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"Tactical Upcycling in Urban Informality: A Socio-Technical Analysis of Recycled Plastic Envelopes in Bhopal's Transitional Settlements"

Shubh Jain[1], Ar. Shefali Soni[2]

[1]Student, School of Architecture, RGPV, Bhopal
[2]Asst. Professor, School of Architecture, RGPV, Bhopal

Abstract - This research investigates "Tactical Upcycling" of the locally abundant, organic, recycled plastic waste, including but not limited to HDPE sheets, LDPE films, and discarded vinyl banners, employed at primary building envelope components within transitional urban housing. Shifting from lab-based experimental research, this study takes on a socio-technical perspective to record how the global poor in Bhopal leverage the material properties of the waste stream to adapt shelter to climatic extremes. The research methodology used is qualitative in nature, comprising of Photographical surveys, On-site mapping, Semi-structured Interview with residents of selected informal clusters in the study area. The qualitative research approach allows to study "Vernacular Performance" of plastic skins, which meant to measure the thermal lag, protect for moisture during monsoon and measure the passive cooling through the spontaneous layering. This research records "Architecture without Architects" responses as possible alternatives to conventional expectations of material performance, eventually proposing a frugal bottom-up sustainable cladding framework. These results imply that such informal practices could be very scalable low-cost climate-responsive design strategies and advocate for the formal integration of upcycled polymers in low-income housing policies in future prospective central India.

Key Words: tactical upcycling, upcycled polymers, building envelope, recycled plastic waste, vernacular performance, passive cooling.

1.INTRODUCTION

Rather than the high-tech processes used to transform the material in the lab, this research focuses on low-tech, manual approaches that rely on hand-work and readily available tools. This is a deliberate choice and, in part, a reflection of the context studied—transitional neighborhoods in different Global South metropolises. Like the many informal recyclers who survive on the cities' waste and are adept with their hands, we see potential in plastic waste that can sometimes be transformed into something valuable with simple techniques and cheap tools. The informal recyclers who work with it every day already understand its potential to be. By shifting the focus from the laboratory to the streets of Bhopal, this research seeks to legitimize such informal practices. It is an endeavor to narrow the schism between high-end material science and the "frugal innovation" sprouting in the home garden, evidence that the answer to climate-responsive housing lies not in some obscure material yet to be created, but in the waste we have been producing all along.

1.1PURPOSE OF STUDY

The research will focus on building science rather than design theory instead of arguing for increased attention to climate, it will take for granted that buildings need to respond to their environment. In the world of formal housing production, the problem is not a lack of climate-responsive designs, but the fact that houses aren't built according to them. Thus, this study proposes a descriptive, process-based level of analysis through the lens of technical logic.

1.2SCOPE & LIMITATIONS

SCOPE

1. This study looks at only recycled flexible plastics – PVC flex banners, HDPE sheets, and woven polypropylene sacks.

2. This study examines how these materials in their skin function as building envelope perform in terms of thermal comfort (heat) and waterproofing (monsoon rain).

LIMITATIONS

1. The study only considers recycled flexible polymers (PVC, HDPE, PP) and does not assess the most common other informal materials, such as scrap metal, wood, or mud.

2. Thermal and moisture performance is based on field measurements and secondary literature rather than laboratory testing under controlled, highly accurate conditions.

3. Only the building skin is examined and not the foundation, the superstructure

2.METHODOLOGY

2.1 Study Area: Bhopal, Madhya Pradesh

The study is situated in Bhopal, a city characterized by a Composite Climate with extreme temperature variations. The research focuses on two distinct "transitional" clusters:

- **Informal settlements near Bhopal Junction/Railway edges:** Areas with high densities of "temporary" cladding.
- **Fringe settlements in Old Bhopal:** Where traditional building methods intersect with modern waste materials.

Fig - 1: Google Map Image showing Orange Circle with Informal Settlements near Bhopal Junction & Blue Circle showing Fringe Settlements in Old Bhopal

2.2 Physical Characteristics

1. **Material Types:** Documentation of commonly used upcycled polymers such as Flex Banners (PVC/Polyester), Heavy-duty Polyethylene (HDPE) sheets, and woven plastic sacks.
2. **Layering Logic:** Observation of how residents use "Air Gaps" between multiple layers of plastic to create **Passive Insulation**.
3. **Fixing & Joinery:** Analysis of low-cost attachment methods (wires, stones, heat-welding) and their impact on the material's durability against wind and UV degradation.
4. **Reflectivity & Color:** Assessment of how different colors (e.g., white vs. printed banners) affect the **Solar Reflectance** and heat absorption of the dwelling.

Fig.- 2: Material Types

2.3 Data Collection Methods

The research used a Triangulation Method, which allowed us to validate data with other methods rather than using an expensive device for verifications. This included:

1. **Photographic Documentation:** Conducting a systematic visual survey of no less than 15-20 dwellings to develop a catalog of different "Upcycling Typologies."
2. **Semi-Structured Interviews:** Engaging in casual conversational interviews with 5-10 residents to gain insight into the human experience of the material.
3. **Annotated Sketching:** Producing highly detailed architectural "Section Drawings" of the wall and roof assemblies in order to chart the movement of heat and air.
4. **Temporal Observation:** Making visits to the settlements at two different times of the day to see how the material performs under conditions of peak solar load.

2.4 Analytical Tools

1. **Typological Mapping:** Create a "Catalogue of Informal Cladding" based on the photos taken, using Adobe Illustrator or manual drafting.
2. **Climatic Mapping:** Overlay the theoretical needs of a building against the actual solutions found in the settlements using existing weather data for Bhopal.
3. **Comparative Matrix:** Create a qualitative table comparing the "Informal Plastic Skin" against "Standard Tin Sheets" or "Brick Walls" based on resident feedback and visual inspection.
4. **Photo-Interpolation:** Use visual evidence of material "wear and tear" to estimate the Life Cycle and UV-degradation rate of the upcycled polymers.

3.FINDINGS

1. **Layered Flex Banners (PVC)**

Insulation: Multiple layers create **air gaps** that block radiant heat better than single-sheet metal.
Albedo: White-backed banners are flipped outward to reflect solar radiation during Bhopal's 40°C+ summers.

2. **HDPE & Jute Hybrids**

Monsoon Response: HDPE provides a 100% waterproof barrier, while jute layers offer evaporative cooling during humid months.
Fixing: "Tactical weight" (stones/wire) keeps the skin flexible and tear-resistant during high winds.

3. **Woven Plastic Sacks (PP)**

Breathability: The weave allows passive air infiltration, preventing heat stagnation in cramped settlements.
Durability: Shows the highest UV degradation, requiring replacement every 6–8 months.

4.IMPACTS ON THE URBAN ENVIRONMENT

1. **Positive Impacts**

i) **Landfill:** Intercepts non-biodegradable PVC and HDPE, preventing them from entering Bhopal's Adampur landfill.
ii) **Zero Carbon:** Eliminates energy-intensive manufacturing and transport emissions by using locally "found" materials.
iii) **Passive Energy Savings:** Reduces the need for mechanical cooling by utilizing natural thermal lag and air gaps.

2. **Negative Impacts**

i) **Microplastic Loss :** UV-induced brittleness causes the plastic to fragment into particles that contaminate soil and water.
ii) **Chemical Leaching:** Heavy monsoons can wash toxic inks and additives from printed banners into the ground.
iii) **Fire Toxicity:** Accidental ignition releases hazardous **dioxins** and carbon soot into the high-density urban air.

5. RECOMMENDATIONS

1. **Technical Refinements:** Apply a thin layer of lime-wash or recycled resin to prevent plastic brittleness and microplastic shedding.
2. **Design & Policy Integration:** Provide residents with standardized bamboo frames and "clipping" systems for secure and aesthetic installation.
3. **Construction & Structural Tactics:** Suggest roughening the surface of smooth PVC banners to allow for better adhesion of secondary coatings like **solar-reflective paint** or thermal plasters.
4. **Maintenance & Monitoring:** Recommend that residents use **plastic "fins" or louvers** (made from stiff HDPE) over windows to provide shade while still allowing the cross-ventilation crucial for Bhopal's humid monsoon nights.
5. **Future Research:** Use low-cost sensors to track long-term indoor temperature stability in upcycled dwellings.

6. CONCLUSION

The informal settlements of Bhopal illustrate that sustainable innovation is often driven by necessity, as “waste” is creatively reconceptualized as a high-performance building skin. This paper documents the Tactical Upcycling of PVC banners and HDPE sheets and verifies that both spontaneous layering and “air-gap” logic can offer efficient thermal cooling and monsoon protection, with almost no associated cost. The paper concludes by presenting a series of test units that measured the material and assembly properties of these upcycled, end-of-life materials. Overall, this study argues for a radical reconsideration of architectural practice: away from energy-intensive materials and toward a frugal circular economy which respects the resourcefulness of informal builders, to develop a more resilient, waste-free urban future for Central India.

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REFERENCES

- https://mppcb.mp.gov.in
- https://www.mdpi.com/journal/sustainability
- https://unhabitat.org
- https://worldgbc.org