional Building
69	Passive	Space	Radiant Barrier, Low Emissivity Surface	Static MLP Panel	Micro Enterprise, Institutional Building
70	Active	Storage	Thermoelectric Refrigeration	Thermo Electric Peltier	Street Vendors
71	Passive	Space	Active Air Movement	Turbo Ventilators	Micro Enterprise, Institutional Building
72	Passive	Space	Reduced Thermal Conductivity, Multi-Chamber Frame Design	Unplasticized Polyvinyl Chloride Windows	Micro Enterprise, Institutional Building
73	Passive	Storage	Insulation	Vacuum Insulated Panel Boxes	Street Vendors, Micro Enterprise, Institutional Building
74	Passive	Storage	Ventilation	Ventilated Produce Crates (Perforated HDPE)	Street Vendors, Micro Enterprise, Institutional Building
75	Passive	Space	Radiant Barrier, Low Emissivity Surface, Night Sky Radiation	Vertical Cane Blind (MLP Covered)	Street Vendors, Micro Enterprise, Institutional Building
76	Passive	Space	Shading, Evapotranspiration, Thermal Mass	Vertical Garden	Micro Enterprise, Institutional Building
77	Passive	Space	Reflection, High Emissivity	White Tiles	Micro Enterprise, Institutional Building
78	Passive	Space	Reflection	Window Tints	Micro Enterprise, Institutional Building
79	Passive	Space	Insulation, Low Emissivity Surface, Radiant Barrier	Wood Wool Panel (MLP Covered)	Micro Enterprise, Institutional Building
80	Passive	Storage	Evaporative Cooling (Passive)	Zeer/Pot in Pot Coolers (Unglazed clay+Wet sand)	Street Vendors, Micro Enterprise



11.1. Conclusion from Solution Mapping

The solution mapping exercise identified 80 cooling interventions which are applicable to all 3 typologies i.e Institutional buildings, Micro Small and Medium Enterprises (MSMEs) and Street vendors for both space and storage cooling. The identified cooling solutions span active cooling technologies, passive cooling retrofits, evaporative techniques, shading devices, insulated storage and ventilation enhancements.

Despite the diversity, the identified cooling solutions rely on a common set of cooling principles. These include:

- Solar radiation reduction through shading, radiant barrier, reflective surfaces etc.
- Thermal insulation to reduce heat transfer using materials such as EPS, Polyurethane Foam (PUF) panels, aerogel, biomass and wood wool panels.
- Natural and forced ventilation to remove the accumulated heat through ventilators, fans etc.
- Evaporative cooling using water based cooling methods such as clay pots, swamp cabinets etc.
- Mechanical or refrigeration-based cooling powered by grid electricity or solar energy.
- Thermal mass and thermal energy storage using materials that delay heat transfer including PCM-based solutions and traditional roof assemblies.

The mapping highlights that passive interventions - including reflective surfaces, insulation, ventilation constitute the majority of identified solutions as they require minimal operational energy, are affordable and can be adapted to resource constrained settings. Active cooling technologies, while effective for maintaining low temperatures, are generally associated with high capital costs and maintenance needs.

Another key inference is that no single solution addresses all use cases. Solutions vary according to cooling objectives (human thermal comfort vs preservation of perishable goods), operating conditions, maintenance and affordability. Hence, effective cooling interventions for all the three typologies require context-specific combinations of passive and active interventions rather than reliance on single cooling technology.

12. Context-to-Solution Match Matrix

The Table below presents a Context/House-to-Solution-Match Decision Support Matrix that can be employed to identify appropriate solutions as a function of Climate Zone, Structural attributes of the house, and Socio-Economic conditions prevalent in the particular context especially related to water availability, economic resources available to support roof rehabilitations (such as waterproofing prior to installation of roof retrofits), regular maintenance etc.

Context-to-Solution Match Matrix									
Parameters	Context	Criterion	Solutions						
			RTG ¹⁰ - LSM ¹¹ - BM ¹²	RTG - HSM ¹³ - BM	IRB ¹⁴ - MLP ¹⁵ - TM ¹⁶	ERB ¹⁷ - MLP - TM	ERB - MLP - TM - VCB ¹⁸ - MLP WR ¹⁹	PET BOT ²⁰ - CM ²¹	PET BOT - DS ²²
Climate Zone Match	Warm&Humid Climate	Suitable for Warm & Humid Climate	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Climate Zone Match	Hot & Dry Climate	Suitable for Hot & Dry Climate	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Climate Zone Match	Composite Climate	Suitable for Composite Climate	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Climate Zone Match	Temperate Climate	Suitable for Temperate Climate	Yes	Yes	Yes	Yes	Yes	Yes	Yes

¹⁰ Roof Top Garden

¹¹ Low Soil Mass

¹² Bamboo Mesh

¹³ High Soil Mass

¹⁴ Internal Radiant Barrier

¹⁵ Multi Layer Plastic

¹⁶ Tarpaulin Mounted

¹⁷ External Radiant Barrier

¹⁸ Vertical Cane Blind

¹⁹ Wrapped

²⁰ Bottles

²¹ Crate Mounted

²² Directly Secured

Context-to-Solution Match Matrix									
Parameters	Context	Criterion	Solutions						
			RTG ¹⁰ - LSM ¹¹ - BM ¹²	RTG - HSM ¹³ - BM	IRB ¹⁴ - MLP ¹⁵ - TM ¹⁶	ERB ¹⁷ - MLP - TM	ERB - MLP - TM - VCB ¹⁸ - MLP WR ¹⁹	PET BOT ²⁰ - CM ²¹	PET BOT - DS ²²
Environmental Factors	High-Speed Winds	Suitable for High-Speed Winds	No	No	Yes	No	Partially	Yes	Yes
Environmental Factors	Fauna	Compatible with Mid-Sized Animals on Roof (Cat, Dog etc.)	No	No	Yes	No	Yes	Yes	Yes
Environmental Factors	Fauna	Does Not Exacerbate Risk from Pests	No	No	Yes	Yes	Yes	Yes	Yes
Structural Context	Limited Load Bearing Capacity	Suitable for Limited Load Bearing Capacity	Partially	No	Yes	Yes	Yes	No	Partially
Structural Context	Highly Sloped Roofs	Suitable for Highly Sloped Roofs	Partially	No	Yes	No	Yes	Partially	Partially
Structural Context	Post-installation Roof Use	Suitable for Post-installation Roof Use	Partially	Partially	Yes	Partially	Yes	No	No
Structural Context	Tall Roofs	Suitable for Tall Roofs	Partially	Partially	Yes	Partially	Yes	Yes	Yes
Structural Context	Roof Access	Suitable for Limited Roof Access	Partially	No	Yes	Yes	Yes	Partially	Partially
Socio-Economic Context	High-Density Settlements	Suitable for High-Density Settlements	Partially	Partially	Yes	Yes	Yes	Yes	Yes
Socio-Economic Context	Infrequent Maintenance	Suitable for Infrequent Maintenance	Partially	Partially	Yes	Partially	Yes	Yes	Yes
Socio-Economic Context	Limited Waterproofing	Suitable for Limited Waterproofing	Partially	No	Yes	Yes	Yes	Yes	Yes
Socio-Economic	Limited Water Availability	Suitable for Limited Water	Partially	No	Yes	Yes	Yes	Yes	Yes



Context-to-Solution Match Matrix									
Parameters	Context	Criterion	Solutions						
			RTG ¹⁰ - LSM ¹¹ - BM ¹²	RTG - HSM ¹³ - BM	IRB ¹⁴ - MLP ¹⁵ - TM ¹⁶	ERB ¹⁷ - MLP - TM	ERB - MLP - TM - VCB ¹⁸ - MLP WR ¹⁹	PET BOT ²⁰ - CM ²¹	PET BOT - DS ²²
Context		Availability							
Socio-Economic Context	Limited Power Availability	Suitable for Limited Power Availability	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Human Context	Houseowners	Suitable for use/management by Elderly / Physically Challenged	Partially	No	Yes	No	Partially	Partially	Partially

13. Benchmarking

This section includes benchmarking of passive cooling solutions that cBalance has implemented in the past in the cities of Delhi, Mysore and Chennai.

Table: Thermal Comfort Performance Indicators - In-Operation vs. Business As Usual (BAU)												
Solution Variant/Description	DBT	DBT	DBT	DBT	MRT	MRT	MRT	MRT	Roof Temp.	Roof Temp.	Roof Temp.	Roof Temp.
	Peak Delta	Peak Delta Time	Min Delta	Avg. Delta	Peak Delta	Peak Delta Time	Min. Delta	Avg. Delta	Peak Delta	Peak Delta Time	Min. Delta	Avg. Delta
Biomass Panel - Banana Fibre & Waste Paper	1.7	15	-1.2	0.8	5.3	14	0.4	1.9	4.4	13	-0.1	1.8
Biomass Panel - Sunhemp Fibre & Waste Paper	2.1	14	0.2	1	6.1	14	0.2	2.1	5.5	12	-0.3	2.4
Wood Wool-Vertical Cane Blind	2.1	15	-2.1	0.8	6.6	14	-1.3	2.3	6.7	12	-7.3	1.7
Internal Radiant Barrier	0.7	14	-1.6	-0.2	3.8	13	0.4	2	4.4	13	-0.1	1.4



PET Bottles - Crate Mounted	0.8	15	-1.9	-0.3	5.2	14	-3	1.2	5.8	12	-3.4	1.4
PET Bottles - Directly Secured	2.4	11	-2.5	0.5	4.5	14	-2	1.1	5.3	12	-1.4	1.7
External Radiant Barrier	1.9	15	-2.5	0.3	3.6	14	-1.7	0.6	6.2	12	-1.8	0.9
External Radiant Barrier + Vertical Cane Blind	2.3	15	-2	0.4	4.3	14	-2.4	1.1	6.9	13	-2.6	1.6
Internal Radiant Barrier + Vertical Cane Blind	0.8	13.0	-0.5	0.0	7.4	11.0	-1.8	1.8	15.9	11.0	-1.6	7.5
Rooftop Garden	2.8	14.0	0.3	1.3	6.2	14.5	1.4	3.1	10.9	13.5	0.2	5.8
Alufoil - Static - Metal Framed	1.1	12.0	-0.2	0.6	4.2	13.0	1.9	3.1	12.9	13.0	2.8	8.1
Alufoil - Pipe Motor - Tarpaulin Mounted	1.6	11.0	0.3	0.9	2.6	13.0	0.4	1.6	10.0	13.0	1.7	6.2
MLP - Chain Sprocket - GI Sheet Mounted	1.4	11.0	0.0	0.5	2.6	13.0	0.7	1.7	10.6	13.0	1.8	6.2

14. Vendor And Solutions Database

This section compiles a structured database of suppliers, manufacturers, and solution providers involved in active and passive cooling systems. It includes their profiles, location, contact information, product information, pricing and service capacity. The objective is to create a ready reference for procurement teams and implementation partners/fabricators for their engagement.

Vendor products were evaluated on the following parameters:

- Lead Time (Production + delivery) (in days)
- Warranty on Product (in years)
- Warranty on Compressor (in years)
- Warranty on Battery (in years)
- Warranty on Electronic/Electrical components (in years)
- Local Service availability in Bhubaneswar
- Spare Parts Availability (Compressor / Electronics/others)
- Lead time for Spare Parts (in days)
- Resilient strength for Street vending
- Unit Cost (INR)
- Specification

Based on the current Bhubaneswar vendor list, the solutions with the strongest apparent local supply chains are rooftop gardens, which have by far the largest vendor network, followed by DC compressor freezers/fridges with three unique suppliers. Reflective umbrellas, EPS box coolers, Zeer/Pot-in-Pot coolers, and external radiant barriers each have two listed suppliers.



To access master database, refer “Solution Vendor Database” Tab>

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The summary table below provides a quick view of the Solution Type, Manufacturer Name and their address.

Solutions Vendor Summary Table				
Sr No	Solution/Variant	Company / Manufacturer Name	Address	Phone Number
1	DC Compressor Freezer/Fridge	Lingaraj Enterprises	Saheed Nagra,Plot no 636, Saheed Nagar	8093 705 659
2	EPS Box Coolers	Maa Tarini Icebox and Sintex Store	Unit-4, Fish Market	9114 120 216
3	External Radiant Barrier	Industrial Chain and Mills Store	144, Cuttack Road, 751006	8328 819 316
4	Insulated Ice Chest Box	Maa Tarini Icebox and Sintex Store	Unit-4, Fish Market	9114 120 216
5	Jute/khadi/charcoal Swamp Cabinets	Orissa State handicrafts	D-2&3, In front of hyundai Showroom, Rasulgrah Industrial Estate	7205 899 599
6	Low Energy / Energy Efficient Ceiling Fans	Kavitasolar	231,Railway Rd, New Defence, colony, muradnagar, Ghaziabad	9837 261 007
7	Micro Cold Room	Pratishtha Life Care	Pratishtha Life Care, Plot No - 1242/5 Khata No - 1057/573 Bomikhal ,Anand Nagar, Canal Road,	8047 693 781
8	PCM/ Eutectic box Thermal Battery	Tessol	Thermal Energy Service Solutions Private Ltd, R-511, TTC Industrial Area, MIDC	8447 695 436
9	PolyUrethane Foam Coolers	Maa Gouri wholesaler thermocoal store	Unit-4, Fish Market	9090 072 233
10	PV Powered Fan (DC)	Kavitasolar	231,Railway Rd, New Defence, colony, muradnagar, Ghaziabad	9837 261 007
11	Refrigerated E Kart/tricycle	Skyrider Electric	Skyy, Rider Electric Pvt Ltd, CIT Campus, near Gram Tarang, Bhubaneswar, Jatni,	8926 088 398



Solutions Vendor Summary Table				
Sr No	Solution/Variant	Company / Manufacturer Name	Address	Phone Number
			752050	
12	Roof Top Garden	Rajdhani Nursery	Bajarang Vending Zone, Shop no 13, Unit-2, Market Building	9937 3263 99
13	Solar Direct Drive (SDD) Freezer/Fridge	Oxynueron India private limited	E171, D Block, Sector 63, Noida, Hazratpur Wajidpur	7942 955 360
14	Ventilated Produce Crates (perforated Hdpe)	Sudarshan	7RHX+8P6	9938 438 098
15	Zeer/Pot in Pot Coolers (Unglazed clay+Wet sand)	Garima Pottery Studio	5/261, Milan Paradise, Sailashree Vihar, Chandrasekharapur	7749 013 879
16	Biomass Panel (MLP Covered)	Beejpatra - Biomass Panels, Borgaon, Madhya Pradesh	Borgaon	8087 502 186
17	PET Bottles - Crate Mounted	Urban Kabadiwala	Convention, Plot no-7/1799, Infocity Ave, adjacent Sai Mandir Lane, beside infosys	9078 028 941
18	Magra Wool - 20 mm	Samakhya Foundation	West Guru Angad Nagar Laxmi Nagar	8447 967 539
19	Turbo Ventilators	Airwell	T-42, Shakriba Ind Estate, Nika Tube Cross Road, Phase-4, GIDC Vatva,382445.	9437 002 675
20	Wood Wool Panel (MLP Covered)	Priyanka Enterprises	574/575, Plot No. 573, Ekamra Kanana Rd, near hanuman marble, Jayadev Vihar	9090 907 799
21	Mangalore Tiles	Nuvocotto Chennai	8/1116 Poonamallee High Road, [Opposite TATA Motors Showroom], Arumbakkam, Koyambedu	9884 869 790
22	Khus Curtains / Blinds	Khus Plaza	H N 2 lane2 Matru vihar,Budharaja Sambalpur 768004	9556 697 070
23	Compressed Stabilized Earth Block	Earth Block	Virgonagar	7019 933 100



Solutions Vendor Summary Table				
Sr No	Solution/Variant	Company / Manufacturer Name	Address	Phone Number
24	Madras Terrace Roof Slab	Madras Terrace Architects	Mount Casa Blanca, 702, Anna Salai	7200 090 909
25	Retractable Awnings – White PVC-Coated Fabric (Solar Reflectivity Index 85-95)	Dibya Enterprise	Plot No. 1958, 4081, Cuttack Rd, Chintamaniswar, Laxmisagar	8018 002 533
26	Bamboo Corrugated Roofing Sheet	Bambooz	Subramanyan Industrial, Survey no 22/1, Subramanyam Industry Area Road , Off, Hulimavu - Begur Road, Hulimavu Main Rd, Krishna Layout, Hulimavu	9535 684 329
27	Reflective Umbrella	Sonu Traders	Unit-2 , Bhubaneswar	7873 393 401

15. Fabricator Database

This section captures the fabricators identified for implementing active, passive, and hybrid cooling solutions in Bhubaneswar .Our approach to finding the fabricators began with a desktop search, mainly through Google, looking for workshops located close to our target sites. Once we found basic details like the fabricator’s name, address, and phone number, we contacted them directly.During the first call, we briefly introduced ourselves, explained the nature of our work, and asked a few screening questions. If the fabricator responded quickly and showed interest, we shared sample design images over the phone and tried to schedule an in-person visit. Meeting them personally helped us understand their capability, workshop setup, and whether they were a good fit to move forward with. In the meeting, design details and implementation plan was discussed and their willingness was confirmed. This process allowed us to filter out non-responsive or unsuitable fabricators and shortlist those who were reliable, experienced, and willing to collaborate.

15.1. Summary Table

The summary table above provides a quick view of the shortlisted fabricators The information used for interviewing includes the following:



- Service Category & Sub-Category show what type of fabrication work they offer.
- Experience & Team Size indicate their operational capacity.
- Scope Fit tells whether they have done similar work before
- Aggregator Capability shows if they can manage multiple tasks or take up end-to-end responsibilities.

Fabricator Summary Table				
Sr No.	Material/Service Category	Sub Category	Vendor Name	Address
1	General Fabrication	Cutting, Forming, Welding, Machining	Rajdhani Stainless Steel	348/1381, Okil Baag, Cuttack Road, Laxmi Sagar, Bhubaneswar
2	General Fabrication	Cutting, Forming, Welding, Machining	Rupam Designs	Plot No-788/1350, Rupam Designs, Near Sum Hospital, Sampur, Durga Madhab Nagar, Bhubaneswar
3	General Fabrication	Cutting, Forming, Welding, Machining	Sai Fabrication	Postal Colony, VSS Nagar, Bhubaneswar -751010
4	General Fabrication	Cutting, Forming, Welding, Machining	Lingaraj Techno Projects	13/23, Forest Colony, MIG-II, BDA Colony, Chandrasekharapur, Bhubaneswar
5	General Fabrication	Cutting, Forming, Welding, Machining	Basudev Industries	Plot No A41/2, Rasulgarh Industrial Estate, Saheed Nagar, Bhubaneswar
6	General Fabrication	Cutting, Forming, Welding, Machining	Bhagabati Fabricators	Plot No. 1464/2397, IRC Village, Bhubaneswar

Note: For full details, certifications, safety compliance, and additional parameters, refer to the complete Fabricator Database Sheet Tab >[ThermIC_SELCO_Project_Management_Tracker](#)

15.1.1. Fabricator Evaluation Parameters

- A. Basic Identification
 - a. Fabricator Name
 - b. Address
 - c. Primary and Secondary Phone Numbers
 - d. Location Coordinates (if captured)
- B. Service Profile
 - a. Material / Service Category
 - b. Sub-Category (e.g., cutting, welding, machining)
- C. Experience & Capability



- a. Have they done similar work before? (Scope fit)
- b. Experience (years)
- c. Team Size
- d. Can they act as an Aggregator?(Can they handle multiple fabrication tasks, manage material, coordinate workers, etc.)
- D. Quality & Certification
 - a. Do they have Quality Process Certifications?
Examples: ISO 900,WPS,POR,WPQ
 - b. Material Traceability
 - c. Any proof or documents shared?
- E. Occupational Health & Safety
 - a. Are they ISO 45001 certified?
 - b. If not, what kind of safety practices do they follow?(Workshop safety, PPE usage, fire safety, etc.)
- F. Additional Observations
 - a. Responsiveness
 - b. Attitude and willingness to collaborate
 - c. Condition of workshop
 - d. Constraints or risks
 - e. Notes from field visit

16. Technical Analysis Summary

This section presents a synthesis of comparative insights across the identified solutions (both active and passive), correlating quantitative evidence on temperature reduction, associated costs, durability and the potential for solar integration.

To access Technical Analysis Summary Database, refer “Cooling Solutions Technical&Cost Summary” Tab>

[ThermIC_SELCO_Project_Management_Tracker](#)



16.1. Technical And Cost Comparison Table

16.1.1. Passive Cooling Solutions

Technical and Cost Comparison-Passive Cooling Solutions											
Sr No.	Cooling Technology	Cooling Service	Variant	Principle	I/PTR ²³ - Value (oC)	ATR ²⁴ -Value (oC)	STR ²⁵ -Value (oC)	Cost (INR)	Cost (INR) - Unit	Life span (years)	Solar Integration
1	Passive	Storage	PCM ²⁶ / Eutectic box Thermal Battery	PCM, TM ²⁷	12.5	NA ²⁸	NA	36,500	per piece	12	NA
2	Passive	Space	Reflective Umbrella	Reflection, Shading	NA	5.5	10	1,050	per piece	6	NA
3	Passive	Space	Reflective Tarpaulin	Reflection, Shading	NA	Not available	10	110	sqft	6	NA
4	Passive	Space	Vertical Cane Blind (MLP Covered)	RB ²⁹ , LES ³⁰ , NSR ³¹	NA	3.5	10	80	sqft	6	NA
5	Passive	Space	Static MLP Panel	RB, LES	NA	4	6	225	sqft	6 ³²	NA
6	Passive	Space	Static Alufoil	RB, LES	NA	4	6	69	sqft	6	NA
7	Passive	Space	Internal Radiant Barrier	RB, LES, NSR	NA	1.5	4.5	68	sqft	6	NA
8	Passive	Space	External Radiant Barrier	RB, LES, NSR	NA	2	7.5	195	sqft	4	NA

²³ Internal/Product Temperature Reduction

²⁴ Air Temperature Reduction

²⁵ Surface Temperature Reduction

²⁶ Phase Change Material

²⁷ Thermal Mass

²⁸ Not Applicable

²⁹ Radiant Barrier

³⁰ Low Emissivity Surface

³¹ Night Sky Radiation

³² Life Span for MLP Panel frame is 6 years whereas for MLP sheet it is 1 year.

Technical and Cost Comparison-Passive Cooling Solutions

Sr No.	Cooling Technology	Cooling Service	Variant	Principle	I/PTR ²³ - Value (oC)	ATR ²⁴ -Value (oC)	STR ²⁵ -Value (oC)	Cost (INR)	Cost (INR) - Unit	Life span (years)	Solar Integration
9	Passive	Space	Biomass Panel (MLP Covered)	Insulation, LES, RB	NA	2	5	365	sqft	9	NA
10	Passive	Space	Wood Wool Panel (MLP Covered)	Insulation, LES, RB	NA	2	6.5	205	sqft	9	NA
11	Passive	Storage	Ventilated Produce Crates (Perforated HDPE)	Ventilation	NA	1	NA	450	per piece	6	NA
12	Passive	Storage	Zeer/Pot in Pot Coolers (Unglazed clay+Wet sand)	Evaporative Cooling (Passive)	11	NA	NA	2,645	per piece	2	NA
13	Passive	Storage	Clay Pot (Matka) +Wet Cloth Wrap	Evaporative Cooling (Passive)	7.5	NA	NA	2,575	per piece	2	NA
14	Passive	Space	Evaporative Cart Canopy	Evaporative Cooling (Passive)	NA	Not available	NA	160	sqft	4	NA
15	Passive	Storage	EPS Box Coolers	Insulation	6.5	NA	NA	850	per piece	2	NA
16	Passive	Storage	PolyUrethane Foam Coolers	Insulation	6.5	NA	NA	6,250	per piece	8	NA
17	Passive	Storage	Insulated Ice Chest Box	Insulation	6	NA	NA	3,350	per piece	8	NA
18	Passive	Storage	Vacuum Insulated Panel Boxes	Insulation	7.5	NA	NA	30,250	per piece	10	NA
19	Passive	Space	PET Bottles - Directly Secured	Thermal Mass	NA	2.5	7	69	sqft	3	NA



Technical and Cost Comparison-Passive Cooling Solutions											
Sr No.	Cooling Technology	Cooling Service	Variant	Principle	I/PTR ²³ - Value (oC)	ATR ²⁴ -Value (oC)	STR ²⁵ -Value (oC)	Cost (INR)	Cost (INR) - Unit	Life span (years)	Solar Integration
20	Passive	Space	PET Bottles - Crate Mounted	Thermal Mass	NA	2	7	99	sqft	7	NA
21	Passive	Space	Roof Top Garden	Shading, Evapotranspiration, Thermal Mass	NA	3.5	7	330	sqft	NA	NA
22	Passive	Space	Expanded Polystyrene (EPS)	Insulation	NA	3	9	145	sqft	10	NA
23	Passive	Space	Gypsum Board	Insulation	NA	3	5.5	85	sqft	15	NA
24	Passive	Space	Mangalore Tiles	Insulation	NA	4	9	150	sqft	50	NA
25	Passive	Space	Poly Urethane Foam Panel	Insulation	NA	4	11	275	sqft	19	NA
26	Passive	Space	Hourdi Blocks	Insulation, Thermal Mass	NA	4	6.5	113	sqft	40	NA
27	Passive	Space	Reinforced Cement Concrete Slab	Thermal Mass	NA	NA	NA	225	sqft	58	NA
28	Passive	Space	Kadapa + Cement Screed	Thermal Mass	NA	Not available	Not available	205	sqft	35	NA
29	Passive	Space	Precast Concrete Slabs	Thermal Mass, RTC ³³	NA	Not available	Not available	150	sqft	38	NA

³³ Reduced Thermal Conductivity



Technical and Cost Comparison-Passive Cooling Solutions											
Sr No.	Cooling Technology	Cooling Service	Variant	Principle	I/PTR ²³ - Value (oC)	ATR ²⁴ -Value (oC)	STR ²⁵ -Value (oC)	Cost (INR)	Cost (INR) - Unit	Life span (years)	Solar Integration
30	Passive	Space	White Tiles	Reflection, High Emissivity	NA	Not available	10	90	sqft	18	NA
31	Passive	Space	Cool Roof Paint	Reflection, RTC	NA	1.5	12.5	58	sqft	3	NA
32	Passive	Space	Pre-Painted Galvalume Sheet (PPGL)	Reflection, High Emissivity	NA	Not available	Not available	180	sqft	18	NA
33	Passive	Space	Polyvinyl Chloride Boards (PVC)	Insulation, Reflection, RTC	NA	2.25	8	93	sqft	12	NA
34	Passive	Space	Cool Canvas	RB, Shading	NA	Not available	10	100	sqft	2	NA
35	Passive	Storage	Sabjee Cooler - Rukart	Insulation, Evaporative Cooling (Passive)	13	NA	NA	25,000	sqft	10	NA
36	Passive	Space	Khus Curtains / Blinds	Shading, Evaporative Cooling (Passive)	NA	Not available	7.5	75	sqft	2	NA
37	Passive	Space	Corrugated Recycled Tetra Pak Sheet (PolyAl roofing sheet)	Reflection, RTC, Insulation	NA	3	6.5	100	sqft	5	NA
38	Passive	Space	Bamboo Corrugated Roofing Sheet	RTC, Thermal Mass	NA	3.5	8	95	sqft	13	NA
39	Passive	Space	Onduline Sheet	RTC, Insulation	NA	Not available	7	110	sqft	14	NA



Technical and Cost Comparison-Passive Cooling Solutions											
Sr No.	Cooling Technology	Cooling Service	Variant	Principle	I/PTR ²³ - Value (oC)	ATR ²⁴ -Value (oC)	STR ²⁵ -Value (oC)	Cost (INR)	Cost (INR) - Unit	Life span (years)	Solar Integration
40	Passive	Space	Multiwall Polycarbonate Sheet	Insulation	NA	Not available	6.5	255	sqft	10	NA
41	Passive	Space	Bison Board	Insulation, RTC	NA	Not available	8	123	sqft	25	NA
42	Passive	Space	Bamboo Mat Board	Insulation, RTC	NA	3	8	138	sqft	20	NA
43	Passive	Space	Compressed Stabilized Earth Block	Thermal Mass, RTC	NA	3.5	8	160	sqft	45	NA
44	Passive	Space	Inverted Earthen Pots/ Clay tiles	Evaporative Cooling (Passive), RB, Thermal Mass	NA	4	11	110	sqft	18	NA
45	Passive	Space	Madras Terrace Roof Slab	Thermal Mass, Insulation	NA	4.5	Not available	365	sqft	60	NA
46	Passive	Space	Magra Wool - 20 mm	³⁴ RTC, Insulation	NA	Not available	4	120	sqft	60	NA
47	Passive	Space	Porotherm Block Masonry	Insulation, Thermal Mass	NA	Not available	Not available	250	sqft	50	NA
48	Passive	Space	Turbo Ventilators	Active Air Movement	NA	2	NA	3,250	per piece	13	NA
49	Passive	Space	Fibre Based-Modular Roof panels - 20mm Thick	RTC, Insulation	NA	Not available	Not available	270	sqft	25	NA

³⁴ Reduced Thermal Conductivity

Technical and Cost Comparison-Passive Cooling Solutions											
Sr No.	Cooling Technology	Cooling Service	Variant	Principle	I/PTR ²³ - Value (oC)	ATR ²⁴ -Value (oC)	STR ²⁵ -Value (oC)	Cost (INR)	Cost (INR) - Unit	Life span (years)	Solar Integration
50	Passive	Space	Rockwool Slabs - 30mm/50mm	RTC, Thermal Mass	NA	Not available	7	225	sqft	25	NA
51	Passive	Space	Pre-Painted Galvanized Iron Sheet	RB	NA	Not available	Not available	200	sqft	20	NA
52	Passive	Space	Glass Wool	RTC, Insulation	NA	3.5	6	195	sqft	11	NA
53	Passive	Space	Spray Foam	RTC, Insulation	NA	Not available	Not available	1,250	sqft	18	NA
54	Passive	Space	Aerogel Insulation	RTC	NA	6	Not available	1,000	sqft	25	NA
55	Passive	Space	Extruded Polystyrene Insulation Board	RTC	NA	Not available	Not available	195	sqft	30	NA
56	Passive	Space	Brick Bat Coba	Thermal Mass, Insulation	NA	Not available	4	210	sqft	20	NA
57	Passive	Space	Shade Net	Active Air Movement, Reduced Surface Heat Gain	NA	Not available	5	110	sqft	7	NA
58	Passive	Space	Honeycomb Panels	Insulation, Thermal Mass	NA	Not available	4	165	sqft	10	NA
59	Passive	Space	Window Tints	Reflection	NA	Not available	4	110	sqft	11	NA
60	Passive	Space	Unplasticized Polyvinyl	RTC, Multi-Chamber	NA	Not available	Not available	950	sqft	30	NA



Technical and Cost Comparison-Passive Cooling Solutions											
Sr No.	Cooling Technology	Cooling Service	Variant	Principle	I/PTR ²³ - Value (oC)	ATR ²⁴ -Value (oC)	STR ²⁵ -Value (oC)	Cost (INR)	Cost (INR) - Unit	Life span (years)	Solar Integration
			Chloride Windows	Frame Design							
61	Passive	Space	Lime Concrete	Reflection, Thermal Mass	NA	Not available	5.5	200	sqft	35	NA
62	Passive	Space	Retractable Awnings – White PVC-Coated Fabric (Solar Reflectivity Index 85-95)	Reflection, Shading	NA	Not available	Not available	215	sqft	9	NA
63	Passive	Space	MLP Umbrella	LES	NA	0.4	7.8	5,015 ³⁵	per piece	6	NA
64	Passive	Space	MLP Tarpaulin	LES	NA	Not available	Not available	40	sqft	6	NA
65	Passive	Space	Vertical Garden	Shading, Evapotranspiration, Thermal Mass	NA	Not available	Not available	880	sqft	9	NA

16.1.2. Active Cooling Solutions

³⁵ Replacement Cost of MLP sheet is INR 5/sq ft. For 3 layers it is INR 15/sq ft.

Technical and Cost Comparison- Active Cooling Solutions

Sr No.	Cooling Tech.	Cooling Service	Variant	Principle	I/PTR ³⁶ - Value (oC)	ATR ³⁷ -Value (oC)	STR ³⁸ -Value (oC)	Cost (INR)	Cost (INR) - Unit	Life span (years)	Solar Integration
1	Active	Storage	DC Compressor Freezer/Fridge	Mech VCR ³⁹	-17.5	NA	NA	45,000	per piece	10	Yes
2	Active	Storage	Solar Direct Drive (SDD) Freezer/Fridge	Mech VCR	5	NA	NA	78,000	per piece	10	Yes
3	Active	Storage	Micro Cold Room	Mech VCR	7.5	NA	NA	365,000	per piece	13	Yes
4	Active	Storage	Refrigerated E Kart/Tricycle	Mech VCR	6	NA	NA	194,000	per piece	6	Yes
5	Active	Storage	Thermo Electric Peltier	TER ⁴⁰	7.5	NA	NA	4,325	per piece	4	Yes
6	Active	Storage	Jute/Khadi/Charcoal Swamp Cabinets	EC ⁴¹ (Passive)	Not available	NA	NA	580	sqft	4	Yes
7	Active	Storage	Evaporative Cabinets with DC Fan	EC (Direct)	7.5	NA	NA	1,563	per piece	4	Yes
8	Active	Storage	Indirect Evaporative Boxes	EC (Indirect)	Not available	NA	NA	3,963	per piece	6	Yes
9	Active	Space	PV Powered Fan (DC)	AAM ⁴²	NA	Not available	NA	6,150	per piece	4	Yes
10	Active	Space	PV Exhaust Ventilator	AAM	NA	Not available	NA	7,250	per piece	4	Yes
11	Active	Space	Low Energy Solar DC Cooler	EC (Direct)	NA	3.5	NA	8,500	per piece	8	Yes

³⁶ Internal/Product Temperature Reduction

³⁷ Air Temperature Reduction

³⁸ Surface Temperature Reduction

³⁹ Mechanical Vapour Compression Refrigeration

⁴⁰ Thermoelectric Refrigeration

⁴¹ Evaporative Cooling

⁴² Active Air Movement



Technical and Cost Comparison- Active Cooling Solutions											
Sr No.	Cooling Tech.	Cooling Service	Variant	Principle	I/PTR ³⁶ - Value (oC)	ATR ³⁷ -Value (oC)	STR ³⁸ -Value (oC)	Cost (INR)	Cost (INR) - Unit	Life span (years)	Solar Integration
12	Active	Space	Ambiator	EC (Direct)	NA	4.5	NA	29,000	per piece	8	Yes
13	Active	Space	Low Energy / Energy Efficient Ceiling Fans	AAM	NA	Not available	NA	4,750	per piece	13	Yes
14	Active	Space	Low Energy / Energy Efficient Exhaust fans	AAM	NA	Not available	NA	2,300	per piece	8	Yes
15	Active	Space	Low Energy / Energy Efficient Wall Fans	AAM	NA	Not available	NA	3,500	per piece	8	Yes

17. Recommendation Overview

17.1. Objective and Scope

To analyse the site assessment data, market research findings and stakeholder consultations, and to provide and elaborate on a finalized design solution specific to each site.

17.2. Outputs

A summarised table as well as detailed description of the design solutions for the 30 sites, i.e., 6 Institutions, 12 Micro & Small Businesses, and 12 Street Vendors. The detailed description includes - renditions, pre-requisites, implementation plan, cost and budget estimate summary, risks, challenges, and mitigation.

18. Recommendation Methodology

This section presents the methodological framework used to recommend the finalized design solution.



18.1. Use of Site Assessments

Site assessments were a key methodological tool used to inform and validate the final design recommendations for space and storage cooling. The assessments enabled context-specific evaluation of feasibility, performance, and user suitability, ensuring that solutions proposed responded to real site conditions rather than generic assumptions.

A total of 30 sites were assessed, comprising 6 institutional buildings, 12 microbusinesses, and 12 street vendors. Physical site visits were conducted, supported by user interactions, direct observation, and on-site measurements wherever feasible. Assessments were carried out during operational/working hours to capture actual thermal conditions and usage patterns.

The assessment framework covered following parameters:

- Built and spatial characteristics (roof and wall materials, shading, ventilation, and structural constraints)
- Thermal and environmental conditions (indoor air and surface temperatures, airflow patterns, etc.)
- Use and occupancy patterns (number of users, hours of operation, activity type, and storage requirements etc.)
- Infrastructure and operational constraints (electricity availability, maintenance capacity, and portability needs)

While a common framework was applied, the assessment emphasis varied by typology. Institutional buildings were evaluated for integrated and long-duration cooling potential, microbusinesses for retrofit feasibility and operating cost sensitivity, and street vendors for mobility, low-cost deployment, and minimal electricity dependence.

18.2. Use of Market Research Findings

Market research was used to assess the operational and commercial feasibility of the shortlisted cooling solutions. For each solution, key parameters including technical specifications, performance, cost, operation and maintenance requirements, and use cases were reviewed. Primary research involved interactions with vendors who could supply/aid in fabricating these solutions in the city to validate their local availability, pricing, installation needs, and after-sales support.

Vendors were shortlisted based on lead time, warranty provided, cost, and service reliability. Solutions that were not readily available, had long procurement timelines, or posed maintenance challenges were



deprioritized. The market research findings were integrated with site assessment outcomes to ensure that final recommendations were technically sound and implementable at scale.

18.3. Stakeholder Consultations and Co Design

Discussions with relevant stakeholders in the domain of active and passive cooling systems were conducted to finalize on the appropriate solutions. For example, AEEE, an ally of cBalance, was approached to get an understanding of storage cooling solutions. AEEE has previously worked in the development of cold storage units. Discussions focused on identifying cold storage options, transportation, cooling technologies such as PCM-based cooling, vendor practices, market dynamics, and approaches to address cooling challenges. Another example in the form of Biomass Panel recommendations was arrived at based on our previous work with Gramart, a rural collective of women, farmers, artisans, and artists based in Paradsinga, Madhya Pradesh.

For Solar PV integration, the roof design layout was reviewed with the SELCO team before finalizing the Rendition to accommodate the changes needed to integrate the panels, along with the passive retrofits. Relevant design suggestions and feedback were integrated based on SELCO and cBalance's past project learnings.

To integrate local knowledge and user preferences, we used listening sessions, where we gathered feedback, and end user engagement sessions, which involved users in the design process. These approaches helped us reach a design suited to the specific context and make a final recommendation.

19. Summary Profile Table of Selected Sites

Selected Site Table			
Sr No.	Structure Name	Typology	Address
1	Tapaswini Jena, Bakery Storage Space	Micro Business Building	Bharatpur, Bhubaneswar, Odisha
2	Tapaswini Jena, Bakery Office Space	Micro Business Building	Bharatpur, Bhubaneswar, Odisha
3	Tapaswini Jena, Baking Space	Turbo Ventilator	Bharatpur, Bhubaneswar, Odisha
4	Prakash Mohanty	Micro Business Building	Shop No.1, CRPF Vending Zone, Bhubaneswar
5	Prakash Mohanty	Micro Business Building	Shop No. 2 & 3, CRPF Vending Zone, Bhubaneswar



6	Ranjith Behra	Micro Business Building	Shop No. 15, CRPF Vending Zone, Bhubaneswar
7	Antaryami Barik	Micro Business Building	Shop No. 38, CRPF Vending Zone, Bhubaneswar
8	Satyanarayan Senapati	Micro Business Building	Shikarchandi, Bhubaneswar, Odisha
9	Ashok Kumar Nayak	Street Vendor	Khandagiri Chowk
10	Bharati Maharana	Street Vendor	Old town, near Lingaraj temple
11	Archana Sahoo	Street Vendor	Old town, near Lingaraj temple
12	Dilip Kumar	Street Vendor	Old town, near Lingaraj temple
13	Saki Guru	Street Vendor	Old town, near Lingaraj temple

20. Site to Solution Recommendation Table

Solution Recommendation Table			
Sr No.	Structure Name	Space Cooling 1	Space Cooling 2
1	Bakery Storage Space	Internal Radiant Barrier	
2	Bakery Office Space	MLP Static	
3	Baking Space	Turbo Ventilator	
4	Prakash Mohanty, Shop no.1	Vertical Cane Blind	
5	Prakash Mohanty, Shop no. 2&3	Biomass Panel	
6	Ranjith Behra	Vertical Cane Blind	MLP Umbrella
7	Antaryami Barik	Vertical Cane Blind	
8	Satyanarayan Senapati	Vertical Cane Blind	
9	Ashok Kumar Nayak	MLP Tarpaulin	
10	Bharati Maharana	MLP Umbrella	
11	Archana Sahoo	MLP Umbrella	
12	Dilip Kumar	MLP Umbrella	
13	Saki Guru	MLP Umbrella	

21. Logic for Final Solution Selection

Although multiple interventions were identified as technically feasible for each site as suggested by the solution Match Tool, the final decision was taken on the basis of following project wide decision principles:



- Preference for natural and bio-based materials over synthetic alternatives wherever technically feasible.
- Preference for materials and interventions that had demonstrated satisfactory performance during laboratory and testbed evaluations.
- Preference for locally sourced materials that support local value chains and livelihoods over industrially manufactured alternatives.
- Selection of interventions to ensure an adequate number of installations (minimum of three) for each solution type, enabling meaningful comparative performance evaluation across sites.
- Diversification of intervention types across the overall project while maintaining statistically adequate representation for each solution category.

22. Site Overview and Intervention Selection

22.1. Micro Business

22.1.1. Tapaswini Jena

22.1.1.1. Site Overview

The site is a small-scale bakery located in Bhartpur and comprises three distinct functional units:

- Office Space
- Storage and Packing Unit
- Baking Unit

Although these units are part of the same business, they experience different heat exposure conditions. Thus, each unit was assessed independently to identify the most appropriate cooling intervention.

a. Unit 1- Office Space

22.1.1.2. Built Environment Assessment

The office space is intermittently occupied by the owner for administrative activities. The space is enclosed by a tin roof sheet and has a small window that provides limited light and ventilation.



The office space does not have any heat generating equipment. However, prolonged solar exposure on the roof contributes to elevated indoor temperatures, reducing occupant comfort during working hours

22.1.1.3. Heat-related Problem Statements

- Elevated indoor temperatures during daytime
- Thermal discomfort while undertaking administrative work
- Limited natural ventilation

22.1.1.4. Key Factors Influencing Heat

- Tin Sheet roof exposed to solar radiation
- Limited ventilation
- Intermittent occupancy requiring a low-maintenance passive cooling solution

22.1.1.5. Solution Match Tool Assessment

Internal Radiant Barrier - MLP - Tarpaulin Mounted
Vertical Cane Blind (MLP Covered)
PET Bottles - Crate Mounted
Static MLP
Biomass Panel (MLP Covered)

Although multiple interventions were identified, the final selection was guided by the recommendations of Solution Match Tool and project-wide logic (in detail on section 5)

22.1.1.6. Final Intervention Implemented

Considering the intermittent occupancy of the office, absence of internal heat sources, ease of installation, and minimal maintenance requirements, Static MLP Panels were selected. The intervention provides an effective radiant barrier beneath the roof while remaining economical and suitable for a low-occupancy space.



Fig 22.1.6-1 : MLP Static Panel Installation at Office Space

b. Unit 2 - Storage and Packing Unit

22.1.1.7. Built Environment Assessment

The storage unit is used for storing finished bakery products and also serves as a packing area where women workers package products before distribution. The space is occupied between 10:00 am to 6:00 pm.

Although no baking takes place within this room, it is located adjacent to the baking unit. Heat generated by the ovens transfers into the storage space, resulting in stored heat accumulation that affects worker comfort and product handling.

22.1.1.8. Heat-related problem statements

- Heat transfer from the neighbouring baking unit
- Elevated indoor temperatures during packing operations
- Thermal discomfort for workers engaged in packing

22.1.1.9. Key Factors Influencing Heat

- Tin sheet roof exposed to direct solar radiation

- Heat transfer from adjacent baking operations
- Continuous daytime occupancy

22.1.1.10. Solution Match Tool Assessment

The Solution Match Tool shortlisted the following interventions:

Internal Radiant Barrier - MLP - Tarpaulin Mounted
Vertical Cane Blind (MLP Covered)
PET Bottles - Crate Mounted
Static MLP
Biomass Panel (MLP Covered)

Although multiple interventions were identified, the final selection was guided by recommendations from the Solution Match Tool and project-wide logic (in detail on section 5).

22.1.1.11. Final intervention Implemented

The Internal Radiant Barrier was selected because it creates an insulating air layer beneath the roof while reflecting radiant heat away from the occupied space. Compared with static roof interventions, the suspended barrier was expected to provide greater thermal benefit in a space experiencing both roof heat gain and heat transfer from the adjacent baking unit.



Fig 22.1.1.11-1 : Internal Radiant Barrier Installation

c. Unit 3 - Baking Unit

22.1.1.12. Built Environment Assessment

The baking unit is the primary production area where ovens and baking equipment operate continuously throughout the day. Approximately 10 workers occupy the space between 10:00 am and 8:00 PM.

The workspace is enclosed beneath a tin sheet roof and does not have any mechanical ventilation such as ceiling fans. The continuous operation of ovens generates substantial internal heat, making this the hottest area within the bakery site.

22.1.1.13. Heat-related Problem Statements

- Extremely high indoor temperatures due to continuous baking operations.
- Significant heat generated from ovens and baking equipment.
- Poor air circulation.

- Thermal discomfort affecting worker wellbeing and productivity.

22.1.1.14. Solution Match Tool Assessment

While passive roof insulation measures were evaluated, discussion with the end user highlighted the need for a solution that could directly address the significant heat generated during baking operations.

22.1.1.15. Key Factors Influencing Heat

- Continuous operation of high temperature baking ovens
- Tin sheet roof exposed to direct solar radiation
- Absence of mechanical or passive ventilation
- High worker occupancy

22.1.1.16. Final Intervention Implemented

Unlike the other units, where reducing solar heat gain was the primary objective, the baking unit required a solution capable of exhausting internally generated hot air. Based on the operational requirements of the bakery and the preference of the end user, Turbo Ventilator was selected. The Turbo Ventilator promotes natural ventilation by continuously extracting hot air accumulated beneath the roof, thereby improving indoor air movement and reducing heat buildup without relying on electricity.



Fig 22.1.1.16-1 : Turbo Ventilator Installation at Baking Space (Outside View)



Fig 22.1.1.16-2 : Turbo Ventilator Installation at Baking Space (Inside View)

22.1.2. Prakash Kumar Mohanty

22.1.2.1. Site Overview

The site comprises a small-scale food establishment serving breakfast and snack items. The business operates majorly on the first half of the day (6:00 am to 13:00 Pm). The workspace consists of three interconnected shop units (Shop 1, Shop 2 and Shop 3), each serving different operation functions like storage etc.

22.1.2.2. Built environment Assessment

While the shops function as a single unit the thermal conditions vary across the three spaces depending on their use and internal heat generation.

Among the three units, Shop 1 serves as the primary cooking area consisting of gas stoves used for food preparation. This results in significant internal heat generation in addition to prevailing outdoor heat. Shops 2 and 3 are primarily used for storage and other supporting operations, where the thermal comfort is influenced by ambient weather conditions.

22.1.2.3. Heat Sources

The primary sources contributing to heat stress at the site include:

- Direct solar radiation on the building and surrounding surfaces.
- High ambient outdoor temperatures during summer months.

- Heat generated from gas stoves used for continuous cooking operations, particularly within Shop 1.
- Heat transfer between the cooking area and adjoining shops.

22.1.2.4. Key Factors Influencing Heat

- Continuous operation of gas stoves in Shop 1, resulting in a significant internal heat source.
- Heat transfer between the cooking area and adjacent shops.
- High ambient temperatures during summer months.
- Exposure of external wall and roof to solar radiation.

22.1.2.5. Heat related Problem Statements

- Reduction in customer footfall due to heat.
- Elevated indoor temperatures in the cooking area resulting from the usage of a gas stove.
- Significant discomfort for workers engaged in cooking and food preparation.
- Reduced overall comfort for both workers and customers, affecting business operations during periods of extreme heat.

22.1.2.6. Solution Match Tool Assessment

Based on the needs assessment and structural audit, the solution match tool evaluated the site and the following interventions were shortlisted as technically feasible for the site:

Internal Radiant Barrier - MLP - Tarpaulin Mounted
Vertical Cane Blind (MLP Covered)
Static MLP
Biomass Panel (MLP Covered)

Although multiple interventions were identified, the final selection was based on recommendations from the Solution Match Tool and project-wide logic (in detail in section 5).

22.1.2.7. Final Intervention Implemented

The following interventions were implemented:

- a. Vertical Cane Blind (MLP Wrapped) on the exterior wall of Shop 1 (Cooking Area).
- b. Biomass Panel (MLP covered) in Shop 2.
- c. Biomass Panel (MLP covered) in Shop 3.



The combined intervention was intended to reduce the conductive and radiant heat transfer through the roof while simultaneously minimising solar heat gain through the exposed exterior wall of the cooking area, thereby improving thermal comfort for workers and supporting uninterrupted business operations during periods of extreme heat.



Fig 22.1.2.7-1 : Vertical Cane Blind Installation



Fig 22.1.2.7-2 : Biomass Panel Installation

22.1.3. Renjith Behra

22.1.3.1. Site Overview

The site is a neighbourhood grocery store located within the BMC vending zone. The shop operates for extended hours throughout the day, serving customers from the surrounding area. The shop has approximately 250 customers per day.

22.1.3.2. Built environment Assessment

The shop is constructed with a corrugated tin sheet roof and is provided with an internal false ceiling beneath the roof. While the false ceiling offers a degree of insulation from roof heat, the shop continues to experience elevated indoor temperatures.

The shop frontage remains open for customer access, exposing the interior to direct solar radiation during parts of the day and contributing to increased indoor temperatures.

22.1.3.3. Heat- related Problem Statement

The needs assessment identified the following heat related challenges:

- Reduction in customer footfall during periods of extreme heat.
- Long operating hours resulting in prolonged heat exposure.
- Elevated indoor temperatures leading to thermal discomfort for the shop owner.
- Heat accumulation within the shop during prolonged periods of solar exposure.

22.1.3.4. Key Factors Influencing Heat

- Tin sheet roofing exposed to direct solar radiation.
- Long operating hours resulting in prolonged heat exposure.

22.1.3.5. Solution Match Tool Assessment

The solution Match Tool shortlisted the following technically suitable roof-based interventions:

Internal Radiant Barrier - MLP - Tarpaulin Mounted
Vertical Cane Blind (MLP Covered)
Static MLP
Biomass Panel (MLP Covered)

Although multiple interventions were identified, the final selection was guided by recommendations from the Solution Match Tool and project-wide logic (in detail in section 5).

22.1.3.6. Final Intervention Implemented

Although several roof based interventions were identified by the Solution Match Tool, the final solution was refined following the structural audit and discussions with the end user.

The presence of an existing false ceiling indicated that the roof already incorporated a basic insulating layer. Instead, observations during the site assessment showed that direct solar radiation through exposed shop walls was a major contributor to indoor heat again. The

intervention was also aligned with the project's broader decision principles as mentioned in section 5.

The Vertical Cane Blind (MLP Wrapped) was installed along the sun-exposed exterior wall of the shop to reduce direct solar heat gain through the wall surface. The intervention was selected to improve indoor thermal comfort for the occupant. It complemented the existing false ceiling by addressing a heat pathway that was not mitigated through roof insulation alone.



Fig 22.1.3.6-1 : Vertical Cane Blind Installation

22.1.4. Antaryami Barik

22.1.4.1. Site Overview

The site is a neighbourhood salon located within BMC Vending Zone. The business operates throughout the day, from 10:00 am to 8:00 pm, providing grooming services that require customers to remain indoors for extended periods.

22.1.4.2. Built Environment Assessment

The salon is housed within a tin-roof structure with an existing false ceiling. The front facade of the shop is predominantly covered with glass, with a designated entrance for customer access. An air-conditioning unit is also installed to maintain indoor comfort during business hours.

While the false ceiling provides partial insulation from roof heat, the extensive glazed frontage allows significant solar heat gain into the

workspace, increasing the cooling load on the air-conditioning system. Consequently, the air conditioner and ceiling fan operate for extended durations, particularly during hot summer afternoons.

22.1.4.3. Heat-related problem statements

The needs assessment identified following heat-related challenges:

- Increased operation of air conditioning and ceiling fans during hot weather.
- High electricity consumption resulting in increased operating costs.
- Solar heat gain through the glazed shop frontage, reducing the effectiveness of mechanical cooling.

22.1.4.4. Solution Match Tool Assessment

Although multiple interventions were identified, the final selection was based on recommendations from the Solution Match Tool and project-wide logic (in detail in section 5).

Internal Radiant Barrier - MLP - Tarpaulin Mounted
Vertical Cane Blind (MLP Covered)
Static MLP
Biomass Panel (MLP Covered)

22.1.4.5. Key Factors Influencing Heat

- Solar radiation through glass frontage.
- Long operating hours during periods of high ambient temperature.
- Dependence on mechanical cooling to maintain customer comfort.

22.1.4.6. Final Intervention Implemented

The existing false ceiling already provided a degree of insulation beneath the roof, reducing the relative benefit of additional under-roof interventions. The structural audit revealed that the predominant pathway for heat gain was through the front facade.

Thus, after discussion and taking feedback with the end user, a Vertical Cane Blind (MLP wrapped) was identified as the most appropriate solution. This external shading system reduces direct solar radiation before it reaches the glass, thereby lowering the indoor heat gain and reducing the cooling demand on the air-conditioning system while maintaining ventilation and customer access. The intervention was also

aligned with the project's broader decision principles which are listed in section 5.



Fig 22.1.4.6-1 : Vertical Cane Blind Installation

22.1.5. Satyanarayan Senapati

22.1.5.1. Site Overview

The site is a small electrical retail shop located in Shikarchandi Basti. The shop primarily deals with the sale of electrical components and accessories and is occupied by the business owner himself. The shop is open from 10:00 am to 8:00pm.

22.1.5.2. Built Environment Assessment

The shop is constructed with a tin sheet roof and is flanked by adjoining shops on both the sides, resulting in a shared side wall. As a result, there are no windows or other ventilation openings and the only significant opening is the shop frontage. A ceiling fan is present which helps in air circulation.

The shop also contains storage shelves installed just below the roof. These shelves occupy the space typically required for under-roof interventions, making the installation of false ceiling/under-roof based cooling solutions technically challenging.

22.1.5.3. Heat-related Problem Statements

- Elevated indoor temperatures during daytime.
- Limited natural ventilation due to absence of windows.
- Heat accumulation within enclosed space.
- Thermal discomfort for the end user during prolonged working hours.

22.1.5.4. Key Factors Influencing Heat

- Tin sheet roof exposed to solar radiation.
- Absence of ventilation/side windows.
- Heat gain through the open shop frontage during periods of high ambient temperature.

22.1.5.5. Solution Match Tool Assessment

Based on needs assessment and structural audit, the Solution Match Tool shortlisted the following technically suitable interventions:

Internal Radiant Barrier - MLP - Tarpaulin Mounted
Vertical Cane Blind (MLP Covered)
PET Bottles - Crate Mounted
Static MLP
Biomass Panel (MLP Covered)

22.1.5.6. Final Intervention Implemented

Although several interventions were identified as technically suitable, the final selection was refined based on structural characteristics of the shop. Hence, a Vertical Cane Blind (MLP Wrapped) was installed along the open front side of the shop. The intervention was intended to reduce the solar heat gain through the front side of the shop.

The presence of storage shelves immediately beneath the roof significantly limited the feasibility of under-roof interventions. Modifying the shelving system would have disrupted the shop's storage capacity and daily operations.



Fig 22.1.5.6-1 : Vertical Cane Blind Installation

22.2. Street Vendors

Unlike MSMEs, street vendors operate from lightweight, temporary, or semi-permanent vending structures with no or limited scopes for retrofitting. Based on field observations and testings, two portable cooling interventions were developed for street vendors:

MLP - Integrated Umbrella - designed for vendors using individual umbrellas or operating from compact vending structures

MLP Tarapulin - designed for vendors requiring larger shaded areas or operating from semi-permanent structures/stalls.

The final intervention was selected based on following parameters:

- Existing shading arrangement
- Size of vending space
- Ease of installation and portability
- User preference
- Structural feasibility

22.2.1. Renjith Behra

22.2.1.1. Site Overview

The vendor operates a small tea and snack stall using umbrellas as the primary source of shade beside his main shop at BMC vending zone.

22.2.1.2. Built Environment Assessment

The vending setup is portable and temporary, with no permanent structural elements available for mounting larger shading interventions. The existing umbrella provides limited protection from heat and solar radiation.

22.2.1.3. Heat related Problem Statements

- Continuous exposure to direct solar radiation during working hours.
- Thermal discomfort during preparing and serving food.

22.2.1.4. Key Factors Influencing Heat

- Outdoor operation with no shelter
- Direct solar radiation throughout the day

22.2.1.5. Final Intervention Implemented

Considering the compact nature of the vending setup, MLP Umbrella was selected to enhance the thermal comfort without compromising on portability and ease of operation.





Fig 22.2.1.5-1: MLP Umbrella Installation

22.2.2. Ashok Kumar Nayak

22.2.2.1. Site Overview

The vendor operates a mushroom stall where products are displayed over a relatively large vending area.

22.2.2.2. Built Environment Assessment

The vending setup required a larger shaded area to protect both the vendor and the displayed produce. The existing arrangement was suitable for mounting an overhead MLP tarpaulin system.

22.2.2.3. Heat related Problem Statements

- Direct solar exposure affects both vendor comfort and mushroom quality.
- Requirement for a larger shaded workspace.

22.2.2.4. Key Factors Influencing the Heat

- Direct solar radiation throughout the day
- Outdoor operation

22.2.2.5. Final Intervention Implemented

Unlike compact vending setups, the site required shade over a large area. Therefore, the MLP tarpaulin was selected to provide broader coverage for both the vendor and displayed products after end user feedback.

22.2.3. Archana Sahoo

22.2.3.1. Site Overview

Archana Sahoo operates a roadside flower vending stall where flowers are displayed in open for customers.

22.2.3.2. Built Environment Assessment

The vending setup is compact with limited infrastructure and support available for permanent shading retrofits.

22.2.3.3. Heat -related Problem Statements

- Continuous exposure to direct solar radiation.
- Thermal discomfort during working hours.
- Heat affects the freshness of flowers.

22.2.3.4. Key Factors Influencing Heat

- Outdoor vending environment
- Lack of permanent shade

22.2.3.5. Final Intervention Implemented

The MLP-Integrated Umbrella was selected as it provided localized shading and portability.

22.2.4. Dilip Kumar

22.2.4.1. Site Overview

The vendor operates a mobile coconut vending setup.

22.2.4.2. Built Environment Assessment

The vending arrangement is compact and portable, relying on an umbrella as the source of shade.



22.2.4.3. Heat-related Problem Statements

- Direct exposure to sunlight throughout operating hours.
- Increased heat stress during afternoon hours.

22.2.4.4. Key Factors Influencing Heat

- Outdoor vending
- High solar exposure

22.2.4.5. Final Intervention Implemented

The MLP-Integrated Umbrella was selected as it enhances the thermal comfort without compromising on portability and ease of operation.

22.2.5. Bharati Maharana

22.2.5.1. Site Overview

The vendor operates a roadside vegetable stall with a compact vending arrangement.

22.2.5.2. Built Environment Assessment

The vending setup is temporary and the intervention needs to be lightweight and portable.

22.2.5.3. Heat-related Problem Statements

- Direct solar radiation causes thermal discomfort.
- Heat affecting both vendor and vegetable freshness.

22.2.5.4. Key Factors Influencing Heat

- Outdoor vending environment
- Continuous solar exposure

22.2.5.5. Final Intervention Implemented

The MLP-Integrated Umbrella was selected as it enhances the thermal comfort without compromising on portability and ease of operation.

22.2.6. Saki Guru

22.2.6.1. Site Overview

The end user operates a roadside coconut vending in Old Town, Bhubaneswar. The vendor works in an open outdoor environment. As a



result, there is prolonged exposure to direct solar radiation which affects the thermal comfort of the vendor.

22.2.6.2. Built Environment Assessment

The vending setup is temporary and the intervention needs to be lightweight and portable that does not interfere with daily setup and dismantling.

22.2.6.3. Heat-related Problem Statements

- Direct solar radiation causes thermal discomfort
- Heat affects both vendor and product

22.2.6.4. Key Factors Influencing Heat

- Outdoor vending environment
- Continuous solar exposure
- Long working hours under high ambient temperatures

22.2.6.5. Final Intervention Implemented

The MLP-Integrated Umbrella was selected as it enhances the thermal comfort without compromising on portability and ease of operation.



23. Design Details

23.1. Micro Business

23.1.1. Bharatpur Bakery Storage Space - Internal Radiant Barrier

23.1.1.1. CAD Layout

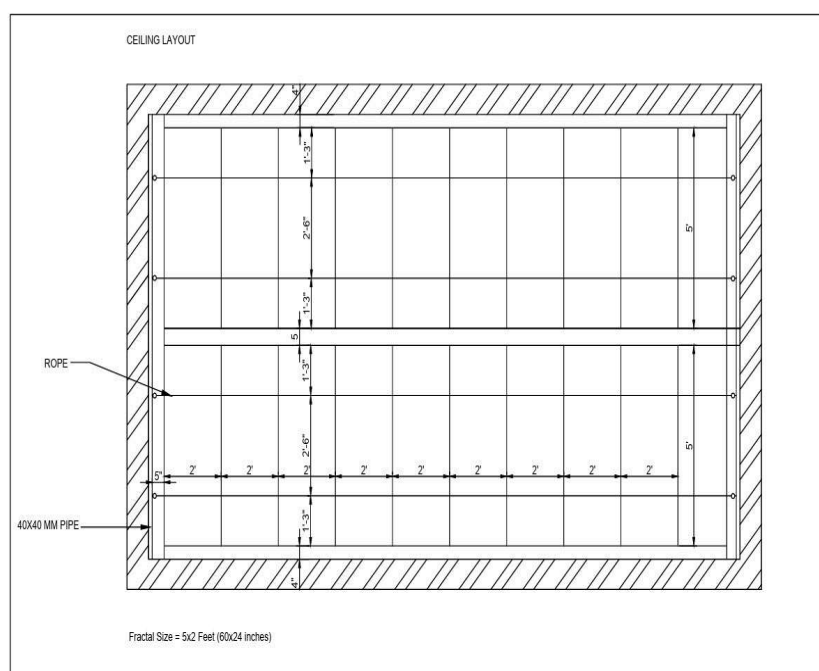


Fig 23.1.1.1-1 : Ceiling Layout

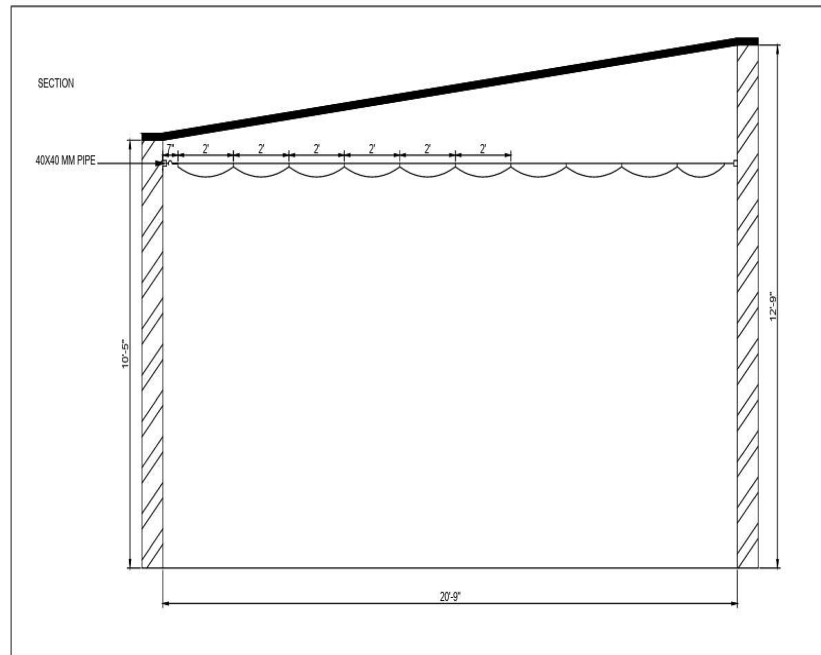


Fig 23.1.1.1-2 : Sectional Layout

SECTION IN DETAIL

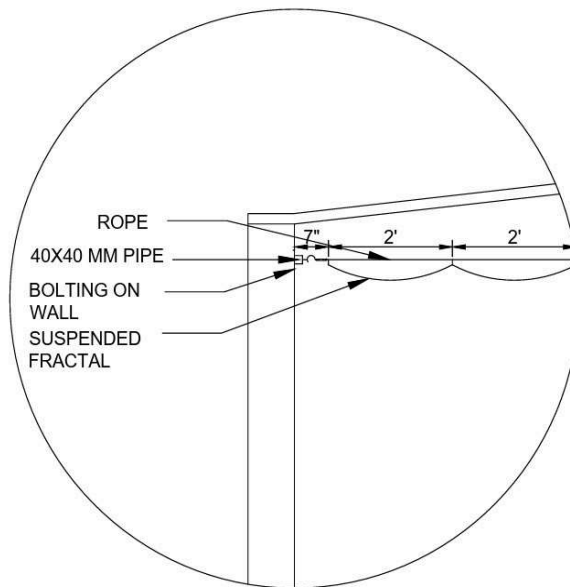


Fig 23.1.1.1-3 : Section in Detail

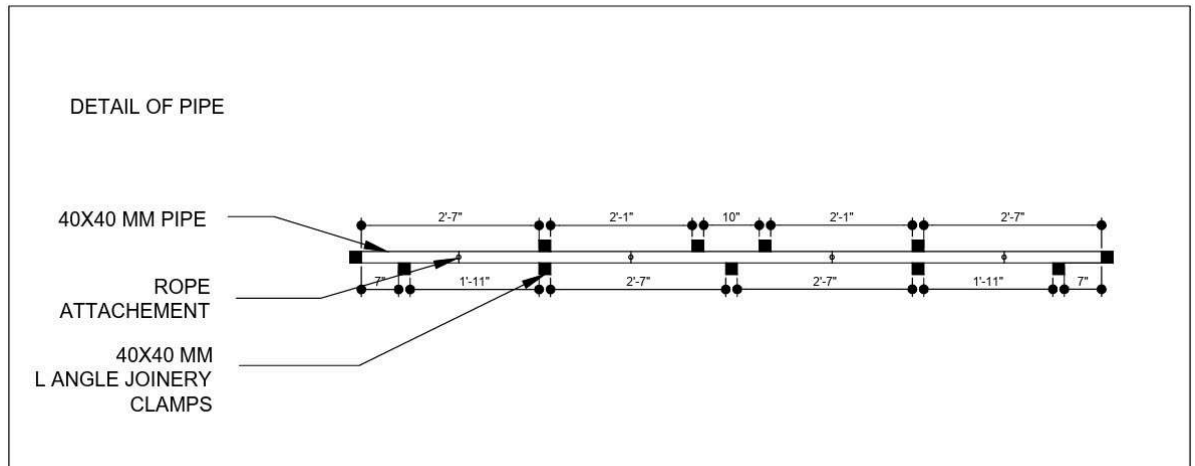


Fig 23.1.1.1-4: Detail of Pipe

23.1.1.2. Pre-requisites

- Assessment and audit of the site should be completed prior to the fabrication.
- The condition of walls should be verified to ensure they can support the anchor bolts.

23.1.1.3. Implementation Plan

The implementation process is implemented in the following four stages:

Stage 1: Site Assessment and Preparation

- Conduct a structural audit.
- Determine the orientation, movement direction, and number of fractals required.
- Map existing electrical fixtures, lighting and fans so that fixtures can be re-routed or repositioned that interfere with the movement of dynamic panels.
- Contact a fabricator along with renditions and Bill of quantities for installation.

Stage 2: Fabrication of MLP Fractals

- Fabricate MLP sheets according to desired measurements using repurposed MLP packets.
- Assemble fabricated MLP sheets into larger fractals.

Stage 3: Installation of Support system

- Install anchor points on walls depending on the orientation of fractals and establish PVC coated steel wire ropes across the room.
- Install curtain rings and tensioning systems to facilitate movement of the fractals.

- Verify alignment, spacing, and structural stability of the support system.

Stage 4: Final Installation & Handover

- Suspend fabricated fractals on a wire-rope system.
- Verify smooth movement of fractals by stress testing (operating 50 times).
- Conduct final quality checks, rectify any installation defects, and handover to the resident.

23.1.1.4. Cost and Budget Estimate Summary

Area of Roof: 229.8 sq.ft.						
Sr. No.	Material	Specifications	Qty (to be procured)	Unit	Cost (INR/Unit)	Total Cost (INR)
1	Anchor fasteners/Hooks		20	nos.	22	528
2	Steel Wire	6mm(core) - PVC clear coated	40	mtr.	35	1,050
3	U-Clamp	8 mm	16	nos.	15	450
4	Plastic Curtain Hooks	1 inch	10	dozen	30	60
6	Turnbuckle	8 mm	10	nos.	75	1,050
7	Pipe length	1 inch dia	40	feet	43	1,720
10	Double Sided High Bond Tape		9	nos.	240	2,206
11	Duct tape		7	nos.	150	1,034
12	Multi Layer Plastic (MLP)	11.09'x20.72	689	sq.ft	5	3,447
12	Bamboo Strips					
13	Ziplocks	12 inch	69	nos.	2	138
	Total					8,546

23.1.1.5. Risks, Challenges and Mitigation

Risk/Challenge	Potential Impact	Mitigation Measure
Obstruction by existing electrical fixtures	Restricted movement of dynamic fractals	Conduct pre-installation mapping and re-routing of fixtures if needed
Sagging of wire ropes over long term usage	Reduced effectiveness and aesthetics	Select appropriate wire diameter and use tensioning mechanisms
Damage to MLP sheets during fabrication	Reduced effectiveness	Handle the MLP sheets/fractals carefully and replace/repair damaged sections before installation

23.1.2. Tapaswini Jena, Bakery Office Space - MLP Static

23.1.2.1. CAD Layout

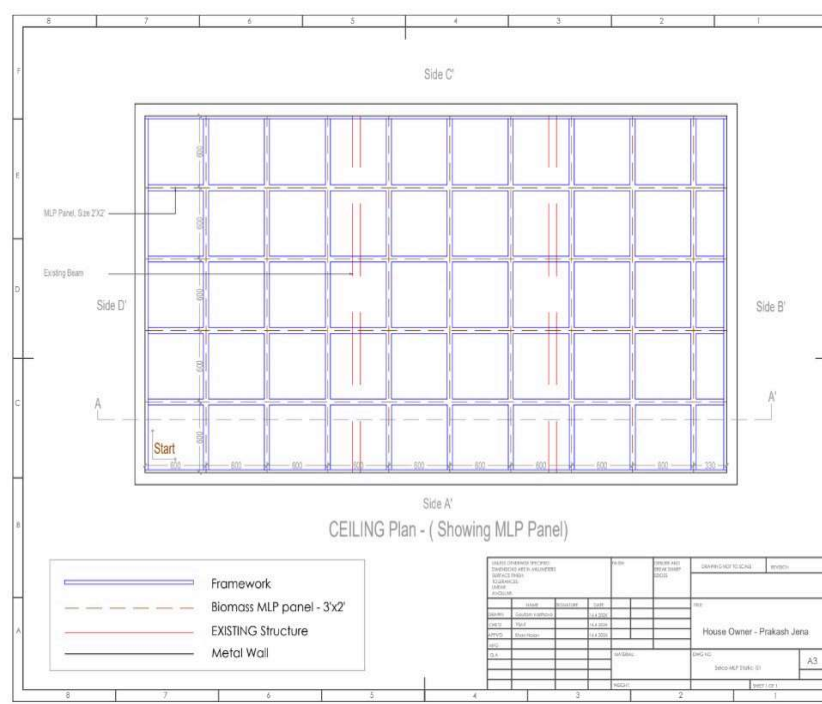


Fig 23.1.2.1-1 : Ceiling Plan

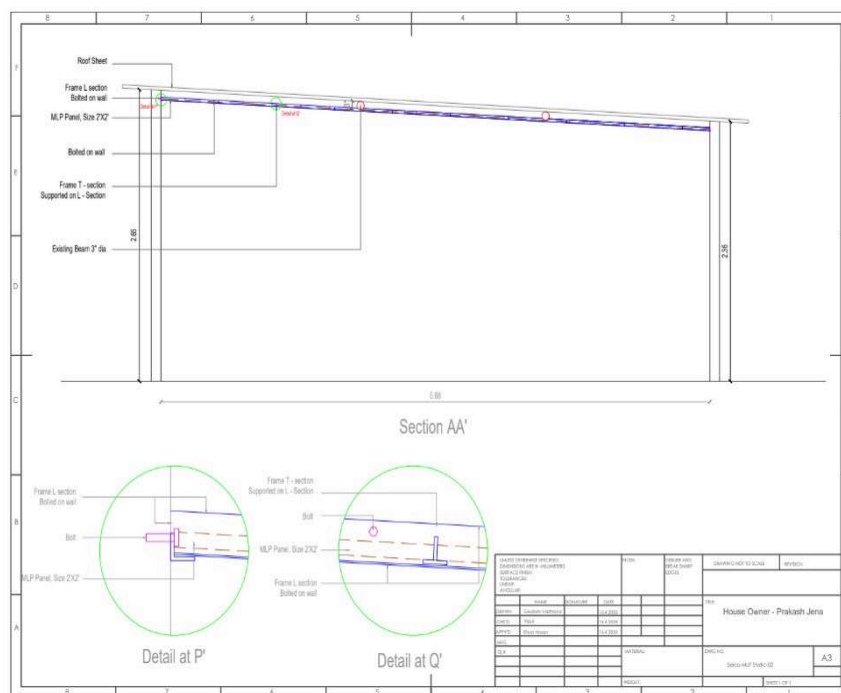


Fig 23.1.2.1-2: Sectional View

23.1.2.2. Pre-requisites

- Accurate measurement of room dimensions should be taken.
- A suitable installation level should be established, which will ensure adequate headroom and occupant comfort post installation.
- The installation layout should be planned to maximise the use of full size panels and minimise cutting and material wastage.

23.1.2.3. Implementation Plan

The implementation process is undertaken in four stages:

Stage 1: Site Assessment and Material Preparation

- Conduct a structural audit.
- Determine the orientation, movement direction, and number of MLP panels required.
- Map existing electrical fixtures, lighting and fans so that fixtures can be re-routed or repositioned.
- Contact a fabricator along with renditions and bill of quantities for installation.
- Collect and sort post consumer MLP packets.
- Clean and process the packets for fabrication.
- Assemble the individual packets into larger MLP sheets (4ft*3ft).

- Procure jute bags, bamboo sticks, duct tapes etc.

Stage 2: Panel Fabrication

- Construct a bamboo frame with size 4ft*3ft to provide structural support and to maintain panel geometry.
- Fabricate MLP sheets into modular panels measuring 4ft*3ft using a jute bag and bamboo frame.
- Inspect panels for proper sealing, continuity, and dimensional accuracy.

Stage 3: Installation and Handover

- Install GI channels below the roof structure at appropriate spacing to support panel loads.
- Mount fabricated MLP panels onto GI channel framework.
- Ensure proper alignment and continuity of installed surface.

23.1.2.4. Cost and Budget Estimate Summary

Area of Roof: 183.7 (sq.ft.)					
Sr. No.	Material	Qty (to be procured)	Unit	Cost (INR/Unit)	Total Cost (INR)
1	MLP Panel (2*2)	53	no	396	21,113
2	GI channels	147	Feet	120	17,634
3	Perimeter channels	73	feet	10	735
5	Ceiling to wall angle clips	29	piece	10	294
6	Channel connectors	66	piece	9	595
7	C clamp	15	per piece	305	4,482
8	Wooden Plug	73	per piece	5	367
9	Duct tape	4	per piece	150	551
10	SDSS screws	73	per piece	3	220
	Total				45,992

23.1.2.5. Risks, Challenges, and Mitigation

Risk/Challenge	Potential Impact	Mitigation Measure
Variability in quality of collected MLP waste	Difficult to fabricate the MLP sheets and results in inconsistent panel appearance	Conduct quality checks and sorting procedures before fabrication
Incomplete bonding/sealing of MLP sheets	Reduced durability and structural integrity	Conduct fabrication quality control checks
Misalignment of GI channel framework	Difficulties during panel installation	Conduct careful measurements and alignment checks before GI channel



23.1.3. Prakash Mohanty, Shop No.1 - Vertical Cane Blind

23.1.3.1. Renditions

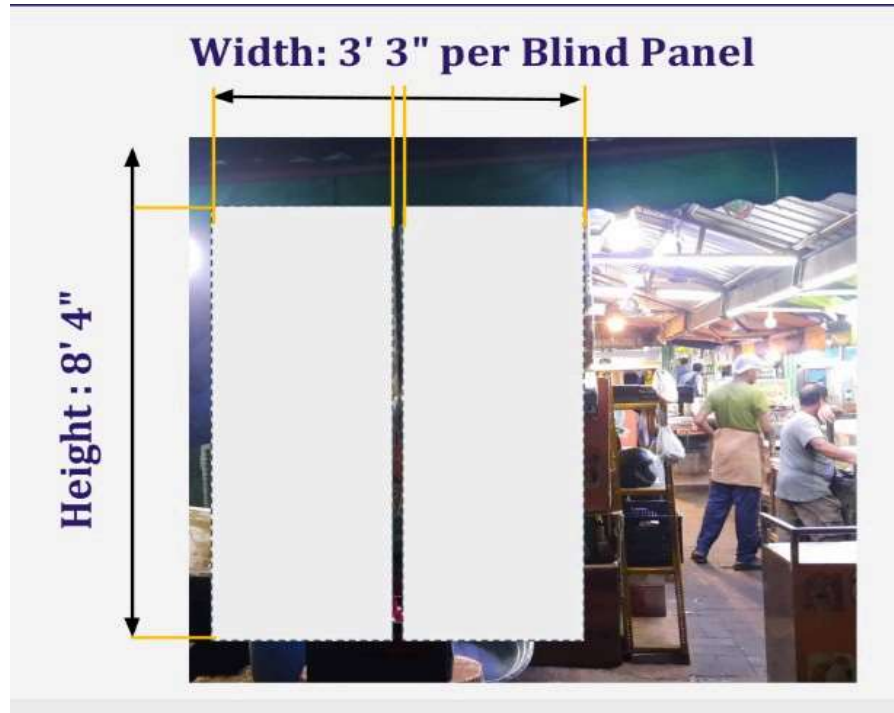


Fig 23.1.3.1-1 : Prakash Mohanty, Shop No.1 - Rendition

23.1.3.2. Pre-requisites

- Suitable support locations should be identified either through existing roof overhang or purlins.
- The installation layout should maintain adequate spacing between adjacent blind modules to facilitate smooth operation.
- Bamboo blinds should be inspected for defects, damage, and dimensional accuracy before attaching MLP sheets to it.
- The installation should not obstruct any ventilation points, entry/exit points etc.

23.1.3.3. Implementation Plan

The implementation process is undertaken in three stages:

Stage 1: Site Assessment and Segmentation

- Survey the building and identify wall sections exposed to direct solar radiation.

- Divide the wall area into segments containing openings (doors, windows, exhaust openings) and solid wall sections.
- Designate blinds in such a way that the openings are not obstructed.

Stage 2: Fabrication of Cane Blind panels

- Determine panel dimensions based on wall geometry and opening locations.
- Limit individual blind width to approximately 4 feet for ease of operation and maintenance.
- Procure bamboo blinds according to site specific dimensions.
- Attach reflective MLP sheets to bamboo blinds using ties and fastenings.

Stage 3: Installation and Handover

- Install anchor bolts into the wall when direct suspension is not feasible.
- Maintain adequate spacing between adjacent modules to facilitate smooth rolling and unrolling operations.
- Suspend fabricated blinds from the support system using equivalent connectors.
- Ensure that blinds roll outward from the building facade to facilitate operation and prevent interference with wall surfaces.
- Verify ease of movement, stability and alignment of all modules.

23.1.3.4. Cost and Budget Estimate Summary

Area of Wall (H*W): 56.03 sq.ft.						
Sr. No.	Material	Specifications	Qty. (to be procured)	Unit	Cost (INR/Unit)	Total Cost (INR)
1	Bamboo Blind Fabrication		56	sq.ft	60	3,362
2	Hooks		6	nos.	10	56
3	Multi-Layer Plastic sheet	3.3'x8.6'x2	224	sq.ft	5	1,121
4	Double Sided High Bond Tape		2	nos.	240	538
5	Duct Tape		1	nos.	150	168
6	GI wire	2mm thick	1	bundle	50	28
7	Zip Ties	12 inch long	22	nos.	2	45
	Total					5,317



23.1.3.5. Risks, Challenges and Mitigation

Risk/Challenge	Potential Impact	Mitigation Measure
Exposure to rain and moisture	Pre-mature deterioration of bamboo blinds	Maintain clearance from ground level and apply protective coating to blinds
Damage due to high winds	Detachment of blinds	Ensure adequate anchoring and use multiple support points
Misalignment between adjacent blinds	Reduced coverage	Maintain proper spacing and installation tolerances

23.1.4. Prakash Mohanty, Shop no. 2&3 - Biomass Panels

23.1.4.1. CAD Layout

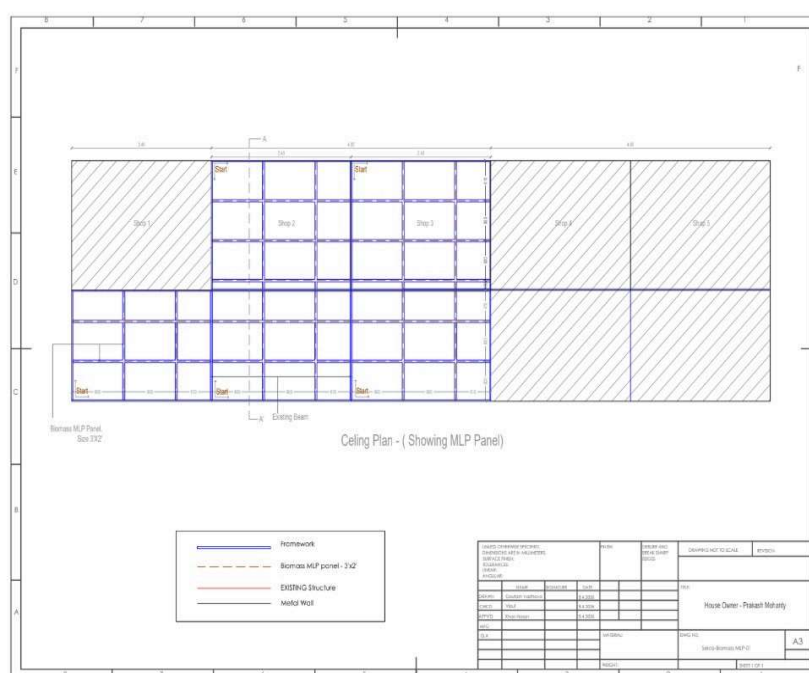
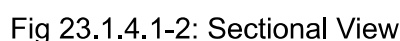


Fig 23.1.4.1-1: Ceiling Plan



- Inspection of roof for leakages, cracks etc. before installation.
- An air gap or minimum clearance between roof and proposed panel installation level should be given for better efficiency and for maintenance activities.
- Adequate headroom should be ensured after installation for occupant safety.
- Biomass panels should be quality checked for dimensional accuracy and any kind of physical damage.
- Tools required for drilling, cutting, and welding should be made available at site during installation.

The implementation process is to be undertaken in three stages:

- Inspect the existing roof condition and identify potential leakage points, damaged roofing sheets.
- Inspect walls for cracks and dampness.
- Repair cracks, joints, and vulnerable areas using appropriate measures.
- Assess roof geometry, slope, electrical wiring, lighting fixtures, and ceiling fans. Repurpose the fixtures if needed.

- Inspect prefabricated biomass panels for dimensional accuracy and physical damage.
- Wrap the panels with MLP sheets, ensuring the reflective surface faces outward.

Stage 3: Installation and Handover

- Develop a panel layout that minimizes cutting and reduces the number of joints.
- Install the GI framework along the room perimeter.
- Place the wrapped biomass panels within the support framework.
- Cut edge panels wherever necessary to achieve complete coverage area and seal cut edges with duct tapes for protective finish.
- Conduct final inspections to verify coverage and finish quality.

23.1.4.4. Cost and Budget Estimate Summary

Area of Roof =(A1+A2)*N: 201.472 (sq.ft.)					
Sr. No.	Material	Qty (to be procured)	Unit	Cost (INR/Unit)	Total Cost (INR)
1	Biomass Panels	201	sq.ft.	140	28,206
2	GI channels	161	Feet	120	19,341
3	Perimeter channels	81	feet	10	806
5	Ceiling to wall angle clips	32	piece	10	322
6	Channel connectors	73	piece	9	653
7	C clamp	16	per piece	305	4,916
8	Wooden Plug	81	per piece	5	403
9	Duct tape	4	per piece	150	604
10	Multi-Layer Plastic sheet	403	sq.ft.	5	2,015
11	SDSS screws	81	per piece	3	242
	Total				57,508

23.1.4.5. Risks, Challenges and Mitigation

Risk/Challenge	Potential Impact	Mitigation Measure
Existing roof leakages	Moisture damage to panels and reduced effectiveness	Undertake roof waterproofing and repairs before installation
Damage to MLP wrapping during installation	Reduced moisture resistance and thermal performance	Inspect panels prior to installation and repair damaged wrapping
Misalignment of GI channel framework	Difficulties during panel installation	Conduct careful measurements and alignment checks before GI channel mounting



23.1.5. Ranjth Behra - Vertical Cane Blind

23.1.5.1. Renditions



Fig 23.1.5.1-1 : Ranjith Behra, Rendition

23.1.5.2. Pre-requisites

- Suitable support locations should be identified either through existing roof overhang or purlins.
- The installation layout should maintain adequate spacing between adjacent blind modules to facilitate smooth operation.
- Bamboo blinds should be inspected for defects, damage, dimensional accuracy before attaching MLP sheets to it.
- The installation should not obstruct any ventilation points, entry/exit points etc.

23.1.5.3. Implementation Plan

The implementation process is to be undertaken in three stages:

Stage 1: Site Assessment and Segmentation

- Survey the building and identify wall sections exposed to direct solar radiation.
- Divide the wall area into segments containing openings (doors, windows, exhaust openings) and solid wall sections.

- Designate blinds in such a way that the openings are not obstructed.

Stage 2: Fabrication of Cane Blind panels

- Determine panel dimensions based on wall geometry and opening locations.
- Limit individual blind width to approximately 5 feet for ease of operation and maintenance.
- Procure bamboo blinds according to site specific dimensions.
- Attach reflective MLP sheets to bamboo blinds using ties and fastenings.

Stage 3: Installation and Handover

- Install anchor bolts into the wall when direct suspension is not feasible.
- Maintain adequate spacing between adjacent modules to facilitate smooth rolling and unrolling operations.
- Suspend fabricated blinds from the support system using equivalent connectors.
- Ensure that blinds roll outward from the building facade to facilitate operation and prevent interference with wall surfaces.
- Verify ease of movement, stability and alignment of all modules.

23.1.5.4. Cost and Budget Estimate Summary

Area of Wall (H*W): 66.805							
Sr. No.	Material	Specifications	Qty/100 sq.ft.	Qty (to be procured)	Unit	Cost (INR/Unit)	Total Cost (INR)
1	Bamboo Blind Fabrication		100	67	sq.ft	60	4,008
2	Hooks		10	7	nos.	10	67
3	Multi-Layer Plastic sheet	3.8'x8.6'x2	400	267	sq.ft	5	1,336
4	Double Sided High Bond Tape		4	3	nos.	240	641
5	Duct Tape		2	1	nos.	150	200
6	GI wire	2mm thick	1	1	bundle	50	33
7	Zip Ties	12 inch long	40	27	nos.	2	53
	Total						6,340

23.1.5.5. Risks, Challenges and Mitigation

Risk/Challenge	Potential Impact	Mitigation Measure
Exposure to rain and moisture	Pre-mature deterioration of	Maintain clearance from ground



	bamboo blinds	level and apply protective coating to blinds
Damage due to high winds	Detachment of blinds	Ensure adequate anchoring and use multiple support points
Misalignment between adjacent blinds	Reduced coverage	Maintain proper spacing and installation tolerances

23.1.6. Antaryami Barik - Vertical Cane Blind

23.1.6.1. Renditions

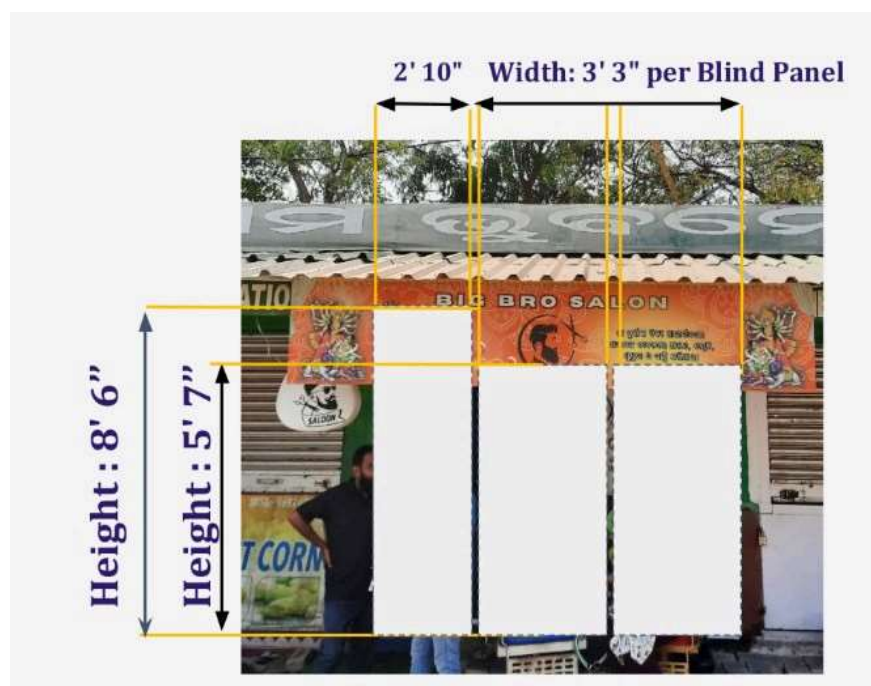


Fig 23.1.6.1-1 : Antaryami Barik, Rendition

23.1.6.2. Pre-requisites

- Suitable support locations should be identified either through existing roof overhang or purlins.
- The installation layout should maintain adequate spacing between adjacent blind modules to facilitate smooth operation.
- Bamboo blinds should be inspected for defects, damage, dimensional accuracy before attaching MLP sheets to it.
- The installation should not obstruct any ventilation points, entry/exit points etc.

23.1.6.3. Implementation Plan

The implementation process is to be undertaken in three stages:

Stage 1: Site Assessment and Segmentation

- Survey the building and identify wall sections exposed to direct solar radiation.
- Divide the wall area into segments containing openings (doors, windows, exhaust openings) and solid wall sections.
- Designate blinds in such a way that the openings are not obstructed.

Stage 2: Fabrication of Cane Blind panels

- Determine panel dimensions based on wall geometry and opening locations.
- Limit individual blind width to approximately 4 feet for ease of operation and maintenance.
- Procure bamboo blinds according to site specific dimensions.
- Attach reflective MLP sheets to bamboo blinds using ties and fastenings.

Stage 3: Installation and Handover

- Install anchor bolts into the wall when direct suspension is not feasible.
- Maintain adequate spacing between adjacent modules to facilitate smooth rolling and unrolling operations.
- Suspend fabricated blinds from the support system using equivalent connectors.
- Ensure that blinds roll outward from the building facade to facilitate operation and prevent interference with wall surfaces.
- Verify ease of movement, stability, and alignment of all modules.

23.1.6.4. Cost and Budget Estimate Summary

Area of Wall (H*W): 62.44 sq.ft.						
Sr. No.	Material	Specifications	Qty (to be procured)	Unit	Cost (INR/Unit)	Total Cost (INR)
1	Bamboo Blind Fabrication		62	sq.ft	60	3,747
2	Hooks		6	nos.	10	62
3	Multi-Layer Plastic sheet	2.9'X8.7', 6.5'X5.7'	250	sq.ft	5	1,249
4	Double Sided High Bond Tape		2	nos.	240	599
5	Duct Tape		1	nos.	150	187
6	GI wire	2mm thick	1	bundle	50	31
7	Zip Ties	12 inch long	25	nos.	2	50
	Total					5,926



23.1.6.5. Risks, Challenges and Mitigation

Risk/Challenge	Potential Impact	Mitigation Measure
Exposure to rain and moisture	Pre-mature deterioration of bamboo blind	Maintain clearance from ground level and apply protective coating to blinds
Damage due to high winds	Detachment of blinds	Ensure adequate anchoring and use multiple support points
Misalignment between adjacent blinds	Reduced coverage	Maintain proper spacing and installation tolerances

23.1.7. Satyanarayan Senapati - Vertical Cane Blind

23.1.7.1. Renditions



Fig 23.1.7.1-1 : Satyanarayan Senapati, Rendition

23.1.7.2. Pre-requisites

- Suitable support locations should be identified either through existing roof overhang or purlins.
- The installation layout should maintain adequate spacing between adjacent blind modules to facilitate smooth operation.
- Bamboo blinds should be inspected for defects, damage, dimensional accuracy before attaching MLP sheets to it.
- The installation should not obstruct any ventilation points, entry/exit points etc.

23.1.7.3. Implementation Plan

The implementation process is to be undertaken in three stages:

Stage 1: Site Assessment and Segmentation

- Assess the building and identify wall sections exposed to direct solar radiation.
- Divide the wall area into segments containing openings (doors, windows, and exhaust openings) and solid wall sections.
- Assign blinds in such a way that the openings are not obstructed.

Stage 2: Fabrication of Cane Blind panels

- Determine panel dimensions based on wall geometry and opening locations.
- Limit individual blind width to approximately 4 feet for ease of operation and maintenance.
- Procure bamboo blinds according to site specific dimensions.
- Attach reflective MLP sheets to bamboo blinds using ties.

Stage 3: Installation and Handover

- Install anchor bolts into the wall when direct suspension is not feasible.
- Maintain adequate spacing between adjacent modules to facilitate smooth rolling and unrolling operations.
- Suspend fabricated blinds from the support system using equivalent connectors.
- Ensure that blinds roll outward from the building facade to facilitate operation and prevent interference with wall surfaces.
- Verify ease of movement, stability and alignment of all modules.

23.1.7.4. Cost and Budget Estimate Summary

Name of the Building: Satyanarayan Senapati, Shikharchandi						
Total MLP Requirement: 203 sq.ft.						
Solutions Assigned: Vertical Cane Blind						
Area of Wall (H*W): 50.69 sq.ft.						
Sr. No.	Material	Specifications	Qty (to be procured)	Unit	Cost (INR/Unit)	Total Cost (INR)
1	Bamboo Blind Fabrication		51	sq.ft	60	3,042
2	Hooks		5	nos.	10	51
3	Multi-Layer Plastic sheet	4.3'X7.1', 2.9'X7.1'	203	sq.ft	5	1,014
4	Double Sided High Bond Tape		2	nos.	240	487



5	Duct Tape		1	nos.	150	152
6	GI wire	2mm thick	1	bundle	50	25
7	Zip Ties	12 inch long	20	nos.	2	41
	Total					4,811

23.1.7.5. Risks, Challenges and Mitigation

Risk/Challenge	Potential Impact	Mitigation Measure
Exposure to rain and moisture	Pre-mature deterioration of bamboo blinds	Maintain clearance from ground level and apply protective coating to blinds
Damage due to high winds	Detachment of blinds	Ensure adequate anchoring and use multiple support points
Misalignment between adjacent blinds	Reduced coverage	Maintain proper spacing and installation tolerances

23.2. Street Vendors

23.2.1. Renjith Behra - MLP Umbrella

23.2.1.1. Pre-requisites

- A new umbrella should be procured if the vendor is not possessing a structurally sound umbrella with no damages.
- Umbrella geometry and size should be measured accurately to arrive at the MLP sheet dimensions.
- Local wind conditions should be assessed to determine whether additional reinforcements or fastenings are needed.

23.2.1.2. Implementation Plan

The implementation process consists of following stages

Stage 1: Site Assessment and Measurement

- Assess the dimensions and geometry of the existing umbrella.
- Measure the canopy area to determine the size of MLP sheets required.
- Identify attachment locations that do not interfere with opening, closing or folding mechanisms.

Stage 2: Fabrication of MLP sheets

- Fabricate MLP sheet assemblies according to dimensions of umbrella canopy.
- Trim and shape the sheets to conform to the umbrella profile.



- Attach velcro strips to both MLP panels and on umbrella canopy.

Stage 3: Installation

- Attach the MLP sheets to umbrellas using Velcro and ensure the reflective surface faces outward.
- Verify that the attachment does not obstruct the umbrella ribs or hinges.

Stage 4: Testing and Handover

- Open and close the umbrella multiple times to confirm smooth operation.
- Verify adequate coverage of MLP on canopy surface.

23.2.1.3. Cost and Budget Estimate Summary

Solution Name: Umbrella MLP						
Area of canopy: 100 sq.ft.						
Sr. No.	Material	Specifications	Qty	Unit	Cost (INR/Unit)	Total Cost (INR)
1	Umbrella		1	Per piece	800	800
2	MLP sheets		8	nos.	70	560
3	Velcro		22	meter	50	1,100
4	Adhesive		500	ml	150	150
	Total					2,610

23.2.1.4. Risks, Challenges and Mitigation

Risk/Challenge	Potential Impact	Mitigation Measure
Increased wind resistance due to added surface layer	Umbrella damage or instability during high winds	Ensure secure attaching and advise the vendors to close umbrellas during extreme wind conditions
MLP sheet detachment during regular use	Reduced thermal performance	Use of good quality velcro and periodic inspections

23.2.2. Ashok Kumar Nayak - MLP Tarpaulin

23.2.2.1. Pre-requisites

- Availability of a vending structure or a temporary frame which can support the tarpaulin.
- Assessing local wind conditions to determine the need of additional anchoring and reinforcements.



23.2.2.2. Implementation Plan

The implementation process consists of following stages:

Stage 1: Site Assessment and measurement

- Assess the dimension of tarpaulin needed based on coverage requirements.
- Identify primary directions of solar exposure throughout the day.
- Determine suitable attachment points/temporary support structure for the tarpaulin.

Stage 2: Fabrication and Attachment of MLP Sheet

- Fabricate three-layer MLP sheet according to required dimensions.
- Procure the tarpaulin sheets and attach the fabricated three layered MLP sheets to the tarpaulin by stitching.

Stage 3: Installation and Handover

- Install hooks and ties/fastening points necessary for securing the tarpaulin.
- Mount the tarpaulin system over the vending structure/place.
- Secure the edges with ropes, ties, and fastening systems to prevent displacement.
- Inspect the installation for stability and coverage.

23.2.2.3. Cost and Budget Estimate Summary

Solution Name: Tarpaulin MLP						
Area of site: 100 sq.ft.						
Sr. No.	Material	Specifications	Qty	Unit	Cost (INR/Unit)	Total Cost (INR)
1	Tarpaulin	10x10	1	Per piece	800	800
2	MLP sheets	5x5	30	nos.	70	2,100
3	Stitching		22	mtr.	50	1,100
4	Red tape		1	mtr.	270	150
	Total					4,150

23.2.2.4. Risks, Challenges and Mitigation

Risk/Challenge	Potential Impact	Mitigation Measure
Exposure to rain and outdoor conditions	Degradation of material over time	Use of weather resistant tarpaulin and periodic inspections



23.2.3. Bharati Maharana - MLP Umbrella

23.2.3.1. Pre-requisites

- A new umbrella should be procured if the vendor is not possessing a structurally sound umbrella with no damages.
- Umbrella geometry and size should be measured accurately to arrive at the MLP sheet dimensions.
- Local wind conditions should be assessed to determine whether additional reinforcements or fastenings are needed.

23.2.3.2. Implementation Plan

The implementation process consists of following stages:

Stage 1: Site Assessment and Measurement

- Assess the dimensions and geometry of the existing umbrella.
- Measure the canopy area to determine the size of MLP sheets required.
- Identify attachment locations that do not interfere with opening, closing or folding mechanisms.

Stage 2: Fabrication of MLP sheets

- Fabricate MLP sheet assemblies according to dimensions of umbrella canopy.
- Trim and shape the sheets to conform to the umbrella profile.
- Attach velcro strips to both MLP panels and on umbrella canopy.

Stage 3: Installation

- Attach the MLP sheets to umbrellas using Velcro and ensure the reflective surface faces outward.
- Verify that the attachment does not obstruct the umbrella ribs, hinges.

Stage 4: Testing and Handover

- Open and close the umbrella multiple times to confirm smooth operation.
- Verify adequate coverage of MLP on canopy surface.



23.2.3.3. Cost and Budget Estimate Summary

Solution Name: Umbrella MLP						
Area of canopy: 100 sq.ft.						
Sr. No.	Material	Specifications	Qty	Unit	Cost (INR/Unit)	Total Cost (INR)
1	Umbrella		1	Per piece	800	800
2	MLP sheets		8	nos.	70	560
3	Velcro		22	meter	50	1,100
4	Adhesive		500	ml	150	150
	Total					2,610

23.2.3.4. Risks, Challenges and Mitigation

Risk/Challenge	Potential Impact	Mitigation Measure
Increased wind resistance due to added surface layer	Umbrella damage or instability during high winds	Ensure secure attaching and advise the vendors to close umbrellas during extreme wind conditions
MLP sheet detachment during regular use	Reduced thermal performance	Use of good quality velcro and periodic inspections

23.2.4. Archana Sahoo - MLP Umbrella

23.2.4.1. Pre-requisites

- A new umbrella should be procured if the vendor is not possessing a structurally sound umbrella with no damages.
- Umbrella geometry and size should be measured accurately to arrive at the MLP sheet dimensions.
- Local wind conditions should be assessed to determine whether additional reinforcements or fastenings are needed.

23.2.4.2. Implementation Plan

The implementation process consists of following stages:

Stage 1: Site Assessment and Measurement

- Assess the dimensions and geometry of the existing umbrella.
- Measure the canopy area to determine the size of MLP sheets required.
- Identify attachment locations that do not interfere with opening, closing or folding mechanisms.



Stage 2: Fabrication of MLP sheets

- Fabricate MLP sheet assemblies according to dimensions of umbrella canopy.
- Trim and shape the sheets to conform to the umbrella profile.
- Attach velcro strips to both MLP panels and on umbrella canopy.

Stage 3: Installation

- Attach the MLP sheets to umbrellas using Velcro and ensure the reflective surface faces outward.
- Verify that the attachment does not obstruct the umbrella ribs, hinges.

Stage 4: Testing and Handover

- Open and close the umbrella multiple times to confirm smooth operation.
- Verify adequate coverage of MLP on canopy surface.

23.2.4.3. Cost and Budget Estimate Summary

Solution Name: Umbrella MLP						
Area of canopy: 100 sq.ft.						
Sr. No.	Material	Specifications	Qty	Unit	Cost (INR/Unit)	Total Cost (INR)
1	Umbrella		1	Per piece	800	800
2	MLP sheets		8	nos.	70	560
3	Velcro		22	meter	50	1,100
4	Adhesive		500	ml	150	150
	Total					2,610

23.2.4.4. Risks, Challenges and Mitigation

Risk/Challenge	Potential Impact	Mitigation Measure
Increased wind resistance due to added surface layer	Umbrella damage or instability during high winds	Ensure secure attaching and advise the vendors to close umbrellas during extreme wind conditions
MLP sheet detachment during regular use	Reduced thermal performance	Use of good quality velcro and periodic inspections

23.2.5. Dilip Kumar - MLP Umbrella

23.2.5.1. Pre-requisites

- A new umbrella should be procured if the vendor is not possessing a structurally sound umbrella with no damages.
- Umbrella geometry and size should be measured accurately to arrive at the MLP sheet dimensions.
- Local wind conditions should be assessed to determine whether additional reinforcements or fastenings are needed.

23.2.5.2. Implementation Plan

The implementation process consists of following stages:

Stage 1: Site Assessment and Measurement

- Assess the dimensions and geometry of the existing umbrella.
- Measure the canopy area to determine the size of MLP sheets required.
- Identify attachment locations that do not interfere with opening, closing or folding mechanisms.

Stage 2: Fabrication of MLP sheets

- Fabricate MLP sheet assemblies according to dimensions of umbrella canopy.
- Trim and shape the sheets to conform to the umbrella profile
- Attach velcro strips to both MLP panels and on umbrella canopy.

Stage 3: Installation

- Attach the MLP sheets to umbrellas using Velcro and ensure the reflective surface faces outward.
- Verify that the attachment does not obstruct the umbrella ribs, hinges.

Stage 4: Testing and Handover

- Open and close the umbrella multiple times to confirm smooth operation.
- Verify adequate coverage of MLP on canopy surface.

23.2.5.3. Cost and Budget Estimate Summary

Solution Name: Umbrella MLP						
Area of canopy: 100 sq.ft.						
Sr. No.	Material	Specifications	Qty	Unit	Cost (INR/Unit)	Total Cost (INR)
1	Umbrella		1	Per piece	800	800
2	MLP sheets		8	nos.	70	560
3	Velcro		22	meter	50	1,100
4	Adhesive		500	ml	150	150
	Total					2,610

23.2.5.4. Risks, Challenges and Mitigation

Risk/Challenge	Potential Impact	Mitigation Measure
Increased wind resistance due to added surface layer	Umbrella damage or instability during high winds	Ensure secure attaching and advise the vendors to close umbrellas during extreme wind conditions
MLP sheet detachment during regular use	Reduced thermal performance	Use of good quality velcro and periodic inspections

23.2.6. Saki Guru - MLP Umbrella

23.2.6.1. Pre-requisites

- A new umbrella should be procured if the vendor is not possessing a structurally sound umbrella with no damages.
- Umbrella geometry and size should be measured accurately to arrive at the MLP sheet dimensions.
- Local wind conditions should be assessed to determine whether additional reinforcements or fastenings are needed.

23.2.6.2. Implementation Plan

The implementation process consists of following stages:

Stage 1: Site Assessment and Measurement

- Assess the dimensions and geometry of the existing umbrella.
- Measure the canopy area to determine the size of MLP sheets required.
- Identify attachment locations that do not interfere with opening, closing or folding mechanisms.



Stage 2: Fabrication of MLP sheets

- Fabricate MLP sheet assemblies according to dimensions of umbrella canopy.
- Trim and shape the sheets to conform to the umbrella profile.
- Attach velcro strips to both MLP panels and on umbrella canopy.

Stage 3: Installation

- Attach the MLP sheets to umbrellas using Velcro and ensure the reflective surface faces outward.
- Verify that the attachment does not obstruct the umbrella ribs, hinges.

Stage 4: Testing and Handover

- Open and close the umbrella multiple times to confirm smooth operation.
- Verify adequate coverage of MLP on canopy surface.

23.2.6.3. Cost and Budget Estimate Summary

Solution Name: Umbrella MLP						
Area of canopy: 100 sq.ft.						
Sr. No.	Material	Specifications	Qty	Unit	Cost (INR/Unit)	Total Cost (INR)
1	Umbrella		1	Per piece	800	800
2	MLP sheets		8	nos.	70	560
3	Velcro		22	meter	50	1,100
4	Adhesive		500	ml	150	150
	Total					2,610

23.2.6.4. Risks, Challenges and Mitigation

Risk/Challenge	Potential Impact	Mitigation Measure
Increased wind resistance due to added surface layer	Umbrella damage or instability during high winds	Ensure secure attaching and advise the vendors to close umbrellas during extreme wind conditions
MLP sheet detachment during regular use	Reduced thermal performance	Use of good quality velcro and periodic inspections



24. Pre-Installation Community Audit

The intention of the pre-installation community audit is to :

1. Assess the vulnerability of a given community to heat stress based on the location, density, material of house structures and settlement design.
2. Study the local socio-economic context to determine the level of social cohesion and potential of the community to collaborate and work on thermal comfort-based livelihood interventions.
3. Evaluate socio-political challenges and opportunities that can either hinder or enhance the accessibility of local residents to thermal comfort solutions.
4. Assess the vulnerability of the settlement to eviction to determine the viability of setting up small-scale thermal comfort retrofit business(es) in the locality.
5. Study the characteristics of existing women's groups to understand the opportunities and challenges to setting up Women Heat Action Cooperatives (WEHACs) in the settlement.
6. Shortlist contextually appropriate cooling solution designs based on the settlements' density, and local and regional climatic conditions.

24.1. Heat Stress Vulnerability Assessment Questionnaire

24.1.1. Institution Buildings

General Information

- 24.1.1.1. Name of Institution
- 24.1.1.2. Address
- 24.1.1.3. Location (Area, Ward, City)
- 24.1.1.4. Type of Institution
 - ☐ School
 - ☐ Anganwadi
 - ☐ Health Facility (PHC / Clinic / Hospital)
 - ☐ Community Hall
 - ☐ Government Office
 - ☐ Shelter / Care Home
 - ☐ Training Centre
 - ☐ Other
- 24.1.1.5. Year of Construction of the Building
- 24.1.1.6. Does the institution operate throughout the year?
- 24.1.1.7. Type of Ownership



- ☐ Government
- ☐ Private
- ☐ Trust / NGO
- ☐ Religious Institution
- ☐ Other:

Socio-Economic & Beneficiary Profile

- 24.1.1.8. Is the building owner supportive of permanent infrastructure modifications (roof, fixtures)?
- ☐ Yes
 - ☐ No
 - ☐ Maybe
- 24.1.1.9. Who is responsible for daily operations and maintenance?
- 24.1.1.10. Total Number of Staff (Regular + Contract)
- 24.1.1.11. Average Number of Daily Beneficiaries / Users
- 24.1.1.12. Description of Beneficiaries (select all applicable)
- ☐ Children (below 6 years)
 - ☐ School-going children
 - ☐ Elderly (60+ years)
 - ☐ Pregnant / Lactating women
 - ☐ Patients / People with illness
 - ☐ Persons with disabilities
 - ☐ General public
 - ☐ Other
- 24.1.1.13. Are any beneficiaries particularly vulnerable to heat stress?
- ☐ Yes
 - ☐ No
- 24.1.1.14. If yes, please specify

Legal & Administrative Status

- 24.1.1.15. Does the institution have a valid operating license / registration?
- ☐ Yes
 - ☐ No
- 24.1.1.16. Type of License / Registration
- 24.1.1.17. Any mandatory safety or health compliance applicable? (select all applicable)
- ☐ Fire Safety
 - ☐ Electrical Safety
 - ☐ Health Department Approval
 - ☐ Labour Compliance
 - ☐ Not aware
 - ☐ Other

Building Function & Operations



- 24.1.1.18. Primary Function of the Building
- ☐ Education
 - ☐ Healthcare
 - ☐ Shelter / Care
 - ☐ Administration
 - ☐ Skill Training
 - ☐ Mixed use
 - ☐ Other:
- 24.1.1.19. Types of activities undertaken (select all that apply)
- ☐ Teaching / learning
 - ☐ Patient care
 - ☐ Administrative work
 - ☐ Food preparation
 - ☐ Sleeping / resting
 - ☐ Storage of goods / medicines / food
 - ☐ Other:_____
- 24.1.1.20. Does the building require temperature-controlled storage?
- ☐ Yes
 - ☐ No
- 24.1.1.21. If yes, what is stored?
- ☐ Medicines / vaccines
 - ☐ Food / perishables
 - ☐ Drinking water
 - ☐ Equipment
 - ☐ Other:_____
- 24.1.1.22. Does the institution need to operate during heat alerts or extreme heat days?
- ☐ Yes
 - ☐ No

Operating Schedule & Occupancy

- 24.1.1.23. Operating hours (start–end)
- 24.1.1.24. Multiple shifts or time blocks?
- ☐ Yes
 - ☐ No
- 24.1.1.25. If yes, specify timings:
- 24.1.1.26. Peak occupancy periods (select all applicable)
- ☐ Morning
 - ☐ Afternoon
 - ☐ Evening
 - ☐ All day

Building Size & Form

- 24.1.1.27. Total built-up area (in sqft)
- 24.1.1.28. Average ceiling height (in m)



Building Envelope & Materials

- 24.1.1.29. Roof material
☐ RCC
☐ Metal / GI sheet
☐ Tile
☐ Thatch
☐ Other: _____
- 24.1.1.30. Wall material
☐ Brick masonry
☐ Concrete
☐ Sheet / temporary
☐ Other
- 24.1.1.31. Is the roof directly exposed to solar radiation?
☐ Yes
☐ No
☐ Other _____
- 24.1.1.32. Roof accessibility for interventions
☐ Yes
☐ No

Ventilation, Shading & Heat Sources

- 24.1.1.33. Natural ventilation available?
☐ Yes
☐ No
- 24.1.1.34. Mechanical ventilation available?
☐ Yes
☐ No
- 24.1.1.35. External shading present (select all)
☐ Trees
☐ Chajjas / overhangs
☐ Awnings
☐ Adjacent buildings
☐ None
☐ Other
- 24.1.1.36. Internal heat sources present (select all)
☐ Cooking equipment
☐ Medical equipment
☐ IT / servers
☐ High occupancy

Utilities, Energy Use & Power Reliability

- 24.1.1.37. Availability of water supply
☐ Continuous
☐ Intermittent
☐ Not available



- 24.1.1.38. Power reliability (frequency of power cuts)
- ☐ Rare cuts
 - ☐ Occasional cuts
 - ☐ Frequent cuts
- 24.1.1.39. Existing power backup (select all applicable)
- ☐ Solar
 - ☐ Generator
 - ☐ Battery / UPS
 - ☐ None
- 24.1.1.40. Is the power backup sufficient to run cooling or storage systems?
- ☐ Yes
 - ☐ No
 - ☐ Maybe
- 24.1.1.41. Power backup testing & servicing schedule
- ☐ Regular (defined schedule)
 - ☐ Occasional
 - ☐ Rare / never
 - ☐ Not Applicable
- 24.1.1.42. Average monthly electricity bill during non-summer months (INR)
- ☐ < 1,000
 - ☐ 1,000 – 3,000
 - ☐ 3,000 – 5,000
 - ☐ 5,000 – 10,000
 - ☐ >10,000
 - ☐ Not available / Not tracked
- 24.1.1.43. Approximate monthly electricity consumption (kWh) during non-summer months, if known
- 24.1.1.44. Average monthly electricity bill during summer months (INR)
- ☐ < 1,000
 - ☐ 1,000 – 3,000
 - ☐ 3,000 – 5,000
 - ☐ 5,000 – 10,000
 - ☐ >10,000
 - ☐ Not available / Not tracked
- 24.1.1.45. Approximate monthly electricity consumption (kWh) during summer months, if known
- 24.1.1.46. Compared to non-summer months, electricity bills during summer are:
- ☐ Same
 - ☐ Slightly higher
 - ☐ Much higher
 - ☐ Not sure



- 24.1.1.47. Which equipment contributes most to increased summer electricity use?
- ☐ Fans
 - ☐ Air coolers
 - ☐ Air conditioners
 - ☐ Refrigeration / cold storage
 - ☐ Not sure
 - ☐ Other: _____
- 24.1.1.48. Has high electricity cost limited the use of cooling systems during summer?
- ☐ Yes
 - ☐ No
 - ☐ Maybe
- 24.1.1.49. Due to high electricity costs, have cooling systems been switched off or used less during peak heat?
- ☐ Yes
 - ☐ No
 - ☐ Not Applicable
- 24.1.1.50. Type of electricity connection
- ☐ Single phase
 - ☐ Three phase
 - ☐ Not sure
- 24.1.1.51. Is a solar PV system installed on-site?
- ☐ Yes
 - ☐ No
- 24.1.1.52. If yes, installed solar capacity (in kW)
- ☐ <1
 - ☐ 1-3
 - ☐ 3-5
 - ☐ >5
- 24.1.1.53. Is surplus roof area available for additional solar installation?
- ☐ Yes
 - ☐ Not sure
- 24.1.1.54. Ability to bear additional electricity cost for cooling or storage systems
- ☐ No additional cost possible
 - ☐ Low increase acceptable
 - ☐ Moderate increase acceptable
 - ☐ Cost not a major constraint
- 24.1.1.55. Preferred type of cooling system (if required)
- ☐ Passive (no power)
 - ☐ Low-energy (fans / DC / evaporative)
 - ☐ Active (AC / refrigeration)
 - ☐ Not sure
 - ☐ Other



- 24.1.1.56. Any safety concerns for installing cooling systems?
☐ Yes
☐ No
- 24.1.1.57. If yes, please specify
- 24.1.1.58. Existing heat mitigation measures (select all applicable)
☐ Fans
☐ Exhaust ventilation
☐ Cool roof paint
☐ False ceiling / insulation
☐ Air conditioning
☐ Cold storage / fridge / cooler
☐ None
☐ Other
- 24.1.1.59. Are these measures adequate during peak summer?
☐ Yes
☐ No
☐ Partially

Awareness, SOPs & Capacity

- 24.1.1.60. Are heat stress management SOPs available?
☐ Yes
☐ No
- 24.1.1.61. Are staff / beneficiaries trained on heat mitigation actions?
☐ Yes
☐ No
- 24.1.1.62. Operation & Maintenance (O&M) capacity for cooling systems
☐ Adequate in-house capacity
☐ Limited capacity
☐ Dependent on external technicians
☐ No capacity
☐ Other: _____
- 24.1.1.63. Key constraints for Operation and Maintenance (select all applicable)
☐ Cost
☐ Skilled manpower
☐ Power reliability
☐ Management approval
☐ None
☐ Other: _____

Surrounding Micro-Climate

- 24.1.1.64. Surrounding micro-climate characteristics (select all applicable)
☐ Dense built-up surroundings



- ☐ Low green cover
- ☐ Trees / parks nearby
- ☐ Water bodies nearby
- ☐ Open area
- ☐ Other:_____
- 24.1.1.65. Perceived outdoor heat intensity around the building
 - ☐ Low
 - ☐ Moderate
 - ☐ High
- 24.1.1.66. Heat stress symptoms observed (select all applicable)
 - ☐ Irritability
 - ☐ Headaches
 - ☐ Dehydration
 - ☐ Muscle cramps
 - ☐ Fatigue
 - ☐ Dizziness / fainting
 - ☐ None
 - ☐ Other:_____
- 24.1.1.67. Time period when symptoms are most severe
 - ☐ Morning
 - ☐ Afternoon
 - ☐ Evening
 - ☐ All day
- 24.1.1.68. Is there a designated room or area used to manage heat-related illness (heat exhaustion / heat stroke)?
 - ☐ Yes
 - ☐ No
- 24.1.1.69. If yes, what type of space is used?
 - ☐ Dedicated heat-stroke / cooling room
 - ☐ First-aid / medical room
 - ☐ General ward / classroom / office
 - ☐ Temporary arrangement during extreme heat
 - ☐ Other:_____
- 24.1.1.70. During peak summer or heatwave periods, approximately how many people are shifted to this room per day due to heat-related discomfort or illness? (persons/day)
 - ☐ 1-2
 - ☐ 3-5
 - ☐ 6-10
 - ☐ More than 10
 - ☐ Data not available
- 24.1.1.71. During extreme heat days, what is the maximum number of people accommodated in the heat-stroke / cooling room at one time?
- 24.1.1.72. Average duration for which a person stays in this room (in minutes)



- ☐ >30
 - ☐ 30-60
 - ☐ 60-120
 - ☐ <120
- 24.1.1.73. What cooling or relief measures are used in this room?
- Ceiling/pedestal fans
 - ☐ Air cooler
 - ☐ Air conditioning
 - ☐ Cold drinking water / ORS
 - ☐ Ice packs / wet cloth
 - ☐ No specific cooling arrangement
- 24.1.1.74. Are there days when the heat-stroke / cooling room reaches full capacity?
- ☐ Yes
 - ☐ No
 - ☐ Not sure
- 24.1.1.75. During the last summer season, were any heat-related medical emergencies reported that required referral to a hospital?
- ☐ Yes
 - ☐ No
 - ☐ Maybe
- 24.1.1.76. If yes, approximate number of such cases last summer
- ☐ 1-2
 - ☐ 3-5
 - ☐ More than 5
 - Data not available
- 24.1.1.77. Does footfall or service utilisation reduce during extreme heat or heatwave periods?
- ☐ Yes
 - ☐ No
 - ☐ Maybe
- 24.1.1.78. During peak summer or heat alerts, how does footfall compare to normal days?
- ☐ No noticeable change
 - ☐ Slight reduction (up to 10%)
 - ☐ Moderate reduction (10–25%)
 - ☐ Significant reduction (more than 25%)
 - ☐ Not tracked
- 24.1.1.79. Which groups are most affected by reduced attendance during heat?
- ☐ Children
 - ☐ Elderly
 - ☐ Patients
 - ☐ General public
 - ☐ Staff



- ☐ Not sure
- 24.1.1.80. Does reduced footfall affect service delivery or program outcomes?
- ☐ Yes
- ☐ No
- ☐ Maybe

Solution Readiness & Need Identification

- 24.1.1.81. Based on current conditions, does the building require intervention for:
- ☐ Space cooling only
- ☐ Storage cooling only
- ☐ Both space & storage cooling
- ☐ No immediate intervention required
- ☐ Not sure
- 24.1.1.82. Any additional comments, constraints, or needs

24.1.2. Micro and Small Business

- 24.1.2.1. Name of Business / Shop
- 24.1.2.2. Name of Owner / Primary Contact
- 24.1.2.3. Contact Number
- 24.1.2.4. Address
- 24.1.2.5. Type of Business
- ☐ Food & Beverage (stall, shop, kitchen)
- ☐ Retail (clothing, grocery, pharmacy, etc)
- ☐ Manufacturing / Workshop
- ☐ Repair / Service unit
- ☐ Storage / Warehouse
- ☐ Mixed use
- ☐ Other: _____
- 24.1.2.6. Service Provider Category
- ☐ Owner-operated
- ☐ Family-run
- ☐ Hired workers
- ☐ Franchise / Chain outlet
- ☐ Other: _____

Ownership, Legal & Compliance Status

- 24.1.2.7. Type of Ownership
- ☐ Self-owned premises
- ☐ Rented / leased
- ☐ Temporary / informal setup
- ☐ Shared space
- ☐ Other: _____



- 24.1.2.8. Does the business have any formal registration or license?
 Yes
 No
- 24.1.2.9. Type of registration (if any)
☐ Shop & Establishment
☐ Trade license
☐ FSSAI
☐ GST
☐ Udyam (MSME)
☐ Not registered
☐ Other:_____

People & Occupancy Profile

- 24.1.2.10. Number of people working in the business
- 24.1.2.11. Average number of customers per day
- 24.1.2.12. Are any workers vulnerable to heat stress? (select all applicable)
☐ Elderly
☐ Women
☐ Persons with illness
☐ Outdoor-facing workers
☐ None
☐ Other:_____
- 24.1.2.13. Average duration workers spend inside the space per day (in hours)
☐ <4
☐ 4-6
☐ 6-8
☐ >8

Business Operations & Use of Space

- 24.1.2.14. Primary activities inside the space (select all applicable)
☐ Selling / customer interaction
☐ Cooking / food preparation
☐ Manufacturing / processing
☐ Repair work
☐ Storage of goods
☐ Packaging
☐ Other:_____
- 24.1.2.15. Does the business require temperature-controlled storage?
☐ Yes
☐ No
- 24.1.2.16. If yes, what items require cooling or temperature control? (select all applicable)



- ☐ Food / perishables
- ☐ Beverages / water
- ☐ Dairy / meat
- ☐ Medicines
- ☐ Raw materials
- ☐ Finished goods
- ☐ Other: _____

Operating Schedule & Heat Exposure

- 24.1.2.17. Daily operating hours
- 24.1.2.18. Days of operation
 - ☐ Daily
 - ☐ 5–6 days/week
 - ☐ Seasonal
 - ☐ Other: _____ -
- 24.1.2.19. Peak business hours
 - ☐ Morning
 - ☐ Afternoon
 - ☐ Evening
 - ☐ All day
- 24.1.2.20. Is work continued during extreme heat days or heat alerts?
 - ☐ Yes
 - ☐ No

Space Size & Physical Characteristics

- 24.1.2.21. Approximate floor area (sqft)
- 24.1.2.22. Average Ceiling height (m)
- 24.1.2.23. Nature of structure
 - ☐ Permanent (RCC / masonry)
 - ☐ Semi-permanent
 - ☐ Temporary (sheet, kiosk, stall)
 - ☐ Other: _____

Building Materials & Exposure

- 24.1.2.24. Roof material
 - ☐ RCC
 - ☐ Metal / GI sheet
 - ☐ Plastic / tarpaulin
 - ☐ Other: _____
- 24.1.2.25. Wall material
 - ☐ Brick / concrete
 - ☐ Metal / sheet
 - ☐ Wood
 - ☐ Fabric / open
 - ☐ Other: _____



- 24.1.2.26. Is the space directly exposed to sunlight?
☐ Yes
☐ No
- 24.1.2.27. Roof accessibility for intervention
☐ Yes
☐ No
☐ Not Applicable
- 24.1.2.28. Orientation / slope direction of the roof
☐ North-facing
☐ South-facing
☐ East-facing
☐ West-facing
☐ Flat roof / No clear slope
☐ Not sure
- 24.1.2.29. Does the roof receive direct sunlight for most of the day?
- 24.1.2.30. Which side of the shop/workspace faces strongest sunlight during the day?
☐ South-facing
☐ West-facing
☐ East-facing
☐ North-facing
☐ Not sure
☐ Open on multiple sides
- 24.1.2.31. Is this side also where most work or customer interaction happens?
☐ Yes
☐ No
☐ Partially
- 24.1.2.32. Does this area receive direct sunlight during peak heat hours (11 AM – 4 PM)?
☐ Yes
☐ No
☐ Maybe
- 24.1.2.33. What type of shading is present on the sun-exposed side? (Select all applicable)
☐ Awning / chajja
☐ Trees
☐ Adjacent building shade
☐ Temporary cloth / tarpaulin
☐ None
- 24.1.2.34. Compared to other parts of the space, is this side noticeably hotter?
☐ Yes
☐ No
☐ Slightly
☐ Not sure



- 24.1.2.35. Does the roof receive direct sunlight for most of the day?
- ☐ Yes
 - ☐ No
 - ☐ Maybe

Ventilation, Shading & Heat Sources

- 24.1.2.36. Natural ventilation available?
- ☐ Yes
 - ☐ No
- 24.1.2.37. Mechanical ventilation available?
- ☐ Yes
 - ☐ No
- 24.1.2.38. External shading present (select all applicable)
- ☐ Trees
 - ☐ Awnings
 - ☐ Adjacent buildings
 - ☐ Temporary shade
 - ☐ None
 - ☐ Other
- 24.1.2.39. Internal heat sources (select all applicable)
- ☐ Cooking equipment
 - ☐ Machinery
 - ☐ Lighting
 - ☐ High occupancy
 - ☐ None
 - ☐ Other: _____

Utilities, Energy Use & Power Reliability

- 24.1.2.40. Electricity connection available?
- ☐ Yes
 - ☐ No
- 24.1.2.41. Average monthly electricity bill during cooler months
- ☐ <1,000
 - ☐ 1,000-3,000
 - ☐ 3,000-5,000
 - ☐ >5,000
- 24.1.2.42. Average monthly electricity bill during summer months
- ☐ <1,000
 - ☐ 1,000-3,000
 - ☐ 3,000-5,000
 - ☐ >5,000
- 24.1.2.43. Compared to cooler months, electricity bills in summer are:
- ☐ Same
 - ☐ Slightly higher
 - ☐ Much higher



- ☐ Not sure
- 24.1.2.44. During peak summer, do you switch off or reduce use of cooling equipment to save electricity cost?
- ☐ Yes
- ☐ No
- ☐ Not Applicable
- 24.1.2.45. During peak summer, which situation best describes your business?
- Cannot use cooling due to high electricity cost
- ☐ Use cooling, but still face produce loss
- ☐ Reduce cooling to save electricity and accept some loss
- ☐ No major issue
- ☐ Not sure
- 24.1.2.46. Frequency of power cuts
- ☐ Not sure
- ☐ Occasional
- ☐ Frequent
- 24.1.2.47. Existing power backup (Select all applicable)
- ☐ Battery / inverter
- ☐ Generator
- ☐ Solar
- ☐ None
- 24.1.2.48. Is a solar PV system installed?
- ☐ Yes
- ☐ No
- 24.1.2.49. If yes, installed capacity (in kW)
- ☐ <1
- ☐ 1-3
- ☐ >3
- ☐ Not sure
- 24.1.2.50. Interest in solar-powered cooling or storage
- ☐ Yes
- ☐ No
- 24.1.2.51. If yes, space available for solar panel installation
- ☐ Yes
- ☐ No
- ☐ Other: _____
- 24.1.2.52. Willingness to use low-energy or non-electric solutions
- ☐ Yes
- ☐ No
- ☐ Not sure
- 24.1.2.53. Is additional roof space available for solar?
- ☐ Yes
- ☐ No
- ☐ Not sure



- ☐ Not applicable
- 24.1.2.54. Ability to bear additional electricity cost for cooling or storage systems
- ☐ No additional cost possible
- ☐ Low increase acceptable
- ☐ Moderate increase acceptable
- ☐ Cost not a major constraint
- 24.1.2.55. Preferred type of cooling system (if required)
- ☐ Passive (no power)
- ☐ Low-energy (fans / DC / evaporative)
- ☐ Active (AC / refrigeration)
- ☐ Not sure
- ☐ Other:_____
- 24.1.2.56. Any safety concerns for installing cooling systems?
- ☐ Yes
- ☐ No
- 24.1.2.57. If yes, please specify

Existing Cooling & Storage Measures

- 24.1.2.58. Existing space cooling measures (select all applicable)
- ☐ Ceiling / table fan
- ☐ Exhaust fan
- Air conditioning
- ☐ False ceiling / insulation
- ☐ None
- ☐ Other:_____
- 24.1.2.59. Existing storage cooling (select all applicable)
- ☐ Domestic fridge
- ☐ Ice box / cooler
- ☐ None
- ☐ Other:_____
- 24.1.2.60. Are current measures sufficient during peak summer?
- ☐ Yes
- ☐ No
- ☐ Partially

Operation & Maintenance Capacity

- 24.1.2.61. Operation & Maintenance (O&M) capacity for cooling systems
- ☐ Adequate in-house capacity
- ☐ Limited capacity
- ☐ Dependent on external technicians
- ☐ No capacity
- ☐ Other:_____
- 24.1.2.62. Ability to bear maintenance cost
- ☐ Low



- ☐ Moderate
☐ High
- 24.1.2.63. Key constraints in operating cooling systems (select all applicable)
- ☐ High electricity cost
☐ Power cuts
☐ Lack of technical support
☐ Space constraints
☐ Maintenance cost
☐ Other : _____

Surrounding Micro-Climate

- 24.1.2.64. Surrounding conditions (select all applicable)
- ☐ Dense built-up surroundings
☐ Low green cover
☐ Road-facing / traffic heat
☐ Trees / green cover nearby
☐ Water bodies nearby
☐ Open Area
☐ Other: _____
- 24.1.2.65. Perceived outdoor heat intensity around the building
- ☐ Low
☐ Moderate
☐ High
- 24.1.2.66. Heat stress symptoms experienced (select all applicable)
- ☐ Fatigue
☐ Headache
☐ Dehydration
☐ Dizziness
☐ Irritability
☐ Muscle cramps
☐ None
☐ Other: _____
- 24.1.2.67. Time period when symptoms are most severe
- ☐ Morning
☐ Afternoon
☐ Evening
☐ All day
- 24.1.2.68. Do you sell items that spoil or lose quality due to heat?
- ☐ Yes
☐ No
- 24.1.2.69. On hot days, do you experience loss or unsold stock due to heat?
- ☐ Yes
☐ No
☐ Maybe



- 24.1.2.70. Compared to cooler months, produce loss during summer is:
- ☐ No Change
 - ☐ Slightly higher
 - ☐ Much higher
 - ☐ Not sure
- 24.1.2.71. On a typical hot day, approximately how much produce is wasted or unsold?
- ☐ No loss
 - ☐ 1-5%
 - ☐ 5–10%
 - ☐ 10–20%
 - ☐ More than 20%
 - ☐ Not sure
- 24.1.2.72. At what time of day does spoilage or quality loss usually start?
- ☐ Morning
 - ☐ Afternoon
 - ☐ Evening

Cooling Need & Readiness

- 24.1.2.73. Based on current conditions, cooling support is needed for:
- ☐ Space cooling only
 - ☐ Storage cooling only
 - ☐ Both space & storage
 - ☐ Not required
 - ☐ Not sure
- 24.1.2.74. If affordable cooling or storage were available, what would be the main benefit?
- ☐ Reduced produce loss
 - ☐ Ability to keep shop open longer
 - ☐ Improved customer comfort and footfall
 - ☐ Lower electricity expense
 - ☐ Less physical stress
 - ☐ Not sure
- 24.1.2.75. Willingness to adopt cooling solutions
- ☐ Yes
 - ☐ No
 - ☐ Depends on cost
- 24.1.2.76. Any additional comments or constraints

24.1.3. Street Vendor

General Information



- 24.1.3.1. Name of Vendor
- 24.1.3.2. Contact Number
- 24.1.3.3. Vending Location / Landmark
- 24.1.3.4. Type of Vending Location
 - ☐ Footpath
 - ☐ Market area
 - ☐ Roadside
 - ☐ Near transport hub (bus stand / station)
 - ☐ Outside institution
 - ☐ Other: _____
- 24.1.3.5. Is the vending location fixed or mobile?
 - ☐ Fixed
 - ☐ Mobile
 - ☐ Semi-mobile

Vendor Category & Business Type

- 24.1.3.6. Type of Vendor
 - ☐ Food vendor (cooked)
 - ☐ Food vendor (raw / fresh)
 - ☐ Beverage vendor
 - ☐ Non-food retail (clothes, accessories, etc.)
 - ☐ Service provider (repair, cobbler, barber, etc)
 - ☐ Other
- 24.1.3.7. Items sold (select all that apply)
 - ☐ Cooked food
 - ☐ Fruits / vegetables
 - ☐ Dairy
 - ☐ Meat
 - ☐ Beverages
 - ☐ Packaged goods
 - ☐ Non-perishable items
 - ☐ Other

Ownership, Legal & Service Type

- 24.1.3.8. Vendor ownership type
 - ☐ Self-owned business
 - ☐ Family-run
 - ☐ Employed vendor
 - ☐ Shared operation
- 24.1.3.9. Do you have a vending license / ID?
 - ☐ Yes
 - ☐ No
- 24.1.3.10. Type of license (if any)
 - ☐ Street Vending Certificate
 - ☐ Municipal ID



- ☐ SHG / Cooperative ID
- ☐ Not Sure
- 24.1.3.11. Who manages daily operations and decisions?
 - ☐ Self
 - ☐ Family
 - ☐ Contractor
 - ☐ Other

People & Occupancy Profile

- 24.1.3.12. Number of people working at the stall
- 24.1.3.13. Average working hours per day (in hours)
 - ☐ <6
 - ☐ 6-8
 - ☐ 8-10
 - ☐ >10
- 24.1.3.14. Are women, elderly, or children involved in vending activities?
 - ☐ Yes
 - ☐ No
- 24.1.3.15. Average number of customers per day

Operating Schedule & Heat Exposure

- 24.1.3.16. Time of day when vending starts
- 24.1.3.17. Time of day when vending ends
- 24.1.3.18. Days of operation
 - ☐ Daily
 - ☐ 5-6 days/week
 - ☐ Seasonal
 - ☐ Other
- 24.1.3.19. Peak business hours
 - ☐ Morning
 - ☐ Afternoon
 - ☐ Evening
 - ☐ All day
- 24.1.3.20. Do you continue vending during extreme heat days?
 - ☐ Yes
 - ☐ No
 - ☐ Maybe
- 24.1.3.21. If yes, why?
 - ☐ Income dependency
 - ☐ No alternative
 - ☐ Peak demand
 - ☐ Other _____
- 24.1.3.22. At what time of day is heat most uncomfortable
 - ☐ Morning
 - ☐ Afternoon



- ☐ Evening
- 24.1.3.23. Do you feel the need for cooling during work hours?
- ☐ Yes
- ☐ No
- ☐ Sometimes

Vending Structure & Space Characteristics

- 24.1.3.24. Type of vending structure
- ☐ Open (no roof)
- ☐ Umbrella
- ☐ Temporary Shed
- ☐ Pushcart
- ☐ Permanent stall
- 24.1.3.25. Approximate stall size
- ☐ Small
- ☐ Medium
- ☐ Large
- 24.1.3.26. Type of roof / cover
- ☐ Cloth/tarpaulin
- ☐ Plastic Sheet
- ☐ Metal sheet
- ☐ Umbrella
- ☐ None
- ☐ Other_____
- 24.1.3.27. Is the stall directly exposed to the sun?
- ☐ Yes
- ☐ No

Ventilation, Shading & Heat Sources

- 24.1.3.28. Natural airflow at vending location
- ☐ Good
- ☐ Moderate
- ☐ Poor
- 24.1.3.29. External shading available (select all applicable)
- ☐ Trees
- ☐ Building shade
- ☐ Flyover/structure
- ☐ Temporary shade
- ☐ None
- 24.1.3.30. Heat sources at the stall (select all applicable)
- ☐ Cooking stove
- ☐ Hot oil/fryer
- ☐ Sun exposure
- ☐ Crowding
- ☐ None
- ☐ Other



Storage & Cooling Needs

- 24.1.3.31. Do you store perishable items during vending hours?
☐ Yes
☐ No
- 24.1.3.32. Do you require cooling for storage?
☐ Yes
☐ No
- 24.1.3.33. Items requiring cooling (select all applicable)
☐ Cooked food
☐ Raw food
☐ Beverages
☐ Dairy
☐ Meat
☐ Medicines
☐ Other_____
- 24.1.3.34. Duration for which items need to be kept cool (in hours)
☐ <4
☐ 4-8
☐ >8
- 24.1.3.35. Do you sell items that spoil or lose quality due to heat?
☐ Yes
☐ No
- 24.1.3.36. Which items are most affected by heat-related spoilage?
(select all applicable)
☐ Fruits
☐ Vegetables
☐ Cooked food
☐ Dairy products
☐ Meat/Fish
☐ Flowers
☐ Other
- 24.1.3.37. On a typical summer day, do you experience loss of produce due to heat or spoilage?
☐ Yes
☐ No
☐ Maybe
- 24.1.3.38. On average, how much produce is wasted or unsold in a day during peak summer?
☐ No loss
☐ Very little (1-5%)
☐ Some (5-10%)
☐ Significant (10-20%)
☐ Very high (>20%)
☐ Not sure
- 24.1.3.39. What are the main reasons for this loss?



- ☐ No storage or cooling facility
- ☐ Ice melts too fast
- ☐ High ambient temperature
- ☐ Power not available
- ☐ Reduced customer demand during heat
- ☐ Other

Existing Cooling & Storage Solutions

- 24.1.3.40. Current space cooling methods (select all applicable)
- ☐ Hand fan
 - ☐ Table fan
 - ☐ Wet cloth/ water splash
 - ☐ Umbrella/Tarpaulin
 - ☐ Other
- 24.1.3.41. Current storage cooling methods
- ☐ Ice box
 - ☐ Thermocol box
 - ☐ Domestic fridge (off-site)
 - ☐ None
 - ☐ Other
- 24.1.3.42. Are these methods sufficient in peak summer?
- ☐ Yes
 - ☐ No
 - ☐ Sometimes
- 24.1.3.43. If better storage were available, what benefit do you expect? (select all applicable)
- ☐ Less wastage
 - ☐ Better product quality
 - ☐ Longer selling hours
 - ☐ Higher income
 - ☐ Less physical stress
 - ☐ Not sure

Energy Access & Power Reliability

- 24.1.3.44. Access to electricity at vending location
- ☐ Yes
 - ☐ No
- 24.1.3.45. If yes, source of electricity
- ☐ Municipal
 - ☐ Shared connection
 - ☐ Nearby connection
 - ☐ Nearby shop
 - ☐ Informal
 - ☐ Other_____
- 24.1.3.46. Frequency of power cuts
- ☐ Rare



- ☐ Occasional
- ☐ Frequent
- ☐ Not applicable
- 24.1.3.47. Power backup available
 - ☐ Battery
 - ☐ Solar
 - ☐ Generator
 - ☐ None
- 24.1.3.48. Monthly electricity expense (approx.)
 - ☐ Zero
 - ☐ 500
 - ☐ 500-1000
 - ☐ 1000
 - ☐ Not Applicable

Solar & Low-Energy Potential

- 24.1.3.49. Interest in solar-powered cooling or storage
 - ☐ Yes
 - ☐ No
 - ☐ Other
- 24.1.3.50. If yes, space available for solar panel installation
 - ☐ On cart
 - ☐ On roof nearby
 - ☐ Not available
- 24.1.3.51. Willingness to use low-energy or non-electric solutions
 - ☐ Yes
 - ☐ No
- 24.1.3.52. Awareness of heat stress risks
 - ☐ Yes
 - ☐ No
- 24.1.3.53. Awareness of heat mitigation practices
 - ☐ Yes
 - ☐ No
 - ☐ Somewhat
- 24.1.3.54. Ability to maintain cooling equipment
 - ☐ Self
 - ☐ Local technician
 - ☐ Not possible
- 24.1.3.55. Key constraints in using cooling solutions (select all applicable)
 - ☐ Cost
 - ☐ Power availability
 - ☐ Space
 - ☐ Theft/Safety
 - ☐ Maintenance
 - ☐ None



☐ Other

Surrounding Micro-Climate

- 24.1.3.56. Surrounding environment (select all applicable)
- ☐ Dense traffic
 - ☐ Concrete/ paved surfaces
 - ☐ Market crowding
 - ☐ Trees/green cover
 - ☐ Open area
- 24.1.3.57. Outdoor heat intensity at vending location
- ☐ Low
 - ☐ Moderate
 - ☐ High

Heat Stress Experience

- 24.1.3.58. Heat stress symptoms experienced (select all applicable)
- ☐ Fatigue
 - ☐ Headache
 - ☐ Dizzines
 - ☐ Dehydration
 - ☐ Muscle cramps
 - ☐ Nausea
 - ☐ None
 - ☐ Other_____
- 24.1.3.59. Time period when symptoms are most severe
- ☐ Morning
 - ☐ Afternoon
 - ☐ Evening

Cooling Need & Readiness

- 24.1.3.60. Cooling support needed for
- ☐ Space cooling only
 - ☐ Storage cooling only
 - ☐ Both space & storage
 - ☐ Not required
 - ☐ Not sure
- 24.1.3.61. Willingness to adopt cooling solutions
- ☐ Yes
 - ☐ No
- 24.1.3.62. Any additional concerns or needs

24.2. Existing Women's Group Assessment Survey

- 24.2.1.1. Are there any existing women's groups (WGs) in the settlement?



- 24.2.1.2. If yes, what are these groups engaged in?
- 24.2.1.3. Are any of these groups engaged in livelihood based activities?
- 24.2.1.4. Are they registered? If yes, are all of them registered? Are some of them registered?
- 24.2.1.5. What are the registered groups recognised as? (eg. SHG, cooperatives, etc)
- 24.2.1.6. Do the WGs in the region operate under a nodal agency? If yes, what is the role of the nodal agency?
- 24.2.1.7. What are the sources of funding/income for the group?
- 24.2.1.8. Do they receive financial and other support from NGOs, organizations, or local government, etc?
- 24.2.1.9. Who organises the groups? (eg. community themselves, CSOs etc)
- 24.2.1.10. What is the process of organising the groups?
- 24.2.1.11. On a scale of 1-5, how well are the groups organised (1 - least organised, 5 - most organised) ? What is the reason for this rating?
- 24.2.1.12. Is any training conducted for the WGs? If yes, who conducts these trainings?
- 24.2.1.13. Any socio-economic and political aspects that are supportive to the groups? (eg. local govt schemes, etc)
- 24.2.1.14. Any socio-economic and political aspects that are challenging to the groups? (eg. gender roles, family resistance, etc)
- 24.2.1.15. Any other relevant points.

24.3. Housing/Structure Density Assessment

- 24.3.1.1. Evaluating the density of micro business/informal settlement establishments is an intricate subject warranting sophisticated analysis by specialists when pursuing larger objectives embedded in the contexts of urban planning, development of climate action / disaster management plans etc.
- 24.3.1.2. For the relatively restricted purposes of identifying appropriate heat-stress mitigation passive or active cooling solutions for micro business establishments structures or small-scale community buildings enmeshed within the general building typology of the area in micro business/informal settlement establishments, and filtering out unsuitable solutions, housing/building density evaluation can acquire a significantly simplified form through approximate observations related to width of alleys traversing the housing-structure network and the spacing between adjacent homes.



- a) Micro business/ settlements with alleys spanning 3-6 feet and 3-shared walls with neighbouring structures (adjacent on either side and at the back) can be classified as 'High Density'
- b) Micro business/ settlements with alleys spanning 6-10 feet and 2-shared walls with neighbouring structures (adjacent on either side but no shared walls at the back) can be classified as 'Medium Density'
- c) Micro business/ settlements with alleys spanning wider than 10 feet and 1-2 or no shared walls with neighbouring structures can be classified as 'Low Density'.

24.4. Local & Regional Climate Analysis

- 24.4.1.1. A rigorous approach to passive-design for new structures warrants a formal climate analysis based on a comprehensive study of the year-round Psychrometric (temperature, humidity) conditions, Wind flow patterns (directions and speeds of local winds, breezes), daytime Solar Radiation levels as well as diurnal temperature variations.
- 24.4.1.2. Such a study is normatively conjugated with the use of a Bioclimatic Design aid (eg. the Givoni-Milne Bioclimatic Chart, reproduced from public sources below) which informs the process of selecting appropriate passive design/passive cooling design elements for proposed designs:

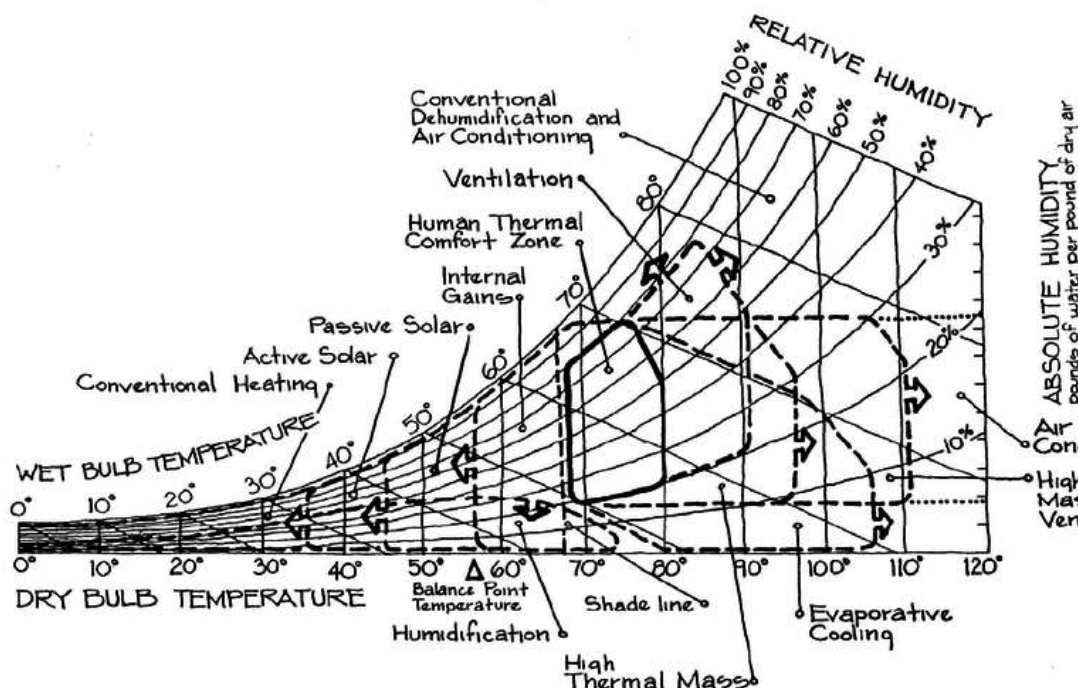


Fig 24.4.1.2-1: Givoni-Milne Bioclimatic Chart

- 24.4.1.3. If the above rigorous analysis is not possible/feasible for the specific context of selection appropriate retrofit strategies/solutions for comprehensive heat-stress mitigation using passive or active cooling approaches, for micro businesses, street vendors and institutional buildings in the Urban Settlements, a significantly simplified analysis through approximate observations related to impact of adjacent structures on local thermal conditions, local and regional climatic 'classification' can provide adequate insights to inform design choices
- 24.4.1.4. The simplified climate analysis process is comprised of the following sub-steps:
 - a) Identifying if adequate shade is available for significant parts of the day either through adjacent trees, other vegetation, and perhaps more importantly - adjacent buildings (especially neighbouring adjacent low-rise buildings or even structures of the same typology but having higher number of floors - eg. a 2-storey structure abutting a 1 storey-structure upon which a roof retrofit is being planned)
 - b) Identifying if direct Solar Radiation is likely to impact the roof and cause significant Solar Heat Gain through Radiation
 - c) Identifying the formal Climatic Zone classification for the city-region under consideration: 1. Hot Dry, 2. Warm Humid, 3. Temperate, 4. Composite and 5. Cold.

25. Pre-Installation Home/Structure Audit

25.1. Structural Integrity

- 25.1.1.1. Measure Floor Plan dimensions in SI Units (metres)
- 25.1.1.2. Measure maximum and minimum house height in metres
- 25.1.1.3. Measure Wall thickness from end to end (including any plaster if present) in inches
- 25.1.1.4. Measure the Openings (doors/windows/ventilations) in metres
- 25.1.1.5. Count the number of Purlins, measure their distance from the walls and the length in meters
- 25.1.1.6. Measure the dimensions of Parapet if present
- 25.1.1.7. Check the materials of all the elements (walls, purlins and parapet)
- 25.1.1.8. Check for any defects, cracks and dampness in walls, purlins and parapet) with the degree of damage as low (<5% area affected), medium (5-10% area affected) and high (>10% area affected)



- 25.1.1.9. Take clear photographs of all walls, floor, purlins and parapet. Examples below
- 25.1.1.10. Take clear photographs of existing damages/seepages from inside and outside.Examples below



Fig 25.1.1.1-1: Walls



Fig 25.1.1.2-1 : Purlins



Fig 25.1.1.3-1 : Parapet



Fig 25.1.1.4-1 : Dampness

25.2. Roof Typology Study

- 25.2.1.1. Classify the roof type as either: a) gabled b) flat c) shed
- 25.2.1.2. Classify the material of the roof as either: a) asbestos b) tin c) GI d) concrete e) mangalore tiles
- 25.2.1.3. Classify the shape of the roof as a) corrugated b) box c) other
- 25.2.1.4. Measure Roof dimensions in metres
- 25.2.1.5. Check for any defects, cracks and dampness in the roof with the damage as low (<5% area affected), medium (5-10% area affected) and high (>10% area affected)
- 25.2.1.6. Take clear photographs of the roof from inside and outside. Example below
- 25.2.1.7. Take clear photographs of existing damages/seepages from inside and from top of the roof with the help of a ladder. Example below



Fig 25.2.1.6-1 : Roof Inside - Plan View



Fig 25.2.1.6-2 : Roof- Top View



Fig 25.2.1.7-1 : Crack in the Roof

25.3. Baseline Thermal Comfort Assessment

25.3.1.1. Take the following readings for each house:

- a) Surface temperature of the walls
- b) Surface temperature of the roof
- c) Surface temperature of the floor
- d) Inside Dry Bulb Temperature (IDBT)
- e) Inside Wet Bulb Temperature (IWBT)
- f) Outside Dry Bulb Temperature (ODBT)
- g) Outside Wet Bulb Temperature (OWBT)

25.3.1.2. Take all the surface temperature readings at three different spots for each structural element (walls, roof, floor) using an Infrared Temperature Gun by standing 2-3 feet away and average them out for each element. Face the entrance door from inside the structure - start measurements from the right wall and cover the remaining walls in a clockwise fashion.

25.3.1.3. Take the inside DBT & WBT readings with the help of a Digital Humidity Meter or Sling Psychrometer by standing in the middle of the room. If using a Sling Psychrometer, before use, open the cap and pour water to soak the wet bulb wick of your psychrometer in water. Once the wick is wet, hold the handle and whirl the psychrometer for 20s in the air. Whirling generates airflow around both the wet

and dry bulbs. Record DBT & WBT immediately. Refill with water before every measurement.

- 25.3.1.4. Take the outside DBT & WBT readings with the help of a Sling Psychrometer by standing in an area outside the house which is directly under the sun.

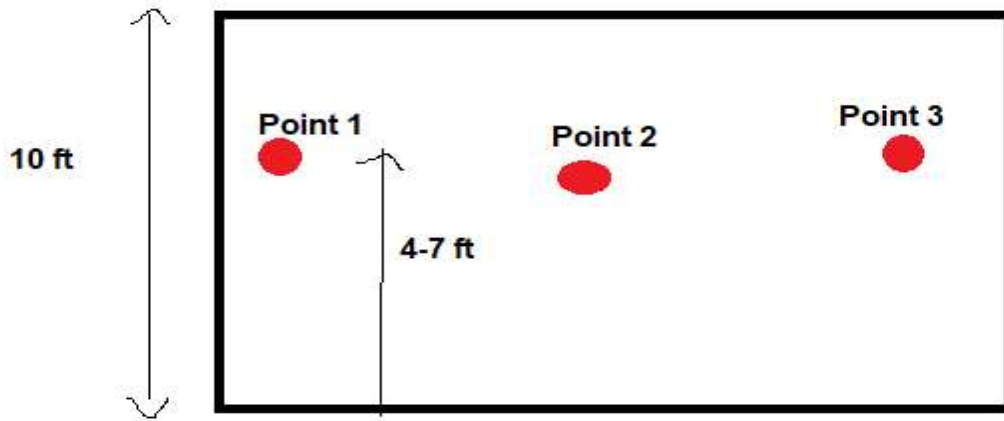


Fig 25.3.1.2-1 Sample Wall Surface Temperature Measurement Points

Temperature Measurement

Reading No	Time Of Measurement	Wall - 1 Temperature	Wall - 2 Temperature	Wall - 3 Temperature	Wall - 4 Temperature	Roof Temperature	Floor Temperature
		(τ)	(τ)	(τ)	(τ)	(τ)	(τ)
Reading 1	3:31	29.5	32.2	32.5	33.7	36.2	30.6
Reading 2	3:32	32.4	32	31.7	32.3	35.3	32.5
Reading 3	3:33	32.2	32.6	33.6	33.1	34.9	29.3
Readings Average							

Humidity Measurement

Reading No	Time Of Measurement	Inside Room DBT	Inside Room WBT	Outside Room DBT	Outside Room WBT
		(τ)	(τ)	(τ)	(τ)
Reading 1	3:35	35	31.5	35.1	30.9
Reading 2	3:36	35.2	31.6	35.2	31.2
Reading 3	3:37	35.3	31.6	35.5	31.2

Figure 25.3.1.2-2: Example of Baseline Thermal Comfort Assessment Form

25.4. As-Built Drawings/Sketches

- 25.4.1.1. When on site, prepare rough sketches of the plan and elevation of the house. Examples below.

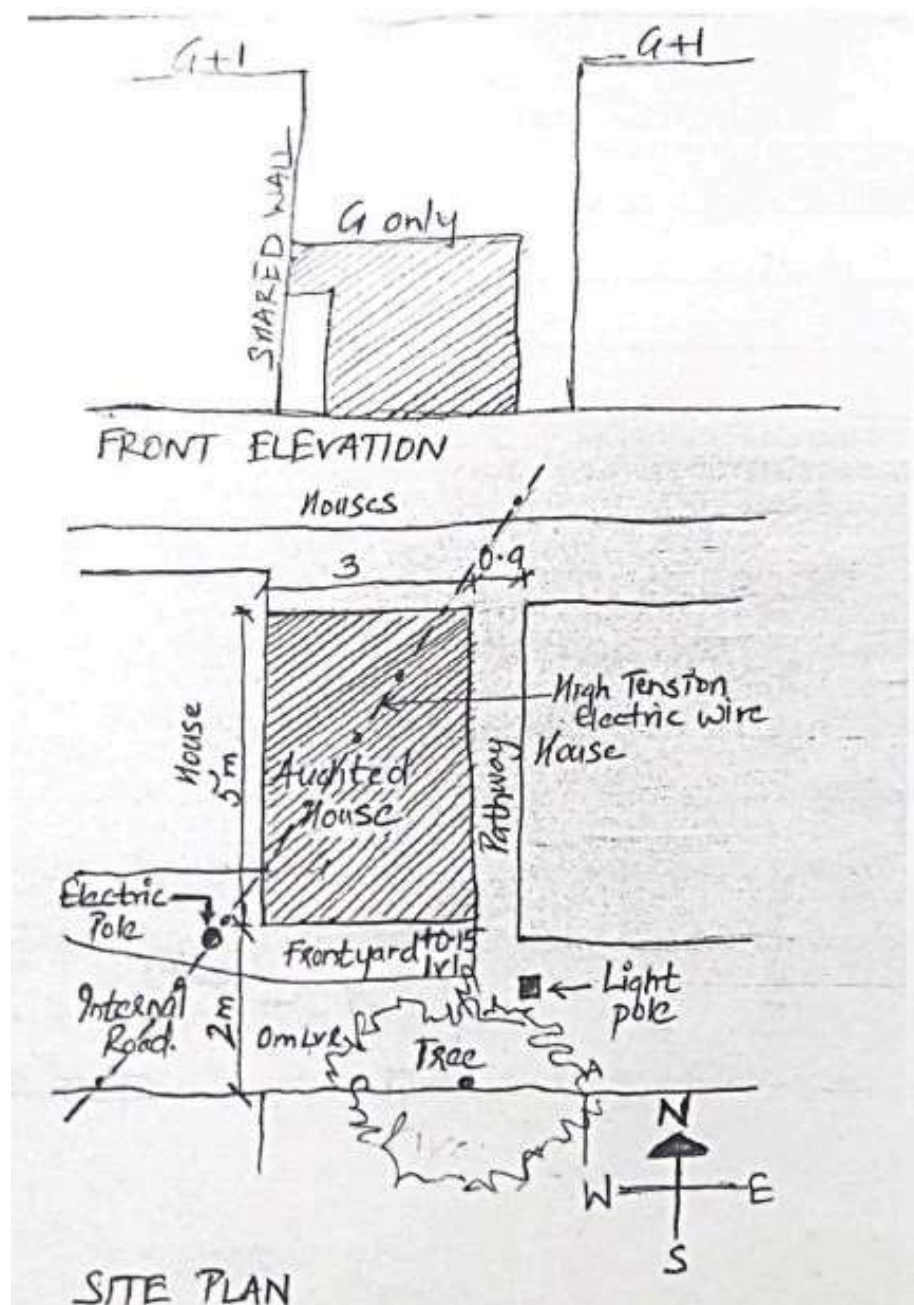


Fig 25.4.1.1-1 : Site Plan

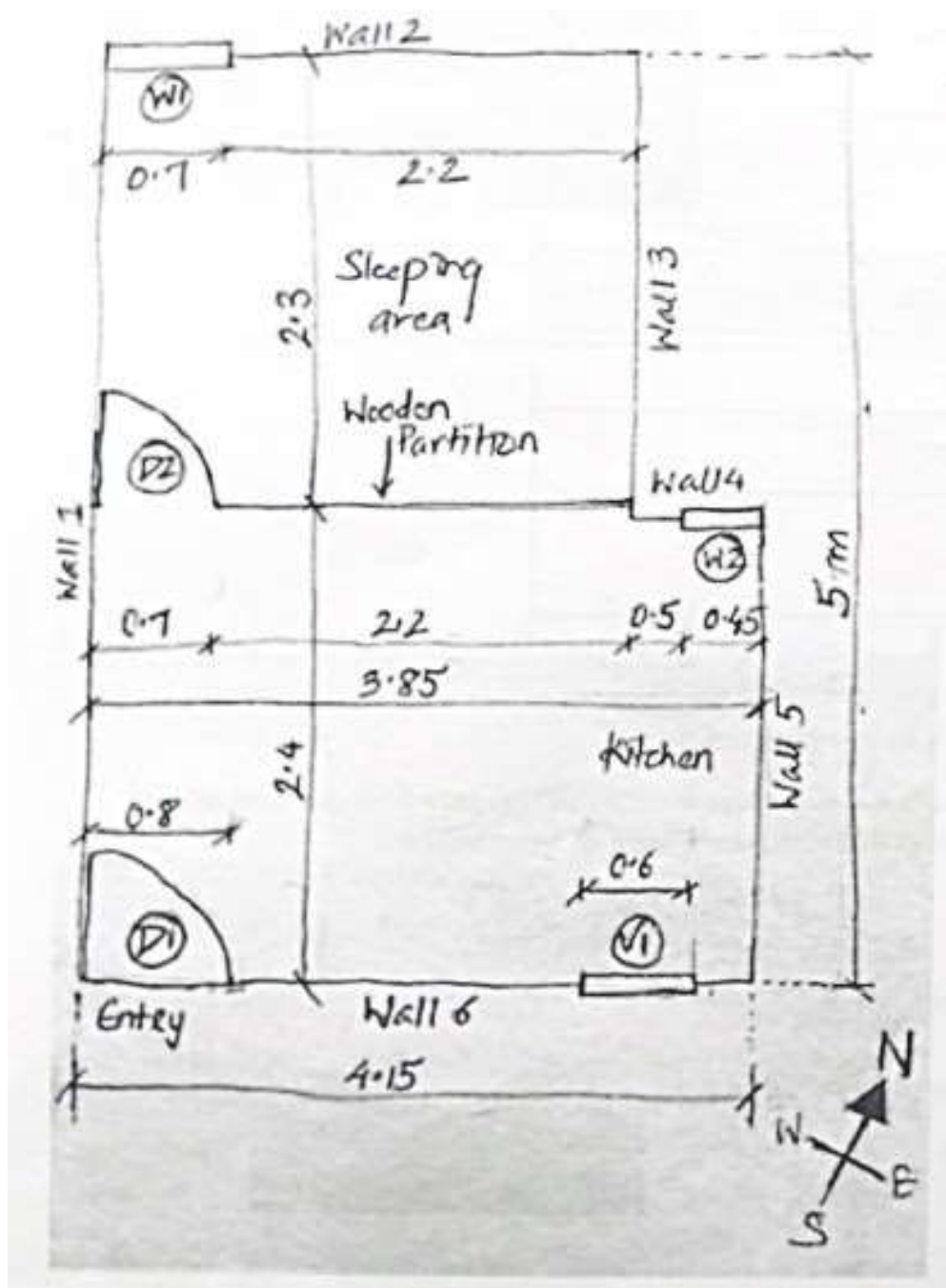


Fig 25.4.1.1-2 : Floor Plan

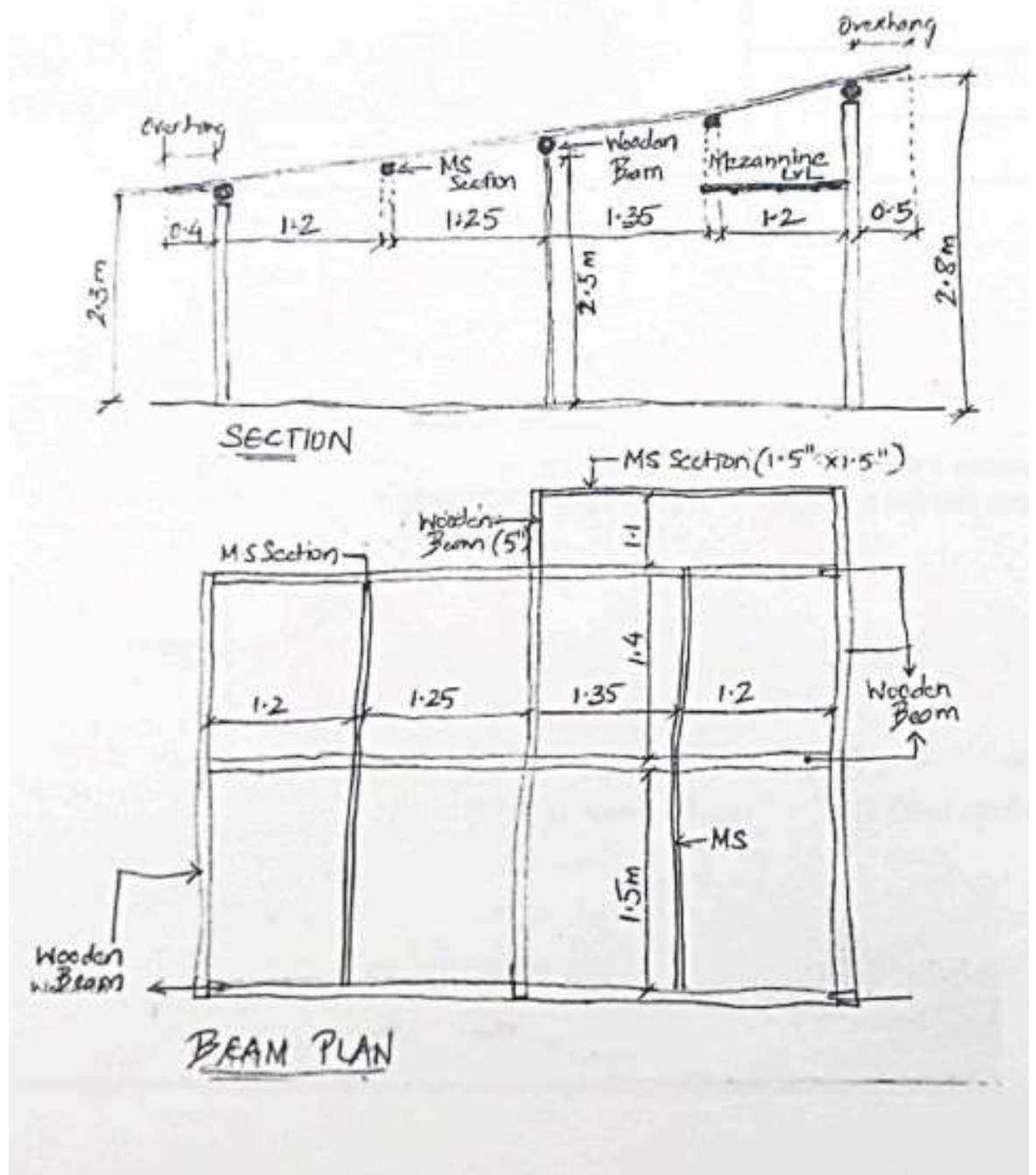


Fig 25.4.1.1-3 : Beam Plan and Section

- 25.4.1.2. Make built drawings/sketches referring to the on-site data collected and the rough sketches of plan and elevation.
Examples below:

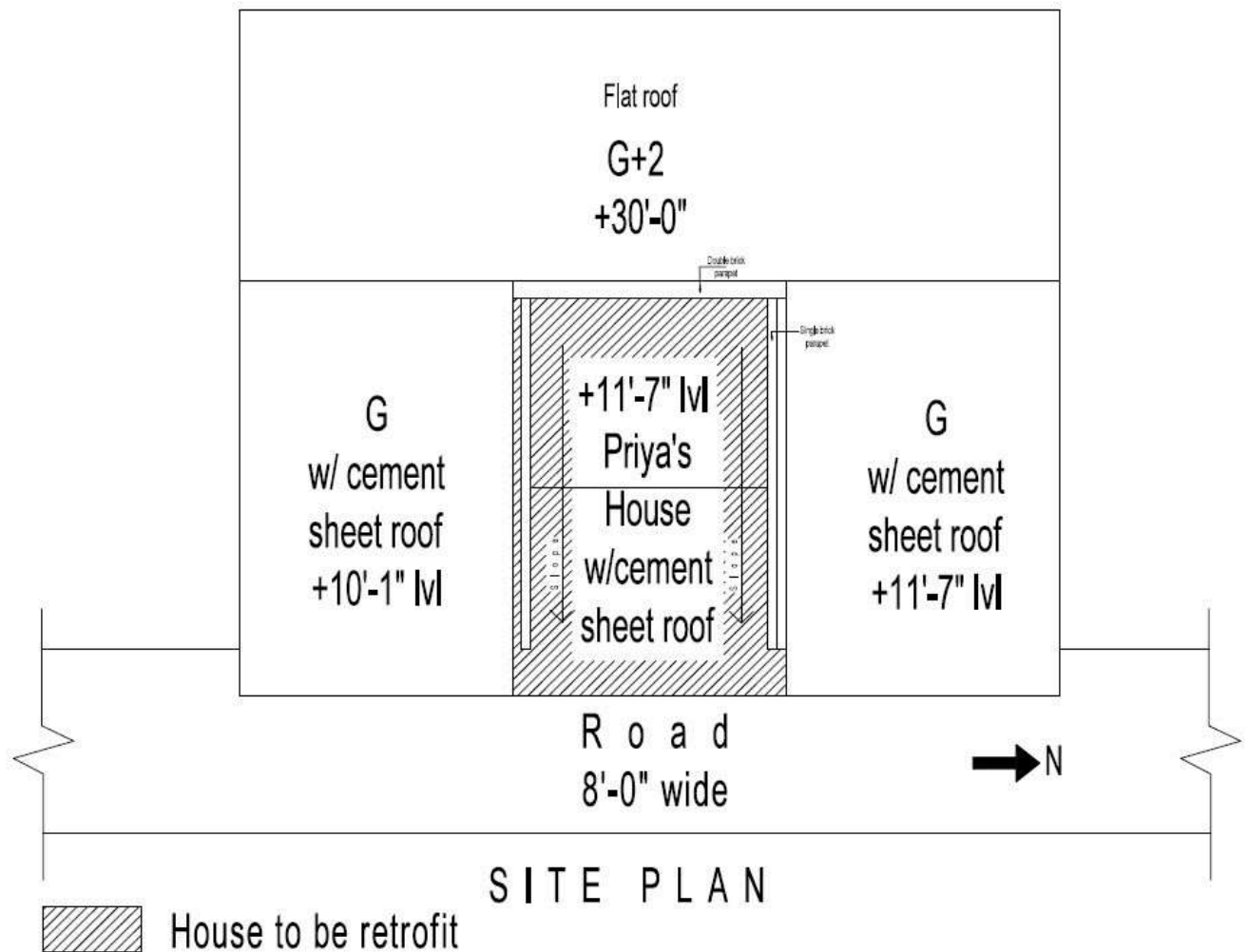


Fig 25.4.1.2-1 : Site Plan

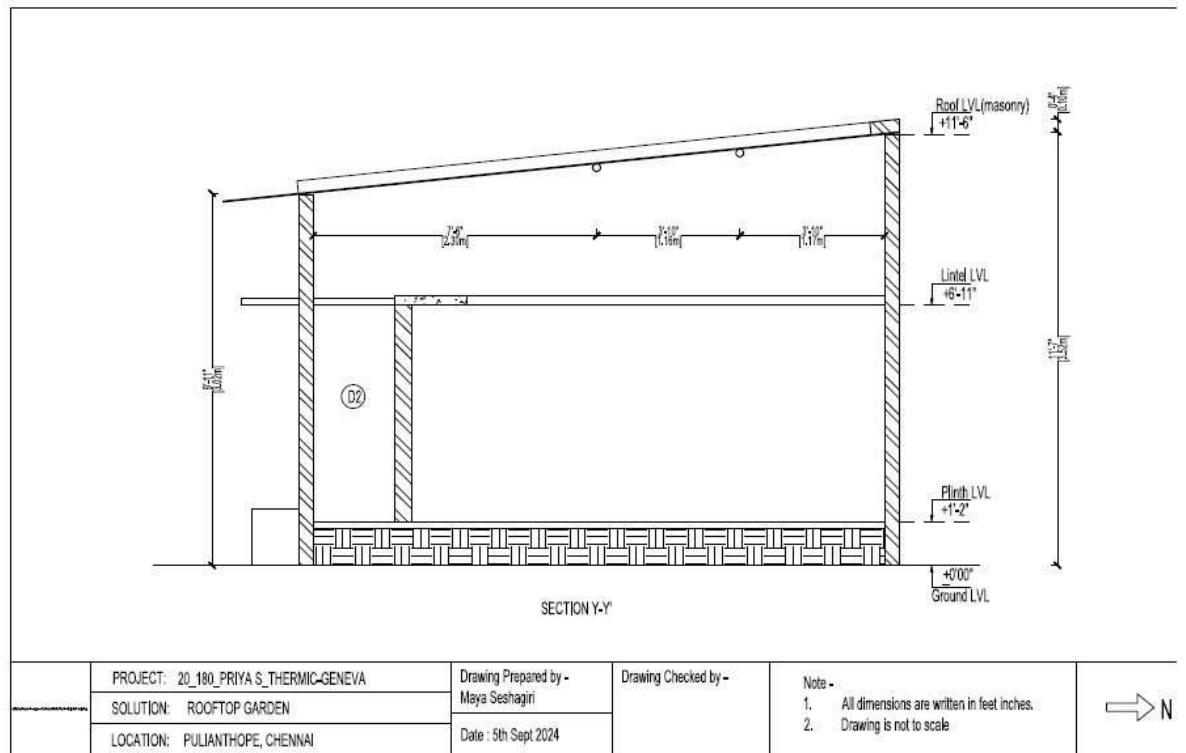


Fig 25.4.1.2-2: Section

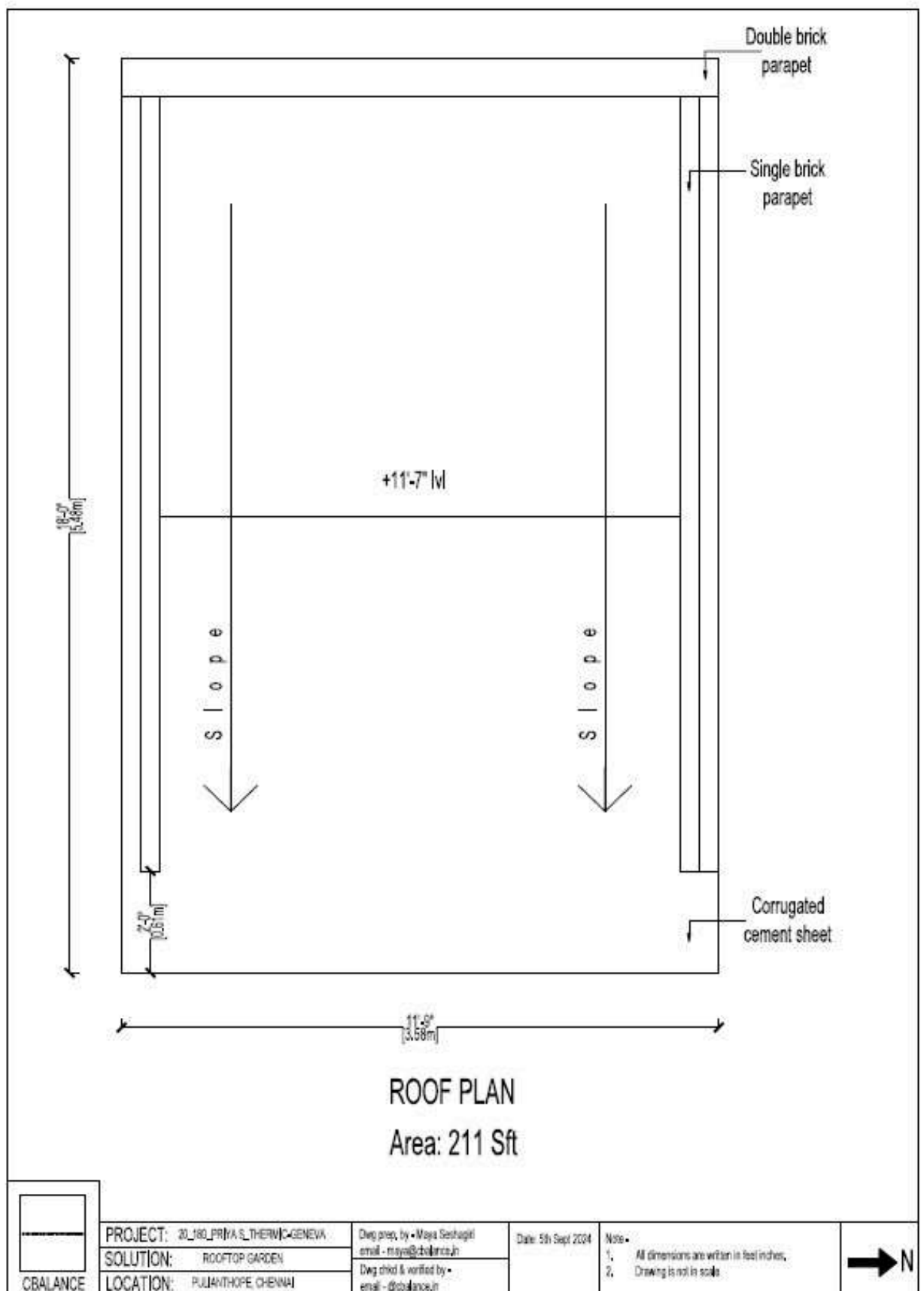


Fig 25.4.1.2-3 Roof Plan

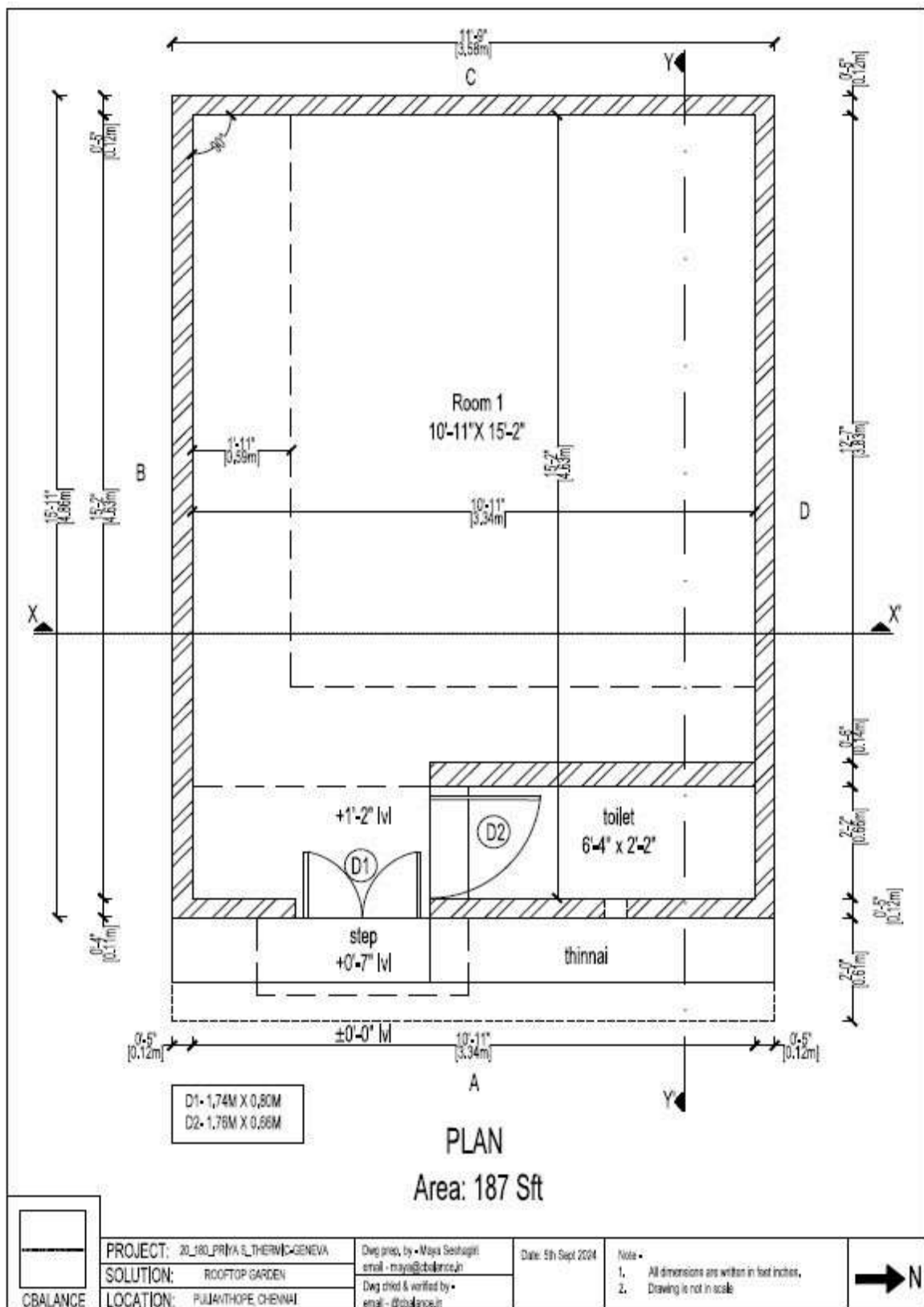


Fig 25.4.1.2-4 : Floor Plan

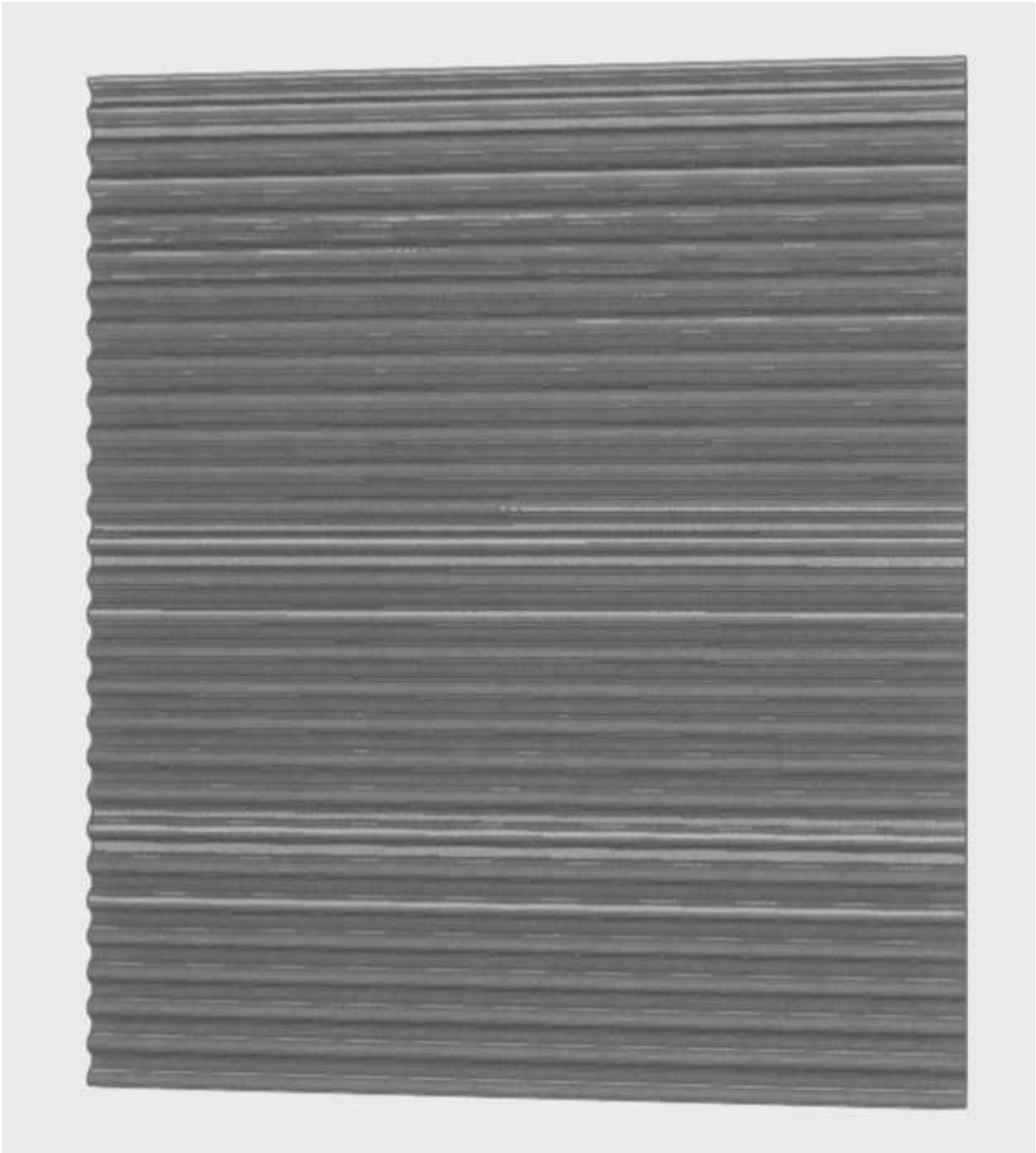


Fig 25.4.1.2-5 : Sketch Top View



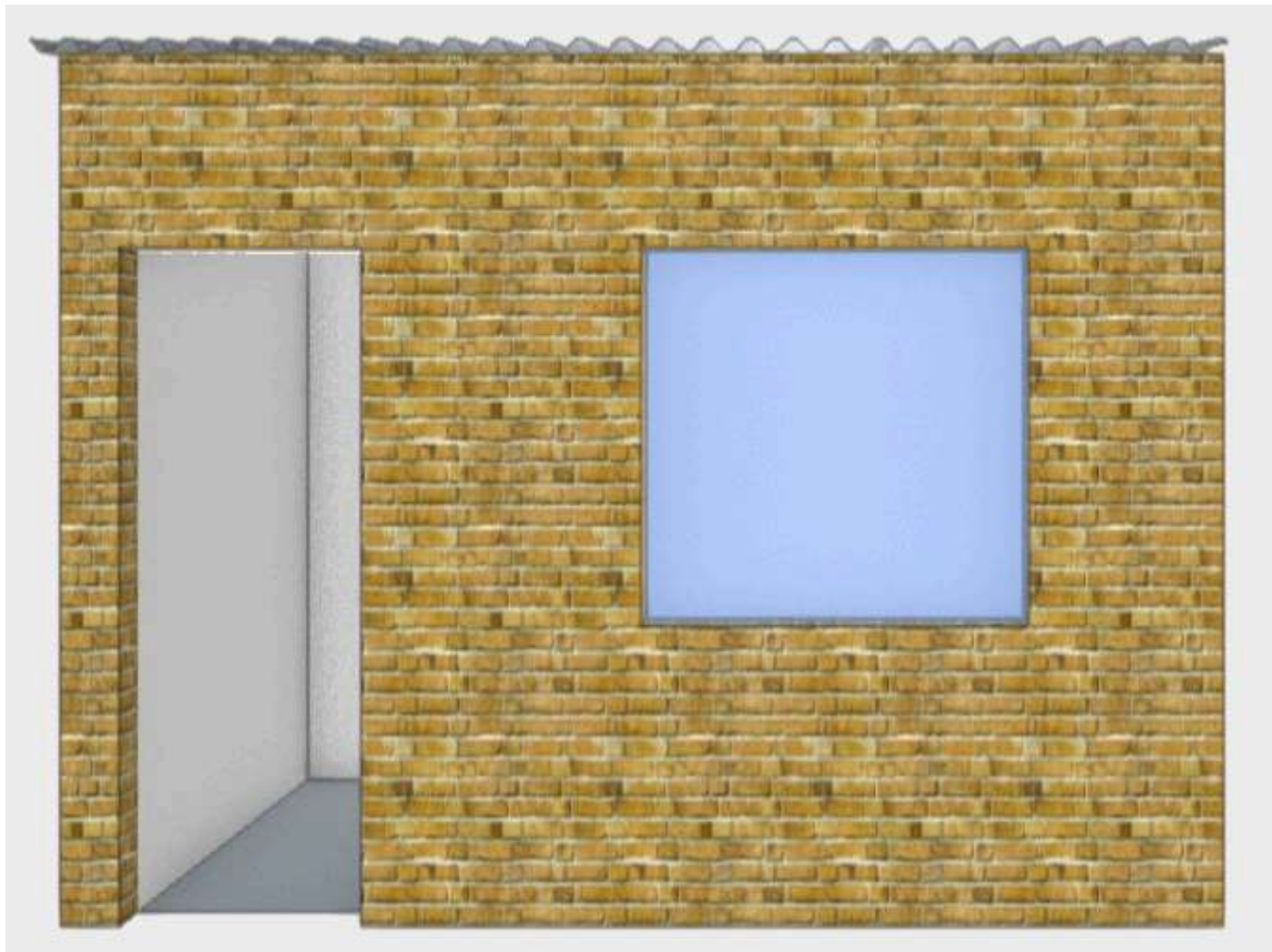


Fig 25.4.1.2-6 : Sketch Front View

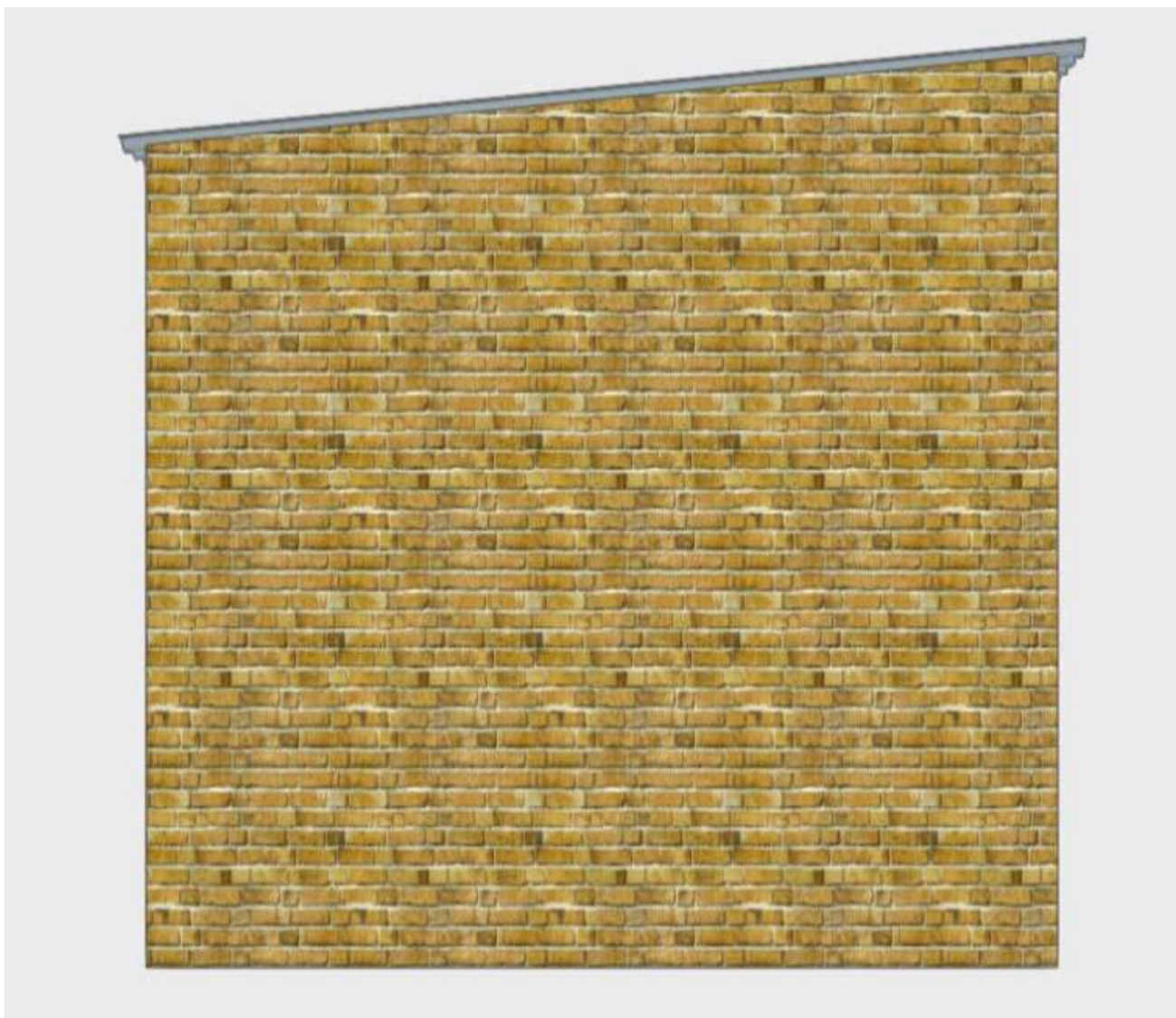


Fig 25.4.1.2-7 : Sketch Side View



Fig 25.4.1.2-8 : Sketch Isometric View

25.5. House-to-Solution Match Analysis

25.5.1.1. Of the Heat-Stress Mitigation Solutions included in the Pilot Study, the solutions compatible with a 'high density' structural configuration are:

- a) PET Bottles in Crates (Thermal Mass)
- b) Biomass Panels wrapped with Low-Emissivity MLP Sheets (Insulation & Radiant Barrier)
- c) Wood Wool Panels wrapped with Low-Emissivity MLP Sheets (Insulation & Radiant Barrier)
- d) Internal Dynamic Radiant Barrier

25.5.1.2. Of the Heat-Stress Mitigation Solutions included in the Pilot Study, the solutions compatible with a 'Medium Density' structural configuration are:

- a) All the above compatible with High Density configuration
- b) Space-Frame (External Dynamic Radiant-Barrier)
- c) Stack Ventilation (despite it not being included in the current Pilot Study; this solution would be compatible if a moderate air

flow is witnessed in the alleys abutting either the front door or windows at the back of the house.

25.5.1.3. Of the Heat-Stress Mitigation Solutions included in the Pilot Study, the solutions compatible with a 'Medium Density' structural configuration are:

- a) All the above compatible with High and Medium Density configurations
- b) Rooftop Gardening
- c) Cross Ventilation (despite it not being included in the current Pilot Study; this solution would be compatible if a moderate air flow is witnessed in the alleys abutting either the front door or windows at the back of the house.

25.5.1.4. If adequate shade is available for significant parts of the day either through adjacent trees, other vegetation, and perhaps more importantly - adjacent buildings, then External Radiant Barriers and Thermal Mass-based solutions (eg. PET Bottles in Crates) can be considered as secondary solutions.

25.5.1.5. If direct Solar Radiation is likely to impact the roof for significant timespans of the day in the Summer months, External Radiant Barriers, Thermal Mass-based solutions as well as Rooftop Gardens (if the housing density analysis presented above indicates adequate feasibility).

25.5.1.6. The Climatic Zone that characterises the region/city should be used as the framework for evaluating appropriateness of passive design solutions for the specific context:

- a) Hot Dry Climatic Zone: appropriate solutions - PET Bottles in Crates (Thermal Mass), Rooftop Gardening (with passive watering strategies and heavily mulched soil to prevent excessive soil-moisture loss), External Dynamic Radiant Barrier, Internal Dynamic Radiant Barrier.
- b) Warm Humid Climatic Zone: appropriate solutions - Rooftop Gardening, Biomass Panels wrapped in Low-Emissivity MLP Sheets, Wood Wool Panels wrapped in Low-Emissivity MLP Sheets, External Static Radiant Barrier, Internal Static Radiant Barrier (note: Dynamic Mechanisms that enable maximizing of the cooling potential of Night-Sky Radiation are never detrimental design features; however the additional cooling benefits of Night-Sky Radiation are greatly undermined in Warm Humid climate conditions and can hence be avoided to perhaps enable inclusion of other passive strategies while maintaining affordability), Cross Ventilation, Stack Ventilation (if feasible in accordance with the outcomes of housing density evaluation)
- c) Temperate Climatic Zone: appropriate solutions - PET Bottles in Crates (Thermal Mass), Rooftop Gardening, External Dynamic



- Radiant Barrier, Internal Dynamic Radiant Barrier, Cross Ventillation, Stack Ventillation (if feasible in accordance with the outcomes of housing density evaluation)
- d) Composite Climatic Zone: appropriate solutions - all of the above

The Table below presents a Context/House-to-Solution-Match Parameter Selector Table that can be employed to identify appropriate solutions as a function of Climate Zone, Structural attributes of the house, and Socio-Economic conditions prevalent in the particular Urban/Informal settlement, Street Vendors, Micro and Small Business, Institutions related to water availability, economic resources available to support roof rehabilitations (such as waterproofing prior to installation of roof retrofits), regular maintenance etc.

Table: Context-to-Solution-Match Parameter Selection Tool

Site: No.20	
SITE NAME	Sample Structure
Criterion	Value
Does the solution need to be.....	
<i>Suitable for Warm & Humid Climate</i>	No
<i>Suitable for Hot & Dry Climate</i>	No
<i>Suitable for Composite Climate</i>	No
<i>Suitable for Temperate Climate</i>	No
<i>Suitable for High-Speed Winds</i>	No
<i>Suitable for Heavy Rainfall</i>	No
<i>Compatible with Mid-Sized Animals on Roof (Cat, Dog etc.)</i>	No
<i>Does Not Exacerbate Risk from Pests</i>	No
<i>Suitable for North Facing Roof (over occupied space)</i>	No
<i>Suitable for Limited Load Bearing Capacity</i>	No
<i>Suitable for Highly Sloped Roofs</i>	No
<i>Suitable for Post-installation Roof Use</i>	No
<i>Suitable for Lower Floors</i>	No
<i>Suitable for Tall Roofs</i>	No
<i>Suitable for Limited Roof Access</i>	No
<i>Suitable for Street Vending</i>	No
<i>Suitable for Economically Deprived Communities</i>	No
<i>Suitable for High-Density Settlements</i>	No



<i>Suitable for Infrequent Maintenance</i>	No
<i>Suitable for Limited Waterproofing</i>	No
<i>Suitable for Limited Water Availability</i>	No
<i>Suitable for Limited Power Availability</i>	No
<i>Suitable for Use/Management by Elderly / Physically Challenged</i>	No
<i>Suitable for Use/Management by Adults</i>	No
<i>Suitable for Peak Afternoon Occupancy</i>	No
<i>Suitable for Night Time Occupancy</i>	No
<i>Suitable for High Occupancy</i>	No
<i>Suitable for Passive Cooling</i>	No
<i>Suitable for Active Cooling</i>	No
<i>Suitable for Space Cooling</i>	No
<i>Suitable for Storage Cooling</i>	No
<i>Suitable for Frozen Foods (<-18°C)</i>	No
<i>Suitable for Cold Holding (0-5°C)</i>	No
<i>Suitable for Chilling Sensitive Products (13-16°C)</i>	No
<i>Suitable for Heat Sensitive Products (15-18°C)</i>	No

Once the relevant parameters are selected from the value column (Yes, No, Partial) the tool compares them against a predefined matrix that maps each solution to its applicable parameters. Based on this comparison, the tool generates a list of solutions that are relevant to the selected conditions or scenario. Below is a list of solutions listed as an example when none of the parameters are selected.

Table: Solutions List

Matching Solutions
Rooftop Garden - Low Soil Mass - Bamboo Mesh
Rooftop Garden - High Soil Mass - Bamboo Mesh
Internal Radiant Barrier - MLP - Tarpaulin Mounted
External Radiant Barrier - MLP - Tarpaulin Mounted
External Radiant Barrier - MLP - Tarpaulin Mounted - Vertical Cane Blind - MLP Wrapped
PET Bottles - Crate Mounted
PET Bottles - Directly Secured



Reflective Umbrella
Reflective Tarpaulin
Static MLP
Static Alufoil
Biomass Panel (MLP Covered)
Wood wool Panel (MLP Covered)
Evaporative Cart Canopy
Expanded Polystyrene (EPS)
Gypsum Board
Mangalore Tiles
Poly Urethane Foam Panel
Hourdi Blocks
Reinforced Cement Concrete Slab
Kadapa + Cement Screed
Precast Concrete Slabs
White Tiles
Cool Roof Paint
Pre-Painted Galvalume Sheet (PPGL)
PVC Boards
Cool Canvas
Khus Curtains / Blinds
Corrugated Recycled Tetra Pak Sheet (PolyAl roofing sheet)
Bamboo Corrugated Roofing Sheet
Onduline Sheet
Multiwall Polycarbonate Sheet
Bison Board
Bamboo Mat Board
Compressed Stabilized Earth Block
Inverted Earthen Pots/ Clay tiles
Madras Terrace Roof Slab
Magra Wool - 20 mm
Porotherm Block Masonry
Turbo Ventilators
Fibre Based-Modular Roof panels - 20mm Thick
Rockwool Slabs - 30mm/50mm

Pre-Painted Galvanized Iron Sheet
Glass Wool
Spray Foam
Aerogel Insulation
Extruded Polystyrene Insulation Board
Brick Bat Coba
Shade Net
Honeycomb Panels
Window Tints
Unplasticized Polyvinyl Chloride Windows
Lime Concrete
Retractable Awnings – White PVC-Coated Fabric (Solar Reflectivity Index 85-95)
PV Powered Fan (DC)
PV Exhaust Ventilator
Low Energy Exhaust Fan (BLDC)
Low Energy Solar DC Cooler
Ambiator
Low Energy / Energy Efficient Ceiling Fans
Low Energy / Energy Efficient Wall Fans
PCM/ Eutectic box Thermal Battery
Ventilated Produce Crates (Perforated HDPE)
Zeer/Pot in Pot Coolers (Unglazed clay+Wet sand)
Clay Pot (Matka) +Wet Cloth Wrap
EPS Box Coolers
PolyUrethane Foam Coolers
Insulated Ice Chest Box
Vacuum Insulated Panel Boxes
Sabjee Cooler - Rukart
DC Compressor Freezer/Fridge
Solar Direct Drive (SDD) Freezer/Fridge
Micro Cold Room
Refrigerated E Kart/Tricycle
Thermo Electric Peltier



26. Solution Supply-Chain Development

26.1. Fabricator Network Identification/Development

26.1.1. Method of Identification

1. Rationale:

To engage with local fabricators humanely and equitably to support the thermal comfort retrofit fabrication process.

2. Approach:

- 26.1.1.1. Show the designs, drawings and sketches of the specific solutions to the fabricators to understand their capacity to fabricate the thermal comfort retrofit.
- 26.1.1.2. Visit their fabrication spaces to gauge their fabrication capacity
- 26.1.1.3. Interview the fabricator to assess the potential for collaboration.

26.1.2. Basic Selection Criteria

- 26.1.2.1. Analyse the fabricator's response to the interview questions and proceed with the next steps if the fabricator's response indicates potential.
- 26.1.2.2. Select a fabricator who seems most suitable for the project work based on the above mentioned evaluation.
- 26.1.2.3. Sign a contract with the selected fabricator.

26.2. Mason Network Identification/Development

26.2.1. Method of Identification

1. Rationale:

To engage with local mason humanely and equitably to support the thermal comfort retrofit masonry work process.

2. Approach:

- 26.2.1.1. Show the designs, drawings and sketches of the specific solutions to the mason to understand their capacity to carry out the masonry work related to the thermal comfort retrofit.



- 26.2.1.2. Visit their ongoing site to gauge their masonry skills
- 26.2.1.3. Interview the mason to assess potential for collaboration.

26.2.2. Basic Selection Criteria

- 26.2.2.1. Analyse the mason's response to the interview questions and proceed with the next steps if the mason's response indicates potential.
- 26.2.2.2. Select a mason who seems most suitable for the project work based on the above mentioned evaluation.
- 26.2.2.3. Sign a contract with the selected mason.

26.3. Tailor Network Identification/Development

26.3.1. Method of Identification

1. Rationale:

To engage with local tailor humanely and equitably to support the thermal comfort retrofit tailoring work process.

2. Approach:

- 26.3.1.1. Show the designs, drawings and sketches of the specific solutions to the tailor to understand their capacity to carry out the stitching work related to the thermal comfort retrofit.
- 26.3.1.2. Visit their shops to gauge their stitching skills
- 26.3.1.3. Interview the tailor to assess the potential for collaboration.

26.3.2. Basic Selection Criteria

- 26.3.2.1. Analyse the tailor's response to the interview questions and proceed with the next steps if the tailor's response indicates potential.
- 26.3.2.2. Select a tailor who seems most suitable for the project work based on the above mentioned evaluation.
- 26.3.2.3. Sign a contract with the selected tailor.

26.4. Material Supply Chain Development

26.4.1. MLP

- 26.4.1.1. Material specification development



1. General Requirements

- a. MLPs shall be obtained from post-consumer packaging that has been discarded or recycled.
- b. Size for MLP packets: approximately 250 mm × 180 mm.
- c. MLPs shall be durable, tear-resistant, and suitable for fabrication into thermal comfort retrofit applications.
- d. MLPs shall be free from excessive contamination including excessive, food waste, sand etc
- e. MLPs shall be suitable for manual handling and further processing using light fabrication tools.

2. Material Composition

- a. Outer layer (Plastic Layer) shall be made of polyethylene (PE) or polypropylene (PP)
- b. The inner layer shall be metallized film to provide a reflective or shiny surface.

3. Physical and Mechanical Properties

- a. Sheet thickness: 0.05–0.15 mm
- b. Tear resistance: Adequate to prevent ripping during fabrication
- c. Flexibility: Sufficient enough to fold or cut without cracking
- d. Heat resistance: Withstand ambient fabrication temperatures, not prone to melting under short-term handling.

26.4.1.2. Supplier research

- 1. Desktop research : Identify recycling companies, waste management firms, Non Governmental Organisations (NGOs), and Self Help Groups (SHGs) dealing in post-consumer MLP waste through web-based platforms such as IndiaMART. Their credentials should be reviewed. Details on pricing, minimum order quantities, and logistics support should also be collected.
- 2. Field research : Engage with local scrap dealers and community-level collection centres. The quality, size consistency (approximately 250mm*180 mm), and durability of the available MLP stocks should be verified after visiting the facilities.

26.4.1.3. Supplier shortlisting and engagement



1. Rationale :

To engage with local NGOs, SHGs, waste management firms and recycling companies in a humanely and equitable way to make sure that there is a steady supply of MLPs.

2. Approach:

- a. Describe and show the drawings and sample material of the MLP to the potential suppliers to understand their capacity to supply the MLPs.
- b. Visit their warehouse to gauge their supply capacity.
- c. Interview the supplier to assess potential for collaboration.
- d. Analyse the supplier's response to the interview questions and proceed with the next steps if the supplier's response indicates potential.
- e. Select a supplier who seems most suitable based on the above mentioned evaluation.
- f. Sign a contract with the selected supplier.

26.4.1.4. Procurement

1. Total MLP requirement should be finalised, including a contingency buffer to accommodate potential wastage.
2. A formal purchase order should be issued detailing quantity, dimensions, and quality specifications of the MLP material.
3. Negotiate and finalise terms including pricing structures, payment schedules, and delivery timelines.

26.4.1.5. Transport and delivery

1. Plan logistics to ensure timely and safe movement of MLPs from supplier's warehouse to fabrication sites
2. Select appropriate transport modes and vehicles, such as fully closed 3-wheeler carriers, to prevent damage of MLPs during transit.
3. Define delivery schedules in accordance with project timelines and fabrication needs.

26.4.1.6. Quality check

1. Inspect incoming MLPs against defined material specifications, including size and durability.
2. Ensure that delivered MLPs are free from contamination, damage, or degradation that could affect the fabrication.



3. Reject or return materials that do not meet expected quality standards.
4. Provide feedback to suppliers on quality issues and work together towards amendment measures.

26.4.2. PET Bottles

26.4.2.1. Material specification development

1. General Requirements

- a. PET bottles shall be obtained from post-consumer use or recycled sources, ensuring standardized 1 litre (1000 ml) capacity.
- b. Bottles shall be lightweight yet durable, suitable for handling, filling, and fabrication purposes.
- c. Bottles must be free from cracks, dents, chemical residues, oil, or food waste contamination.
- d. Labels and caps shall be removable without damaging the bottle surface.

2. Material Composition

- a. Primary material: Polyethylene Terephthalate (PET)
- b. Cap material: High-Density Polyethylene (HDPE) or Polypropylene (PP).
- c. Closure system: Screw cap with standard neck finish (28 mm or 30 mm typical).

3. Physical and Mechanical Properties

- a. Nominal Capacity: 1000 ml (1 litre).
- b. Height: Approximately 250–280 mm.
- c. Weight: 25–35 grams per bottle (standard range for 1L bottles).
- d. Strength: Adequate to hold water without deformation under normal handling.
- e. Flexibility: Capable of slight compression without cracking.
- f. Heat Resistance: Stable under ambient temperatures (up to 60 °C) without distortion.

26.4.2.2. Supplier research

1. Desktop Research : Identify recycling companies, waste management firms, Non Governmental Organisations (NGOs),



and Self Help Groups (SHGs) dealing in post-consumer PET bottle collection through web-based platforms such as IndiaMART. Their credentials shall be reviewed. Also collect details on pricing, minimum order quantities, and logistics support.

2. Field Research : Engage with local scrap dealers and community-level collection centres. The quality, size consistency, and durability of the available PET bottle stocks were verified after visiting the facilities.

26.4.2.3. Supplier shortlisting and engagement

1. Rationale

To engage with local NGOs, SHGs, waste management firms and recycling companies in a humanely and equitable way to make sure that there is a steady supply of PET bottles.

2. Approach

- a. Describe and show the sample materials of the PET bottle to the potential suppliers to understand their capacity to supply the PET bottles.
- b. Visit their warehouse to gauge their supply capacity.
- c. Interview supplier to assess potential for collaboration.
- d. Analyse the supplier's response to the questions and proceed with the next steps if the response indicates potential.
- e. Select a supplier who seems most suitable based on the above mentioned evaluation.
- f. Sign a contract with the selected supplier.

26.4.2.4. Procurement

1. Finalise procurement orders with shortlisted suppliers, ensuring clear communication on bottle specifications and quantity.
2. Negotiate and confirm aspects including pricing, payment schedules, and delivery timelines.
3. Ensure suppliers complied with agreed quality and hygiene standards for PET bottles.

26.4.2.5. Transport and delivery



1. Select appropriate transport modes such as fully covered three-wheelers, small trucks, or vans to protect bottles during transit.
2. Ensure bottles are delivered in bundled, packed, or bagged form to minimize breakage and for easy loading and unloading.
3. Delivery timelines should be monitored to ensure uninterrupted supply.

26.4.2.6. Quality check

1. Inspect each batch of bottles for cracks, dents, deformations etc
2. Verify bottle size, volume (1L capacity) for standardization.
3. Reject or return the bottles that do not meet expected quality standards.
4. Check cleanliness to ensure bottles were free of food waste, oil, or chemical residues.
5. Provide feedback to suppliers on quality issues and work together towards amendment measures.

26.4.3. Biomass Panels

26.4.3.1. Material specification development

1. General Requirements

The panels are manufactured using locally available materials, including plant fibres, crop residues, and wild species sourced from the surrounding ecosystem.

2. Material Composition

The primary raw materials consist of fibres extracted from locally cultivated and wild plants that require minimal processing. The panels installed were made using fibres from Sun hemp, banana stems and fibres, domesticated and wild Roselle, domesticated and wild Okra and Besharam grass.

3. Physical and Mechanical Properties

These biomass-based panels are unique in nature, and Gramart is currently in the pilot phase of their manufacturing and experimentation. This indicates that no formal scientific material testing has yet been conducted. However, future plans include upscaling, streamlining, and mechanizing the production process, while ensuring the panels are prepared with appropriate moisture content and tested for compressive, tensile, and flexural strength, as well as fire resistance, pest



resistance, and thermal and sound insulation properties.

26.4.3.2. Supplier research

1. Desktop Research : Initial exploration was carried out through informal networks. During this process, Gramart Organisation was identified as a potential supplier through recommendations from friends and colleagues.
2. Field Research : A visit was conducted to the Gramart manufacturing facility. The objective was to understand material availability, production capacity, and community-level participation in panel-making.

26.4.3.3. Supplier shortlisting and engagement

1. Rationale

To engage with the supplier in a humanely and equitable way to make sure that there is a steady supply of biomass panels.

2. Approach

- a. Visit their warehouse to gauge their supply capacity.
- b. Interview the supplier to assess potential for collaboration.
- c. Analyse the supplier's response to the interview questions and proceed with the next steps if the supplier's response indicates potential.
- d. Sign a contract with the supplier.

26.4.3.4. Procurement

1. Negotiate pricing structures based on panel size, thickness, and order volume.
2. Agree upon payment schedules and delivery timelines.
3. Develop procurement orders in alignment with project timelines and storage capacity.

26.4.3.5. Transport and delivery

1. Select appropriate transport modes such as light trucks or closed-body three-wheelers to safeguard panels from damage, moisture, or warping during transit.
2. Ensure careful stacking and padding of panels to avoid edge chipping or surface abrasion
3. Monitor delivery schedules to align with installation timelines.



4. Coordinate with supplier and transporters for tracking and safe handover at the site.

26.4.3.6. Quality check

1. Inspect delivered panels for conformity to size, thickness, and structural integrity as per agreed specifications.
2. Check for surface smoothness, absence of cracks, moisture damage, or fungal growth.
3. Provide feedback to supplier regarding defects and request suitable remedial actions or replacements.

26.4.4. Bamboo

26.4.4.1. Material specification development

1. General Requirements
 - a. Acceptable species include *Guadua angustifolia* (preferred for seismic zones due to flexibility), *Dendrocalamus giganteus* and *Phyllostachys edulis* (Moso) can be selected for high fibre density and strength.
 - b. Bamboo shall be harvested from a sustainable source at 3-5 years maturity, as younger culms lack strength and older ones become brittle.
 - c. Culms shall have a minimum diameter of 80mm and wall thickness of 8mm for structural use.
2. Material Composition
 - a. Bamboo shall exhibit typical lignocellulosic composition: 40-50% cellulose, 20-30% hemicellulose, 20-30% lignin, with low extractives (>5%) to ensure durability.
3. Physical and Mechanical Properties
 - a. Density: 600-900kg/m³
 - b. Moisture Content: 10-15%
 - c. Shrinkage(Radial): 8-12%
 - d. Shrinkage(Tangential): 10-16%
 - e. Specific Gravity: 0.6-0.9
 - f. Compressive strength: 40-80 MPa
 - g. Tensile Strength: 100-200 MPa
 - h. Flexural Strength: 80-120 MPa
 - i. Modulus of Elasticity: 10-20 GPa
 - j. Shear Strength: 8-15 MPa



- k. For the purposes of the roof-top gardening project, the focus was to procure pre-ordered bamboo bases for placing the pots and bamboo trellis for shading.
- l. Bamboo diameter to be used: 1.5 to 2 inch
- m. Bamboo size for base: length-10ft (distance between the two opposite parapet walls), width-1ft
- n. Bamboo size for trellis: 4ftx3ft

26.4.4.2. Supplier research

1. Desktop Research : Research and identify potential suppliers who specialize in bamboo products. Consider factors such as their reputation, experience, product quality, pricing, and sustainability practices, minimum order quantities, and logistics support.
2. Field Research : Engage with local bamboo product makers who make bamboo ladders, bamboo mesh etc. The quality, consistency of size and durability of the available bamboo were verified after visiting the facilities.

26.4.4.3. Supplier shortlisting and engagement

1. Rationale

To engage with local bamboo product makers in a humanely and equitable way to make sure that there is a steady supply of required size and quantities of bamboo.

2. Approach

- 26.4.4.4. Describe and show the drawings of the bamboo base and bamboo trellis to the potential suppliers to understand their capacity to supply the fabricated bamboo.
- 26.4.4.5. Visit their warehouse to gauge their supply capacity.
- 26.4.4.6. Interview the supplier to assess potential for collaboration.
- 26.4.4.7. Analyse the supplier's response to the questions and proceed with the next steps if the supplier's response indicates potential.
- 26.4.4.8. Select a supplier who seems most suitable based on the above mentioned evaluation.
- 26.4.4.9. Sign a contract with the selected supplier.
- 26.4.4.10. Procurement



1. Finalize total Bamboo bases and trellis requirements.
2. Initiate formal purchase order detailing quantity, dimensions, and quality specifications of the requirement.
3. Negotiate and finalize commercial terms including pricing structures, payment schedules, and delivery timelines.

26.4.4.11. Transport and delivery

1. Plan logistics to ensure timely and safe movement of fabricated Bamboos from supplier's warehouse to the site.
2. Select appropriate transport modes and vehicles to accommodate the maximum quantity that can be transported, also check for prevention of damage of fabricated Bamboos during transit.
3. Define delivery schedules in accordance with project timelines.

26.4.4.12. Quality check

1. Inspect fabricated Bamboo products(bases and trellis) against defined material specifications, including size and durability.
2. Ensure that delivered Bamboos are free from contamination, damage, or degradation that could affect them.
3. Reject or return materials that do not meet expected quality standards.
4. Provide feedback to suppliers on quality issues and work together towards amendment measures.

26.4.5. Cane Blinds

26.4.5.1. Material specification development

1. General Requirements

Refer Section 3.4.4 General Requirements (Bamboo)

Note: Many sellers use “Bamboo” and “Cane” interchangeably for roll up blinds made from Bamboo. For our purposes, we specify Bamboo because it is stiffer and more uniform, giving it a cleaner and more consistent weave. Cane typically (rattan/reed) is more flexible and unless well sealed, can stretch or warp with moisture. Moreover, Cane Blinds are 8-10 times more expensive than Bamboo Blinds. The term “Cane Blind” for our purposes means material used is Bamboo unless stated otherwise.

2. Material Composition



Refer Section 3.4.4 General Requirements (Bamboo)

3. Physical and Mechanical Properties

Refer Section 3.4.4 General Requirements (Bamboo)

26.4.5.2. Supplier research

1. Desktop Research : Research and identify potential suppliers who specialize in Cane Blind Fabrication. Consider factors such as their reputation, experience, product quality, pricing, and sustainability practices, minimum order quantities, and logistics support.
2. Field Research : Engage with Cane Blind Artisans who make Cane Blinds. The quality, consistency of size and durability of the available bamboo sticks used to make the Blind is verified after visiting the facilities.

26.4.5.3. Supplier shortlisting and engagement

1. Rationale

To engage with local Cane Blind artisans in a humanely and equitable way to make sure that there is a steady supply of required size and quantities of Cane Blind.

2. Approach

- a. Describe and show the photos, material specifications of the Cane Blind to the potential suppliers to understand their capacity to supply the Cane Blind.
- b. Visit their warehouse to gauge their supply capacity.
- c. Interview the supplier to assess potential for collaboration.
- d. Analyse the supplier's response to the questions and proceed with the next steps if the supplier's response indicates potential.
- e. Select a supplier who seems most suitable based on the above mentioned evaluation.
- f. Sign a contract with the selected supplier.

26.4.5.4. Procurement

1. Finalize total Cane Blind requirement along with their sizes..
2. Initiate formal purchase order detailing quantity, dimensions, and quality specifications of the requirement.



3. Negotiate and finalize commercial terms including pricing structures, payment schedules, and delivery timelines.

26.4.5.5. Transport and delivery

1. Plan logistics to ensure timely and safe movement of Cane Blind from supplier's warehouse to the site.
2. Select appropriate transport modes and vehicles to accommodate the maximum quantity that can be transported, also check for prevention of damage of Cane Blind during transit.
3. Define delivery schedules in accordance with project timelines.

26.4.5.6. Quality check

1. Inspect Cane Blinds against defined material specifications, including size and durability.
2. Ensure that delivered Cane Blinds are free from contamination, damage, or degradation that could affect them.
3. Reject or return materials that do not meet expected quality standards.
4. Provide feedback to suppliers on quality issues and work together towards amendment measures.

26.4.6. Silpaulin/Tarpaulin

26.4.6.1. Material specification development

1. General Requirements
 - a. Silpaulin sheets shall be obtained from verified suppliers or authorized dealers, ensuring high-quality waterproofing material.
 - b. Sheets must be of 200 GSM thickness (as used for the Delhi project).
 - c. Material must be lightweight yet durable, UV stabilized, tear-resistant, and suitable for long-term outdoor exposure.
 - d. Sheets should be free from cuts, punctures, or manufacturing defects.
 - e. Edges should be heat-sealed with reinforced hemming to prevent fraying.
2. Material Composition
 - a. Primary Material: Cross-laminated, multi-layered polyethylene-based tarpaulin.
 - b. GSM Used: 200 GSM.
 - c. Coating: UV-stabilized for extended outdoor life.



- d. Color: Blue/Green (as per supplier availability).
- e. Waterproofing: 100% waterproof with heat-sealed joints.

3. Physical and Mechanical Properties

- a. Thickness / GSM: 200 GSM.
- b. Tensile Strength: High tear and puncture resistance suitable for roof covering.
- c. Flexibility: Capable of bending and folding without cracks.
- d. Temperature Resistance: Stable performance under temperatures up to 60°C without material deformation.
- e. Water Resistance: Fully waterproof with sealed edges.

26.4.6.2. Supplier research

1. Desktop Research : Identify authorized Silpaulin distributors, wholesale dealers, and manufacturers through online platforms such as IndiaMART. Details on pricing, GSM options, minimum order quantities, and logistics support should be collected. Also, verify supplier credibility through online reviews and ratings.
2. Field Research
 - a. Engage with local suppliers in dealing in Silpaulin sheets.
 - b. Visit stores or warehouses to inspect the material quality, GSM accuracy, durability, and UV resistance. Compare market rates for required sizes and negotiate bulk purchase pricing.

26.4.6.3. Supplier shortlisting and engagement

1. Rationale

To engage with authorized dealers and verified suppliers to ensure a steady supply of high-quality 200 GSM Silpaulin sheets for the project.

2. Approach

- a. Share the project requirements and sample specifications with potential suppliers.
- b. Visit warehouses to inspect stock quality, GSM certification, and material consistency.
- c. Finalize pricing after confirming supplier credibility and material quality.
- d. Interview the supplier to assess potential for collaboration.



- e. Analyse the supplier's response to the interview and proceed with the next steps if the supplier's response indicates potential.
- f. Select a supplier who seems most suitable based on the above mentioned evaluation.
- g. Sign a contract with the selected supplier.

26.4.6.4. Procurement

- 1. Finalize procurement orders with shortlisted suppliers, clearly specifying GSM, sizes, and quantities.
- 2. Negotiate pricing, payment terms, and delivery timelines.
- 3. Ensure suppliers comply with quality certifications and UV-stabilization guarantees.

26.4.6.5. Transport and delivery

- 1. Use fully covered three-wheelers, trucks, or vans to protect Silpaulin sheets during transit.
- 2. Ensure sheets are packed or rolled properly to avoid tearing or folding damage.
- 3. Confirm delivery timelines to avoid installation delays.

26.4.6.6. Quality check

- 1. Inspect Silpaulin sheets for GSM consistency, punctures, tears, or lamination defects.
- 2. Verify dimensions against ordered sizes.
- 3. Check waterproofing and UV-stabilization specifications.
- 4. Reject or return defective sheets and share feedback with suppliers.
- 5. Maintain quality control logs for tracking material batches.



27. Material List

27.1. BOQ Preparation

27.1.1. Water Filled PET Bottles

	Name of Household	Santosh				
	Name of Solution	Water Filled PET Bottles				
	Area of building (sq.ft)	118				
Sr. No.	Name	Specifications	Qty	Unit	Cost (INR/Unit)	Total Cost (INR)
1	PET Bottle	1L	200.0	nos	1.6	320
2	Silpaulin	200 GSM	118.0	sq. ft.	7.7	909
3	Adhesive	Fevicol Heatx	2.4	Litre	440	1,038
4	MS Strip	75*5 mm	8.0	ft.	40	320
5	MS Angle	50*50*5mm, Length = 2ft	4.0	nos	65	260
	Total					2,847

27.1.2. Water Filled PET Bottles: In Crates

	Name of Household	Gyanti devi				
	Name of Solution	Water Filled PET Bottles: In Crates				
	Area of building (sq.ft)	101.72				
Sr. No.	Material	Specifications	Qty	Unit	Cost (INR/Unit)	Total Cost (INR)
1	PET Bottle	1L	604	nos	1.6	967
2	Silpaulin	200 GSM	102	sq. ft.	7.7	783
3	Crates	490*320*195mm	50	nos	30	1,500
4	Adhesive	Fevicol Heatx	2	Litre	440	880
5	MS Strip	75*5 mm	10	ft.	40	400
6	MS Angle	50*50*5mm, Length = 2ft	4	nos	65	260
	Total					4,790

27.1.3. Under Roof Insulation Panels(Wood Wool Panels)

Name of Household	Noorjahan					
Name of Solution	Under Roof Insulation Panels (Woodwool Panels)					
Area of building (sq.ft)	104.04					
Sr. No.	Name	Specifications	Qty	Unit	Cost (INR/Unit)	Total Cost (INR)
1	Wood Wool Panel	2'*4'	112	sq. ft.	55	6,112
2	L Angle MS pipe for Panels		41	ft.	65	2,665
3	T angles		80	ft.	90	7,200
4	MLP	3'*4'	14	Sheet	60	840
5	Duct tape		1.5		150	225
	Total					17,042

27.1.4. Under Roof Insulation Panels(Biomass Panels - Sunhemp Fibres & Waste Paper)

Name of the Building/Owner	Prakash Mohanty					
Sub Structure Name	Shop 2, Shop 3					
Solutions Assigned	Biomass Panels					
Area of Roof	201.472	sq. ft.				
Sr. No.	Material	Qty/100 sq. ft.	Qty (to be procured)	Unit	Cost (INR/Unit)	Total Cost (INR)
1	Biomass Panels	100	201	sq. ft.	140	28,206
2	GI channels	80	161	Feet	120	19,341
3	Perimeter channels	40	81	feet	10	806
5	Cieling to wall angle clips	16	32	piece	10	322
6	Channel connectors	36	73	piece	9	653
7	C clamp	8	16	per piece	305	4,916
8	Wooden Plug	40	81	per piece	5	403
9	Duct tape	2	4	per piece	150	604
10	Multi-Layer Plastic sheet	200	403	sq. ft.	5	2,015
11	SDSS screws	40	81	per piece	3	242
	Total					57,508

27.1.5. Rooftop Garden (Passive Irrigation)

	Name of Household	Anitha					
	Name of Solution	Rooftop Garden- Passive Irrigation					
	Roof Area (sq.ft)	216					
Sr. No.	Material	Specifications	Qty	Unit	Cost (INR/Unit)	Total Cost (INR)	
1	Bricks	3" X 6'	100	nos.	8	800	
2	Sand and Cement		1	kg	350	175	
3	Bamboo Ladder	10' length	1	nos.	1000	1,000	
4	Bamboo Trellis	4' X 3'	16	nos.	250	4,000	
5	Bamboo Frame	1' X 12'	4	mtrs	350	1,400	
6	Plumbing Materials and Overhead Tank		1	nos.	2,265	2,265	
7	Pump set	1 HP	1	feet	3,200	3,200	
8	Poting Mix		120	kg	18	2,100	
9	Grewing Pot/Container		12	sq.ft	140	1,680	
10	Float Valve Box	Kit	25	nos.	170	4,250	
11	Irrigation Hose And Joineries		1	nos.	525	525	
12	Ziplocks	9" and 12 "	3	nos.	120	360	
13	Garden Net	8' X 10'	320	sq.ft.	2	704	
14	Compost Bucket	20 Lrt	2	nos.	160	320	
15	Seeds	Packet	22	nos.	10	220	
16	Silpaulin	200 GSM	300	sq.ft.	6	1,800	
17	Garden Tools		3	nos.	320	960	
18	Compost Starter	20 ltr	0	kg	420	126	
19	Adhesive		3	kg	450	1,125	
	Total					27,010	

27.1.6. Internal Dynamic Barrier

Nme of Shop Owner	Prakash Jena						
Name of Solution	Internal Dynamic Barrier						
Roof Area (sq.ft)	229.8						
Sr. No.	Material	Specifications	Qty/100 sq.ft.	Qty (to be p	Unit	Cost (INR/Unit)	Total Cost (INR)
1	Anchor Bolt			32		20	640
2	Anchor Bolt (Eye Type)		24	20	nos.	22	440
3	Steel Wire	6mm(core) - PVC clear coated	30	40	mtrs	35	1,403
4	U-Clamp	8 mm	30	16	nos.	15	240
5	MS Square Pipe	40mmx40mm		26	feet		2,000
6	Turnbuckle	8 mm (Eye-Hook)	14	10	nos.	75	750
7	UPVC Pipe	1 inch dia		120	feet	22	2,640
8	Multi Layer Plastic (MLP)	11.09'x20.72	300	689	sq.ft	5	3,447
9	Double Sided High Bond Tape	1 inch	4	9	nos.	240	2,206
10	Duct tape	1.5 inch	3	7	nos.	150	1,034
11	Plastic Curtain Hooks	1 inch	2	10	dozen	30	300
12	Ziplocks	12 inch	30	70	nos.	2	140
	Total						14,601

27.1.7. Tarpaulin MLP



Name	Ashok Kumar Nayak					
Solutions	MLP Tarpaulin					
Area of Umbrella (sqft)	100					
Sr. No.	Material	Specifications	Qty	Unit	Cost (INR/Unit)	Total Cost (INR)
1	Tarpaulin (with Stitching)			1	2500	2,500
2	MLP Sheet	3*4 sq ft	27	Per piece	50	1,350
4	Double Side Sticky Tape		3	Per piece	280	840
	Total					4,690

27.1.8. Umbrella MLP

Name	Saki Guru					
Solutions	MLP Umbrella					
Area of Umbrella (sqft)	28					
Sr. No.	Material	Specifications	Qty	Unit	Cost (INR/Unit)	Total Cost (INR)
1	Umbrella			1	1000	1,000
2	MLP Sheet	3*4 sq ft	9	Per piece	50	450
3	Velcro					1,200
4	Double Side Sticky Tape		1	Per piece	280	280
	Total					2,930



27.1.9. Vertical Cane Blind

Name of Household	Noor Jahan				
Name of Solution	Vertical Cane Blind				
Roof Area (sq.ft)	234				
Wall Area Covered(sq.ft)	64				

Sr. No.	Material	Specifications	Qty	Unit	Cost (INR/Unit)	Total Cost (INR)
1	Bamboo Blind Fabrication	4' x 8' - 2 nos	64	sq.ft	25	1,600
2	Hooks		6	nos.	10	60
3	Multi-Layer Plastic sheet	4' x 8' - 8 nos	256	sq.ft	5	1,280
4	Double Sided High Bond Tape		2	nos.	240	480
5	Duct Tape		1	nos.	150	150
6	GI wire	2mm thick	1	bundle	50	50
7	Zip Ties	12 inch long	20	nos.	2	40
	Total					3,660

27.1.10. Space Frame

Name of Household	Shehnaz Amjad Ali				
Name of Solution	Space Frame				
Roof Area (sq.ft)	100				

Sr. No.	Material	Specifications	Qty estimated	Unit	Cost (INR/Unit)	Total Cost (INR)
1	MS pipe with square cross section: Single leg in a base (For corner supports)	30X30X2mm : length 1.5ft each	12	ft.	40	480
2	MS pipe with square cross section: extra supports	25X25X2mm extra support	50	ft.	40	2,000
3	MS flat (for base support of legs)	25.4*5 mm: length 6" each	8	ft.	50	400
4	Red oxide for metal parts		1.0	ltr	0	0
5	Black paint for metal parts		1	ltr	300	300
6	Rubber end caps(bush) for metal pipes	For 30X30X2mm square pipe	8	nos.	15	120
7	MS Washer(to weld with SS curtain ring)	1inch ID	24	nos.	30	720
8	Turnbuckles	8 inch	16	nos.	80	1,280
9	Fire Retardant Silpaulin (including wastage and extras)	200 GSM(15' x 15')	70	sq. ft.	8	560
10	MLP	(4'x3') - 12sqft	210	sqft	5	1,050
11	PVC pipe for water drainage	4" dia - 1 ft	1	ft	50	50
12	CPVC pipe	3/4" dia - 4.2 ft.	25	ft	45	1,134
13	CPVC pipe	3/4" dia - 3.2 ft	19	ft	45	854
14	Cement	OPC53 grade	1	kg	320	320
15	Crush sand		0.35	kg	250	88
16	Small stone chips	Below 20mm	0.35	cuft	50	18
17	Adhesive: Araldite	Standard Epoxy Adhesive	2	kg	544	980
18	Wire Rope with a plastic coat for winding and unwinding in Pulleys	2mm	40	ft.	30	1,200
19	Wire Rope with a plastic coat for static side support	4mm	54	ft.	45	2,430
20	U Clamp	3mm	20	nos.	15	300
21	Stainless steel curtain ring	Standard Size 1inch	24	nos.	15	360
22	Hooks	Standard Size	24	nos.	5	120
23	Runner pulley	Groove size - 15mm, Dia - 70 mm	6	nos.	180	1,080
	Total					15,853

27.2. Material Procurement

In addition to solution-specific material procurement practices delineated earlier in respective Sections, it is advisable to establish an easily accessible Information Management system, using simple spreadsheet tools (eg. google sheets), to enable effective collation and access to vital information pertaining to shipments.

The information architecture should comprise at least the following types of information:

- Material shipped
- Date of shipping
- Date of estimated arrival (accounting for possibility of delays due to inclement weather or official holidays in the region)
- Origin location
- Destination location
- Shipping Service provider's name
- Shipping Service provider's contact details
- Shipment Tracking Number
- Local warehouse address (useful information to accelerate the process if needed - by arranging for final pickup through your own resources once the shipment has arrived in the city)
- Team Member responsible for tracking and arranging final delivery/self-pickup as required.

28. Pre-Installation Preparation

28.1. Material Procurement

28.1.1. With Fabrication/Installation Partners

- 28.1.1.1. Take printouts of the prototype designs and if possible carry photos/videos of previous installations on your phone/laptop. Show these, explain the prototype designs and answer any questions the fabricator has.
- 28.1.1.2. Visit households to evaluate feasibility of installation with the fabricator.
- 28.1.1.3. Strategize prototype design implementation based on house structure evaluation with fabricator.
- 28.1.1.4. Share BOQs with the fabricator.
- 28.1.1.5. Discuss the types of installation material required based on implementation strategizing discussion with fabricator.
- 28.1.1.6. Discuss the quantity of installation material required with the fabricator.



- 28.1.1.7. Get a tentative daily schedule from the fabricator for material procurement and installation.

28.1.2. Within the Internal Team

- 28.1.2.1. Identify the materials to be procured by the team.
- 28.1.2.2. Conduct an online research of the material suppliers who sell the identified materials.
- 28.1.2.3. Call the material suppliers.
- 28.1.2.4. Get quotations from the materials suppliers.
- 28.1.2.5. Interview the material supplier.
- 28.1.2.6. Select the supplier based on the response to the interview questions and the quotation.
- 28.1.2.7. Finalise the order.
- 28.1.2.8. Get an invoice from the supplier.
- 28.1.2.9. Make payment to the supplier.
- 28.1.2.10. Follow up with the supplier till the material is delivered.

28.2. Ancillary Equipment / Tool Arrangement

28.2.1. For the Fabricator

- Evaluate the need for scaffolding for each specific installation site; ladders are not permissible to reach elevations higher than single story.
 - Evaluate the need for ladders.
 - Rent or procure ladders subsequent to an exhaustive inspection of overall structural integrity , integrity and provision of firm foot holds and hand holds.
 - Evaluate the need for a long wooden stick.
 - Rent or procure a long wooden stick
 - Evaluate the need for a tall stool.
 - Rent or procure a tall stool subsequent to an exhaustive inspection of overall structural integrity , integrity and provision of firm foot holds.
- Conduct 'Inconvenience/Interference' evaluation
 - Check if the neighbours walls or roofs are going to be affected due to the installation.
 - Seek consent from the neighbours in case their walls and roofs are getting affected due to the installation.
- Conduct 'Lighting' evaluation
 - Evaluate need for lighting fixtures such as flood lights, hand lights and area lighting if site work is anticipated in dark working conditions.
 - Procure these lighting fixtures, appliances as necessary.
 - Identify appropriate locations for installation of lighting fixtures.

- Engage with an Electrician to facilitate Installing of lighting fixtures prior to first day of site work.

28.2.2. For the Households

28.2.2.1. Seek installation consent from households.

- Conduct 'Residents Needs' evaluation
 - Check if suggested installation day/time is suitable for households.
 - Connect with households before installation to understand the need to make arrangements for food.
 - Connect with households before installation to check if there is a need for a place for family members to stay during installation.
 - Arrange for a room for residents to stay during installation with support from NGO partners.
- Arrange for a place in the community to store fabrication material with support from NGO partners.
- Check for community members who can support food preparation with support from NGO partners.

28.2.3. For the Internal Team

- Print site supervision checklist, safety checklist, log book and grievance book.
- Establish site supervision team, and team member rotation schedule, consisting of a minimum of 3 team members, with 2 being present on site at all times.
- Orient team members about the prototypes to be installed.
- Orient team members to the purpose and use of the site supervision checklist.
- Conduct Site-Work Training-by-Simulation session
- Assemble Nutrition Kit containing adequate quantities of the following foodstuffs to last for 1 week, checking for their expiry date which should extend beyond the anticipated duration of the site work:
 - Digestive Biscuits
 - Fruits
 - Glucon-D or similar drink mixes, syrups for rapid replenishment of salts and sugar
- Purchase Enabler Kits containing adequate quantities of the following other materials:
 - Pens
 - Torchlight
- Determine location placement of all vital materials to enable unhindered access during all hours of site work.



28.3. Masonry

28.3.1. Planning And Preparation

- Gather the tools and equipments:
 - Bring/obtain basic tools like trowel, level pipe, string line, measuring tape, hammer, block chisel, plumb bob etc.
- Collect materials:
 - Bring/obtain material for masonry work like cement, sand, brick, stone, aggregates(small stone chips), water etc.
 - Wear safety shoes and gloves before the work starts.
- Making the mortar:
 - Put the materials at a dry place where you want to make the mortar.
 - Thoroughly mix the correct amount of cement, sand and chips(if required for strengthening) for the required strength.
 - Add the water and bonding agent(chemical, if required) and mix thoroughly.

28.3.2. Setting The Foundation

- 28.3.2.1. Prepare the base:
 - Make sure the base should be rigid and free from loose materials.
- Moisten the base:
 - Lightly dampen the base with water before applying the mortar.

28.3.3. Laying The Brick/Stone

- 28.3.3.1. Spread the mortar:
 - Apply a layer of mortar on the prepared base to start the first course.
- Construct the corners:
 - Begin by building the extreme corners of the wall to act as guides.
- Use a string line:
 - Stretch a string between the corner bricks to establish the line for exterior and interior edges of the wall.
- Lay the bricks/stones:
 - Place the bricks/stones on the mortar, following the string line and keeping the courses level.
- Fill joints:
 - Apply mortar to the top of each brick/stone before placing the next, ensuring the joints are fully filled with mortar to create a strong bond and avoid the voids.



28.3.4. Finishing Work

- 28.3.4.1. Rake joints:
 - When the mortar is green (still soft), rake out the joints for about 13-19mm to create a space for plastering.
- Curing:
 - Keep the newly laid masonry wet for at least seven days to allow the mortar to cure properly and reach its full strength.

28.4. Roof Preparation

- 28.4.1.1. Order Silpaulin sheet which measures a foot more from all four sides of the rooftop.
- 28.4.1.2. Order Fevicol Heatex (or any other similar adhesive) for sticking Silpaulin
- 28.4.1.3. Order Bitumen Tapes for leakage proofing
- 28.4.1.4. Get the rooftop cleaned.
- 28.4.1.5. Dispose of any waste carefully and responsibly.
- 28.4.1.6. If there are any loose and stray roofing sheets, take them off.
- 28.4.1.7. Identify leakage areas.
- 28.4.1.8. Seal the leakage area by applying bitumen tapes from top and bottom of the roof.
- 28.4.1.9. Put the Silpaulin sheet on the roof and stick it to the roof using Heatex at multiple places with a 1.5-2 feet gap in between.

28.5. Site Safety Preparation

28.5.1. With Fabrication/Installation Partners

- Discuss Safety Protocol with the fabricator - stress on it being a non-negotiable
- Identify and ensure provision (by fabricator) of relevant safety material during fabrication process
 - Rubber/Electrical Safety Gloves (in case of electrical work)
 - Protective Glasses (in case of welding and grinding)
 - Safety Helmet
 - Metal Toe Boots
 - Safety Belts (in case of sites requiring scaffolding or working at heights greater than 12 ft)
- Ensure concurrence with the criterion that site work will be halted if any of the above safety gear is not appropriately used at all times when pertinent.



- Facilitate a safety protocol meeting with the installation supervisor and project workers before commencing installation work.
- Conduct 'Electrical Hazard' evaluation
 - Evaluate the need for an Electrical Safety Audit.
 - Find an electrician in the community with support from NGO partners.
 - Facilitate the conducting of an electrical audit by the electrician for each household to ensure the absence of stray currents and other electrical hazards that can undermine safety during site work.
 - Address any electrical hazard at least 2 days prior to commencement of site work.
 - Fill out Electrical Safety Audit Sheet (see Appendix)
- Conduct 'Fire Hazard' evaluation
 - Evaluate the need for a Fire Safety Audit.
 - Conduct a Fire Safety Audit to identify tasks, materials and locations that warrant the availability of a Fire Safety and Response Kit.

28.5.2. Within the Internal Team

- Ensure team members are informed about forums and avenues to raise workplace concerns, especially those related to unethical conduct, rupturing of trust, and physical or psychological harassment by anyone engaged in the effort.
- Assemble 2 First-Aid Kits containing at least the following, checking for their expiry date which should extend beyond the anticipated duration of the site work:
 - Gauze
 - Electrol powder
 - Soframycin
 - Burnol
 - Dettol
 - Band-aid / Sterilized dressing
 - Scissors
 - Cotton Wool
 - Surgical tape
- Assemble Fire Safety and Response Kits, if necessary as ascertained by referring to conclusions stated in Fire Safety Audit Sheet, containing at least the following, checking for their expiry date which should extend beyond the anticipated duration of the site work:
 - Fire Extinguishers
 - Sand Buckets
- Design, print and laminate signs in multiple languages indicating First-Aid Kit, 'site work in progress' and other potential site hazards



such as slippery conditions, falling objects. electrical hazards, fire hazards etc.

- Identify locations for installing signs.
- Install signs.
- Develop the following emergency contact list and encode into all team member's phones and that a printout of the following is available:
 - Local Hospitals
 - Local Clinics
 - Local Fire Station
 - Local Police Station
 - Taxi/Autorickshaw Persons residing in the settlement
- Print the following:
 - Grievance Booklet
 - Log Booklet
 - Emergency Contact List

29. Performance Evaluation

29.1. Subjective Thermal Comfort Assessment Form Training

29.1.1. Rationale

To train residents/users to document subjective thermal comfort data based on lived experience before and after installation to assess effectiveness of solutions.

29.1.2. Engagement Approach

- 29.1.2.1. Identify a place and time that is convenient to interact and facilitate the meeting with community members with the NGO partners support.
- 29.1.2.2. Invite community members to the meeting and check if the suggested day and time works for them.
- 29.1.2.3. Details of the training method and the assessment form template are mentioned below.



1. Training Team Roles:

- A team member to explain the form filling process
- Team members to support residents to fill the demo form

2. Material:

- Form Booklets translated in the local language
- Pens

3. Training Approach:

- Explain the purpose of the form to residents
- Go through the form guidelines with residents
- Explain the purpose of each question in the form
- Give space to residents to clarify any doubts after each question
- Fill information under the 'General Information' section of the form booklet after explaining the booklets contents
- Ask residents to fill a demonstration form which will be the first form on the booklet, which will support with assessing their understanding of the form and also serve as a reference when they proceed to fill the forms at their houses
- At the end of the meeting inform residents that your team will be available in case they have any doubts while filling the forms later.

Assessment Form Content

1. Guidelines to fill the form-

- It is suggested that the score card be filled by all occupants who use the space.
- Keep the form preferably at the convenient position of the house.(So that you don't skip scoring).
- The form has to be filled 3 times a day for a period of 15-days.
- In the period of 15 days, 7-8 days have to be filled before the installation and 7 days after the installation of the prototype.
- Add the exact time range below the time period.
- It is recommended to score all the indoor comfort levels by sitting /standing at the center of the house/building.
- It is recommended to score all the outdoor comfort levels by sitting /standing open space (Not under a tree or any shade). (you don't have to go very far from the house)
- There are 3 clothing types to choose from:
 - Light clothing = single layered clothing preferably cotton/ sleeveless/ half-length sleeves shirts, half-length pants, nightwear gown.
 - Medium clothing = Half-length/Full length sleeve Shirts, Full pants/trouser, sarees, dress,
 - Heavy clothing = Woollen sweaters, Jackets

- There are 3 activity levels to choose from:
 - Light Activity = Sitting, standing, reclining seat, sleeping.
 - Medium activity = Walking
 - Heavy activity = strenuous work like cleaning, washing, cooking, exercise, running.
- If you are not at home at any time you can skip the cell.
- Few questions have to be scored from 1 to 5, where-
 - 1 is for Unbearable
 - 2 is for Low comfort
 - 3 is for Bearable
 - 4 is for Comfortable
 - 5 is for Pleasant

2. General Information:

- Prototype Installed:
- Name of the representative vendor/occupant member:

3. Form Template



Demo Form
Date: 20/8/2026

Name of the Occupant 			
Type of Occupation	☐ Street Vendor ☐ Tailor ☐ Grocery Shop ☐ Salon ☐ Repair Shop Others _____		
Exact time of reading 			
Note: Kindly check the guidelines above for Light/Medium/Heavy			
What is the level of activity before filling the form? 	☐ Light  ☐ Medium  ☐ Heavy 	☐ Light  ☐ Medium  ☐ Heavy 	☐ Light  ☐ Medium  ☐ Heavy 
What cloth are you wearing while scoring? 	☐ Light  ☐ Medium  ☐ Heavy 	☐ Light  ☐ Medium  ☐ Heavy 	☐ Light  ☐ Medium  ☐ Heavy 
Were you using any cooling aid while filling the form? 	☐ None ☐ Fan ☐ Cooler ☐ Water Sprinkling ☐ Wet Cloth/Towel ☐ Others _____	☐ None ☐ Fan ☐ Cooler ☐ Water Sprinkling ☐ Wet Cloth/Towel ☐ Others _____	☐ None ☐ Fan ☐ Cooler ☐ Water Sprinkling ☐ Wet Cloth/Towel ☐ Others _____
Note: 1 is for Unbearable, 2 is for Low comfort, 3 is for Bearable, 4 is for Comfortable, 5 is for Pleasant			
How comfortable do you feel in your work area right now? 	☐ 1  ☐ 2  ☐ 3  ☐ 4  ☐ 5 	☐ 1  ☐ 2  ☐ 3  ☐ 4  ☐ 5 	☐ 1  ☐ 2  ☐ 3  ☐ 4  ☐ 5 
How comfortable do you feel when standing outside the shaded/protected area? 	☐ 1  ☐ 2  ☐ 3  ☐ 4  ☐ 5 	☐ 1  ☐ 2  ☐ 3  ☐ 4  ☐ 5 	☐ 1  ☐ 2  ☐ 3  ☐ 4  ☐ 5 
How would you rate your ability to concentrate on work?	☐ 1  ☐ 2  ☐ 3  ☐ 4  ☐ 5 	☐ 1  ☐ 2  ☐ 3  ☐ 4  ☐ 5 	☐ 1  ☐ 2  ☐ 3  ☐ 4  ☐ 5 

29.1.3. Field Insights

The subjective assessment is planned for August, as communicated by the SELCO team. However, based on the site visits and a few informal communications, users have noted a significant improvement in thermal comfort post-installation. For Example, in the Bharatpur bakery unit, the

user shared that they felt comfortable sitting in the office space where the MLP Static Panel was installed. Similarly, in the BMC vending zone, a salon shop where VCB was installed reported that AC usage had decreased until the afternoon compared to before the installation.

29.2. Objective Thermal Performance Evaluation

29.2.1. Performance Analysis

Heat Stress Mitigation performance measurement conventionally employs two methods:

1. Manual - using a combination of Dry-Bulb Thermometer for measuring Indoor Air Temperature (Dry-Bulb Temperature: DBT), Digital Humidity Meter for Wet-Bulb (Humidity) measurement, and Infrared Gun for Radiant Temperature Measurement (to enable calculation of Mean Radiant Temperature - MRT) and ascertain Roof Underside) Temperature.
2. Automated - using the Dry-Bulb Temperature and Humidity Sensor

Within the limited time-frame of this current Pilot Demonstration Project, and stemming from the need of the more relevant radiant-temperature measurements which are only possible through Infrared Temperature Guns and not possible without the use of significantly more expensive Black Globe Temperature (BGT) Sensor, it was determined that Manual measurement strategy would be the most prudent and relevant. Measurements, the resulting analysis (using spreadsheet frameworks), and conclusions derived from the Manual measurement method are presented in the Charts, Tables and narratives below.

Table: Thermal Performance Indicators for Assessing Passive Retrofits Effectiveness

Sr No.	Variant ID- Variant Type	Thermal Performance Indicators
1	Variant 01-Vertical Cane Blind - MLP Coated-Biomass Fibre Panel - Banana Fibre & Waste Paper - MLP Wrapped	Indoor MRT
2	Variant 02-Biomass Fibre Panel - Banana Fibre & Waste Paper - MLP Wrapped	Roof Temperature (Under)
3	Variant 03-Vertical Cane Blind - MLP Coated	Wall Radiant Temperature
4	Variant 04-Umbrella - MLP	Roof Temperature (Under)
5	Variant 05-MLP - Static Panel - Metal Framed	Roof Temperature (Under)
6	Variant 06-Internal Dynamic Barrier - MLP	Roof Temperature (Under)
7	Variant 07-CGI Roof - Turbo Ventilator	Indoor DBT

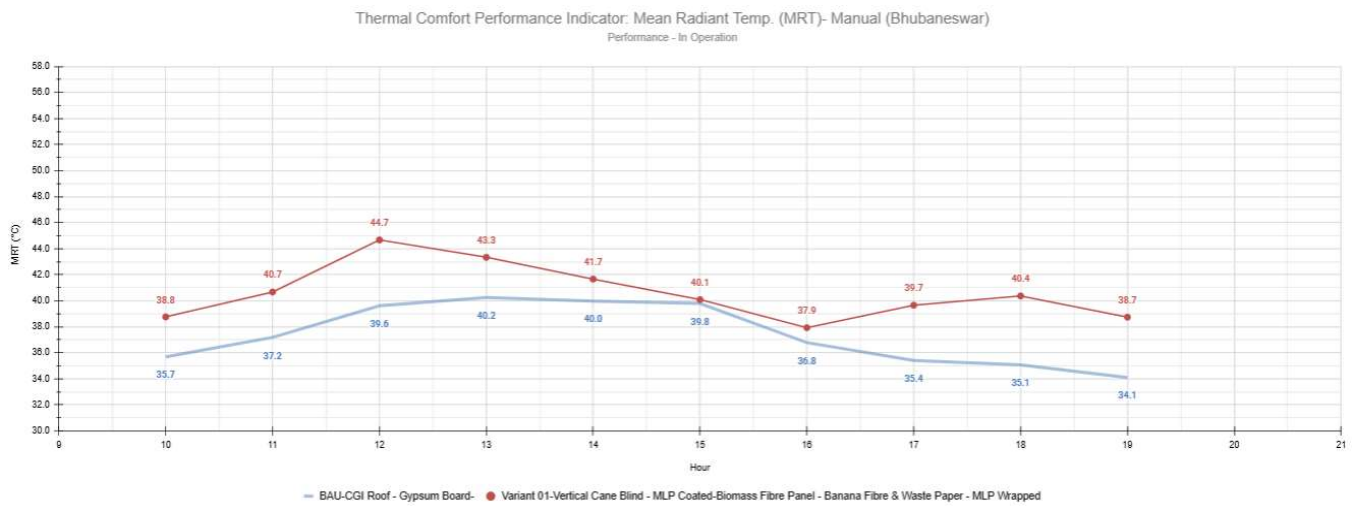


Fig 29.2.1-1 : Thermal Comfort Performance Indicator: Indoor MRT - Manual (Variant 01-VCB+Biomass Panel vs BAU)

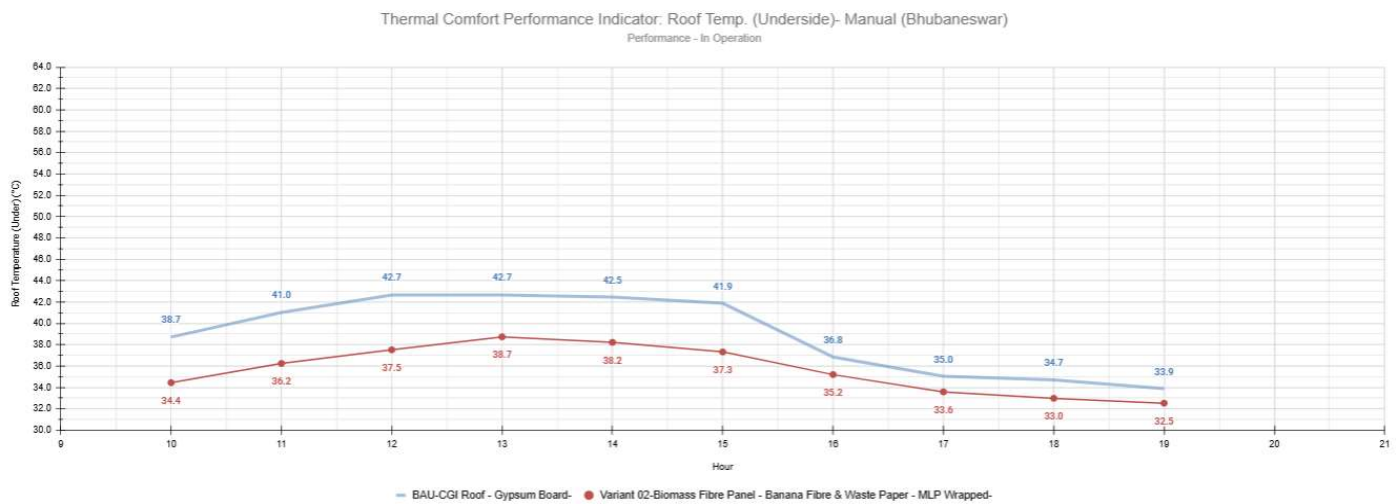


Fig 29.2.1-2 : Thermal Comfort Performance Indicator: - Roof Temp (Under) Manual (Variant 02- Biomass Panel vs BAU)

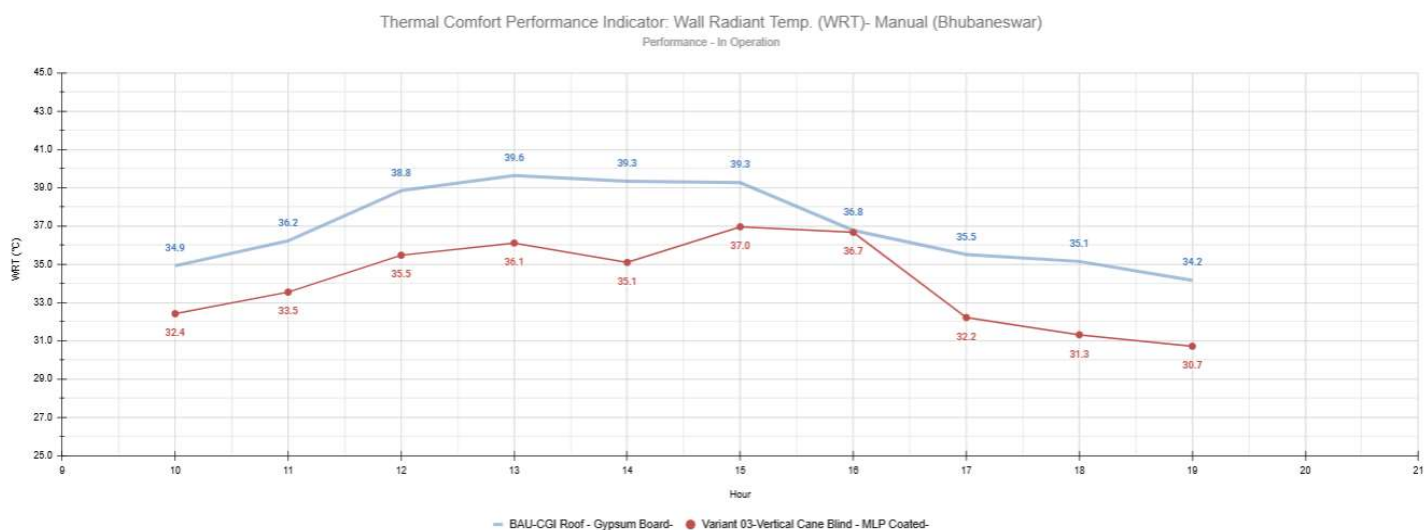


Fig 29.2.1-3 :Thermal Comfort Performance Indicator: Wall Radiant Temperature (WRT) - Manual (Variant 03-VCB vs BAU)

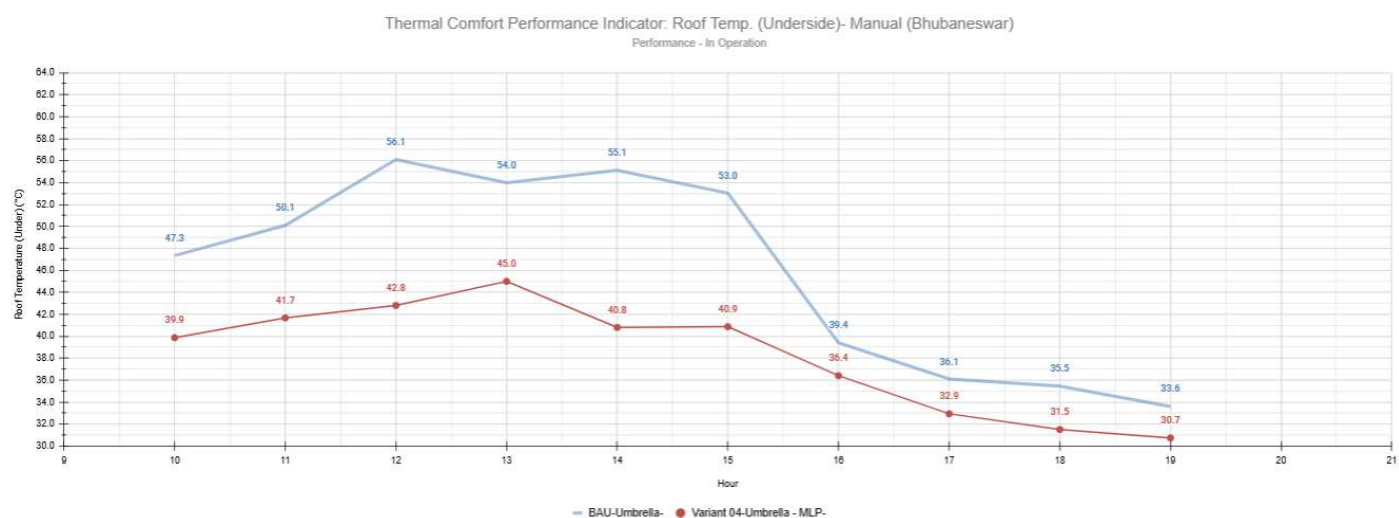


Fig 29.2.1-4 : Thermal Comfort Performance Indicator: Roof Temp (Under) - Manual (Variant 04-Umbrella MLP vs BAU)

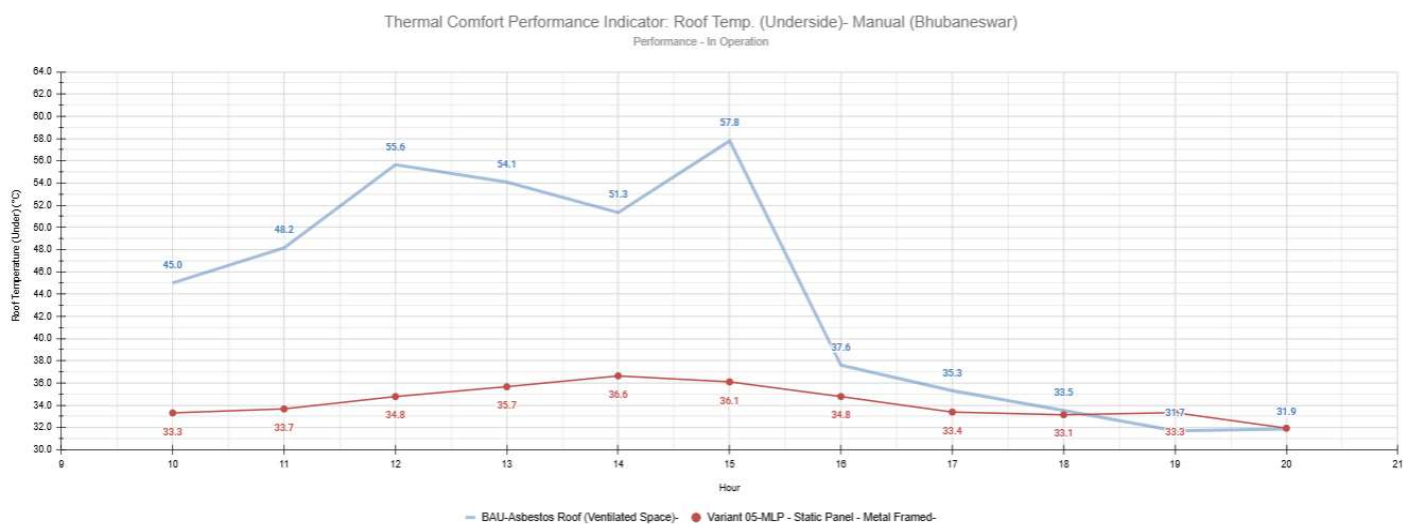


Fig 29.2.1-5 : Thermal Comfort Performance Indicator: Roof Temp (Under) - Manual (Variant 05-Static MLP Panel vs BAU)

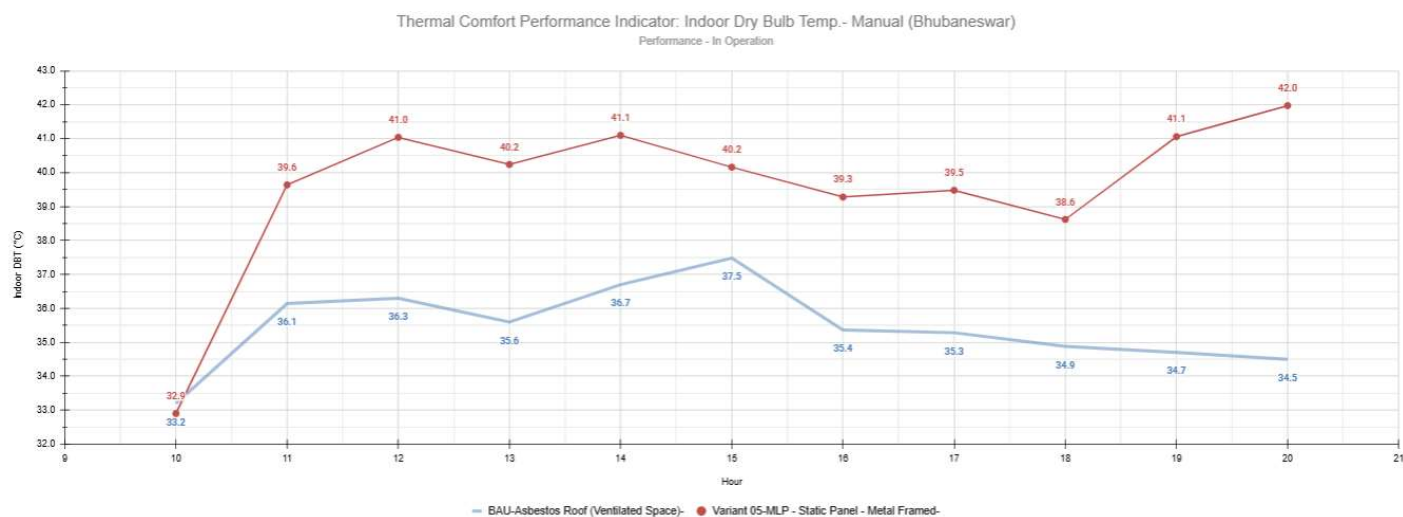


Fig 29.2.1-6 : Thermal Comfort Performance Indicator: DBT - Manual (Variant 05-Static MLP Panel vs BAU)

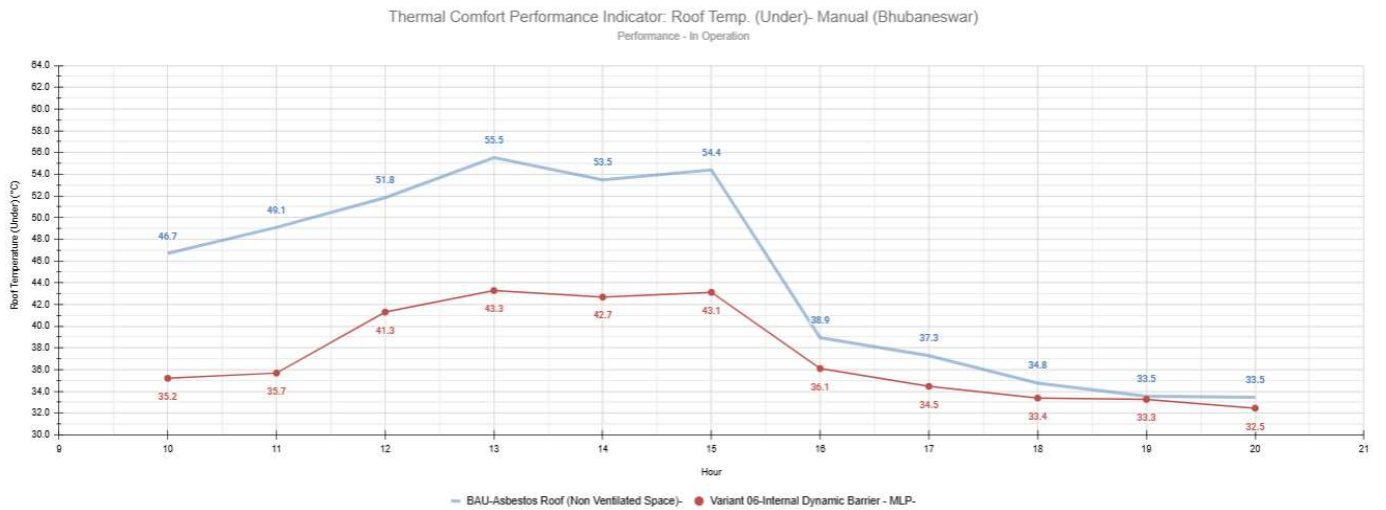


Fig 29.2.1-7 : Thermal Comfort Performance Indicator: Roof Temp (Under) - Manual (Variant 06-Internal Dynamic Barrier vs BAU)

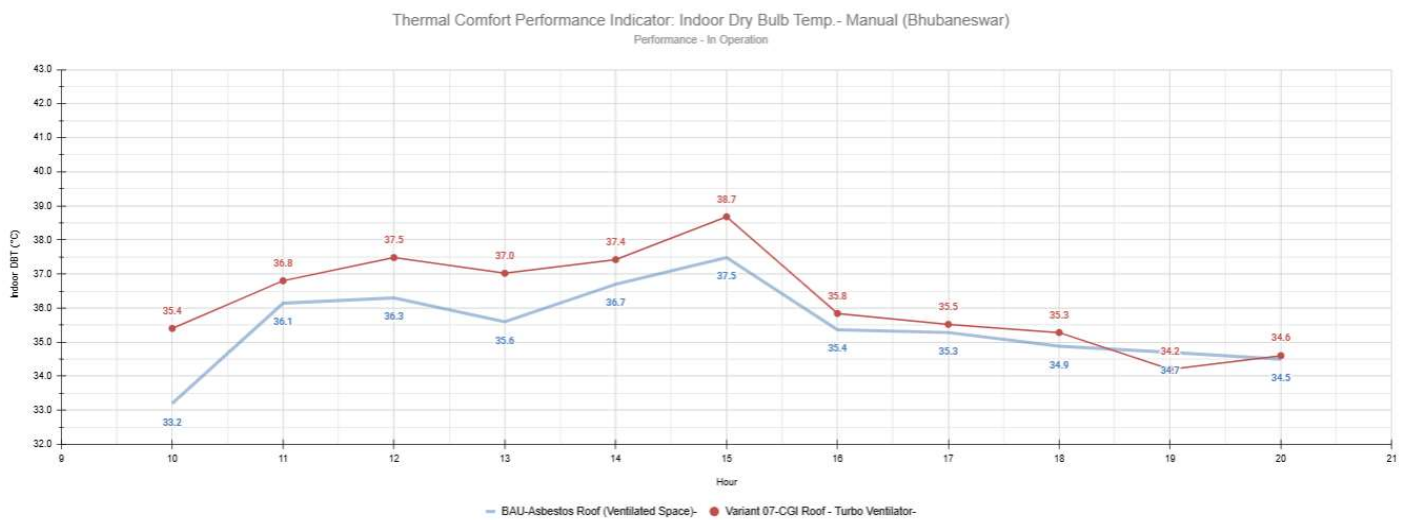


Fig 29.2.1-8 : Thermal Comfort Performance Indicator: DBT - Manual (Variant 07-Turboventilator vs BAU)

Table: Thermal Comfort Performance Indicators vs. BAU (Green highlighted cells represent Thermal Comfort Performance Indicators applicable for validating the effectiveness)

Indicator	DBT	DBT	DBT	DBT	MRT	MRT	MRT	MRT	Roof Temp	Roof Temp	Roof Temp	Roof Temp	WRT	WRT	WRT	WRT
	Peak Delta	Peak Delta Time	Min Delta	Avg. Delta	Peak Delta	Peak Delta Time	Min Delta	Avg. Delta	Peak Delta	Peak Delta Time	Min Delta	Avg. Delta	Peak Delta	Peak Delta Time	Min Delta	Avg. Delta
Variant 01-VCB+ Biomass Panel ⁴³	0.5	15.0	-0.6	0.0	-0.3	15.0	-5.3	-3.2	-1.4	15.0	-12.0	-7.2	0.0	15.0	-4.7	-2.2
Variant 02-Biomass Panel ⁴⁴	0.3	10.0	-0.2	0.1	2.5	15.0	1.1	1.8	5.1	12.0	1.4	3.3	2.2	17.0	0.3	1.5
Variant 03-VCB	1.9	18.0	-0.4	0.6	3.9	14.0	-0.1	2.8	4.0	18.0	-1.0	2.2	4.2	14.0	0.1	2.9
Variant 04-Umbrella - MLP	2.1	19.0	-1.0	0.4	14.3	14.0	2.9	7.8	14.3	14.0	2.9	7.8	0.0	-	0.0	-
Variant 05-MLP - Static Panel	0.3	10.0	-7.5	-4.1	6.3	15.0	-0.2	3.0	21.7	15.0	-1.6	9.6	2.5	14.0	-0.1	1.3
Variant 06-Internal Dynamic Barrier	0.2	12.0	-0.1	0.0	4.1	13.0	0.5	2.4	13.4	11.0	0.3	7.1	2.0	13.0	0.5	1.2
Variant 07-Turbo Ventilator ⁴⁵	0.5	19.0	-2.2	-0.7	-1.1	19.0	-4.4	-2.9	-0.6	19.0	-8.9	-3.7	-1.2	19.0	-4.4	-2.7

⁴³ Refer to Point 9 under Section Results and Discussion

⁴⁴ Refer to Point 10 under Section Results and Discussion

⁴⁵ Refer to Point 12 under Section Results and Discussion

29.2.2. Results and Discussion

The thermal comfort indicator-based performance analysis presented in the Charts and Tables above, yield the following conclusions:

1. Indoor Air Temperatures (DBT) for all Solutions except MLP Static Panel and Turboventilator were much less impacted relative to the BAU Structure. It must be noted however, that evaluation of indoor air temperature phenomenon requires extensive sensor-based data gathering at frequent intervals which was undermined during this Pilot Study due to time constraints. Extended sensor-based data collection from the BAU and Pilot Structures is required to make scientifically rigorous claims about the influence of these Solutions on Indoor Air Temperature.
2. Since all the solutions are designed to mitigate the influence of solar ingress/heat gain through the roof, it was anticipated that the primary beneficial impact of the Pilot Installations would be observed through measurements of Roof (Underside) Temperature. The measurement of performance indicators confirms this anticipated effect.
3. Roof (Underside) Temperatures for the following Solutions were significantly reduced relative to the BAU Structure.
 - Variant 05-MLP - Static Panel - Metal Framed
 - Variant 04-Umbrella - MLP
 - Variant 06-Internal Dynamic Barrier - MLP
 - Variant 02-Biomass Fibre Panel - Banana Fibre & Waste Paper - MLP Wrapped
4. In terms of Peak Under Roof Temperature Delta, the 'Ranking' of Solutions is as follows (highest rank = lowest Under Roof Temperature vs. BAU structure):

Rank	Solution	Delta (°C)
1	Variant 05-MLP - Static Panel - Metal Framed-	21.7
2	Variant 04-Umbrella - MLP-	14.3
3	Variant 06-Internal Dynamic Barrier - MLP-	13.4
4	Variant 02-Biomass Fibre Panel - Banana Fibre & Waste Paper - MLP Wrapped-	5.1

5. In terms of Peak MRT Delta, since there is only one variant combination, its Peak MRT Delta vs BAU is as follows:

Rank	Solution	Delta (°C)
1	Variant 01-Vertical Cane Blind - MLP Coated-Biomass Fibre Panel - Banana Fibre & Waste Paper - MLP Wrapped	-0.3



6. In terms of Wall Radiant Temperature (WRT) Delta, since there is only one variant, its Peak WRT Delta vs BAU is as follows:

Rank	Solution	Delta (°C)
1	Variant 03-Vertical Cane Blind - MLP Coated-CGI Roof - Gypsum Board	4.2

7. In terms of Indoor DBT Delta, since there is only one variant, its Indoor DBT Delta vs BAU is as follows:

Rank	Solution	Delta (°C)
1	Variant 07-CGI Roof - Turbo Ventilator	0.5

8. The solutions that performed better than 'median' performance in terms of Roof Radiant Temperature were:
- MLP-Static Panel
 - Umbrella-MLP
9. For Variant 01-Vertical Cane Blind - MLP Coated-Biomass Fibre Panel - Banana Fibre & Waste Paper - MLP Wrapped, the structure has a gas stove and heaters installed for cooking. It is most likely that the performance evaluation is influenced by the heating equipment used for cooking, which adds to the surface heat gain of the interior walls and roof. The average MRT value of -3.2 supports this possible influence. In addition, the respective BAU structure was dropped from the measurement plan because the BAU structure user installed a false ceiling during performance monitoring, and no alternative BAU structure could be identified during the performance monitoring window. For the purposes of this analysis, the closest possible BAU is an identical adjacent structure with a gypsum false ceiling, chosen to calculate the delta. However, this is not an ideal scenario for assessing the solution's effectiveness. Further data collection with a CGI Roof as BAU is recommended, and corresponding analysis is required to validate the observation regarding the relative effectiveness of the solution in comparison with the BAU.
10. For Variant 02- Biomass Fibre Panel - Banana Fibre & Waste Paper - MLP Wrapped, further data collection with a CGI Roof as BAU is recommended, and corresponding analysis is required to validate the observation regarding the relative effectiveness of the solution in comparison with the BAU.
11. For Variant 03-Vertical Cane Blind - MLP Coated-CGI Roof - Gypsum Board, the WRT readings show a peak delta of 4.2 and an average delta of 2.9, indicating relative effectiveness compared to the BAU structure. This needs further investigation by conducting ON-OFF operation temperature performance monitoring to corroborate the findings, since the BAU structure was not identical to the installation structure.

12. For Variant 07-CGI Roof - Turbo Ventilator: the solution works by enhancing ventilation and airflow. However, based on the measurement analysis, the average DBT observed is -0.7, indicating no improvement in the thermal comfort parameter. Since the structure has ovens and heaters for baking, it is most likely influencing the DBT. In addition, a similar BAU was not available for comparison, so a nearby structure with an asbestos roof was chosen as the BAU for this analysis. The findings warrant the next set of temperature monitoring with a similar BAU, and the heating equipment to be temporarily shut down for 3 days to validate the observation of relative effectiveness compared to the BAU.
13. As a process, it is recommended that, for dynamic solutions, ON-OFF temperature performance monitoring be conducted to validate the solution's effectiveness.
14. For Variant 05-MLP-Static Panel, refer Figure 28, the DBT values are significantly higher than the BAU. Possible reasons could be the presence of an attached kitchen to the office space, sharing a common door, and a lack of ventilation in the kitchen. This needs further investigation to confirm whether kitchen DBT influences the office space DBT.
15. It must be noted however, that it is likely that some of the performance evaluations are influenced in materially significant ways (eg. shade from adjacent trees or structures which may supplement the thermal benefit of the installed solution). The current data-gathering methodology is not designed to isolate the influence of surrounding structures/physical features. Further data collection and analysis is required to unequivocally validate the observation related to relative effectiveness of solutions in comparison with each other and the BAU context.

30. Cost

The Table below presents the Material, Labour and Transport Costs for the spectrum of solutions comprising this Pilot Demonstration Project. The following salient points must be noted and integrated into any subjective conclusions/interpretations drawn from this cost-accounting analysis, especially for transposing into the development of 'scaling' models and/or Policy Advocacy:

1. Material costs and labour hours are functions of the finite scale of the Pilot Project. It is anticipated that costs related to fabrication, procurement of materials, and engagement of persons providing labour power will reduce by 15-20% below the values provided here for an amplified operation scale.
2. Enhanced solution design, optimisation of material fabrication processes, pre-fabrication of modular parts used, as well as local fabrication of materials such as Biomass Panels are sources of further costs reduction.



3. Sweat Equity (i.e. residents contributing their own labour power to the fabrication, installation process etc.) is a source of further mitigating the unit cost of solutions and thereby moderating the need for external financial assistance. In the current analysis, Sweat Equity contributions are primarily related to MLP-sheet fabrication and installation, PET Bottle filing etc.. It is possible to amplify the scope of Sweat Equity beyond this set of activities (eg. applying adhesives and sticking Silpaulin sheets for water-proofing) through rigorous community-based training programmes that could be integrated into future 'scaling' plans - thereby enhancing the affordability of these solutions for economically vulnerable communities.

Table: Cost distribution of solutions implemented in Bhubaneswar

Solution	Area (sq.ft.)	Material Cost (INR)	Labour (hrs)	Potential Sweat Equity Effort (hrs)	Wage Rate (INR/hr)	Transport Cost (INR)	Total Cost (INR) - without Sweat Equity	Total Cost (INR) - with Sweat Equity	Unit Cost (INR/sq. ft.) - without Sweat Equity	Unit Cost (INR/sq. ft.) - with Sweat Equity
Biomass Panel - MLP Coated	201	83574	32	10	150	0	88374	86604	439	430
Internal Dynamic MLP Barrier	230	18572	50	42	150	0	26072	18638	113	79
Vertical Cane Blind - MLP Coated	60	3,495	12	4	150	0	5,295	4,695	88	78
Internal Static MLP Barrier	184	38360	46	38	150	3000	49185	43485	262	236
Umbrella - MLP Coated	50	2300	13	13	150	1000	5250	3300	105	66
Tarpaulin - MLP Coated	100	1850	20	10	150	1000	5850	4350	59	44

Table: Cost distribution of solutions implemented in other cities

Solution	Area (sq.ft.)	Material Cost (INR)	Labour (hrs)	Potential Sweat Equity Effort (hrs)	Wage Rate (INR/hr)	Transport Cost (INR)	Total Cost (INR) - without Sweat Equity	Total Cost (INR) - with Sweat Equity	Unit Cost (INR/sq. ft.) - without Sweat Equity	Unit Cost (INR/sq. ft.) - with Sweat Equity
PET Bottles (Single Layer)	118	2,900	12	6	150	600	5,300	4,400	45	37
PET Bottles (in Crates)	185	5,980	24	10	150	800	10,380	8,880	56	48
Wood Wool Panel	104	8,320	32	10	150	1,500	14,620	13,120	141	126
Rooftop Garden	215	27,010	32	12	150	1,300	33,110	31,310	154	146

Link of BOQ Sheet: [ThermIC_SELCO_Project_Management_Tracker](#) > Tab: BOQs of Solutions

31. Timeline & Resource Planning

Work Package Timeline (Oct 2025 – June 2026)										
Sr. No.	Work Package	Oct 2025	Nov 2025	Dec 2025	Jan 2026	Feb 2026	Mar 2026	Apr 2026	May 2025	June 2026
1	Inception Report									
2	Solution Market Research and mapping, vendor mapping									
3	Solution Awareness and engagement with end users									
4	Need assessment									
5	Finalizing solutions to suit the individual Interventions									
6	Baseline & Monitoring plan and framework									
7	Procurement of the solution									
8	Implementation & Training									
9	Catalogue of the solutions and the intervention sites									



10	Documentation, Reporting and Stakeholder presentation									
11	Knowledge Partner Support (As and when planned by SELCO Foundation within the timeline of the agreement)									

32. Strategy and Next Steps

The following principles undergird our recommended strategy for amplifying the scale of the heat-stress mitigation solutions through the establishment of local economic production based cooperatives anchored by trained local individual or micro-small scale fabricators, installers and maintenance contractors and with ownership vested in members of producer cooperatives (Women's Heat Action Cooperatives - WEHACs) that belong to, and reside in, the communities that they serve.

1. To limit the unintentional harm caused by rapid scaling, stemming from unforeseen unintended consequences, we recommend graduated scaling (from pilot scale to municipal ward-level scale) eventually achieving meso-scale (i.e. a regional scale - at city or multiple cities in a state/geographically contiguous climate zone) under the aegis of any one organization and refraining from directly participating in national/global scaling - and instead sharing knowledge/tools/solution designs etc. with other civil society to enable meso-scaling in other regions of national and global territory.
2. All design solutions and related technical materials (installation guides, maintenance manuals etc.) developed as part of this pilot project and those evolving henceforth but attributable to this intellectual resource base, should be unencumbered from 'intellectual property' related restrictions and should be open-sourced to producer-cooperatives and other similar economic arrangements which strictly prohibit unearned income for proxy owners (i.e. private investors) and rent-seeking for capital.
3. Production efficiency considerations should not be the dominant deciding criterion for choices related to process automation (for fabrication, installation etc.). Production scale and speed should be regulated to protect the long-term health of the economic landscape present day production considerations and related decisions should not hamper long term productivity; indiscriminate automation which locks-in dependency on hi-tech non-locally repairable equipment with spare parts procured through elaborate, energy intensive global or national supply chains undermine the overall resilience of the production system, increase total energy use and can precipitate conditions of reduced productivity in the long term due to supply-chain and energy-supply shocks in an increasingly unstable and uncertain geopolitical climate. As a corollary, the production system must be explicitly aligned with principles and concepts of



- appropriate technology and must accede no control or role to AI, IOT, ML etc. technologies which are categorized as irrelevant technologies for this process.
4. The governance of economic units that will engage in meso-scaling must be configured so as to privilege the economic interests, sovereignty and agency of informal settlement residents (the central stakeholder and rights-holders in this context) and secondarily member-owners of WEHACs
 5. Plurality of needs, heterogeneity of housing typologies, and diversity of living contexts necessitates repudiation of the monoculture-fetishizing technocratic approach to scaling; the patent-free appropriate technology solutions upon which the economic production system hinges must be characterized by a high degree of diversity and be ever vigilant of tendencies of capital, either explicitly oriented towards brazen capital accumulation or mimetic 'development' ideologies that reproduce the failed conditions of market economics that precipitated the gross inequities being addressed in the first place, to favor convergence and consolidation of solutions that inevitably fail to account for the heterogeneity of contexts and are intentionally or inadvertently imposed upon communities.

32.1. Scaling Roadmap (From Pilot to Intermediate to Scale transition)

The following foundational aspects of ecosystem transformation are imperative to be established for solution-specific meso-scaling missions to then be mounted

1. Establishment of a R&D&D (Research, Development & Deployment) Facility for enhancing the Technology Readiness Level (TRL) of Solutions co-created/vetted by design-build teams in conjunction with community-based design advisory panels to produce durable solutions that exhibit ability to withstand UV radiation, high winds, heavy rain, dust, corrosion, animal, and can function effectively without frequent maintenance (because of almost no direct roof access)
2. Developing alternate material solutions for transitioning away from microplastic generating materials eg. multi-layered plastics that currently serve as low-emissivity surfaces for radiant barriers, with light-colored natural fabrics with low-emissivity.
3. Coupling settlement-scale rainwater harvesting and groundwater recharge with individual home/business built-space related solutions, to leverage the beneficial compounding effect of concomitantly addressing solar heat gain and Urban Heat Island effects.
4. Establishing a One-Stop-Shop (OSS) Technical and Finance Assistance Facility serving as a match-maker between funds from government schemes, microfinance, CSR funds, patient capital etc. and WEHACs



A broad delineation of the recommended trajectory of meso-scaling is presented below:

1. Establish 1 Women Heat Action Cooperatives (WEHACs) consisting of approx. 15 women per MLA constituency in the Bhubaneswar Metropolitan which comprises the MP constituencies of BHUBANESWAR CENTRAL (MADHYA), BHUBANESWAR NORTH (UTTAR) and EKAMRA-BHUBANESWAR i.e. 18 MLA Constituencies with a ratio of 6 MLA constituencies per MP constituency) - to deploy a diverse mix of appropriate cooling solutions presented,
2. Establish Digital & Physical One-Stop-Shop (OSS) (1 physical shop per 6 MLA constituencies) that serves as a technical and finance assistance facility for WEHACs; link the facility with following types of funds/schemes that are already operational but have not been linked to heat action solutions in the past:
 - a. Patient-capital
 - b. Impact-investment
 - c. Micro-finance institutions
 - d. CSR funds
 - e. State Disaster Mitigation Funds
 - f. Urban Development Fund
 - g. National Urban Livelihood Mission (NULM) related Funds
3. In addition to the above, investigate and aim at securing 'seed capital' for WEHACs through MLA-LAD funds of the 18 MLAs
4. Secure approx. INR 45 Lakh seed capital per WEHAC (approx. 2% of the MLA-LAD funds over a 5-year term in a MLA constituency) to commence operations with 150 'customers' per year (i.e. 10 structures per WEHAC member per year), with a maximum of 30 'customers' per WEHAC member after 3 years of operation, who receive maintenance services for the approx. 3-5 years solution lifespan followed by a re-installation process of upgraded designs reflecting the state-of-the-art of the solution at the relevant time.
5. Through the above process, establish a 'cool roof district' containing approx. 450 homes/structures (typical size of an informal settlement in India) per MLA constituency that operate and earn income from self-sustaining micro-scale Women-owned businesses that fabricate, install, and maintain heat-action solutions.



32.2. Climate-specific readiness/pathway to scale

Solution	Application Context	Tech-Readiness Level Enhancement Needs	Supply Chain Development Needs	State Support Needs
Internal Static MLP Barrier	• Warm & Humid Climates • Daytime-only Occupied Structures with Corrugated Sheet Roofs	• Process efficiency for fabricating MLP sheets from post-consumer recycled waste • Radiant temperature reduction optimization • Modular, design for disassembly-based false-ceiling mounting frame	• Post-consumer recycled waste procurement • MP Sheet fabrication facilities	• Extended Producer Responsibility related obligations enforcement for large corporations employing MLP packaging
Internal Dynamic MLP Barrier	• Hot & Dry Climate • Diurnally occupied structures with Corrugated Sheet Roofs, adequate ceiling height and clearance from obstruction for lateral movement/folding	• Process efficiency for fabricating MLP sheets from post-consumer recycled waste • Radiant temperature reduction optimization • Enhanced modularity for rapid assembly and disassembly • Reducing gaps between panels to enhance ceiling coverage	• Post-consumer recycled waste procurement network • MP Sheet fabrication facilities	• Extended Producer Responsibility related obligations enforcement for large corporations employing MLP packaging

Biomass Panel - MLP Coated	• Warm & Humid Climates • Daytime-only Occupied Structures with Corrugated Sheet Roofs	• Process efficiency for fabricating MLP sheets from post-consumer recycled waste • Radiant temperature reduction optimization • Reduction in drying time during Biomass Panel production • Weight reduction • Increased durability • Improved fire and water resistance • Modular, design for disassembly-based false-ceiling mounting frame	• Post-consumer recycled waste procurement network • MP Sheet fabrication facilities • Biomass Panel fabrication facilities	• Extended Producer Responsibility related obligations enforcement for large corporations employing MLP packaging • Forest biomass produce access recognized and actively supported via sincere application of protections guaranteed under Forest Rights Act
Vertical Cane Blind - MLP Coated	• Hot & Dry Climate • Diurnally occupied structures with Corrugated Sheet Roofs, adequate ceiling height and clearance from obstruction for lateral movement/folding	• Process efficiency for fabricating MLP sheets from post-consumer recycled waste • Radiant temperature reduction optimization • Enhanced modularity for rapid assembly and disassembly • Enhanced durability of MLP-attachment	• Post-consumer recycled waste procurement • MP Sheet fabrication facilities • Cane blind fabrication facilities or procurement network	• Extended Producer Responsibility related obligations enforcement for large corporations employing MLP packaging

		nt to cane blind surface • Smooth operation of cane binds spanning multi-year operation		
Umbrella - MLP Coated	• Hot & Dry Climate • Street vendors	• Process efficiency for fabricating MLP sheets from post-consumer recycled waste • Radiant temperature reduction optimization • Enhanced modularity for rapid assembly and disassembly • Enhanced durability of MLP-attachment to underside of umbrella surface • Smooth operation of MLP-coated umbrellas spanning multi-year operation	• Post-consumer recycled waste procurement • MP Sheet fabrication facilities	• Extended Producer Responsibility related obligations enforcement for large corporations employing MLP packaging

33. Insights Overview

The insights shared in this report are based on learnings from the 'Climate-Smart Cooling Solutions for Vulnerable Urban Communities in Bhubaneswar' implemented in collaboration with SELCO Foundation. The initiative focused on addressing heat stress among vulnerable livelihoods, particularly focussing on street vendors and micro, small and medium enterprises (MSMEs) operating in heat-exposed environments across Bhubaneswar.



The interventions were implemented across three locations in the city of Bhubaneswar: CRPF BMC Vending Zone, Shikarchandi and Bharatpur. These four locations present a diverse set of small business establishments and street vendors that are highly exposed to rising urban temperatures. MSMEs in these locations often operate in poorly insulated, light weight structures with limited protection from heat accumulation and direct solar radiation.

Exposure to prolonged heat can significantly affect the health, comfort, productivity and livelihoods of these communities. As these vendors and business owners spend most of their daily time in outdoor/heat accumulated spaces they are particularly vulnerable to extreme heat events. Thus, it is critical to have scalable, affordable, and locally adaptable cooling solutions which can improve their thermal comfort and sustain their livelihoods.

In the 13 selected sites, a suite of passive cooling interventions was developed, tested, and refined for implementation. These included a) Internal Radiant Barriers, b) Multi-Layer Plastic (MLP) Static Panels, c) Vertical Cane Blinds, d) Biomass Panels, e) MLP Tarpaulin and f) MLP Umbrellas. These cooling interventions were designed using recycled materials with a special emphasis on affordability, ease of deployment and above all suitability for operational requirements of street vendors and MSMEs.

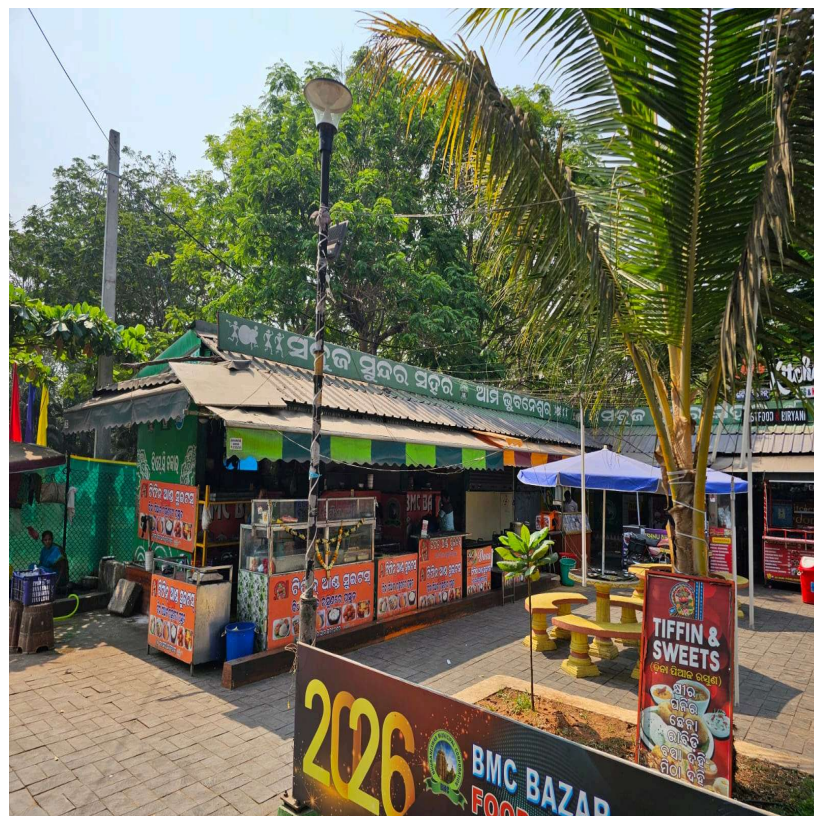


Fig 33-1 : BMC Vending Zone

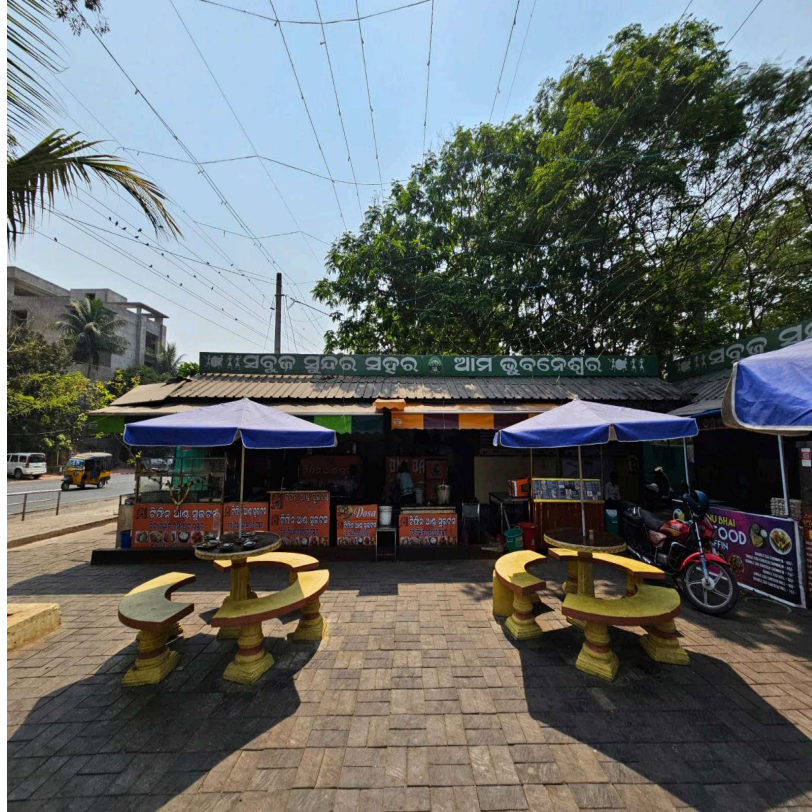


Fig 33-2 : BMC Vending Zone

This report shares 'Community Engagement Insights' and 'Cooling Solution Refinement Insights' based on work conducted for implementation of the 'Informal Housing Thermal Comfort Program' in Bhubaneswar, Odisha.

34. Community Engagement Insights

34.1. Community Engagement Process

The engagement process with street vendors and MSMEs across CRPF BMC Vending Zone, Shikarchandi, Bharatpur and Old Town, commenced with a baseline survey aimed at understanding the impacts of heat on their livelihoods. The baseline survey majorly explored how rising temperatures affect working hours, customer footfall, thermal comfort, productivity, health and various coping mechanisms adopted by vendors and business owners. The findings of the survey highlighted the need for context specific cooling interventions as prolonged exposure to heat was affecting economic activities and wellbeing of the participants.



Fig 34.1-1 : Baseline Survey

A subset of vendors and MSMEs representing different business typologies and operating conditions were shortlisted for further engagement. To understand spatial constraints, nature of heat exposure, operational requirements and the suitability of various cooling interventions detailed needs assessments and structural audits were conducted at each site. Various factors such as orientation, operating hours, availability of shade, type of structure and feasibility of installation were considered during the assessments.

Based on findings from needs assessments and structural audits, a Solution Match Tool was developed to support the identification of appropriate solutions for each end user. The tool incorporated key parameters such as heat exposure conditions, structural characteristics, and user preferences. Based on these inputs the tool generated a shortlist of suitable interventions for each end user. Out of these shortlisted interventions by the tool, a maximum of three solutions were taken to the end users. The shortlisted solutions, along with their expected benefits and operational considerations were presented to the participants through one-on-one discussions. Based on these discussions with the end users, a final intervention was selected for each site. The selected solutions were subsequently fabricated and installed in the selected sites after conducting a baseline temperature performance monitoring.

The end users were oriented on the purpose of interventions after the installation. Post installation, with the help of end users, a performance monitoring was conducted again along with the Core Carbon X (CCX) team. Subjective feedback is to be collected periodically to understand thermal comfort improvements and perceived impacts on work conditions and customer comfort.

34.2. Insights

34.2.1. Baseline Surveys and Needs Assessments

- **Understanding livelihood impacts of heat before proposing solutions is essential:** Baseline surveys revealed that impacts of heat extended beyond thermal comfort as participants reported reduced working hours, loss of customers during peak afternoon hours, decreased productivity etc. Rather than assumed solution proposals the livelihood-focussed baseline surveys helped ensure that interventions were aligned with actual user needs.
- **Different business typologies experience heat differently:** The baseline surveys highlighted significant differences between street vendors and MSMEs on how they experience heat. The street vendors were primarily affected by lack of shade and direct solar radiation whereas MSMEs experienced heat accumulation as they operate in enclosed or semi-enclosed structures. This reinforced the importance of conducting site-specific assessments rather than adopting a 'one-size-fits-all' intervention strategy.

34.2.2. Solution Match Tool

- **A structured decision-support tool improves transparency and consistency in solution selection:** A Solution Match Tool was developed to systematically identify suitable cooling interventions for the end users. This reduced subjectivity in the solution selection process ensured that recommendations were based on a consistent set of criteria across sites.

34.2.3. Solution Identification and Selection

- **Needs assessments and structural audits, and decision-support tools should jointly inform solution selection:** It was observed that thermal comfort varied significantly across locations. Factors like structural configuration, operating patterns, type of business influenced the suitability of different interventions. The Solution Match tool ensured that solution recommendations were both technically feasible and

contextually relevant by incorporating these factors/variables to be incorporated into the decision making process.

- **Providing multiple solution options improves user ownership:** End users were presented with a minimum of three possible interventions instead of one. This enabled them to compare alternatives and choose the best that matched their operational requirements. This process inserted trust and ownership during implementation.

34.2.4. Stakeholder Engagement

- **One-on-one engagements are more effective than group consultations for livelihood interventions:** Vendors and MSMEs operate under diverse conditions and schedules. Hence, unlike household based interventions where community/participatory workshops are often effective, individual discussions allowed participants to communicate specific operational constraints and provided opportunities to tailor solution options based on their suggestions.
- **Building Trust is critical for successful implementation:** Many end users were initially skeptical about the purpose of interventions. Involving them throughout the decision making process, continuous engagement, and transparency helped in building confidence and participation.

34.2.5. Fabrication and Installation

- **Involvement of the Core Carbon X (CCX) Team was essential to support a smooth fabrication and installation process:** The CCX team played an important role in coordinating between the end users and project installation team throughout the implementation process. As they were familiar with the local contexts and their relationships with end users helped streamline the communication processes and logistical arrangements.

34.2.6. Installation Performance Monitoring

- **Dedicated Core Carbon X (CCX) monitoring team help ensure consistency and quality of performance data:** The performance monitoring was conducted by trained members of CCX team pre and post installation. Since many end users operated throughout the day and could not be expected to undertake monitoring themselves, having a dedicated team helped in collection of data while minimising disruption to business operations.





Fig 34.2.6-2 : CCX Team Taking Temperature Measurements

34.2.7. Critical and Subjected Feedback

- Structured feedback mechanisms are essential for understanding user experiences beyond technical performance:** While temperature monitoring provides insight into thermal performance, user feedback is critical for understanding aspects like comfort and usability which can influence long-term adoption as much as thermal performance itself.
- Critical feedback sessions and periodic subjective comfort assessments are planned as part of the next phase of the program:** The project team intends to conduct structured feedback interactions with the participating end users following a sufficient period of intervention usage. The objective of these engagements will be to understand experiences with installed solutions, their perceived impacts on thermal comfort, challenges encountered during use and suggestions for future improvements. A subjective feedback form will be shared with the end users to get a better understanding of their improved thermal comfort.

35. Cooling Solution Refinement Insights

35.1. Water Filled PET Bottles

35.1.1. Prototype Testing Refinements

PET bottle prototype testing was conducted using testbeds. Three testbeds, each measuring 4 ft × 3 ft, were prepared for comparison. A 1000 W Halogen Lamp was positioned above each test bed to simulate Solar Radiation. Temperatures were recorded hourly between 10:00 a.m. to 6:00 p.m. The temperature differences between the testbeds were analyzed to conclude which prototype works better.

The test beds were as follows:

- Testbed 1: Business As Usual (BAU), that is, without PET bottles (Fig 35.1.1-1)
- Testbed 2: PET bottles placed in roof troughs with a silapulin layer in between bottles and roof (Fig 35.1.1-2)
- Testbed 3: PET bottle prototype variants (Fig 35.1.1-2)



Fig 35.1.1-1 : BAU Testbed

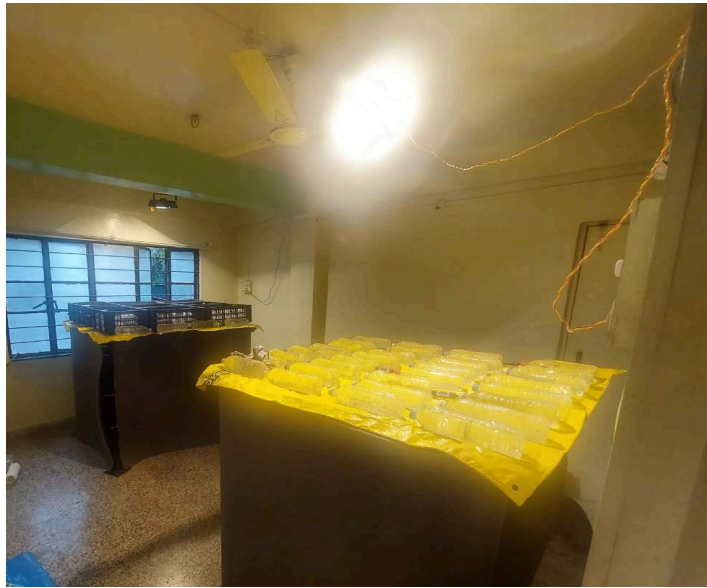


Fig 35.1.1-2 : Testbed (2) and (3)

Testbed 3 was refined using a combination of PET bottle arrangements and additional cooling materials, to determine the most effective PET bottle prototype version. Details of the prototypes experimented with are mentioned below.

Prototype Variants

- Prototype 1: PET bottles were painted with Prakritik white natural paint (Figure 3.1.3), as it provided a high-emissivity and low-absorptivity (that is, white) layer. This prototype demonstrated a reduced under-roof temperature of range 0.4 degree to 2 degree celsius.



Fig 35.1.1-3 : PET Bottles with Prakritik White Natural Paint on Testbed

- Prototype 2: A single layer of PET bottles were introduced in crates (Figure 3.1.4). This prototype demonstrated a reduced under-roof temperature of range 0.2 to 2.2 degree Celsius.



Fig 35.1.1-4 : Left to Right: PET Bottle in Crates Single Layer, Double Layer, and Triple Layer

- Prototype 3: A double layer of PET bottles were introduced in crates (Figure 3.1.4). This prototype demonstrated a reduced under-roof temperature range of 0.4 to 4.2 degree Celsius.
- Prototype 4: The second layer of PET bottles was placed in a staggered pattern to fill the gaps of the first (Figures 3.1.5 and 3.1.6). This arrangement demonstrated a reduced under-roof temperature range of 0.3 to 0.9 degree Celsius.



Fig 35.1.1-5 : PET Bottles Placed in Staggered Pattern Inside Crate (Top View)



Fig 35.1.1-6 : PET Bottles Placed in Staggered Pattern Inside Crate (Side View)

- Prototype 5: To introduce adequate spacing between the two layers, bamboo sticks were introduced between the first and second layer (Fig 35.1.1-7 and Fig 35.1.1-8). This was done for better heat dissipation. This arrangement demonstrated a reduced under-roof temperature range of 0.3 to 0.6 degree C.



Fig 35.1.1-7 : Bamboo Sticks for Adequate Spacing Between First and Second Layer (Top View)

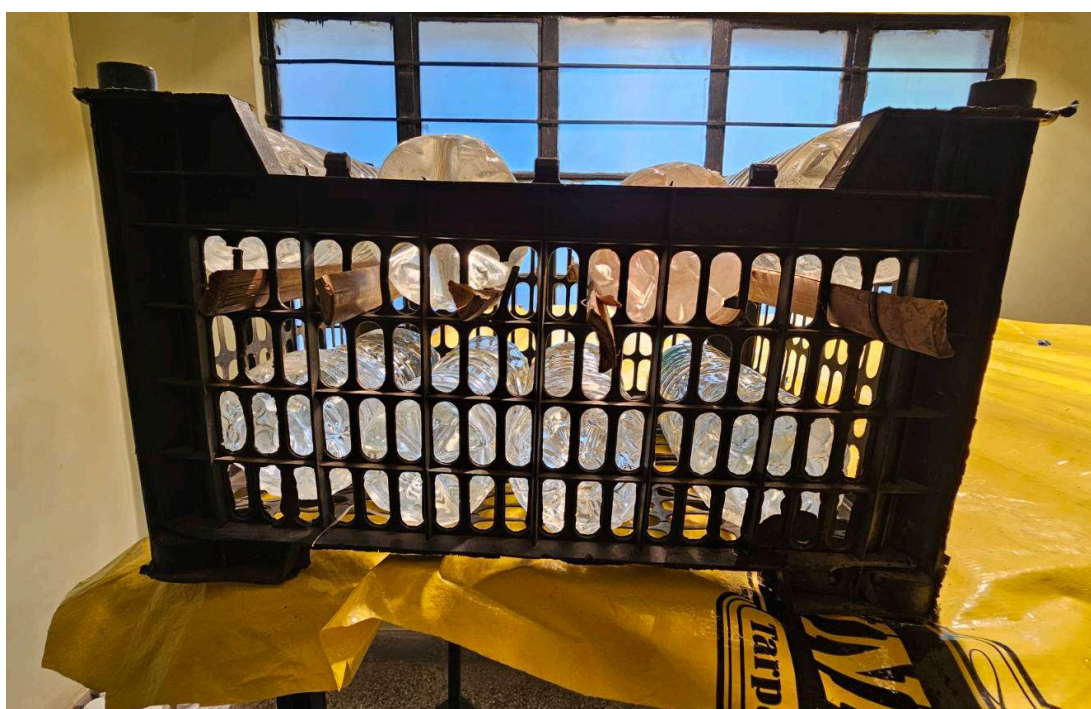


Fig 35.1.1-8 : Bamboo Sticks for Adequate Spacing Between First and Second Layer (Side View)

- Prototype 6: An Alufoil sheet with the shiny surface facing downward was introduced to experiment with enhancing the effectiveness of Prototype 4 as it provided a low-emissivity surface (Fig 35.1.1-9). This

prototype demonstrated a reduced under-roof temperature range of 0.1 to 2.7 degree Celsius.

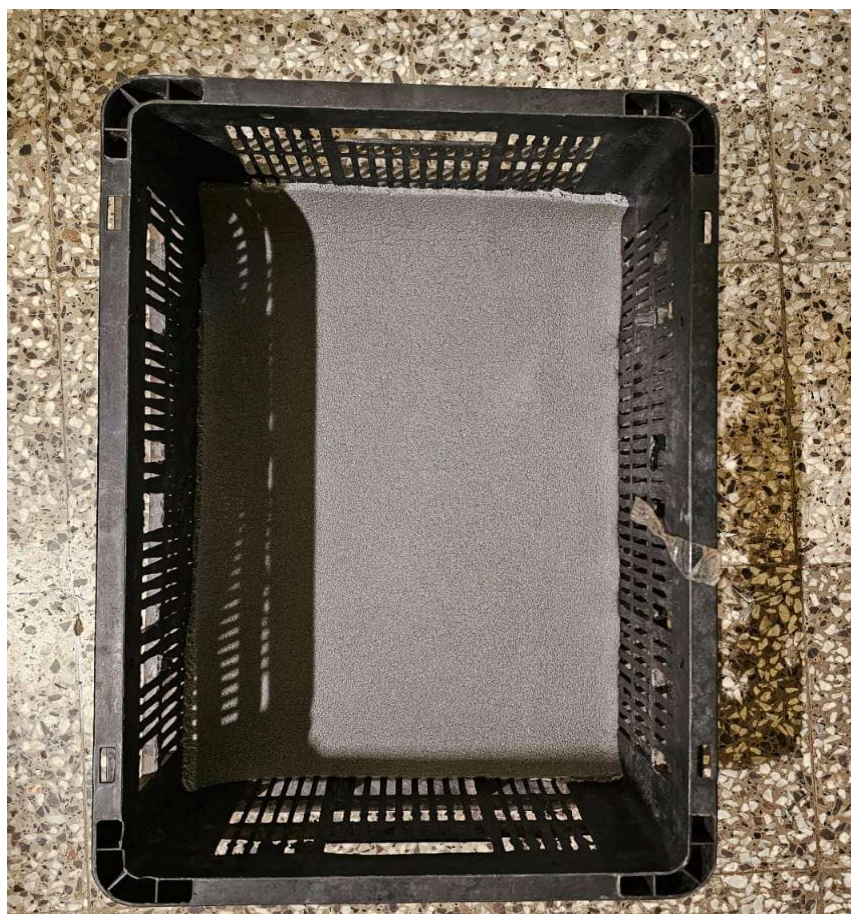


Fig 35.1.1-9 : Crate with Alufoil Base

- Prototype 7: A Multi-Layered Plastic (MLP) sheet with the shiny surface facing downward (Fig 35.1.1-10) was introduced to enhance the effectiveness of prototype 4 as it also provided a low-emissivity surface. This prototype demonstrated a reduced under-roof temperature range of 0.2 to 3.5 degree Celsius.



Fig 35.1.1-10 : Crate with MLP Base

- Prototype 8: Two layers of MLP sheets were placed on the base of the crate and using bamboo sticks the bottles were raised from the base of the crate for sufficient air circulation (Fig 35.1.1-11 and Fig 35.1.1-11). This prototype demonstrated a reduced under-roof temperature range of 1.3 to 7.78 degree C.

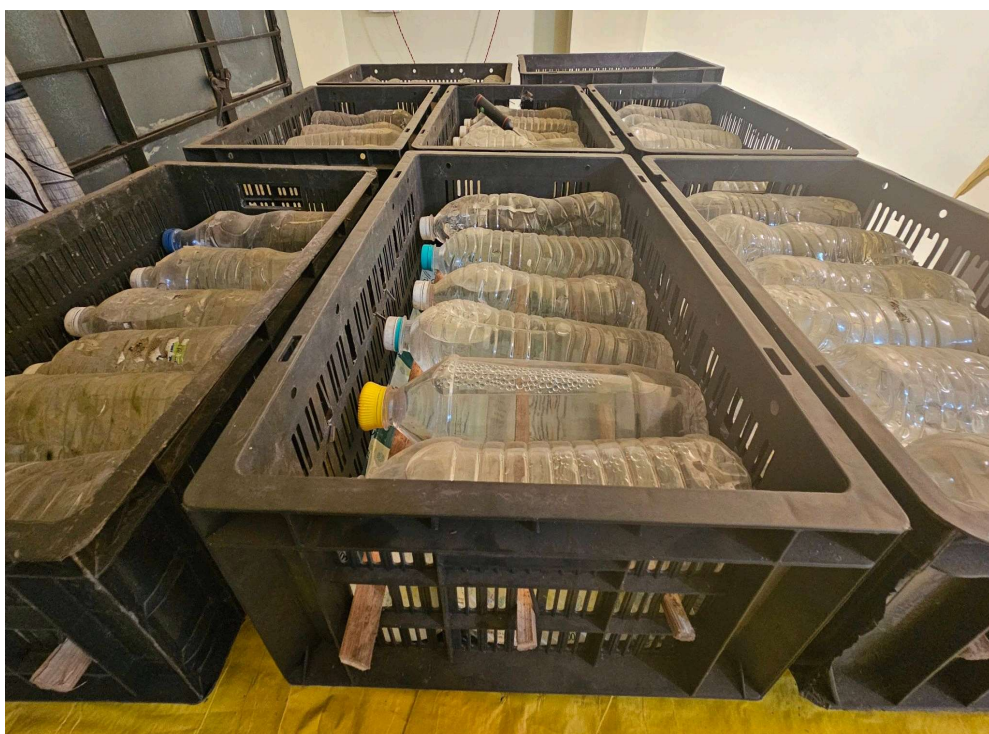


Fig 35.1.1-11 : Crate with Elevated Bamboo Base



Fig 35.1.1-12 : Crate with Elevated Bamboo Base (Side View)

35.1.2. Pre-Fabrication Process Refinements

There were no refinements in the pre-fabrication stage since the solution was not selected for installation.

35.1.3. Fabrication Process Refinements

There were no refinements in the fabrication stage.

35.1.4. Installation Process Refinements

There were no refinements in the installation stage

35.1.5. Post-Installation Process Refinements

There were no refinements in the post-installation stage.

35.2. Space Frame

35.2.1. Prototype Testing Refinements

- Reduction of horizontal members and subsequent pulley assembly: Prototype 1 has a horizontal member between the legs (Fig 35.2.1-1) onto which pulleys were mounted. To reduce the weight of the horizontal member, tensioned horizontal wires were installed and pulleys clipped onto it.

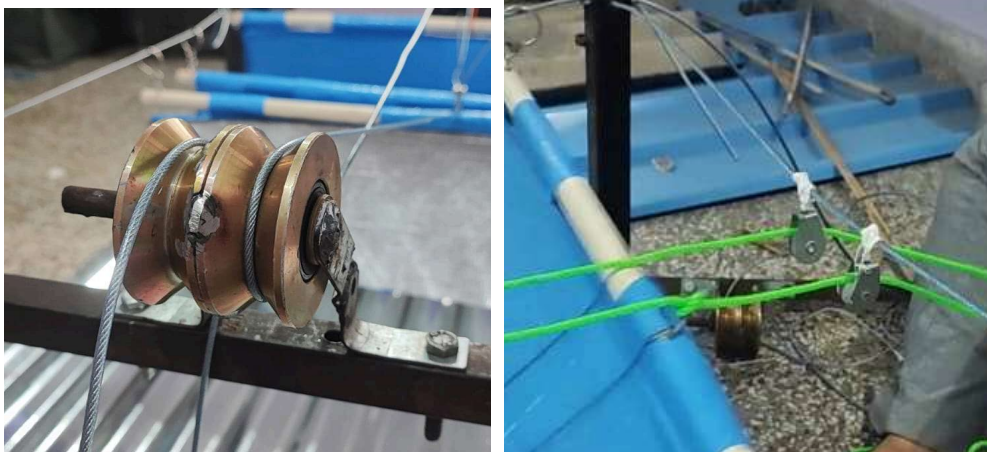


Fig 35.2.1-1 : Left Image: Prototype 1 over the Frame
Right Image: Prototype 2 with Pulleys Clipped to Steel Wire Rope

- Clamp based supports (not commissioned for installation as it needs further testing): Ideating on the lines of modularity, we tested and developed clamp based support for the space frame (Fig 35.2.1-2).



Fig 35.2.1-2 : Prototyping the Clamp-Based Support for Space Frame

35.2.2. Pre- Fabrication Process Refinements

- Shift from Alufoil to MLP as a Low Emissivity Barrier: Alufoil has been used previously as a market ready low emissivity barrier in previous installations, but MLP has been explored intentionally to move away from Alufoil as it is an industrial produce.



Fig 35.2.2-1 : Left image: Prototype 1 with Alufoil (an Industrial Product) as Low Emissivity Barrier Right Image: Prototype 2 with MLP Sheets for the Same Function (Made Inhouse)

35.2.3. Fabrication Process Refinements

- Evolution in design of dripline: The shape of the dripline has evolved as observed. Prototype 1 has been ideated as having a larger surface area of adhesion but was failing in the basic functionality of water drainage. Hence the re-ideation of a base with a greater space for drainage.



Fig 35.2.3-1 : Left: Prototype 1 with Smaller Dripline Right: Prototype 2 with Wider Dripline

35.2.4. Installation Process Refinements

There were no refinements in the installation stage

35.2.5. Post-Installation Process Refinements

There were no refinements in the post-installation stage

35.3. Rooftop Gardening

Variant 1 - Low Soil Mass - Bamboo Mesh (Passive Irrigation)

35.3.1. Prototype Testing Refinements

There have not been any prototype testing refinements.

35.3.2. Pre-Fabrication Process Refinements

- Garden stand (Figure 3.3.1): Earlier bamboo was the main component of the stand, stretching from parapet to parapet. However, we tried an easy-to-assemble, lightweight, modular garden stand made from UPVC. This was designed after structural audit, in response to the slope of the roof and lack of space. A pair of pots can be accommodated on a stand, with each stand having a maximum load capacity of 40 kilograms. The weight of the stand is 1.5 kilograms per square foot.
- Wicking pot (Figure 3.3.2): Float valve-based wicking irrigation system was used earlier, where the supply from the overhead tank runs whenever the water level in the wicking bed reservoir reduces. The high water temperature was a common concern with this design, so we switched to a traditional wicking bed made with plastic containers, granules, and geofibre.



Fig 35.3.2-1 : Garden Stand



Fig 35.3.2-2 : Classical Wicking Pots Connected Together (the Highlighted Yellow Line Trails the Drip Pipe and Shows Levels Leading to The Lower Levels of the Pots)

- Garden pot (Fig 35.3.2-3): Previously, we used a ready-made plastic container for wicking irrigation. This time, we upcycled used plastic containers and milk crates from the scrap market.



Fig 35.3.2-3 : Upcycled Plastic Container as Garden Pot

- Submersible pump (Fig 35.3.2-4): In the informal settlements, the houses were very close together and there was no space to keep a regular water pump, additionally, there were safety issues. To address

this, we used a handy, low-power submersible pump (used in aquariums).



Fig 35.3.2-4 : Submersible Pump Connected with Hosepipe

35.3.3. Fabrication Process Refinements

- Water hydraulics (Fig 35.3.3-1): Ensuring that water was supplied pots placed at a higher level without overflowing into ones at lower level was a major challenge during installation. During the first installation, we found that the existing design was not useful for irrigating pots kept on sloped roofs, as the water flowed unevenly and most of the pots did not receive sufficient water in 30 minutes of irrigation. Then, at the Pulianthope field station, we conducted rigorous experiments and tried around 24 combinations of variables to reach the final design, which was then tested in a field trial. This hydraulic system was then adopted for installations.



Fig 35.3.3-1 : Hydraulic Experiment for Irrigation Line at Field Station

- Scaffolding structure (Fig 35.3.3-2): Keeping a scaffolding structure for shading on top of a sloped roof was a great challenge. The slope, uneven roof surface, and lack of pinning or holder space caused problems, as did the wind. With the help of seasoned bamboo workers, we developed a bamboo-based scaffolding system attached to a trellis.



Fig 35.3.3-2 : Scaffolding Structure with Shade Net

35.3.4. Installation Process Refinements

- Wicking pot reservoir material (Fig 35.3.4-1): Initially, we used 10–12 mm chips (gravel) to fill the reservoir. However, after we changed the irrigation piping system, the chips constrained the water flow, so we changed to 25 mm regular chips, which are usually used for concrete. A 2" dia PVC pipe was also added to facilitate water flow. Thereafter, the water flow was smooth and consistent.



Fig 35.3.4-1 : 25 mm Granules with PVC Pipe in Filled Wicking Pot Reservoir

- Lightweight Expanded Clay Aggregate (LECA) balls (Fig 35.3.4-2):
Initially, we used only concrete granules to fill the reservoir, which added weight to the pot. To reduce the weight of the wicking pots on the sloping roof, we switched to using 18–30 mm LECA balls. This reduced the weight of the pots by 4–5 kg each.



Fig 35.3.4-2 : 20-30 mm LECA Balls Place with Chips, Granules, and Pipe

- Wicking bed barrier: We changed the wicking bed barrier cloth from geofibre to shade net. Initially, we used geofibre as a barrier to separate the wicking bed reservoir and the potting mix. The cloth was difficult to obtain and expensive, so we used 90 percent shade net for the same purpose. This was comparatively easy to obtain and cheaper.
- Irrigation Line: For the irrigation line, we initially used a combination of 12 mm, 16 mm, and 20 mm drip line pipes, but the water flow was inadequate. Only the 20 mm pipe had a better water flow between pots. So we changed all the piping to 20 mm diameter.
- Submersible water pump connector (Fig 35.3.4-3): Since the pump is not fixed at a place, it needs to be disconnected from the overhead water line and kept inside the house. We noticed that repeatedly removing and replacing it with bare hands would be challenging for the household and could also damage the pump. To address this, we repurposed a car wash hose connector as an easily removable pipe connector.



Fig 35.3.4-3 : Easy Removable Hose Pipe Connector

Variant 2: Rooftop Garden - High Soil Mass - Grow Bag

35.3.5. Prototype Testing Refinements

No refinements have been made to this prototype.

35.3.6. Pre-Fabrication Process Refinements

- Wicking pot (Fig 35.3.6-1): We previously used a float valve-based wicking irrigation system, in which water from the overhead tank was supplied to the wicking bed reservoir as the water level decreased. The main concern with this design was the high water temperature, so we changed to a classic wicking bed made with plastic containers, granules, and geofibre.



Fig 35.3.6-1 : Wicking Pot Placed on Top Of RCC Roof

- Garden pot (Fig 35.3.6-2): Previously, we used a ready-made plastic container for wicking irrigation. This time, we upcycled used plastic containers and milk crates sourced from the scrap market.



Fig 35.3.6-2 : Upcycling Plastic Container to Garden Pot

- Garden stand (Fig 35.3.6-3): On top of Reinforced Cement Concrete (RCC) roofs, we previously used a bamboo scaffolding frame as a garden stand. Bamboo of a particular species is used for this, whose

availability is seasonal. During the installation period, it was not available locally and the bamboo suppliers were suggesting an interstate order for bamboo. Therefore, bamboo was opted out, and regular bricks and upcycled plastic materials were used to make stands instead.



Fig 35.3.6-3 : Using Brick and Upcycled Plastics as Garden Stand

35.3.7. Fabrication Process Refinements

No refinements were made in the fabrication process.

35.3.8. Installation Process Refinements

No refinements were made in the installation process.

35.3.9. Post-Installation Process Refinements

We noticed a very low survival rate for transplanted saplings after a week of installation, so we replaced transplanting with direct sowing and noticed a better survival rate.

35.4. Internal Dynamic Barrier

35.4.1. Prototype Testing Refinements

Prototype 1 of Internal Dynamic Barrier fractal measured 4ft X 3ft and was suspended on two wire ropes. A sag was observed in the fractal in the closing and opening positions.



Fig 35.4.1-1 : Prototype 1 without Supports Forming a Bowl Shape

Prototype 2, PVC pipes were introduced along the fractal at two feet intervals. This countered the sag, but increased the effective weight of the fractal.



Fig 35.4.1-2 : Prototype 2 with Intermediary Supports

To arrive at the most effective number of MLP layers used as Low Emissivity Barriers taking into consideration the factor of weight was important. The reduction in emissivity was tested where different number of MLP layers (Two, Four, and Six) were placed and compared amongst each other. With the exercise described, we were able to arrive at the conclusion of using four MLP layers.

Prototype 3, For a large span roof (example span greater than 15 feet), to reduce the weight of the fractal, the astar fabric layer was removed and only 3 layers of MLP were used. In addition, the fractals were suspended from two wires instead of 3 to reduce friction and allow them to move with less constraint. To counter the sag introduced in the width of the fractal, a UPVC pipe was used at every 2 feet of attachment for a span of 20 feet. For the handling mechanism, pulleys were introduced (2 at the rear end and 1 at the front) to allow smooth transition of vertical to horizontal pulling force of handling wire.

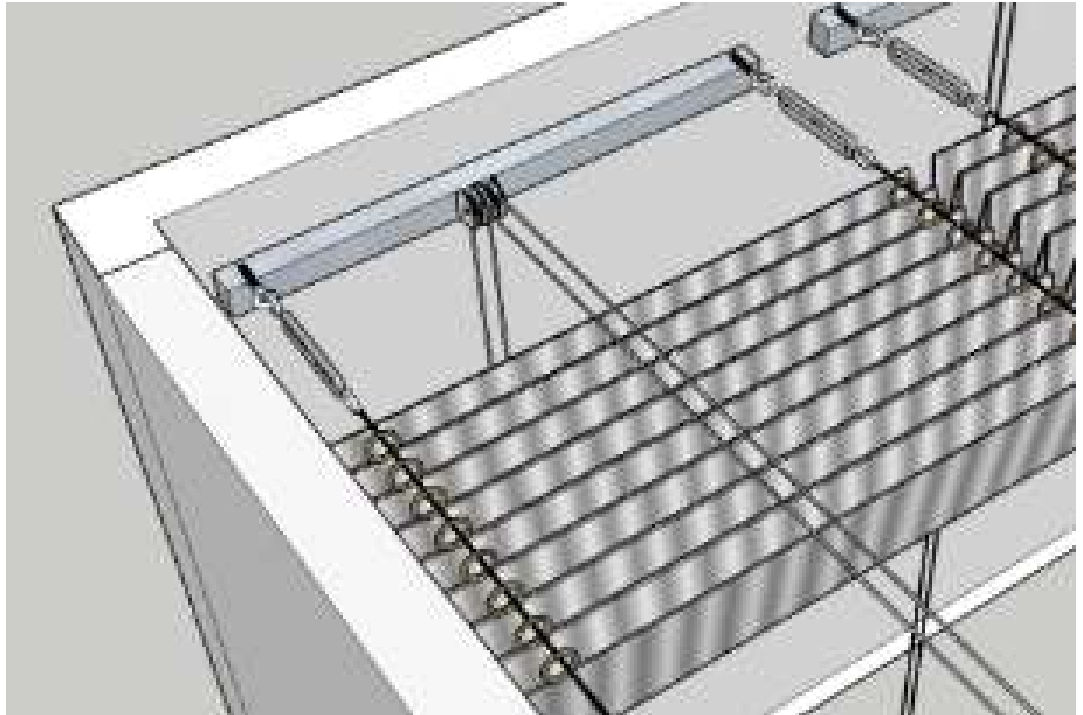


Fig 35.4.1-3 : Current Installation (Prototype 3) with two supporting wires and pulley handling mechanism.

35.4.2. Pre-Fabrication Process Refinements

All fractals and associated attachments were pre-manufactured before assembly. No fractal assembly activities, including pipe fixing or attaching curtain rings to the pipe supports, were carried out on the ground. This approach significantly reduced the overall installation time from 3 days to just 5 hours compared to previous IDB installations.

35.4.3. Fabrication Process Refinements

In houses where the roof height is low, handling mechanism can be skipped. The opening and retraction of Dynamic Barrier can be done by hand.

35.4.4. Installation Process Refinements

There were no refinements during the installation process.

35.4.5. Post-Installation Process Refinements

There were no post-installation refinements.

35.5. Vertical Cane Blind

35.5.1. Prototype Testing Refinements

An initial prototype of 4 feet in width and 10 feet in length (vertical drop) was fabricated. The size of the MLP lengthwise was kept greater by 6-8 inches than the Bamboo Blind to not hinder easy rolling and unrolling.



Fig 35.5.1-1 : Prototype 1 of Vertical Dynamic Barrier

As the MLP was adhered to the Bamboo Blind only at the top and bottom of the fractal, folds were sometimes observed on the fractal. Hence the MLP sheets were tacked to the Bamboo Blinds at a grid of 1.5 feet.

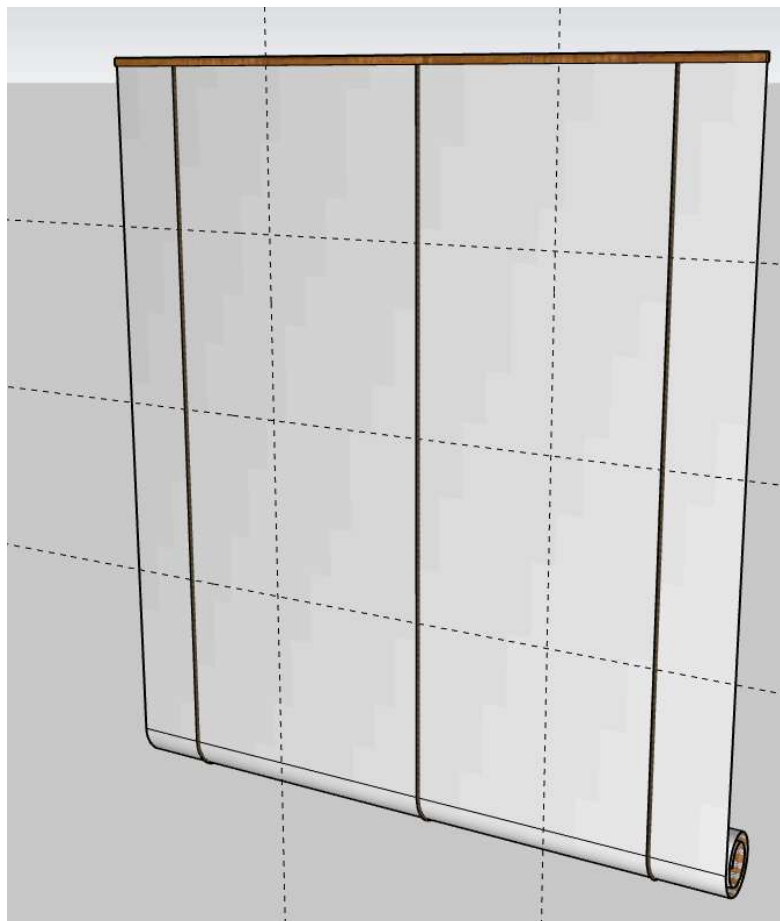


Fig 35.5.1-2 : Placement of Zip Tacks at the Intersection of Dotted Lines
Adhering the MLP to the Cane Blind

35.5.2. Pre- Fabrication Process Refinements

There were no refinements in the pre-fabrication process.

35.5.3. Fabrication Process Refinements

- The Bamboo Blinds were painted with waterproof wood paint to ensure a level of weatherproofing which was not performed in Prototype 1.
- For additional reinforcement during adhering MLP sheets to the Bamboo blind, zip ties were used at both the shorter ends.

35.5.4. Installation Process Refinements

Instead of fixing the primary bamboo member into the hook, Galvanised Iron (GI) wires were used to tie the topmost bamboo member to the supports established.

35.5.5. Post-Installation Process Refinements

There were no refinements in the post-installation process.

35.6. Biomass Panel

35.6.1. Prototype Testing Refinements

Biomass panel prototype testing was conducted using testbeds. Two testbeds, each measuring 7inch × 7inch × 7inch, were prepared for comparison. A 500 W Halogen Lamp was positioned above both testbeds to simulate Solar Radiation. Temperatures were recorded hourly between 10:00 a.m. to 6:00 p.m. The temperature differences between the testbeds were analyzed to conclude which prototype works better.

- Test bed 1: BAU, that is, without any panels (Fig 35.6.1-1).
- Test bed 2: Testbed with Biomass Panel (Fig 35.6.1-2).

Since the biomass panel is an underroof solution, these were placed inside the respective testbed, about 1.5 inches below the GI sheet (Fig 35.6.1-2).



Fig 35.6.1-1 : BAU Testbed



Fig 35.6.1-2 : Biomass Panel Testbed (Top View without GI Sheet)

Testbed with biomass panels demonstrated better cooling with a reduced temperature of 0.2 to 6.9 degree C when compared to BAU testbed.

35.6.2. Pre- Fabrication Process Refinements

There were no pre-fabrication process refinements.

35.6.3. Fabrication Process Refinements

To waterproof the biomass panels it was covered with MLP sheets. It was covered such that the shiny side of the MLP sheets were oriented outwards on both sides (Fig 35.6.3-1).



Fig 35.6.3-1 : Biomass Panel Draped with MLP

35.6.4. Installation Process Refinements

There were no refinements in the installation process of the design.

35.6.5. Post-Installation Process Refinements

Daily inspections were conducted over a 7-day period to monitor the structural response of walls to the newly introduced load. Inspections revealed that both installations were compatible with the house structures. Hence no refinements were necessary.

35.7. Wood Wool Panel

35.7.1. Prototype Testing Refinements

Wood Wool panel prototype testing was conducted using testbeds. Two testbeds, each measuring 7inch × 7inch × 7inch, were prepared for comparison. A 500 W Halogen Lamp was positioned above both test beds to simulate Solar Radiation. Temperatures were recorded hourly between 10:00 a.m. to 6:00 p.m. The temperature differences between the testbeds were analyzed to conclude which prototype works better.

- Testbed 1: BAU, that is, without any panels (Fig 35.7.1-1)
- Testbed 2: Testbed with Wood Wool panel (Fig 35.7.1-2)



Fig 35.7.1-1 : BAU Testbed



Fig 35.7.1-2 : Wood Wool Panel Testbed (Top View without GI Sheet Covering)

Since the Wood Wool panel is an underroof solution the panel was placed inside the respective testbed, about 1.5 inches below the GI sheet (Figure 3.7.2). Testbed with Wood Wool panel demonstrated a reduced temperature range of 0.1 to 6.2 degree C when compared to the BAU testbed. Consequently, it was decided to install Wood Wool panels in one of the households.

35.7.2. Pre- Fabrication Process Refinements

There were no refinements in the pre-fabrication stage

35.7.3. Fabrication Process Refinements

There were no refinements in the fabrication stage

35.7.4. Installation Process Refinements

There were no refinements in the installation process of the design

35.7.5. Post-Installation Process Refinements

There were no refinements in the post-installation of the design

35.8. Umbrella MLP

35.8.1. Prototype Testing Refinements

Prototype 1:SSwasher and cable tie method

- MLP sheets were cut into triangular panels matching the segments of the umbrella (Fig 35.8.1-1).



Fig 35.8.1-1 : Cutting of MLP Sheets into Triangular Shapes

- SS washers were placed at equal intervals along the border edges of each triangular MLP panel (Fig 35.8.1-1).

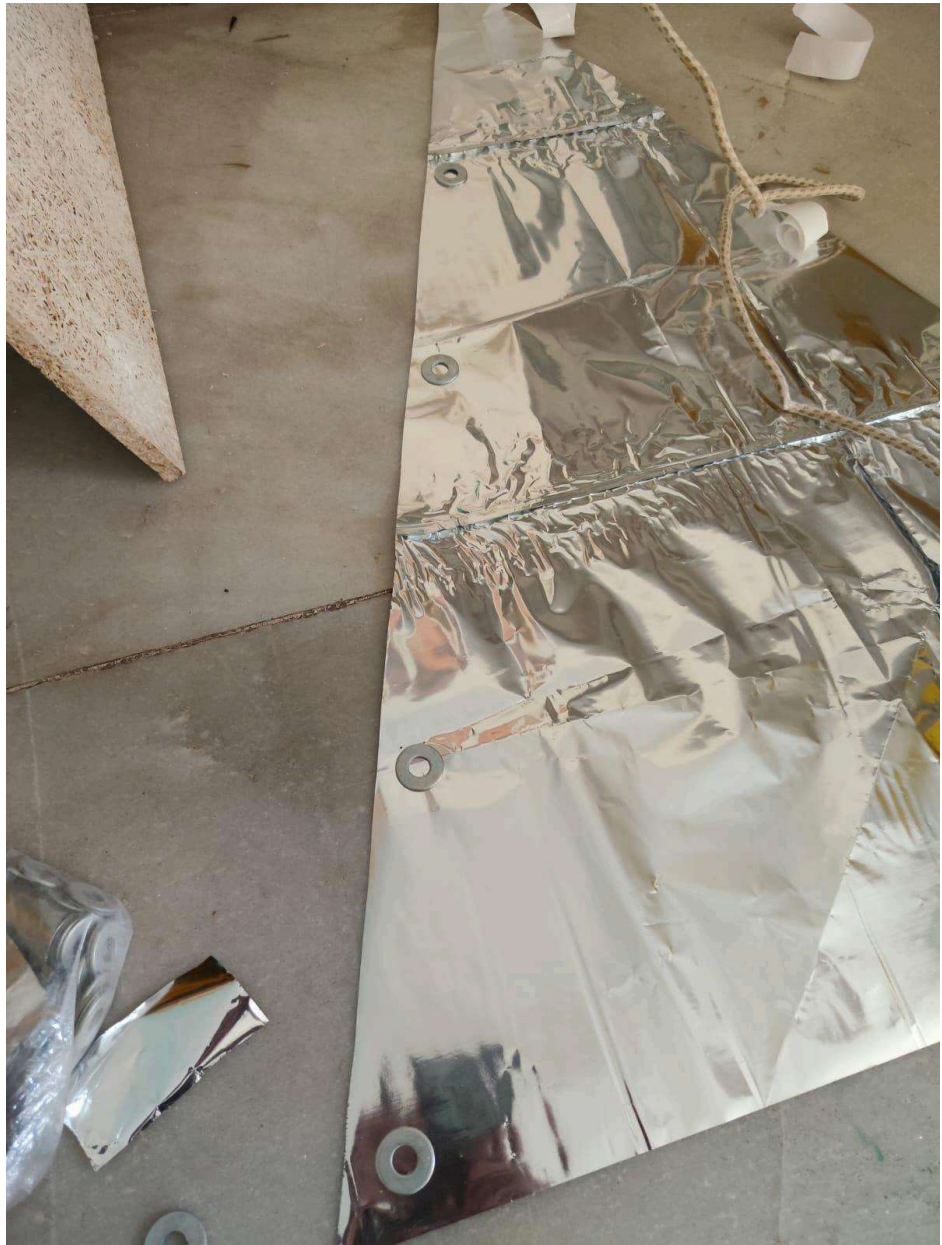


Fig 35.8.1-2 : Placing of SS washers



Fig 35.8.1-3 : Placing of Additional MLP Strips(Front side)

- A small additional strip of MLP was placed over each washer and adhered to the panel surface, sandwiching the washer between the two MLP layers with the shiny side of the covering strip facing downward, keeping the washer concealed and flush (Refer Fig 35.8.1-4)

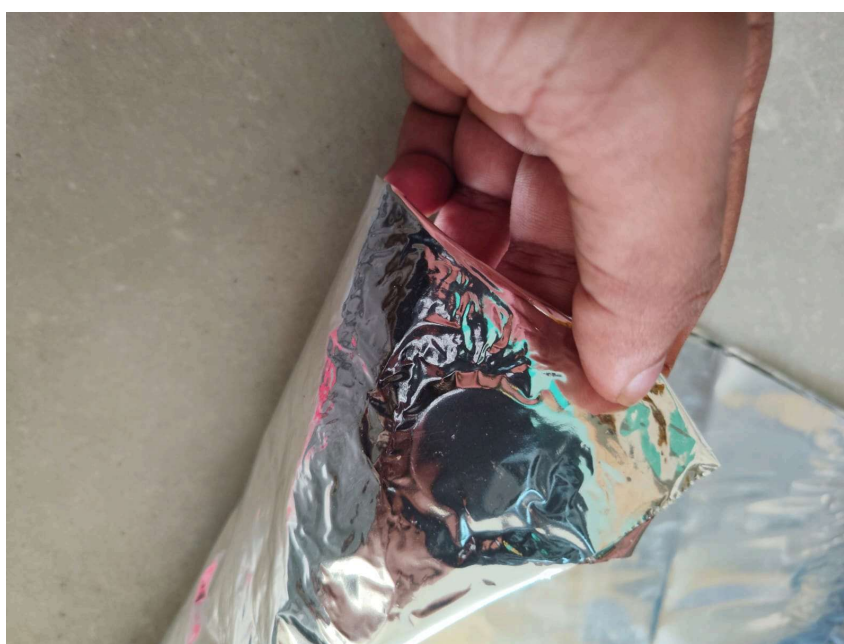


Fig 35.8.1-4 : Placing of Additional MLP Strips(back side)

- A hole was made through the MLP at each washer location, with the washer acting as a reinforcement rivet point to prevent tearing. (Fig 35.8.1-5)



Fig 35.8.1-5 : Making of Hole at each Washer Location

- Plastic cable ties were passed through each hole and tied to the corresponding spoke of the umbrella to secure each panel in place (Fig 35.8.1-6).



Fig 35.8.1-6 : Securing MLP Panels using Plastic Ties

Prototype 2 :Direct Velcro Adhesive on Umbrella Fabric:

- Velcro strips were attached directly onto the umbrella fabric surface along the spoke lines on both sides of each triangular segment. (Fig 35.8.1-7)



Fig 35.8.1-7 : Attaching of Velcro Strips

- MLP triangle panels were then pressed onto this velcro to attach them to the umbrella. (Fig 35.8.1-8)



Fig 35.8.1-8 : Triangular Panels Attached to Umbrella Underside

Prototype 3 :Velcro on Spokes (Final Refined Method)

- Hook-side velcro strips with self-adhesive backing were fixed along the length of each spoke, oriented with the hook surface facing downward and the adhesive side fixed to the spoke. (Fig 35.8.1-9)

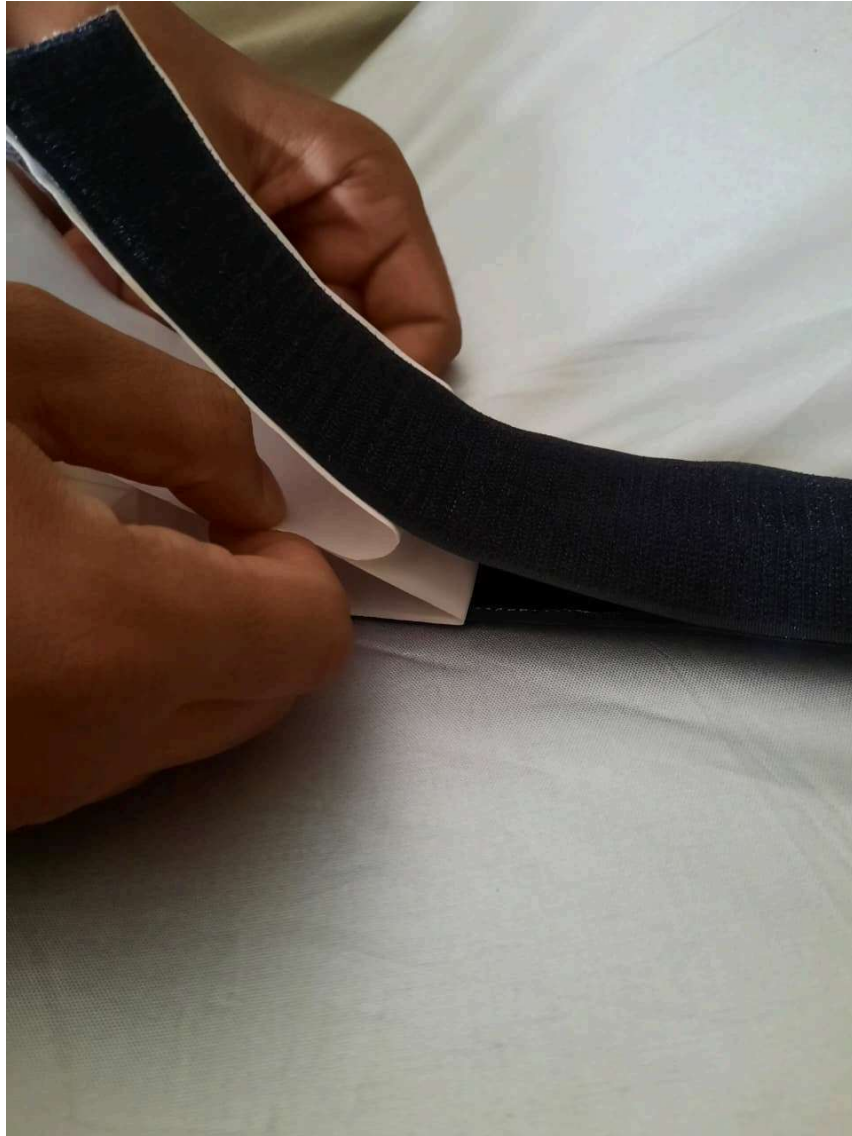


Fig 35.8.1-9 : Attaching of Hook Side Velcro Strips

- Loop-side velcro strips were layered on top of the hook strips, with the adhesive side facing upward to receive the MLP panels. (Refer Fig 35.8.1-10)



Fig 35.8.1-10 : After Attaching of Velcro Strips

- MLP triangle panels were doubled two MLP sheets bonded together per segment - so the shiny reflective surface faces outward on both faces (Fig 35.8.1-11).



Fig 35.8.1-11 : MLP sheets Bonded Together

- The MLP panels were pressed onto the upward-facing adhesive of the loop-side velcro, securing them firmly to the spokes. This method eliminated damage to the umbrella fabric, allowed easy panel

detachment and replacement, and reduced heat-related adhesive failure as the spokes are less directly exposed to prolonged heat compared to the fabric surface (Fig 35.8.1-12).



Fig 35.8.1-12 : MLP Sheets Pressed to the Umbrella

- To assess durability, the completed Umbrella MLP with the velcro spoke attachment was subjected to a stress test the umbrella was opened and closed approximately 50 times, and the MLP panels were subjected to sudden oscillations around its axis manually around 50 times to simulate wear from repeated handling and wind movement in field conditions.



Fig 35.8.1-13 : Umbrella After Stress Test

35.8.2. Pre-Fabrication Process Refinements

- Measuring the spoke length and triangular segment dimensions of the umbrella prior to cutting was established as a mandatory step to ensure MLP panels fit accurately without gaps or excess overhang.
- A standard overcut of 1 to 2 cm on all border edges of each MLP triangle was introduced to prevent panels from falling short during attachment.

35.8.3. Fabrication Process Refinements

- The attachment method was refined across three prototypes, moving from SS washer and cable tie to direct fabric velcro to spoke-mounted velcro as the final method.
- MLP panels were doubled two sheets bonded per segment to ensure the shiny reflective surface faces outward on both faces of the panel, improving thermal performance.

35.8.4. Installation Process Refinements

There were no refinements in the installation process of the design since it was not selected for installation.

35.8.5. Post-Installation Process Refinements

There were no refinements in the post-installation of the design since it was not selected for installation.

35.9. Tarpaulin MLP

35.9.1. Prototype Testing Refinements

Prototype 1: Stitch Feasibility Test on Sample Piece

- To verify that MLP can be successfully stitched onto a tarpaulin without tearing or causing damage to either material, a small sample piece of tarpaulin was taken as a test piece (Fig 35.9.1-1).



Fig 35.9.1-1 : Piece of Tarpaulin

- One layer of MLP sheet was placed on top of the sample tarpaulin piece and taken to a tailor for machine stitching (Fig 35.9.1-2).



Fig 35.9.1-2 : Tarpaulin and MLP Piece

- The MLP was stitched to the tarpaulin along all four border edges. (Fig 35.9.1-3)



Fig 35.9.1-3 : MLP and Tarpaulin Stitched Together

- Additional stitch lines were run across the body of the sheet at equal distances from one another, parallel to the shorter edge, to test the feasibility of intermediate stitching for anchoring the MLP uniformly to the tarpaulin (Refer Fig 35.9.1-4)



Fig 35.9.1-4 : After Stitching of Additional Stitch Lines

- The stitched sample was inspected for tearing at the stitch lines, puckering of the MLP surface, and integrity of the bond between the MLP and tarpaulin at both the border and intermediate stitch lines.



Fig 35.9.1-5 : Zoom In View of Additional Stitch Lines

35.9.2. Pre- Fabrication Process Refinements

There were no refinements in the pre-fabrication stage since the solution was not installed until now.

35.9.3. Fabrication Process Refinements

There were no refinements in the fabrication stage since the solution was not installed until now.

35.9.4. Installation Process Refinements

There were no refinements in the installation process of the design since it was not installed until now.

35.9.5. Post-Installation Process Refinements

There were no refinements in the post-installation of the design since it was not installed until now.

35.10. MLP Static

35.10.1. Prototype Testing Refinements

There were no prototype testing refinements.

35.10.2. Pre- Fabrication Process Refinements

There were no pre-fabrication process refinements.

35.10.3. Fabrication Process Refinements

The frame of the MLP panels were changed from bamboo to plywood to enable mounting on the false ceiling framework.





Fig 35.10.3-1 : Use of Plywood instead of Bamboo as Frame Material

35.10.4. Installation Process Refinements

There were no installation process refinements.

35.10.5. Post-Installation Process Refinements

Daily inspections were conducted over a 2-day period to monitor the structural response of walls to the newly introduced load. Inspections revealed that installation was compatible with the house structure. Hence no refinements were necessary.

36. General Technical Brief

The General Technical Brief sets out the process and quality-control checklists that govern fabrication and installation work across some of the passive cooling solutions mapped/implemented on site in Bhubaneswar during the study and also the ones that cBalance has implemented in other cities. It is organised into three parts.

The Fabrication section covers how raw materials are shaped and prepared before reaching the site: metal (cutting, bending, drilling, welding), PVC pipe (cutting, drilling,

screwing), tarpaulin (cutting, folding, stitching), and bamboo (cutting, splitting, shaping, joining, finishing).

The Installation section covers how components come together on site: plumbing work is detailed here in full, while material-specific installation steps, bamboo placing, curtain installation, pulley arrangement, and wire rope tightening are addressed in their respective solution briefs (Rooftop Garden, Space Frame and Internal Dynamic Barriers).

The post-installation checks are common to all solutions, whether they are static or dynamic.

Throughout the sections, each checklist follows the same "what to check, and what happens if you don't" format, so fabricators, installers, and QC personnel can see not just the task in front of them but the specific defect, safety risk, or rework it's meant to prevent. The goal is one consistent standard across teams and materials, from the first cut to the final commissioning check.

36.1. Fabrication

36.1.1. Metal Fabrication

36.1.1.1. Cutting

- Verify material specifications (type, size, thickness)
 - If material specification is not done properly, then incorrect material may be used, leading to defective parts or scrap.
- Check for any surface defects or damage
 - If defects are not identified, then they may affect the cutting process or final product quality.
- Confirm cutting plan and sequence
 - If cutting plan and sequencing is not followed then errors in cutting sequence or dimensions may occur.
- Ensure proper safety gear is worn
 - If proper safety gear (safety gloves, safety helmet, safety goggles etc) is not worn, then the operator may be at risk of injury from sharp edges or debris.
- Check for correct cutting tool and equipment for material type
 - If incorrect tools are used, then cuts may be of poor quality or tool/equipment may be damaged.



- Cutting Process Checks:
 - Monitor cutting process for accuracy and quality
 - If the process is not monitored, then errors or defects may go unnoticed.
 - Use templates or jigs for cutting the complex shapes for precision
 - If templates or jigs are not used, then cuts may not be accurate which leads to defective parts.
- Post-Cutting Checks:
 - Inspect cut edges for quality and accuracy
 - If thorough inspection is not done, then defects or errors may go unnoticed.
 - Deburr the cut edges
 - If cut edges are not deburred then it affects the final product quality.
 - Verify dimensions and tolerances
 - If dimensions are not verified then parts may not be fit for function correctly.
 - Adjust equipment or process if cuts are not meeting specifications
 - If adjustments are not made then continued production may result in more defective parts.

36.1.1.2. Bending

- Pre-Bending Checks:
 - Check the internal radius of the bend
 - a minimum radius (often at least 1x thickness, or R/T ratio) is needed to prevent cracking.
 - Check Bend Angle
 - Check the final desired angle of the bend to avoid defective parts, rework, assembly or functional issues.
 - Check the Bend Line
 - Check the specific line along which the bend will occur to prevent error in bending along specific lines to prevent defective parts, rework, assembly or functional issues.
 - Bend Allowance/K-factor



- Check the length of the material along the neutral axis of the bend that is required for a specific angle and bend line. Incorrect bend allowance calculation may result in insufficient or material “stretch” during bending.
 - Check bending Force
 - Check the pressure required to make the bend, which is affected by the material, thickness and the length.
 - Insufficient bending force may result in incomplete or partial bend, incomplete bend angle, increased springback(returning to its original shape)
 - Excessive bending force may result in over-bending or deformation of the material, cracking or fracture, damage to the bending tool or equipment..
 - Check bend Sequence
 - Check the order in which bends are performed, which can affect the final part.
 - Specify process Tolerances
 - Specify acceptable tolerances for dimensions and angles. Any error in acceptable tolerance will lead to dimensional inaccuracies, quality issues, rework or increased scrap, assembly or functional problems.
 - Ensure proper safety gear is worn
 - If proper safety gear (safety gloves, safety helmet, safety goggles etc) is not worn, then the operator may be at risk of injury from insufficient or excessive bending force.
- Bending Process Checks:
 - Use correct bending tools and equipment for material type
 - If incorrect tools are not set correctly, then bends may be of poor quality or material may be damaged.
 - Set correct bending parameters(angle, radius etc)
 - If incorrect bending parameters are used, then bends may not meet specifications and result in defective parts.
 - Monitor bending process for accuracy and quality

- If the bending process is not monitored, errors or defects may go unnoticed.
- Post-Bending Checks:
 - Inspect bent parts for quality and accuracy
 - If thorough inspection is not done, then defects or errors may go unnoticed.
 - Verify dimensions and angles meet specifications
 - If dimensions are not verified then parts may not be fit for function correctly.
 - Check for any sign of material stress or deformation
 - If stress or deformation is not identified, then parts may fail in service.
 - Adjust equipment or process if cuts are not meeting specifications
 - If adjustments are not made then continued production may result in more defective parts.

36.1.1.3. Drilling

- Pre-Drilling Checks:
 - Confirm drilling plan and sequence
 - If the drilling plan is not verified, then errors in hole location or size may occur.
 - Check for any surface defects or damage
 - If defects are not identified then they may affect the drilling process or hole quality.
 - Ensure proper safety gear is worn
 - If proper safety gear (safety gloves, safety helmet, safety goggles etc) is not worn, then the operator may be at risk of injury from sharp edges or debris.
- Drilling Process Checks:
 - Use correct drill bits and equipment for material type
 - If incorrect drill bits are used, then holes may be of poor quality or drill bits may be damaged.
 - Set correct drilling parameters(speed, feed rate etc)
 - If incorrect drill bits are used, then holes may be of poor quality or drill bits may be damaged.
 - Monitor drilling process for accuracy and quality
 - If drilling process is not monitored, errors or defects may go unnoticed



- Use lubricant as necessary
 - If lubricant is not used, then drill bits may overheat or wear excessively.
- Post Drilling Checks:
 - Verify hole size and location with specifications
 - If holes do not meet specification, then parts may not fit or function correctly.
 - Deburr the holes
 - If holes are not deburred then it affects the final product quality.
 - Adjust equipment or process if holes are not meeting specifications
 - If adjustments are not made then continued production may result in more defective parts.

36.1.1.4. Welding

- Pre-Welding Checks:
 - Verify material specifications (type, size, thickness)
 - If material specification is not done properly, then incorrect welding parameters may be used, leading to defective parts or scrap.
 - Confirm welding plan and sequence
 - If the welding plan is not verified, then errors in weld location or quality may occur.
 - Ensure proper fit-up and alignment of the parts
 - If parts are not properly aligned, then weld may be uneven or defective.
 - Clean and prepare the surface to be welded
 - If surfaces are not clean, then weld quality may be compromised, leading to defects.
 - Ensure proper safety gear is worn
 - If proper safety gear (safety gloves, safety helmet, safety goggles etc) is not worn, then the operator may be at risk of injury from sharp edges or debris.
- Welding Process Checks:
 - Use correct welding process and equipment for material type
 - If an incorrect welding process is used, then weld may be of poor quality or material may be damaged.



- Set correct welding parameters(voltage, current, speed etc)
 - If incorrect parameters are set, then welds may not meet the specifications or material may be damaged.
- Monitor welding process for accuracy and quality
 - If the welding process is not monitored, errors or defects may go unnoticed.
- Use proper shielding gas and consumables
 - If the proper shielding gas or consumables are not used correctly, then weld quality may be compromised.
- Post Welding Checks:
 - Inspect weld for quality and accuracy
 - If inspection is done thoroughly, then defects or errors may go unnoticed.
 - Verify weld strength and integrity meet the specification
 - If welds do not meet specification, then parts may not be structurally sound.
 - Check for distortion or warping
 - If distortion or warping is not identified, then parts may not fit or function properly.
 - Adjust equipment or process if holes are not meeting specifications
 - If adjustments are not made then continued production may result in more defective parts.

36.1.2. PVC Pipe Fabrication

36.1.2.1. Cutting

- If the diameter is less than 2 inches
 - Use a ratcheting PVC cutter for clean, burr-free cuts.
- If the diameter is more than 2 inches
 - Then opt for a fine toothed hacksaw or miter saw to minimize splintering.
- If using a power saw
 - Then ensure the blade speed is low (under 3000 RPM) to prevent melting the PVC material.
- If cut edge shows burr or roughness



- Then deburr with a utility knife or sandpaper to ensure smooth fitting assembly.
- If cutting multiple pipes to the same length
 - Then use a measuring tape and stop block for consistency.
- If precision is critical
 - Then employ a digital caliper for verification.

36.1.2.2. Drilling

- If drilling holes smaller than ½ inch
 - Then use a standard twist drill bit.
- If drilling holes larger than ½ inch
 - Then use a spade or hole saw bit designed for plastics to avoid cracking.
- If the PVC is thin-walled (Schedule 40 or less)
 - Then drill at low speed (500-1000RPM) with light pressure to prevent melting or fracture
- If the PVC is thicker (Schedule 80)
 - Then moderate speed is acceptable.
- If the hole need to be precise in location
 - Then mark with a centre punch and use a drill guide.
- If multiple holes are required
 - Then create a template for alignment.
- If debris accumulates during drilling
 - Then pause to clear chips to avoid overheating.
- If the material softens
 - Then apply a coolant like water or stop to let it cool.
- If drilling near the pipe end
 - Then support the interior with a wooden dowel to prevent collapse
- If the pipe is curved
 - Then use a flexible drill extension for access.

36.1.2.3. Screwing

- If using threaded fittings
 - Then apply PVC primer and cement first for non-threaded joints.
- If threads are involved



- Then use a PTFE tape on male threads to ensure a leak-proof seal.
- If screwing with self-tapping screws
 - Then pre-drill pilot holes 80% of the screw diameter to avoid splitting
- If the PVC is brittle
 - Then use screws with coarse threads for better grip.
- If torque is applied manually
 - Then hand-tighten plus ¼ turn.
- If using a power driver
 - Then set to low torque (under 20 in-lbs) to prevent stripping or cracking.
- If assembling in wet conditions
 - Then use waterproof thread sealant
- If assembling in high pressure applications
 - Then verify fittings are rated for the PSI to avoid failure.
- If disassembling is anticipated
 - Then prefer mechanical screws over glued joints
- If permanent assembly is required
 - Then combine screwing with adhesive for reinforced strength.

36.1.3. Tarpaulin Fabrication

36.1.3.1. Cutting

- If tarpaulin roll is large or requires consistent dimensions across multiple pieces
 - Then use an automated or computer controlled cutting machine on a flat table
- If cutting smaller custom pieces manually
 - Then mark the measurements with chalk and use sharp-heavy scissors to prevent fraying or uneven edges
- If material has a coated side (PVC or polyethylene)
 - Then cut with the coated side facing up to minimize scratches or damage during handling.

36.1.3.2. Folding

36.1.3.2.1. If preparing hems for reinforcement



- Then fold the edges inward by 1-2 inches (single or double fold based on thickness), use weights to hold folds in place for accuracy.
- 36.1.3.2.2. If folding for multi-panel assembly
 - Then align edges precisely and fold along marked lines
- 36.1.3.2.3. If misalignment occurs
 - Then unfold and reposition to prevent wrinkles
- 36.1.3.2.4. If incorporating eyelets later
 - Then ensure folds are wide enough (at least 2 inches) to accommodate reinforcement
- 36.1.3.2.5. If folding in a high-volume production
 - Then use folding jigs or template for consistency
- 36.1.3.2.6. If folding manually
 - Then measure each fold with a ruler to maintain uniformity.

36.1.3.3. Stitching

- 36.1.3.3.1. If using sewing machines for hems
 - Then select heavy-duty needles(e.g., size 16-18)
- 36.1.3.3.2. If joining multiple panels
 - Then use a flat-felled or overlap seam with double stitching for waterproofing
- 36.1.3.3.3. If seams leak during testing
 - Then apply seam sealant post-stitching.
- 36.1.3.3.4. If quality control detects uneven stitching
 - Then inspect and restitch affected areas, always backstitch at ends to secure threads against unraveling.

36.1.4. Bamboo Fabrication

36.1.4.1. Cutting

- Pre-Cutting Checks:
 - 36.1.4.1.1. If the bamboo is freshly harvested and shows signs of high moisture (e.g., green color or flexibility)
 - Then allow it to dry naturally in a shaded, ventilated area for 4-6 weeks to prevent cracking during processing.
 - 36.1.4.1.2. If the intended use is for load-bearing structure



- Then select mature bamboo poles(3-5 years old) with uniform diameter and straight growth
- 36.1.4.1.3. If the intended use is for light weight application
 - Then select younger poles
- 36.1.4.1.4. If pests or fungi are visible on the surface
 - Then treat with natural preservatives like borax solution before proceeding to cutting.
- Cutting Process:
- 36.1.4.1.5. If the bamboo pole length exceeds the required size by more than 20%
 - Then mark cutting points at nodes to maintain strength and avoid splitting, cut using a sharp saw or machete perpendicular to the grain.
- 36.1.4.1.6. If cutting tools are dull
 - Then sharpen them first to ensure clean cuts, otherwise ragged edges may lead to uneven splitting later.
- 36.1.4.1.7. If cut sections are intended for immediate use
 - Then remove any branches or leaves at the nodes.
- 36.1.4.1.8. If cut sections are intended for later use and storing
 - Then bundle and store vertically to prevent warping.

36.1.4.2. Splitting Process

- 36.1.4.2.1. If the bamboo diameter is greater than 10cm
 - Then use a splitting knife or wedge starting from the thinner end to create even strips
- 36.1.4.2.2. If the bamboo diameter is less than 10cm
 - Then split manually with a mallet for finer control.
- 36.1.4.2.3. If splits show irregular tearing or fiber damage
 - Then apply light oil to the tool blade for smoother penetration, otherwise proceed directly if bamboo is well-dried.
- 36.1.4.2.4. If the desired strip width is less than 2cm for weaving
 - Then splits into quarters first and refine further
- 36.1.4.2.5. If desired strip is for construction purpose



- Then aim for wider halves or thirds to retain structural integrity.

36.1.4.3. Shaping

- 36.1.4.3.1. If shaping requires bending (e.g., for curves)
 - Then heat the strip over a flame or steam them for 10-15 minutes until pliable.
- 36.1.4.3.2. If shaping does not require bending
 - Then proceed to planning or sanding for flat surfaces.
- 36.1.4.3.3. If the surface is rough or uneven after splitting
 - Then use a plane or scraper to smooth.
- 36.1.4.3.4. If knots are present
 - Then sand them down carefully to avoid weakening the material.

36.1.4.4. Joining

- 36.1.4.4.1. If joining for permanent structures
 - Then use natural bindings like rattan or screws with pilot holes to avoid cracking.
- 36.1.4.4.2. If joining for temporary structures
 - Then opt for lashing with ropes or wires.
- 36.1.4.4.3. If joints involve end-to-end connections
 - Then use fish-mouth cuts or dowels for alignment.
- 36.1.4.4.4. If joints involve side-to-side connections
 - Then apply adhesive like epoxy after sanding contact surfaces for better adhesion.
- 36.1.4.4.5. If the assembly shows gaps or instability after initial
 - Then reinforce additional braces or glue, otherwise test load-bearing capacity before final use.

36.1.4.5. Finishing

- 36.1.4.5.1. If final product will be exposed to the weather
 - Then apply a protective coating like varnish or oil.
- 36.1.4.5.2. If final product will be used indoors
 - Then apply polish for aesthetics.
- 36.1.4.5.3. If any cracks appear during or after processing
 - Then discard affected pieces and restart with new material.



36.2. Installation

36.2.1. Plumbing Work

36.2.1.1. Site Preparation

- 36.2.1.1.1. Verify material specifications (type, size, thickness)
 - If material specification is not done properly, then incorrect material may be used, leading to defective parts or scrap.
- 36.2.1.1.2. Check for any defects or damage pieces
 - If defects are identified, then they may affect the cutting process or final product quality.
- 36.2.1.1.3. Check for correct cutting tool and equipment for material type
 - If incorrect tools are used, then cuts may be of poor quality or tool/equipment may be damaged.
- 36.2.1.1.4. Confirm plumbing plan and sequence
 - If cutting plan and sequencing is not followed then errors in cutting sequence or dimensions may occur.

36.2.1.2. Piping and Alignment

- Install supports at 1m intervals for exposed pipes. If supports are plumb and gaps comply
 - Then connect to fixtures, else realign and reinforce supports.

36.2.1.3. Valve and Fixture Installation

- Install valves (e.g., stop cocks, gate valves etc) at inlets and tees. Ensure flow direction and accessibility.
 - If valves are operable and oriented correctly, then proceed to testing; else replace or reorient and verify.

36.2.1.4. Insulation and Protection

- Insulate hot water pipes. Wrap underground copper pipes with protective tape.
 - If insulation is intact and if there are no corrosion risks, then integrate with the



system; else apply additional protection and reinspect.

36.2.1.5. System Testing and Commissioning

- Conduct water/air tests on the full system. Install backwater valves where required and label cleanouts.
 - If tests hold pressure and no leaks are detected, then approve for use and clean site; else locate issues, repair and retest.

36.2.2. Bamboo Placing

This section is covered under the Roof Top Garden solution subhead.

36.2.3. Curtain Installation

This section is covered under the Space Frame and Internal Dynamic Barriers solutions subhead.

36.2.4. Pulley Arrangement

This section is covered under the Space Frame and Internal Dynamic Barriers solutions subhead.

36.2.5. Wire Rope Tightening

This section is covered under the Space Frame and Internal Dynamic Barriers solutions subhead.

36.2.6. Placing The Pots

This section is covered under the Roof Top Garden solution subhead.

36.3. Post-Installation Check

- 36.3.1. Ensure that the fabricator has completed the work as per design specifications.
- 36.3.2. For static solutions, conduct a knock test for panels by knocking 5 times each at all the corners, 3 random places along the edges, and 5 random places in between.
- 36.3.3. For dynamic solutions, open and close the solution fifty times.
- 36.3.4. Look closely for any cracks, gaps, alignment issues and damages to the structure and rectify them if found.



37. Cooling Solution-Specific Technical Brief

37.1. Internal Dynamic Barrier

37.1.1. Pre-Installation Staging

A. Supports:

- Determine the orientation of the fractal, i.e. the direction of movement for the fractal.
- Identify a location that the steel wires can be supported from, either by anchoring to the wall or welding to metal purlins on the roof or placing a square MS pipe on the wall

B. Placement and Design Decisions :

- Implement a static barrier, for roof regions around the fan (in case it is coming in the fractal movement).
- Implement a dynamic barrier, for the rest of the roof.

C. Removal and Rerouting of Barriers to Dynamic Movement :

- Rewire and reposition lights and other electrical fixtures that might hinder the movement of the dynamic barrier.

37.1.2. Fabrication

A. Establish Supports:

- If support can be taken from the wall i.e. if the wall is plastered, drill anchor bolts to the wall.
- In case of unplastered walls, undertake bracing on either side of the wall (see Fig 37.1.2-1 and Fig 37.1.2-2).
- If support cannot be taken from the wall, weld the anchor bolts to the purlins (See *white arrow* in Fig 37.1.2-1)



Fig 37.1.2-1 : Support taken from a metal section

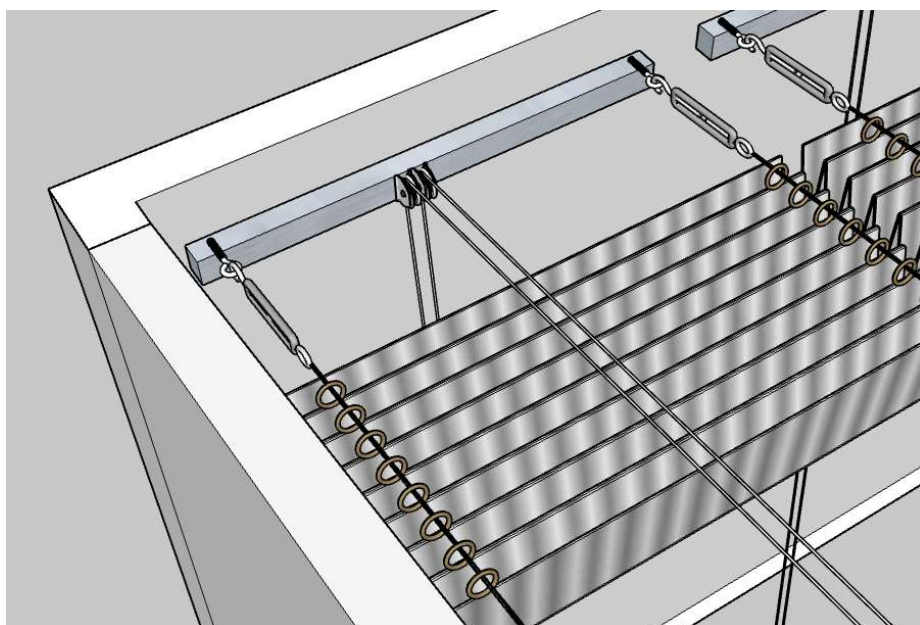


Fig 37.1.2-2 : Rear end part of the IDB fractal

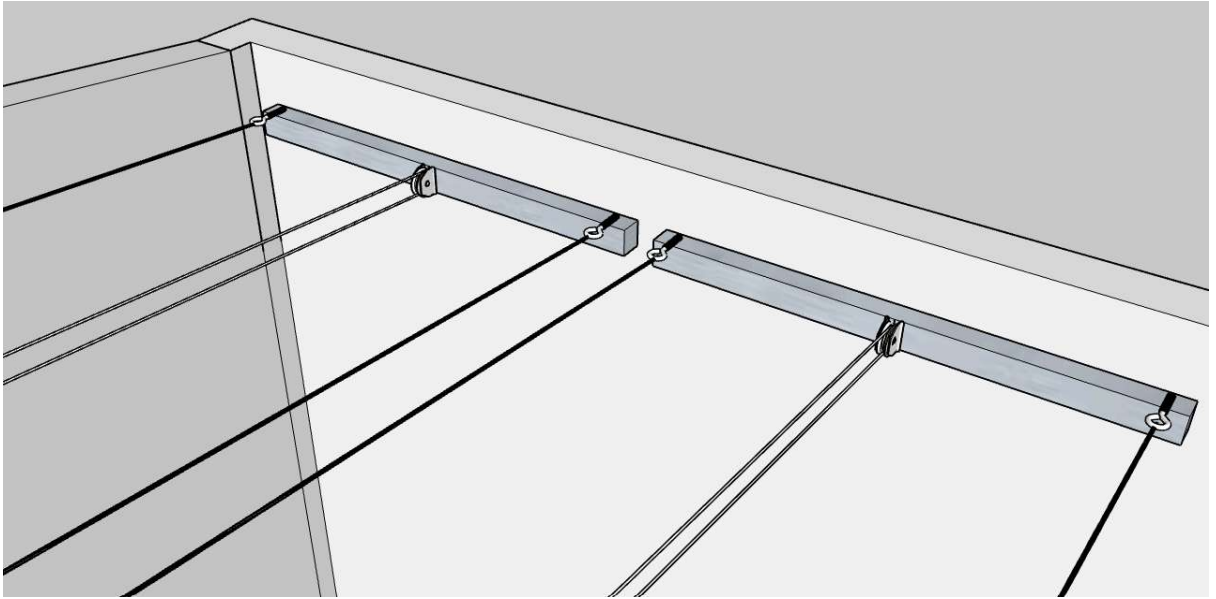


Fig 37.1.2-3 : Front end part of the IDB fractal

B. Establish Wire Rope:

- Decide on the thickness of the wire depending on the span of room. A 4-5mm core is ideal for spans up to 10ft.
- Loop the PVC coated steel wire to the hook of the anchor bolt and secure it with the help of U-clamps (Fig 37.1.2-4)
- Place the desired number of curtain rings (depending on the measure of the folds 4" or 6") through each wire in orientation facing away from the fractal (Fig 37.1.2-5)
- Loop the other free end of the PVC coated steel wire to a tension fastener and tighten the wire using a U-clamp (Fig 37.1.2-6)



Fig 37.1.2-4 : Establishing wire rope to wall using U-clamps

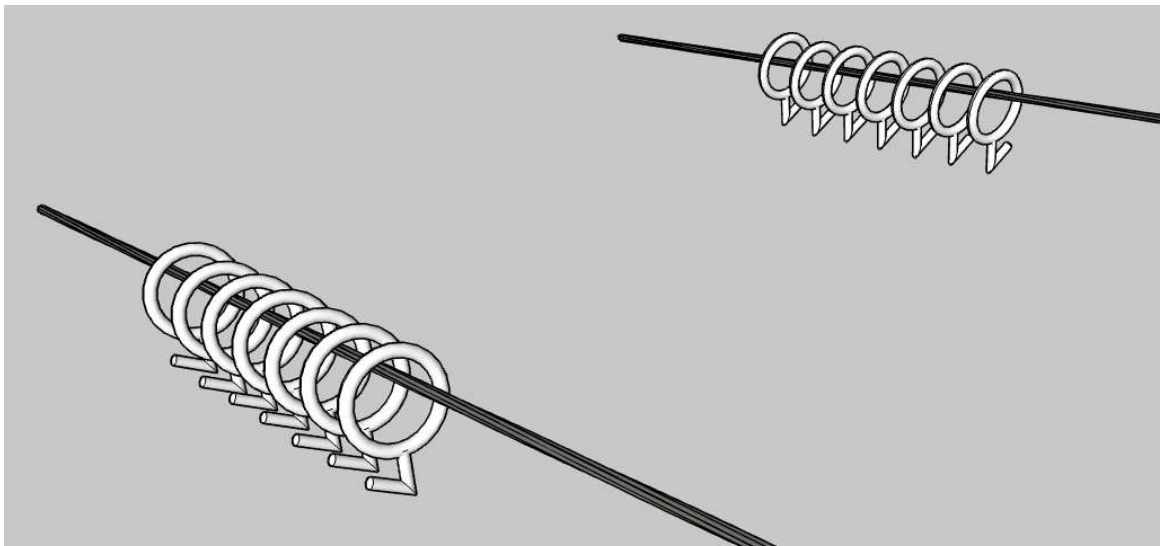


Fig 37.1.2-5 : Orientation of curtain rings



Fig 37.1.2-6 : Establishing wire rope tensioning system on the rear side (using turn buckle as shown in the image above). Use a U clamp to attach wire on the eye side of the turn buckle. The hook end of turn buckle is inserted into the eye of the anchor bolt attached to the wall/purlin.

C. Fabricate Dynamic Barrier Panels

- Take the MLP Roll sheet of required length (as an example, 23 feet in length for a 20-foot room length to accommodate a 3-inch loop every 2 feet for supporting UPVC/PVC pipe of 0.75 inch diameter)



Fig 37.1.2-7 : MLP Roll Strips (1 feet each) placed adjacent to each other to make a 5 feet width panel

- Adjust the width of the Panel by increasing or decreasing the number of MLP Strips as shown in Figure 1.7. (Note: To ensure fast and smooth open and close movement of fractals, avoid making the panel width of more than 5 feet.)
- Make a thin crease (1inch) of MLP such that the shiny side of the adjacent and the creased MLP is touching each other and Iron the crease. (Refer Fig 37.1.2-8 and Fig 37.1.2-9)



Fig 37.1.2-8 : Making 1 inch crease (shiny side touching each other) before ironing.



Fig 37.1.2-9 : MLP Sticking using Iron

- After ironing all the strips, reverse the 20 feet x 5 feet MLP sheet and mark sections of 2 feet with 3 inch gap after every 2 feet as shown in Figure 1.10 and 1.11.



Fig 37.1.2-10: Marking sections at a distance of 2 feet along the length

- Along the outer edges of the 3 inch gap stick a marking paper tape (this is to ensure when the loop is made by folding the 3 inch gap, the paper tape ensures the folding is perpendicular to the length of the sheet) see Fig 37.1.2-11.



Fig 37.1.2-11 : Placing paper tape for marking 3 inch loop

- Fold along the paper tape such that the inner edges of the paper tape are in line and touching each other and a 3 inch gap forms a loop underneath. Put a duct tape from above to close the loop. Repeat the

same process for all the 11 gaps (11 loops will form in a 20 feet length with 2 feet gap between each loop) (see Figure 1.12 and 1.13)



Fig 37.1.2-12 : Placing paper tape for marking 3 inch loop

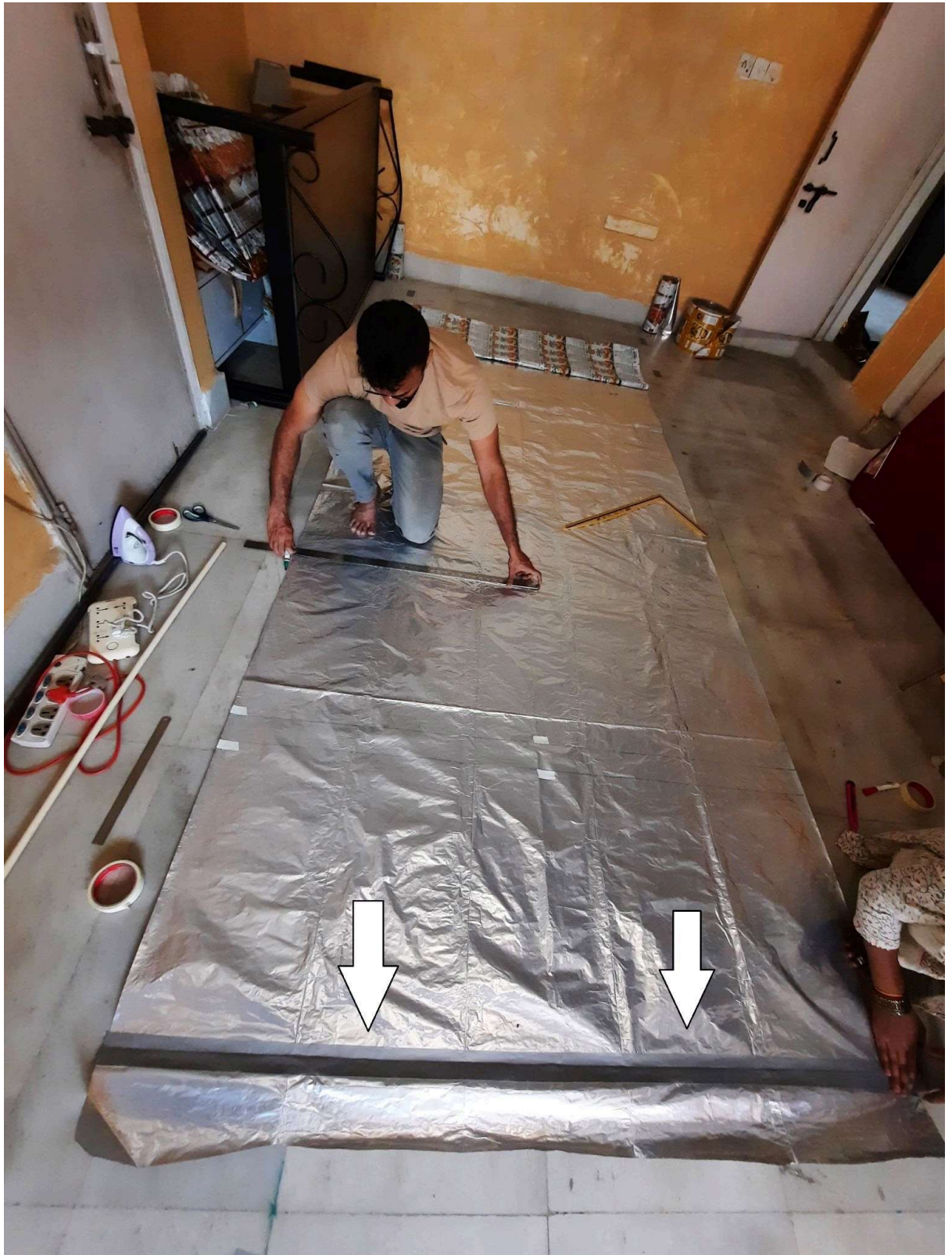


Fig 37.1.2-13 : Placing paper tape for marking 3 inch loop

- Make 2 new sheets (20 feet by 5 feet width without loops) so as to form a 3 layer MLP fractal. Position the 2 new sheets underneath the MLP sheet with the loops (see Fig 37.1.2-14)

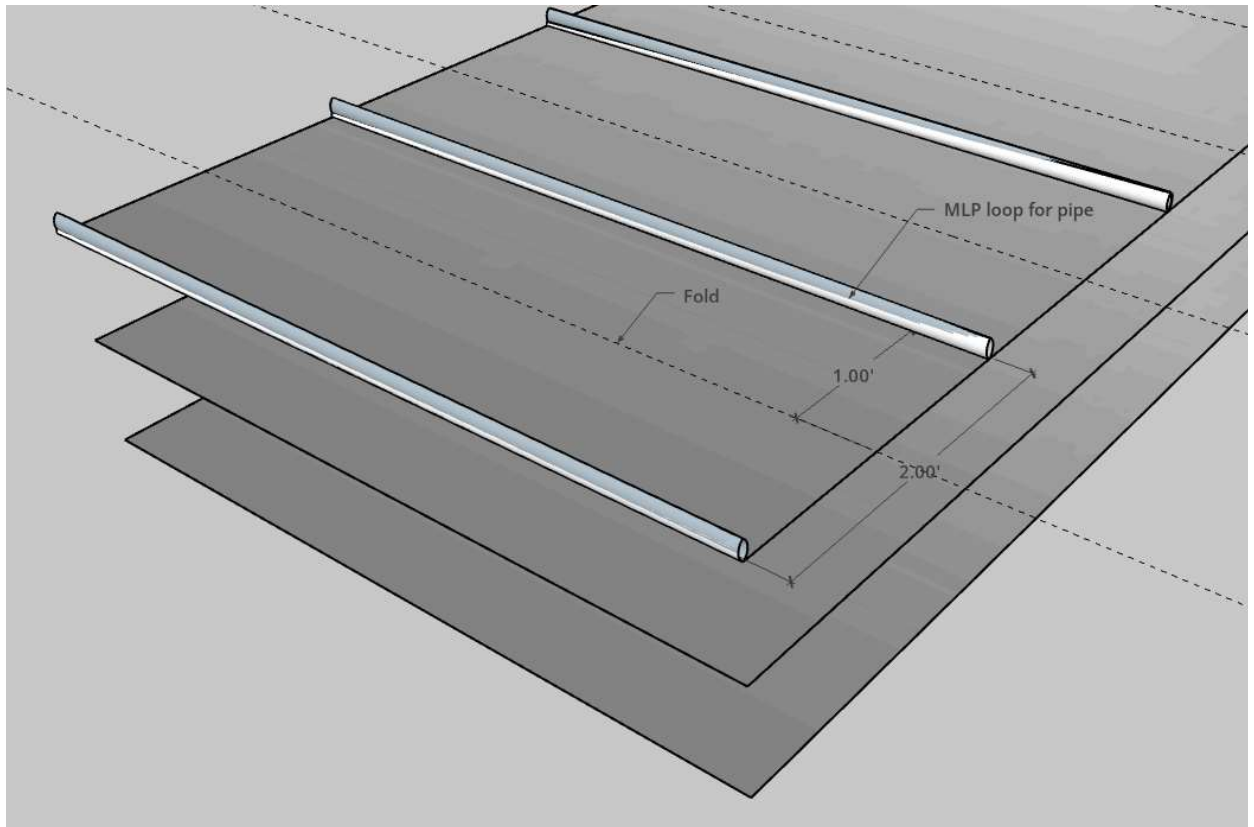


Fig 37.1.2-14 : Arrangement of three layers of MLP sheets

- On one of these new sheets (without the loop), place double side sticky tape on the non shiny side along the entire length with 1 feet gap along the length.



Fig 37.1.2-15 : Placing high strength double side sticky tape for sticking 3 MLP layers

- Remove the cover of the double side sticky tape and place the second MLP Sheet of 20 feet by 5 feet length (without loops) on top of this one facing the shiny side towards the non shiny side such that it firmly sticks to the surface.
- Repeat the same process and place double side sticky tape on the non shiny side of the second MLP.

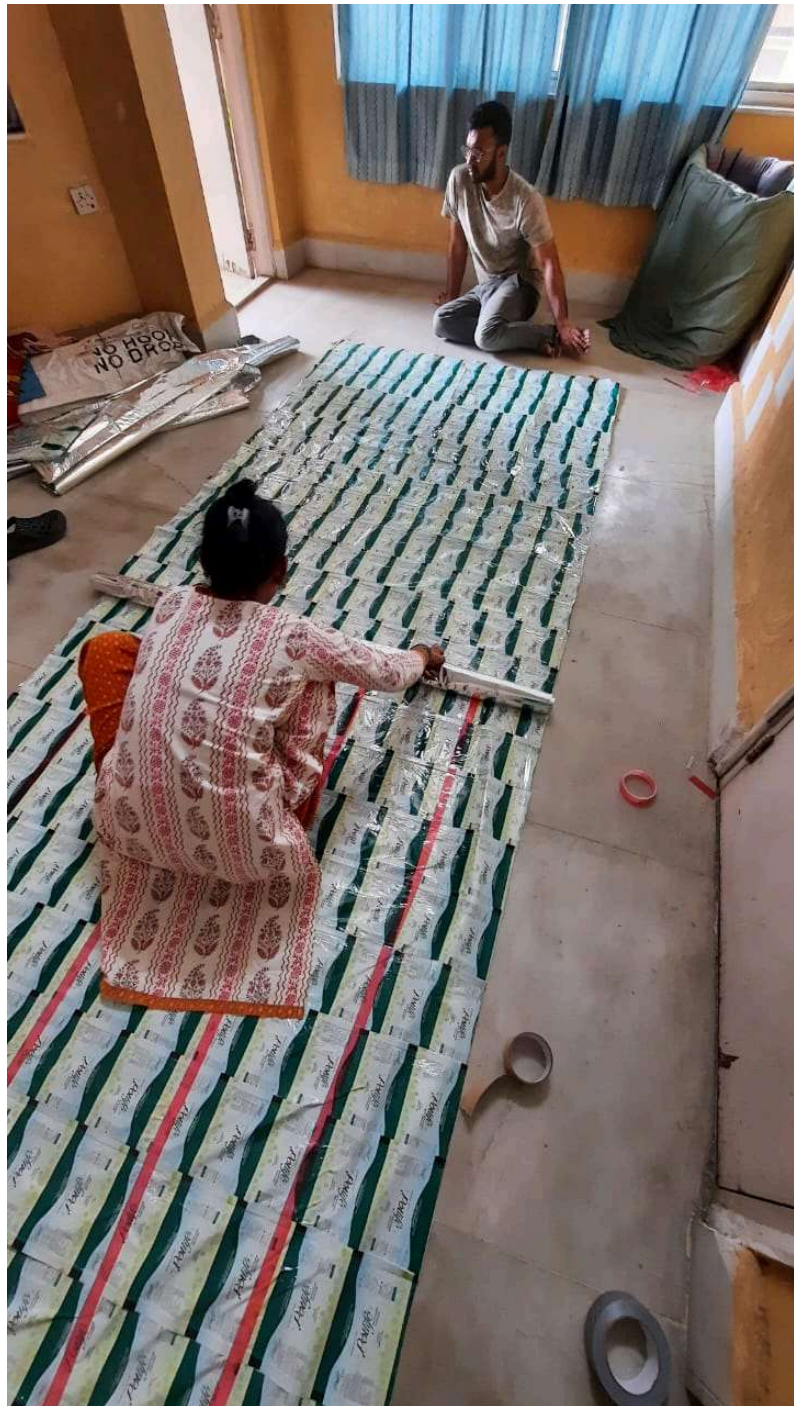


Fig 37.1.2-16 : Removing the sticky tape cover while unrolling the MLP layer so that it sticks in alignment.

- Remove the tape cover and place the MLP sheet (the one with loops) on the top such that the 3 inch loops are visible on top and fold the sheet such that an overhang of 1 foot height forms after folding the 2 feet gap between the two loops.
- Fold and staple (see Fig 37.1.2-17) along the edges and put a duct tape sealing all the edges except the loop openings (Loop openings need to be sealed post UPVC pipe is placed)



Fig 37.1.2-17 : Stapling the edge along the length.

- Make slits of 1 inch at the midpoint of each half of the loop (i.e. at a distance of 1.25 feet from both ends for a 5 feet width of fractal) for placing curtain hooks.(Fig 37.1.2-18)



Fig 37.1.2-18 : Make a 2 inch deep and 0.5 inch width slit along the loops. Ensure to make slits at the mid point of two halves of the loop for inserting the two curtain hooks.

- Place the curtain hooks in the two slits and insert 3/4th inch UPVC pipe of 5 feet length. (see Fig 37.1.2-19)



Fig 37.1.2-19 : Placing curtain hooks into the slit, inserting the UPVC pipe through the MLP loop, and passing it through the curtain hook to lock it in place.

- Repeat the entire process for all the 11 loops and place duct tape on the openings of the loop so that the UPVC pipe does not move.(see Fig 37.1.2-20)



Fig 37.1.2-20 : Image showing completed

37.1.3. Installation

- Hook the inverted curtain eyelets placed onto the pipe to the eyelets placed on the steel wire by lifting the pipe starting from the front end and then moving towards the rear end hooks. (Refer Fig 37.1.3-1 and Fig 37.1.3-2)



Fig 37.1.3-1 : Hooking of inverted curtain eyelets to the eyelets placed on steel wire.

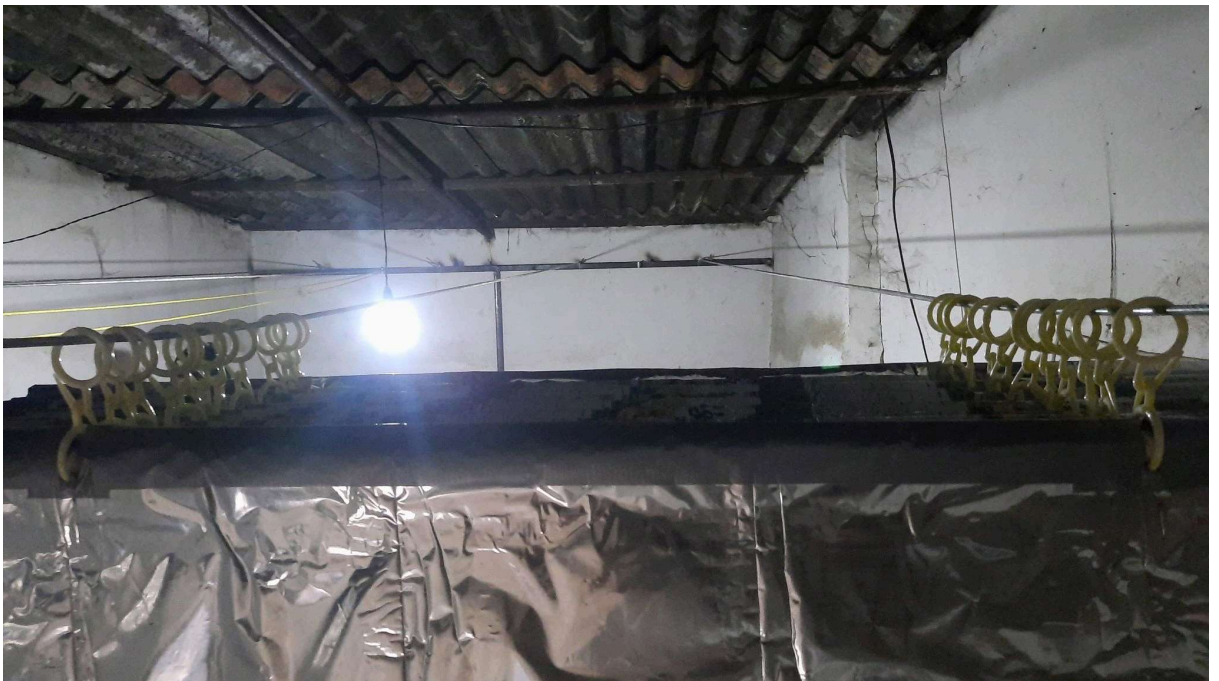


Fig 37.1.3-2 : Top View post hooking the IDB fractal on the steel wire.

- Using zip tags, tie the two rear curtain rings of the fractal to the anchor bolt (Refer Fig 37.1.3-3).



Fig 37.1.3-3 : Arresting the movement of rear end of fractal using zip tags

- Tie a nylon wire for handling at the middle of the front end of the pipe (Refer Fig 37.1.3-4 and Fig 37.1.3-5)



Fig 37.1.3-4 : Attaching nylon rope to the front end pipe of the fractal



Fig 37.1.3-5: Attaching nylon rope to the front end pipe of the fractal

- Take the other free end through the pulley in the front, then down one of the two pulleys at the rear. Leaving enough loop for accessible handling, through the next pulley, take the nylon wire and tie it exactly at the place where the first knot was placed on the front pipe. (Refer Fig 37.1.3-6 , Fig 37.1.3-7)

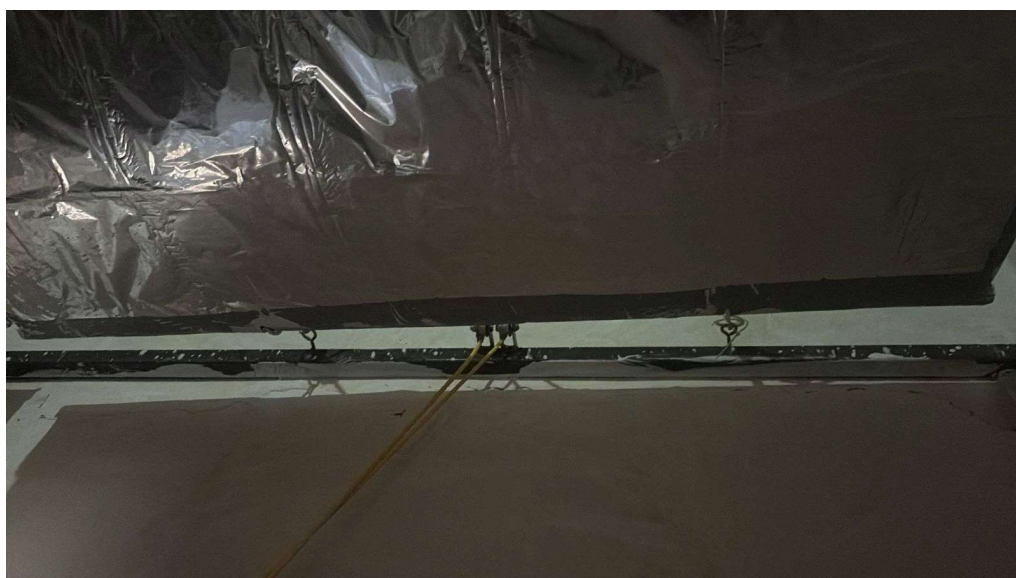


Fig 37.1.3-6 : Handling mechanism at rear end - nylon wire loop going through two individual pulleys.

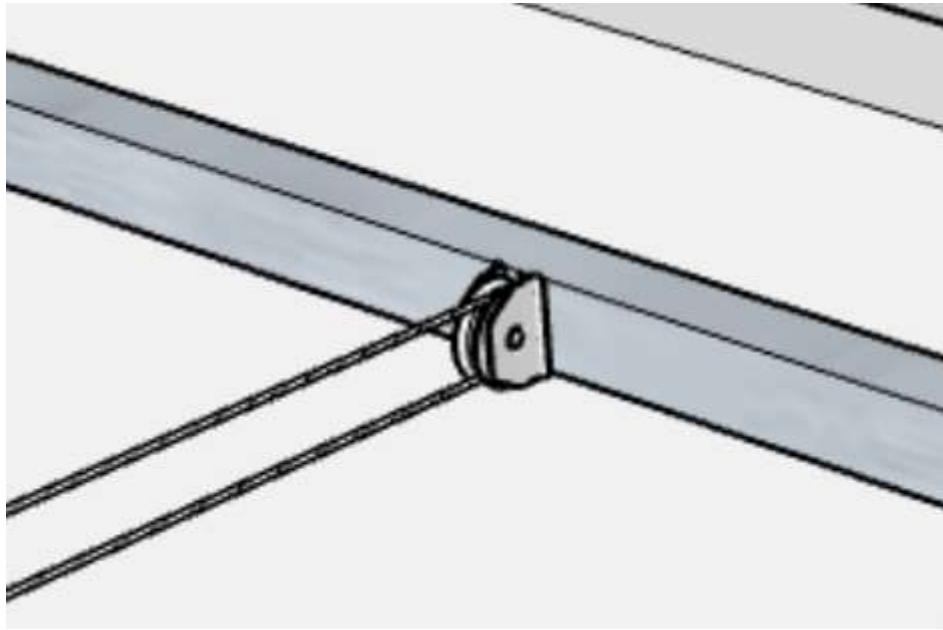


Fig 37.1.3-7 : Handling mechanism at front end - nylon wire loop going through front pulley.



Fig 37.1.3-8 : Fractals (in open position) covering the underside of the Roof.

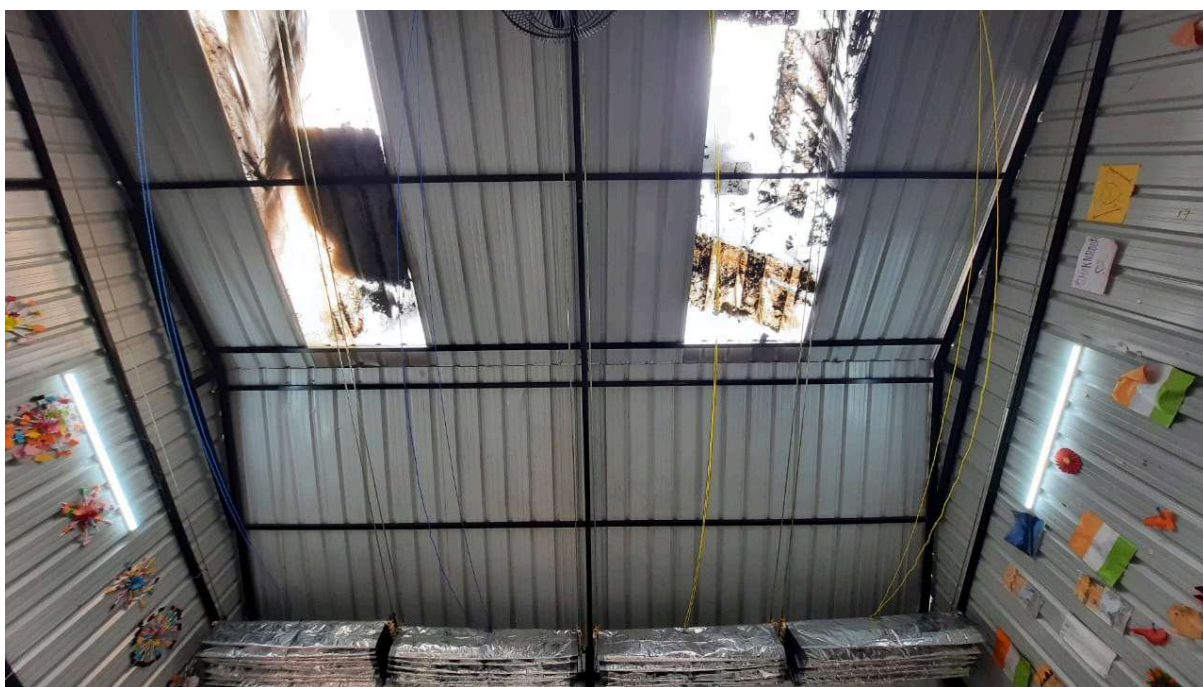


Fig 37.1.3-9 : Fractals (in closed position) exposing the underside of the Roof.

37.1.4. Operation

- Pulling one side of the nylon wire loop down would unfurl the fractal and the other end would retract it back (Refer Figure 1.28 and Figure 1.29).
- Tug at the nylon wire with uniform gentle force and not spurts of violent force.
- In case any resistance is observed, kindly pull back in the opposite direction and retry.

37.1.5. Maintenance

37.1.5.1. Monthly Maintenance Checklist

- 37.1.5.1.1.1. Use a dry and soft cloth to clean the shiny surface of the installation.

37.1.5.2. Quarterly Maintenance Checklist

- 37.1.5.2.1.1. Grease the PVC coated steel wires, over which the Dynamic Barrier slides, every quarter.

- 37.1.5.2.1.2. Introduce tension into the system by tweaking at the tension fastener, as and when any sag is observed in the fractal.

37.1.5.3. Annual Maintenance Checklist

- 37.1.5.3.1.1. Clean the rear end of the fractal i.e. the side facing the roof, by uninstalling the fractal by untangling hooks from the curtain runner.

37.1.6. Do's and Dont's

- Ensure that the dynamic barrier is used as such - like a dynamic barrier: extended (i.e. covering the roof bottom surface) in the day-time at about 7 am, and retracted (folded to expose the roof bottom surface) in the night-time at about 6pm.
- Do not use the steel wire ropes to hang or suspend any heavy object(s).

37.2. Biomass Panels

37.2.1. Pre-Installation Staging

Over the roof

- Ensure that the roof is leak proof :
 1. Clean the roof thoroughly to identify repair points.
 2. Identify weak points such as J hooks.
 3. Fill in the weak points and cracks with cement mortar and waterproof solution.
 4. Ensure that the application of any sealant on a corrugated roof does not hamper smooth water flow during rains.
- In cases where there are lots of cracks and multiple joints in the roof owing to multiple roofing sheets placed of small sizes, considering the context is houses in informal settlements made up of quick fix materials, cover the roof with Silpaulin sheet to prevent the leakage inside the house over the installed panels.

Under the roof

- Remove all the items in the house that are inflammable such as clothes lying in the open, bedsheets or cover bedspreads with wet sheets, cylinder, etc. to avoid risk of catching fire from sparks of Metal welding and glander cutter.



- Study the roof slope and mark the level of the installation on the four walls, either parallel to the slope or straight. Ensure a minimum gap between roof and panel installation layer of 6" for air insulation and electrical wiring/repair.
- Ensure that the clear height from the floor post the installation and other contextual objects present such as electrical wiring, fan, etc. is minimum 6'6" to have a psychological comfort and safety.
- Once the installation level is planned, remove the fans or reposition lights and any other electrical fixtures that hinder the installation of the panels, below the level of installation to make the roof ready for the installation.

37.2.2. Biomass Panel Fabrication

The panels are being made by the GramArt⁴⁶ Project in Paradsingha, a village in the Maharashtra-Madhya Pradesh border. They are completely handmade. Below are the steps of the process of the panel making.

- Identify plants to source fibres that are native (*preferable*) with fibres that are easy to extract with minimal processing. (The plants used to make the panels photographed in this document comprise: Sun hemp, wild & domesticated Roselle, wild & domesticated Okra or Ladies Finger and Besharam grass or Bush Morning Glory)
- Harvest the plants (Fig 37.2.2-1)

⁴⁶ The Gramart project is a small-scaled enterprise working in the intersection of agro-ecology and art creating products that are sourced and made into finished goods locally, employing local labour and trading with care while being conscious of the whole chain of production to consumption.



Fig 37.2.2-1 : Plant fibre harvesting

- Dry the harvested plants (Refer Fig 37.2.2-2)



Fig 37.2.2-2 : Sun drying and air drying the harvested plants

- Thresh the plants to harvest seeds for sowing during the next season (Refer Fig 37.2.2-3)
- Soak the dried & de-seeded plants in water (Refer Fig 37.2.2-4)



Fig 37.2.2-3: Plant threshing



Fig 37.2.2-4: Soaking threshed plant matter in water

- Manually extract fibres from the soaked plants (Refer Fig 37.2.2-5)



Fig 37.2.2-5 : Remove the fibrous parts from the rest of the plant

- Dry fibres after extraction (Refer Fig 37.2.2-6)



Fig 37.2.2-6: Fibre drying

- Gather crop residue and wild plants that can be used to increase the binding nature of the panels, offering termite resistance, without the processing required for tough plant fibres. Cut fibres, crop residue & wild collections into small bits(Fig 37.2.2-7)



Fig 37.2.2-7: Cut fibres and wild plant collections into small pieces

- Make sodium carbonate (soda ash) locally by using wood ash.
- Boil the cut fibre, crop residue and wild collection pieces in sodium carbonate solution to dissolve lignin in it to make the pulp softer & brighter. (Refer Fig 37.2.2-8)



Fig 37.2.2-8: Boil the fibre pieces in sodium carbonate (soda ash)

- Grind the boiled fibres to a pulp in a mixer (Refer Fig 37.2.2-9)



Fig 37.2.2-9 : Grind the boiled fibres to a pulp in an industrial mixer

- Make fibre panels, the measurements based on the installation site:
 - Spread the fibre pulp in a wooden mould.
 - Press the fibres to drain the water (Refer Fig 37.2.2-10)



Fig 37.2.2-10 : Lay out the fibres in a wooden mould within a water tank

- Press the panels to remove excess water (Refer Fig 37.2.2-11)



Fig 37.2.2-11: Press the panels to remove excess water

- Sun-dry the panels (Refer Fig 37.2.2-12)



Fig 37.2.2-12: Sun-dry the panels

- Label the different panels made of different raw materials appropriately (Refer Fig 37.2.2-13)



Fig 37.2.2-13 : Label the panels according to their raw materials

37.2.3. QA/QC of Biomass Panels

1. **Structur** Fig 37.2.3-1 : Check for surface cracks

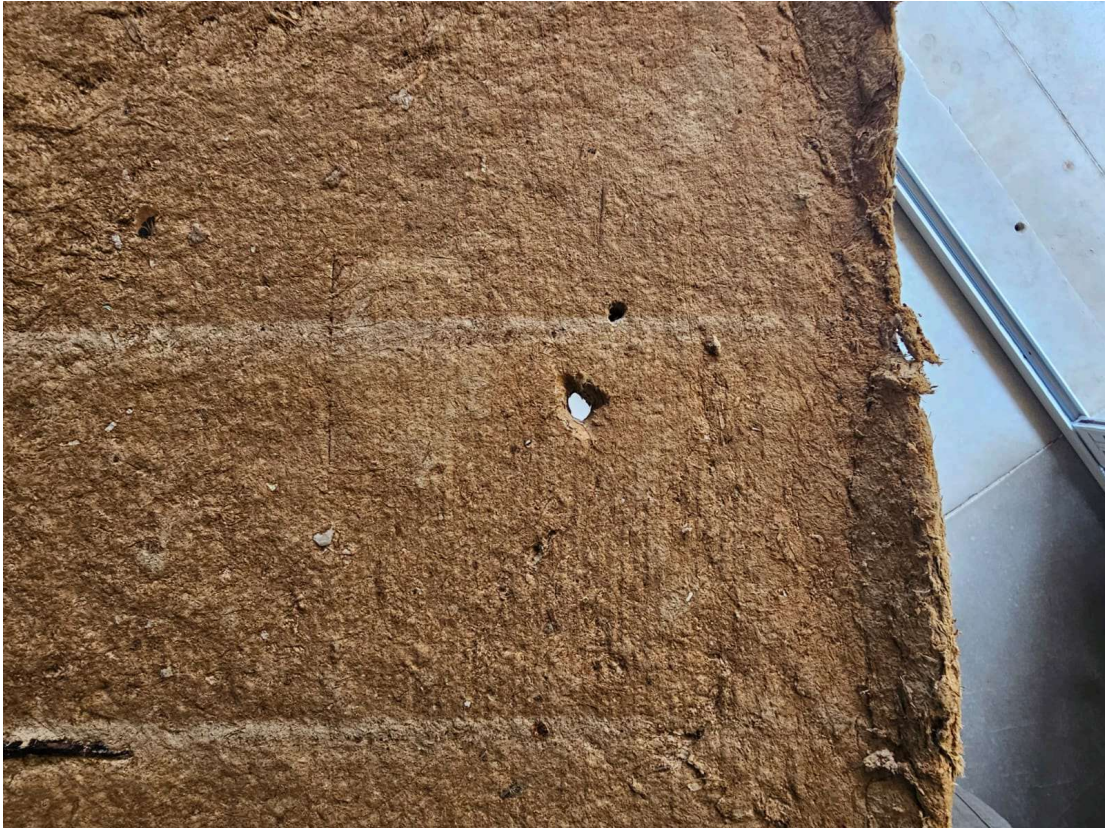


Fig 37.2.3-2 : Check for visible holes or gaps

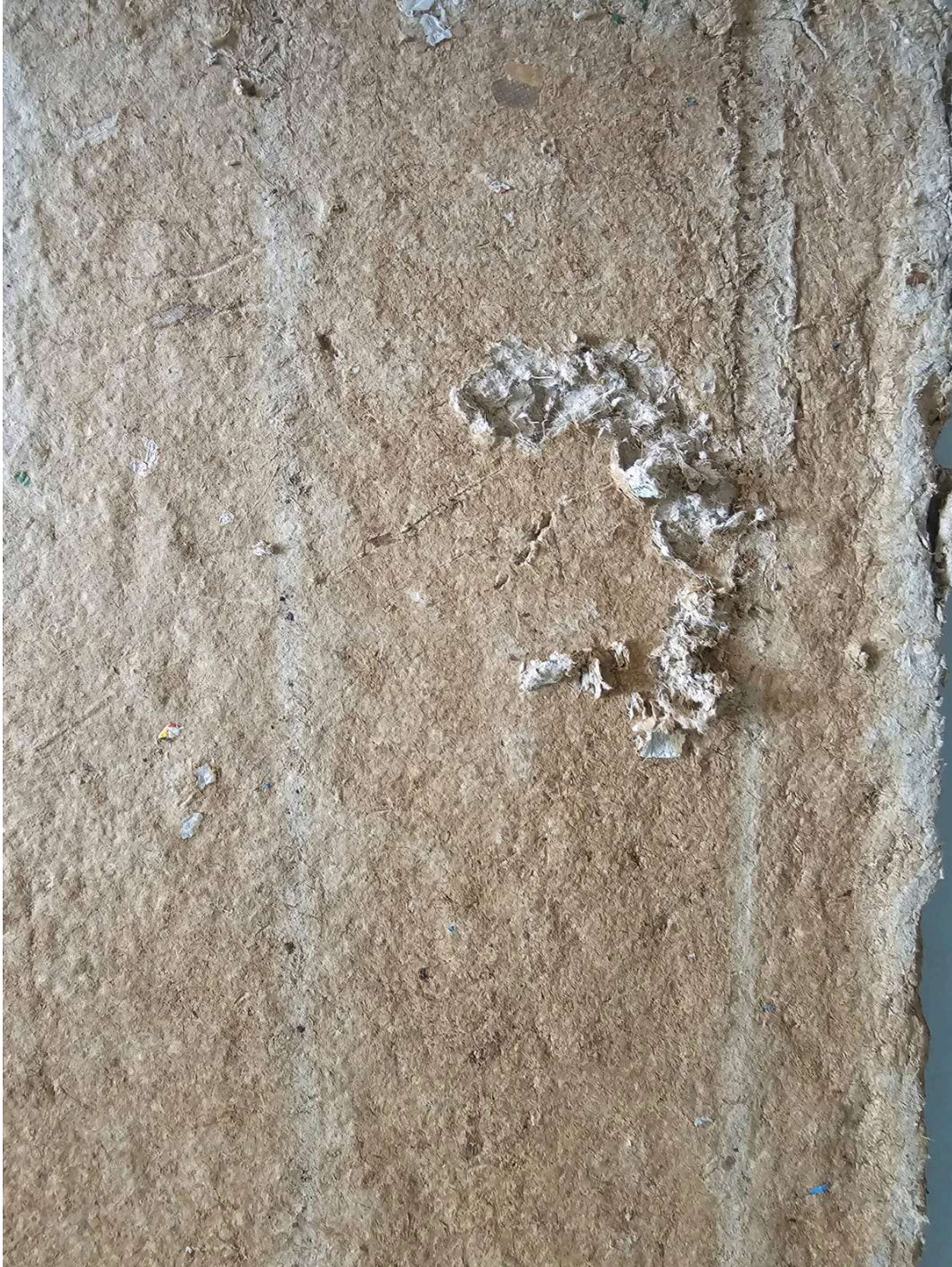


Fig 37.2.3-3 : Check for surface peeling or delamination

2. Panel Shape & Dimensions





Fig 37.2.3-4 : Check for warping/bending



Fig 37.2.3-5 : Check if panel thickness is at least 15mm and there is uniformity in thickness



Fig 37.2.3-5 : Check if corners are intact (not broken/chipped)

3. Moisture/ Storage condition
 - a. Check for moisture marks/fungus/mold growth



Fig 37.2.3-5 : Ensure panels are stored on raised pallets

37.2.4. Wrapping the Panel with MLP

There are natural compounds and solutions available that can be applied to make the Biomass panel water and pest resistant such as Lime Plaster, Cashewnut oil, etc. However these solutions cannot single handedly address water and pest resistance, for example, cashewnut oil brings high quality of water resistance but is highly inflammable. This implies combinations of such different natural solutions need to be tried to make it full proof. In this case, in order to address this, the panels are wrapped with Multi-Layer Plastic (MLP) (Fig 37.2.4-1) sheet ensuring that shiny surface faces

outside using big size stapler pins and duct tapes to give extra strength. With this the panels are ready to be installed under the roof.



Fig 37.2.4-1 : Wrap the panel with shiny surface facing outside and staple it

37.2.5. Installation

- Plan the panel layout based on purlins, entrance, loft and other contextual considerations in such a way that maximum full panels are accommodated with minimum cutting of the panels and minimum joints are there and the joints come in straight lines.
- Mark the 4 walls with coloured thread indicating the line on which drilling for the support frame will happen. If using a steel alloy frame as support, choose a width that can seat the thickness of the panel, if using MS then choose an appropriate L angle (Refer figure 2.15)



Fig 37.2.5-1 : MS L-angle lengths being prepared for panel support frame

- Drill and fix the support on the edge of one wall and on the opposite edge. (Refer Fig 37.2.4-2)



Fig 37.2.5-2 : MS L-angle drilled at a height of 14" approx(in this instance) from top of wall on all 4 walls to form the support frame

- Drill and fix the next support length according to the width of the panel. The entire installation should be in a single plane without slope. (Refer Fig 37.2.5-3)



Fig 37.2.5-3: MS support frame in a single plane

- For a steel-alloy frame, get extra support from the main roof by tying steel wires in different places between the frame and a roof purlin/roof anchor (Refer Fig 37.2.5-4). This is an alternative way to fix under-roof panels, however the present installation was done with support of MS framework.

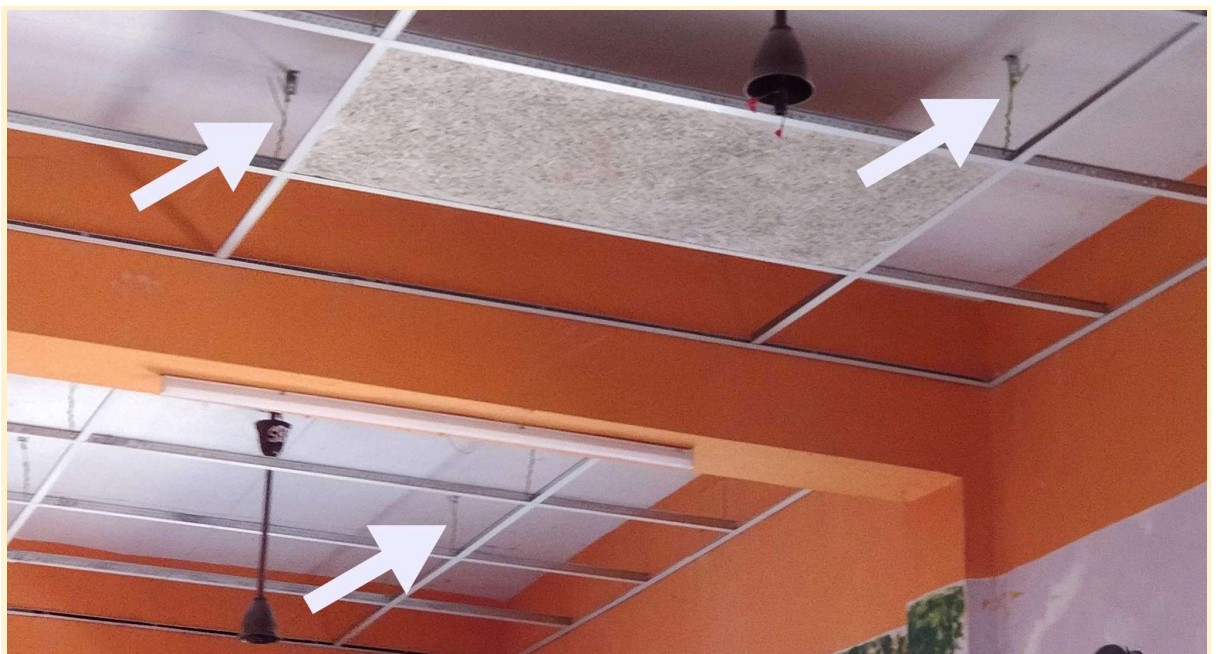


Fig 37.2.5-4 : Extra roof support

- Lay the panels snugly within the supports
- Measure the residue areas to figure out how many panels require cutting towards the edges of the wall after whole panels are laid. Cut the whole panels and tape the cut end with aluminium tape (Refer Fig 37.2.5-5 and Fig 37.2.5-6)



Fig 37.2.5-5 : Cut the whole panel



Fig 37.2.5-6 : Tape the cut end with aluminium tape

- The installation should occupy the entire space leaving no gap in the edges of walls to prevent movement of small animals.(Refer Fig 37.2.5-7)



Fig 37.2.5-7 : Metal support framework with panels in place with no gap in the ends

37.2.6. Maintenance

37.2.6.1. Monthly Maintenance

- Look for visible signs of discolouration, powdering of panels, wet patches and in case of leaks, remove respective panel and address the specific spot with adhesives/mortar either from under the roof or over the roof

37.2.6.2. Quarterly Maintenance

- If you find gaps have formed between the wall edge and support frame, over time, address it to ensure the gap is covered
- Look for visible signs of discolouration, powdering of panels, wet patches and in case of leaks, remove respective panel and address the specific spot with adhesives/mortar either from under the roof or over the roof

37.2.6.3. Annual Maintenance

- Check the MS supports for rusting and paint them
- If you find gaps have formed between the wall edge and support frame, over time, address it to ensure the gap is covered
- Look for visible signs of discolouration, powdering of panels, wet patches and In case of leaks, remove respective panel and address the specific spot with adhesives/mortar either from under the roof or over the roof

37.2.7. Do's and Dont's

37.2.7.1.1. Do clean the roof off cobwebs from time to time

37.2.7.1.2. Do not take naked flames close to the ceiling



- 37.2.7.1.3. Do check regularly if the water is leaking from the roof cracks
- 37.2.7.1.4. Do not keep anything inflammable in the room during the time of installation

37.3. Wood Wool Panels

37.3.1. Pre-Installation Staging

Over the roof

- Ensure that the roof is leak proof :
 - Clean the roof thoroughly to identify repair points.
 - Identify weak points such as J hooks.
 - Plug weak points with cement mortar+water proof solution.
 - The application of any sealant on a corrugated roof should not hamper smooth water flow during rains.

Under the roof

- Mark the level of the installation on the four walls, ensuring a minimum gap of 6" between roof and installation for electrical wiring/repair and 6'-6" between floor and installation and other contextual considerations such as electrical wiring, shelving, position of windows etc.
- Based on the above, rewire and reposition lights and other electrical fixtures that might hinder the installation of the panels
- Plan the panel arrangement based on entrance, loft, and other contextual considerations.
- Measure the area for the panel installation to assess how much of the panel requires cutting towards the edges of the wall after whole panels are laid.
- Remove fans before installation

37.3.2. Installation

- Mark the 4 walls with coloured thread indicating the line on which drilling for the support frame will happen
- If using a steel alloy frame as support, choose a width that can seat the thickness of the panel but if using MS then choose an appropriate L angle (Refer Fig 37.3.2-1)



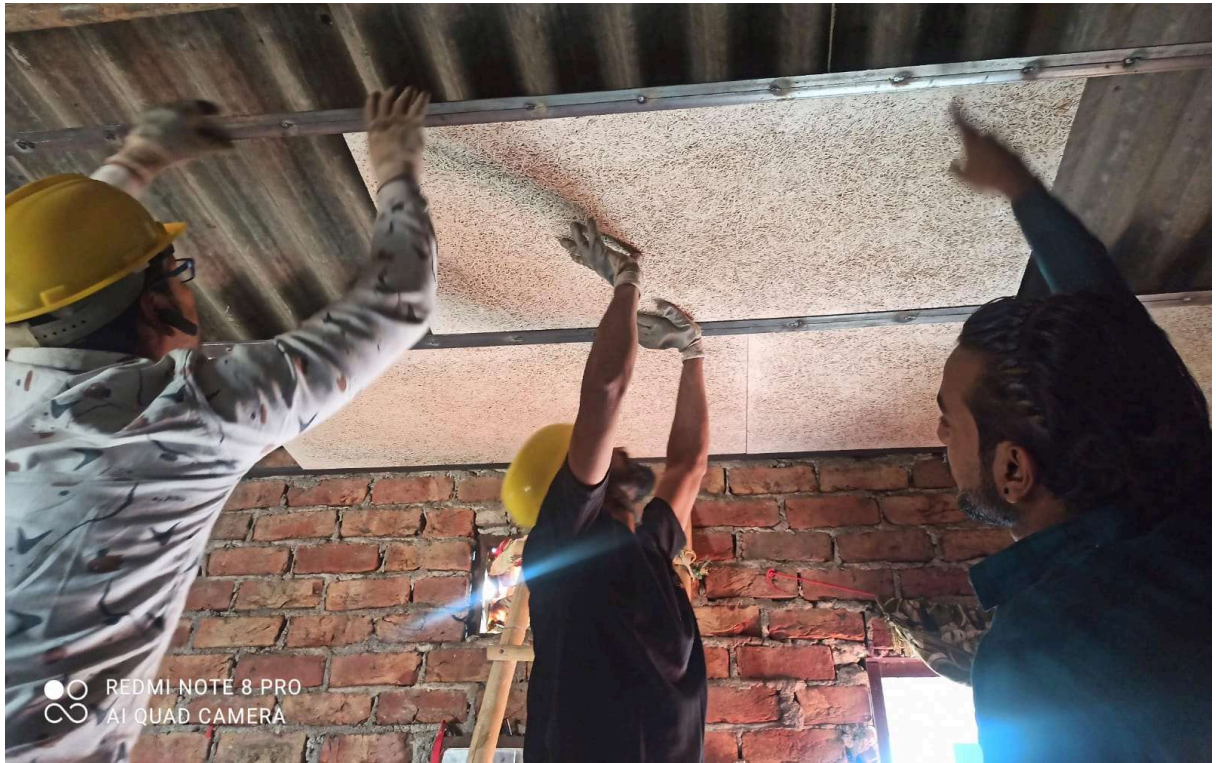


Fig 37.3.2-1 : MS support frame for panels-installation in progress

- Drill and fix the support on the edge of one wall and on the opposite edge. Drill and fix the next support length according to the width of the panel. Try to ensure the entire installation is a single plane without slope.(Refer Fig 37.3.2-2)

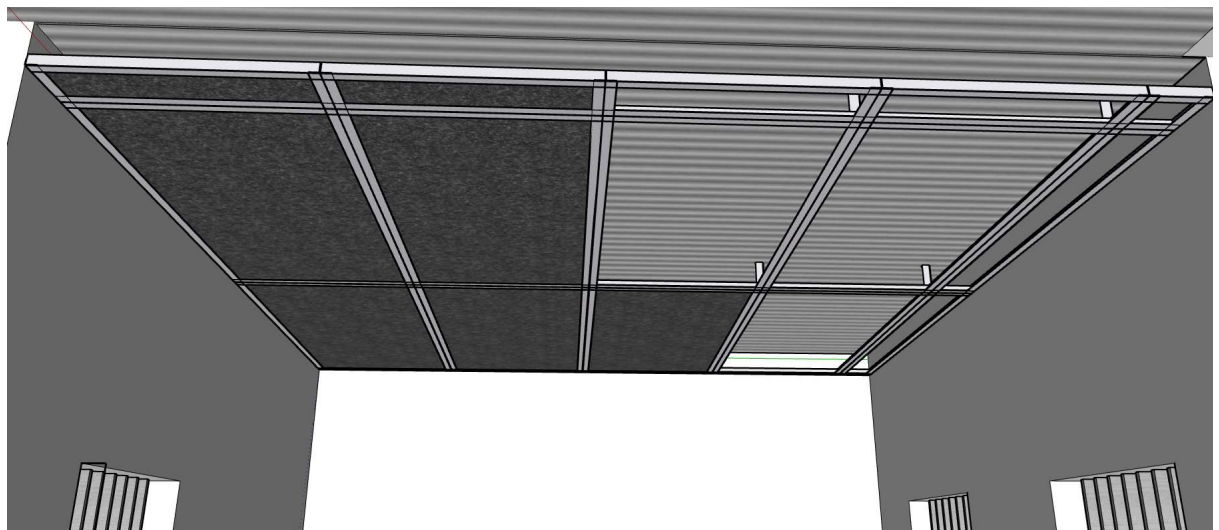


Fig 37.3.2-2 : Metal frame support for panels-installation in progress

- For a steel-alloy frame, get extra support from the main roof by tying steel wires in different places between the frame and a roof purlin/roof anchor (Refer Fig 37.3.2-3). This is an alternative way

to fix under-roof panels, however the present installation was done with support of MS framework.



Fig 37.3.2-3 : Extra roof support

- Lay the panels ensuring they sit snugly within the supports (Refer figure 37.3.2-4,5,6)



Fig 37.3.2-4 : Metal support framework with panels in place



Fig 37.3.2-5 : MS support framework with panels in place



Fig 37.3.2-6 : Steel alloy support framework with panels in place

- Ensure the installation leaves no gap in the edges of walls to prevent movement of small animals

37.3.3. Maintenance

37.3.3.1. Monthly Maintenance

- Look for visible signs of discolouration, powdering of panels, wet patches and see if the specific panels can be removed and replaced
- In case of powdering down from the panel, apply a layer of transparent paint to the specific panels and return them to place
- In case of leaks, remove respective panel and address the specific spot with adhesives/mortar either from under the roof or over the roof

37.3.3.2. Quarterly Maintenance

- If you find gaps have formed between the wall edge and support frame, over time, address it to ensure the gap is covered
- Look for visible signs of discolouration, powdering of panels, wet patches and see if the specific panels can be removed and replaced
- In case of powdering down from the panel, apply a layer of transparent paint to the specific panels and return them to place
- In case of leaks, remove respective panel and address the specific spot with adhesives/mortar either from under the roof or over the roof

37.3.3.3. Annual Maintenance

- Check the MS supports for rusting and paint them
- If you find gaps have formed between the wall edge and support frame, over time, address it to ensure the gap is covered
- Look for visible signs of discolouration, powdering of panels, wet patches and see if the specific panels can be removed and replaced
- In case of powdering down from the panel, apply a layer of transparent paint to the specific panels and return them to place
- In case of leaks, remove respective panel and address the specific spot with adhesives/mortar either from under the roof or over the roof

37.3.4. Do's and Dont's

- Do clean the roof off cobwebs from time to time
- Do not take naked flames close to the ceiling
- Do check regularly if the water is leaking from the roof cracks



- Do not keep anything inflammable in the room during the time of installation

37.4. Rooftop Garden Low Soil Mass

37.4.1. Pre-Installation Staging

- Ensure That The Roof Is Leak Proof (Waterproofing)
 - Clean the roof thoroughly to identify repair points.
 - Identify weak points such as J hooks. Plug weak points with cement mortar+water proof solution.
 - The application of any sealant on a corrugated roof should not hamper smooth water flow during rains.
- Make a Walkable Parapet Wall
 - Inspect the parapet wall and repair any damaged or weak areas.
 - Make the parapet wall safe for walking by increasing the width to at least one foot by masonry activity (refer Fig 37.4.1-1).



Fig 37.4.1-1 : Parapet wall after repair works

- Ensure an easy access to roof
- Use a sturdy ladder to access the roof.
- Ensure access to Water on the Roof - Includes Installation Pump Set and Overhead Tank
 - 37.4.1.1.1. Determine if the roof can support the weight of a water tank.
 - 37.4.1.1.2. Get the household's approval to install the tank to ensure everyone is on board with it.

- 37.4.1.1.3. Evaluate and procure materials for the necessary masonry, plumbing, and electrical works required to support the tank's installation.
- 37.4.1.1.4. Carry out the necessary works, including masonry, plumbing and electrical works.
- 37.4.1.1.5. Once all necessary works are complete, install the water tank on the roof, ensuring it is safely and securely in place (refer Fig 37.4.1-1.5-1).



Fig 37.4.1-1.5-1 : Over Head Tank After Installation

- Make sure that all raw materials are on site before installation
 - Prepare the potting mix at least 21 days before planting or sowing. Include manure such as cow dung, vermi-compost, cocopeat, perlite for better fertility. In case

of paucity of time, market available potting mix can also be procured.

- Procure growbags or pots suitable for rooftop planting.
- Procure drip irrigation materials, fabricated bamboo frames and trellis.
- Prepare or purchase saplings based on the planting plan.
- Procure irrigation materials, fabricated bamboo trellis, 18-30 mm LECA ball (refer Fig 37.4.1-1.5-3) and 20-25 mm chips-uses for concrete mix (refer Fig 37.4.1-1.5-4)



Fig 37.4.1-1.5-2 : 18-25 mm LECA Ball



Fig 37.4.1-1.5-3 : 25 mm Concrete chips

37.4.1.1.6. Procure ¾ inch UPVC pipe and joineries

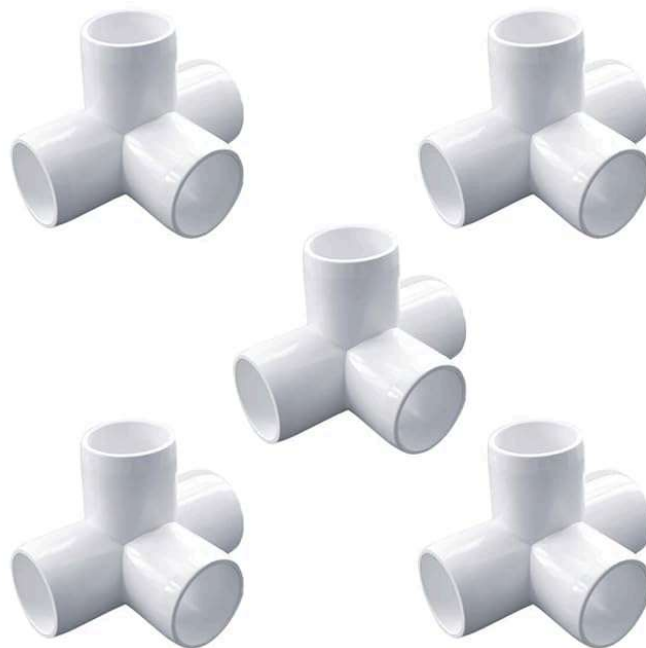


Fig 37.4.1-1.6-1 : UPVC four way joinery

37.4.1.1.7. Procure 30 mm rain cell mat as per the number of garden stands



Fig 37.4.1-1.7-1: 30 mm Rain Cell Mat

- 37.4.1.1.8. Procure submersible water pump with 15 feet lifting capacity and ½ inch hose

37.4.1.1.10. Prepare a drawing including Irrigation line

37.4.2. Fabrication

- Prepare garden stand as per requirement
 - Materials; $\frac{3}{4}$ inch 2 set of 4-way and 4 set of 3-way joinery, 12 feet of $\frac{3}{4}$ inch UPVC pipe, zip tag, 3 nos of rain cell mat
 - Tools; UPVC cutter, file, spirit level scale
- Process of making a single Garden stand-
 - Cut $\frac{3}{4}$ inch UPVC pipe into four of 12-inch size Three of 14-inch size. Both use for base frame
 - Cut a single piece -7 inch for base leg, then as per the roof and parapet slop cut the rest of the legs. A total of six sets of legs are required for each pot and each leg length is different from the rest.
 - Now connect the legs and base frame with UPVC joineries.
 - Once after assembling the set connect, it to a rain cell mat with a zip tag. Check whether any rain cell mats cracked/broken
 - Place it on top of roof (one side leg will be on top of roof and other side will be one top of roof) then check the levelling with a spirit level. The stand should be either straight or gentle slope 5-degree slope towards the parapet wall. If not, legs needs to be adjusted as per requirement
 - Each stand level should be verified before placing the garden pot on top.



Fig 37.4.2-1 : Sample Garden stand

- Prepare Wicking pot as per requirement
 - Materials; Plastic container (size and shape- Round shape- 9–10-inch dia and 11-14 inch, Rectangular- 9*14*8 W*L*H), 20 mm drip pipe as per size of pot, 20 mm connector with rubber washer 2 nos, 20-25 mm concrete chips, 18-30 mm LECA ball, Geofiber/ 90% Shade net as per pot size, Potting mix, Mulching materials (coconut fibre, dry leave, dry sugar cane bags, etc)
 - Tools; Axum blade, pipe cutter, Scissor, 6 mm Hole maker/drilling machine, 1 ltr tin for Measurement, 20 mm hole maker/drilling machine, Water bucket and sieves for washing
- Process of making a single Wicking pot-
 - Phase -1
 - If container collected from upcycling unit, then wash it well, ensure that no oil/grease particles



Fig 37.4.2-2 : Removing oil and dust from upcycled container

- Then cut the pot as per the size, make sure that pot doesn't have any holes and dysfunction.
- Make sure that pot can sit flat in the ground and won't bounce to the sides
- Make two hole sizes of 20 mm 3 inch above from the bottom of the container.



Fig 37.4.2-3 : Making 20mm hole with driller

- Make sure that both holes are the same height and no holes or cracks below this. If so either seal it or don't use the container
- Attach the 20 mm rubber washer to the container (Fig 37.4.2-4).



Fig 37.4.2-4 : Washer and connector attached to the pot

- Attach the 20 mm drip corner to the hole
- Make 6 mm holes 5 inch above from the bottom of the container in random space. These holes referred drainage holes (refer Fig 37.4.2-5)



Fig 37.4.2-5 : Drainage hole making on pot

- Phase -2
 - Wash LECA ball well, remove all the dust and debris, no need to dry it out



Fig 37.4.2-6 : Washing concrete chips

- Wash concrete chip well ensure no dust or cement mix in it (refer Fig 37.4.2-6)
- Fill the LECA ball first into the pot.
- Then Fill the concrete chips, the ideal ratio between both is 1.5:2 ratio (refer Fig 37.4.2-7)



Fig 37.4.2-7 : LECA ball and Concrete mix layered in the pot

- Cut the geofabric/shade net as per the area of the container



Fig 37.4.2-8 : Cutting geofabric as per the area of pots

- Place it on top of concrete chips. Now the area underneath fabrics is referred to 'reservoir' (refer Fig 37.4.2-9:)



Fig 37.4.2-9 : Place Geofibre on top of concrete chips

- Phase-3
 - Fill the potting mix in the container, little by little. Ensure the mix is not going to reservoir to the edges. If so, carefully, remove the soil



Fig 37.4.2-10 : Pot filled with potting mix and mulched with coconut fibre

- Fill the potting mix on a 5-7 inch high
 - Fill the mulching material on top it
 - Keep the wicking pot under sunlight
 - Run water through a connector placed reservoir, pour it until it overflows from the opposite connector.
 - Make sure water not entering to the potting mix
 - Rest it for another 2-3 hours as per the intensity of sun
 - Observe weather water wicking up. If yes, then repeat the process for making required pots. If not, dismantle it and check for the missing steps and correct it.
- Prepare trellis
 - Materials; 3 inch dia bamboo, Bamboo splits, Coir/rope, Joining cable, Nile, Brick, Shade net
 - Tools; Bamboo splitting tools, Knife, axum blade, scissors

- Process of making a Trellis
 - Measure the width of the roof, distance between parapet to parapet.
 - Cut the 3. inch dia bamboo accordingly. Two bamboo required for each trellies
 - Keep the both bamboos in 30-36 inch difference.
 - Weave the between place with bamboo splits.



Fig 37.4.2-11 : Bamboo trellis making process

- Use either good quality binding wire or coir to bind the splits
- Bind the splits in a rectangular pattern.
- Then lay the green net on top of the trellis



Fig 37.4.2-12 : Green net attaching to the Bamboo trellis

- Place a brick on top of parapet wall before placing the trellis
- Note: Finish trellis installation work before placing the garden stand on the roof.



Fig 37.4.2-13 : Trellis after finishing all works

- Prepare scaffolding structure to shade net
 - Materials; 2 dia and 1-inch dia bamboo poles, rope, shade net.
 - Tools; Bamboo splitting tools, Knife, axum blade, scissors
- Process of scaffolding structure
 - Cut the 2dia bamboo poles 4- 5 feet as per the slope of roof and parapet wall
 - Keep it vertically then close to trellis.

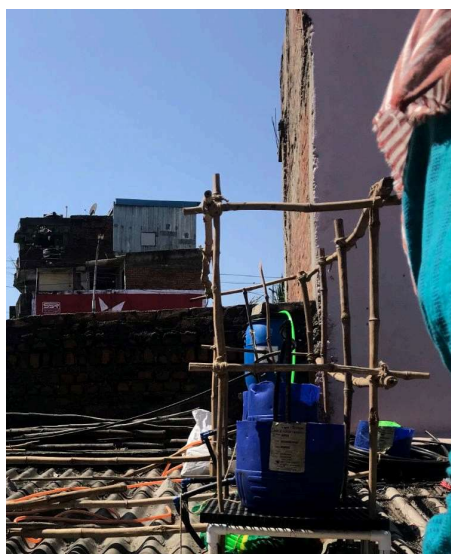


Fig 37.4.2-14 : Scaffolding under construction

- Join all the bamboos together then attach it with coir

- Spread the green net on top of the scaffolding



Fig 37.4.2-15 : Scaffolding after finishing all works

37.4.3. Installation

- Ensure all pre-installation works has been completed
- Ensure house owner present at the day of installation
- Ensure all the Safety gears including the first aid kit available at site
- Mark the area where the garden stands, trellis will be placed
- Mark the Irrigation pipeline passages
- Communicate it well with installer/helpers
- Install the trellis system
 - Installation process shall begin with trellis
 - If pre-made trellis are arranged then, ensure there is no damage during transport and shipment. If so, address those before attaching to the roof
 - If the fabrication is arranged on site, then follow the fabrication steps.
 - Ensure there is walkable space between trellis.
 - Ensure the trellis is not sagged down to the roof
 - Ensure there is gap between roof and trellis
 - Ensure each corner of trellis is sitting well on top of bricks.
 - Ensure there is 9" gap between garden stand and trellis
 - Ensure shade net is well attached with trellis
- Install the scaffolding structure
 - Install scaffolding- refer fabrication note
 - Ensure vertical and horizontal poles are not sagging to any sides
 - Ensure shade net cover well on top and half of high sun exposed side
 - Ensure the vertical poles were attached to the 3 dia bamboo (part of trellis)
 - Ensure the structure standing straight

- Install Garden Stand
 - Refer fabrication session for preparation of stand
 - Keep the stand on the top roof and parapet. Three legs on each side
 - Ensure all the joineries are tight and intact
 - Check the levelling with spirit level scale, if its not levelled change the leg or adjust the leg by trimming
 - Ensure all Rain cell mat tight and intact and not sagging down

- Install Wicking pot
 - Refer to the fabrication session for preparation of the wicking pot.
 - Ensure there are enough pots available on site during installation.
 - Place it on top of the garden stand.
 - Ensure they are placed straight and steady, and do not sag to either side.
 - Place two pots on each stand.
 - Connect the reservoir of each pot with a 20 mm drip pipe (3–4 inches).
 - If the pot is not filled with potting mix, fill it up.
 - Then add enough mulch.
 - Recheck all the pots to ensure that each pot has enough potting mix and mulch, that all pairs of pots relate to a drip pipe and that the garden stand is not sagging due to the weight of the pots.

- Install the submersible motor
 - Cut the ½ inch hose pipe to the required length between the overhead tank and the water source.
 - Cut again at a distance of 4 feet from this point.
 - Attach the motor to the 4-foot piece.
 - Attach the male thread of the 'hose pipe connector' to the other end of the 4 foot piece.
 - Attach the female thread of the 'hose pipe connector' to the longer pipe.





Fig 37.4.2-16 : Submersible installation along with hose pipe

- Lay the longer pipe where the overhead tank is located under the garden stand.
- Connect the longer pipe to the inlet of the overhead tank.



Fig 37.4.2-17 : $\frac{1}{2}$ Hose pipe laid under garden stand connected to over head tank

- Run water through once and check the water flow to the tank.



Fig 37.4.2-18 : Water over flowing through the Tank's outlet

- If no water is flowing due to the height, adjust the water source by lifting it up until the required height is reached.
- Run the motor and check the water flow. If no water is flowing, either repair or replace the motor.
- Communicate thoroughly with the house owner about the daily usage and maintenance of the motor. the house owner about the daily usage and maintenance of the motor.
- Give a hands-on demonstration on the day of installation.
- Lay the irrigation pipeline
 - Follow the irrigation map and measure the distance between the garden stand and cut the 20 mm drip pipe as per requirements. Make sufficient pieces.
 - Then connect the as per the plan with the wicking pot



Fig 37.4.2-19 : Wicking pot connected each other with drip pipe marked in Yellow color

- Ensure joineries are sealed
- Connect pipe with over head tank, keep 20” mm value between irrigation line and tank
- At the end, the outlet gives an extension pipe if required. Ensure that houseowner can see the outlet
- Now, run fill the water to the tank
- Open the valve completely and check water flow to the pot.
- Check water leaking through the drainage holes, then stop the valve.
- If yes, then reduce the water pressure by adjusting the valve. Ideally open the valve 50% capacity.
- Then check if the leakage is happening or not.
- If still the pots are leaking then, close the valve first, then check for any blockages in the outlet particular pot.
- If everything is alright, then open the valve as mentioned 50 %, run the water until water flow is noticed from the last pot’s outlet.
- Once after this, check the moisture content in the potting after 2-3 hours, to very the wicking process happens or not
- Follow the irrigation map, measure the distance between the garden stand and cut the 20 mm drip pipe according to the requirements. Make enough pieces.
- Then connect as per the plan with the wicking pot.
- Ensure the joints are sealed.
- Connect the pipe to the overhead tank, leaving a 20 mm gap between the irrigation line and the tank.
- At the end, provide an extension pipe if required. Ensure the householder can see the outlet.
- Run and fill the tank with water.
- Open the valve completely and check the water flow to the pot.
- Check for water leaking through the drainage holes, then close the valve.
- If necessary, reduce the water pressure by adjusting the valve. Ideally, open the valve to 50% capacity.

- Check for any leakage.
 - If the pots are still leaking, close the valve first and check for any blockages in the pot's outlet.
 - If everything is OK, open the valve to 50% capacity and run the water until you notice a flow from the last pot's outlet.
 - After this, check the moisture content in the potting after 2–3 hours to verify that the wicking process is happening.
- Sowing seeds/Planting sapling to the pots
 - Ensure the grow containers have a moist soil environment using wicking irrigation.
 - If the seeds are ready to plant, soak them (especially gourd seeds) for at least four hours beforehand.
 - Plant the soaked seeds in a corner close to the trellis at a maximum depth of two inches.
 - If there are ready-to-plant saplings available, position them in a corner close to the trellis.
 - Plant bushy plants such as chillies and aubergines in the middle or on the side of the grow containers that are not next to the trellis.
 - Include at least one plant from the bean family in each grow container and maintain a minimum distance of six inches between each plant.
 - Mulch the pots with dry biomass such as sugarcane bagasse or dry leaves.

37.4.4. Maintenance

Materials to carry during maintenance visit:

- Safety gear
 - Safety Helmet
 - Ladder
 - First Aid Kit
- Tools
 - Plant Prunner
 - UPVC Cutter
 - Axoum Blade
 - Garden Fork
 - Trowel
 - Scissor
 - Spirit Level/ Bubble Level
 - Power Tester
 - Tape Measurement- 5 mtr



- Cutting Player
- Manual Drill bit (20 mm)
- Needle (5 mm)
- Other Materials
 - Inoculant
 - Pest Repellent
 - Lubricant oil
 - Mulch
 - Compost

37.4.4.1. Plant Health



Fig 37.4.4-1 : Healthy plant



Fig 37.4.4-2 : Diseased plant (pale green and brown spotted leaves)

Bi-weekly Maintenance

Sr.No	What To Check For	Resolution Guidelines
1	Is the plant looking healthy? i.e. are the stems and branches drooping/leaves discolored (pale green, yellow spots)/ is the foliage scanty/Is the plant being attacked by insects or pests?(ref fig 4.1.2 and 4.1.3)	• Ensure the pots are mulched • Ensure the soil is moist • Ensure inoculant is sprayed as prescribed intervals i.e. once every 10 days • Ensure pest repellent spraying is done in 15 day intervals

Monthly Maintenance

Sr.No	What To Check For	Resolution Guidelines
1	Is the plant looking healthy? - i.e. are the stems and branches drooping/leaves discolored (pale green, yellow spots)/ is the foliage scanty/Is the plant being attacked by insects or pests?(ref fig 4.1.2 and 4.1.3)	Even after following the biweekly care, If the plant does not look well : • Remove the infected plant and plant new sapling. • Do not repeat the same plant type, for example, if the removed plant is Pumpkin, then plant Bottle gourd.

Quarterly Maintenance

Sr. No	What to Check For	Resolution Guidelines
1	Are there overly grown or mature plants - harvested fruits/leaves multiple times, growth stunted, or plant dried, etc.?	• Identify and carefully remove these plants. Replace them with new, healthy plants. • When planting new plants, add a handful of compost to the containers to replenish the soil nutrients.

Annual Maintenance

Sr. No	What to Check For	Resolution Guidelines
	NA	NA

37.4.4.2. Potting Mix/Soil

Bi-weekly Maintenance

Sr. No	What to Check For	Resolution Guidelines
1	Is the soil moist?	• Check the pipe line • Ensure the pots and pipe line are intact and release the water to the pot



		Manually verify the moisture level in the soil.
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Quarterly Maintenance

Sr.No	What To Check For	Resolution Guidelines
1	Is there a presence of white particles similar to salt?	Scoop out the white particles from the pot
2	Is the soil compact on poking?	Loosen the soil with garden tools, while ensuring that the roots are not damaged
3	Is the potting mix component retained after heavy rains?	If the potting mix is washed away, then refill the pot with sufficient quantity of potting mix/compost
4	Has the water drained well after heavy rains?	If the water is not draining even after two days, then replace the potting mix or redo the potting process to remove the blockage

Annual Maintenance

Sr. No	What to Check For	Resolution Guidelines
	NA	NA

37.4.4.3. Garden Pot

Bi-weekly Maintenance

Sr. No	What to Check For	Resolution Guidelines
	NA	NA

Quarterly Maintenance

Sr.No	What To Check For	Resolution Guidelines
1	Is there any obstruction in a pot overflowing with water?	Remove the obstruction and ensure the pot is retaining a proper shape, for example, if the outlet is blocked by stones or soil particles in a wicking pipe, then remove the obstacles.



2	Is there any crack or damage to the pots?	Replace the damaged pots
3	Is there any leakage in the water reservoir area?	Use M-Seal to seal the pot after draining out the water. If that does not resolve the problem, replace the pot.

Annual Maintenance

Sr. No	What to Check For	Resolution Guidelines
1	Is the water flow from the outlets slow?	Dismantle the wicking pot including the 'elbow' shaped wicking pipe and scoop out the white particles (If chlorine water is supplied regularly, there are chances that white particles will be deposited in the wicking pipe within a year) and other obstacles. It can be reused after a wash.

37.4.4.4. Garden Stand

Bi-weekly Maintenance

Sr. No	What to Check For	Resolution Guidelines
	NA	NA

Quarterly Maintenance

Sr.No	What To Check For	Resolution Guidelines
1	Are the legs settled firmly on the parapet and asbestos ridge such that the stand is horizontally level?	- Replace the couplers/joints that are damaged or problematic - Push all the pipes into the couplers/joints firmly so that all the legs settle on the roof firmly without any gaps causing tilting of the stand
2	Has any coupler/joint (2-way, 3-way or 4-way coupler) come loose?	
3	Are there any broken pieces?	
4	Is there any damage to the drain cell mat?	Replace drain cell mat
5	Is the drain cell mat sitting well on top of the UPVC frame?	Untie and correct it-ensure mats are attached to each other well, through its inbuilt locks. All the edges of the mat should be placed on top of the UPVC pipes and then tie/ziplock it.



Annual Maintenance

Sr. No	What to Check For	Resolution Guidelines
1	Strength of UPVC parts	If the UPVC parts have disintegrated or look fragile then replace the part with a new one.

37.4.4.5. Scaffolding and Trellis (Shade Net)

Bi-weekly Maintenance

Sr. No	What to Check For	Resolution Guidelines
	NA	NA

Quarterly Maintenance

Sr.No	What To Check For	Resolution Guidelines
1	Is the bamboo scaffolding that supports the shade net wobbly?	Perform the necessary tying, adjustments, or replacements to keep the system in good condition.
2	Has the shade net come off?	

Annual Maintenance

Sr. No	What to Check For	Resolution Guidelines
	NA	NA

37.4.4.6. Submersible Pump and Hose Pipeline

Bi-weekly Maintenance

Sr. No	What to Check For	Resolution Guidelines
1.	NA	NA



Monthly Maintenance

Sr. No	What to Check For	Resolution Guidelines
1.	Is the householder following the instruction manual of the submersible pump ?	• Carry a printout of Tamil translated instructions, verify whether the householder is familiar with it • Manually verify the working conditions of the pump set • If pump is not oiled as per the instructions, then oil it immediately - Pump needs to be oiled every month
2	Is the hose pipe connection in working condition?	• Verify with the household about the connector's condition as per the initial directions. • Clarify all doubts and instruct them about the proper way, that is, remove the pipe connector after unlocking it- follow the arrow marked in connector

Quarterly Maintenance

Sr. No	What to Check For	Resolution Guidelines
1.	Hosepipe's working condition	• Check whether the pipe has any leakage issues and, if it does, cut the parts and reconnect them using a hose pipe connector.
2	Check the working condition of motor	• Run the motor, observe any disfunctionality, repair as per instructions.

Annual Maintenance

Sr. No	What to Check For	Resolution Guidelines
	NA	NA

37.4.4.7. Bamboo Trellis



Bi-weekly Maintenance

Sr.No	What To Check For	Resolution Guidelines
NA	NA	NA

Monthly Maintenance

Sr.No	What To Check For	Resolution Guidelines
1	Are the creepers growing away from trellis?	Ensure active climbing plants like gourds, cucumbers, and pole beans are in pots and trained towards the trellis.
2	Are there any unwanted plant residuals in the trellis?	Regularly remove any dry leaves, debris, or other materials from trellises. These can be placed inside the pots, on top of the soil as mulch.

Quarterly Maintenance

Sr. No	What to Check For	Resolution Guidelines
1	Ensure Structural Integrity	- Carefully inspect the bamboo frames and trellis to identify any areas that are damaged or compromised. Carefully remove the damaged bamboo frames or trellis sections. Replace them with new, sturdy bamboo or alternative materials as needed. When installing the new components, make sure they are properly secured and integrated into the existing system. - Adjust and reinforce the connections to maintain the overall structural integrity of the trellis and support system.

Annual Maintenance

Sr. No	What to Check For	Resolution Guidelines
	NA	NA



37.5. Water Filled PET Bottles

37.5.1. Pre-Installation Staging

- Ensure that the roof is cleaned thoroughly.



Fig 37.5.1-1 : Cleaning Of Roof

37.5.2. Fabrication

- Fill the one litre PET bottle with water. Ensure that the bottles are free of cracks, dents and also leakproof.



Fig 37.5.2-1 : Filling Of PET Bottles

- Cut MS strip to match the width of the roof. This strip will act as holding guards and prevent the bottles from sliding down (Refer figure 5.3)



Fig 37.5.2-2 : Cutting Of MS Strip

- Fabricate MS angles for the roof edge to function as a support frame. Ensure the angle provides a slight overhang beyond the roof edge.

37.5.3. Installation

- Apply adhesive (Heat X) over the roof to ensure the Silpaulin bonds firmly with the roof



Fig 37.5.3-1 : Applying Of Adhesive Over The Roof

- Stick Silpaulin across the roof, ensuring it aligns with the corrugation pattern



Fig 37.5.3-2 : Sticking Of Silpaulin Across The Roof

- Press the Silpaulin firmly to eliminate air pockets and allow the adhesive to set. Ensure there is no lifting or folding.



Fig 37.5.3-3 : Final View After Application Of Silpaulin

- Apply adhesive (Heat-X) only to the base of each PET bottle (the part that will touch the roof), not on the sides or top



Fig 37.5.3-4 : Application Of Adhesive Along The Bottle Side Which Touches The Roof

- Place the adhesive applied bottles in the trough of the roof with equal spacing.



Fig 37.5.3-5 : Placing Of Bottles In The Trough Of Roof With Equal Spacing



Fig 37.5.3-6 : Final View After Placing Of PET Bottles

- Once all bottles are placed, secure the MS strips across the roof to hold the bottles in place.



Fig 37.5.3-7 : Securing Of MS Strip Through Welding



Fig 37.5.3-8 : Final View After MS Strip Installation



Fig 37.5.3-9 : Top View After MS Strip (highlighted by red arrows) Installation

37.5.4. Maintenance

37.5.4.1. Monthly Maintenance

- Ensure PET bottles are in place and have not shifted due to wind, rain, or vibrations.
- Verify bottles are still firmly attached to the silpaulin.
- Lightly clean bottles and crates to prevent algae, dirt, or moss buildup.

37.5.4.2. Quarterly Maintenance

- Check for wear, small tears, or loosening of adhesive or sealing material. Repair if needed.
- Make sure no stagnant water is collected around bottles, which can attract mosquitoes.

37.5.4.3. Annual Maintenance

- Remove all bottles, clean them thoroughly, and wash the silpaulin surface.
- Replace PET bottles that are discolored or have lost strength.
- Check if the silpaulin sheet has weakened. Replace if degraded.

37.5.5. Do's and Dont's

- Use clear, good-quality PET bottles with caps tightly closed.
- Keep bottles completely filled with water for maximum heat absorption.
- Conduct extra checks after heavy rain, storms, or high wind.
- Don't use bottles that are already brittle or weak as they can crack under heat.
- Don't overload one section of the roof i.e. distribute bottles evenly.

37.6. Water Filled PET Bottles In Crates

37.6.1. Pre-Installation Staging

Over the roof

- Ensure that the roof is cleaned thoroughly





Fig 37.6.1-1 : Cleaning Of Roof

37.6.2. Fabrication

- Fill the 1 litre PET bottle with water. Ensure that the bottles are free of cracks, dents and also leakproof.



Fig 37.6.2-1 : Filling Of Water In Pet Bottles

37.6.3. Installation

- Apply a small amount of adhesive (Heat-X) to ensure the Silpaulin bonds firmly with the roof.



Fig 37.6.3-1 : Applying Of Adhesive Above The Roof

- Place the Silpaulin sheet evenly across the roof.



Fig 37.6.3-2 : Placing Of Silpaulin Above Roof

- Take each crate and align accordingly above the Silpaulin, ensuring they are firmly positioned



Fig 37.6.3-3 : Placing Of Crates Above Roof

- Once the crates are positioned, lay the MLP sheet over the crates. Ensure that the reflective (shiny) side of the MLP sheet is facing downward, towards the roof, to provide a low emissivity surface



Fig 37.6.3-4 : Placing Of MLP Sheets Inside The Crate

- Place the water-filled 1 litre PET bottles into the crates in two layers: The first layer should be placed side by side at the bottom. The second layer should be staggered, meaning each bottle sits in the gap between the bottles in the first layer, forming an interlocking pattern as shown in



Fig 37.6.3-5 : Placement Of Bottles In Crates (Second Layer Sits In The Gap Of First Layer)

- Repeat the above steps for all crates until the entire roof surface is covered uniformly.
- If the roof slope is steep and there's a risk of the crates sliding down, install MS (Mild Steel) strips along the roof edge to keep the crates securely in place as described in section 2.5.2



Fig 37.6.3-6 : Final Placement Of Pet Bottle In Crates

37.6.4. Maintenance

37.6.4.1. Monthly Maintenance

- Ensure crates and PET bottles are in place and have not shifted due to wind, rain, or vibrations.
- Look for any PET bottles that are punctured, cracked, or leaking water. Replace if needed.
- Lightly clean bottles and crates to prevent algae, dirt, or moss buildup.

37.6.4.2. Quarterly Maintenance

- Ensure waterproofing sheets remain intact, with no peeling, tears, or displacement.
- Recheck alignment of crates, especially on sloped roofs, and re-secure if any slippage is noticed.

37.6.4.3. Annual Maintenance

- Empty and clean all crates and bottles thoroughly to remove dust, algae, or sediment.
- Replace PET bottles showing discoloration or deformation.
- Check plastic crates for cracks or warping. Replace the damaged crates.

37.6.5. Do's and Dont's

- Keep bottles filled to capacity to ensure proper thermal performance.
- Conduct inspections after heavy rain or strong winds
- Don't overload the roof - stick to recommended load-bearing capacity.
- Don't skip periodic checks.

37.7. Space Frame

37.7.1. Pre-Installation Staging

A. Supports:

- The fractal widths decided modularly are - 3 feet and 4feet, so the placement of modular concrete bases need to be decided according to the area of the roof.
- Depending on the decision, the number of supports - single legs or double legs with metal sections need to be cast separately.

B. Placement and Design Decisions :

- Determine the orientation and length of the fractals, i.e. the direction of movement for the fractals. This would be dependent on the slope, placement of handling mechanism, and location of walls. The supports ideally need to be placed on top of roofing sheeting where it is supported by the wall below.

C. Removal of any objects :

- The roof needs to be cleared of any objects or sheets and thoroughly scrubbed with wire brush at locations where the concrete base would be adhered.

37.7.2. Fabrication

A. Wood work:

- Make a wooden box of the size 7"X7" with a depth of 3" (Refer Fig 37.7.2-1), with a GD clamp for easier removal of the shuttering post casting.





Fig 37.7.2-1 : Wooden shuttering with GD clamp

B. Metal work:

- Cut the 30mmX30mm box section of 2mm gauge thick into lengths of 18 inches each for the support legs of fractal.
- At the base, MS flats of the dimensions - 25.4X5mm of length 4 inches are welded in a '+' shape as shown in the picture for better stability. In case of a middle module(the base is supporting two fractals), two modules are welded together.(Refer Fig 37.7.2-2)

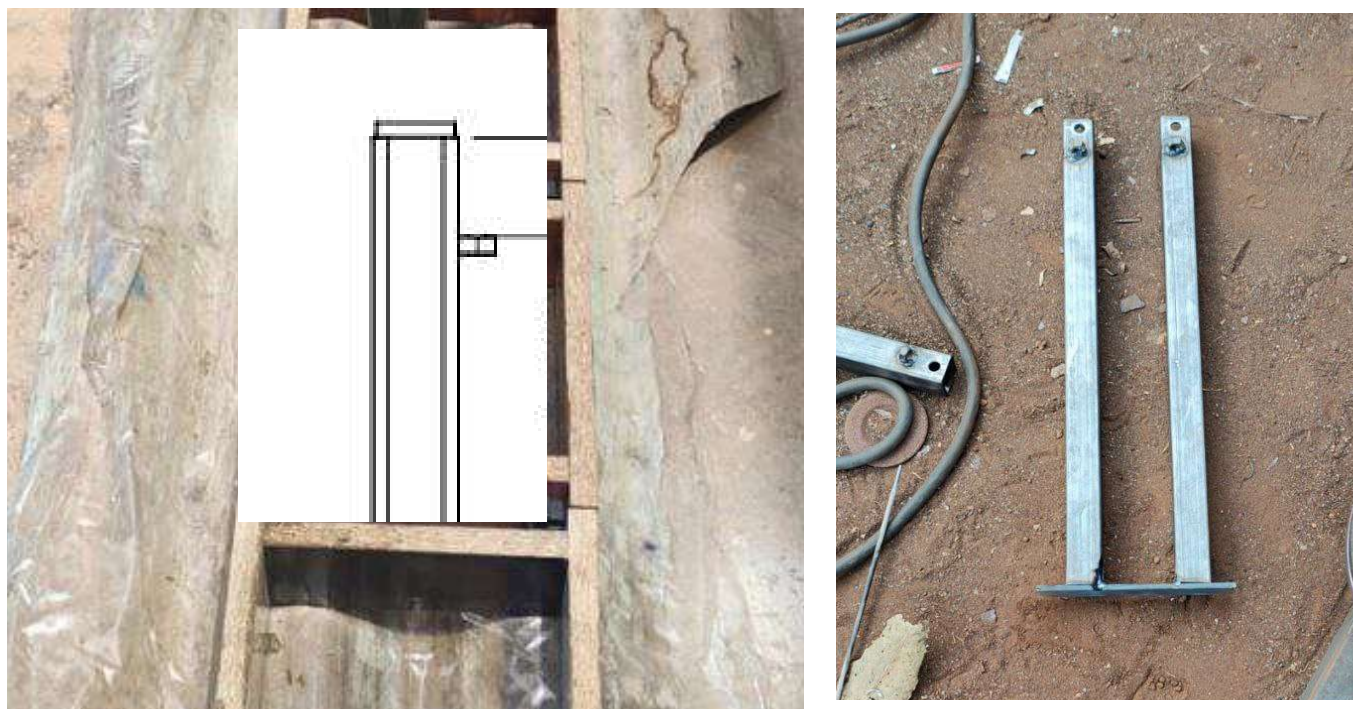


Fig 37.7.2-2: Supports at the base

- Weld the hook part of Tension Fastener to two adjacent sides of the MS Pipe at 1.4" from the top.(Refer Fig 37.7.2-3)

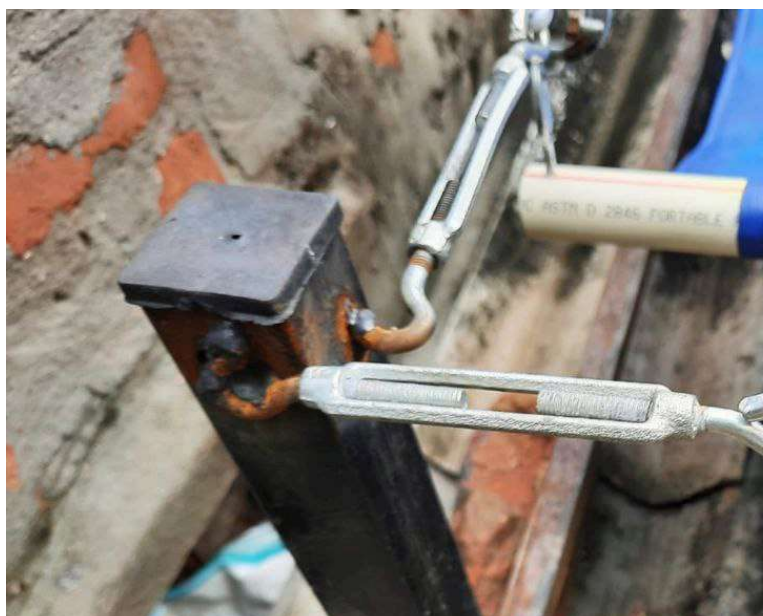


Fig 37.7.2-3 : Hooks welded at adjacent faces of the box section

- Paint red oxide first to protect from corrosion and then apply black paint.(Refer Fig 37.7.2-4)

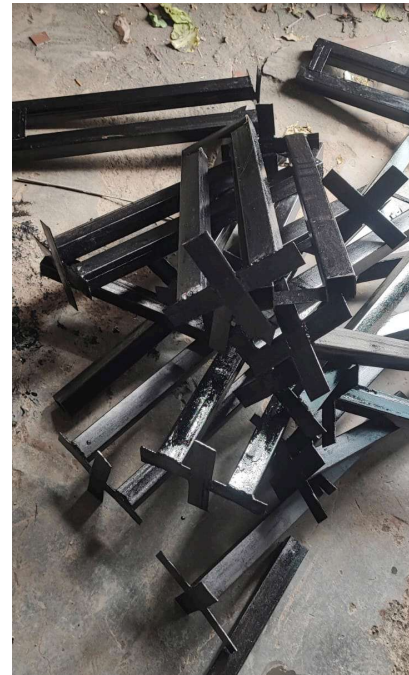


Fig 37.7.2-4 : Painting of Box Sections

C. Masonry work:

- Procure a roofing sheet for mould of similar roofing profile as the house where the solution needs to be deployed.
- Moisten the roofing sheet and lay the plastic sheet over it so that the plastic adheres to the roof without any folds that might be translated to the cast. This helps easier removal of the cast. Apply used engine oil inside moulds(wooden boxes) to facilitate easy removal of the mould after casting. (Refer Fig 37.7.2-5)



Fig 37.7.2-5 : Placing of moulds on roofing sheet

- Take a 4" pvc pipe of 1 ft length. Place it against the edge of the roof. (Refer Fig 37.7.2-6)

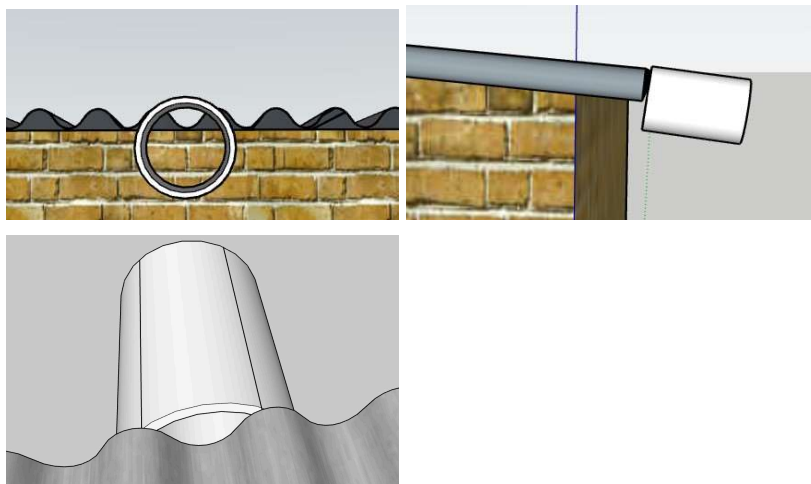


Fig 37.7.2-6 : Placing of PVC pipe

- Mark the two points where the pvc pipe meets the roof and draw straight lines till the other end of the pipe and cut it. (Refer Fig 37.7.2-7)

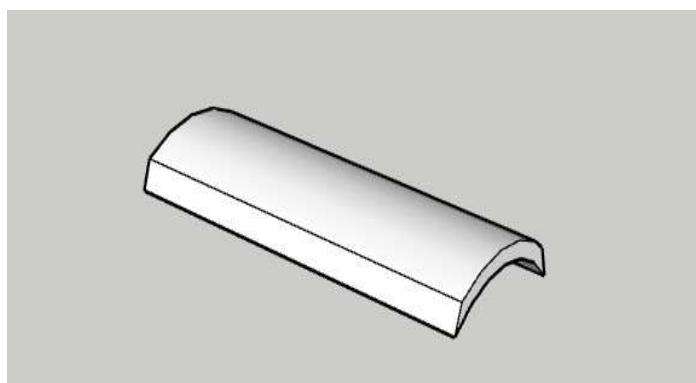


Fig 37.7.2-7 : Placing of PVC pipe

- Place the PVC pipe segment on the roofing profile and in the wooden mould.
- Put a layer of cement water solution on inside the moulds and on the sheet surface. Fill the troughs of the mould with concrete and compact them using a stick by blowing 25 strokes at each level of 1 inch. There might be a bit of wastage with concrete pouring out from the sides. Make an attempt to reduce it. Place the legs carefully and ensure they



Fig 37.7.2-8 : Casting the support with drip line

are vertical as the filling and compacting of concrete takes place. Level the top surface of concrete after reaching the desired height of 3". (Refer Fig 37.7.2-8)

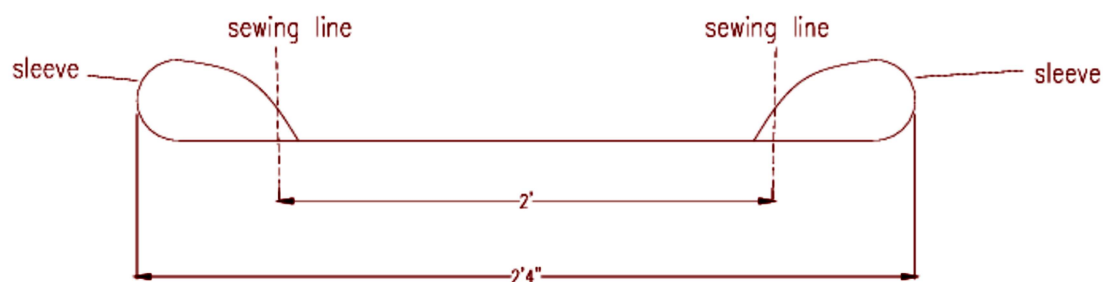
- After 24 hrs of casting, remove the mould at the GD clamps. After opening the cast, clean the dripline of any remnants of cement. Put the concrete base in the water for 7 days. Use a bucket/inflatable pool for water. After 7 days, remove the base from water and let it dry.(Refer Fig 37.7.2-9)



Fig 37.7.2-9 : Curing the cast

D. Tailoring work:

- Cut panels of tarpaulin in the size of 3'x2'8" (2inch gap for pipe sleeves on both ends) and 4'X2'8" as pre-estimated taking into consideration (Refer Fig 37.7.2-10)



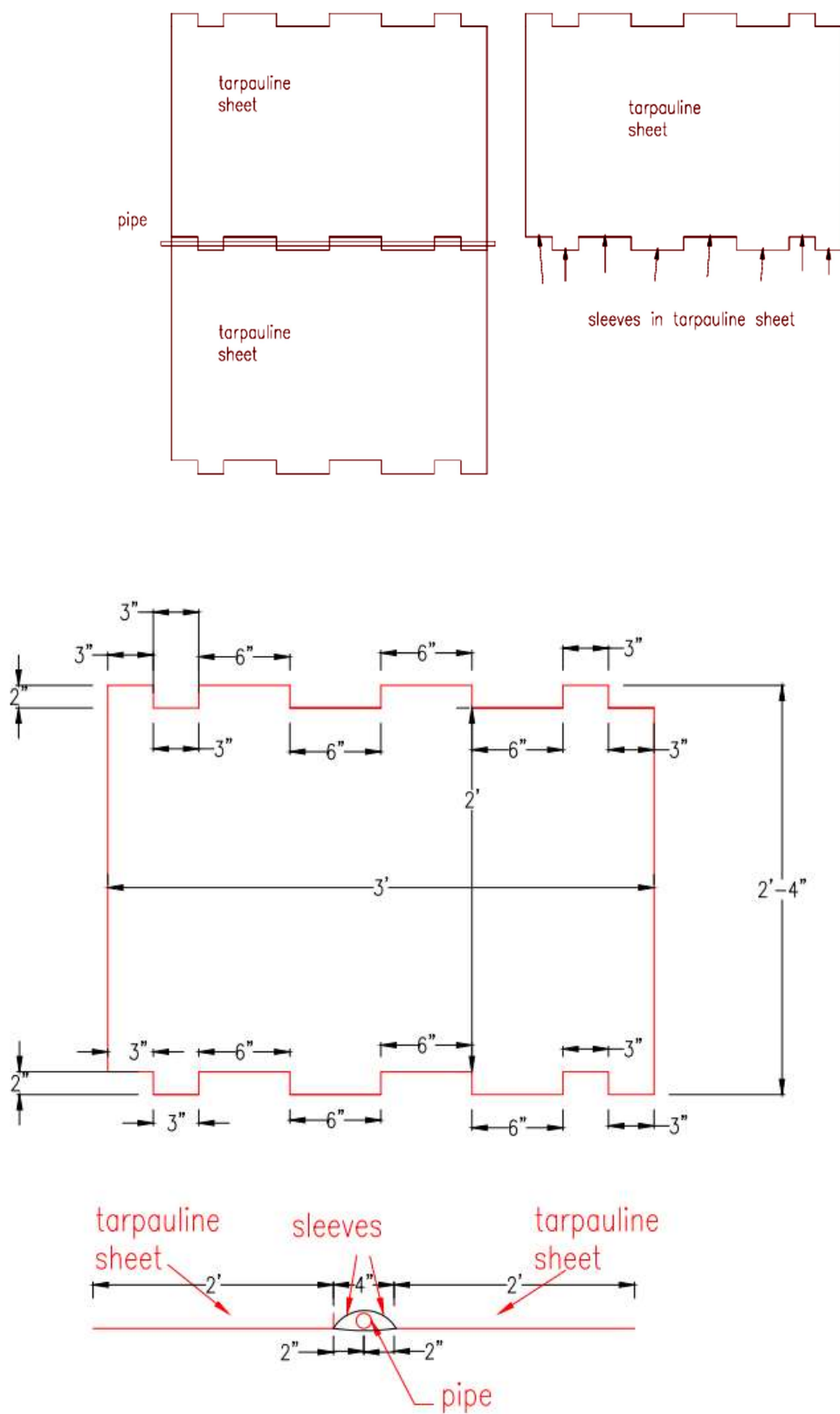


Fig 37.7.2-10 : Drawing of Stitching

- Cut 4 MLP layers of same dimensions and adhere it to the Tarpaulin sheet using the same process as described in the Internal Dynamic Barrier.(Refer Fig 37.7.2-11)



Fig 37.7.2-11 : Attaching MLP to Tarpaulin

E. PVC Pipe Work:

- Cut CPVC pipe of size 1" inch dia in lengths of 3'-2" and 4'-2". Measure the midpoint of the pipe and draw a "+" mark. Along the same line draw 2 more "+" marks which are 1" from the end of the pipe on each side. Ensure that these marks are collinear. Drill holes at the marked places with a drill bit whose diameter is less than that of the hook(5 mm drill bit) to be screwed. (Refer Fig 37.7.2-12)



Fig 37.7.2-13 : Marking of points to attach hooks.

- Attach the hooks with the pipe. (Refer Fig 37.7.2-14)



Fig 37.7.2-14 : Attaching hooks.

F. Curtain Assembly Work:

- Once the panels are ready, we need to connect them with the CPVC pipe.

- Take 2 panels and arrange them side by side. Now to connect the panels, slowly slide the CPVC pipe through the round sleeves eventually interlocking both the panels. (Refer Fig 37.7.2-15)



Fig 37.7.2-15 : Inserting intermediary PVC pipes to make the fractal.

- Based on the length needed for the house, the curtain will have 'n' number of panels. The interlocked panels will be folded into the curtain.
- Weld metal curtain rings to metal washers. (Refer Fig 37.7.2-16)



Fig 37.7.2-17 : Welding washer to metal curtain rings

37.7.3. Installation

A. Establishing Supports on the Roof:

- Mark out the exact location of the placement of the cast base supports. Use a wire brush to clean the roof and the base of the concrete blocks and roughen up both surfaces.
- Apply a thin layer of Araldite over both surfaces - cleaned patch of roof as well as the region on the base cast coming in contact with the roof. Place the concrete blocks with legs on that adhesive. Also

apply adhesive at the periphery of the concrete block in contact with the roof. Wait overnight (24hrs) for the concrete blocks to be properly stuck to the roof.

B. Barrier(Curtain) work with Wire-Rope:

- Using fabricated turn buckles, establish primary members(all four sides) for the fractals to slide on. Ensure that the designated number of fabricated metal curtain rings are put in orienting in a uniform direction. Induce tension into the system. (Refer Fig 37.7.3-1)



Fig 37.7.3-1 : Hooking up fractals to curtain rings

- Attach fractals to the rings on the steel rope. (Refer figure 7.17)

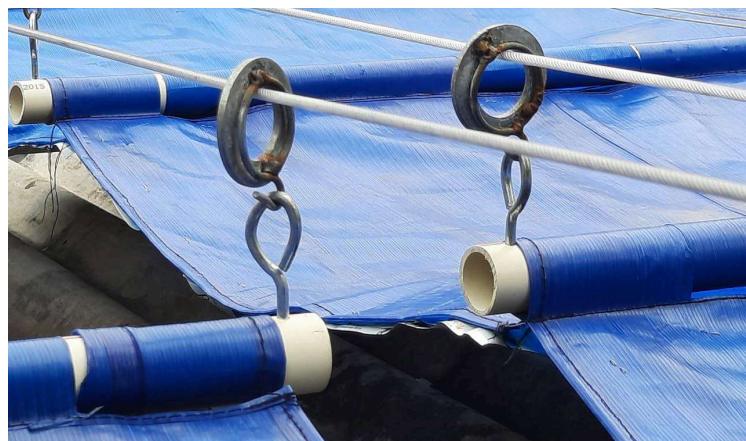


Fig 37.7.3-2 : Hooking up fractals to curtain rings

Operator's rope and pulley arrangement:

- Attach two pulleys at the center of the front steel wire rope and one at the rear steel wire rope of each fractal. Run a handling wire from the start of the first fractal through one of the pulleys in the front, down into a loop for handling, back through the second pulley at the front, passing through the rear pulley and attached to the front horizontal pipe, using a crimp. (Refer Fig 37.7.3-3)



Fig 37.7.3-3 : Placement of pulleys on front and rear end of the fractal along with handling mechanism

- Arrest the movement of the rear end of the fractal by tying the last set of curtain rings to the turnbuckle.



Fig 37.7.3-4 : Operating wire (highlighted by red) passing over pulleys used to open and close the fractal

37.7.4. Operation

- Similar to the Internal Dynamic Barrier, when you pull one end of the handling wire, the fractal opens and vice-versa.
- Tug at the nylon wire with uniform gentle force and not spurts of violent force.
- In case any resistance is observed, kindly pull back in the opposite direction and retry.

37.7.5. Maintenance

37.7.5.1. Monthly Maintenance

None

37.7.5.2. Quarterly Maintenance

- Grease the PVC coated steel wires, over which the Dynamic Barrier slides, every quarter.
- Introduce tension into the system by tweaking at the tension fastener, as and when any sag is observed in the fractal.

37.7.5.3. Annual Maintenance

- Check for any rupture on the Low-emissivity barrier and replace the particular fractals if necessary.

37.7.6. Do's and Dont's

- Ensure the roofing sheets to which base is being adhered to is properly attached to the structure.
- Use only slow setting Araldite.

37.8. MLP Static Panel

37.8.1. Pre-Installation Staging

Over the roof

- Ensure that the roof is leak proof :
 - Clean the roof thoroughly to identify repair points.
 - Identify weak points such as J hooks.
 - Plug weak points with cement mortar+water proof solution.
 - The application of any sealant on a corrugated roof should not hamper smooth water flow during rains.

Under the roof

- Mark the level of the installation on the four walls, ensuring a minimum gap of 6" between roof and installation for electrical wiring/repair and 6'-6" between floor and installation and other contextual considerations such as electrical wiring, shelving, position of windows etc.



- Based on the above, rewire and reposition lights and other electrical fixtures that might hinder the installation of the panels
- Plan the panel arrangement based on entrance, loft, and other contextual considerations.
- Measure the area for the panel installation to assess how much of the panel requires cutting towards the edges of the wall after whole panels are laid.
- Remove fans before installation

37.8.2. Fabrication

- 37.8.2.1.1. Make a 2 feet by 2 feet (0.75-1 inch thick) plywood frame



Fig 37.8.2.1.1-1 : Plywood Frame (2 feet by 2 feet)

- 37.8.2.1.2. Take 4 MLP layers, 2 Jute layers and 2 Bamboo strips (2 feet length, 1 inch thick, 0.5 inch width and assemble the components. (Refer F Fig 37.8.2.1.1-2 & 3)
- 37.8.2.1.3. Use a punch stapler to attach all the components together on the plywood frame. Don't punch staple in the middle of the MLP Static panel since

- 37.8.2.1.4. this may damage/tear the MLP sheet from the center of the panel (Refer Fig 37.8.2.1.1-4)
In Fig 37.8.2.1.1-3 some of the MLP sheets are shiny on both sides, This is completely fine. Ensure shiny side faces down in case one of the faces is non shiny.

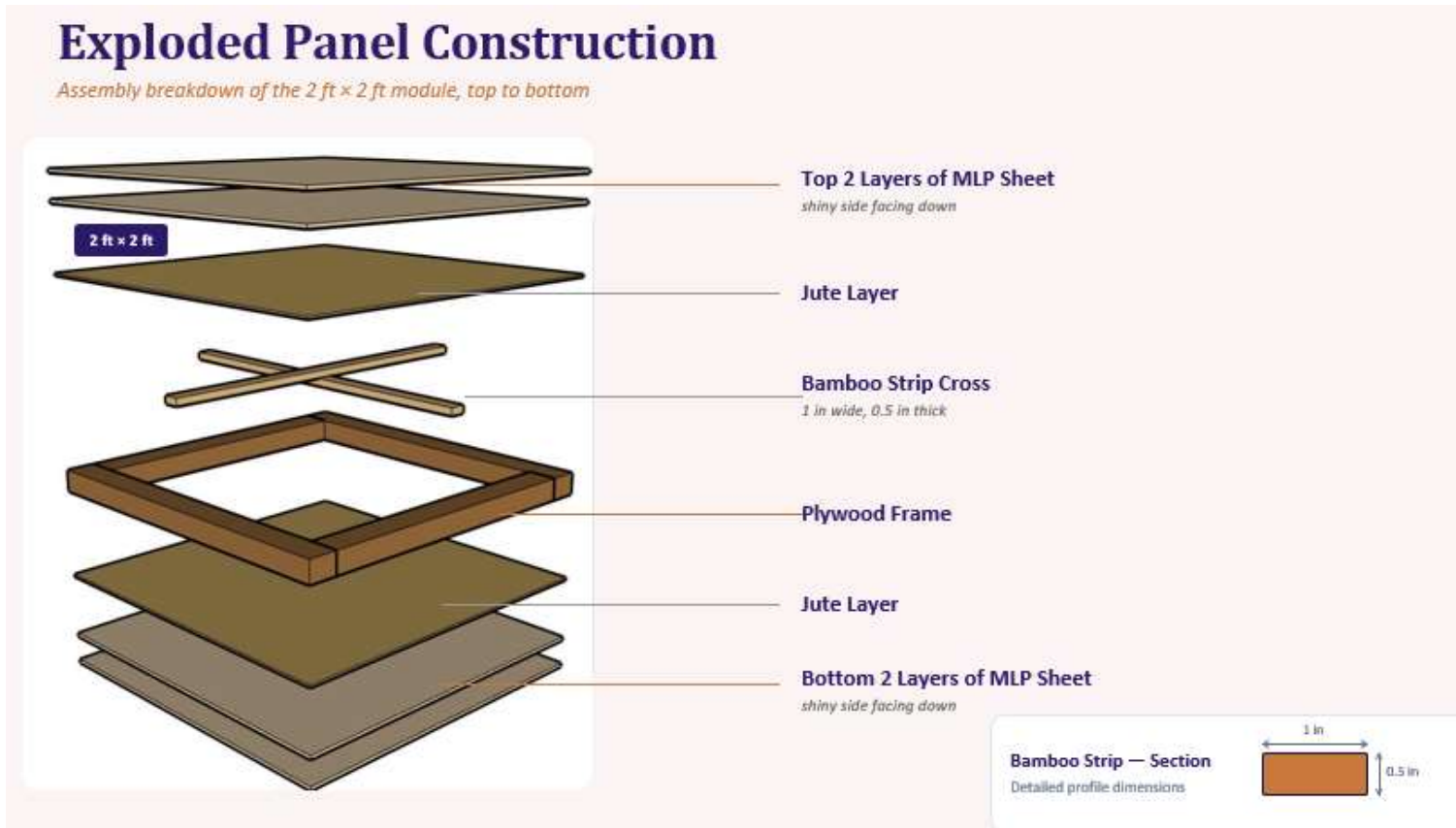


Fig 37.8.2.1.1-2 : Cross Section of MLP Static Panel



Fig 37.8.2.1.1-3 : Actual cross section of MLP Static Panel



Fig 37.8.2.1.1-4 : Attaching the components to the plywood frame with punch staple

- 37.8.2.1.5. Take a 3 feet by 4 feet MLP sheet as the bottom last layer and wrap it completely around the MLP frame so as to cover it entirely



Fig 37.8.2.1.5-1 : Positioning MLP Layer of size 3feet x 4 feet at the bottom for wrapping the assembly.

- 37.8.2.1.6. Using duct tape, firmly attach the edges of MLP to the panel
- 37.8.2.1.7. Attach the remaining free ends to cover the entire panel



Fig 37.8.2.1.6-1 : Join all the free ends of MLP at the back side of the panel using duct tape.

- 37.8.2.1.8. Final assembled panel
- 37.8.2.1.9. During installation, if panels need resizing at corners or edges to fit the space: remove the MLP cover, cut the frame to size, then re-wrap it.



Fig 37.8.2.1.8-1 : Final assembled MLP Static Panel

37.8.3. Installation

- Mark the 4 walls with coloured thread indicating the line on which drilling for the support frame will happen (Refer Fig 37.8.3-1)
- If using a steel alloy frame as support, choose a width that can seat the thickness of the panel but if using MS then choose an appropriate L angle.



Fig 37.8.3-1 : Marking on the wall

- Drill and fix the support on the edge of one wall and on the opposite edge. Drill and fix the next support length according to the width of the panel and place the supporting T Sections (Refer Fig 37.8.3-2)

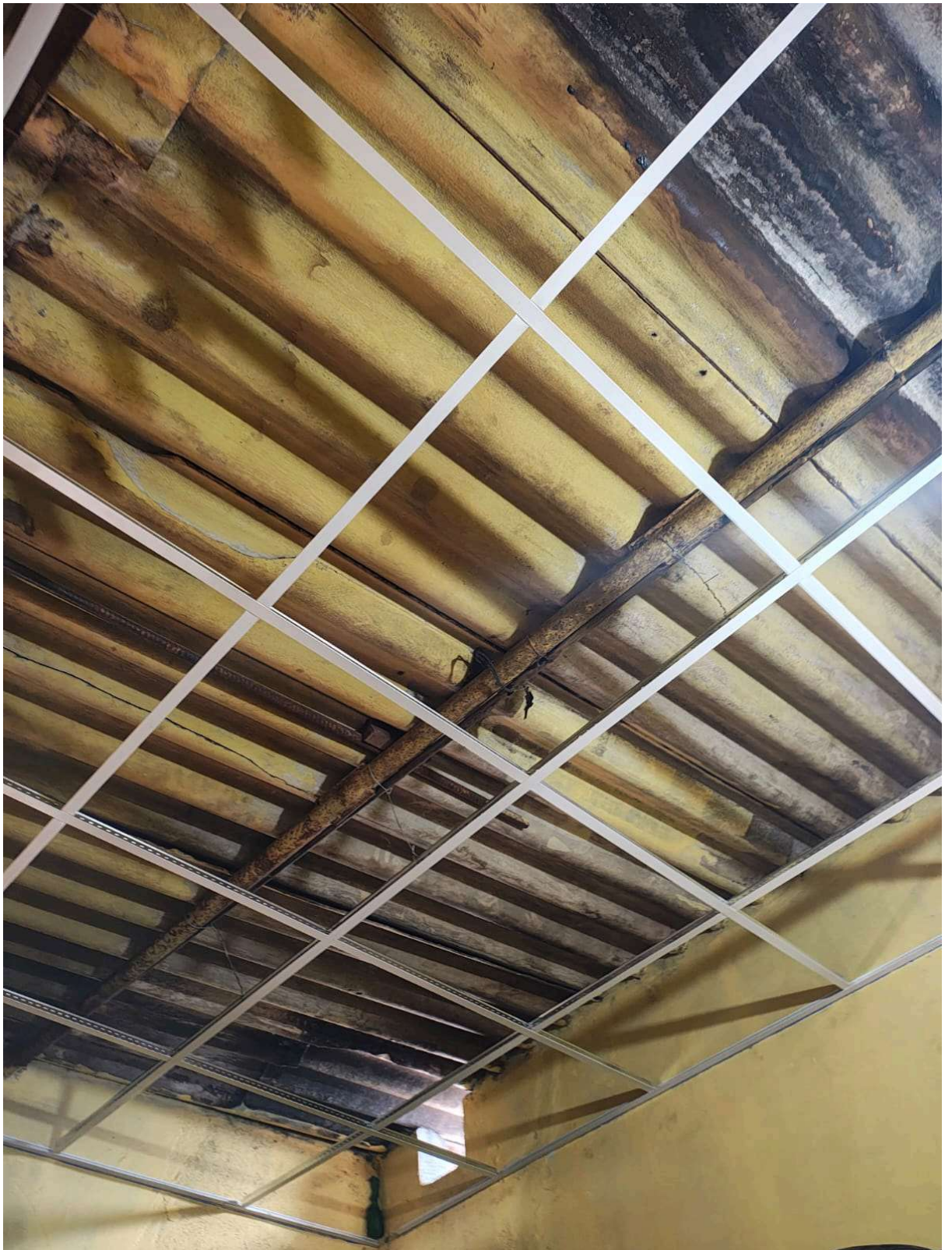


Fig 37.8.3-2 : Metal frame support for panels-installation in progress

- For a steel-alloy/aluminium frame, get extra support from the purlins by tying steel wires in different places between the frame

and a roof purlin/roof anchor (Refer Fig 37.8.3-3). This is an alternative way to fix under-roof panels.



Fig 37.8.3-3 : Extra roof support

- Lay the panels ensuring they sit snugly within the supports (Refer Fig 37.8.3-4 & 5)

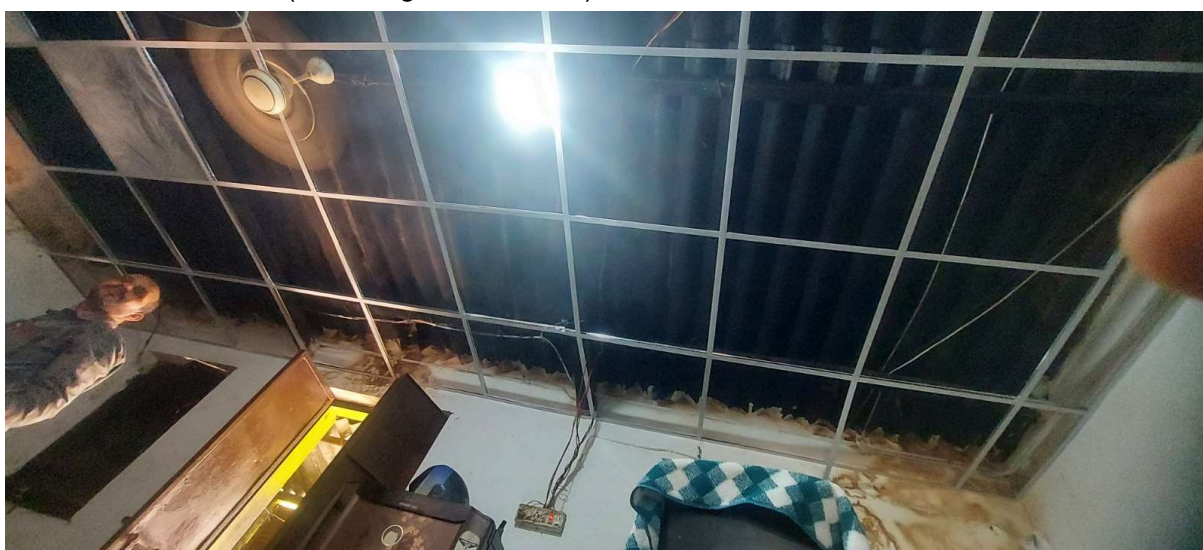


Fig 37.8.3-4 : Aluminium channel support framework with few panels in place



Fig 37.8.3-5 : Aluminum channel framework with all panels in place

- Ensure the installation leaves no gap in the edges of walls to prevent movement of small animals

37.8.4. Maintenance

37.8.4.1. Monthly Maintenance

- Look for visible signs of discolouration, powdering of panels, wet patches and see if the specific panels can be removed and replaced
- In case of powdering down from the panel, apply a layer of transparent paint to the specific panels and return them to place
- In case of leaks, remove respective panel and address the specific spot with adhesives/mortar either from under the roof or over the roof

37.8.4.2. Quarterly Maintenance

- If you find gaps have formed between the wall edge and support frame, over time, address it to ensure the gap is covered
- Look for visible signs of discolouration, powdering of panels, wet patches and see if the specific panels can be removed and replaced
- In case of powdering down from the panel, apply a layer of transparent paint to the specific panels and return them to place
- In case of leaks, remove respective panel and address the specific spot with adhesives/mortar either from under the roof or over the roof

37.8.4.3. Annual Maintenance

- Check the MS supports for rusting and paint them
- If you find gaps have formed between the wall edge and support frame, over time, address it to ensure the gap is covered
- Look for visible signs of discolouration, powdering of panels, wet patches and see if the specific panels can be removed and replaced
- In case of powdering down from the panel, apply a layer of transparent paint to the specific panels and return them to place
- In case of leaks, remove respective panel and address the specific spot with adhesives/mortar either from under the roof or over the roof

37.8.5. Do's and Dont's

- 37.8.5.1.1. Do clean the roof off cobwebs from time to time
- 37.8.5.1.2. Do not take naked flames close to the ceiling
- 37.8.5.1.3. Do check regularly if the water is leaking from the roof cracks
- 37.8.5.1.4. Do not keep anything inflammable in the room during the time of installation

37.9. Umbrella MLP

37.9.1. Pre-Installation Staging

- 37.9.1.1.1. Cut the MLP in the same size as a street vendor umbrella diameter.
- 37.9.1.1.2. Inspect the umbrella frame for structural integrity - check all spokes, the central pole, and the fabric for damage or rust before proceeding with next steps.
- 37.9.1.1.3. Ensure the following materials are on site before beginning fabrication - a) MLP sheets, b) glue tape velcro (hook side), c) velcro loop side strips, and stitching materials.



37.9.2. Fabrication



Fig 37.9.2-1 : Measuring the underside of the Umbrella spoke length and segment dimensions

- 37.9.2.1.1. Open the street vendor umbrella fully and lay it face-down on a flat clean surface with the underside facing upward. Using a measuring tape, measure the length of each spoke from the central hub to the outer tip, and the width of each triangular segment at its widest point at the outer edge. Note these dimensions as they will serve as the template for cutting both the velcro strips and the MLP panels.



Fig 37.9.2.1.1-1 : Measuring & Cutting the velcro strip to the exact length of the spoke

- 37.9.2.1.2. Cut the velcro strips to match the length of each spoke. Each spoke requires two pieces of velcro, one piece running from the central hub to the midpoint of the spoke, and one from the midpoint to the outer tip - leaving a small gap at the midpoint joint to allow the umbrella to open and close freely without stress on the velcro. Cut one set of strips for all spokes in this manner.



Fig 37.9.2.1.2-1 : Peeling the adhesive backing paper from the velcro hook strip before application

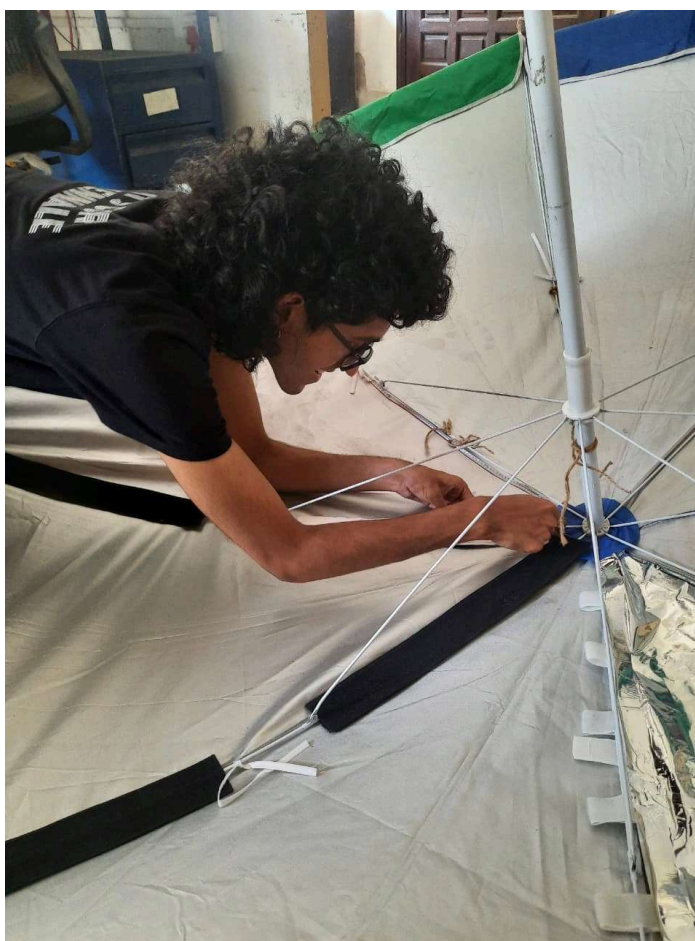


Fig 37.9.2.1.2-2 : Team Member attaching Velcro strip

- 37.9.2.1.3. For each spoke, take the first velcro strip, this is the hook side (the hard, rough surface). Orient it such that the hook side faces downward toward the umbrella fabric and the adhesive (sticky) side faces upward. Do not remove the full adhesive backing paper at once. Peel back only a small section at the top and bottom end of the strip first. Press these two exposed ends firmly onto the spoke to anchor the strip in alignment. Once aligned correctly, slowly pull the remaining backing paper out from between the velcro and the spoke, pressing down along the length as you go. This prevents the strip from misaligning or sticking to itself before placement is confirmed. Repeat for all spokes.

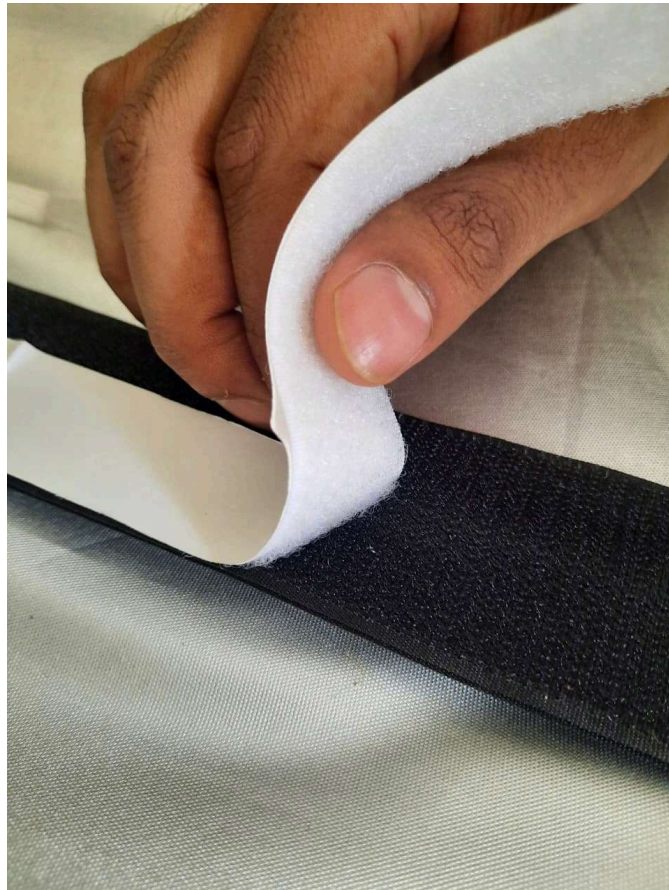


Fig 37.9.2.1.3-1 : Close-up of velcro hook side (black/rough) and loop side (white/soft) being separated, showing the self-adhesive backing



Fig 37.9.2.1.3-2 : Top view of umbrella laid flat showing velcro

strips covered to spoke

- 37.9.2.1.4. Take the second velcro strip, this is the loop side (the soft, fuzzy surface). Press it onto the hook side strip already fixed to the spoke so both velcro sides engage and hold together. The adhesive (sticky) side of the loop strip now faces upward, away from the umbrella. This upward-facing sticky surface is what the MLP panel will attach to. Repeat for all spokes.



Fig 37.9.2.1.4-1 : Cutting of Mlp according to measurements taken



Fig 37.9.2.1.4-2 : MLP cut in Triangular shapes

- 37.9.2.1.5. Cut the MLP panels into triangular shapes to match each segment of the umbrella. Cut each triangle slightly larger than the measured segment size approximately 1 to 2 cm extra on each border edge

to ensure the panel fully covers the segment without falling short during attachment. Two MLP sheets are stuck together for each panel so the shiny (reflective) surface faces outward on both the upper and lower faces of the panel.



Fig 37.9.2.1.5-1 : MLP triangle is attached to umbrella with loop side(soft velcro)
Attached to mlp non shiny side



Fig 37.9.2.1.5-2 : Ensures the panel is correctly positioned before full adhesion.

- 37.9.2.1.6. To attach each MLP triangle panel to the umbrella, place the panel on top of the soft velcro strips on the spokes with the non-shiny side facing the umbrella fabric. Do not remove the full adhesive backing from the loop-side velcro at once. Peel back only the very edge of the backing at one corner first and press the MLP panel to that point. Align the panel carefully across all three borders of the segment. Once satisfied with the alignment, slowly peel the remaining backing paper out while pressing the MLP down onto the velcro along each spoke. This step-by-step peeling ensures the panel is correctly positioned before full adhesion.



Fig 37.9.2.1.6-1: Shiny (reflective) side of MLP panels facing upward full umbrella covered, visible from top, showing the silver reflective surface of MLP across all 8 segments

- 37.9.2.1.7. Repeat the above step for all remaining segments until the full umbrella surface is covered with MLP panels. Inspect the completed installation to confirm all panels are flush against the umbrella fabric, all borders are seated on the velcro strips, and the shiny reflective side is uniformly facing upward.

37.9.3. Installation

- 37.9.3.1.1. Erect the umbrella pole at the vendor's site and open the umbrella fully.



- 37.9.3.1.2. Confirm all MLP panels are securely attached to the velcro strips along the spokes and no panel is lifting or misaligned after the umbrella is opened.
- 37.9.3.1.3. Orient the umbrella such that the shiny (reflective) side of the MLP panels faces upward toward the sky, maximising reflection of incoming solar radiation away from the vendor and goods below. If any panel has shifted during opening, press it firmly back onto the velcro strips.
- 37.9.3.1.4. Operation



Fig 37.9.3-1 : Another angle of the reflective MLP surface from top

- 37.9.3.1.5. Open the umbrella fully before 8 am to shield the vendor and goods from direct solar radiation.
- 37.9.3.1.6. The velcro attachment allows panels to be detached individually for cleaning or replacement without removing the full solution.
- 37.9.3.1.7. At the end of the day or during heavy rain, the umbrella can be closed and the MLP panels fold along with the umbrella fabric naturally due to the flexible velcro attachment.

37.9.4. Maintenance

37.9.4.1. Monthly Maintenance

- Use a dry, soft cloth to wipe the shiny surface of the MLP panels to remove dust and maintain reflective efficiency.



Check all velcro joints for loosening and press them back firmly where needed.

37.9.4.2. Quarterly Maintenance

- Inspect the MLP panels for any tears, punctures, or delamination of the double-layered sheets. Replace any damaged panel. Check the hook-side velcro on the spokes for adhesive failure and re-glue if required.

37.9.4.3. Yearly Maintenance

- Remove all MLP panels, clean them thoroughly, and inspect the umbrella frame for rust or structural weakening. Reattach panels after inspection.

37.9.5. Do's and Dont's

- Ensure the umbrella is fully open and stable before attaching or detaching MLP panels.
- Do not fold the umbrella forcefully when MLP panels are attached as this may tear the velcro or delaminate the MLP sheets.
- Do not expose the MLP panels to open flame or high heat sources in close proximity.

37.10. Tarpaulin MLP

37.10.1. Pre-Installation Staging

- Visit the site and measure the area to be covered as per the user's specific requirement length and width of the tarpaulin to be used.
- Inspect the installation site for any sharp protrusions, rough edges, or structural issues that could damage the MLP or tarpaulin during or after installation.
- Ensure all materials are on site before beginning fabrication tarpaulin sheet of required dimensions, MLP sheets, red double-sided tape, grey industrial duct tape, and stitching materials.

37.10.2. Fabrication



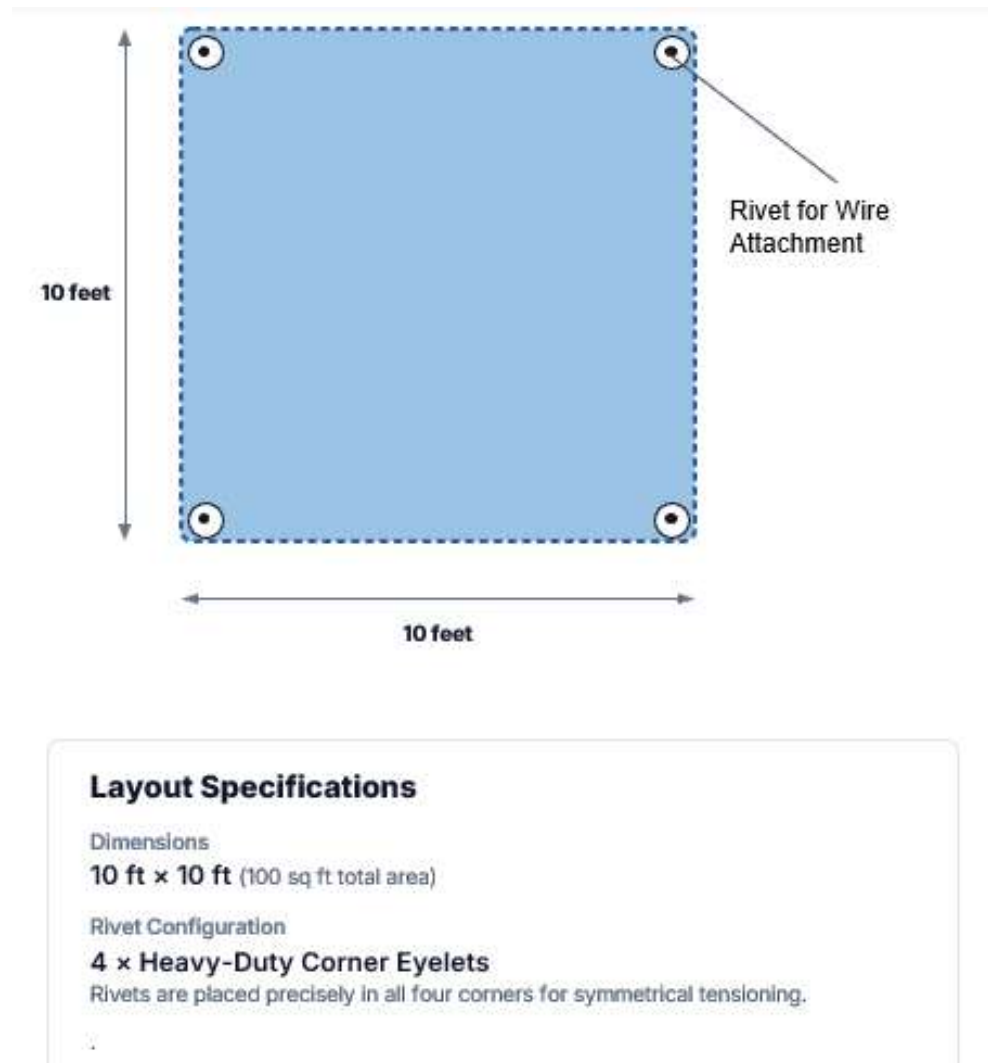


Fig 37.10.2-1 : Top View of Tarpaulin Showing Rivet and Eyelet Locations at Four Corners for Wire Attachment



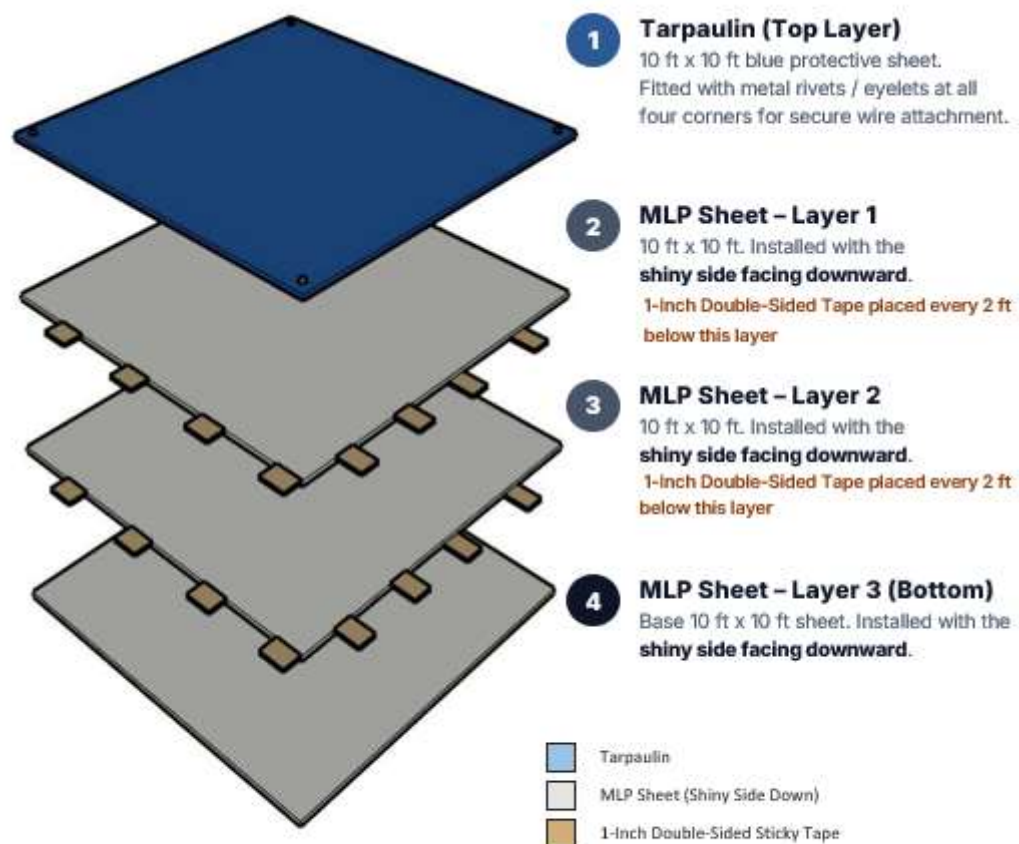
Fig 37.10.2-2:Tarpaulin Sheet of Required Dimensions

- Cut the tarpaulin sheet to the required dimensions as measured during the pre-installation staging.



Fig 37.10.2-3 : MLP Sheet Placed Over Tarpaulin for Alignment and Size Verification

- Cut MLP sheets to match the dimensions of the tarpaulin. Three MLP layers will be stacked and bonded to form one composite MLP sheet.



STACKING ORDER: 1 Tarpaulin (Top) → 2 MLP Layer 1 → 3 MLP Layer 2 → 4 MLP Layer 3 (Bottom)
Double-Sided Tape (Interspersed)

Fig 37.10.2-4 : Exploded View Stacking Order of Tarpaulin and Three MLP Layers with Double-Sided Tape Placement

- Place the first MLP sheet flat on a clean surface with the shiny side facing down. Apply red double-sided tape across the non-shiny surface in parallel strips with uniform spacing, covering the full area.
- Peel the cover from the double-sided tape and place the second MLP sheet on top, pressing firmly to bond the two layers together.
- Repeat the same process, apply red double-sided tape to the top surface of the second MLP sheet and bond the third MLP sheet on top, ensuring all three layers are firmly adhered to form a single composite sheet.
- Seal all four borders of the three-layer MLP composite sheet with grey industrial duct tape, running it along the full perimeter to prevent delamination at the edges and to protect the layers from moisture ingress.

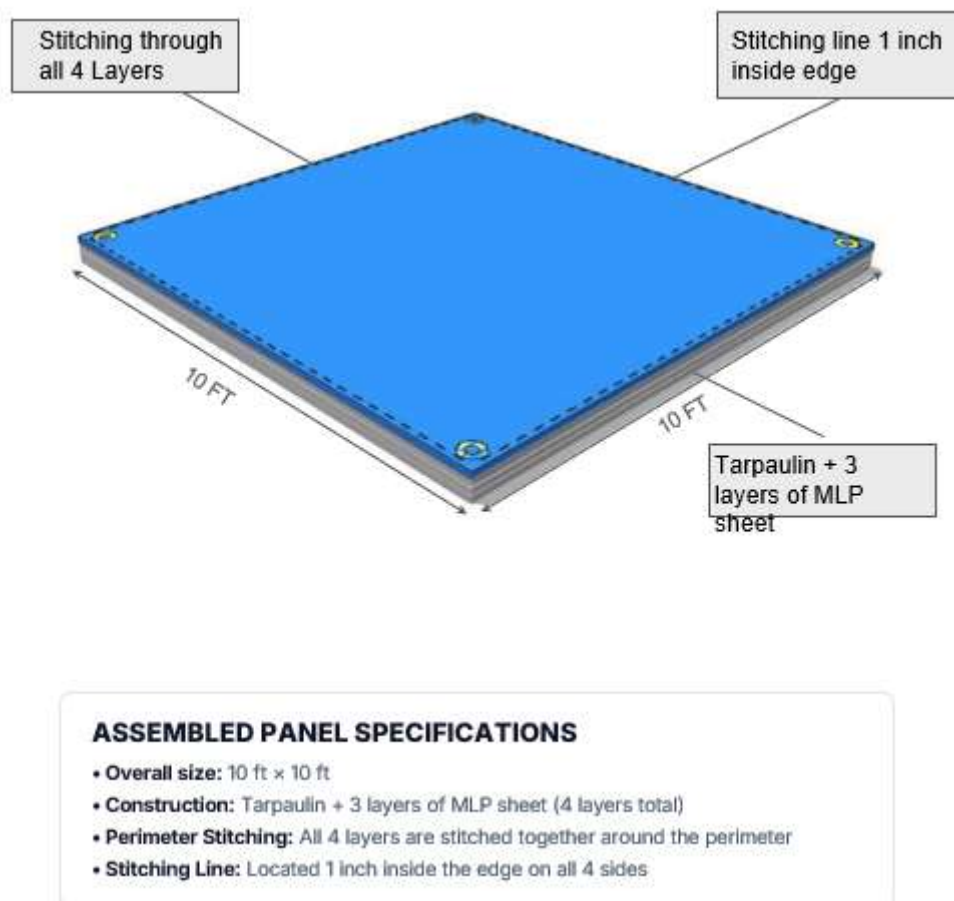


Fig 37.10.2-5 : Assembled Tarpaulin MLP Panel — Four Layers Stitched Together with Stitching Line 1 Inch Inside Edge on All Four Sides

- Place the fabricated MLP composite sheet on top of the tarpaulin, aligning edges carefully. Stitch the MLP composite sheet to the tarpaulin along all four borders, and at regular intervals in between with appropriate spacing to ensure the MLP sheet is uniformly anchored to the tarpaulin and does not shift or buckle.

37.10.3. Installation

- Position and install the Tarpaulin MLP in its intended location as per the user's site requirements.
- Ensure the shiny (reflective) surface of the outer MLP layer is oriented to face the direction of incoming solar radiation upward for overhead coverage.
- Secure the tarpaulin edges using existing tarpaulin fastening mechanisms such as hooks, ropes, or clamps appropriate to the site.
- Check that the MLP sheet is not pulling loose from its stitched attachment to the tarpaulin and that all stitched borders are intact.

37.10.4. Operation

- The Tarpaulin MLP is a passive static solution no active user operation is required during the day.
- The three-layer MLP composite bonded to the tarpaulin adds radiant heat reflection and thermal mass to the conventional tarpaulin, reducing heat gain for the space below.
- Position the Tarpaulin MLP in place before 8 am for maximum effectiveness during peak solar hours.

37.10.5. Maintenance

37.10.5.1. Monthly Maintenance

- Wipe the shiny surface of the MLP with a dry cloth to remove dust.
- Check that the stitching securing the MLP to the tarpaulin is intact at all borders and intermediate stitch lines.

37.10.5.2. Quarterly Maintenance

- Inspect the duct tape sealing the borders of the MLP composite sheet for peeling or lifting.
- Re-seal with fresh grey industrial duct tape where needed.
- Check for any delamination of the three MLP layers and press back using red double-sided tape or replace the panel if required.

37.10.5.3. Yearly Maintenance

- Remove the Tarpaulin MLP, clean both the tarpaulin and MLP surfaces, and inspect the tarpaulin for tears or weakening.



- Replace the MLP composite sheet if layers have significantly degraded.

37.10.6. Do's and Dont's

- Ensure stitching is done at regular uniform intervals to prevent the MLP sheet from bunching or shifting over time.
- Do not use single-sided tape as a substitute for red double-sided tape as it will not provide sufficient bonding between MLP layers.
- Do not expose the MLP composite sheet to open flame or sharp objects that could puncture or melt the plastic layers.
- Conduct additional checks after heavy rain or strong winds to ensure the installation is secure and no stitching has come undone.

37.11. Vertical Bamboo Blind

37.11.1. Pre-Installation Staging

- Divide the wall area to be covered into segments where the openings(door and windows) are present 'vs' where they aren't.
- Delineate the segments where the openings aren't present, is where the dynamic barrier should be fabricated. (Refer Fig 37.11.1-1 & 2)

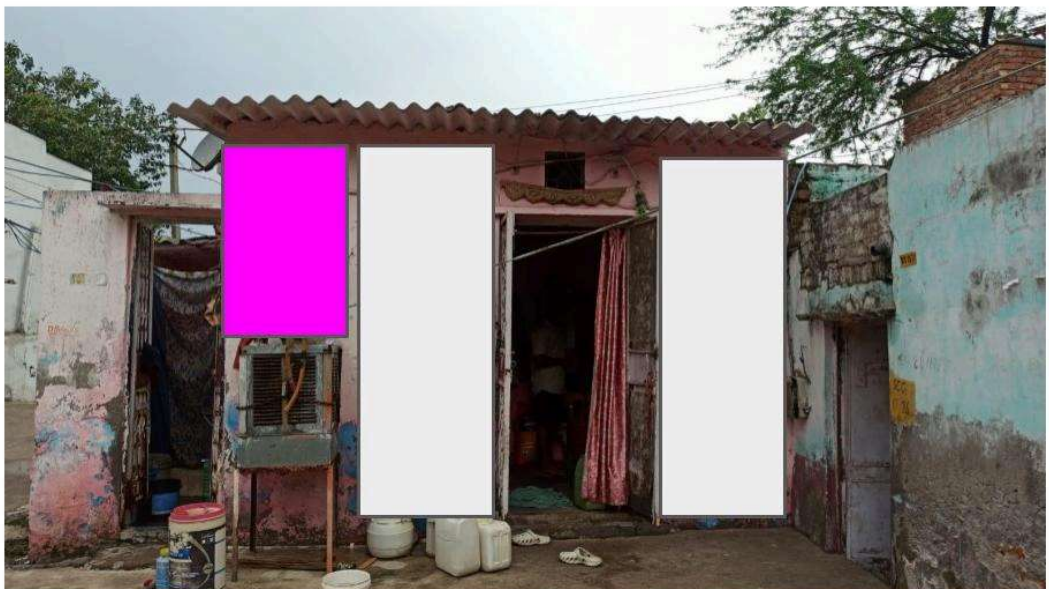


Fig 37.11.1-1 : Delineating the Dynamic(white) and Static components(pink)



Fig 37.11.1-2: Delineating the Dynamic(white) components

- The spaces above and below the window, as well as above the door are to be designated for static barriers.
- Check for any possibility of pre-existing truss or member near the roof overhang, so the barriers can be suspended directly from them. If yes, please test if the member can take the load of the Bamboo Blind. If not, we will have to take supports from the wall by driving anchor bolts.

37.11.2. Fabrication

A. Preparation of Vertical Barrier:

- The width of the dynamic barrier shall be taken as the distance between the openings(door and window) and one of the openings to the edge of the wall. Consider 4 feet to be the maximum width of each fractal. Employ a second fractal in case of larger widths.
- For the length, avoid considering the entire wall height and limit it to 1.5 feet less than the wall height. We will place the Vertical

Barrier in the middle of the wall and not to either extreme. If the Cane Blind is touching the ground, it is prone to faster degradation.

- For the width of the static barrier, take it 6" less than the actual span of the opening. This is to provide a buffer between adjacent fractals to facilitate dynamic movement.
- Order for the manufacturing of Bamboo Blinds with the said dimensions. Cut 3 MLPs each equal to the size of manufactured Bamboo Blinds in width and 6 inches longer than the length of the Cane Blind.
- Adhere MLPs to the Bamboo Blind, using the zip tag ties as we did for the Internal Dynamic Barrier in the middle.
- Put a duct tape over the edges and use plastic ties (20-30mm length) to tie the shorter edges to Bamboo stick at top and bottom along the length.(Refer Fig 37.11.2-1)

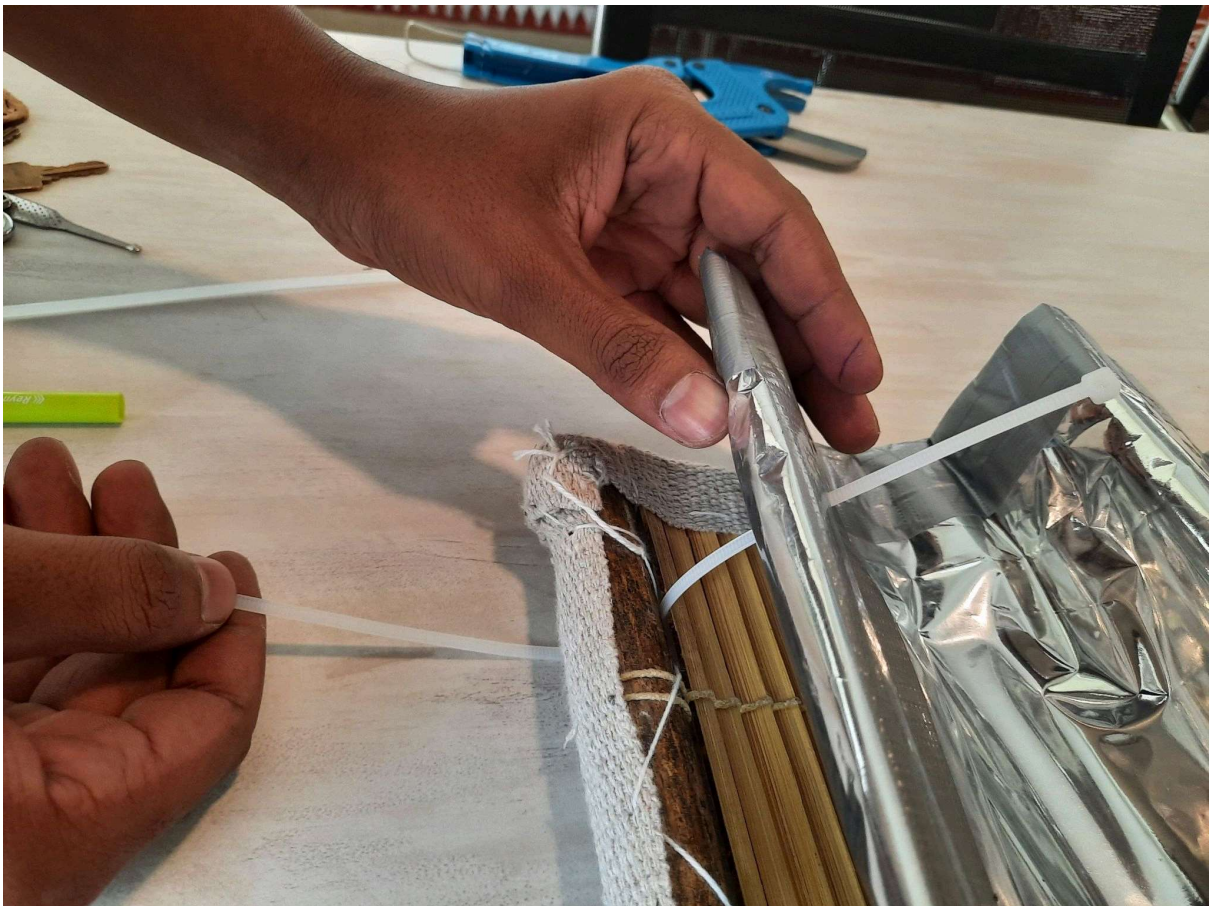


Fig 37.11.2-1 : Fixing the edges with plastic ties to bamboo stick at the top and bottom section

B. Establishing Supports:

- If there is an existing overhang purlin, which can take the load of a Vertical Barrier, utilise it to hang the Vertical Barrier. (Refer figure 11.3)

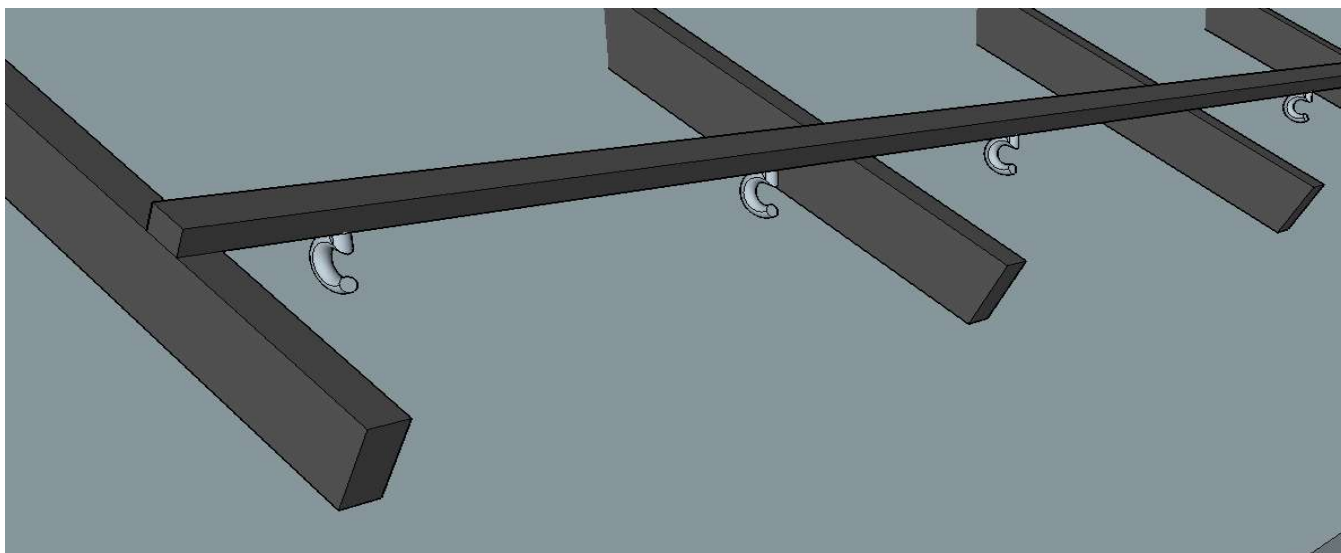


Fig 37.11.2-2 : Fabrication of supports for Vertical Barrier (variant 1)

- In case that isn't available, drill holes to the wall at a level from where measurements were taken from.
- Follow the same pattern of support positions as that of Internal Dynamic Barrier - 5 inches from either end and one at the mid point - 3 supports per fractal.
- Ensure there is at least a buffer of 6 inches between adjacent fractals to facilitate easy rolling and unrolling (Refer Fig 37.11.2-3)



Fig 37.11.2-3 : 6-inch buffer between adjacent installations

37.11.3. Installation

- With a help of a Galvanised Iron wire tie the topmost Bamboo section to the hooks.
- Ensure the rolling is happening to the outer side. (Refer Fig 37.11.3-1)

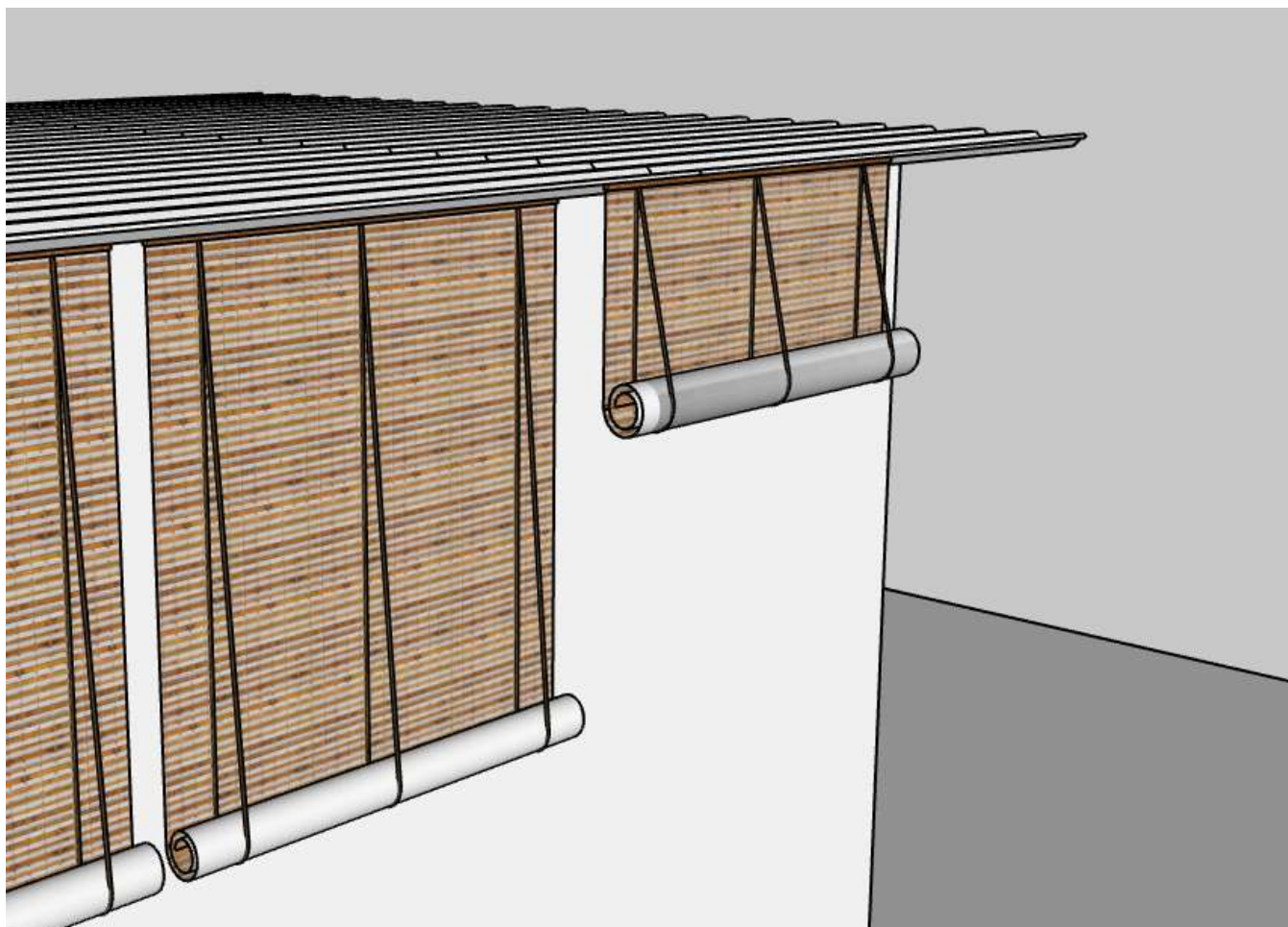


Fig 37.11.3-1 : Rolling of the Vertical Barrier to the outside

37.11.4. Operation

- The Vertical Barrier is to be opened before 8 am, shielding the structure from direct sunlight.
- By sunset, about 6pm, the barrier can be rolled up, so that the walls/ structure is exposed to night sky radiation.

37.11.5. Maintenance

37.11.5.1. Monthly Maintenance

- Use a dry and soft cloth to clean the shiny surface of the installation.

37.11.5.2. Quarterly Maintenance

- Check if there have been any ruptures to the Multi-Layer Plastic sheet caused by abrasion or anything else.

37.11.5.3. Annual Maintenance

- Check for signs of oxidation at the Galvanised Iron wires, using which the Bamboo section has been suspended.

37.11.6. Do's and Dont's

- While stapling, keep the axis of stapler perpendicular to the Bamboo Stick. Having them on the same axis longitudinally will split the Bamboo.
- While inserting the primary bamboo section into the hook supports established, ensure that the movement of handling rope isn't being hindered.
- During the rainy season, it is advisable to keep opening the Vertical Barrier intermittently to let off water which might have gotten logged within the fractal. This is to help discourage mold formation due to water logging.

38. Site Safety and Equity Checklist

38.1. Installation Preparation Checklist

38.1.1. With Fabrication/Installation Partners

- Discuss non-negotiable criterion with partner
 - Safety Protocol
 - Adherence to timelines.
 - No employment of child labor (i.e. a person below the age of 18).
 - No harm to persons, animals and plants.



- Following Labour Laws and payment of minimum wages as per regional laws, rules and regulations.
- Identify and ensure provision (by partner) of relevant safety material during fabrication process
 - Rubber/Electrical Safety Gloves (in case of electrical work)
 - Protective Glasses (in case of welding and grinding)
 - Safety Helmet
 - Metal Toe Boots
 - Safety Belts (in case of sites requiring scaffolding or working at heights greater than 12 ft)
- Ensure concurrence with the criterion that site work will be halted if any of the above safety gear is not appropriately used at all times when pertinent.
- Discuss prototype designs with the fabricator.
- Visit households to evaluate feasibility of installation with the fabricator.
- Strategize prototype design implementation based on house structure evaluation with fabricator.
- Share BOQs with the project partner.
- Discuss the types of installation material required based on implementation strategizing discussion with fabricator.
- Discuss the quantity of installation material required with the fabricator.
- Get a tentative daily schedule from the fabricator for material procurement and installation.
- Facilitate a safety protocol meeting with the installation supervisor and project workers before commencing installation work.
- Agree that material use practices will be rooted in sufficiency with efforts taken to minimize material wastage.
- Conduct 'Site Access' evaluation
 - Evaluate the need for scaffolding for each specific installation site; ladders are not permissible to reach elevations higher than single story.
 - Evaluate the need for ladders.
 - Rent or procure ladders subsequent to an exhaustive inspection of overall structural integrity , integrity and provision of firm foot holds and hand holds.
 - Evaluate the need for a long wooden stick.
 - Rent or procure a long wooden stick

- Evaluate the need for a tall stool.
- Rent or procure a tall stool subsequent to an exhaustive inspection of overall structural integrity , integrity and provision of firm foot holds.
- Fill out Site Access Audit Sheet (**see Appendix**)
- Conduct 'Electrical Hazard' evaluation
 - Evaluate the need for an Electrical Safety Audit.
 - Find an electrician in the community with support from NGO partners.
 - Facilitate the conducting of an electrical audit by the electrician for each household to ensure the absence of stray currents and other electrical hazards that can undermine safety during site work.
 - Address any electrical hazard at least 2 days prior to commencement of site work.
 - Fill out Electrical Safety Audit Sheet (**see Appendix**)
- Conduct 'Fire Hazard' evaluation
 - Evaluate the need for a Fire Safety Audit.
 - Conduct a Fire Safety Audit to identify tasks, materials and locations that warrant the availability of a Fire Safety and Response Kit.
 - Fill out Fire Safety Audit Sheet (**see Appendix**)
- Conduct 'Inconvenience/Interference' evaluation
 - Check if the neighbours walls or roofs are going to be affected due to the installation.
 - Seek consent from the neighbours in case their walls and roofs are getting affected due to the installation.
 - Fill out Interference/Inconvenience Audit Sheet (**see Appendix**)
- Conduct 'Lighting' evaluation
 - Evaluate need for lighting fixtures such as flood lights, hand lights and area lighting if site work is anticipated in dark working conditions.
 - Procure these lighting fixtures, appliances as necessary.
 - Identify appropriate locations for installation of lighting fixtures.
 - Engage with an Electrician to facilitate Installing of lighting fixtures prior to first day of site work.
 - Fill out Lighting Audit Sheet (**see Appendix**)

38.1.2. With Community Members

- Seek installation consent from households.



- Conduct 'Residents Needs' evaluation
 - Check if suggested installation day/time is suitable for households.
 - Connect with households before installation to understand the need to make arrangements for food.
 - Connect with households before installation to check if there is a need for a place for family members to stay during installation.
 - Arrange for a room for residents to stay during installation with support from NGO partners.
 - Fill out Residents Needs Audit Sheet (**see Appendix**)
- Arrange for a place in the community to store fabrication material with support from NGO partners.
- Check for community members who can support food preparation with support from NGO partners.

38.1.3. Within Project Coordination Team

- Print site supervision checklist, log book and grievance book.
- Establish site supervision team, and team member rotation schedule, consisting of a minimum of 3 team members, with 2 being present on site at all times.
- Orient team members about the prototypes to be installed.
- Orient team members to the purpose and use of the site supervision checklist.
- Conduct Site-Work Training-by-Simulation session (**see Appendix**)
- Ensure team members are informed about forums and avenues to raise workplace concerns especially those related to unethical conduct, rupturing of trust, and physical or psychological harassment by any one engaged in the effort.
- Assemble 2 **First-Aid Kits** containing at least the following, checking for their expiry date which should extend beyond the anticipated duration of the site work:
 - Gauze
 - Electral powder
 - Soframycin
 - Burnol
 - Dettol
 - Band-aid / Sterilized dressing



- Scissors
- Cotton Wool
- Surgical tape
- Assemble **Fire Safety and Response Kits**, if necessary as ascertained by referring to conclusions stated in **Fire Safety Audit Sheet**, containing at least the following, checking for their expiry date which should extend beyond the anticipated duration of the site work:
 - Fire Extinguishers
 - Sand Buckets
- Assemble **Nutrition Kit** containing adequate quantities of the following foodstuffs to last for 1 week, checking for their expiry date which should extend beyond the anticipated duration of the site work:
 - Digestive Biscuits
 - Fruits
 - Glucon-D or similar drink mixes, syrups for rapid replenishment of salts and sugar
- Purchase **Enabler Kits** containing adequate quantities of the following other materials:
 - Pens
 - Torchlight
- Determine location placement of all vital materials to enable unhindered and access during all hours of site work.
- Design, print and laminate signs in multiple languages indicating First-Aid Kit, 'site work in progress' and other potential site hazards such as slippery conditions, falling objects. electrical hazards, fire hazards etc.
- Identify locations for installing signs.
- Install signs.
- Develop the following emergency contact list and encode into all team member's phones and that a printout of the following is available:
 - Local Hospitals
 - Local Clinics
 - Local Fire Station
 - Local Police Station
 - Taxi/Autorickshaw Persons residing in the settlement
- Print the following:



- Grievance Booklet
- Log Booklet
- Emergency Contact List

38.2. During-Installation Checklist

- Commence work with minimum interference to the surroundings so as not to create any pedestrian blockage or obstruction and prevention of injuries.
- Discuss installation details with the fabricator.
- Begin work only when there are a minimum of 2 workers to support the process.
- Conduct the following routine cyclical tasks during the installation :
 - Halt work if a minimum of two workers and site safety supervisor are not present on site at any point in time.
 - Halt work if any safety gear is not appropriately used at all times when pertinent.
 - Check for minimum interference/ obstruction in the pedestrian pathway.
 - If a ladder is used, check that a person is constantly engaged in holding the ladder firmly in place with their legs and arms.
 - Check that the water bottles are filled.
 - Offer water and other nutritional supplements every hour.
 - Offer a 5-10 minute pause every hour.
 - If child labour is present follow steps mentioned in the **‘Emergency Protocol’ checklist.**
 - Warn by-passers about possible dangers if they are in close proximity to the installation work.
 - Check that no harm is done to the inhabitants and their belongings
 - Click photographs and videos after every hour.
- Provide project workers with a torch in case of dark working conditions.
- Attempt to resolve any grievances by project workers and residents non-violently.
- For minor injuries/ accidents, use the first aid kit.
- For major injuries/accidents take the injured person to the nearest clinic or hospital.
- For electrical hazards follow the steps mentioned in the **‘Emergency Protocol’ checklist.**



38.3. Post-Installation Checklist

- Check that no loose ends or gaps remain which can cause water ingress, enable entry of pests etc.
- Thoroughly check the integrity and safety prototype installation before re-inhabitancy, so that no casualties or injury is incurred on the inhabitants of the house.
- Fill out **log book** with following details:
 - Any property damage and reimbursement amounts to be commissioned.
 - Grievances by project workers and residents in the grievance book.
 - Work to be done the next day, as discussed with the fabricator
 - Reporting time for the next day.
- Check that installation material is cleared from the residents house.
- Check that the waste is segregated and appropriately disposed off by the fabricator
- Update the residents about the day's work and the work that will happen tomorrow.
- Inform residents about the installation team's reporting time for the next day (if applicable).
- Place the following in the material storage room:
 - First Aid Kit
 - Fire Safety and Response Kit
 - Nutrition Kit
 - Enabler Kit
 - Wooden Stick
 - Ladder
 - Stool
 - Booklets and Checklists
 - Safety Gear
- Have a handover call with the next day's team to get updates on the following :
 - Read **log book** entries.
 - Commence reimbursement for any damage to residents
 - Any particular safety measures to be mindful of in relation to next day's work.
 - Any Nutrition Kit elements that need to be purchased.
 - Any First Aid Kit materials that need to be purchased.



- Any First Safety and Response Kit materials that need to be purchased.
- Any Enabler Kit materials that need to be purchased.
- Any Ladders to be purchased/rented
- Any Stools to be purchased/rented
- Any Sticks to be purchased/rented
- Any changes to site supervision team composition
- Upload photographs to the pre-decided documentation database at the end of the day.
- Additional tasks on the last day of installation at a given household :
 - Thorough checking of the prototype installation before re-inhabitancy, so that no casualties or injury is incurred on the inhabitants of the house.
 - Share numbers of project team members with household members after wrapping up installation and inform them to reach out immediately in case of installation related issues.
 - Remind household members to fill the thermal comfort assessment forms for 7 days post- installation and inform them that they can reach out to project team members in case of any queries and concerns.
 - Ensure that the material storage space is cleared by the fabricator.
 - Pay the room rent for the material storage space to the owner and collect a receipt for the same (as applicable).
 - Inform the room owner that the work is complete and that the space has been cleared.

38.4. Emergency Protocol Checklist

38.4.1. In case of Child Labor

- Halt the work
- Inform the fabricator that we do not support child labour and will make a call to 1098 (Childline India Foundation Helpline) if we learn that this practice will continue in the future.
- If the fabricator ensures you that child labour won't continue in the future, make him/her state the same in writing and sign his/her declaration.



- Once the fabricator signs the declaration, ask him/her to make provisions for a legal-aged project worker to support the installation process.

38.4.2. In case of Electrical Shock

- Disconnect the power supply (if possible) or use a wooden stick to separate the person from the electric current.
- Don't attempt to touch the person until you're certain the power supply is cut.
- As soon as the victim has been freed from the electrical source, call for an ambulance or medical help.
- While waiting for the ambulance, check whether the patient is conscious and breathing.
- If the person is unconscious and has stopped breathing, begin Cardiopulmonary Resuscitation (CPR).
- Keep doing CPR until medical help arrives.
- Place the patient in a recovery position if he or she is already breathing.
- You can prevent shock by laying the patient flat on the ground, with the head slightly lower than the body.
- If the person is conscious and breathing is normal, and if burns are present, cover with gauze, and do not apply ointment or lotion.
- Immediately report all accidents leading to personal injuries and/or property damage to the Project Director.



39. Appendix

39.1.1. Supervisor's Log Sheet

Date:	Home owners name:
Installation Supervisor's name:	Safety Inspector's name:

Sr. No	Particulars of work (i.e. Delay in commencing installation work, presence of child labour and property damage details- whenever applicable)



Details of work to be done the next day: Grievance Sheet

Name of the solution:	House owner's name:	Reporting time:
Details of Steps to be involved in the next day's work, sequentially :		

39.1.2.

Sr. No	Name	Date	Grievance	Resolution



39.1.3. Emergency Contact Numbers

Hospital	
Clinic	
Fire Station	
Fire Brigade	



Ambulance	
Police	

39.1.4. Site-Work Training-by-Simulation

What would you do in a the following situation:

1. A community member expresses anger when a project worker enters the prayer area of the house with shoes on.
2. There is a household with one room and project workers accidentally damage the bed in the installation process. The homeowner is agitated and asks you to stop the work.
3. Workers express discomfort while working and using safety gloves while working in an area with electrical wires. They state that using gloves is a hindrance to the work.
4. A worker encounters a finger injury while using the drill.
5. The worker comes back to work the next day without a bandage and you notice nail polish on the wound in place of the bandage.
6. Installation equipment is blocking the roadway for a vegetable vendor passing by the installation house with her cart.
7. Dormer window installation is going on and the project worker is about to cut the tin-sheet of the roof. What are the steps you would undertake prior to this activity?
8. There is a nursing mother and child in an installation household. What are the steps you would take to ensure their safety?



39.1.5. Site access audit sheet (above the roof solution)

Site name: _____

Audit date: _____

Audited by: _____

Sr No	Particulars	Yes/No	Remarks (if any)
1.	Is permission to access the site granted by the relevant authority?		
2.	Is the building structurally sound and can support the installation?		
3.	Does the building have steps leading to the terrace?		
4.	Is scaffolding required for the specific site (as ladders can't reach elevations higher than single storey)?		
5.	If scaffolding is not required, is a ladder required for the specific site?		
6.	Is the site accessible easily by road (so that materials can be transported to site)?		
7.	Analyse whether using heavy vehicle machinery is necessary (to lift materials to the roof).		
8.	Analyse whether there is sufficient space for on site fabrication of solution?		
9.	Are there any tree branches bending down towards the terrace/sheet which needs to be cut so that installation can happen smoothly?		
10.	Is the site a community building, if yes what's the office working time.		
11.	Can the installation happen when the office is in progress ?		
12.	Does the site have a toilet facility?		



13.	Is the site a residential building, if yes, what's the convenient time for installation?		
14.	Does the site have a storage area?		
15.	Does the site have a drinking water facility?		
16.	Is electricity available on site during the planned installation hours		



39.1.6. Site access audit sheet (below the roof solution)

Site name: _____

Audit date: _____

Audited by: _____

Sr no	Particulars	Yes/No	Remarks
1.	Is permission to access the site granted by the relevant authority?		
2.	Are stools required for installation?		
3.	Is the building structurally strong to hold the installation?		
4.	Is there a leakage issue in the building?		
5.	Is the site accessible easily by road (so that materials can be transported to site)		
6.	Is there sufficient space for on site fabrication of solution?		
7.	Is the site a community building? If yes, what's the office working time?		
8.	Can the installation happen when the office is in progress ? (in case of a community building)		
9.	Is the site a residential building, if yes, what's the convenient time for installation?		
10.	Is the drinking water facility available at site?		
11.	Does the site have a toilet facility?		
12.	Is the electricity available on site during the planned installation hours?		
13.	Does the site have a storage area?		

39.1.7. Electrical Safety Audit sheet (To be done in presence of an Electrician)

Site name: _____

Audit date: _____

Audited by: _____

Electrician Name: _____

Sr No	Particulars	Yes/No	Remarks
1.	Validate the following by engaging an electrician - - proper grounding and bonding of electrical equipment - protective devices like circuit breakers and fuses are in place		
2.	Check whether there is any electrical equipment in locations close to installation space and needs to be moved.		
3.	Check if the wall sockets present are working and are safe to use.		
4.	Check whether there are any electrical power lines running close to the roof which can undermine safety.		
5.	Check if the power in the building is stable enough to use the equipment (like a welding machine).		

39.1.8. Electrical Safety Audit sheet (To be done in presence of an Electrician)

Site name: _____

Audit date: _____

Audited by: _____

Electrician Name: _____

Sr No	Particulars	Yes/No	Remarks (If No, mention corrective action)
1.	Are all plugs, sockets, and electrical fittings sufficiently robust for safe use? (e.g., no cracks, loose connections, exposed wires)		
2.	Are all electrical fuse/junction boxes in the premises securely fixed, closed, and undamaged?		
3.	Are fuses, circuit breakers, and other electrical devices correctly rated for the circuit they protect? (e.g., proper amperage rating)		
4.	Is access to fuse boxes prevented and the key held by a responsible person?		
5.	Are main switches readily accessible and clearly identified, with all members of the premises knowing how to use them in an emergency?		
6.	Are all electrical installations checked periodically and repairs carried out by a competent electrician?		
7.	Are all cables and wires in the premises properly enclosed and have no exposed electrical conductors?		



8.	Are all electrical connections in the premises properly spliced or joined using approved methods (e.g., wire nuts, terminal blocks) and free of any tape or other temporary fixes?		
9.	Are all electrical equipment in the premises properly grounded to prevent electrocution or fire?		
10.	Are all electrical wires in the premises protected from dampness and standing water?		
11.	Are all aisles and passageways in the premises free from any electrical wires that could create a tripping hazard or impede movement?		
12.	Are all visible electrical wires in the premises securely fixed, with no loose or hanging wires?		
13.	Are all electrical equipment/s located in the vicinity of the proposed solution installation space designed and installed in a way that prevents any interference with the installation, maintenance, and operation of the solution?		
14.	Are all power lines located near/above the roof sufficiently far away and/or properly insulated to avoid any safety risks during installation, maintenance, and operation of the solution?		

39.1.9. Fire Safety Audit sheet

Site name: _____

Audit date: _____

Audited by: _____

Sr no	Particulars	Yes/No	Remarks
1.	Are the flammable materials stored properly and in designated areas?		



2.	Is the site premises free from excessive clutter and combustible waste?		
3.	Are there any fire extinguishers available throughout the building? If not, a sand bucket or a portable fire extinguisher or a water drum to be placed at the location.		
4.	Check if there are multiple entry and exit points.		
5.	Is there a LPG cylinder present at the site? If yes, is the regulator tested for gas leakage?		
6.	Paste a poster at the site premises explaining the emergency to do steps during a fire outage.		
7.	Check whether there is a fire station nearby. If yes, collect the fire station numbers.		
8.			

Fire safety kit

Sr no	Materials	Procured (yes/no)
1.	Portable fire extinguisher	
2.	Fire Blankets	
3.	First aid Kit	
4.	Sand bucket/water drum	

39.1.10. Interference/Inconvenience Audit Sheet

Site name: _____

Audit date: _____

Audited by: _____

Sr no	Particulars	Yes/No	Remarks
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1.	Assess if the adjoining neighbours' walls or roofs are going to be affected due to installation.		
2.	Seek consent from the neighbours in case their walls and roofs are getting affected due to the installation.		
3.	Will the installation noise affect the people living in the vicinity? If yes, consent is sought for the same?		
4.	Check with the residents about the installation timings.(work timings of residents, old age/baby rest time etc to be included)		

39.1.11. Lighting Audit Sheet

Site name: _____

Audit date: _____

Audited by: _____

Sr no	Particulars	Yes/No	Remarks
1.	Evaluate the need for lighting fixtures at the site.		
2.	Assess the need of flood lights, hand lights and area lighting if site work is anticipated in dark working conditions.		
3.	Procure the lighting fixtures, appliances if necessary.		



4.	Identify appropriate locations for installation of lighting fixtures.		
5.	Engage with an Electrician to facilitate installation of lighting fixtures prior to the first day of site work.		

39.1.12. Resident Needs Audit Sheet

Site name: _____

Audit date: _____

Audited by: _____

Sr no	Particulars	Yes/No	Remarks
1.	Check if suggested installation day/time is suitable for households.		
2.	Check with households before installation to understand the need to make arrangements for food.		
3.	If the access to the site is through another building, seek permission from the neighbour.		
4.	Check with households before installation if there is a need for a place for family members to stay during installation		
5.	Assess if there is sufficient space for placing stools/ladders so that no object is moved from their original place. If the original place of any materials is to be changed the same is communicated with		



	the house owner and permission is sought.		
6.	If a room is required for residents to stay during installation? Arrange with support from NGO partners if needed.		

