MANUAL OF PRACTICE

THE INFORMAL HOUSING THERMAL COMFORT PROJECT

MARCH 2023

CBALANCE
carbon • cost • community • climate

ACKNOWLEDGEMENTS

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TABLE OF CONTENTS

Acknowledgements 1

I. About the Project 3

II. About the Manual 4

III. Approaches to Co-create and Implement Experimental Informal Housing Thermal Comfort Retrofits. 5

A. Community Engagement Process 5

1. Initial Engagement and Co-creation 7

2. Community Engagement after Design Refinement 15

3. Post Installation Engagement 23

B. The Technical Design Process 28

1. Overview 28

2. Overarching Design Stages 29

Stage 1 – Material Finalisation 29

Stage 2 –Design 30

Stage 3 – Fabrication and Installation 40

Stage 4 – Performance Measurement 53

3. Solution Specific Information 54

A. Ecoboard 54

Mechanism 1 – Sliding 54

Mechanism 2 – Chain and Sprocket 56

B. Alufoil 59

Mechanism 1 – Sliding 59

Mechanism 2 – Chain and Sprocket 60

Mechanism 3- Pipe Motor 63

Mechanism 4 – Static 65

C. Roof Top Gardening 66

Mechanism 1 – Wooden Frame 66

Mechanism 2– Grow Bags 69

D. Dormer Window 73

E. Woodwool Panel

F. Water-Filled PET Bottle 76

C. Academic Engagement Process 79

1. Collaboration with Architecture and Engineering Colleges 79

2. Board of Studies Engagement for Curriculum Change 80

I. ABOUT THE PROJECT

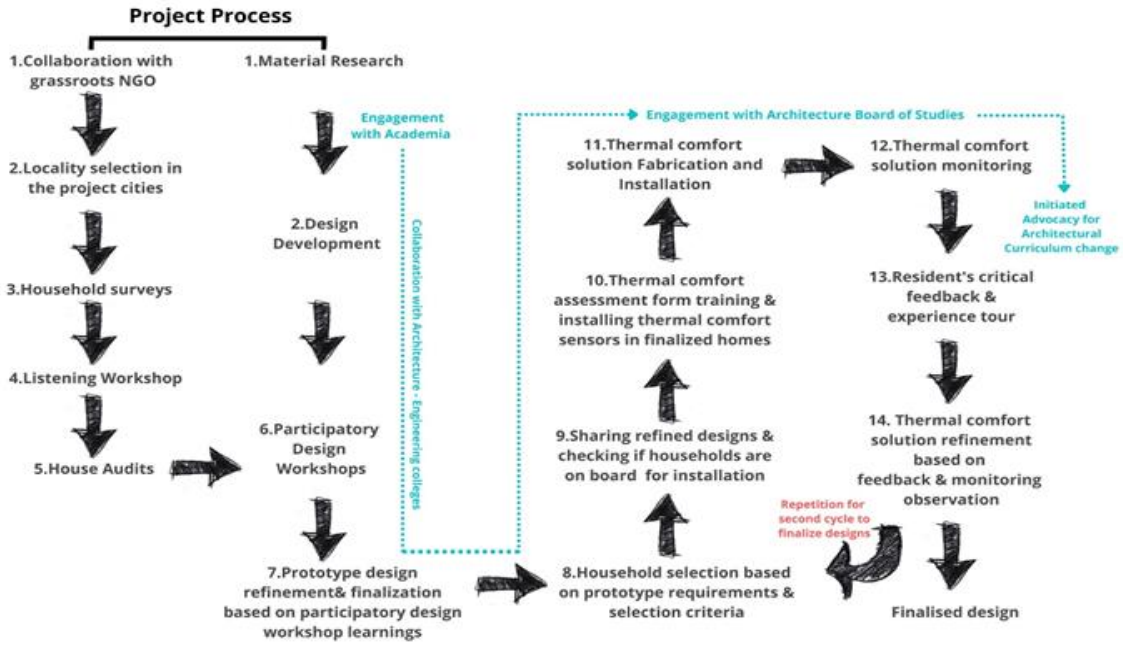
The Informal Housing Thermal Comfort Project (Pilot) is a multidisciplinary and multi-stakeholder experimental project aimed at co-creating thermal comfort solutions with informal housing communities with support from (formal and informal) built space professionals and academia.

The intervention was implemented in two cycles– the prototype design cycle and the design finalization cycle. The stakeholders that were a part of this multi-disciplinary project include NGO partners, community members, designers, architects, engineers, fabrication and installation persons, academicians and the board of studies of Architectural colleges.

The first cycle of the project comprised of listening, participatory design, critical feedback workshops, thermal comfort assessment form filling training and resident experience tours amidst other community engagement endeavours. The focus of the prototype design cycle was to contextualize the thermal comfort solutions 'with' community members and to test the effectiveness of materials and mechanisms from a list of shortlisted solutions such as Ecoboard, Alufoil, etc. At this stage, solutions were installed in a few houses in two cities (Pune and Bangalore) respectively in homes of residents who agreed to work on experimenting with the co-created solutions which were monitored for a month. They were then revisited for the second iteration of designs. Students from architecture and engineering colleges contributed to the first cycle under as part of their internship program.

During the design finalization cycle, the aim was to refine the design of instillations that needed enhancements and install them in a few more houses respectively, in addition to reinstalling certain installations that needed refinement in the initial houses. There were houses that dropped off from the experiment and new houses that joined midway. The second cycle involved a few community engagement endeavours similar to the first stage which included a meeting to share refined designs and the list of selected households, thermal comfort assessment form filling training, critical feedback workshops and experience tours to harness resident feedback to support the process of finalizing the designs. Additionally, engagement with Architecture Board of Studies members to advocate for curriculum change to incorporate informal housing and sustainable architecture perspectives in university curriculum was also initiated during this cycle.

The flow chart provides an overview of the process flow of each cycle.



Considering the installations were already carried out in cities of Pune and Bangalore as pilot phase of our endeavour working towards the issue of Heat stress in Informal settlements, there were already a set of learning on functioning of materials, collaboration with local organizations, material research, etc. Considering this as a base certain steps in the above flow chart were skipped for our work in Mumbai and Delhi, such as Household surveys (which were prior identified and partly combined with house audits), first design cycle (installation happened directly over 9 selected houses), Thermal comfort solution refinement and Engagement with Academia.

II. ABOUT THE MANUAL

This manual shares the 'How' of the work undertaken as part of the 'Informal Housing Thermal Comfort' project in four cities till now starting with Shindevasti in Pune and Jyothipura in Bangalore; followed by Rahulnagar, Lalmitti in Mumbai and Bhalswa landfill area in Delhi.

It therefore focuses on 'Approaches to co-create and implement experimental Informal Housing Thermal Comfort retrofits' and comprises of 2 broad sub sections - Community Engagement Process and Technical Process.

The Community Engagement section is divided into three major parts: 1. Initial Engagement and Co-creation 2. Community Engagement after Design Refinement and 3. Post Installation Engagement.

The Technical Process section is also divided into three major parts: 1. General Design Process 2. Stage Wise Understanding and 3. Solution Specific Information.

These sections share the rationale and approach to the various steps that were undertaken to facilitate the project in collaboration with diverse stakeholders. They comprise of questionnaires, checklists, workshop designs and other elements, as applicable. These components are placed in boxes in the manual.

It is advisable to note that the 'approaches' shared in this manual are not hardbound and can and must be tweaked to suit different contexts. For instance, there have been instances where different approaches have been undertaken in different cities and tweaks were made instantaneously on the site to respond to the need of the hour. A community engagement approach that works in one community, therefore might not necessarily work in another.

Similarly, it is also vital to understand that while some of the thermal comfort interventions mentioned in this manual might work in certain contexts, they might not necessarily work in others. The weather conditions, spatial characteristics of a region and the receptiveness of a homeowner to a given solution are few crucial factors among a host of other factors that culminate to ensure that an intervention truly serves peoples thermal comfort needs.

The dynamic nature of 'experimental' and 'community centric' interventions is a key characteristic that warrants attention.

Therefore, the intention is also to keep revising the content of this manual, as new learnings emerge on this journey of ensuring thermally comfortable living conditions by working 'with' inhabitants of marginalized urban settlements.

III. APPROACHES TO CO-CREATE AND IMPLEMENT EXPERIMENTAL INFORMAL HOUSING THERMAL COMFORT RETROFITS.

A. COMMUNITY ENGAGEMENT PROCESS

The community engagement process was initiated by identifying and collaborating with grassroots NGO partners in Mumbai and Delhi. Collaboration was followed by identifying a project locality in each city. This was followed by rapport building endeavours with community members through household surveys, followed by 'workshops' to 'listen to' and 'co-create' thermal comfort retrofit designs with the community. 'House audits' were conducted and preceded 'community meetings' to share refined designs with the households that had been modified based on their inputs during the participatory design workshop, proceeded the community workshops. The 'meetings' were also a space to share the criteria for household selection along with the list of households who were selected during the first and second cycle of the project, respectively. Consent was sought to proceed with installations and partner households were trained on filling thermal comfort assessment forms and thermal sensors were installed in their homes. This was followed by fabrication and installation of the thermal comfort retrofits. Critical feedback workshops and household visits were facilitated to harvest resident's feedback post installations, to learn about any refinements that could support enhancing the installations to support with finalizing the designs.

Engagement with residents is still continuing to ensure that the thermal comfort endeavours spirit of working 'with' the community is alive and endures with time. Following are a few community engagement guidelines that are applicable across all community interactions

COMMUNITY ENGAGEMENT GUIDELINES

1. Objectives of the project should be the primary guideline for engagement.
2. The interests of the community should be top most priority.
3. Strictly define areas of intervention and non-intervention
4. Do not give assurance of anything outside the scope of the project.
5. Consent and transparency:
    a. Seek consent before speaking, documenting discussions (in any form), etc. with community
    b. members.
    c. Be transparent about how/where information that will be documented as part of various
    d. interactions will be shared.
    e. Be clear about our reasons for wanting to work with the community, what you are hoping to
    f. offer and your approach at working towards it.
    g. Let the community know that you want to work 'with' and 'not for' them.
6. Empathetic interaction: Speak and interact with the community, the way you'd like people to speak and interact with you. Place yourself in the shoes/slippers/sandals of the people you interact with. Be respectful, honest and kind.
7. Stay grounded: Sit with the community, eat what they offer you (if you cannot- decline politely), preferably wear garments that resonate with the community.
8. Build a rapport with the community: Recognize that you are engaging with the community to build a relationship with them and work together. You are not there as just data collectors! Besides, good rapport can support meaningful and authentic conversations.

9. Build a rapport with the community: Recognize that you are engaging with the community to build a relationship with them and work together. You are not there as just data collectors! Besides, good rapport can support meaningful and authentic conversations.

10. Have a community led discussion : In all interactions create a space where community members recognize themselves as knowing more than you do (which they obviously do!) about their situation. Besides intermittent prompts, let the community lead conversations. Use symbols, illustrations and other means of communication to facilitate discussion with members who might not be literate. Convey that no one else is better suited to discuss their situation and decide what they need and do not need. (As a facilitator: Listen more, speak less)

11. Have a community led discussion: In all interactions create a space where community members recognize themselves as knowing more than you do (which they obviously do!) about their situation. Besides intermittent prompts, let the community lead conversations. Use symbols, illustrations and other means of communication to facilitate discussion with members who might not be literate. Convey that no one else is better suited to discuss their situation and decide what they need and do not need. (As a conversation/discussion facilitator: Listen more, speak less)

12. Non- intrusive documentation: Non-intrusive documentation is essential to avoid disrupting authentic conversations. (options - taking notes, audio recordings etc, with community consent)

13. Respect: Respect community member's boundaries (time, privacy, topics they express discomfort with, etc.), opinions, and culture.

14. Patience: Sessions might be delayed, community members might have quite a few questions for you, community members might express scepticism, etc. Be patient with them and yourselves as you embark on the journey of knowing each other.

15. Create an empathetic and safe listening space: Pay attention to non-verbal cues by community members that hint at discomfort, etc. and address the situation accordingly. Create a space where community members feel comfortable discussing themselves and their lives/people in their lives. A space where there is no feeling of privacy invasion or being forced to speak. A space where anyone feels free to walk away from the space if they want to without feeling obliged to sit, speak, and interact with you.

16. Humility: Acknowledge your privileges and viewpoints that emerge from your position. Recognize that as an outsider, you know a fragment about community members and their journeys. Be humble enough to recognize the things you might not know/understand and seek clarity from the community about the same.

17. Be willing to unlearn: Let go of the socio-cultural, academic, experiential baggage you come with, when you engage with the community. Every person /community has different stories to tell, that need to be acknowledged and not subjected to our baggage's. As far as possible, prevent your baggage from influencing your engagement.

18. Speak from personal experience/ I: Encourage participants and yourselves to take responsibility for your experiences. Eg. Replace 'he/she did'.... with 'I felt --- when--- happened', etc

The following sections provide information on the rationale and approach to different community engagement steps.

1. INITIAL ENGAGEMENT AND CO-CREATION

1.PARTNERING WITH GRASSROOTS NON-GOVERNMENTAL ORGANISATIONS (NGO)

RATIONALE:

To collaborate with grassroots NGOs partners to help facilitate rapport building with local communities in project locations

APPROACH:

1) Identify NGOs working in your project city through existing networks or online research
2) Narrow down on NGOs based on the work they are engaged in (preferably those engaged in the realm of informal housing upgrades)
3) Explore the NGOs values and approach of interacting with the community and their relationship with the community to check if it resonates with your projects engagement approach (eg. Do they consider the community as partners, do they respect and harness the communities' knowledge? Do they have authentic relationships of trust with the community? Or do they impose solutions and disregard the communities' knowledge and experience?)
4) Reach out to NGOs that align the most with your projects values and approach
5) Share details about the 'Why', 'How' and 'What' of your project and inquire if they would be interested in exploring ways to work with you.
6) If the NGO expresses interest in engaging with your organisation, set up a meeting and 'listen' to the NGOs 'Why', 'How' and 'What' of working with the stakeholders they engage with.
7) Explore ways to engage meaningfully with the community, through meaningful and respectful exchange of ideas with the partner NGO
8) If the NGOs work and approach to working resonates with the overall approach of the project, proceed to:
    1. Discuss the project duration
    2. Share and agree upon specific areas of the project where the NGO partners support will be needed
    3. Share and agree upon the roles and responsibilities of the NGO partner and the project team
    4. Share and agree upon the effort hour contribution that is feasible based on the project funding capacity
9) Draft a 'partnership agreement' with the above-mentioned and other relevant information.
10) Share a signed copy of the partnership agreement with the NGO partner for their signature.

    Selected places where the NGO partner supported with community engagement are mentioned in the respective steps.

2.LOCALITY SELECTION

RATIONALE:

To identify a locality that aligns with the projects needs

APPROACH:

1. Make a list of locality selection criteria, which could include:
    a. A tenure protected informal settlement
    b. Has members engaging in home-based work
    c. Locality is particularly vulnerable to heat stress/adjacent to heat-generating industries/ factories/ any economic activity
    d. Locality will not be affected by large scale infrastructure projects in the future

e. Community Space: Potential areas of thermal comfort intervention could be a space utilised by the community for various purposes (for eg. Balwadi centre). Such a space could also be useful in engaging with the community members collectively, for the purpose of workshops or training sessions, for example.
f. Households in the community are primarily built with heat trapping materials
g. NGO partner have a presence in the community
h. Locality has some history of participation either with NGO partner or the community is proactive in solving its own problems
i. Desirable: Locality is close to the organisation's office/primary field members' home

2. Draft a questionnaire based on locality selection criteria.

The following questionnaire can be used as a basis for locality selection :

Questionnaire - Locality Selection

Field Visit no:

Date of visit:

Location (City):

Settlement name:

GPS Coordinates(Optional):

NGO representative details (Name, contact no):

CB team member name:

---

*Note for field team:

Kindly click photographs of:

1. House structures
2. Location geography (open spaces, green cover, waterbodies, etc.) - [*in case this is not possible, we can navigate for the same on google earth, based on GPS coordinates.]*
3. Other notable aspects, based on your judgement.

Place your photographs based on the template in the following folder: ---(add folder location details)

Kindly upload interview responses to the following file ---(add file details)

Questions:

Social Attributes (Questions for NGO partner):

1. What is the duration of the NGO partner's relationship with the community?
2. How many households does the settlement comprise of?
3. What is the population of the settlement?
4. Do the households belong to a particular caste, religion, work group or is it a mixed community?
5. What diverse occupations are community members engaged in?
6. Are there community members who are engaged in home-based work? (approx. how many households)
7. Does the community have a history of being proactive in solving their problems?
8. Is the settlement tenure protected? (can also check city development plan)
9. How is the relationship between the community and local politicians? (prompts: has there been a history of prolonged resistance, etc or are issues resolved collectively)

10. Are there any existing community groups/associations in the settlement? If yes, what issues do they work on and who is part of these groups?
11. Are there any infrastructure projects planned in this location in the future that might demand resettlement/rehabilitation?
12. Is heat stress an issue residents are concerned about? (based on NGO partners' judgement)
13. If yes, what are these claims based on?
14. Would you recommend that we engage with local politicians before initiating project work?
15. Miscellaneous details

Physical attributes (Can be noted during field visits/in conversation with NGO partner):

1. Distance of the settlement from Pune office/Bangalore field members home (in km)
2. Does the settlement design indicate a lack of daylight/ventilation? *(can substantiate this with photographs, if possible)*
3. Are there any notable factors indicating that the locality is vulnerable to heat stress? (eg. adjacent to heat-generating industries/ factories/ any economic activity)
4. What are the house structures in the settlement? (a healthy mix of house structures is preferable)
    a. Semi kuccha - tin roof and tin walls
    b. Semi pucca - Brick wall and Tin roof
    c. Pucca - Brick wall and Concrete slab
    d. Others (please specify)
5. Are houses in the community primarily built with heat trapping materials? (eg. asbestos roofs,etc.)
6. Are there any community spaces (eg. Balwadi centres, community hall, etc) that could serve as spaces for pilot prototype implementation/installation?
7. Miscellaneous details

3.LISTENING WORKSHOP

RATIONALE:

- To create a space for people inhabiting informal settlements to share their experiences on issues they face across different seasons during the year.
- To understand already existing heat battling mechanisms and practices followed by the communities.
- To listen to community's discomforts, concerns and suggestions
- To emphasize the projects approach of 'co-creation' and 'participatory' action to community members to facilitate a spirit of 'partnership' and 'collaboration'

APPROACH:

1. Run the design of your workshop by the NGO partner and tweak the design to suit the context, based on the NGO partners' suggestions.
2. Identify a place and time that is convenient to interact and facilitate listening workshops with the NGO partners support.
3. Invite community members to the workshop and check if the suggested day and time works for them.

Details of role, responsibilities and workshop design are mentioned below.

(Please note: While the description and information below encapsulates all elements that were planned for the workshop, elements were tweaked and/or eliminated based on the need of the hour)

A. Facilitation team roles and no. of members

(*Note: All team members to participate in the introduction and icebreaker session*)

1. Documentation persons (note taking, audio recording, photography): 2
2. Facilitators: 2-3
3. Community mobilization persons (NGO field team members): 1-2

B. Material:

Charts with symbols (1), sketch pen set (1), pencils, erasers, book for note taking, pen, audio recording device (phone), post-its, refreshments, garbage bags.

C. Setting & Participants:

Community space, rugs/mats or chairs that can be moved. (Community members and facilitators sitting on the floor in a circle. Elderly members, people with health conditions who are unable to sit on the floor sit at elevated positions and are part of the circle too.)

D. Workshop Flow (max. 2 hours):

1. Group introductions, ice-breaker and check-in (20 mins):

a. Community members and CB members state their name and share anything else they want to about themselves (eg. what is your favourite thing to do).
b. Ice breaker- Common ground/The sun shines on

(Format: Place chairs side by side in a circle with one less chair than number of people. Person in the centre says, "The sun shines on ...." filling in the blank with a statement that is true for them. All others in the circle for whom it is also true stand up and switch places (those for whom the statement does not apply stay seated) with the person making the statement trying to take someone's place. The person in the centre then repeats the statement filling in with some other 'truth'. It is best to start with simple visible statements. E.g. "...all those wearing white", "...having pockets", "... carrying keys", "...hair tied up". Can also include statements which have varied interpretation or not visible. E.g. "who's birthdays are between June and December", "who don't like chocolate".)

Or

Interacting in twos (switching after a couple of rounds)
{*sample prompts: What I ate for dinner, last night's dream, the place (or the view from the place) I spend most of my day, I can talk about} or could ask the group to come up with 2-3 questions they would like to ask each other*}

c. Check-in (How are you feeling right now?)

2. Introduction, consent and setting the tone (20 mins)

a) Introduce your organisation
b) State how you got to know about the community, your relationship with the partner NGO and community members who you may have met before (and will support in facilitating the session.)
c) Explain why you are here:
- Share your project story
- Purpose of the listening session:
  (Suggested script: *We have experience in the domain of thermal comfort, however, we want to understand your perspective and know if this is an issue you experience and would like to work towards resolving. We want to hear from you and understand your situation before we explore possibilities of collaborating to address thermal comfort and other related issues. You are the leaders and we will just facilitate this session. The purpose of this session therefore is for us to learn from you and understand your situation, since nobody knows your needs better than you.*)

d) Give the community space to ask us questions / suggestions they might have for the session- (A space to co-create principles for the session- eg. phones off, one person speaks at a time, etc)
e) Seek consent for documentation.
f) Create a safe space i.e. Ensure that community members feel safe, comfortable and own the space: Give them the option to speak in the group discussion, speak to anyone from our team after the discussion, share thoughts in any other form that is comfortable.

3. Problem Diagnosis: **Illustrating and listening (40 mins)**

a. Illustration

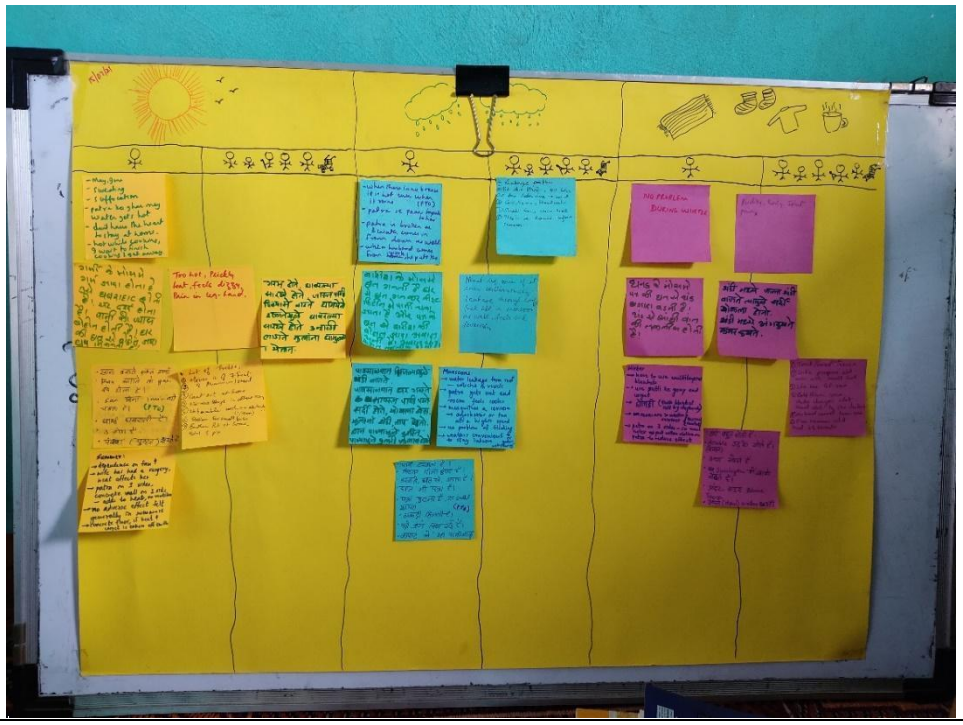
Suggested script: *As discussed before and if you are now ready to engage with discussing issues prevailing in your households and community, we would like to begin with an activity: We have three charts before us. Each of them represent different seasons of the year* ***(Summer, monsoon, winter****- we can have symbols drawn).*
[**The chart is divided into two parts to indicate - Individual issues (an image of a woman/man drawn on the chart to symbolize this) and community issues (symbols of men, children, elderly, physically disadvantaged, etc drawn to indicate this on the chart)]*

We would like to ask you to think about issues you face at an individual level, as men/women who are involved in household activities, caregiving, livelihood generating activities and possibly other activities, too and at the community level, [prompts: eg. in summer there might be issues of water shortage (you could draw a tap to indicate this if you cannot write), electricity cuts, difficulty sleeping, travelling long distances for work, leaky roofs in rainy season, flooding, illnesses in monsoon, lack of toilets, etc] and you can draw/write issues you notice at the community level [eg. unemployment, difficulty studying due to electricity cuts, lack of health facilities, heat strokes in summer, etc.] It is okay if the issues overlap across the seasons.
Format: Focus on one season at a time. Distribute post-it's across the room at the start of each season issue mapping exercise. Facilitators and other team members can support the community with writing and/or illustrating, as applicable.

b. Listening

Format and prompts for discussion:

- *Thank you for sharing these issues. Could some of you explain a few of them in detail.*



- *Which of the above mentioned issues have you'll addressed/are addressing as a community?*
- *Who are the people that are involved in addressing these issues?*
- *What are the challenges you/other members face as you go about addressing issues? and how do you overcome them? (e.g. Stakeholders who support them, hinder them, etc.)*
- *Are there any governance mechanisms in place?*

4. Exploring concerns and possibilities of collaboration (30 mins) :

a) Discuss probabilities of addressing thermal comfort related issues and other co-benefits through engaging with the community (eg. addressing roof related issues that might be interlinked with passive cooling retrofits, etc.)
b) Check with the community: *What has been your experience with previous such projects? What are your concerns? Even judgments? Hopes? What needs are important to you in the process?*
c) After hearing everyone: *how are you feeling about all this? What comes up for you?*
d) If the community considers thermal comfort or other related issues as issues they would like to work toward resolving ask them if they would like a day or two to reflect and give them an overview of future steps of the project (e.g. workshops, etc.)
e) Final Closing Around: what else do you want to share with the group? what are you leaving with?

4. PARTICIPATORY DESIGN WORKSHOP

RATIONALE:

- To harness information to facilitate the co-creation of context-specific thermal comfort solution designs with local communities.

APPROACH:

1. Run the design of your workshop by the NGO partner and tweak the design to suit the context, based on the NGO partners' suggestions.
2. Identify a place and time that is convenient to interact and facilitate the participatory design workshop with the NGO partner's support.
3. Invite community members to the workshop and check if the suggested day and time works for them.

Details of role, responsibilities and workshop design are mentioned below.

(Please note: While the description and information below encapsulates all elements that were planned for the workshop, elements were tweaked and/or eliminated based on the need of the hour)

A. Facilitation team roles and no. of members

a. Documentation persons (note taking, audio recording, photography): 2
b. Facilitators: 2
c. Team members well versed with designs – One per design
d. Community mobilization persons (NGO field team members): 1-2

B. Material for the session:

Physical design models, note taking book, pen, chart paper, sketch pens, phone audio recording device,

C. Setting & Participants:

Community space, rugs/mats or chairs that can be moved. (Community members and facilitators sitting on the floor in a circle. Elderly members, people with health conditions who are unable to sit on the floor sit at elevated positions and are part of the circle too.)

D. Workshop Flow

Option 1 (approx 2.5 hours)

1. **Introduction and check-in (10 mins)**
   ThermIC team and community members share their names and what they do (if there are new members present) and how they are feeling.
2. **Introduce the flow of the workshop and the Why of the workshop/project** (5 mins)
   a. Listening workshop recap, including community knowledge harnessed and any visuals of that. (any more ideas you want to share before we explore the prototypes?)
   b. Sharing prototype ideas with the community: *We will introduce a few options to address issues of thermal comfort, which might also address ----(water tightness, etc….) These are just suggestions and through this engagement we are hoping to refine these/ eliminate options you think might not work, so that we can develop a final model that can be integrated in your house. Please keep in mind, we are exploring solutions with you, this is an experiment,and we are inviting you to participate with us in order to co-create solutions that can be useful to you and many others to come.*
3. **Sharing prototypes and brainstorm with the community (1 hour 20 min) :-**

a.World Cafe style (1 hour 5 min) – separate 'stations' for each model and the participants divide themselves into groups. First send participants to the station for the model they will likely be getting. They will have extra time in this first station - 20 minutes. Then ask the participants to go to another station (not as a group, each household goes randomly to a new station) while the facilitator/host remains at their same station. They will have 10 minutes each in these stations. Can have a chart paper in each station to capture thoughts/feelings about the prototype.

(Here is a sample script you can use: "*Now we will explore 6 different models that we will are hoping to experiment with as potential roofing solutions to be installed in your homes. We first want to describe how each of these prototypes works and explore their properties. Then we want to hear input and ideas from you, including any modifications you may suggest. We have 5 stations set up around the hall, one for each prototype. Everyone will get time to visit all 5 stations. You can begin with the station for the model that we consider most suitable for installing in your home.*

We will have a host at each station. There is a model of the prototype at each station. The host will help describe each model, the properties of the materials involved, the costs and demonstrate the installation process on the small model. You can ask questions or share your experience and ideas as well. There will be a chart paper in each station, you can use this to capture any ideas or feelings about the prototype, including any suggested modifications. Feel free to draw as well. The chart paper will remain in each station, this way the next group can see what you captured.

We invite you to divide yourselves up and explore each station with your family member. You will have 20 minutes for the first station, and 10 minutes for each station after that. The host will stay in their station. Any questions?")

b. The host describes the model, highlighting properties, costs, pros and cons, installation process, etc. They also invite questions and discussion, especially drawing out if any participants have had experience with such a model. This can include a brainstorm of possible modifications (for example, replacing one material with a local material).

(Tentative points to consider sharing with the community while sharing prototypes:

- Name of the prototype
- Material
- Installation process
- Working mechanism (note: Use relatable examples to explain the working mechanism of the model eg. to explain alufoil, you can explain how it works as a cap creating a barrier between the sun and the person inside the house.)
- Lifespan
- Weight of the installation
- Benefits and limitations- ventilation, noise, day/night benefits etc
- Estimated heat stress reduction
- Degree of alteration (how will the intervention impact the house structure?)

(Reminders: Leave space for questions to encourage community participation, keep a track of the time)

At the end of the 5 rounds, give them 5-10 minutes back in their first station again for a final review.

4. Brainstorm for Future Experimentation (in whole group, 15 minutes)

"We really would like these solutions to be a co-creation. You all are experts in your homes, your needs, and resources available. We would like to start by having a brainstorm of new ideas, this could involve modifying one of the existing prototypes or a new idea altogether. For this brainstorm, all our ideas are welcome, we will not be criticizing them. We encourage you to be creative. This is all part of an exploration and experimentation, to discover what is possible. These ideas may be used as part of future prototype design." Any new ideas, suggestions?

5. Discussion: Project team architects and community (20 mins)

Architects and the community discuss any questions or concerns about the prototypes or the new suggestions.

6. Way Forward (10 mins)

Explain the next steps and approx. dates for next engagement with the community.

7. Wrapping up (5 mins):

a. *Any final questions?*
b. *A couple of words of what you are leaving with*...

Option 2 (approx 2.5 hours)

*Note- Kindly refer to content from option 1 for description/tentative narratives of specific parts.

1. Introduction and explaining workshop flow : 20 mins

- Introduction and check-in (5 mins)
- Revisiting listening workshop to draw a connection with the participatory design workshop (5 mins)
- Explaining the purpose and flow of the participatory design workshop (10 mins)

*****Seek consent to click photographs, take notes, record videos...

2. Explaining models and brainstorming (15 mins per model) - 1 hour 10 mins

(Based on the space available you can choose to bring one model in the room at a time. If you have two rooms, you can ask residents to move from one room to the other, etc. Use any approach that seems suitable to the context)

- Design team member shares basic details of the working model
- Residents are asked what they think about the model

(Pause to let residents think and share what they feel about the model (go around the room and give residents space to pass their turn to speak to another resident if they need some more time to think. Come back to them later)

- Pose prompts to trigger discussion
- Make space for residents to share their concerns and note them down
- Make space for residents to share how they'd resolve certain issues they observe with the models?
- Ask residents to provide other suggestions etc. for the model

Participatory Design workshop, Pune

3. Give residents time to experience the models in a room alone - 7-10 mins

4. Final thoughts on the models (Questions, concerns, suggestions) - 10 mins

5. Way Forward - 10 mins

2. COMMUNITY ENGAGEMENT AFTER DESIGN REFINEMENT

1. HOUSEHOLD SELECTION DECISION SHARING

RATIONALE:

- To share refined prototype ideas with community members
- Share reasons/criteria for prioritizing certain households as experiment partners
- Share residents' responsibilities (eg. thermal comfort assessment, etc), next steps of the project

APPROACH:

1. Work on household selection criteria.

The selection criteria for this project comprised of:

- Structural feasibility of a household for a particular design
- Houses with poor conditions

- Age of the structure (old houses were preferable)
- Residents preference
- Residents with a unique prototype preference
- Other social characteristic based criteria (wherever applicable)

2. Identify a place and time that is convenient to interact and facilitate the meeting with community members with the NGO partners support.
3. Invite community members to the meeting and check if the suggested day and time works for them.

Details of role, responsibilities and meeting design are mentioned below.

(Please note: While the description and information below encapsulates all elements that were planned for the meeting, elements were tweaked and/or eliminated based on the need of the hour)

b) Facilitation team roles and no. of members

- Documentation persons (note taking, audio recording, photography): 2
- Facilitators: 2
- A design team member: 1
- Community mobilization persons (NGO field team members): 1-2

c) Material for the session:

- Images/videos of final prototype design
- Be prepared with information about selection criteria, next steps and approx days/dates for next engagements.
- List of households who have been shortlisted as experiment partners

d) Meeting flow

Note* The meeting outline for the first and second cycle were similar. However, information conveyed to residents varied in relation to the no. of houses that were selected etc. were based on the cycle requirements. The information below reflects details that were shared during the first cycle.

Option 1: Timespan (45 mins)

- Welcome and make space to share any feelings/thoughts etc. since our last interaction (5 mins)
- Share purpose of this meeting (2 mins)
- Share selection criteria (10 mins)
- Share refined designs we have worked on based on the community's suggestions - show prototype images/videos and explain modifications (10 mins)
- Discuss questions, concerns, etc. (10 mins)

OR

- Explain one prototype at a time and take questions/concerns etc related to that prototype immediately. (20 mins)
- Are you okay with these suggestions and ready to embark on this experimental journey with us? Or would you like some time to think about this and consult your family members and get back to us in a day?

[Note : Make clear that if it doesn't work for them, you will remove the structure and we will share a form on the day of the thermal comfort assessment to formalize the partnership that will mention your teams responsibilities towards the community and also mention the support you will need from them before and after installation]

- Share next steps, expectations from participants and discussion

Suggested text: *If you agree, we will also give you a document saying that you are willing to partner with us which will mention the support we need from you and our responsibilities, both. Someone from our team will sign this and we'll need one of your family members to sign this as well. We'll share this in detail during our meeting on ------ (day of thermal comfort assessment meeting)*

Post-meeting: after a selected period of time, go to the 5 households individually and check if they agree. If anyone drops out, then households on the waitlist will be informed and invited to join.

Visit households who are not shortlisted at the moment and update them on the status of the engagement progress. Household visit interaction format is shared at the end of this section.

Option 2:

Same as option 1 but combine 2-3 prototype groups together. Households who have prototypes with similar working mechanisms and completely different working mechanisms could be clubbed in the same groups, respectively (eg. Group 1: Ecoboard, Alufoil, Group 2: Dormer window, wool panel, Group 3: rooftop gardening, PET bottles). (Suggestion: Can invite waitlisted households to the meeting as well and households who are not selected can be informed individually)

Option 3:

Large group meeting:

Approach is to bring all households together (selected and shortlisted) so they hear about their status from us, all at once, rather than from others where conflict may brew for some time before we can address it. The suggested text for subsections are same as option 1.

- Welcome and appreciating everyone for joining in this *experiment* (5 min)
- Describe modified prototypes based on suggestions (10 min)
- Explain household selection criteria (10 min)
- Read off households: (5 min)

First phase, second phase, then 'waitlist' pending if anyone drops out

- Take any concerns or comments about process or about prototypes (20 min)
- Next steps - give people time to think about it before agreeing or not (for example 2 days).

Make it clear that if it doesn't work for them, you will remove the structure (5 min)

---

e) Household visit interaction format:

Suggested text for explanation: How *have you been? Thank you for your suggestions during the workshops, they were very helpful and our team has been working on them. As discussed during our workshops we have the capacity to work only with 15 households, as part of our experiment. For now, we have selected few households. We selected the households based on a few criteria:*

- Structural feasibility
- Prioritize houses with poor conditions
- Age of the structure (old houses are preferable)
- Top three priorities of residents
- Whoever has a unique prototype preference

We will work on installing prototypes in these 5 households for now and hope to monitor them for 2-3 months, initially. This will help us understand if we need to make any more modifications before proceeding with installations in the next 10 households. If we find that a particular prototype is inappropriate, we will eliminate it from the next set of installations and replace it with another option. We will organise visits to these households as well and will invite you for the same when these happen. On this day we'll also give you

the opportunity to share your preference list again.

Learnings from the homeowner's experience, our observations and your feedback as well will help us understand if we need to modify/eliminate any prototypes. This entire process will take approximately 2 months from now.

We will get back to you after two months to inform you if you have or have not been shortlisted for the next phase. We have a workshop and also a small training session then. Do you have any questions? concerns?

3. PARTNERSHIP AGREEMENT

RATIONALE:

- To seek residents consent to participate in the experimental installation in writing
- To seek residents' cooperation towards supporting with monitoring work post-installation
- To assure the residents of the project teams responsibility towards attending to any issues that might arise due to the installation

APPROACH:

1. Draft a consent form
2. Translate the form in the local language.
3. Identify a day and time to meet residents and share consent form details with residents with support from the NGO partner
4. Read the form/ask residents to read the form
5. Check if the content of the form is agreeable to residents
6. Fill the form details/Ask residents to fill the form details
7. Project team and resident to sign the form
8. One copy to be kept with the project team and the other to be kept with the resident

The template of the 'Partnership Agreement Form' is shared below.

Informal Housing Thermal Comfort Project

Partnership Agreement – Community Resident and cBalance

I …… and my family, residents of ……., volunteer to be part of the 'Informal Housing Thermal Comfort Project' experiment and agree to have the thermal comfort solution ……installed as part of our house structure.

We agree to keep the installation as part of our house structure for a period of 12 months to support the monitoring process. (From ……to…….).

We also agree to have the thermal comfort sensors installed in our house for monitoring purposes during the months of March, April and May 2022, and 15 days in the Month of October 2021 and October 2022, respectively. We will notify the Project team incase any issues arise due to the sensor and will leave it untouched unless necessary. We will also support filling the thermal comfort assessment form during this period.

I am aware that this is an experiment. Therefore, in case there are any unforeseen damages/dangers that might emerge during the monitoring period we will request the cBalance team to remove the installed solution. After residents contact the cBalance team incase of any critical issue, cBalance will remove the solution within 2-5 days after evaluating the situation with the residents.

Since this is an experiment, the cBalance team will bear all costs associated with installation, maintenance, monitoring and removal of the thermal comfort solution for a period of 12 months from ……to……

The cBalance team ensures that all information available in relation to …… (solution name) has been shared with the household.

The cBalance team will reimburse any costs that might emerge due to damages caused by the prototype installation for a period of 12 months, since the date of installation. However, cBalance will not reimburse damages caused due to factors beyond control for eg. Natural calamities, fires, etc.

At the end of 12 months since the date of installation, if the residents express a desire to remove the solution cBalance team would get it removed.

Post 12 months since the date of installation, if residents express interest in retaining the solution, the cBalance team will not support any maintenance and would not be responsible for removal of the installed solution.

Signatories:

Home Owner Name: ……..

Sign/Thumb Impression of Home Owner & Date:……

Tenant name (if applicable) :……..

Sign/Thumb Impression of Tenant & Date:……

cBalance team member name :……

Sign/Thumb impression of cBalance team member & Date: ……..

In consultation with:

NGO partner name: ……

Name:……..

Sign/Thumb impression & Date:……

4. THERMAL COMFORT ASSESSMENT FORM TRAINING

RATIONALE:

To train residents to document subjective thermal comfort data based on lived experience before and after installation to assess the effectiveness of a given installation.

APPROACH:

1. Identify a place and time that is convenient to interact and facilitate the meeting with community members with the NGO partners support.
2. Invite community members to the meeting and check if the suggested day and time works for them.

Details training method and the assessment form template are mentioned below.

A. Training Team Roles:

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

B. Material:

- Form Booklets translated in the local language
- Pens

C. 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

a. Guidelines to fill the form-

- It is suggested that the score card be filled by all family members.
- Elders of the family can help kids to fill out forms.
- 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 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.
- 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 score 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

---

b. General Information:

- Prototype Installed:
- House no.:
- Name of the representative household member:

---

c. Form Template

Day 1
Date:

Name of the family member			
Time-Range	Breakfast	Lunch	Dinner
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
Is the fan switched on or off?	☐ On ☐ Off	☐ On ☐ Off	☐ On ☐ Off
	Note: 1 is for Unbearable, 2 is for Low comfort, 3 is for Bearable,4 is for Comfortable, 5 is for Pleasant		
Rate the thermal comfort - Inside	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Rate the thermal comfort - Outside	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

3. POST INSTALLATION ENGAGEMENT

1. EXPERIENCE TOUR

RATIONALE:

- To learn about community's general acceptance of the installed solutions and their willingness to invest in them.
- To understand community member's inclination to have the prototypes that have been piloted in a few homes in their vicinity, installed in their homes
- To understand the possibility of the community owning and facilitating the retrofitting solutions through local women cooperatives.
- To learn of any improvements that need to be made to the installation to suit the community's need and context, better.

The aim of understanding the above mentioned aspects was gather insights on augmenting informal housing thermal comfort efforts in more informal settlements in the future, with support from women's cooperatives across different cities in India

APPROACH:

1. Share the tour plan with the NGO partner for refinements
2. Fix a date and time for the tour with support from the NGO partner
3. Check if the date and time works for community members

Details of roles, responsibilities and tour design are mentioned below.

B. Roles and Responsibilities:

a. Tour Guide - To lead community members to different houses during the tour and click photographs during the tour.
b. Coordinator
   - To give an introduction to the tour
   - To coordinate between groups to ensure the smooth flow of the tour and also click photographs.
   - To also be available for any intermittent support needed during the tour /open house period (eg. to be at a given house when other team members need bio breaks, etc)
c. Information sharing and data gathering person - To stay stationed at a given house and share information about a given prototype with tour participants and other visitors.
d. Snack and drink distribution person - To be available at the snack and drink distribution counter and serve them to residents at the end of the tour.

C. Material: Tour route sheet, feedback form booklets, pens

D. Tips:

- Remember to take everything that comes in the spirit of learning eg. more/less people might come to the tour than expected and the tour might not go as planned, therefore approaching this event without any expectation might help deal with how things go on field gracefully.
- If you are unsure about your response to certain questions posed by residents you musn't be ashamed to admit it and can say that you will check with other team members and will inform the homeowner about the response later. In such cases make a note of the person's phone number so that you can get back to them.
- If someone is judging a solution in front of the homeowner and it seems like the homeowner is

being negatively impacted by the comments, you can try and ask the person what they like about it to create a balance between positive and negative feedback.
- Keep the experimental nature of this process alive for the community eg. sharing failures with relevant prototypes.
- Emphasise to community members that the sole purpose of this exercise is to document their thoughts on these prototypes. This was an experiment through which your team hopes to learn about the effectiveness of these prototypes. Once we get feedback our intention is to refine the designs as needed and share these designs and skills with womens groups who can manufacture this by themselves and provide these solutions to more communities.

E. Tour format:

- Tour participants and guides gather in one place at a pre-decided time and a short introduction is given about the tour.
- Tour guides to follow the pre-planned route and lead participants to different houses.
- Residents who are willing to complete the tour are led to all houses. Those who choose to discontinue the tour after an hour or in between are encouraged to continue but are not forced to stay.
- One CB representative to be present in each house to share prototype details and collect feedback based on the feedback form when tour participants visit the house

F. Suggested script/s for interacting with residents:

- Before beginning the tour/ for any resident who comes to the open house and is not part of the tour (bits and pieces from the script can be used as applicable) :

Welcome and thank you for coming!

We will be visiting some houses where we have worked on different thermal comfort solutions with the residents over the past year. These people came for some meetings where we had discussions about these experimental solutions and they gave us their suggestions too. There have been some cases where we installed a prototype and there were some issues with them for eg. there was some leakage during the rains, and that was problematic to houses with dormer window, alufoil etc. All the residents have stood by us as we worked on making these experimental solutions better.

Now we have worked on a total of 8 different solutions with support from community members. We have installed these in 15 houses overall in Shindevasti. We will share details about the thought behind these solutions and want your feedback on them to understand your thoughts on the installations. We will not be installing in any more houses at the moment, because in the future we aim to work with women's groups who can start manufacturing the useful and affordable solutions by themselves and this will help more communities deal with heat stress and also give women a source of income, without being dependent on external entities for support. Therefore, we will be grateful if you can give us feedback so that we can learn about what works and what doesn't work and can take things forward, in other places, accordingly. We do not have any intention to commercialise these products.

Any questions?

- **At the house:**

- *Welcome!*
- *This is called —---------- (make sure to pronounce the name clearly, in parts)*
- *Let people observe the solution (2 mins per person)/ in cases where people cannot observe the solution keep videos/images handy*
- *This is how this cools the place (Explain the working principle and mechanism using relatable examples)*
- *Do you have any questions?*

G. Feedback Questionnaire:

Feedback Questions for Residents:

Name:
Sex : Male /Female
Age : .....

A. How much would you rate this experimental solution?

☹ 😕 😐 🙂 😄
1 2 3 4 5

B. How would you rate how much the installation is helping with thermal comfort/cooling inside the house?

☹ 😕 😐 🙂 😄
1 2 3 4 5

C. How much would you be willing to pay for this/What do you think would be a reasonable amount to pay for this? .....

D. Any feedback (things you like, things you don't like, concerns or questions?)
.....
.....
.....
.....

E. For CB- If you do not have an answer to any question/is posed by residents :
   a. Make a note of the question/s here
      :.....
      .....
      .....
      .....
   b. Residents Phone number :.....

F. Can you think of anything that can make this solution better?.....
.....
.....
.....

2. CRITICAL FEEDBACK

RATIONALE:

- To create a space for residents who have thermal comfort solutions retrofitted in their houses to share their views and honest feedback on the issues, benefits of the installed prototype in their houses
- To receive inputs on a reasonable investment amount for the installation of a given solution in their homes.
- To receive inputs on ways to enhance the approach of working with communities for future reference.

APPROACH:

1. Run the design of your critical feedback by the NGO partner and tweak the design to suit the context, based on the NGO partners' suggestions.
2. Identify a place and time that is convenient to interact and facilitate the critical feedback workshop/meet them at their houses with the NGO partners support.
3. Invite community members to the workshop/inform them about the planned time of your visit to their home and check if the suggested day and time works for them.

Details of role, responsibilities and workshop/interview design are mentioned below.

(Please note: While the description and information below encapsulates all elements that were planned for the critical feedback, elements were tweaked and/or eliminated based on the need of the hour. The critical feedback methods varied for the first and second cycle, given that the duration between the first set of installations and the critical feedback was shorter by a few weeks, as compared to the second cycle.)

First Cycle Feedback:

A. Roles and Responsibilities:

a. Interviewer: 1
b. Note taker: 1

B. **Material:** Interview question sheet, note taking book and a pen
C. **Format:** One-on-one interviews with residents at their homes.

D. Interview Questions:

1. How has your experience been with the installation?
2. Observed benefits

(Refer to household survey for and listening workshop notes for prompts : Health benefits based on initially mentioned health issues, sleep benefits, time spent indoors & outdoors, ease of working in the house, impact on children's studies, etc.)

4. Issues faced
    A. Any feedback from extended family, friends, neighbours, etc..
    B. Recommendations:
5. Anything you would change about the installation process/installation itself?
6. Would you recommend that others invest in this solution?
7. Is there another solution you might prefer now? (ask only after they've experienced it for a few months)
8. Do you think it would be beneficial if your community as a whole invests in this?
9. Any other thoughts, comments, or questions?
10. Wrapping up:*Thank you for sharing your thoughts and experiences with us. We are here in case you need any maintenance support, etc.*

Second Cycle Feedback:

A. Team Roles and Responsibilities:

a. Facilitator: 1
b. Design team members (to respond to community's questions): 1
c. Documentation person (note taking and photography): 1
d. Community mobilization person/s: 1

B. Material:

0. Workshop flow document
1. Images of installations
2. Video capturing the projects journey in the locality (optional)

C. Workshop Flow (Approx. 1.5 hours)

1. Introduction (5 mins)

*(*Suggested Script*: Welcome! Thank you for working with us over the past year and for all the love and we have received*

from you. You'll have made us feel at home here and we are grateful to you for that. We are grateful that you stood by us even when things did not work out, in terms of issues that you faced during the rains, etc.). You'll were also patient with us during the installation process, especially during times when we took more time to work on the installations than expected. There are some of you who were not there with us from the beginning and still trusted us and decided to work with us. Your trust in us is helping us move forward hopefully.

We want to show you a video to take you down memory lane: video (2 mins)

We want to remind you as we had shared with you at the start that this is an experiment and as we go further on this journey, this will help us to learn about what works and what does not work which will help us when we work with women's groups in the future. The intention is to work with women's groups so that they can manufacture these solutions and provide them as products in their own communities. Therefore, your feedback is very valuable. We know that some of you gave us your feedback when we came to your homes, last time. However, it has been a while since then and we hope to learn about any more experiences you have to share with us today.

These are the —--- installations we will be discussing today. (show images))

Before commencing the critical feedback: Make an agreement that one person speaks at a time.

2. Critical feedback questions

- **General feeling:(5 mins)**

- How are you feeling about the installation in your house?
- Happy/Not happy

(go around the room- the same format can be followed for the next subsections)

- **Issues: (30 mins)**

- For those who are not happy - what are the issues you are facing with these installations?
- Project team addresses concerns (if applicable)
- *Any issues that are coming to your mind after listening to this?* (to others)
- Project team addresses concerns (if applicable)
- Issues you are anticipating in the future (during different seasons - summer, winter, monsoon)
- Project team addresses concerns (if applicable)

- **Benefits: (20 mins)**

- *We would like to know how this installation has benefitted you and your family members so far?* (Prompt : *Do you remember that initially, we had discussed a range of issues you'll face in summer such as difficulty in sleeping, doing housework, loss of appetite, children finding it difficult to study and the elderly finding it difficult to stay indoors)*

(prompt residents to share benefits during the day and night, both)

- **Recommendations: (10 mins)**

- Any recommendations for things we can improve in the installations?
- Any recommendations for things we can improve on based on how we have interacted with you?

- **Thoughts on investment: (10 mins)**

- Would you recommend that others invest in this solution?
- What do you think would be a reasonable investment/ideal cost for these solutions?

- **Other thoughts: (5 mins)**

- Is there any other solution you might prefer now?
- Any other thoughts, comments, etc.…? / questions from others. (10)

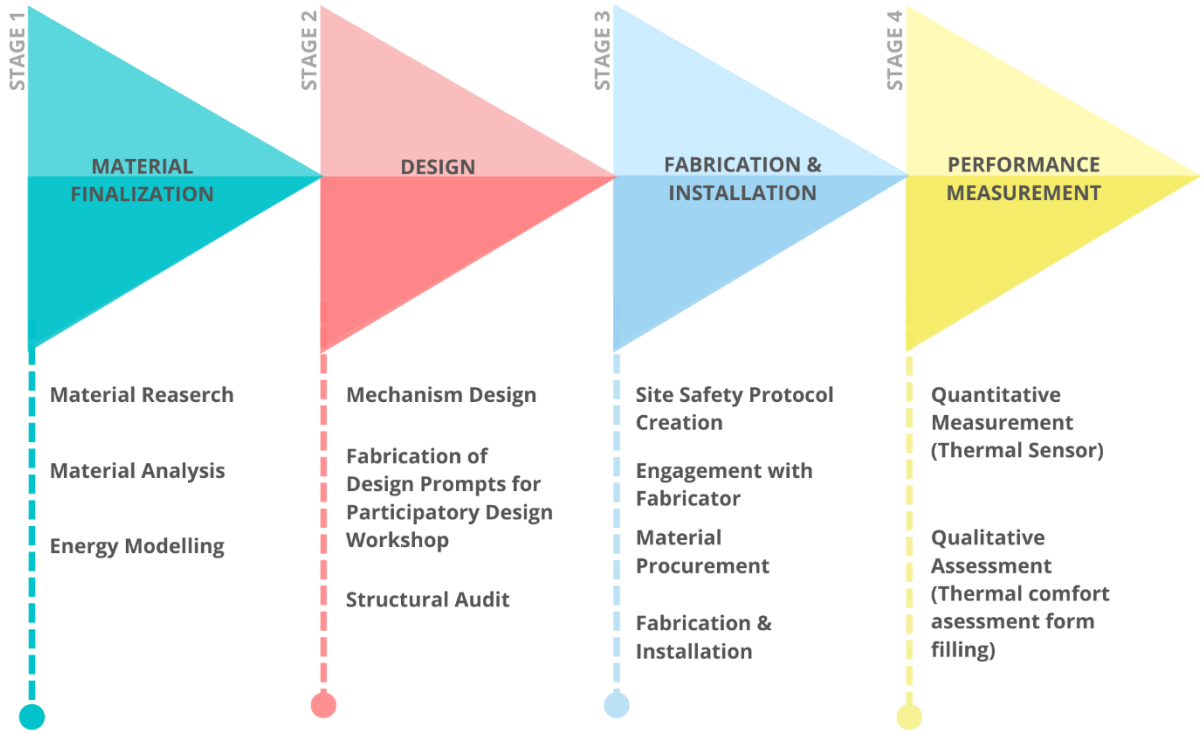
3. Wrapping up:

Thank you for sharing your thoughts and experiences with us. Our work here is not over, but it has just begun. We will keep coming to hear about how the installations are functioning. We are here in case you need any maintenance support, etc.

IV. THE TECHNICAL DESIGN PROCESS

1. OVERVIEW

The design process occurred in 4 re-iterative stages which included material research and study, energy modelling, mechanism design, fabrication and installation. The material research focused on identifying materials that support combatting solar heat. During the material study phase, shortlisted materials were analysed against a scoring sheet. The materials were studied to understand certain physical properties like fire resistance, corrosion resistance, thermal conductivity, weight capacity, water absorption, etc. Thereafter, design mechanisms were worked on to support using the material to support with minimizing indoor temperatures in informal structures. The design process was facilitated by internal design team members with guidance from academic design mentors. After the tentative finalization of selected designs, working models were fabricated and shared with community residents at 'Participatory Design Workshops' as design prompts to support co-creating and contextualizing the designs before finalizing them for installation. Inputs from the participatory workshops led to iterations in the initial designs. A structural audit was conducted across homes to decipher which solution may be appropriate for each household. Once the designs were finalized and suitable house structures were identified and residents' consent was sought for the installation, fabricators were brought on-board before the final stage of design for an integrative design-build process, leading up to the installation stage. After installation, readings from sensors were recorded along with the feedback from residents regarding their thermal comfort through 'thermal comfort assessment forms' to understand the performance of the solutions both quantitatively and qualitatively. The stages and steps are illustrated in the diagram below.



2. OVERARCHING DESIGN STAGES

This subsection provides an overview of the overarching stages that were common for all the thermal comfort retrofits that were designed as part of the project. The stages described span material finalization, design, fabrication, installation and performance measurement.

STAGE 1 – MATERIAL FINALISATION

The material finalization processes happened parallel to the pre-installation community engagement process. This section primarily elaborates on 3 aspects: 'Material research and methodology', 'Detailed material study parameters and analysis process' and 'Energy Modelling of the materials.

1. MATERIAL RESEARCH

RATIONALE:

To have a list of materials that can be possibly used as retrofitting materials over the existing roofs of informal settlements to reduce the indoor temperature of informal structures.

APPROACH:

1. Prepare a list of heat combatting materials for detailed material study and analysis through online research.
2. Identify material dealers and manufacturers through online research.
3. Conduct a market study of streamlined materials by connecting with authorised dealers and manufacturers.
4. Gather applied knowledge and wisdom from allies who are working or have experience in the domain of structure cooling based on your networks or through online research.

2. MATERIAL STUDY

RATIONALE:

To study and analyse the selected materials in detail to support finalizing suitable materials for prototype design and installations.

APPROACH:

- Analyse each material identified during the material research stage based on the following criteria:
    - Scientific principles: Thermal conductivity, thermal mass, density, fire and corrosion resistance, water absorption and resistance and UV absorption.
    - Engineering aspects: Weight, load bearing capacity, thickness, sturdiness and wind resistance.
    - Environmental aspects: Embodied energy, water footprint, reusability, recyclability, energy footprint and local availability of the material.
    - Socio-economic aspects: Cost, lifespan, maintainability, local install ability.
    - Applicability (Architectural or Utilitarian): Spatial and structural application patterns, infrastructural requirement and roof application of the material or solution.
- Conduct a comparative analysis of the materials
- Rule out materials that are not suitable
- Conduct a secondary round of analysis for shortlisted materials

3. ENERGY MODELLING AND FULL-SCALE PROTOTYPE TESTING

RATIONALE:

To analyse the projected impact of reduction in temperatures of the selected materials

APPROACH:

Conduct building heat simulations of the shortlisted materials using Design Builder Software (or any other software) for building heat simulation for different type of houses in informal settlements i.e. Kutcha (tin roofed and walled), Semi-pucca (tin roofed and brick walled) and Pucca (brick walled and concrete slabbed) houses.

STAGE 2 –DESIGN

This subsection gives an overview of the design process. The process was initiated after the material finalization stage. It was a re-iterative process which took multiple iterations to reach the final design. This section includes 2 other parts apart from the primary focus on 'Mechanism Design', namely 'Design Prompts' and 'Structural Audit' both of which informed the final design.

1. MECHANISM DESIGN

RATIONALE:

To design a range of simple, affordable and effective thermal comfort solutions comprising over and under the roof, static and dynamic solutions.

APPROACH:

1. Identify criteria that can support the mechanism design process. The criteria for this project included:
    - Simplicity
    - Affordability
    - Local availability materials
    - Experiment with certain sheet or panel-based solutions to test mechanisms based on the concepts of Radiant Barrier + night sky radiation
2. Inform design team members to conduct research about different mechanisms.
3. Ask team members to brainstorm each solution to come up with a design drawing.
4. Schedule weekly internal review sessions with team members to make space to share work progress and receive inputs from other team members.
5. Seek inputs from experienced design persons such as academic and product design mentors on bi-weekly basis.
6. Work on initial design prompts that can be presented to the community for their input.
7. Present the first cut of designs to the community at 'participatory design workshops' to facilitation the co-creation and contextualisation of designs based on their inputs.

2. DESIGN PROMPTS FOR PARTICIPATORY DESIGN WORKSHOPS

RATIONALE:

To fabricate working models that would serve as design prompts for the residents in the participatory design workshops. These were made to highlight some of the working mechanism ideas for the finalised solutions and to also prompt the residents to come up with more ideas

APPROACH:

1. Make a design drawing for each solution and explain it to the fabricator.
2. Evaluate options for locally available materials.
3. Work on identifying simple fabrication techniques for each solution with the fabricator.
4. Ask for the fabrication of 3 ft by 3 ft models for all the design ideas.

Design Prompt: Ecoboard Sliding

Design Prompt: Dormer Window

3. STRUCTURAL AUDIT

RATIONALE:

1. To understand the structure of the house to support refining the design.
2. To decide on which solution is best suited for a particular house structure.

APPROACH:

1. Create a structural audit questionnaire (can be found below)
2. Visit each house and fill the questionnaire with support from residents who are willing to support the audit process.

Questionnaire to Study Existing Structure for Prototype Designing

Team Member Name:

Date & Time:

House No. & Address:

House owner Name:

Note:

Attach photographs for reference.

Take all measurements in meters.

- **General:**

1. What are the dimensions of the structure?

Dimension	Value (in metres)	Comments/ Additional Remarks
Length		
Width		
Height		

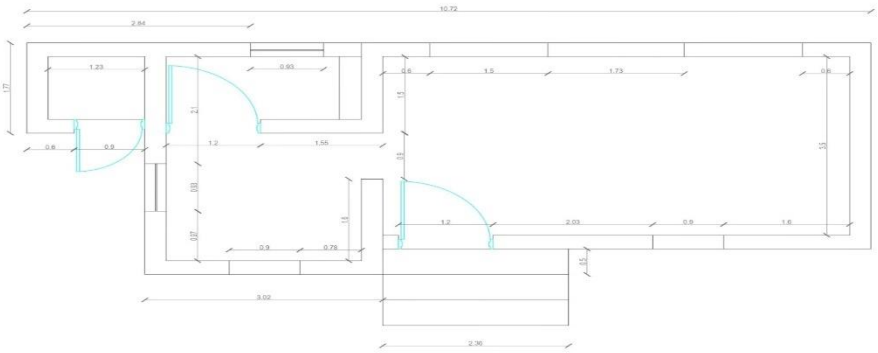
2. What is the temperature during the survey? (Average of 3 measurements/ readings)

- Surface temperature of the walls (℃)
- Surface temperature of the roof (℃)
- Surface temperature of the floor (℃)
- Inside Dry Bulb Temperature (℃)
- Inside Wet Bulb Temperature (℃)
- Outside Dry Bulb Temperature (℃)
- Outside Wet Bulb Temperature (℃)

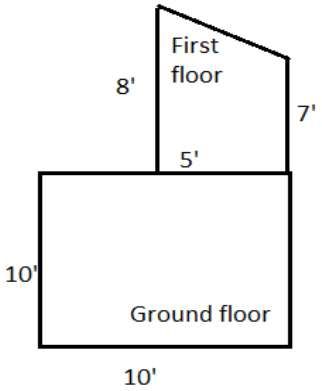
1. What is the layout and orientation of the house? (Direction towards north)

Note:

- *Carry hardcopy of the map of the area to be audited.*
- *Mark the house and its given number on with the help of Google Maps live location. The North will be fixed on the hardcopy.*



Plan



Section

- *To be more precise, in the box given below sketch SLD (single line diagram) PLAN and SECTION of the house with the rooms and other details.*
- *Check the North direction with the help of a compass and note is beside the plan.*
- *While sketching the Plan of the house/structure, label the existing doors (D1, D2), windows (W1, W2) and ventilators (V1, V2).*
- *Get the following details:*

1. *How many rooms are available in the house? (Example- 1 room, 1 toilet, backyard etc.)*
2. *Are there any adjoining structures around the house? If yes, how many and in which direction (N/S/E/W)?*
3. *Is there roof access for installation and maintenance? Ex. Staircase*
4. *Are there high-tension electric wires on the rooftop?*
5. *Do we have outdoor space access for the operation of dynamic mechanisms? (eg. Alufoil chain sprocket needs minimum. 3 feet gap on at least one side of the house)*

6. *How is water stored for use? (Ex : Overhead Tank, Sump, Hand Pump and Drums)*

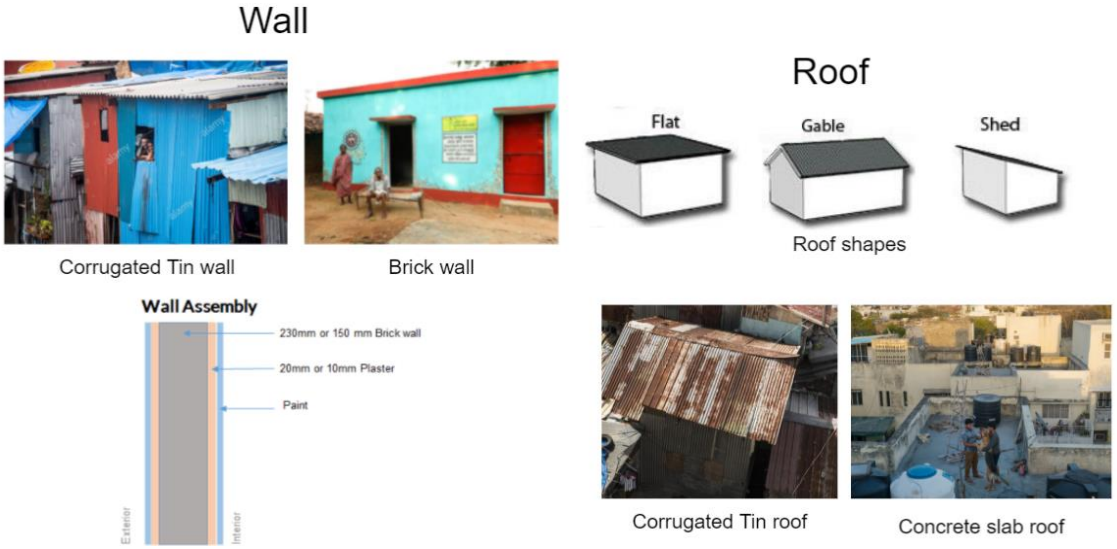
- Structural Details of Walls, Roof and Floor -

1. Structure Assembly:

Structure Component (Composition - Assembly)		Type*	Layer 1	
			Material*	Thickness (in mm)
Roof	Flat, Gable, Shed			
Wall	Brick wall, Corrugated tin wall			
Parapet	No type available	NA		

**Notes:*

(i) Roof types; Wall types; Floor types (check reference images below)



(ii) If the roof is sloping, measure the angle (slope). (Below are the instructions to measure roof angle)

Smaller Wall Height (m)	*Larger Wall Height (m)*	*Wall Width (m)*	*slope= tan-1(Larger Height - Smaller Height Wall Width)*

(iii) Enter NA if something is not applicable

- Other details of the Structural components:

*Note: *Ask Residents if the auditor can't see any leakage. **Attach pictures of damp surface*

Structural Component	Year of installation/ latest repair	Cracks	Leakage*	Corrosiveness*	Fire Resistance
		Good: approximately <5% area affected Average: 5-10% area affected Bad: >10% area affected	Good: approximately <5% area affected Average: 5-10% area affected Bad: >10% area affected*	Good: No corrosion Average: <5% area affected Bad: >5% area affected	Good: Fireproof Bad: Fire prone
Roof					
Wall					
Parapet					

- <u>Daylight and Ventilation</u>
- How is the Day lighting and Air ventilation in the structure?
  Note: Take this measurement in the center of the structure.
  Measure through Lux Light Meter by keeping it on the floor, switch off all lamps in the structure and measure only daylight

  What is illuminance? _____ lux
  (*Note: Illuminance is a measure of how much the incident light illuminates the surface*)

  a. Daylight - (rate on the scale)

- Very Poor
- Poor
- Sufficient
- Strong
- Very strong

  b. Ventilation - (rate on the scale)

- Still

- Slightly Still
- Just Right
- Slightly breezy
- Too breezy

- How many openings are available in the house?

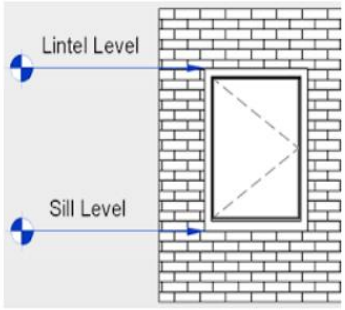
a. Door-

b. Window-

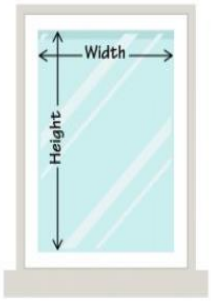
c. Ventilator-

	Window Name	**Window Size**	**Door Name**	**Door Size**	**Ventilator**	**Ventilator Size**
	e.g.W1/W2	**(In metres)**	**e.g.D1/D2**	**(In metres)**	**e.g.V1/V2**	**(In metres)**
Height						
Width						
Sill Level						
Lintel Level						

**Note: Keep the labelling for the doors/windows/ventilators same as the sketch in the General Section. Reference images given below:*



Sill Level and Lintel Level of an opening



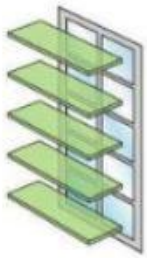
Height and width of an opening

- What are the types & sizes of shading devices in the household?

Shading Device

Chhajja

Awning



Horizontal shade

Vertical shade

Ventilator

Exhaust Fan

Jhali Window

Opening in the wall

Sr. No.	Opening name (eg. D1, W1)	Type of shading device used*	Size of shading device used (length x width x thickness)
1			
2			
3			

Note:

1.Keep the labeling for the doors/windows/ventilators same as the sketch in the General Section. Reference images given below:

2.Reference image of shading devices

3.Anything above Lintel level which helps in air and light exchange is a Ventilator.Ex: Exhaust fan, Jhali, Opening in the wall etc

- Additional Information

1. Roof (Supporting) Structure Material - on which the roof is resting or is set up (Example - GI sections/ wood/ bamboo)

2. Water supply system available in structure?(If yes How many tap connections) mention if any leakages found.

3. Rate the structure strength (out of 10)? Post scoring, Kindly describe and elaborate further.

   Note : Sturdy support, no structural enhancement : 7-10 , Medium support, need a few structural enhancements : 4-6, Poor/Damaged support, needs complete structural revamp : 0-3

4. Which day would be preferable to you for the participatory design workshop?

- Sunday
- Monday
- Tuesday
- Wednesday
- Thursday
- Friday
- Saturday

5. What time would be preferable to you for the participatory design workshop?

- Morning
- Afternoon
- Evening

- Solution Specific Questionnaire:

Sr. No.	Solution Name	Selection Criteria	Applicability on current structure	Reason
1	Alufoil (Static)	• Tin walls or brick walls (both are fine) • Sloping or flat roof both are fine • Should have a frame or brick wall to fix the ms sections	Yes / No	
	Alufoil (Dynamic)	• Wall type - Sturdy? • Roof strength - Adequate beam support? • Roof integrity - Any	Yes / No	

		cracks/leakages present? • Roof Parapet - Can a MS Box section structural frame be fixed on the roof parapet?		
2	Modular Roofing Panels	• Sturdy, brick walls • Sloping or flat roof both are fine • Should have a frame or brick wall to fix the ms sections	Yes / No	
3	Fiberglass Insulation	• Flat or slight slope preferred • Structure should have high roof (9-10ft) • Waterproofing needs to be in place (Walls & roofs)	Yes / No	
4	Dormer Window	• Metal roof • Sturdy, brick walls • Sloping roof • Direction of Slope - Ideally facing North and North-East; but can also be installed in North-west, West and East directions	Yes / No	
5	Rooftop Urban Gardening	• Sturdy, brick walls • Sloping roof to drain out water • Accessible roof height (single storey) • 2 side access preferred • Should have own or nearby water source	Yes / No	
6	Water-filled PET-bottles	• Sturdy, brick walls • Flat or slight slope preferred • Accessible roof height (single storey) • Should have own or nearby water source	Yes / No	
7	Wool Panels	• Clear height of the room • Stable walls (Brick / RCC). • The roof should be stable for bearing the load of the installation. • Space between existing roof	Yes / No	

		structure and solution to devise the installation mechanism		
8	Ecoboard static	• Sturdy, brick walls • Flat or slight slope preferred • Structure should be rectangular or square in shape.	Yes / No	

STAGE 3 – FABRICATION AND INSTALLATION

The section provides an overview of 3 processes which were common for the fabrication and installation of all the prototypes. It elaborates on 'Site Safety Protocols', 'Engagement with Fabricators', 'Material Procurement' which supported the final 'Design and Installation Process'

1. SITE SAFETY PROTOCOLS

RATIONALE:

- To ensure safe and dignified working conditions for project workers
- To ensure the safety of inhabitants who open their homes to be part of the experimental endeavour

APPROACH:

1. Reflect on the processes involved in the fabrication and installation to determine possible spaces where caution is warranted to ensure safe and dignified living and working conditions during site work
2. Create a check list of factors that need to be taken care of before, during and after site work

The checklists below can be referred to for site safety procedures.

Safety Protocol Checklist

Date: ..... **Safety supervisor**: .....

Pre installation work:

- Have a handover call with the previous day's team to get updates on the following:
- Any safety measures to be mindful of in relation to today's work.
- Any eatables that need to be purchased.
- Any medical supplies that need to be purchased.
- Arrive at the material storage room 20 minutes prior to the scheduled installation time.
- Ensure the availability of the following items:

- Water (not packaged)
- Biscuits
- Fruits (e.g., Bananas)
- Torchlight
- Grievance booklet
- Log booklet
- Pen

- Check that the first aid kit with the following material is available.
  - Gauze
  - Electral powder
  - Soframycin
  - Dettol
  - Band aid
  - Scissors
  - Cotton
  - Surgical tape
- Have a contact list of the following available to address unforeseen events:
  - Hospitals
  - Clinics
  - Fire station
  - Police station
- Carry the above-mentioned food items, booklets, and first aid kit to the installation site.
- After reaching the site, ensure that arrangements are made for residents (whenever applicable)
  - Food arrangements
  - Arrangements to move to a temporary safe space/location during installation
- Check that the installation supervisor is present on site.
- If child labour is present, follow steps mentioned in the 'Emergency Protocol' checklist.
- Check that the following are available at the site:

- A sturdy ladder
- A wooden stick

- Check that the project workers are wearing/have carried the following safety equipment:
  - Hand gloves (rubber gloves in case of electrical work)
  - Protective glasses (in case of welding and grinding)
  - Safety helmet
  - Safety shoes.
- Facilitate a safety protocol meeting with the installation supervisor and project workers before commencing installation work.

During installation work:

- Regular/Timely tasks during the installation process
- Remind project workers to wear protective gear as and when required.
- Remind project workers to drink water after every hour.
- Check that the water bottles are filled.
- Check that ladders have firm footholds and handholds before a project worker climbs.
- When a ladder is used, inform the installation supervisor to hold the ladder firmly from the lower side.
- Warn by-passers about possible dangers if they are near the installation work.
- Check that no harm is done to the inhabitants and their belongings
- 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.
- In case the installation work continues when it is dark, ensure that a torch is used.

Post installation work:

Daily tasks:

- Allocate 5-10 minutes post installation to:
- Update the logbook
- Make a note of any grievances by project workers and residents in the grievance book.
- Check the status of eatables and first aid kit supplies and make a note of anything that needs to be

purchased the next day.

- Place the following in the material storage room:
- first aid kit
- Wooden stick
- Eatables
- Booklets and checklists.

Additional tasks on the last day of installation at a given household:

- 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.

Emergency Protocol Checklist:

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.
- One the fabricator signs the declaration, ask him/her to make provisions for a legal-aged project worker to support the installation process.

If a person meets an electric current

- 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.

1.ENGAGEMENT WITH FABRICATOR

RATIONALE:

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

CRITERIA:

To identify:

- A fabricator who is ready to and has the capacity to undertake the work in the long-term
- A fabricator based in and around the locality.
- A fabricator who agrees to adhere to safety protocols during the fabrication process.

APPROACH:

1. Send a questionnaire to potential fabricators. (The template questionnaire is in the box below)
2. Analyse the fabricators response to the questionnaire and proceed with the next steps if the fabricators response to the questionnaire indicate potential.
3. Show the designs of the specific solutions to the fabricators to understand their capacity to fabricate the thermal comfort retrofit.
4. Visit their fabrication spaces to gauge their fabrication capacity
5. Select a fabricator who seems most suitable for the project work based on the above mentioned evaluation.
6. Sign a contract signed with the selected fabricator, (a template contract is in the box below the questionnaire under this section)

Interview Questionnaire for Fabricators

1. Name of the Fabricator
2. Location
3. You will provide fabrication for which solutions? (Select all that are applicable)
    a. Alufoil
    b. Wood Wool Panel
    c. Rooftop Urban Gardening
    d. Ecoboard
    e. Water-filled PET bottles

f. Dormer Window

4. How many employees present?
    a. 0-5
    b. 6-10
    c. 11-15
    d. 16-20
    e. 21-25
    f. 25+
5. How many machines present in the workshop?
    a. 0-5
    b. 6-10
    c. 11-15
    d. 16-20
    e. 21-25
    f. 25+
6. Approx. annual turnover in Rs.
    a. 0-1 lakh
    b. 1-3 lakh
    c. 3-5 lakh
    d. 5-7 lakh
    e. 7-10 lakh
    f. 10 lakh+
7. Child workers present?
    a. Yes
    b. No
8. What are some ways in which you will look to reduce wastage of materials?
9. What are some ways in which you will look to recycle materials?
10. Are you willing to provide warranty for your fabrication? If yes, how much?
11. What is the cost quotation for the selected design(s)? (If possible, provide cost break-up of solutions)

Fabricator Contract

cBalance Solutions Pvt. Ltd. is a knowledge-centric social enterprise rooted in sufficiency and social equity. We build tools to reduce carbon footprint and bridge the gap between climate-crisis knowledge and action by hand holding collectives into integrating the climate-emergency and climate-justice into their actions.

Someshwar Associates is a --- based company working in the field of construction, fabrication and installation.

This contract would lay down the guidelines on Safety, security and humane equity of all stakeholders involved on the fabrication site. Project Lead from Fabricator side, cBalance side and/or involved CSO side would require it to thoroughly go through it and ensure its implementation on the ground.

Safety and Security Guidelines:

- There is enough supply of basic personal protective equipments (*Safety glasses, Flame-resistant gloves, Ear plugs / earmuffs, Welding helmet, Oil-resistant shoes, protective clothing*) for all involved in work.
- All workers should always wear safety gloves and glasses without exception.
- Keep your fabrication shop/site organised, clean and free to clutters. All tools and equipments are kept in their places before and after use. Disorganized floors and messy areas can lead to falls and other injuries, so keep everything organized to ensure the highest safety precautions for you and your team members.
- Emergency contact numbers (Local Ambulance, Fire Station, Local Police station, local doctors, co-workers, important people, etc) be displayed at visible locations and be educated to all regular working people on the site.
- Fire Extinguishers be installed on the site and checked regularly for its proper functioning.
- Ensure a working ambient clean environment is maintained on the site. Enough natural sunlight, air ventilation, and fans are available.
- Basic Medical Kit box be available with all required items in it.
- Clean drinking water and appropriate basic sitting facilities are available.
- Communicate safety rules clearly and hold people accountable.Safety policies must be communicated clearly and effectively to all staff members, including visitors and new team members.
- All the waste generated (oils, metals, plastics, hazardous materials, etc) be appropriately segregated and disposed of which is not harming the environment in any sense.

Humane Social Equity Guidelines

- No child labour be involved during the work on the site.
- No exploitation of labour - labour laws to be followed, minimum wages as per the laws and market to be paid to the workers and helpers.
- Dignity of Labour to be maintained and followed at all levels, especially during conflicts.

- In case of any minor/major injuries or casualty, immediate nearby medical assistance be provided to the victim irrespective of his/her social or economic background.
- Maintain respectful, mindful & professional relationships with all team members and visitors, be it internal or external.

Since the project involves installation activities in the selected houses in the informal settlement, the work should be commenced keeping in consideration certain levels of safety, social equity by both installers and cBalance team coordinator, to ensure fairness and undisturbed environment by the retrofitting related processes and activities. Below are some of the checklists and protocols requested to be kindly followed:

For Installers:

- The installer needs to thoroughly check the installation after the prototype has been installed, in order that no gaps or loose ends are left, which could lead to a variety of happenings such as water leakages, rats, insects, etc. coming in from the gaps. It should be confirmed before the house is re-inhabited.
- Similarly, in case of prototypes which are to be opened/slided open or closed, the mechanical apparatus and functionality of it should be checked after the installation.
- In the installations with electrical work, safety measures to be followed so that no person in the house is harmed due to any carelessness.
- Safety gears and protective implements should be worn and used by all the workers.
- Lighting facilities such as flood lights, hand lights and area lighting should be placed in case of dark working conditions.
- A certain sense of organization and cleanliness be followed while working, the implements or tools should not be spread on the floor in the house. No garbage or leftovers, leave the place better than you found it.
- Child Labour is strictly prohibited. No child below 14 years of age shall be employed to work.
- Labour laws shall be followed, and minimum wages as per the laws and market shall be paid to the workers and helpers.
- No person/animal shall be harmed while the work and installation is being conducted and carried out.
- Medical assistance in case of any injuries be handy and available.
- The time and dignity of the families in whose house the work/installation is being commenced, be respected and the work schedule be adjusted according to their timings and comfort. This is primarily because, the community we are working in are a part of Informal economy i.e., daily wage earners. The time and livelihood conditions to be taken at the priority.
- Sufficiency of materials shall be followed, with minimal waste while at work.

For cBalance team:

- Thorough checking of the prototype installation before re-inhabitancy, so that no casualties or injury is incurred on the inhabitants of the house.

- Work shall be commenced with minimum interference to the surroundings so as not to create any pedestrian blockage or obstruction and prevention of injuries. The cBalance team member should be coordinating the timings and installation logistics with the family, before and after the installation.
- Make sure that the safety measures are followed on site, at work.
- Fair working hours and compensation shall be provided for all the project workers.
- Provide project workers with accessible means to raise workplace concerns. Discipline/ harassment and grievance procedures shall be made available for all.
- All accidents leading to personal injuries and/or property damage shall be reported immediately to the supervisor from cBalance Team.
- In case there are any injuries onsite, caused due to the installations/work fault at any stage of the work, the required medical assistance be provided by the team. First-aid kits including sterilized dressing, cotton wool and antiseptic cream shall be made available at readily accessible places.
- Materials provided by the cBalance team as listed below. Someshwar Associates will have to procure rest of the assembly materials except these given below.

Sr. No.	Material	Concerned Solution
1	Wood wool material sheet	Wood wool insulation

Fabricator Deliverables

Sr. No.	Installation
1	Wood wool panels in household 1
2	Wood wool panels in household 2
3	Pet bottle installation in household 3
4	Pet bottle installation in household 4

Payment Terms:

Sr. No.	Category	Percentage	Amount (INR)
1	Advance Payment	60%	30,000
2	Payment After Installation	40%	20,000

	Total	100%	50,000

Duration of partnership:

15th December 2021 to 24th December 2021 (Extendable subject to installation period)

Authorization:

_____	_____
Fabricator Name **Fabricators Shop name**	**Organisation Member Name** **Organisation Name**

2.MATERIAL PROCUREMENT

RATIONALE:

To procure materials for fabrication and installation.

CRITERIA:

1. To look for places where materials can be purchased at a reasonable cost
2. To look for places closest to the installation site

APPROACH:

1. Come up with the Bill of Material for each solution.
2. Conduct research of material selling places located near the installation site.
3. On identifying a suitable place, ask for the materials to be transported to the installation site.

3. FABRICATION AND INSTALLATION

RATIONALE:

To fabricate and install experimental thermal comfort retrofits.

CRITERIA:

- To use simple fabrication techniques.
- To ensure that the fabrication gets completed in a timely manner.
- To carry out installation with minimum disturbances to the residents and neighbours.

APPROACH:

The approach to fabrication and installation is described in the checklist below.

Fabrication and Installation Preparation Checklist

With external entities (fabricator, community members and NGO partner):

- Check if installation consent is sought from the households.
- Discuss the non-negotiables with the fabricator
    - Safety Protocol
    - Adherence to timelines
    - No child labour
- Discuss list of safety material needed during fabrication process
    - Hand gloves (rubber gloves in case of electrical work)
    - Protective glasses (in case of welding and grinding)
    - Safety helmet
    - Safety shoes
- 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.
- 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.
- 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 place in the community to store fabrication material with support from NGO partners.
- Arrange for a room for residents to stay during installation with support from NGO partners.
- Check for community members who can support food preparation with support from NGO partners.
- Find an electrician in the community with support from NGO partners.
- Get an electrical audit done by the electrician for each household to ensure safety.

- 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.

Within the team:

- Orient team members to the purpose and use of the site supervision checklist.
- Conduct mock site-supervision 'role play' / situation-simulation session.
- Orient team members about the prototypes to be installed.
- Arrange for torches for workers and supervisors if working in the evening past sunset.
- Print site supervision checklist, logbook and grievance book.
- Purchase first aid kit material.
    - Gauze
    - Electral powder
    - Soframycin
    - Dettol
    - Band aid
    - Scissors
    - Cotton
    - Surgical tape

<u>Fabrication and Installation Supervision Checklist</u>

Date: ..... Installation supervisor: .....

Pre installation work:

- Have a handover call with the previous day's team to get updates on the following:
- Work done the previous day.
- Work to be done today.
- Any other specific installation suggestions.
- Checklist and logbook availability on site.
- Any property damages
- Charge your phone fully before you leave for the site.

- Arrive at the material storage room 20 minutes prior to the scheduled installation time.
- Check that installation material is available at the site before work begins.
- Check for the presence of the safety supervisor.

During installation work:

- Discuss installation details with the fabricator before the work begins.
- Don’t let the installation work begin unless there are a minimum of 2 workers to support the process.
- Regular/timely tasks during the installation:
- Halt the work if a minimum of two workers are not present on site at any point in time.
- Check for minimum interference/ obstruction in the pedestrian pathway.
- Click photographs and videos after every hour.
- Provide project workers with a torch in case of dark working conditions.
- In cases of property damage note the cost of reimbursement in the logbook.
- Check that no loose ends or gaps remain at the end of the installation.

Post installation work:

Daily tasks:

- Update the logbook with the day's installation details.
- Discuss the work to be done the next day with the fabricator and enter details in the logbook.
- Decide on the reporting time for the next day and note it in the logbook.
- Check that installation material is cleared from the resident's house.
- Check that the waste is segregated and appropriately disposed of by the fabricator
- Update the residents about today's work and the work that will happen tomorrow.
- Inform residents about the installation team’s reporting time for the next day (if applicable).
- Keep the checklist and logbook in the material storage room.
- Schedule a call with the next day's supervisor to share installation updates.
- Upload photographs to the pre-decided documentation database at the end of the day.
- Communicate property damage (if any) to the admin team the next day and commission reimbursement to the house owner thereafter

Additional tasks on the last day of overall installations:

- 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

STAGE 4 – PERFORMANCE MEASUREMENT

This subsection gives an overview of the thermal comfort performance measurement process. It consisted of two parts, the quantitative measurement and the qualitative measurement, the processes of both have been documented below.

1. QUANTITATIVE MEASUREMENT (PHYSICAL SENSORS)

RATIONALE:

To objectively measure the thermal comfort performance of the thermal comfort retrofits.

APPROACH:

1. Install a memory card in the thermal sensor to capture readings
2. Tag the name of the person who's house the sensor will be installed in on the sensor
3. Install sensors in each house 7 days prior to the installation
4. Install one sensor in a house in the neighbourhood where no installation has/will be undertaken
5. Install one sensor outdoors to capture outdoor measurements
6. Remove the sensor eight days after the installation
7. Analyse the data to estimate the thermal comfort performance of each household in comparison to the surroundings and neighbouring house temperature

2.QUALITATIVE MEASUREMENT (THERMAL COMFORT ASSESSMENT FORM FILLING)

RATIONALE:

To subjectively estimate the thermal comfort performance of the households

APPROACH:

1. Prepare a thermal comfort assessment form (refer to the 'Thermal Comfort Assessment Form Training' sub-section under the 'Community Engagement' section of the manual for the form template)
2. Train residents to fill the form
3. Ask residents to fill the form continuously 7 days prior to the installation and 8 days after installation
4. Collect the form from residents 8 days after the installation.
5. Analyse the data to understand the subjective thermal comfort performance of each solution.

3.SOLUTION SPECIFIC INFORMATION

This section provides a detailed description of each thermal comfort retrofit experimented with as part of this project. Each subsection provides a basic description of a given retrofit followed by describing its working mechanism. It shares its material requirements and describes the fabrication and installation process followed by maintenance guidelines, as applicable. This information is supported by the working drawing and installation image for each retrofit.

A. ECOBOARD

DESCRIPTION

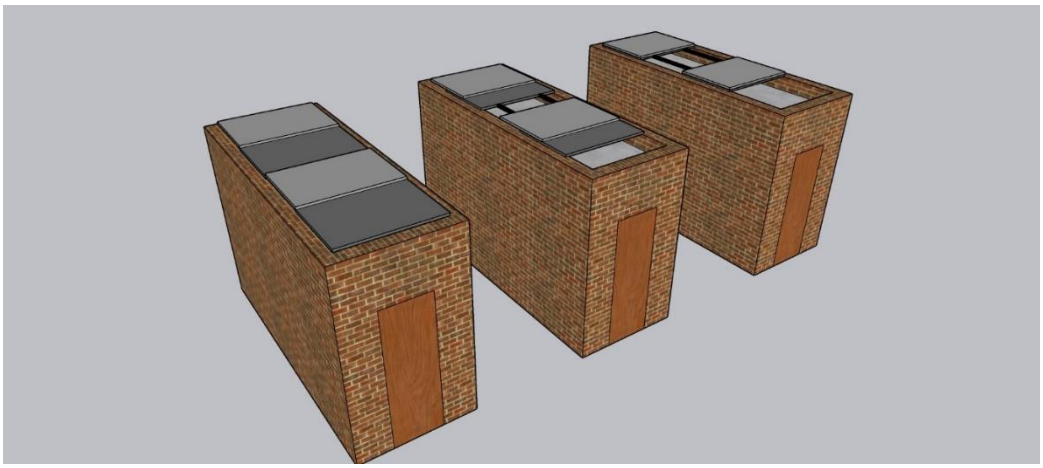
These boards are made from multi-layer plastic which are hard to recycle and end up in landfills usually. Tetra packs and other plastic objects are compressed under high temperature to create a consolidated board that can later be used to make furniture, as doors and other objects.

MECHANISM 1 – SLIDING

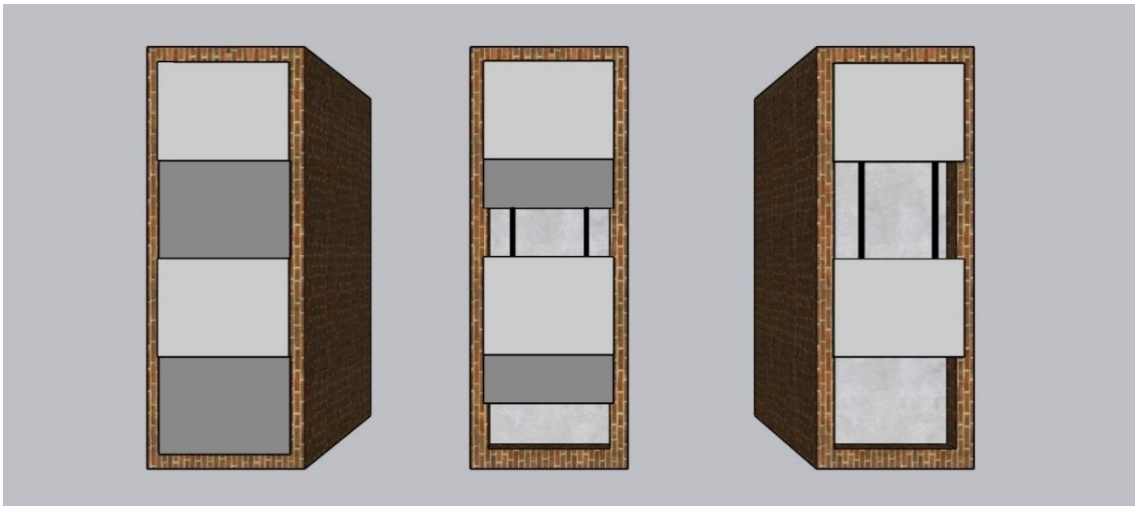
1. MECHANISM DESCRIPTION

The sliding mechanism operates like sliding drawers, wherein channels and rollers help slide the boards to one end of the house to allow night sky radiation to facilitate cooling within the house at night. A pulley mechanism is incorporated within the system to handle the sliding movement.

2. WORKING DRAWINGS



Sliding mechanism (upper view): (left to right) closed, opening, open



Sliding mechanism (upper view): (left to right) closed, opening, open

3. MATERIAL REQUIREMENTS

Eco board, metal pipe with square cross-section, metal-based c-type channels, metal strips, nuts, bolts, long bolt, metal pipes

4. FABRICATION AND INSTALLATION

1. Make fractal design of 12 ft x 8 ft.
2. Calculate the fractals required for the roof.
3. Work out the geometry of the fractals on the roof.
4. Build a metal framework base on the roof.
5. Bolt the framework base to the roof with bolts.
6. Make the static frames on top of the framework by welding the strips.
7. Fix the material on this frame.
8. Beneath the static frame, make another frame through welding the metal strips to house the material.
9. Provide c-channels on the sides for the bottom frame to slide in them.
10. Weld the connecting pipes on the frame.
11. Weld the other side of connecting pipes to the other similar frame.
12. Fix the material on these frames.
13. Weld the nut beneath the base frame.
14. Weld long bolt beneath the bottom frame and ass it through the nut. This is called the half-nut mechanism.
15. Provide a long handle on the nut and bring it down to human height.

5. INSTALLATION IMAGE

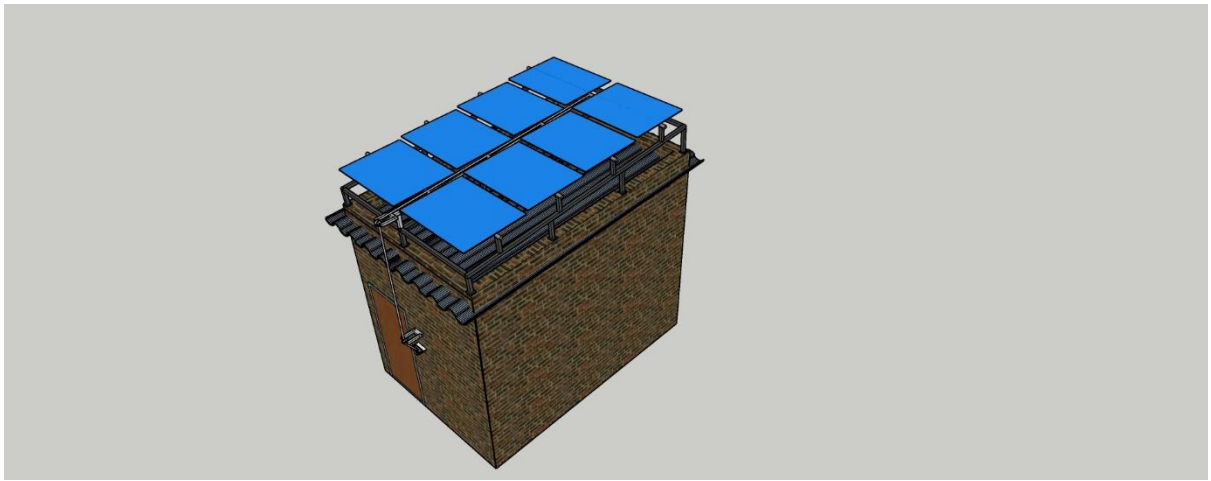
Ecoboard Sliding (Closed)

MECHANISM 2 – CHAIN AND SPROCKET

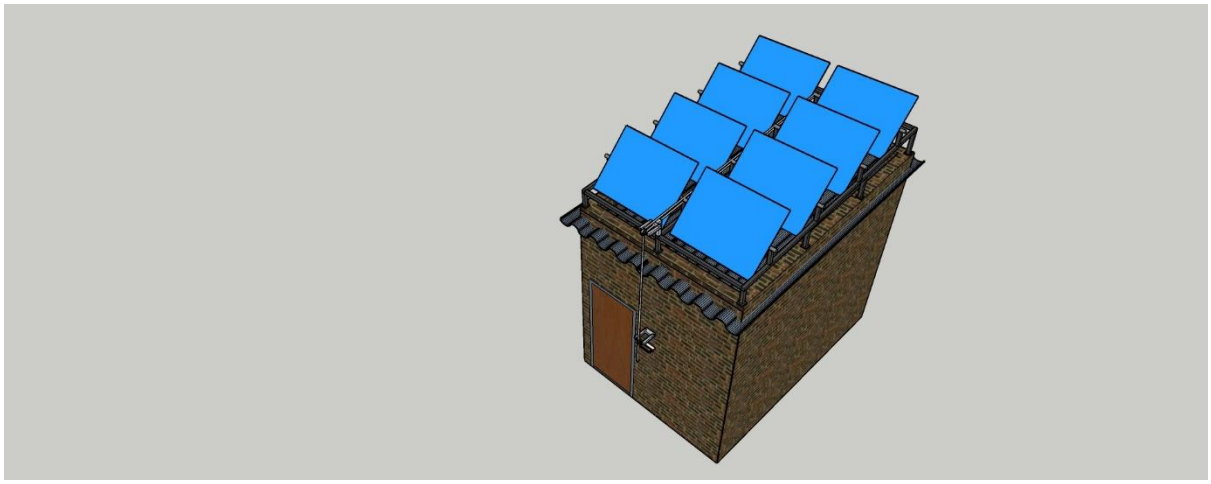
1. MECHANISM DESCRIPTION

The chain-sprocket mechanism works on the principle of louvres, wherein all the panels of the louvres can be opened and closed at the same time to allow radiant barrier and night-sky radiation as required. The movement is enabled with the help of chain and sprockets. It is operated with the help of a bicycle pedal which can move the chain in both the directions to a certain extent to enable the dynamic motion.

2. WORKING DRAWING



Chain-sprocket upper View- Closed Panels



Chain Sprocket Upper view: Open Panels

Chain Sprocket Operation

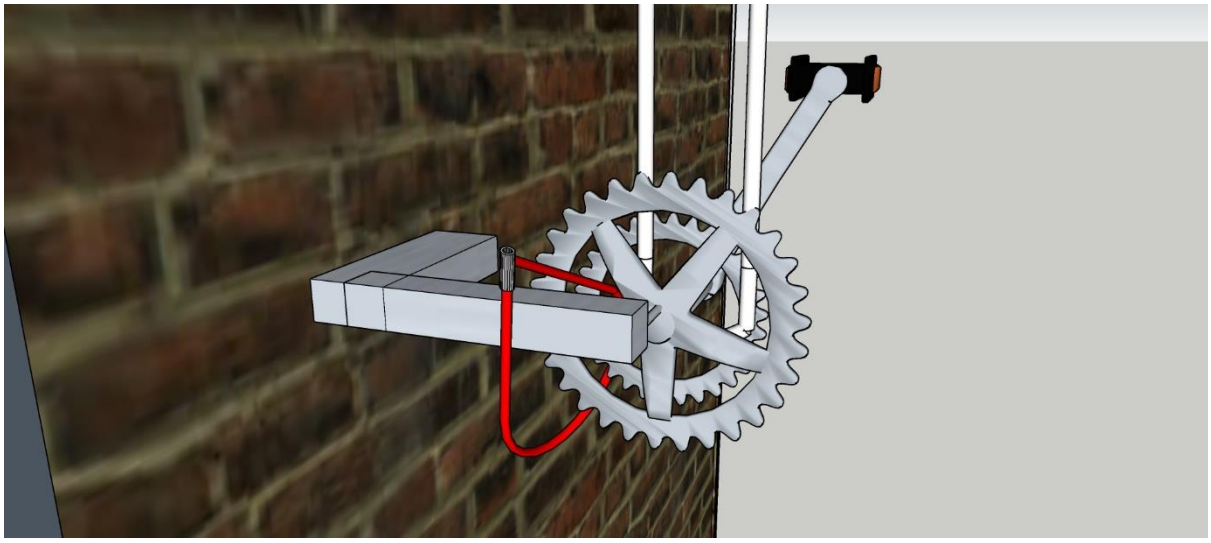
3. MATERIAL REQUIREMENTS

Ecoboard (Conduct aerodynamic analysis of the panels on a software (eg. Ansys fluent) to determine the optimum panel size), metal pipe with square cross section, metal pipe with circular cross section, metal strips, PPGI/GI sheet, bearings (the inside diameter of bearing should match the outside diameter of round pipe), chains, sprockets, self-screws, pulley.

4. FABRICATION AND INSTALLATION

1. Make a fractal design of 12 ft x 8 ft.
2. Calculate the fractals required for the roof.
3. Work out the geometry of the fractals on the roof.
4. Make base frame using square pipes.
5. Weld the support on the base frame using square pipes.
6. Fix base frame on the roof.
7. Weld bearing support pillars using flat metal strips.
8. Weld bearing collars on the metal strips.

9. Fix bearings inside the collars.
10. Insert sprockets inside the round pipe and weld them.
11. The sprockets need to be aligned and welded perfectly in a straight line for smooth functioning of the chains.
12. Synchronize the chains and fix them.
13. Insert the pipes inside the bearing.
14. Make frames using metal strips.
15. Fix the Ecoboard on the frames.
16. Place the framed ecoboard on the round pipe and ensure that there is no sagging.
17. Proceed to weld frames on the round pipe.
18. Fix the pulley in front of the first frame.
19. Fix another pulley down in line with the last pulley so that it is accessible to the human hand
20. Fix chains between the last two pulleys
21. Fix a pedal on the last pulley.
22. Provide a pedal lock on the pedal for locking the mechanism in one position.



Pedal System : Zoomed view

5. INSTALLATION IMAGE

Ecoboard Chain Sprocket (Closed and Open)

B. ALUFOIL

DESCRIPTION

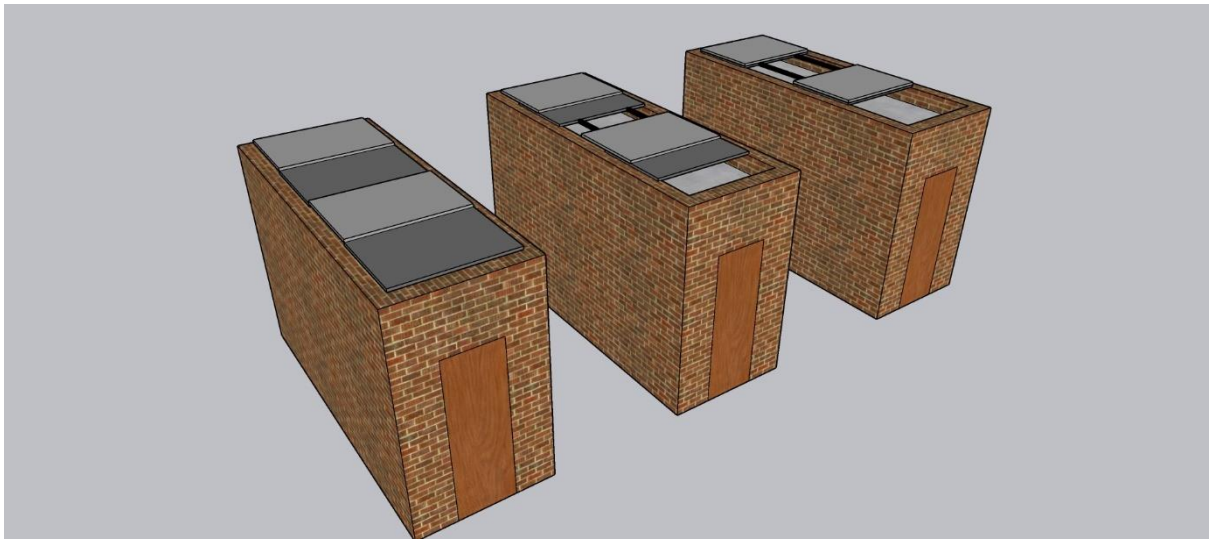
Cross-linked polyethylene foam (also known as XLPE) is a closed-cell foam characterised by a compact feel and resistance to water. It is covered with a low-emissivity and high reflectivity aluminium coating on one side which ensures no heat is emitted inside the space.

MECHANISM 1 – SLIDING

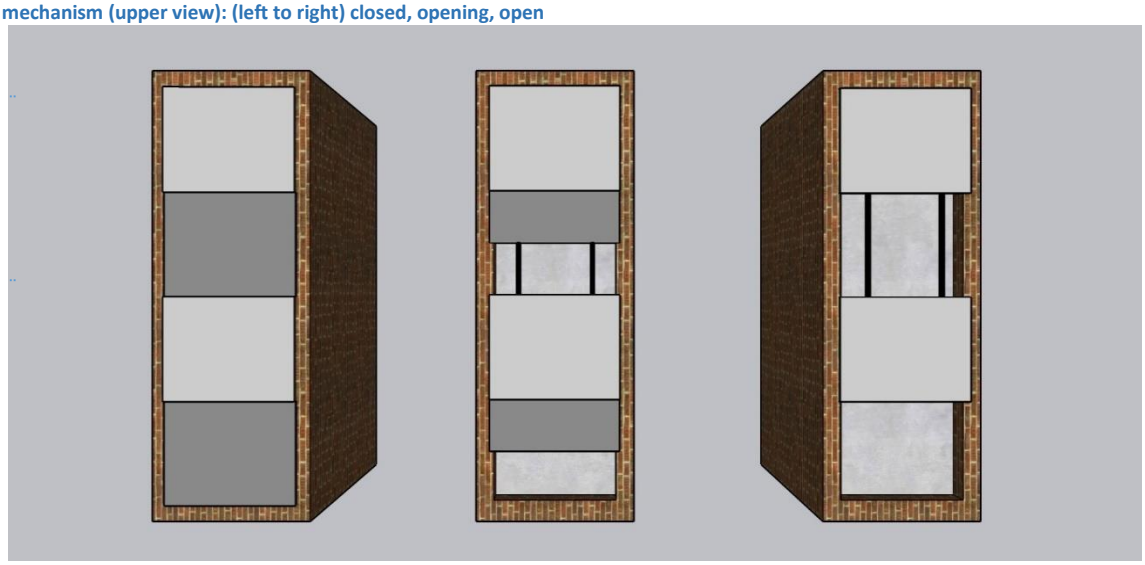
1. MECHANISM DESCRIPTION

The sliding mechanism operates on the principles of sliding drawers, wherein channels and rollers help slide the boards to one end of the house to allow radiant barrier and night sky radiation principles at play. A pulley mechanism is incorporated within the system to handle the sliding movement for the resident.

2. WORKING DRAWINGS



Sliding mechanism (upper view): (left to right) closed, opening, open



3. MATERIAL REQUIREMENTS

Alufoil, metal pipe with square cross-section, metal-based c-type channels, metal strips, sliding roller bearings, nuts, bolts, pulley, rope

4. FABRICATION AND INSTALLATION

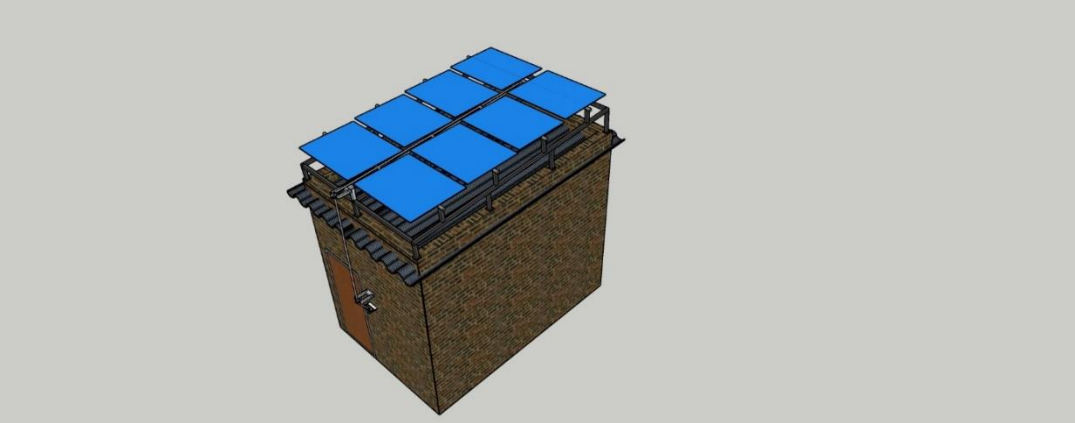
2. Make fractal design of 12 ft x 8 ft.
3. Calculate the fractals required for the roof.
4. Work out the geometry of the fractals on the roof.
5. Build a metal framework base on the roof.
6. Bolt the framework base to the roof with bolts.
7. Make the static frames on top of the framework by welding the strips.
8. Fix the material on this frame such that the shiny side is facing down.
9. Attach GI sheets on top of the material.
10. Beneath the static frame, make another frame through welding the metal strips to house the material.
11. Fix the material on this frame such that the shiny side is facing down.
12. Attach GI sheets on top of the material.
13. Provide c-channels on the sides for the bottom frame to slide in them.
14. Weld the connecting pipes on the frame.
15. Weld the other side of connecting pipes to the other similar frame.
16. Weld the nut beneath the base frame.
17. Weld long bolt beneath the bottom frame and ass it through the nut. This is called the half-nut mechanism.
18. Provide a long handle on the nut and bring it down to human height.

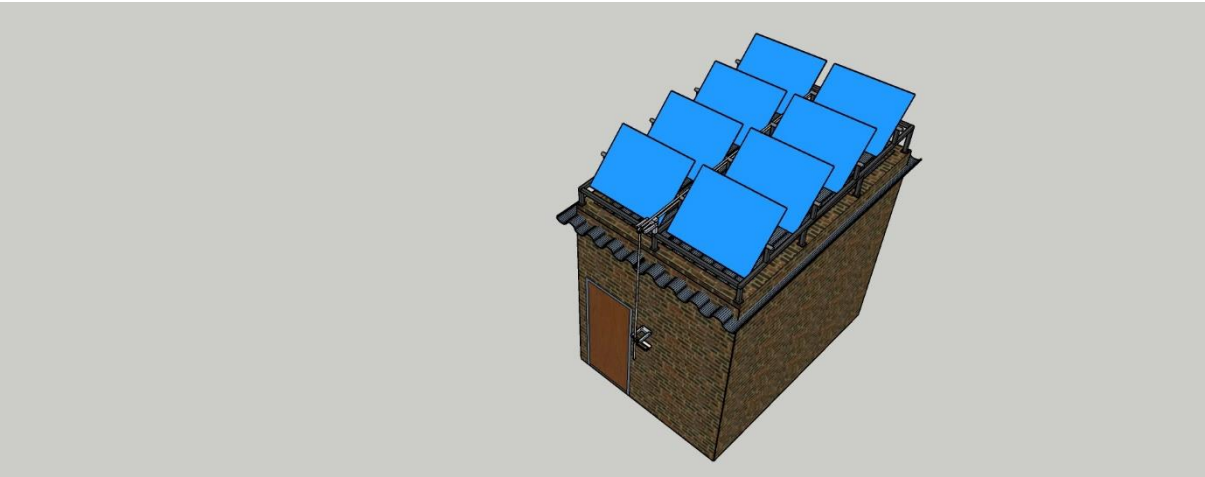
MECHANISM 2 – CHAIN AND SPROCKET

1. MECHANISM DESCRIPTION

The chain-sprocket mechanism works on the principle of louvres, wherein all the panels of the louvres get opened and closed at the same time to allow radiant barrier and night-sky radiation as required. The movement is enabled with the help of chain and sprockets. It is operated with the help of a bicycle pedal which can move the chain in both the directions to a certain extent to enable the dynamic motion.

2. WORKING DRAWING





Chain sprocket upper view: Open panels

Chain sprocket: Operation

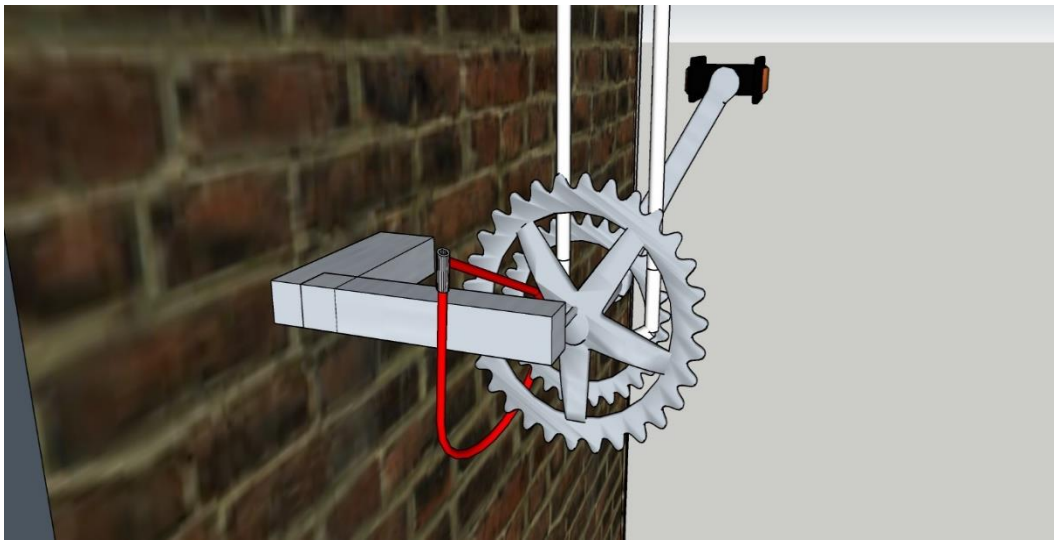
4. MATERIAL REQUIREMENTS

Alufoil, metal pipe with square cross section, metal pipe with circular cross section, bearings (The inside diameter of bearing should match the outside diameter of round pipe), chains, sprockets, self-screws, pulley, rope

5. FABRICATION AND INSTALLATION

1. Make a fractal design of 12 ft x 8 ft.
2. Calculate the fractals required for the roof.
3. Work out the geometry of the fractals on the roof.
4. Make base frame using square pipes.
5. Weld the support on the base frame using square pipes.
6. Fix the base frame on the roof.
7. Weld bearing support pillars using flat metal strips.
8. Weld bearing collars on the metal strips.
9. Fix bearings inside the collars.
10. Insert sprockets inside the round pipe and weld them. The sprockets need to be aligned and welded perfectly in a straight line for smooth functioning of the chains.

11. Insert the pipes inside the bearing.
12. Make frames using metal strips.
13. Fix the GI sheet on Alufoil using self-screws. The non-shiny side of the alufoil should be facing the GI sheet.
14. Fix the GI sheet with alufoil on the frames with the alufoil facing the roof i.e., the GI sheet should be facing the sky.
15. Weld frames on the round pipe.
16. There should be no sagging in the round pipe
17. Synchronize the chains and fix them.
18. Fix the pulley in front of the first frame.
19. Fix another pulley down in line with the last pulley so that it is accessible to the human hand
20. Fix chains between the last two pulleys
21. Fix a pedal on the last pulley.
22. Provide a pedal lock on the pedal for locking the mechanism in one position.



Pedal System: Zoomed view

6. INSTALLATION IMAGE

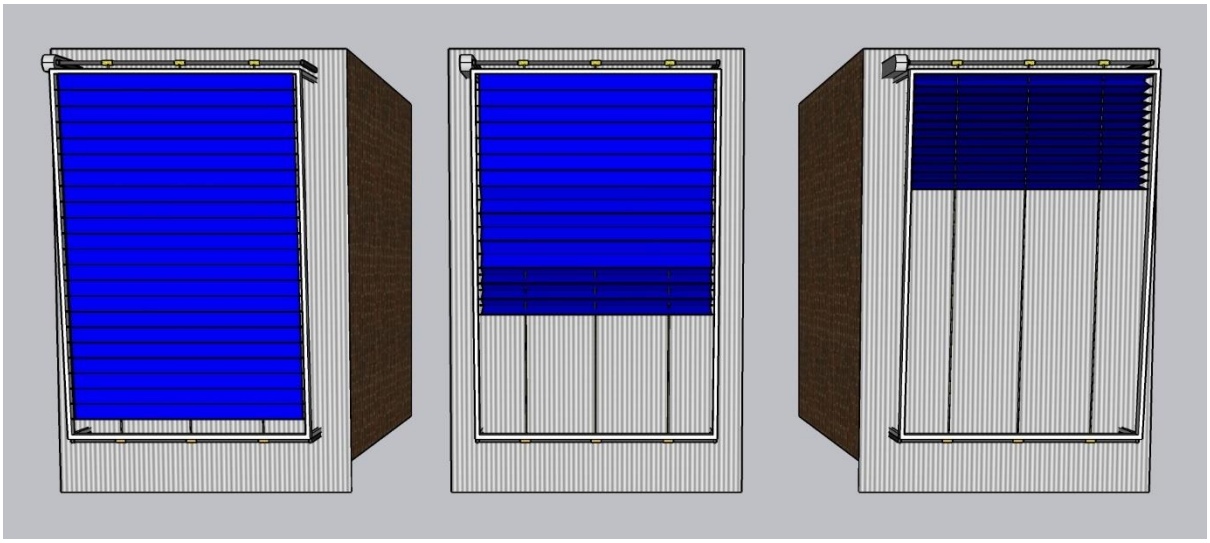
Alufoil Chain Sprocket Installation

MECHANISM 3- PIPE MOTOR

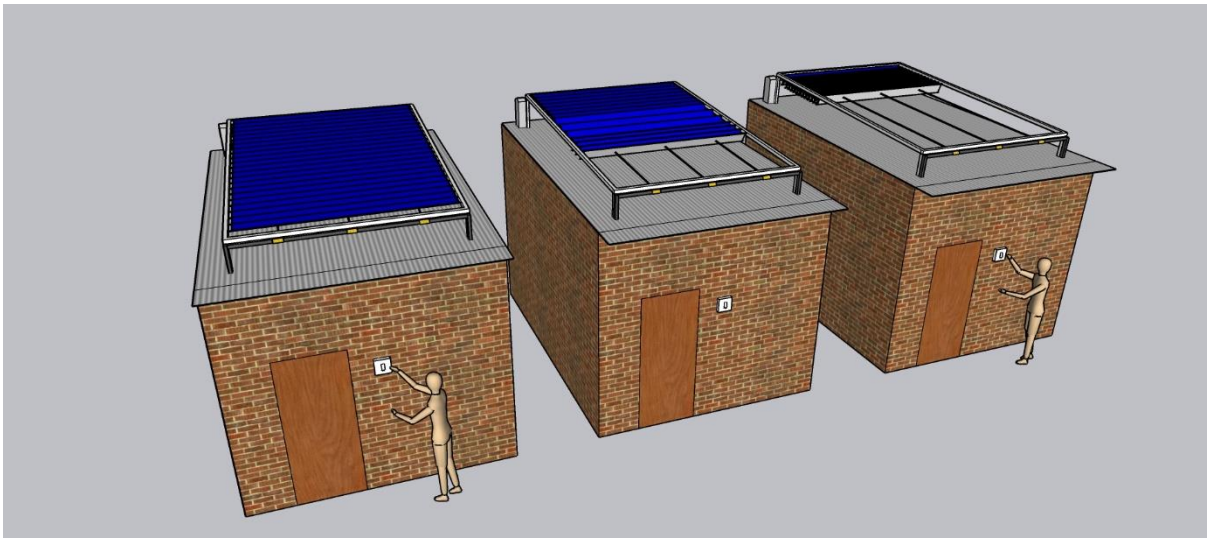
1. MECHANISM DESCRIPTION

The pipe motor mechanism is like an automated curtain mechanism where the Alufoil sheet can be folded and unfolded as required to work as a radiant barrier during the day and facilitate night sky radiation at night. The Alufoil is supported on a rope which winds and unwinds to enable opening and closing the alufoil that is resting on it. The rope is wound on the pipe which is controlled by a motor. There is a switch to enable the opening and closing of the mechanism.

2. WORKING DRAWINGS



Pipe motor mechanism (uper view): (left to right) closed , opening, open



Pipe motor mechanism operation: (left to right) closed , opening, open

3. MATERIAL REQUIREMENTS

Alufoil (The thickness of the alufoil should not be more than 8 mm) , metal pipe with square cross section, metal pipe with circular cross section, bearings (The internal diameter of bearing should match the outside diameter of round pipe) , chains, sprockets, self-screws, steel wire rope with pvc coating, silpaulin (The

silpaulin needs to be at least 120 gsm to ensure long life), nylon rope, thread and needle for sewing alufoil, motor, motor coupling, motor housing, motor cover, hole buttons, silpaulin sewing thread and needle.

4. FABRICATION AND INSTALLATION

1. Make a fractal design of 12 ft x 8 ft.
2. Calculate the fractals required for the roof.
3. Work out the geometry of the fractals on the roof.
4. Make base frame using square pipes.
5. Weld the support on the base frame using square pipes.
6. Weld inverted u-channels on the sides.
7. Put runners inside these channels.
8. Fix the base frame on the roof.
9. Weld bearing support pillars using flat metal strips.
10. Fix bearings inside the collars.
11. Fix pipe inside the bearings such that pipe goes through the bearing and extends on one side.
12. Fix the motor housing.
13. Fix the motor inside the housing.
14. Fix the motor cover on top of the motor
15. Connect the extended pipe and motor with the help of a coupling.
16. Divide the silpaulin into equal number of parts such that each part doesn't exceed 2 feet.
17. Make creases at every division.
18. Put a hollow steel pipe and sew it at every division to make the crease more visible.
19. Install hooks on the sides of these pipes.
20. Connect the hooks to the runners installed inside the side channels.
21. The hooks need to be exactly beneath the runners to avoid it being dragged behind them.
22. Towards the top side of each division of the creased silpaulin, make holes from which the rope will pass.
23. Fix the hole buttons in these holes.
24. Cut the Alufoil strips of the size of each panel.
25. Sew the Alufoil on the underside of the silpaulin such that shiny side is facing downward using Speb 7 or Fevicol SR 996.
26. Wind the steel wire ropes on the round pipe in one direction.
27. Pass the ropes from the hole buttons.
28. Pass the ropes over the pipe on the other end and bring it back to the initial position.
29. The mechanism should not experience sagging. For this tension in the rope is critical.
30. Wind the ropes on the pipe in the opposite direction.
31. Attach flip switch to the motor with the help of an electrician which rotates in the opposite direction when flipped.
32. The pipe which is connected to motor needs to be in one line with no sagging.

5. INSTALLATION IMAGE

Alufoil Pipe Motor (Closed)

MECHANISM 4 – STATIC

1. MECHANISM DESCRIPTION

This is a fixed/static installation and does not involve moving parts.

2. MATERIAL REQUIREMENTS

Alufoil, Fevicol SR 996/Speb 7 adhesive, metal pipe with square cross-section, metal strips, GI sheets, self-screw, paint

3. FABRICATION AND INSTALLATION

APPROACH 1 (under the roof installation):

1. Apply adhesive on the underside of the roof.
2. Apply adhesive on the non-shiny side of the alufoil.
3. Paste the alufoil onto the roof. Ensure the shiny side faces down.
4. Stick from one direction to ensure that no air gaps get created.

APPROACH 2 (over the roof installation):

1. Cut GI sheets according to the roof measurements.
2. Cut Alufoil sheet according to the size of the GI sheets.
3. Stick the alufoil sheet to the GI sheet. The adhesive must be applied on the non-shiny side of the alufoil.
4. Cut square cross-section metal pipes according to make a frame.
5. Place this frame at 0.5 ft height from the roof to ensure there is provision for little airflow beneath it.
6. Paint the frame.

7. Fix the alufoil with GI sheet on the metal frame using self-drilling screw. Ensure the shiny side is facing down.

4. INSTALLATION IMAGE:

C. ROOF TOP GARDENING

DESCRIPTION

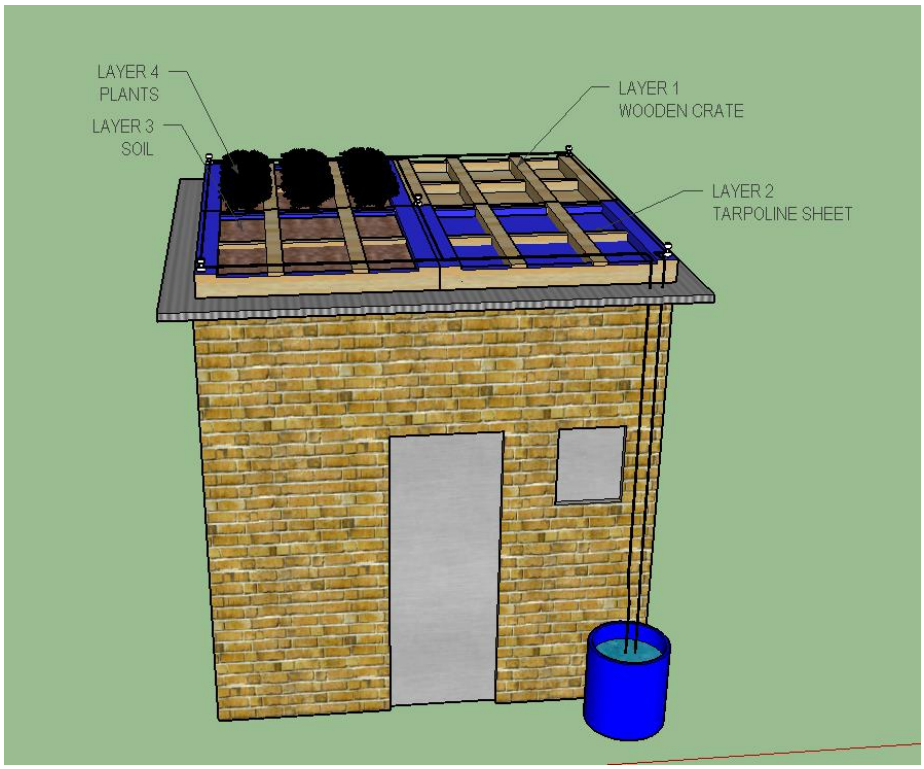
A layer of vegetation cultivated in diverse ways on the roof eg. In pots, brick beds, wooden crates, grow bags, etc.

MECHANISM 1 – WOODEN FRAME

1. MECHANISM DESCRIPTION

A rectangular or square structure with wooden planks installed on the roof serves as a growing space for vegetables and fruits which facilitate shading and cooling through the thermal mass of the soil, in addition to serving as a source of food for the homeowner.

2. WORKING DRAWING



3. MATERIAL REQUIREMENTS

Wooden planks, soil, compost, manure, cocopeat, native seeds (avoid seeds of plants like pumpkin, gourd, etc to avoid heavy load on the roof.), native seedlings (avoid plants like pumpkin, gourd, etc to avoid heavy load on the roof.), red-oxide paint, tarpaulin sheet, green net, bamboo sticks or wooden planks, zip locks, irrigation system (motor pump, PVC pipes, driplines, valves)

4. FABRICATION AND INSTALLATION

1. Ensure that roof is strong enough to bear the load of the soil, water and people who walk on the roof.
2. Vertical support beams of the house structure on which roof is laid should be grounded at least 1 foot deep.
3. Once it is ensured that structure has the capacity to bear the load of the installation the installation work can be commenced by cleaning the rooftop.
4. Apply red oxide paint on the roof and allow it to dry for 30 mins.
5. Spread a tarpaulin sheet over the roof.
6. Prepare a wooden frame according to the shape of the roof. It should be placed over the tarpaulin sheet.
7. The frame should be situated along the slope of the roof.
8. Ensure that a walking space of at least 1 foot is available at all edges of the roof.
9. Keep a holding rope along the pathway to support homeowners walk along the pathway.
10. Make holes on frame towards the lower side of the roof slope to support water drainage.
11. Fix chicken wire mesh (1.6 mm gauge) at the opening of the hole from outside the structure.
12. Prepare potting mix with soil, cocopeat, compost, neem cake/bonemeal powder. Suggested composition is soil (30%), cocopeat (45%), compost (20%), Neem cake/bone meal (5%). It is

recommended that the amount of soil be added and more biomass along with Biochar/charcoal be added to the potting mix.

13. Put the potting mix on the tarpaulin and spread it equally on all sides of the structure.
14. Ensure that the soil depth is at least 4-6 inches (Note: 15 bags of potting mix with 25 kgs in each bag is sufficient for a 40 square feet structure of 8 inches' depth.)
15. Sprinkle water so that the entire soil layer is wet.
16. Check for any cracks or bending under the roof.
17. If a bend is observed, immediately stop the work and provide extra beam support to the roof structure, so it can bear extra load.
18. Implement a drip irrigation system on the structure. For this:
    - Lay the drip lines on the soil
    - Fix the valves for every drip line and connect all drip lines with a common pipe
    - Connect this pipe to a water motor (1/2 hp capacity) kept in the house near water tank.
    - Connect the water motor to an electricity source.
    - Check that the water drops fall inside the bag and not outside
    - Fix any issues of water leakage on the path of pipes or on the roof.
    - Depending on the height of the roof and pressure of water, adjust time of watering so soil gets irrigated well.
19. After installing the irrigation system, raise 4 bamboo sticks on the roof.
20. Using zip-locks tie the green net to the bamboo sticks at a height of at least 3 feet from the roof.
21. Give an extra support stick from the centre of the green net. It should look like a cone-shaped elevated green shade net structure.
22. Place trellis sticks at the edge of the structure.
23. Separate sowing lines for each plant type to be made in the soil with fingers.
24. Ensure plant lines are at least 2 inches away from water drip line.
25. Put seeds of vegetables and plants (as appropriate for the season) at maximum depth of 2 inches in the soil.
26. Cover the seeds gently with soil.
27. Apply a light layer of dry grass on the soil as mulch.

5. MAINTENANCE GUIDELINES

1. Ensure that a staircase is available to access the roof whenever needed.
2. Limit frequent walking on the roof.
3. Check the soil moisture and overall health of plants periodically (at least once a week).
4. Regular checks to be made for rats, cats, dogs and other small animals who might build their homes or sleep in the soil.
5. Evaluate for any water leakage or cracks in pipes of drip irrigations system (at least once a week).
6. Evaluate for any water leakage or cracks in pipes of drip irrigations system once a week.
7. The roof should be checked regularly for any bending due to the weight.
8. If bending is observed the strength of the structure should be enhanced or the weight of the intervention will need to be reduced.
9. Ensure water availability in the water tank daily.
10. In case of failing of automated watering or no electricity, water the plants manually.
11. In case green net structure falls due to heavy winds or any other reason, reconstruct it back quickly.
12. Follow seasonal multi cropping of seeds.
13. After each season (3-4 months), rehash entire soil and mix more compost, cocopeat or manure to it and layer the soil again. Keep remnants of previous plants as biomass.
14. Keep irrigating the soil at least twice a day in summer season.

15. Clean the chicken mesh at drainage holes at least once in 3 months.
16. During monsoon, if water logging in the soil is found then manually remove the water.
17. Replenish with soil if too much of erosion is observed.

6. INSTALLATION IMAGE

At the end of the next section (with growbags)

MECHANISM 2– GROW BAGS

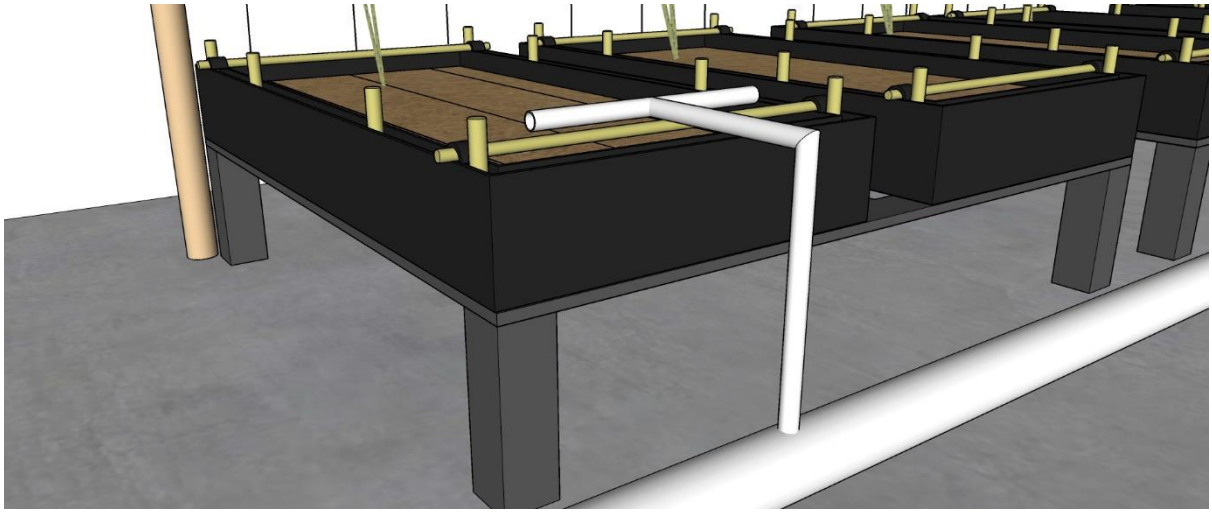
1. MECHANISM DESCRIPTION

Vegetables and fruits are grown over the roof in growbags. Growbags are made up bio fibre material. This installation supports cooling through shading and thermal mass of the soil, in addition to serving as a source of food for the homeowner.

2. WORKING DRAWING

Rooftop garden: zoomed out view.

Rooftop Garden: zoomed in roof view.



Rooftop Garden: Watering System

3. MATERIAL REQUIREMENTS

Growbags (4*2 square feet), bricks, soil, compost, manure, cocopeat, native seeds (avoid seeds of plants like pumpkin, gourd, etc to avoid heavy load on the roof.), native seedlings (avoid seeds of plants like pumpkin, gourd, etc to avoid heavy load on the roof.), green net, bamboo sticks or wooden planks, zip locks, irrigation system (motor pump, PVC pipes, driplines, valves)

4. FABRICATION AND INSTALLATION

1. Ensure that roof is strong enough to support the load of the soil, water and people who walk on the roof.
2. Vertical support beams of the house structure on which roof is laid should be grounded at least 1 foot deep.
3. Once it is ensured that structure is ready to bear the load of the installation the installation work can be commenced by cleaning the rooftop.
4. Make stands for grow bags with a height by welding square pipes.
5. Place growbags on the stands such that the longer side of the bag is along the slope
6. Ensure walking space of 1 foot at least is left from all edges of the roof.
7. Keep at least 2 feet between 2 growbags as walking space.
8. Prepare potting mix with soil, cocopeat, compost, neem cake/bonemeal powder. Suggested composition is soil (30%), cocopeat (45%), compost (20%), Neem cake/bone meal (5%).
9. Put the potting mix in the bags and spread it equally on all sides of the bag.
10. Ensure soil depth is at least 4-6 inches (Note: One growbag can have 100 kgs potting mix with soil height of 3 inches.)
11. Fix bamboo sticks (of 1 foot each) at all the 4 corners, so a proper rectangular shape of bag is maintained.
12. Tie ropes in a mesh form to make guideways for creepers to grow.
13. Sprinkle water over the entire soil layer.
14. Implement a drip irrigation system on the structure. For this:
    - Lay the drip lines on the soil
    - Fix the valves for every drip line and connect all drip lines with a common pipe
    - Connect this pipe to a water motor (1/2 hp capacity) kept inside the house near water tank.
    - Connect the water motor to an electricity source.

- Check that the water drops fall inside the bag and not outside
- Fix any issues of water leakage on the path of pipes or on the roof.
- Depending on the height of the roof and pressure of water, adjust time of watering so soil gets irrigated well.

15. After installing the irrigation system, raise 4 bamboo sticks on the roof.
16. Use zip-locks to tie green net to the bamboo sticks at a height of at least 3 feet from the roof.
17. Give an extra support stick from the centre of the green net. It should look like a cone-shaped elevated green shade net structure.
18. Place trellis sticks at the edge of the structure.
19. Separate sowing lines for each plant type to be made in the soil with fingers.
20. Ensure plant lines are at least 2 inches away from water drip line.
21. Put seeds of vegetables and plants (as appropriate for the season) at maximum depth of 2 inches in the soil.
22. Cover the seeds gently with soil.
23. Apply light layer of dry grass on the soil as mulch.

5. MAINTENANCE GUIDELINES

1. Ensure that a staircase is available to access the roof whenever needed.
2. Limit frequent walking on the roof.
3. Check the soil moisture and overall health of plants periodically (at least once a week).
4. Regular checks to be made for rats, cats, dogs and other small animals who might build their homes or sleep in the soil.
5. Evaluate for any water leakage or cracks in pipes of drip irrigations system (at least once a week).
6. The roof should be checked regularly for any bending due to the weight.
7. If bending is observed the strength of the structure should be enhanced or the weight of the intervention will need to be reduced.
8. Ensure water availability in the water tank on a daily basis.
9. In case of failing of automated watering or no electricity, water the plants manually.
10. In case green net structure falls due to heavy winds or any other reason, reconstruct it quickly.
11. Follow seasonal multi cropping of seeds.
12. After each season (3-4 months), rehash entire soil and mix more compost, cocopeat or manure to it and layer the soil again. Keep remnants of previous plants as biomass.
13. Keep irrigating the soil at least twice a day in summer season.
14. During monsoon, if water logging in the soil is found then manually remove the water.
15. Replenish with soil if too much of erosion is observed.

6. INSTALLATION IMAGE

Rooftop Garden: Grow Bag (left), Wooden Frame (right)

Rooftop Garden Irrigation System

D. DORMER WINDOW

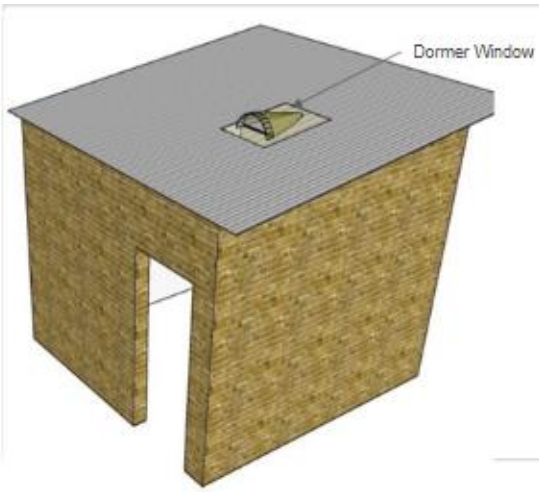
DESCRIPTION

Dormer window is a hump shaped window that is designed to be retrofitted onto existing corrugated steel/tin/cement roofs. It is made of fibreglass moulded into a hump to be retrofitted. The pane is made of translucent plastic to diffuse light and avoid glare.

1. MECHANISM DESCRIPTION

The mechanism works on the principle of convective ventilation where warm air rises up and vents out of the Dormer window. The window ideally needs to be fit on the highest available height for the principle to function. The fibre reinforced plastic is moulded into a hump with an opening at the bottom towards interior of the house to allow warm air to circulate and vent. The gap is covered with a metal net to prevent insects and other animals from getting in the house.

2. WORKING DRAWINGS



Over the Roof View

Under the Roof View

3. MATERIAL REQUIREMENTS

Hump shaped male and female mould made up of wood, fibre reinforced plastic (FRP) sheet (3 mm), roofing sheet cutter, nuts and bolts, cement, waterproofing solution, metal net.

4. FABRICATION AND INSTALLATION

1. Fabricate and prepare the hump shaped mould with the curved part at a height of at least 15 cm (this is the height up to which water splashes after hitting the roof during rains, hence this height will avoid the water to enter through the window's opening) that can be used to fabricate every dormer window structure in one piece.
2. Fabricate the base of the dormer window as per exact measurements of crest and trough of the roofing sheet of the structure where the dormer window will be installed.
3. Manufacture and cast the dormer window in one piece using the mould technique so that no cracks or openings are left for water inlet or leakage, based on the following steps:
    - Lay the FRP sheet over the male part of the mould.
    - Heat the FRP sheet
    - Put the female mould on the sheet and press it

- Mould the plastic sheet in such a way that the semi-circular opening is covered with a small overhang of around 4-5" to prevent the rains from coming in the house.

4. Cover the semi-circular opening that will be facing outward above the roof with a metal net for preventing insects, animals and birds from entering the house through the dormer window.
5. Identify a suitable location on the roof to install the dormer window using the guidelines below:
    - The highest part in the room.
    - Opposite the existing window or the door for the stack ventilation principle to work in the house, where the door/window becomes an inlet and dormer acts as an outlet.
    - Maintain at least a 4 feet distance of the opening from the fan, so it does not create counter air pressures that can pull and circulate the warm air that collects at the top
6. Cut the portion of the roof identified through the above analysis based on the dormer window dimensions.
7. Install the front part i.e., the opening of the dormer window towards the slope of the roof to prevent the rainwater coming in the house.
8. Install the opening of the window facing the leeward side.
9. Fix the dormer window with the help of self-tapping screws as well as adhesive in between the sheet of dormer window and the roof with the horizontal holds resting on the existing roof.
10. Apply a coat of silicon along the joint between the window and existing roof to prevent water leakage and strengthen the joints.
11. Provide u-channels from the periphery of the dormer window from the inside and extend them outside the house to make guideways for water that might enter the house.
12. Include sliding mechanism to open and close the window from the inside by using aluminium sliding mechanism.

5. INSTALLATION IMAGE

E. WOOD WOOL PANEL

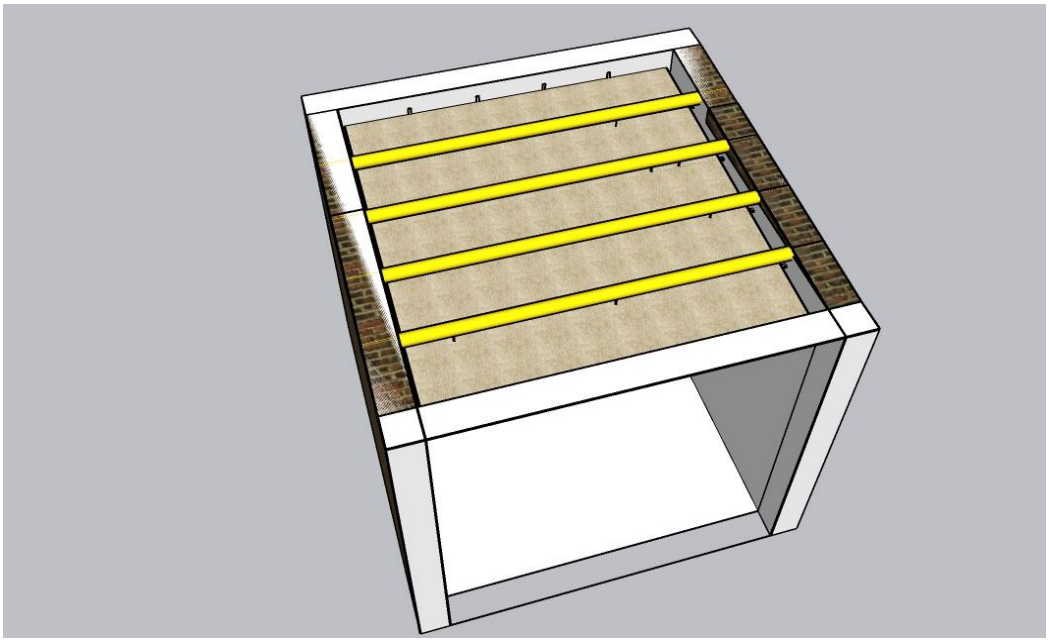
DESCRIPTION

Wood Wool Panel is an environment-friendly, recyclable material made from wood wool, cement and water. It is installed under the roof.

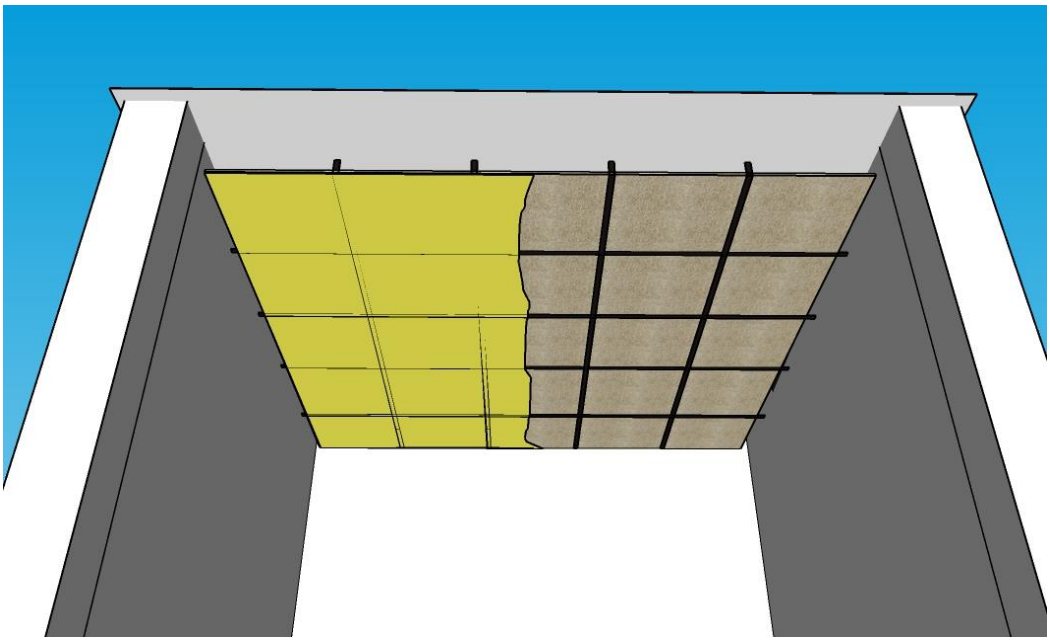
1. MECHANISM DESCRIPTION

This is a fixed/static installation and does not involve moving parts.

2. WORKING DRAWING



Wood Wool: Upper view (minus roof)



Wood Wool: Under the roof view (panels and silpaulin both visible)

3. MATERIAL REQUIREMENTS

Wood wool panels, L-angle metal plates, Small metal pieces for support, GI wire

4. FABRICATION AND INSTALLATION

1. If there are cracks on the roof close/seal the cracks by using adhesives, stick tar sheet. Place a tarpaulin sheet or extra roofing sheet over the cracks if none of the other sealing solutions are available.
2. Cut 4 L-angles each being of the size of the edge of the wood wool panel.
3. Paint them
4. Weld one L-angle on one end of the house beneath the roof
5. Weld the second L-angle at a distance equal to the width of the panel
6. Weld the third L-angle connecting one end of the above two sides
7. Fix the panel inside these three-support frames
8. Weld the fourth L-angle
9. Repeat the process for the other panels
10. Stick a tarpaulin sheet from beneath to prevent any particles falling from the board

5. INSTALLATION IMAGE

F) WATER FILLED PET BOTTLE

DESCRIPTION

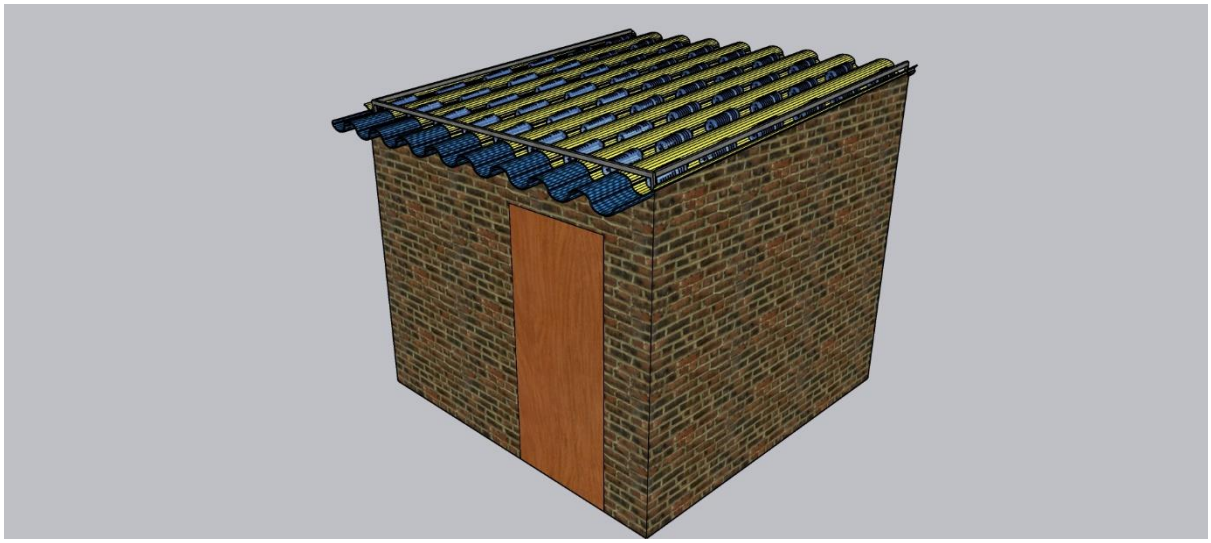
Plastic PET Bottles which are generally used for packaging water or beverages are filled with water and placed above the roof.

1. MECHANISM DESCRIPTION

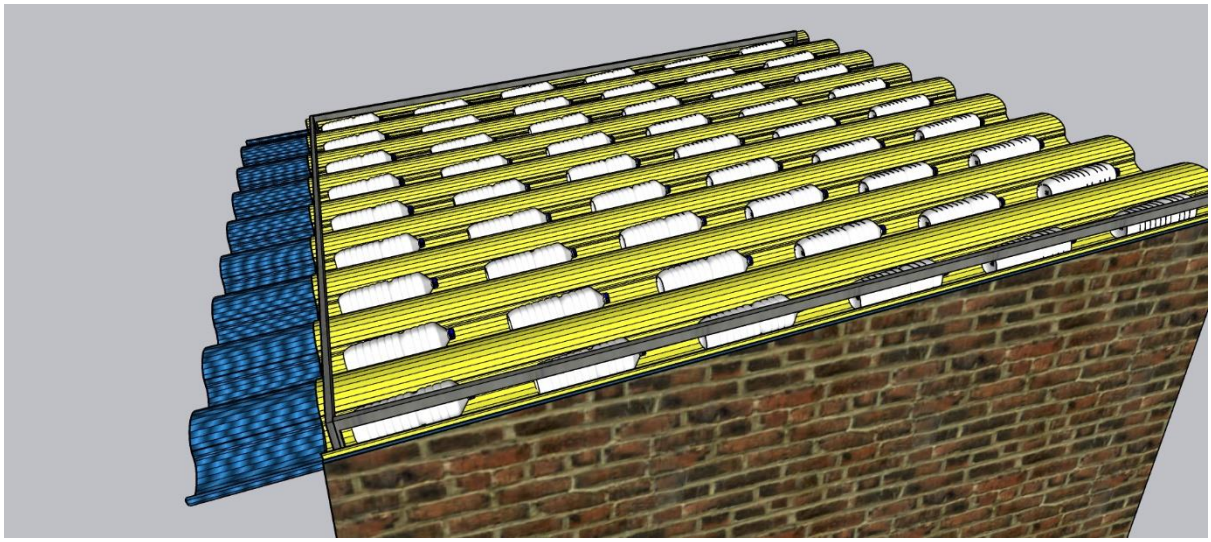
Water has the highest specific heat capacity than any liquid. Specific heat is defined as the amount of heat one gram of a substance must absorb or lose to change its temperature by one degree Celsius. For water, this amount is one calorie, or 4.184 joules. Thus, it can absorb a lot of heat before its temperature rises. This trait helps it to stabilize temperature in its surroundings. To benefit from this heat resisting property of water,

discarded PET bottles are filled with water and stuck on the roof. This low cost, zero energy passive thermal comfort solution increases the thermal mass of the roof i.e., its ability to store heat, for a longer duration before letting it seep into the house through the day and reversing the heat transfer process of the water during the night, since the warmed water during the day gets cooled during the night due to the drop in ambient temperature, which in turn keeps the roof cool the next morning even when the sun starts to heat up.

2. WORKING DRAWING



Water filled PET bottles: Zoomed out view



Water Filled PET bottles: Zoomed-in view

3. MATERIAL REQUIREMENTS

Old or new plastic bottles without any cracks, water to fill bottles, HDPE material tarpaulin sheet, good quality adhesives - Fevicol SR 996 &Speb 7 adhesive.

4. FABRICATION AND INSTALLATION

I. Bottle Preparation :

A. METHOD 1: The bottles are stuck without any coating and with an estimation of 1 bottle/sq. ft.

B. METHOD 2: The bottles are painted with white reflective paint. An average thermal comfort improvement of 1 deg C as compared to the base case has been observed through this method by experimentation.
C. METHOD 3: The bottles are coated with low-emissivity plaster. An average thermal comfort improvement of 1 deg C as compared to the base case has been observed through this method by experimentation.
D. METHOD 4: The intensity of bottles is increased to 2 bottles/sq. ft. to increase the thermal mass on the roof through higher volume of water. An average thermal comfort improvement of 2 deg C as compared to the base case has been observed through this method by experimentation.

II. Bottle Installation

1. Remove dust or any obstacles from the roof.
2. Apply adhesive on the roof and place a double layer of tarpaulin over it. (Single layer of tarpaulin is also sufficient; however double layering gives an extra protection from monsoon.)
3. Wait for minimum 15 minutes for the tarpaulin to stick to the roof.
4. Check at random points, if tarpaulin is glued adequately to the roof or not. Come down from the roof post this activity.
5. Remove all labels from the bottles.
6. Fill all bottles with normal temperature water and fix the caps tightly. Ensure there is no water leakage from any side of the bottle.
7. Gently carry the bottles on the roof and place them at a regular interval from each other.
8. The points below share guidance on how to place the bottles:
    - If roof has trough and crest (like a wave) then place bottles in trough gaps. This will ensure that water does not get stagnant on the roof due to the bottles.
    - Point the cap of the bottle in the opposite of the slope of the roof.
    - Good spacing would be 4-6 inches between two bottles.
    - Leave half foot space on all the edges of the roof for walking.
    - If the structure has very high strength (e.g., Very strong roof sheet, good supports), no. of bottles = 2 x roof area in sq. ft.
    - If the structure has high strength (e.g., Adequately strong roof sheet, adequate supports), no. of bottles = 1.5 x roof area in sq. ft.
    - If the structure has average strength, no. of bottles = roof area in sq. ft.
    - If the structure has weak strength (e.g., cracked sheets, weak support), no. of bottles = 0.75 x roof area in sq. ft.
    - Ensure that bottles are not fixed on broken or bent parts of the roof.
9. Apply Fevicol or SR 996 adhesive to one side of PET bottle and to tarpaulin sheet.
10. Place each PET bottle over the glue and apply some pressure, so that it sticks firmly.
11. Perform a random check to see if the bottles are glued well to the tarpaulin.
12. Install a pipe frame on the periphery of the roof at low height (lower than the width of bottle) on three sides (lower end and on the sides) to prevent the bottles from falling down in case it comes off.

5. MAINTENANCE GUIDELINES

1. Check the roof once a month for any cracks or misplaced bottles.
2. Replace bottles as applicable.

6. INSTALLATION IMAGE

C.ACADEMIC ENGAGEMENT PROCESS

'Academic engagement' was part of the effort to catalyse the heads, hearts and hands of the architects of the future to work with people living in marginalized urban spaces.

The engagement comprised of:

1) Collaboration with students of architecture and engineering as part of college internships to create space for them to collaborate with the project team and build their capacities and work towards ensuring thermally comfortable homes for inhabitants of informal settlements

2) Engaging with the Architecture Board of Studies to advocate for the seamless integration of Informal Housing, sustainable cooling and related socio-ecological justice perspectives in Architecture curriculum.

The steps undertaken to facilitate the two engagements are mentioned below.

1. COLLABORATION WITH ARCHITECTURE AND ENGINEERING COLLEGES

RATIONALE

- To create a space for architecture and mechanical engineering undergraduate students to develop their skills and manifest their academic knowledge in practice by working hands-on on the issue of heat stress with communities inhabiting informal settlements in a participatory manner.
- To sensitize professors of architecture to the issue of thermal comfort in informal settlements and create a space for them to contribute to the co-creation of solutions by playing the role of design mentors in the project.

APPROACH

1. Identify specific areas of engagement for architecture and engineering students within the project
2. Connect with professors of local architecture and engineering colleges in your project area to introduce the project
3. Propose the thought of engaging with students through the internship
4. If professors' express interest, co-create the internship engagement with them and identify a suitable time period to engage students in the internship
5. Propose the idea of professors playing the role of design mentors who guide students through the internship in collaboration with the project team
6. Send internship invitations with the project details to students and get to know them through a suitable method such as a form filling exercise to assess their motivation and/or a in person interview
7. Reach out to students who are selected
8. Orient students to the overall work of the organisation and share details of the projects 'Why', 'What' and 'How'.
9. Ensure that students are getting mentored by the team members on specific tasks. However, don't spoon-feed them
10. Create a safe space for students to share their suggestions, questions and concerns uninhibitedly, throughout the project process
11. Share specifics of student's roles and responsibilities
12. Schedule periodical reviews with students, mentors and the project team to guide, receive inputs and assess the progress of the work
13. Involve students in desk work and on-field engagement both, to ensure a holistic learning experience that nourishes their head, hearts and hands i.e. involve students in material research, etc design,

curriculum review, community engagement, house audits, installation supervision and other places where they can contribute and learn, parallelly.

14. Ask students to document their project work in writing
15. Schedule a review call with students at the end of the internship to learn about their experiences and understand how such engagements can be sustained and replicated in the future

2. BOARD OF STUDIES ENGAGEMENT FOR CURRICULUM CHANGE

RATIONALE:

To analyse and identify architecture curriculum gaps through the lens of exclusion of Informal Housing, Thermal Comfort and sustainable architecture perspectives and make a case for the inclusion of these perspectives to Board of Studies members.

APPROACH:

1. Identify the architecture university/s your project team would like to collaborate with.
2. Download the most recent curriculum from a university website.
3. Review the curriculum at a preliminary level to understand its overall flow
4. Invite architecture students to share their first-hand experiences on curriculum gaps they observe as 'learners'
5. Critically analyse each subject of the curriculum to identify gaps and potential spaces for the seamless integration of Informal Housing, Passive (sustainable) design and thermal comfort that can facilitate contributing to socio-ecological justice related architecture perspectives through architecture education.
6. Make suggestions for the integration of missing elements in the curriculum (This can be in the form of a theory subject or an activity)
7. Summarize the findings from the curriculum analysis to make the case for the integration of missing perspectives through a position paper
8. Create a 'Pedagogy Manual' which encapsulates all the activities suggested in the curriculum.
9. Identify and reach out to the heads of BoS of universities of the analysed curriculum.
10. Share the position paper to catalyse them to engage in the effort for curriculum change
11. Once Board of Studies members express interest in working on curriculum change, reach out to them to understand pathways to facilitate participatory curriculum modelling.
12. Understand the change management process of the University to identify the ideal time to propose curriculum change based on their curriculum change schedule/ cycle.
13. Identify appropriate communication models based on the curriculum change cycle of the university. (eg. Since one of the universities that was engaged with as part of the project was already in between its curriculum change process, the curriculum change recommendations were shared with them, which was followed by engaging over a collective session with all the BoS members over a meeting. In the other university, one-on-one listening approach was considered to listen to BOS members views on the proposition for the inclusion of informal housing, thermal comfort, passive design topics as part of the curriculum. The engagement was halted after this step, since the BOS members were not at the curriculum change stage of their work and were supposed to be re-elected in the year to come)
14. Propose a visit to the 'Informal Housing Thermal Comfort' intervention site for grounding in the issue, followed by a roundtable where Board members and project team can meet and co-create the curriculum and move towards capacity building on new concepts as part of the recommendation.

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