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Transparency, Surveillance & Safety In Industrial Architecture - Textile Upcycling Hub

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ABSTRACT –

The swift increase in textile waste in India, especially in growing urban areas like Pune, has created a demand for sustainable waste management strategies, including upcycling. Nevertheless, conventional industrial and recycling settings frequently suffer from negative perceptions and encounter considerable obstacles related to operational safety, health risks (including exposure to toxic waste, dust, and noise), and social marginalization. To tackle these challenges, it is imperative to develop industrial environments that are not only efficient but also safe, legible, and socially inclusive.

This study investigates the integration of transparency, surveillance, and safety within a unified architectural framework for a Textile Upcycling Hub.

Transparency, in this regard, transcends simple material selection, acting as a symbol of modernity and trust, mitigating the social alienation frequently linked to waste management facilities by fostering community engagement and promoting "eyes on the street."

By utilizing the principles of Crime Prevention Through Environmental Design (CPTED), such as natural surveillance and territorial reinforcement, the constructed environment can inherently discourage criminal activity and improve the perceived safety for both employees and visitors.

A Textile Upcycling Hub is a centralized facility that manages the end-of-life process – i.e. upcycling - of textile waste. From collection and sorting, to design, production, and retail. The primary aim of this study is to establish design strategies that ensure operational efficiency, user security, and community engagement. Through a strategic synthesis of visibility and controlled access, the design of the hub should aim to balance the high transparency required for public-facing retail zones with the controlled visibility and zoning necessary for hazardous production areas.

Keywords – textile waste, industrial architecture, transparency, surveillance, safety, community engagement

I. INTRODUCTION

A. *Background*

1) *Waste Generation*

India stands as one of the world's largest textile producers, which brings an acute challenge in managing the resulting waste. Globally, the industry produces approximately **92 million tons of textile waste annually**, a significant portion of which is driven by "fast fashion" and the prevalence of plastic-based synthetic fibers. (Gambhire, Sehgal, & Shokeen, 2024)

Findings regarding the Indian context and upcycling include:

Waste Landscape: Traditional disposal methods in India, such as landfilling and incineration, have proven inadequate and environmentally harmful, leading to soil, water, and air contamination (Gambhire, Sehgal, & Shokeen, 2024)

Value Chain: Within the Indian textile waste value chain, current data suggests that **34% of material is used as wearables or resold**, 25% is recycled, 19% is downcycled, and **17% ends up in landfills.** (Gambhire, Sehgal, & Shokeen, 2024)

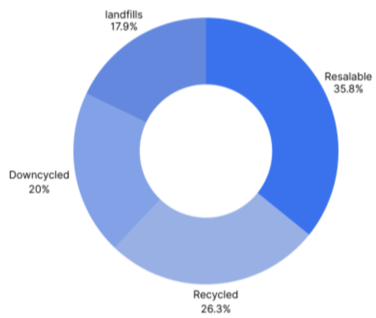

Fig 1.1: Distribution of end of life of textile waste (Source: Author)

Upcycling Potential: Burgeoning urban centers (like Pune) face pressure to shift from these linear "take-make-waste" models to circular ones. Innovative methods, such as the **"Fabrick" technique**, involve compressing textile waste with bio-based binders to create durable, brick-like structures for interior partition walls and furniture. (Kagitci, 2022)

Economic Opportunity: Repurposing textile waste is noted as a cost-effective strategy that creates new jobs in collection and processing while promoting **community engagement** around sustainability. (Gambhire, Sehgal, & Shokeen, 2024)

2) *Need for safe, legible, and socially inclusive industrial spaces*

As industrial environments shift toward recycling and upcycling, there is a fundamental need to redesign these spaces to be safe, legible, and inclusive to overcome historical stigmas of social exclusion and operational hazards.

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- **Safety:** Industrial safety must move beyond mere "audited safety" (observable factors) to **"True Safety,"** which includes perceived safety and the individual motivation to behave safely. The integration of **3rd Generation CPTED** (Crime Prevention Through Environmental Design) utilizes technological advancements like smart lighting and real-time monitoring to enhance security without creating unsightly urban clutter. (Lindhout & Reniers, 2022)
- **Legibility:** A **legible urban system** - where users can navigate with confidence - is a critical step toward a safer environment. Interactive digital signage and smart unit placement help citizens understand and navigate complex industrial or urban hubs, reducing the likelihood of crime and increasing navigation ease. (Raj & Patil, 2023)
- **Social Inclusivity:** Public and industrial spaces must be designed to be accessible to everyone regardless of gender, race, or ethnicity to improve **subjective well-being**. **2nd Generation CPTED** emphasizes that social cohesion and neighborhood health are as important as physical design for preventing crime and mitigating social isolation. (Raj & Patil, 2023)
- **Transparency and Trust:** In industrial contexts, architectural transparency serves as a tool for **accountability and trust-building**. Highly permeable building frontages that border pedestrian paths (active frontages) support **"eyes on the street,"** making industrial zones feel like integrated parts of the community rather than isolated, dangerous enclaves. (Sadeghi, Sani, & Wang, 2015)

B. *Aim and Objectives*

Aim:

To study and establish design strategies that integrate transparency, surveillance, and safety within recycling architecture, ensuring operational efficiency, user security, and community engagement while maintaining environmental responsibility.

Objectives:

- To understand the role of architectural transparency in reducing stigma associated with waste management facilities.
- To examine spatial planning strategies that enable effective visual and technological surveillance.
- To analyse safety measures required in recycling environments handling textile waste.
- To explore zoning techniques that separate hazardous processes from public interaction zones.
- To propose design guidelines that balance openness with controlled access.

C. *Scope and Limitations*

Scope:

The study focuses on exploring the integration of transparency, surveillance, and safety within the architectural design of a textile upcycling hub, particularly in an urban Indian Context.

- Examination of architectural strategies such as material selection, façade design, and spatial zoning to enhance visibility and safety.
- Application of CPTED principles for improving natural and technological surveillance.
- Analysis of user groups – workers, designers, visitors, and community, and their spatial and safety requirements.
- Development of design guidelines for balancing openness with controlled access in semi-public industrial spaces
- Consideration of functional aspects
- Focus on qualitative and design-based research leading to conceptual and spatial design implications.

Limitations:

The research acknowledges specific boundaries to maintain its focus on architectural planning:

- The study does not deeply analyse mechanical engineering systems of recycling machinery.
- Cost analysis of advanced surveillance technologies is not comprehensively covered.
- Environmental performance simulations (acoustic, thermal, air quality modelling) are beyond the detailed scope.

II. INDUSTRY AND TRANSPARENCY

A. *Industrial building materiality*

An industrial building is based on various factors – functionality, location, scale, end product, etc. The material palette is typically composed of robust features, utilitarian options suited for heavy loads, weather resistance, and low maintenance. The main focus for choosing the material prioritizes strength, longevity, with exposed elements like steel beams, concrete floors, and brick walls define the aesthetic. The key materials often consist of:

- Steel – for framing and beams due to high tensile strength.
- Concrete for foundations, floors and walls, offering thermal mass.
- Bricks for durable exterior that can withstand industrial wear,
- Glass for large windows to maximize natural light.
- Metal panels or composites for roofing and cladding.

These materials support open floor plans and visible utilities, aligning with the industrial minimalism. Industrial buildings prefer using modular elements, as it allows them to have flexibility in spaces along with providing future scope for adaptive reuse.

These materials offer different design benefits. They reduce ornamentation costs and promote sustainability by minimizing finishes. Steel and concrete together boost fire resistance and load-bearing capacity.

Colour palette: Industrial palettes use muted, practical tones from the materials themselves- greys from concrete and steel, earthy rust browns, and charcoal blacks – to hide wear and add depth.

B. How visibility/transparency affects the built environment

Visibility and transparency in built environment primarily refer to the architectural design principles that use materials like glass to connect indoor and outdoor spaces, while visibility ensures clear sightlines for navigation and safety. These elements enhance user experience, sustainability, and accessibility in urban structures. Visibility and transparency significantly influence both actual safety risks and the way safety is perceived within urban spaces.

- **Safety Perceptions:** The design and structure of the built environment affect physical and mental well-being; in neighbourhoods where the fear of crime is high, transparency can mitigate social isolation by encouraging activity. (Asten, Milias, Bozzo, & Psyllidis, 2023)
- **Vitality and Interaction:** High visual permeability (transparency) can increase the vitality of sidewalks, often triggered by commercial activities that provide "eyes on the street". (Dameria & Fuad)
- **Environmental and Symbolic Change:** The extensive use of glass in the 21st century has caused a major shift in the built environment, serving as a primary material for contemporary public buildings and acting as a symbol of modernity. (Sadeghi, Sani, & Wang, 2015)
- **Thermal and Social Balance:** In certain architectural contexts, such as traditional Iraqi "shanashil" transparency is used as a tool to balance privacy, daylight, and thermal comfort. (Alqalami, 2020)

C. Defining the three concepts – transparency, surveillance, safety

Transparency: In an architectural context, it is defined as the use of open materials (like glass) or a combination of form and meaning. (Sadeghi, Sani, & Wang, 2015) In safety management, it is the degree of health and safety-related information transmission between stakeholders. (Lindhout & Reniers, 2022) It is often measured by visual permeability, which relates to the number and quality of openings in a building facade. It also refers to both, physical openness – using glass or perforated materials for natural light, visibility and structural clarity – and operational openness, like clear safety protocols, maintenance logs, and communication to build trust and prevent hazards. (Dameria & Fuad)

Surveillance: This is the byproduct of how citizens normally use public spaces (Asten, Milias, Bozzo, & Psyllidis, 2023). It can be **natural (passive)** - where human presence and window placement allow residents to oversee public areas - or **formal**, involving integrated monitoring systems such as cameras, sensors, AI analytics, and access controls to oversee operations, detect intrusions, and track compliance in industrial facilities. (Dameria & Fuad)

Safety: Distinguished between **actual safety** (crime rates) and **perceived safety** (subjective feelings of security). The concept of **"True Safety"** includes audited safety (observable factors), perceived safety (safety climate), and real safety (individual intention/motivation). (Dameria & Fuad) (Asten, Milias, Bozzo, & Psyllidis, 2023)

Concept	Role in Industrial Architecture	Example Impact
Transparency	Open layouts and information sharing	Improves working conditions, as areas no more remain shaded or at the back-end.
Surveillance	Monitoring high-risk zones	Enables quick intruder response
Safety	Combined risk mitigation	Lowers injuries through proactive oversight

Table 2.1: Role and impact of different concepts (Source: Author)

D. Transparency in architecture

1) Concept of transparency (visual, social, material)

Visual Transparency refers to the literal permeability of light and sightlines through materials like glass facades or perforated panels, blurring indoor-outdoor boundaries in factories or warehouses. It improves operational oversight by allowing clear views of machinery and workflows, as seen in modern plants with extensive glazing for natural illumination and safety monitoring. (Dameria & Fuad)

Fig 2.1: Visual Transparency (Source: Author)

Social Transparency symbolizes openness, trust and democratic access, fostering community engagement around industrial sites through visible processes and public interfaces. (Lindhout & Reniers, 2022)

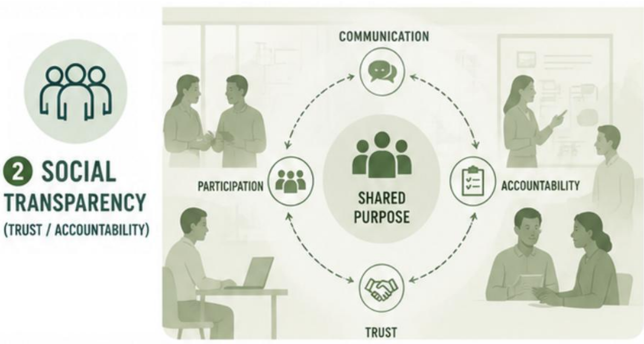

Fig 2.2: Social Transparency (Source: Author)

Material Transparency involves the physical properties of substances such as glass, meshes, or translucent composites that permit partial light passage while offering durability for industrial loads. (Sadeghi, Sani, & Wang, 2015) Materials like

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low E-glass balance insulation with visibility, reducing energy use in factories. Phenomenal transparency arises from layered effects, creating depths and social continuity beyond literal see-through.

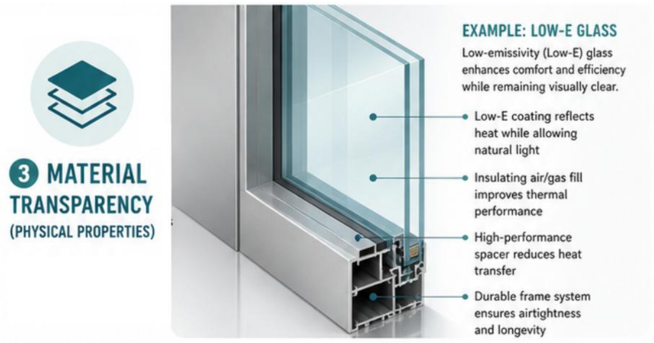

Fig 2.3: Material Transparency (Source: Author)

Types	Role in Industrial Architecture	Example Impact
Visual	Workflow visibility	Enhances safety monitoring
Social	Stakeholder trust	Builds community relations
Material	Durable light permeable facades	Boosts efficiency and sustainability

Table 2.2: Role and impact of different transparency types (Source: Author)

2) *Glass, perforated screens, double-skin façades, and legibility of space*

The transparency of buildings alters the perceptions of safety, social opportunities, and exposure among occupants and the general public. Different user groups perceive glass in varying ways. Some categorize it as protective some as exposing – with factors such as vulnerability and privacy influencing these perceptions

Visibility – Natural transparency is incorporated via elements like windows, glazed frontages. It increases sightlines and can raise perceived safety via "eyes on street" mechanisms.

Some users – especially more diverse, lower incomes, or health stressed (user) groups report that glass spaces feel unprotected or exposing rather than reassuring.

Glass/glazing often makes the occupants conscious of the surroundings and often reassert private boundaries when glass has been used. This showcase varied emotional responses from anxiety and control.

E. *Surveillance*

Surveillance describes architectural designs where structures actively monitor occupants and surroundings, embedding observation into form and function for control and security.

1) *Role of CCTV, access control, and spatial layouts in everyday surveillance*

CCTV provides real time visual oversight, strategically placed for maximal coverage of workflows and perimeters in industrial sites, deterring hazards and aiding incident response. Access control-via biometrics, keycards or turnstiles – regulates entry to zones, integrating with CCTV for layered verification and data analytics.

Spatial layouts amplify everyday surveillance through "natural" sightlines, like open-plan factories with elevated control rooms or chokepoints funnelling movement past cameras. Together, they form a "transparency for safety" triangle, where layouts ensure visibility, tech enforces it, and architecture normalizes constant watching. (Raj & Patil, 2023)

F. *Safety, CPTED, and natural surveillance*

Safety, CPTED, and natural surveillance form a design triad that enhances security in built environments by leveraging architecture to deter crime and promote safety organically. Safety involves creating structures that minimize risks through clear sightlines, intuitive navigation, and hazard resistant materials, extending prior discussions on transparency and surveillance. In industrial contexts like factories, it is applied via open layouts that prevent accidents and support emergency access, integrating visual oversight for worker protection. (WBDG , n.d.)

1) *Principles of Crime Prevention Through Environmental Design (CPTED)*

CPTED designs environments to reduce crime opportunities via natural surveillance, access control, territorial reinforcement, maintenance, and activity support, differing from mechanical barriers like fences.

- Natural Surveillance: Maximizes visibility to discourage crime by ensuring potential offenders feel observed, using elements like windows overlooking paths, good lighting and minimal obstructions. In industries it could be applied via elevated walkways in factories for workers to monitor machinery and perimeters passively. (WBDG , n.d.)
- Natural access Control: Designs guide movement through predictable paths like sidewalks, gateways, and clear entrances, reducing concealed routes while allowing legitimate flow. Factories apply this via single controlled entry points with adjacent parking, funneling traffic past surveillance zones. (WBDG , n.d.)
- Territorial Reinforcement: Uses landscaping, fencing, and signage to define ownership and boundaries, fostering resident or worker responsibility over spaces. Industrial sites reinforce this with branded perimeter walls and low hedges that signal care without blocking views. (WBDG , n.d.)

G. *Synthesis: Linking transparency, surveillance, and safety*

1) *Conceptual framework for how these three concepts interact with the built form and user experience*

Transparency, surveillance, and safety interconnect in architecture to create secure, efficient built environments where visual openness supports monitoring and risk reduction.

Conceptual Interactions

Transparency provides the physical and perceptual foundation by enabling light permeability and sightlines, which

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feed into surveillance mechanisms like natural oversight or embedded tech. Surveillance operationalizes this visibility into active or passive control, deterring threats while safety emerges as the outcome – reduced accidents and crime through proactive design. In industrial settings, glass facades (transparency) allow worker monitoring (surveillance), preventing hazards (safety) per CPTED.

Built Form Dynamics

In physical structures, transparent materials like glazing pair with CPTED layouts - clear paths and active frontages - to amplify natural surveillance, minimizing blind spots. Embedded systems integrate invisibly, balancing openness with privacy, while panoptic elements centralize oversight in factories. This synthesis forms a "transparency-safety triangle," where material choices enhance operational visibility without compromising durability.

User Experience Impacts

Users perceive safety through psychological cues: transparency fosters trust via openness, surveillance induces self-regulation, and their synergy boosts confidence in navigation. Workers in textile plants feel empowered by visible processes, reducing fear while maintaining productivity; however, excess monitoring risks alienation if privacy erodes.

Concept	Built form role	User experiences
Transparency	Sightlines/materials	Openness/trust
Surveillance	Tech/layouts	Awareness/control
Safety	Risk mitigation	Confidence

Table 2.3: Framework synthesis (Source: Author)

H. *Principles for architectural design - CPTED-based spatial layout*

Clear sightlines: Layouts prioritize unobstructed views through open plans, strategic window placement, and minimal visual barriers, enabling natural surveillance across work zones and perimeters. In factories, this means aligning machinery rows with elevated oversight platforms and glazing towards entrances, reducing blind spots.

Defined movement paths: Design interconnected, predictable routes like wide corridors, chokepoints, and lit pathways that guide legitimate traffic while exposing deviations to observation. Industrial applications include single-entry loading docks funneling past control stations, avoiding isolated service alleys. (Dameria & Fuad)

Active frontages: Position active areas - such as offices or break rooms - along perimeters with windows overlooking parking and approaches, creating "eyes on the street" effects. Factories benefit from admin blocks facing yards, blending worker activity with boundary monitoring. (Raj & Patil, 2023)

Zoned Transitions: Create graduated zones from public (parking) to semi-private (loading areas) to secure interiors via landscaping, low walls, and signage, reinforcing territoriality. This supports industrial security by transitioning textile waste zones through gated buffers

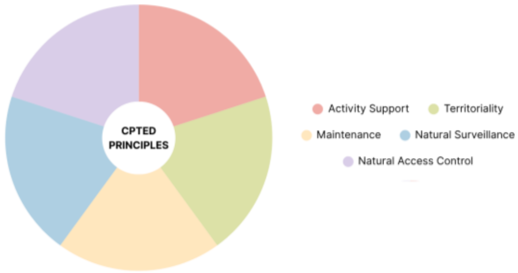

Fig 2.4: CPTED Principles (Source: Author)

I. *Context and typology: Textile upcycling hub*

A textile upcycling hub serves as a centralized facility that transforms pre and post-consumer textile waste into high-value and sustainable products through upcycling or recycling processes, integrating sustainability with community engagement.

1) Functions: collection, sorting, design, production, display, retail

Collection: Gathering of residue (from factories) or used textiles from homes, industries, boutiques, etc. via bins, take back programs or door-to-door collection systems.

Sorting: The collected waste undergoes manual or automated classification based on type of fibre, colour, quality, density, reusability. (Sandberg & Pal, 2024)

Design: Sorted materials inform creative prototyping where designers reimagine waste into patterns, prototypes and specifications, blending aesthetics with structurl viability for upcycled goods. This phase emphasizes innovation, like turning fabric remnants into modular furniture, aligning with sustainable manufacturing. (Kagitci, 2022)

Production: Upcycling occurs through cutting, sewing, assembly, and finishing on adapted machinery, producing items like bags or apparel with minimal energy. They also need to ensure quality control, traceablity and minimal waste workflows in the hub layout. (Sandberg & Pal, 2024)

Display: Finished products are showcased with educational panel of the process, material origins, and environmental impact to engage the visitors and buyers. Interactive exhibits highlight upcycling stories, fostering transparency and market appeal.

Retail: The on-site shops sell upcycled goods, generating revenue to sustain operations while promoting circular consumption. Models include direct-to-consumer outlets.

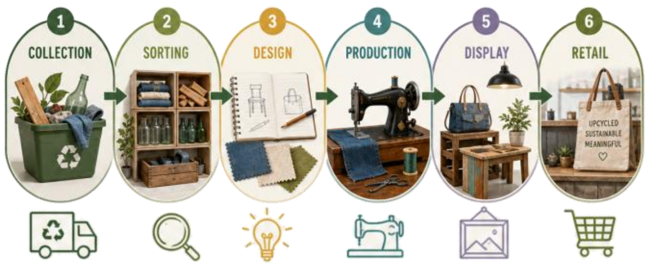

Fig 2.5: A linear diagram illustrating the hub's workflow (Source: Author)

*2) **Typical spatial and safety issues (noise, fumes, dust, informal labour)***

Textile upcycling hubs face spatial and safety challenges from handling diverse waste, often in informal settings prevalent in India, amplifying risks like dust inhalation and poor ventilation. (Jayakumari, et al., 2024)

Noise Issues: Mechanical shredding, sorting machines, and sewing operations generate high-decibel noise (80-100 dB), requiring isolated zones and acoustic barriers to prevent hearing loss and fatigue. Poorly planned open layouts exacerbate propagation, violating standards. The solutions often include enclosed production pods with sound-absorbing materials. (Jayakumari, et al., 2024)

Fumes: Chemical residues from dyes and finishes release volatile organic compounds (VOCs) during sorting or cleaning, causing respiratory irritation without local exhaust ventilation (LEV). Spatial clustering of wet processes near entries spreads fumes. Therefore, a hub needs to be zoned based on the requirement of ventilation, and negatively pressured rooms with scrubbers to contain and treat emissions. (Fashion Sustainability, 2025)

Dust: Fiber shredding produces respirable cotton dust and microplastics, leading to byssinosis ("brown lung") in informal workers lacking masks or dust extraction. Open sorting areas create airborne hazards; mitigation via enclosed conveyor systems, negative pressure enclosures is essential.

Informal labor risks: Migrant or casual workers face amplified vulnerabilities: no PPE, irregular training, child labor, and injury from sharps or machinery, compounded by poverty-driven unsafe practices. Crowded, unmarked spaces heighten slips or stampedes; legible zoning, training areas, and inclusive designs (e.g., accessible paths) promote formalization. (Fashion Sustainability, 2025)

J. User profiles

Waste Picker collectives: These groups, often marginalized migrants in India, aggregate and deliver bulk textile waste, requiring accessible drop-off zones with shaded sorting bays and rest areas. They benefit from formal training spaces and fair payment kiosks to transition from landfills to hub operations, reducing health risks like dust exposure. (H&M Foundation, 2024)

Informal workers: Casual laborers handle sorting, shredding, and basic assembly, facing hazards like noise and fumes, so they need zoned workshops with PPE stations, clear emergency paths, and multilingual signage. Flexible shift areas with canteens promote retention while enforcing safety protocols absent in street-level work. (Fashion Sustainability, 2025)

Designers: Creative professionals prototype upcycled products from sorted fibers, using open studios with natural light, tool benches, and material libraries for experimentation. Collaborative zones foster innovation, linking waste streams to high-value outputs like modular textiles. (Kagitci, 2022)

Visitors: Tours, workshops, and educational exhibits draw eco-conscious individuals, necessitating viewing galleries, interactive displays on upcycling processes, and safe circulation paths separated from production. Elevated walkways provide transparency into operations, enhancing public trust.

Local community: Residents engage via retail, drop-offs, and events, using multipurpose plazas for markets or skill-sharing to build ownership and reduce stigma around waste work. Inclusive features like ramps and seating support intergenerational participation.

*1) **Safety and privacy as key concerns***

Safety concerns: Workers face acute risks from dust inhalation causing byssinosis, chemical fumes triggering respiratory issues, noise-induced hearing loss, and machinery injuries, particularly among informal laborers lacking PPE. Spatial solutions demand zoned ventilation with HEV systems, enclosed shredding pods, and legible emergency paths illuminated per CPTED standards. Integrating transparency via glazed oversight panels enables supervisors to monitor hazards without invading personal space. (WBDG , n.d.) (Fashion Sustainability, 2025)

Informal waste pickers and casual workers require shielded changing areas, break rooms, and rest zones away from visitor viewing galleries to prevent stigmatization and ensure mental wellbeing. Open production layouts risk exposing personal data or health vulnerabilities; frosted glazing and strategic screening maintain surveillance for safety while preserving individual autonomy. Community engagement spaces must separate public retail from private worker zones to avoid intrusive oversight. (Glover, 2026)

III. DESIGN PROPOSITION: TEXTILE UPCYCLING HUB

A. Site strategy and massing

Textile upcycling hubs require site strategies that optimize solar access, wind flow, and community integration while adhering to CPTED principles for safety. (WBDG , n.d.)

*1) **Orientation***

Position the hub's long axis east-west to capture morning light for sorting/display areas and shade production sheds during peak afternoon sun. North-facing glazing maximizes daylight for design studios while south elevations use perforated screens for ventilation, linking transparency with natural surveillance over approaches. (Lindhout & Reniers, 2022)

*2) **Setbacks***

Mandatory 6-10m front setbacks accommodate collection bays and shaded plazas, creating defensible space per CPTED territoriality while allowing truck maneuvering without street congestion. Side/rear setbacks (3-5m) with low boundary walls and planting enable passive oversight from active frontages, mitigating informal labor risks through visibility.

*3) **Relationship with street and community***

Active retail/display faces the street with setback glazing and entry canopies, drawing community footfall while screening noisy shredding behind landscaped buffers. Angled entry sequences funnel waste-pickers past security without stigmatizing flow, supporting social inclusion.

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Element	Design response	Safety/Community Benefit
Orientation	East-west axis, North glazing, South perforated screens	Energy efficiency, surveillance
Setback	6-10m front buffers	Defensible space, access
Street Interface	Active retail frontage/ public area.	Natural surveillance

B. *Building envelope and facade*

1) *Use of glass, perforated metal, and patterned glass*

Industrial buildings/upcycling hubs can use layered building envelopes combining glass, perforated metal, fabric like screens and patterned glass to balance transparency, safety and environmental control. (Meda, 2021)

Glass applications: Strategic glazing on north and east facades maximizes daylight for design studios and sorting areas while minimizing solar heat gain in Pune's climate. Low-E coated glass with fritted patterns provides one-way visibility for CPTED natural surveillance, allowing worker oversight without visitor intrusion. Vertical greenhouses integrate collection zones, filtering fumes while showcasing transparency. (WBDG , n.d.)

*Fig 3.1: Glass and **Safety vs.** Privacy Interaction (Source: Author)*

Fabric-Like Screens: Upcycled textile membranes—tensioned ETFE or recycled fibre composites—form lightweight, adaptive shading on south/west exposures, retracting for winter gain. These respond to wind/fume loads with sensors, embodying "liquid surveillance" through embedded air quality monitors while expressing upcycling ethos. (Meda, 2021)

Perforated Metal Screens: Custom perforated metal panels clad production sheds, enabling cross-ventilation to extract dust and noise (up to 30dB reduction) while ensuring structural durability against machinery vibration. Patterns derived from textile weaves reinforce hub identity, doubling as privacy screens for informal worker zones per safety-privacy balance. (Finish Facades, n.d.)

Patterned Glass: Frosted or sandblasted glass partitions sorting from public display zones, maintaining privacy for waste-pickers while allowing supervisory sightlines critical for informal labor safety. Acid-etched motifs from textile waste patterns unify aesthetic, linking material transparency with operational process visibility.

1) *Visual permeability*

Visual permeability varies by level in textile upcycling hubs to optimize surveillance, privacy, and environmental performance, aligning ground-level activity support with upper-level operational oversight. (WBDG , n.d.)

High permeability at street-facing plinths can install large patterned glass and perforated screens for active frontages, enabling natural surveillance of retail/display and collection bays while buffering dust/noise from production interiors. Transparent entry sequences with fabric-like screens draw community engagement, fostering CPTED territoriality without exposing informal workers. Fritted glazing can ensure one-way views for safety monitoring.

Similarly on the upper floors the viewing gallery could be raised so as to enable viewing along with no disturbance to the workshop/industrial activities.

C. *Interior zoning and transparency*

1) *Reception and retail: high transparency towards street*

These areas should adopt an "Open and Transparent" layout, located adjacent to the sidewalk to evolve through pedestrian flows. This facilitates "two-way directional" natural surveillance, making the entrance feel welcoming and safe. (Natapov, Cohen, & Dalyot, 2024)

2) *Sorting and production: semi-transparent, layered, with internal glazing*

These zones can utilize phenomenal transparency to create ambiguous boundaries between work areas. Perforated load-bearing screen walls made of silk-based bricks can isolate these rooms from public corridors while allowing for porosity and controllable views. (Kagitci, 2022)

3) *Storage and back-of-house: controlled visibility, secure*

Opacity indicates more private, hidden areas. These zones benefit from a "minimized visual exposure" scenario, suitable for segregated uses that strive to avoid surveillance and exposure. Smart glass can be used here to switch between transparent and opaque states as needed. (Natapov, Cohen, & Dalyot, 2024) (Alqalami, 2020) (Abdulahaad, Ra'ouf, & M. Hasan, 2023)

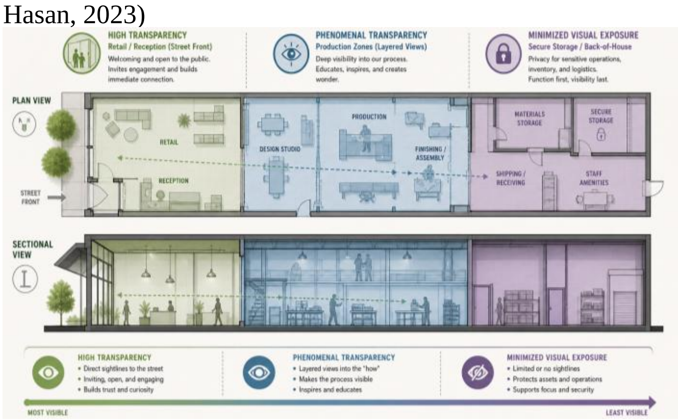

Fig 3.2: Zoning and Visibility Spectrum (Source: Author)

D. *Human-scale and social experience*

1) *Spaces for informal interaction, waiting, and informal learning*

Transparency can be used to create three-dimensional worlds that encourage people to come together to read, learn, and communicate. (Abdulahaad, Ra'ouf, & M. Hasan, 2023)

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Modern office designs prioritize shared workstations and spacious resting areas to avoid a state of disorder and improve employee well-being. (Kagitci, 2022)

*2) **Zones of withdrawal and privacy for workers and visitors***

Acoustic comfort is vital for human well-being in busy environments. Sound-absorbent wallcoverings made of cotton or viscose-based composites, and desk dividers can be implemented in meeting rooms or individual hubs to lower background noise and provide acoustic privacy. Using bio-based materials in these spaces can also mitigate "eco-anxiety" by creating a warm, calm environment. (Kagitci, 2022)

IV. METHODOLOGY

A. *Research Approach*

The research adopts a qualitative, design-oriented and exploratory approach to investigate the relationship between transparency, surveillance and safety in industrial architecture – textile upcycling hub. The study is structured in three interconnected phases: literature review, analytical synthesis and design implications. It begins with a literature review on industrial materiality, visibility, and transparency in built environment. From this – three concepts – transparency, surveillance and safety are identified and synthesized into a conceptual framework to understand their interrelationship and impact on user experience.

The framework is then applied to a textile upcycling hub as a case study, analyzing functions, user profiles, site strategy, massing, façade, and interior zoning. The CPTED principles are integrated to develop a safe and efficient spatial layout, leading to key design implications and conclusions for the hub and semi-public spaces.

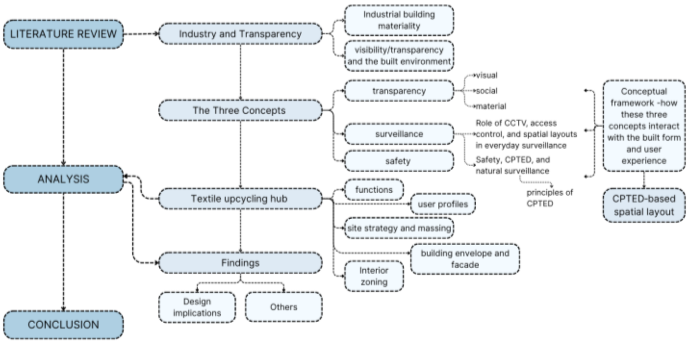

Fig 4.1: Methodology (Source: Author)

V. FINDINGS

A. *Findings for the Textile Upcycling Hub Proposition*

Acoustic and Material Performance: Viscose-based composites with small-sized fibers (4–6 mm) demonstrate the best performance for absorbing low-frequency sounds, making them ideal for meeting rooms and shared office spaces

Thermal Control through Design: Perforated traditional patterns provide thermal comfort by creating a **buffer zone** that manages heat and daylight while maintaining internal privacy

Facade Permeability: To maximize community engagement and safety, retail and reception zones should be located with **minimal setbacks** from the sidewalk to ensure physical permeability and direct visual connection

Floor-Level Surveillance: Natural surveillance from **ground-floor and first-floor windows** is a much more significant predictor of safety than visibility from higher floors.

B. *Design implications*

Zoning Scenarios:

- **Collaborative Collection:** Integrating collection points within the hub (similar to in-store retail collection) improves donor convenience and ensures a higher quality of upcycling feedstock.
- **Maximized Visual Access:** Recommended for retail and reception to thrive on pedestrian flow and surveillance.
- **Phenomenal Transparency:** Effective for production zones, creating ambiguous, layered spaces that define work areas without total visual isolation.
- **Minimized Visual Exposure:** Best for secure storage or back-of-house areas where surveillance avoidance is necessary.

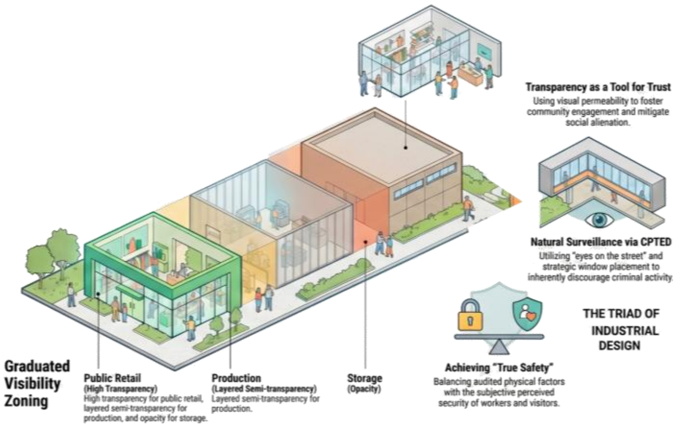

Fig 5.1: Visibility Zoning (Source: Author)

- **Advanced Glazing:** Double-skin facades and smart glass technology are essential for managing solar heat gain and controlling light transmittance into the facility.
- **Worker Well-being:** High transparency in workspaces encourages people to come together to learn and communicate, while **sound-absorbent dividers** and bio-based materials mitigate noise-related stress.

The following figure explains how transparency, active frontages, and application of CPTED in spatial layouts help in designing an interactive and public visible spatial layout and design.

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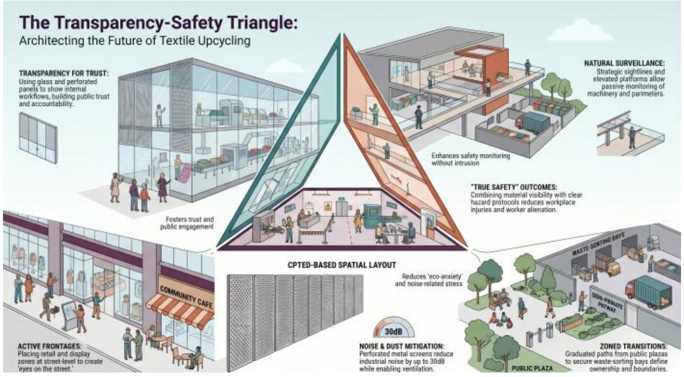

Fig 5.2: The Transparency-Safety Triangle (Source: Author)

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