

DESIGNING FOR TRANSPARENCY: INTEGRATING WASTE MANAGEMENT FACILITIES INTO MALAYSIAN COMMUNITIES

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ABSTRACT

Waste management facilities are often designed for functionality, isolated from the public, limiting community engagement, and fostering negative perceptions. Transparency in architecture, through glass facades, open layouts, and visible structures, enhances accessibility, visual openness, and connection between spaces and users. This study explores how architectural transparency can bridge this gap, making waste management facilities more visible, accessible, and integrated into the communities they serve. Using a qualitative case study approach, this research examines two facilities: the Kamikatsu Zero Waste Centre in Japan and the Batu Maung Waste Transfer Station in Malaysia. Data gathered from site visits and document analysis reveal that transparent design helps clarify waste processes, build public trust, and encourage greater community involvement in sustainable practices. Transparency in waste facilities is achieved through visual openness, public engagement, material honesty, environmental integration, and perceptual awareness. These strategies collectively enhance public trust, engagement, and sustainability. Future research should explore a broader range of facilities globally, assess the long-term effects of transparency strategies on public engagement, and investigate the impact of transparency beyond aesthetics, particularly in promoting sustainable behaviours.



Keywords: *Transparency, Waste Management facilities, Community Engagement, Sustainability, Architectural Design*

INTRODUCTION

The growing global waste crisis has become a pressing concern, with the volume of municipal solid waste expected to rise dramatically—from 2.3 billion tonnes in 2023 to 3.8 billion tonnes by 2050. This surge is driven by rapid urbanisation, population growth, and insufficient waste management systems, particularly in developing countries (Besen & Fracalanza, 2016; Kaza et al., 2018). In Malaysia, the situation mirrors these global trends, with over 30,000 tonnes of waste being discarded daily. Despite efforts to promote recycling and reduce waste, public awareness and participation remain low, and much of the country's waste still ends up in landfills, many of which are close to reaching full capacity (Malaysia Waste Management Solutions, 2022). The Malaysian government has set ambitious targets to improve waste management, but challenges persist in achieving these goals. While waste-to-energy facilities and the adoption of circular economy principles have been proposed as solutions, the design of waste management infrastructure still often prioritises functionality over public interaction, leading to a disconnect between the public and the waste systems they rely on (Muller, 2018).

Historically, waste management facilities have been located on the outskirts of urban areas to minimise their visibility, creating a disconnect between the public and waste processes. This lack of transparency has reduced opportunities for education and participation in sustainable practices. The physical separation of these facilities has also contributed to their perception as unpleasant or undesirable (Nobile, 2018), diminishing public understanding of the waste cycle. As a result, communities are less likely to engage with or support recycling programmes. Research by Georgoulas et al. (2015) and Malik et al. (2015) highlights the importance of visibility and accessibility in encouraging participation, yet many facilities remain poorly integrated into urban areas. While attention is increasing on improving waste management infrastructure, the role of architectural transparency in fostering community engagement remains underexplored. This research aims to explore how transparency in the design of waste

management facilities can enhance the relationship between these facilities and the communities they serve, transforming them into active, engaging parts of the urban fabric. This shift could improve public understanding and participation, hence promoting a more sustainable approach to waste management.

Transparency in Architecture

Transparency in architecture uses clear or translucent materials to enhance visual connectivity between interior and exterior spaces, promoting openness and accessibility. By minimising partitions and incorporating open floor plans, transparency fosters spatial flow, natural ventilation, and daylighting, creating a dynamic and engaging atmosphere (Erkartal & Uzunkaya, 2019). Symbolically, transparent designs convey values of openness, honesty, and community engagement, particularly in public buildings (Fidanci, 2022). Over time, the use of transparent materials has evolved, from functional purposes like ventilation and lighting during the Industrial Revolution to a key aesthetic tool in modern architecture, blending the built environment with nature (Abbas & Dewidar, 2022). Today, transparency in architecture is a multidimensional notion that enhances the quality of the experience and visuals of the buildings, making them more inviting and engaging to the community and surrounding context.

Principle of Transparency in Architecture

The principles of transparency in architecture encompass visual openness, spatial integration, symbolic meaning, public engagement, environmental considerations, and perceptual effects. These principles enhance connectivity, foster inclusivity, improve sustainability, and create dynamic spatial experiences. By integrating transparency, architecture can promote public interaction, strengthen environmental awareness, and enrich user perception within built environments.

a) Visual Openness and Integration of Spaces

Many scholars highlighted the relationship of visual openness and connectivity with architectural transparency, achieved by using clear materials and low-opacity materials to provide unobstructed views and connections between spaces. Thus, visual accessibility and open environments are

created by allowing unrestricted movement and connectivity within and between spaces (Fidanci, 2022; Liu & Liu, 2023). This approach improves the visual appearance of a building and cultivates the sense of connection between spaces within a building and connection between the building and its surroundings. In the work of Riken Yamamoto's architecture, integration of the building with its surroundings creates a seamless transition between interior and exterior spaces, fostering a sense of welcoming and accessibility in the design, thus enhancing public engagement (Souza, 2024). Visual openness and spatial integration enhance architectural transparency by using clear materials to create seamless connections within and beyond the building, fostering accessibility and public engagement. However, balancing transparency with privacy, climate control, and functional zoning is crucial in maintaining both aesthetic appeal and occupant comfort.

b) Symbolic Meaning and Public Engagement

Transparency in architecture symbolises openness, trust, and accessibility, particularly in public buildings. Transparent facades promote civic engagement and create spaces that foster inclusivity (Baratto, 2023). Transparent designs convey values of honesty and clarity, making buildings more approachable and reinforcing institutional transparency in operations (Vercelloni, 2021). These symbolic elements encourage community interaction and strengthen the bond between architecture and its users (Sadeghi et al., 2015). The symbolic use of transparency in architecture reinforces values of openness, trust, and inclusivity, strengthening public engagement by making institutional functions visible and accessible. However, while transparency fosters democratic interaction, it must be carefully balanced with privacy, security, and contextual appropriateness to ensure both its symbolic significance and operational functionality.

c) Environmental Integration

Transparency also integrates natural light and enhances environmental sustainability by reducing the need for artificial lighting. The strategic use of glass maximises light penetration, creating energy-efficient interiors while fostering a connection to the natural environment (Abdulhaad et al., 2023). This integration enhances comfort and promotes environmental awareness, making transparency a powerful tool for sustainable design (Fidanci, 2022). Environmental integration through architectural transparency enhances sustainability by optimising natural light, reducing energy consumption, and

fostering a connection with nature. However, while transparent materials improve environmental quality and occupant well-being, their thermal performance and potential glare issues must be carefully managed to balance energy efficiency with comfort.

d) Simultaneous Awareness and Perceptual Effect

Transparency enhances the spatial experience by allowing multiple views and perspectives to be perceived simultaneously. This concept of "phenomenal transparency" facilitates the creation of dynamic spaces where the movement and interaction between different areas are fluid and continuous (Abbas & Dewidar, 2022). By dissolving physical and visual boundaries, transparent architecture creates a sense of coherence and depth within the building (Erkatal & Uzunkaya, 2019). Simultaneous awareness in architectural transparency enhances spatial perception by enabling layered views and seamless transitions between spaces. While this approach enriches user experience and connectivity, excessive transparency may lead to visual overstimulation or compromise privacy, requiring careful spatial hierarchy and material selection to balance openness with functional needs.

Importance of Transparency for Community Integration

Architectural transparency fosters openness, inclusivity, and safety, particularly in public buildings. Transparent design bridges the gap between public and private spaces, encouraging community engagement and blurring traditional boundaries. Liu and Liu (2023) argue that transparent designs remove spatial divisions, creating diverse and inviting environments. Transparency enhances visibility of activities within buildings and conveys trust and accessibility, as seen in public facilities. Transparent facades promote public interaction by making operations visible and fostering accountability (Rault, 2020). This design approach supports community integration, improves social dynamics, and contributes to energy efficiency (Abbas & Dewidar, 2022). Ultimately, transparency strengthens the relationship between buildings and their communities, encouraging more active participation in public life (Moosom & Noor, 2023). Transparency in architecture strengthens community integration by fostering openness, accessibility, and engagement. While it enhances safety, inclusivity, and environmental sustainability, its effectiveness depends on balancing visual permeability with privacy and contextual responsiveness. Overuse

of transparency without thoughtful spatial and material strategies may compromise comfort, security, or energy efficiency, requiring a nuanced approach to its application.

Integrating Transparency in Waste Management Facilities

In waste management, transparency plays a critical role in fostering community engagement and sustainability. Traditionally isolated, these facilities can adopt transparent designs to demystify waste processing and reduce stigma (Muller, 2018). Incorporating educational rooms, exhibition spaces, and public viewing areas transforms them into interactive hubs, fostering public trust and accountability (Nobile, 2018). Transparency strengthens spatial connectivity, using glass facades and open layouts to integrate these facilities into the urban fabric (Georgoulas et al., 2015). Sustainable strategies, such as maximising natural light and optimising ventilation, enhance energy efficiency while reinforcing environmental responsibility (Nobile, 2018). These architectural interventions not only improve functionality but also position waste facilities as educational tools, encouraging public participation in sustainability efforts. By making waste management processes visible, architecture plays a crucial role in reshaping perceptions and promoting community-driven waste reduction initiatives (Muller, 2018; Georgoulas et al., 2015).

RESEARCH METHODOLOGY

This study adopted a case study approach to investigate how architectural transparency and community-integrated design enhanced the relationship between waste management facilities and their surrounding communities. Case selection followed strict criteria, ensuring the inclusion of fully operational facilities that incorporated transparency elements such as glass facades, open layouts, and public engagement initiatives like tours and educational programmes. Facilities that were under construction, lacked transparency features, or had limited public interaction and data availability were excluded. This systematic selection process ensured the study focused on relevant, data-driven cases, providing practical insights for architects, urban planners, and policymakers seeking to design participatory and sustainable waste facilities.

Data collection integrated primary and secondary sources to achieve a comprehensive analysis. Architectural plans, design documents, and community reports were examined to verify the application transparency strategies, while site visits offered direct observations of spatial configurations and public engagement patterns. Stakeholder interviews complemented the findings, offering diverse perspectives on the perceived effectiveness of design strategies. A qualitative approach, using content and cross-case comparison, was used to identify recurring themes and best practices in aligning waste facilities with community needs. Ethical considerations were strictly followed, including informed consent, anonymity, and secure data management. Research validity was strengthened through triangulation of data sources and peer reviews, ensuring reliability and robust conclusions. This methodology established a robust framework for examining how transparency-focused architectural strategies could reshape waste management facilities as open, community-engaged spaces.

FINDINGS AND DISCUSSIONS

Transparency in waste management facilities is crucial for fostering public trust, encouraging community participation, and improving operational efficiency. Unlike general architectural transparency, which typically enhances openness and connectivity in conventional buildings, transparency in waste facilities serves functional, educational, and environmental objectives. It provides visibility into waste processes, promotes environmental accountability, and strengthens the facility's role as an interactive public space. The following sections highlight key transparency components specifically relevant to the architectural design of waste management facilities. Through a case study approach, this research analyses selected waste management facilities that have successfully implemented transparent design principles.

Identification of Transparency Elements in Architectural Design for Waste Management Facilities

The Main Components of Transparency for Waste Management Facilities

Transparency in architecture incorporates visual openness, symbolic meaning, environmental considerations, and perceptual effects. These dimensions influence user experience and community perception while offering both functional and aesthetic benefits. Architects can apply these elements to develop sustainable and inclusive waste facilities.

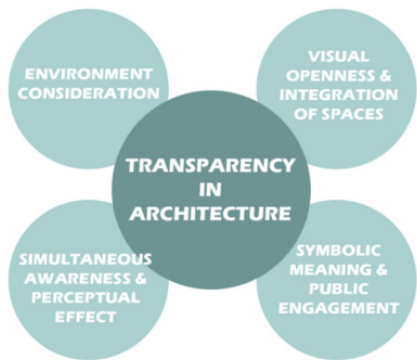


Figure 1. The Elements of Transparency in Architecture

Source: Author, 2024

Visual Openness and Integration of Spaces

The use of glass facades, open interior layouts, and viewing corridors enhances public accessibility to waste management processes, demystifying operations and reducing negative perceptions. Facilities featuring designated viewing platforms enable visitors to witness sorting, recycling, and waste treatment directly, reinforcing public awareness of waste systems. Moreover, spatial integration between operational zones and public areas ensures that transparency is not merely visual but also experiential, facilitating controlled and safe community interaction.

Symbolic Meaning and Public Engagement

Transparency in waste management facilities symbolises environmental accountability and institutional openness. Public-facing architectural features, such as transparent enclosures and educational display areas, reinforce the facility's openness, making waste management processes more understandable and approachable. These features further encourage community engagement through guided tours, workshops, and interactive exhibitions, transforming waste facilities from isolated industrial zones into active educational and civic engagement spaces.

Environmental Considerations

Architectural transparency in waste facilities contributes to sustainability by optimising natural daylighting, minimising the reliance on artificial lighting, and integrating passive ventilation. Transparent enclosures and semi-open structures reduce energy consumption while maintaining functionality and hygiene in waste processing areas. Additionally, strategically positioned openings and shading devices regulate indoor climate, improving occupant comfort and operational efficiency without compromising hygiene standards.

Simultaneous Awareness and Perceptual Effect

Designing for simultaneous awareness in waste management facilities ensures that users—whether workers, visitors, or the general public—maintain an intuitive grasp of spatial layout and activity flow within the facility. Large viewing panels, elevated walkways, and clearly marked public observation zones enhance spatial legibility, allowing visitors to follow waste processing stages safely. This perceptual transparency enriches educational experience and supports behaviour shifts toward responsible waste management practices.

Analysis and Comparison of Transparency Elements in Existing Waste Management Facilities

The selected case studies consist of facilities located in urban and rural settings, each presenting unique challenges and opportunities for incorporating transparency. By comparing these facilities, we aim to highlight the impact of transparency on community engagement and identify effective strategies for integrating transparency into the design of waste management facilities.

Facility A: Kamikatsu Zero Waste Centre, Kamikatsu, Tokushima, Japan



Figure 2. Kamikatsu Zero Waste Centre, Kamikatsu, Tokushima, Japan

Sources: A Small Town Asks ‘Why?’: Toward a Zero-Waste World, 2021

The Kamikatsu Zero Waste Centre, designed by Hiroshi Nakamura and NAP (Abdel, 2023), embodies the town's pioneering zero-waste initiative launched in 2003. This initiative, promoting reduce, reuse, and recycle principles, boasts a recycling rate exceeding 80% (Lee & Inuma, 2022). The facility’s design emphasises transparency to integrate sustainability with community engagement.

Visual Openness and Integration of Spaces

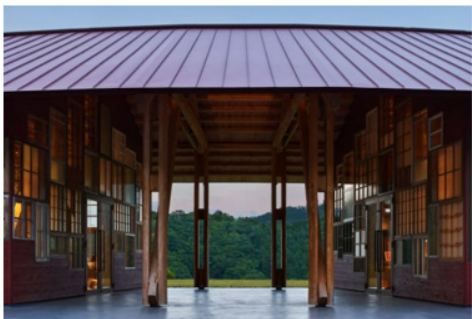


Figure 3. The Reused Fixtures from Traditional Townhouses between KuruKuru Shop, Encounter Hall and Community Hall

Sources: Kamikatsu Zero Waste Centre | Hiroshi Nakamura & NAP, 2021

Reused windows from local traditional townhouses are incorporated into the facade, creating seamless views between the KuruKuru Shop,

Encounter Hall, and Community Hall (Kamikatsu Zero Waste Centre | Hiroshi Nakamura & NAP, 2021).[1.1] The open-plan, horseshoe-shaped layout optimises visibility and workflow, facilitating efficient waste sorting while enhancing operational flow and visitor accessibility.

Symbolic Meaning and Public Engagement

The centre's public spaces, like the KuruKuru Shop and Community Hall, encourage interaction and transparency (Hana Abdel, 2020).[2.1] Guided tours, workshops, and the INOW[3.1] programme engage visitors in hands-on activities such as tea harvesting and composting, fostering commitment to the zero-waste lifestyle (A Small Town Asks 'Why?': Toward a Zero-Waste World, 2021).



Figure 4. Community Hall as Public Spaces that are Accessible to the Public

Sources: Hana Abdel, 2020

Environmental Consideration

The facility blends harmoniously with its natural surroundings through glass fixtures, natural ventilation, and exposed cedar wood structures that reduce construction waste (Griffiths, 2021). This design reduces energy consumption and promotes a strong connection to nature, enhancing user well-being.



Figure 5. The Exposed Timber Structure

Sources: Griffiths, 2021

Simultaneous Awareness and Perceptual Effect



Figure 6. The Simultaneous Spatial Awareness

Sources: Hana Abdel, 2020

Transparent panels dissolve boundaries between spaces, enabling continuous visual connection and layered spatial experiences (Hana Abdel, 2020). This enhances depth and spatial complexity, creating a dynamic and engaging architectural environment.

The Kamikatsu Zero Waste Centre serves as a model of sustainable design, balancing environmental, social, and operational goals to inspire broader community participation and awareness.

Facility B: Batu Maung Waste Transfer Station, Penang, Malaysia



Figure 7. Batu Maung Waste Transfer Station, Penang, Malaysia

Source: Facebook - Eurasia Express Sdn Bhd, 2021

The Batu Maung Waste Transfer Station in Penang, in operation since December 2018, exemplifies advanced waste management through innovative systems like vertical compression, organic waste composting, and biogas generation (Construction Plus Asia, 2019; SteelPedia, 2019). It processes domestic waste to be transported to Pulau Burung Landfill, prioritising sustainability and efficiency.

Visual Openness and Integration of Spaces

Transparent materials, including large windows and floor-to-ceiling glass panels, promote visual openness, allowing visitors to observe operations while maintaining safety. The design enhances monitoring and educates the public on waste processes.

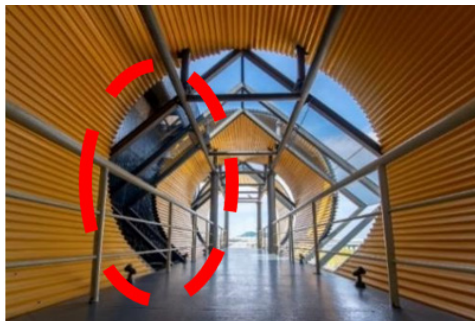


Figure 8. Transparent Material along Tubular Pathway

Source: Facebook - Malaysian Architect, 2021

The Green Bulk Waste (GBW) building integrates glass facades to connect interiors with exterior views, fostering transparency and public trust. An open floor plan with minimal structural elements ensures seamless visual continuity, improving workflow and spatial efficiency.



Figure 9. Glass Façade with Floor-to-ceiling Transparent Material Panels
Source: SteelPedia-Batu Maung Waste Transfer Station, 2019

Symbolic Meaning and Public Engagement

Strategically located near public spaces like bicycle lanes, food courts, and fishing spots, the station fosters community awareness and reduces stigma around waste facilities (SteelPedia, 2019). Public areas, such as pedestrian pathways, edible gardens, and a man-made pond, are integrated with transparent facades, encouraging social acceptance and engagement.



Figure 10. Location of Batu Maung Transfer Station
Source: Google Map, 2024



Figure 11. The Transparent Façade of Waste Process Building Integrated with Public Realm

Source: SteelPedia-Batu Maung Waste Transfer Station, 2019

Educational tours, an interactive gallery, and an education theatre provide opportunities for the public to learn about waste management, with access available by appointment through Majlis Bandaraya Pulau Pinang (MBPP).

Environmental Consideration

The facility maximises natural light with skylights and tinted glass, reducing energy consumption while creating well-lit, pleasant environments for workers and visitors (SteelPedia, 2019). Solar panels further minimise carbon emissions. Open structural frameworks and natural ventilation enhance environmental integration, with designs that connect interior spaces to views of the sea and surrounding landscapes, fostering a harmonious aesthetic.

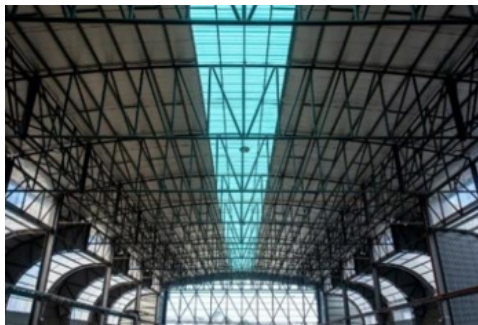


Figure 12. The Exposed Structure and Skylight at GBW Building

Source: SteelPedia-Batu Maung Waste Transfer Station, 2019

Simultaneous Awareness and Perceptual Effect

Layered spatial organisation, such as the tubular visitor pathway attached to the waste process building, offers simultaneous views of various operational zones, creating depth and continuity in design (SteelPedia, 2019). The facility's visual openness enriches spatial experiences and reinforces connections between architecture and purpose.



Figure 13. Attached Tubular Pathway to the Building

Source: SteelPedia-Batu Maung Waste Transfer Station, 2019

Comparative Analysis

This study compares transparency in the Kamikatsu Zero Waste Centre in Japan and the Batu Maung Waste Transfer Station in Malaysia, examining open layouts, visual access to processes, and integration with public spaces. Despite their cultural and geographical differences, these shared approaches highlight the universal value of transparency in waste management design. The findings generate key strategies to guide future facility designs toward fostering inclusivity and sustainability.

Visual Openness and Integration of Spaces

Kamikatsu Zero Waste Centre fosters community engagement through adaptive reuse and seamless indoor-outdoor transparency, promoting waste awareness. Batu Maung prioritises controlled visibility with structured transparency for operational efficiency. While both enhance public perception, a balance between engagement and functionality is key to maximising transparency's impact in waste facility design.

Table 1. The Comparison of Visual Openness and Integration of Spaces Elements

Architectural Features of Transparency	Kamikatsu Zero Waste Centre, Japan	Batu Maung Waste Transfer Station, Malaysia
Visual continuity between spaces	Reused windows create continuous views between KuruKuru Shop, Encounter Hall, and Community Hall, allowing seamless transitions.	Consistent visual access along visitor pathways and large transparent panels between waste process areas and the control room for better surveillance.
Permeability between interior and exterior	Reused façade fixtures blur boundaries between interiors and the valley's natural beauty, providing visual access to public space activities.	Floor-to-ceiling transparent façades at the GBW building offer visual access to waste process areas.
Open-plan layout	Horse-shoe open plan with visible waste management processes for public observation.	Open-plan operation building with minimal structural elements and unobstructed views; open outdoor waste process area ensures visual access.

Source: Author, 2024

Symbolic Meaning and Public Engagement

Kamikatsu fosters public engagement through open access, community spaces, and interactive programmes, while Batu Maung limits access but promotes awareness via tours and strategic location. Kamikatsu's cedar structure symbolises environmental harmony, whereas Batu Maung's steel reflects industrial efficiency. Both demonstrate transparency's role in enhancing trust and sustainability in waste management.

Table 2. The Comparison of Symbolic Meaning and Public Engagement Elements

Architectural Features of Transparency	Kamikatsu Zero Waste Centre, Japan	Batu Maung Waste Transfer Station, Malaysia
Public accessibility	Open to the public without reservations; includes a community centre.	Accessible only by reservation for educational tours or on designated open days; gated property.
Community integration	Features community spaces like Kurukuru Shop, Community Hall, and Why Hotel; hosts education tours and programmes; encourages public involvement in waste sorting, recycling, and selling goods.	Hosts educational tours; includes public spaces like pathways and man-made landscapes but is not fully open to the public; proximity to bicycle lanes and public hotspots fosters social acceptance.
Exposed structure	Cedar wood framework emphasises clarity and honesty of materials while blending with nature.	Steel framework showcases functionality with a straightforward and unpretentious design.

Environmental Consideration

Kamikatsu integrates nature through reused fixtures, maximising natural light and ventilation while minimising waste with unprocessed cedar. Batu Maung enhances sustainability with solar panels and ecological features like ponds and gardens. Both facilities demonstrate how transparency fosters environmental harmony, reducing energy use and strengthening connections between waste management and nature.

Table 3. The Comparison of Environmental Consideration Elements

Architectural Features of Transparency	Kamikatsu Zero Waste Centre, Japan	Batu Maung Waste Transfer Station, Malaysia
Natural lighting and ventilation	Reused fixtures enhance natural light; open spaces allow ventilation and valley views.	Skylights reduce artificial lighting; open spaces and tubular pathways promote ventilation.
Connection with nature	Floor-to-ceiling fixtures and open spaces blend the facility with its surroundings.	Man-made ponds, edible gardens, and transparent elements connect with the sea and landscape.
Sustainable practices	Uses unprocessed cedar logs to minimise waste.	Solar panels reduce carbon emissions.

Source: Author, 2024

Simultaneous Awareness and Perceptual Effect

Both facilities use transparency to enhance spatial awareness and connectivity. Kamikatsu’s open-plan layout ensures uninterrupted visual links, fostering engagement. Batu Maung’s tubular pathway offers layered visibility, deepening public understanding of waste processes. These strategies reinforce transparency as a tool for demystifying waste management and promoting public environmental consciousness.

Table 4. The Comparison of Simultaneous Awareness and Perceptual Effect Elements

Architectural Features of Transparency	Kamikatsu Zero Waste Centre, Japan	Batu Maung Waste Transfer Station, Malaysia
Fluid transition between spaces	Transparent panels between spaces ensure seamless visual connections.	Integrated spaces allow layered experiences and depth within waste zones.
Simultaneous spatial awareness	An open floor plan provides awareness of various parts of the building.	Tubular pathways enable awareness of waste processing zones inside and out.

Source: Author, 2024

Architectural Transparency Strategies for Waste Management Facilities

This section outlines proposed strategies for integrating architectural transparency into waste management facilities, drawing on insights from case studies of the Kamikatsu Zero Waste Centre in Japan and Batu Maung Waste Transfer Station in Malaysia. These strategies aim to enhance functionality while fostering community engagement and environmental awareness. By adopting these approaches, waste management facilities can become integral to sustainable urban development, encouraging openness and collaboration in promoting sustainability.

Visual Access to Waste Process Areas

Providing visual access to waste processes is a key transparency strategy. The Kamikatsu Zero Waste Centre features open visitor pathways near its stockyard, while Batu Maung employs transparent materials along visitor pathways and large windows for surveillance and educational purposes. Strategically incorporating walkways and observation areas with transparent partitions allows visitors to safely observe operations, promoting transparency, trust, and public education about waste management.

Table 5. The Visual Access to Waste Process Area

Visual Access To Waste Process Areas	
Kamikatsu Zero Waste Centre, Japan	Batu Maung Waste Transfer Station, Malaysia
 Open visitor pathways	 Large windows and transparent materials along tubular pathways

Source: Author, 2024

Open Design Layout

Kamikatsu and Batu Maung prioritise open layouts with minimal structural obstructions, facilitating seamless visual connectivity. An open design strategy involves creating flexible layouts with large, unobstructed spaces to enhance inclusivity and ease of navigation for staff and visitors. This approach fosters a welcoming environment and supports the facility’s operational efficiency.

Table 6. The Open Design Layout

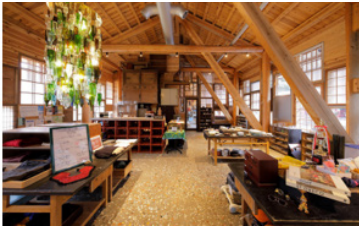
Open Design Layout	
Kamikatsu Zero Waste Centre, Japan	Batu Maung Waste Transfer Station, Malaysia
 Horseshoe open-plan design	 Minimal structural obstruction

Source: Author, 2024

Integration with Public Spaces

Integrating public spaces enhances community engagement. Kamikatsu includes areas like the Community Hall and Kuru-Kuru Shop, while Batu Maung incorporates pedestrian pathways and proximity to public amenities. Designing facilities with parks, gardens, or community centres reduces the stigma surrounding waste facilities and promotes interaction between operational and recreational spaces.

Table 7. The Integration with Public Spaces

Integration With Public Spaces	
Kamikatsu Zero Waste Centre, Japan	Batu Maung Waste Transfer Station, Malaysia
 The commercial space (Kuru Kuru Shop) is one of the public spaces at the facility	 Public spaces near and within the facility

Source: Author, 2024

Public Accessibility

Facilities like Kamikatsu demonstrate the value of unrestricted access, allowing visitors to freely explore most areas without reservations. Batu Maung complements this with strategic public pathways. To improve accessibility, facilities should design open layouts and guided pathways that demystify waste processes, fostering openness and trust while promoting community involvement.

Table 8. Public Accessibility

Public Accessibility	
Kamikatsu Zero Waste Centre, Japan	Batu Maung Waste Transfer Station, Malaysia
 Unrestricted access to most areas without reservations	 Located near public amenities

Source: Author, 2024

Educational Programs

Educational initiatives are essential for public engagement. Kamikatsu and Batu Maung offer tours and workshops to teach visitors about recycling

and waste separation. Strategically incorporating educational spaces, such as lecture halls and interactive exhibits, extends learning opportunities. Virtual tours and online resources can further enhance community understanding and support for sustainable practices.

Table 9. Educational Programs

Integration With Public Spaces	
Kamikatsu Zero Waste Centre, Japan	Batu Maung Waste Transfer Station, Malaysia
	
Educational tours and hands-on learning experiences	Educational tours to understand the waste process along the tubular pathways

Source: Author, 2024

Natural Light and Ventilation

Maximising natural light and ventilation reduces energy use and enhances comfort. Kamikatsu utilises glass fixtures for daylight penetration and open spaces for ventilation, while Batu Maung incorporates skylights and open designs. Facilities can strategically include skylights, large windows, and ventilation systems to create energy-efficient, well-lit environments that support sustainability.

Table 10. Natural Light and Ventilation Utilisation

Natural Light And Ventilation Utilisation	
Kamikatsu Zero Waste Centre, Japan	Batu Maung Waste Transfer Station, Malaysia
	
Extensive use of operable glass fixtures maximises light penetration and utilises the natural ventilation	Skylights and open designs create well-lit spaces and also allow natural ventilation into the buildings

Source: Author, 2024

Connection to Nature

Blending facilities with natural surroundings fosters harmony and well-being. Kamikatsu uses floor-to-ceiling fixtures and timber materials, while Batu Maung incorporates landscaped areas and sea views. Strategies such as green roofs, gardens, and natural materials create aesthetically pleasing spaces and reinforce the facility’s ecological commitment.

Table 11. Connection to Nature

Connection To Nature	
Kamikatsu Zero Waste Centre, Japan	Batu Maung Waste Transfer Station, Malaysia
	
Floor-to-ceiling fixtures and timber material to integrate with the natural environment	Integrating landscapes and maximising sea views fosters harmony with nature

Source: Author, 2024

Sustainable Design Practices

Sustainability is integral to transparency. Kamikatsu utilises unprocessed cedar logs to minimise waste, while Batu Maung uses solar panels for energy efficiency. Adopting eco-friendly materials, renewable energy systems, and water conservation techniques reduces environmental impact and demonstrates commitment to sustainability.

Table 12. Sustainable Design Practices

Sustainable Design Practices	
Kamikatsu Zero Waste Centre, Japan	Batu Maung Waste Transfer Station, Malaysia
	
Utilises local cedar wood and unprocessed logs for the structure's design	Utilising a solar panel system for operation buildings

Source: Author (2024)

Proposed Architectural Transparency Strategies

Table 13. The Key Architectural Transparency Strategies for Waste Management Facility

Architectural Transparency Strategies	Descriptions	Effects
Visual access to waste process area	Transparent walkways and partitions for viewing operations (e.g., glass viewing areas).	Educates the public and builds trust by showcasing facility operations to demystify facility operations.
Open design layout	Flexible, unobstructed layouts (e.g., open plan spaces with minimal partitions, a multipurpose hall with minimal structural obstruction).	Improve spatial flow and inclusivity by facilitating ease of movement and visual connectivity between different areas.

Integration with public spaces	Parks, gardens, or community centres within or near facilities (e.g., adjacent food forest or agro-waste educational farm).	Normalised waste facilities by blending them into daily life with casual visits, spontaneous engagement and recreational activities to increase public presence and demystifying the waste process.
Public accessibility	Open access to most facility areas (e.g., public spaces within the facilities).	Fosters community involvement by promoting openness, trust, and inclusivity.
Educational programmes	Guided tours and sustainability education (e.g., composting demos)	Raises environmental awareness by engaging the public, raising awareness, and strengthening support for sustainable practices to drive behavioural change in the community.
Environmental integration	Natural light and ventilation (e.g., skylights, windows, and open designs).	Enhances occupant well-being by reducing energy use and maximising natural ventilation to improve occupant comfort.
	Connection with nature (e.g., designs integrating natural elements like landscapes and green roofs).	Strengthens human-nature connection by enhancing aesthetics and harmony with surroundings.
Sustainable design practices	Use of reclaimed materials and renewable systems (e.g., solar panels and local reclaimed timber and fixtures).	Reduces environmental impact by promoting eco-friendly practices aligned with sustainability goals.

Source: Author, 2024

CONCLUSION

This study highlights the significance of architectural transparency in waste management facilities as a tool to enhance community engagement, foster environmental sustainability, and improve operational efficiency. Drawing on case studies from the Kamikatsu Zero Waste Centre in Japan and the Batu Maung Waste Transfer Station in Malaysia, key elements and strategies were identified to promote openness and integration in design.

Transparency in architectural design involves visual openness, symbolic meaning, and environmental integration. For example, the use of transparent materials and open-plan layouts enhances visibility and

connectivity, making spaces more inviting and accessible. The Kamikatsu Zero Waste Centre's large windows and repurposed fixtures exemplify this approach effectively. Transparent facades and community-centred layouts convey a message of inclusiveness, encouraging public trust and participation, as reflected in the educational efforts of both case studies. Additionally, incorporating natural light and biophilic designs enhances sustainability and occupant well-being.

Effective strategies include enabling visual access to waste processing areas through transparent partitions and pathways, adopting open layouts, and integrating public amenities like green spaces and communal areas. Public accessibility and guided educational programming help deepen the public's understanding and strengthen involvement. Together, these approaches contribute to the creation of socially inclusive, environmentally sound, and publicly accepted waste management environments.

Future research should examine transparency strategies across a broader range of cultural and geographic settings to evaluate their adaptability and effectiveness. Longitudinal studies could offer deeper insights into the evolving public perceptions of these facilities, while mixed-methods approaches combining surveys and statistical analysis may reveal measurable impacts like recycling rates and participation levels. In addition, examining behavioural shifts linked to transparent designs could reveal their role in fostering sustainable habits. Beyond aesthetics, the impact of transparency on operational efficiency and community engagement should be further analysed. Validation from experts such as architects and environmental scientists will strengthen the applicability of recommendations.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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