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FINAL ARCHITECTURAL DESIGN STUDIO

THE DESIGN OF

ECO VISION

RESEARCH AND EDUCATIONAL TOURISM CENTER IN PIYUNGAN LANDFILL 2.0 REVITALIZATION PROJECT USING REGENERATIVE ARCHITECTURE PRINCIPLES

20512177

Putri Kinanti Shinta Pratiwi

Supervised by

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The Design of
Eco-Vision
Research and Educational Tourism Center in
Piyungan Landfill 2.0 Revitalization Project
using Regenerative Architecture Principles

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Studio Akhir Desain Arsitektur
2025

Perancangan
Eco-Vision
Pusat Riset dan Wisata Edukasi
di Proyek Revitalisasi Piyungan Landfill 2.0
dengan Prinsip Arsitektur Regeneratif

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validation *sheet*

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THE DESIGN OF ECO-VISION, RESEARCH AND EDUCATIONAL TOURISM CENTER IN PIYUNGAN LANDFILL 2.0 REVITALIZATION PROJECT USING REGENERATIVE ARCHITECTURE PRINCIPLES

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statement of *originality*

I, Putri Kinanti Shinta Pratiwi, as the author of this book, hereby declare that all content, except where otherwise cited, is my original work. The ideas and processes presented in the writing and development of this final project were developed by me, with consideration given to the feedback from the supervisor and examiners. This completed project has been submitted to the Department of Architecture at the Islamic University of Indonesia for educational purposes and publication, while the intellectual property rights remain with the author.

Yogyakarta, 3rd March 2025
Author



Putri Kinanti Shinta Pratiwi

preface

Assalamualaikum Wr. Wb.

Praise and gratitude are given to Allah SWT for His mercy and love, which have enabled the author to persevere and successfully complete her education at the Department of Architecture at Universitas Islam Indonesia. With His blessing, the author was able to overcome various challenges throughout the process of completing this thesis. The thesis project presented is titled "The Design of Eco-Vision, Research and Educational Tourism Center in Piyungan Landfill 2.0 Revitalization Project using Regenerative Architecture Principles".

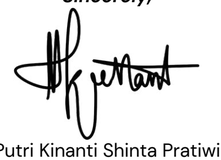
The process of completing this thesis was both challenging and demanding, requiring significant commitment, perseverance, and resilience. However, this accomplishment would not have been possible without the support and encouragement of those who provided guidance and assistance throughout the journey, both physically and mentally. Their contributions and motivation played a crucial role in the successful completion of this project. Therefore, the Author would like to formally extend the deepest appreciation and sincere gratitude to:

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The author fully acknowledges that this report is not without its shortcomings and that there is always room for improvement. Despite thorough efforts to ensure its quality, certain aspects may still benefit from further refinement. Therefore, constructive criticism and thoughtful suggestions are highly welcomed and deeply appreciated, as they contribute to the continuous enhancement of this work.

Wassalamualaikum Wr. Wb.

Sincerely,



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list of *contents*

TITLE PAGE i
VALIDATION SHEET & STATEMENT OF ORIGINALITY iii
PREFACE v
AUTHOR'S PROFILE vii
LIST OF CONTENTS viii
ABSTRACT x
DESIGN PREMISE xi

CHAPTER 1 — INTRODUCTION 2
- Backgrounds 4
- Problem Statement 7
- Scope of Problem 9
- Design Method 11
- Design Approach 13
- Design Hypotheses 15
- Originality, Novelty, and Design Excellence 16

CHAPTER 2 — SITE ANALYSIS AND CONTEXT STUDY 18
- Site Information 20
- Site Analysis 21
- Site Context Study 33

CHAPTER 3 — DESIGN PROBLEM STUDIES 38
- Design Theme Study 39
- Typology Study 49
- Precedent Study 59

CHAPTER 4 — ARCHITECTURAL DESIGN 66
- Functional Zoning 67
- Space Requirements 73
- Design Requirements 75
- Architectural Concept 77
- Materiality and Construction Method 81
- Design Result 87

LIST OF REFERENCES & ATTACHMENTS 113

Department of Architecture
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THE DESIGN OF

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RESEARCH AND EDUCATIONAL TOURISM CENTER IN PIYUNGAN LANDFILL 2.0 REVITALIZATION PROJECT USING REGENERATIVE ARCHITECTURE PRINCIPLES

Universitas Islam Indonesia
2025

THE DESIGN OF ECO-VISION, RESEARCH AND EDUCATIONAL TOURISM CENTER IN PIYUNGAN LANDFILL 2.0 REVITALIZATION PROJECT USING REGENERATIVE ARCHITECTURE PRINCIPLES

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ABSTRACT: *The project addresses Indonesia's pressing waste management challenges epitomized by the overburdened Piyungan Landfill in Yogyakarta, which consistently exceeds its daily waste intake capacity. Concurrently, Yogyakarta grapples with a scarcity of green spaces, violating Indonesian law mandating 30% green coverage, thus compromising biodiversity and residents' well-being. This project envisions a transformative approach by revitalizing Piyungan Landfill into an Eco-Vision Research and Educational Tourism Center, integrating waste management education, research, and eco-tourism through regenerative architecture. The project introduces advanced waste processing technologies alongside interactive learning environments, where visitors can experience waste-to-energy processes, material recovery, and ecological restoration firsthand. Through immersive exhibitions, guided tours, and hands-on workshops, the center fosters public awareness and active participation in sustainable waste practices while demonstrating the potential for circular economy solutions. Additionally, the design prioritizes habitat restoration and green space expansion, ensuring that education is embedded within a thriving natural environment. By merging waste management, education, and tourism, the project aims to create an engaging platform for students, researchers, policymakers, and the general public, fostering cross-sector collaboration and promoting long-term environmental resilience in Yogyakarta.*

Keywords: Educational tourism, landfill restoration, waste management, community engagement, regenerative architecture

design *premise*

This project envisions the transformation of Piyungan Landfill into an integrated waste management and educational tourism hub, demonstrating sustainable waste practices through regenerative design. By combining advanced waste processing technologies with immersive educational experiences, the project aims to shift public perception of waste from a problem to a resource, fostering a culture of environmental responsibility.

At its core, the revitalized site will feature a state-of-the-art waste management facility, including a waste-to-energy plant, an advanced landfill system, a wastewater treatment plant, and constructed wetlands. These systems will not only optimize waste processing efficiency but also serve as educational tools, offering visitors a firsthand look at sustainable waste management strategies.

Surrounding these infrastructure elements, the project integrates a Research and Educational Tourism Center, designed to engage the public in interactive learning. This center will house laboratories and offices for environmental research, a gallery and museum showcasing waste management innovations, and viewing decks and boardwalks that provide guided experiences of the facility. Visitors can participate in hands-on workshops on plastic recycling, tree planting, composting, and sustainable living, as well as explore immersive AR and VR exhibitions. Community spaces such as an eco-market, a café, and multifunctional rooms will encourage social interaction, knowledge exchange, and community-driven sustainability initiatives.

A key aspect of the project is green area restoration, integrating regenerative landscapes with the built environment. Reclaimed landfill sections will be rewilded with native vegetation, forming ecological buffers that enhance biodiversity while providing natural spaces for recreation. The constructed wetlands will play a dual role—purifying wastewater while serving as a habitat for local wildlife and an educational site for visitors. Green infrastructure, including vertical gardens and permeable surfaces, will further reinforce the project's ecological resilience.

Applying regenerative architecture principles, the design prioritizes energy efficiency, material circularity, and symbiosis between human activity and nature. Passive design strategies, renewable energy integration, and adaptive reuse of waste materials will minimize the project's environmental footprint.

This project seeks to establish a model for sustainable landfill revitalization, demonstrating how waste management facilities can evolve into centers of innovation, education, and ecological renewal. By transforming waste into a resource and engaging communities in sustainability efforts, the Eco-Vision Research and Educational Tourism Center will serve as a catalyst for environmental awareness and regenerative urban development.



chapter 1

introduction

Backgrounds
Problem Statement
Scope of Problem
Design Method
Design Approach
Design Hypotheses
Originality and Novelty

back*grounds*

Indonesia, with a population of over 281 million people (CIA, 2024), faces a huge challenge in managing waste. Each year, the country produces more than 19 million tons of waste (Ministry of Environment and Forestry, 2024), and a significant portion, about 33.18%, is left unmanaged. Within Indonesia, the Special Region of Yogyakarta highlights this waste problem while also dealing with a shortage of green spaces, making the situation even more urgent.

Yogyakarta, located in central Java, produces 1,231.55 tons of waste every day (BAPPEDA, n.d.). However, the region can only handle 756 tons of this waste daily, leaving a large amount of waste unaddressed. The main landfill in the area, Piyungan, is supposed to handle 650 tons of waste each day (Humas Pemda DIY, 2023), but it regularly receives more than 700 tons from Yogyakarta and nearby cities like Bantul and Sleman. By July 2023, the height of waste in some parts of the landfill reached 140 meters, far exceeding its intended capacity. This situation is a ticking time bomb, requiring immediate and effective solutions to prevent a larger environmental disaster.

The waste crisis in Yogyakarta stems from a mix of poor waste management policies and a lack of public awareness. Current waste management policies are not sufficient to handle the increasing amount of waste, leading to piles of unmanaged garbage. Additionally, many residents do not know enough about proper waste management practices. Without widespread public education and awareness campaigns, the community cannot effectively participate in solving the waste problem. Therefore, improving both policy and public understanding is crucial to addressing the waste crisis in Yogyakarta.

At the same time, Yogyakarta is experiencing a shortage of green spaces. With 1,317 people living in each square kilometer, the region is heavily crowded (BPS DIY, n.d.). Green spaces in Yogyakarta, including parks and gardens, make up only 23.34% of the city's area (Warta Kota Yogyakarta, 2024). This is below the 30% required by Indonesian law for healthy urban living. The lack of green spaces not only reduces the quality of life for residents but also threatens local wildlife and plants. Without enough green areas, Yogyakarta risks losing its natural beauty and biodiversity.



Yogyakarta in Waste Crisis, UGM Expert: Why the Outcry Now?

News Report 20 August 2023, 19.25 By : Salma

Green spaces play a critical role in urban environments. They help reduce pollution, provide areas for recreation, and support biodiversity. In crowded cities like Yogyakarta, green areas offer a necessary escape from the concrete jungle, helping to improve mental health and overall well-being. Moreover, green spaces help mitigate the effects of climate change by absorbing carbon dioxide and releasing oxygen. Ensuring adequate green areas in cities is essential for sustainable urban living.

To tackle the waste and green area crises, Yogyakarta needs better policies and greater community involvement. The existing laws, such as Law No. 26 of 2007 on Spatial Planning, require cities to have at least 30% of their area as green spaces. However, these laws need to be enforced more strictly. Additionally, the government should introduce new policies that promote sustainable waste management practices and increase green spaces.

Community involvement is also crucial. Residents need to be educated about the importance of reducing, reusing, and recycling waste. Public campaigns can help raise awareness and encourage people to participate in waste management efforts. Schools, local organizations, and media can play significant roles in spreading knowledge and motivating the community.



Addressing Yogyakarta's environmental challenges requires collaboration between the government, private sector, and residents. Government agencies can create and enforce policies, while businesses can invest in sustainable practices and technologies. Residents can contribute by adopting environmentally friendly habits and participating in community initiatives.

Partnerships between different sectors can also lead to innovative solutions. For example, universities can conduct research on sustainable practices, businesses can fund green projects, and community groups can lead grassroots movements to clean up and green their neighborhoods.

Yogyakarta faces significant challenges with waste management and green space shortages. However, with better policies, increased public awareness, and collaborative efforts, the region can overcome these issues. By implementing comprehensive waste management strategies and creating more green spaces, Yogyakarta can move towards a sustainable and healthy future. Protecting the environment and ensuring a high quality of life for residents are essential goals that require immediate and concerted action. Through these efforts, Yogyakarta can preserve its natural beauty and create a livable environment for generations to come.

problem *statement*

MAIN ISSUE

The lack of proper waste management education and awareness which led to ineffective waste disposal practices and environmental degradation.

ARCHITECTURAL ISSUES

1. Absence of built infrastructure to observe and understand waste processing, making waste management an isolated, unseen process.
2. Inadequate infrastructure for waste management processes.
3. Limitations in available space for waste disposal.
4. Fragmented green spaces due to unmindful urban development which disrupts wildlife corridors and isolates populations of flora and fauna.

NON-ARCHITECTURAL ISSUES

1. Public unawareness and misconceptions about waste management, leading to poor waste segregation, excessive landfill dependency, and lack of individual responsibility.
2. Limited collaboration between stakeholders (government and communities) to promote sustainable waste solutions through education.
3. Negative social perception of landfills as dirty, unapproachable areas, discouraging public interest in engaging with waste education initiatives.

ECO-VISION

problem formulation

1. How can architectural interventions facilitate community engagement and awareness about proper waste management practices and the importance of biodiversity conservation?
2. How can regenerative architecture address the inefficiency of waste management systems in Piyungan Landfill while simultaneously promoting biodiversity and restoring green areas in Yogyakarta?

objectives

1. To create an educational hub that provides interactive and research-based learning on waste management, and promote community involvement by designing spaces that encourage participation in sustainable waste practices.
2. Rehabilitating Piyungan Landfill as an integrated waste management facility, utilizing regenerative architectural solutions to optimize waste processes, promote biodiversity, and expand habitat for flora and fauna through green area restoration.

design goals

FOSTER ECOLOGICAL EDUCATION

The project aims to create an engaging educational hub that raises public awareness about waste management and sustainability. Through interactive learning spaces such as galleries, laboratories, AR/VR experiences, and observation decks, visitors will gain hands-on knowledge about recycling, waste-to-energy technologies, and circular economy principles. Workshops, community programs, and eco-market initiatives will foster a culture of environmental responsibility. The presence of outdoor learning will further support activities related to sustainable waste practices and conservation efforts.

REVITALIZE WASTE MANAGEMENT

This goal involves relocating the landfill to optimize space and reduce ecological impact. Waste-to-energy technologies will be added to convert waste into renewable energy, significantly decreasing the volume of waste and generating powers. A comprehensive wastewater treatment plant and constructed wetlands will be established to manage landfill leachate, restore water quality, and support local biodiversity. These initiatives aim to create a sustainable, closed-loop waste management system that minimizes environmental harm and promotes resource recovery.

CREATE WILDLIFE HABITATS

Another key goal of the project is to restore and enhance green spaces within and around the landfill site to promote biodiversity and ecological resilience. This involves reclaiming portions of the landfill for ecological restoration, planting native vegetation, and creating wildlife habitats. Green infrastructure will be integrated to improve habitat connectivity and support local flora and fauna. These green spaces will also provide recreational and educational opportunities for the community, with trails, picnic areas, and observation points for activities such as birding and nature walks.

scope of problem

Matrix of Design Thinking

	radical problem	practical problem	formal problem	symbolic problem
designer (Architect)	Ensure that the architectural solutions and infrastructure adhere to waste management and environmental sustainability laws. This involves thorough research and integration of legal requirements into the design process to guarantee compliance.	Select suitable materials and construction methods that align with sustainability goals while ensuring structural integrity and functionality of the transformed landfill site. Balance aesthetic considerations with practicality to create spaces that are both visually appealing and functional for the intended purposes.	Ensure that the architectural design of the waste management and community facilities aligns with aesthetic considerations while integrating sustainable and functional elements. This involves creating visually appealing structures that harmonize with the surrounding landscape and reflect the cultural identity of the community.	Create architectural solutions that reflect the values and aspirations of the community. This involves incorporating symbolic elements such as cultural references, environmental symbolism, and visual aesthetics that resonate with the local context and inspire a sense of identity and pride.
clients (Local government authorities, environmental organizations, and community stakeholders)	Prioritize sustainability and community engagement over conventional landfill management practices, committing to investing in innovative design solutions that promote environmental stewardship and social well-being.	Involves budgetary considerations, resource availability, and regulatory compliance. Clients must ensure that design proposals are economically feasible, use locally available materials, and adhere to environmental and building regulations to mitigate risks and ensure project success.	Uphold the project's aesthetic vision and design intent while meeting project objectives and budgetary constraints. This involves collaborating with designers to ensure that the final built environment reflects the desired aesthetic qualities and effectively communicates the project's goals and values.	Demonstrate commitment to sustainability and community well-being through the development and operation of the project. This involves embracing symbolic gestures such as green building certifications, public outreach campaigns, and partnerships with local stakeholders to convey a sense of environmental stewardship.
users (Local residents and visitors)	The client's directive may emphasize maximizing the project's effectiveness within the allocated budget. This requires the designer to propose cost-effective solutions without compromising the quality or functionality of the sustainability hub.	Relates to the ease of access and usability of the facilities within the transformed landfill site. Users expect well-designed pathways, signage, and amenities that enhance their experience and facilitate their engagement with educational, recreational, and community activities.	Appreciate and engage with the aesthetic and spatial qualities of the designed environment while maintaining functionality and usability. This includes experiencing visually pleasing and well-organized spaces that enhance the overall user experience and promote a sense of well-being.	Engage with the waste management facilities and community spaces in a manner that aligns with shared values and collective identity. This includes participating in educational programs, cultural events, and environmental initiatives that reinforce community solidarity and foster a sense of belonging.
regulations (Government Regulations, Regional Regulations, and Ministry Regulation)	Minister of Environment and Forestry Regulation Number P.68/MENLHK/SETJEN/KUM.1/12/2017 on the Technical Guidelines for Environmental Quality Standards and Effluent Quality Standards	Government Regulation Number 81 of 2012 on Waste Management Article 18 Paragraph 4 about temporary waste storage requirements and Article 23 Paragraph 3 about landfill locations	Bantul Regency Regional Regulation Number 5 of 2011 concerning Buildings Article 14 Paragraph 1 about Building Basic Coefficient and Article 15 Paragraph 1 about Building Floor Coefficient	Government Regulation Number 81 of 2012 on Waste Management Article 35 about the role of the community in the waste management process

design *methods*

BACKGROUND AND ISSUES

The initial phase of the research involved an extensive study of Piyungan Landfill to understand the lack of public awareness and education on waste management practices. The research identified key issues such as the absence of educational infrastructure, limited community engagement in waste management initiatives, and negative perceptions of landfills as unapproachable, unsanitary spaces. Site surveys provided insights into how waste is currently processed, highlighting the disconnect between waste management operations and public understanding. Additionally, the study examined the potential for integrating sustainable tourism elements to enhance visitor engagement while promoting ecological restoration.

ANALYSIS AND SYNTHESIS

Following data collection, a thorough analysis was conducted to explore how waste management education and tourism can be effectively integrated within a landfill revitalization project. Comparative studies of waste education centers and eco-tourism projects provided valuable insights into spatial programming and user engagement strategies. Regenerative architectural principles were analyzed to determine how built environments can facilitate hands-on learning, interactive exhibits, and direct observation of waste management processes. This phase also assessed sustainable design approaches for creating engaging educational experiences, including AR/VR exhibitions, interactive workshops, and community-led programs. By synthesizing environmental science, visitor behavior, and architectural strategies, the research ensured that the proposed solutions were both educational and impactful.

DESIGN PROBLEM

The third phase translated key findings into specific design challenges. One of the primary issues was how to transform a landfill into an inviting educational space that fosters curiosity and engagement. The project needed to balance functional waste processing areas with interactive learning spaces, ensuring visitor safety while allowing real-time observation of waste management operations. Other challenges included integrating regenerative strategies to restore ecological balance and creating engaging tourism elements that appeal to a broad audience. Community participation was identified as a crucial factor, requiring the design to include flexible spaces for workshops, exhibitions, and collaborative sustainability initiatives. Each challenge was addressed by matching operational needs with architectural solutions that enhance public education and environmental awareness.

DESIGN CONCEPT

The final phase involved developing a cohesive design concept that merges waste management education with sustainable tourism. The concept envisions Eco-Vision, a Research and Educational Tourism Center where visitors can learn through direct engagement with waste processing, recycling innovations, and circular economy practices. The design integrates viewing decks, exhibition galleries, research labs, eco-markets, and nature-based experiences to create a holistic educational environment. Sustainable design principles such as passive cooling, renewable energy systems, and green infrastructure were incorporated to align with the project's environmental goals. By transforming Piyungan Landfill into a center for learning, community engagement, and ecological restoration, the project aims to redefine how waste management is perceived, shifting it from a hidden industrial process to an open, educational, and inspiring experience.

design approach: *regenerative architecture*

Regenerative architecture has its conceptual roots in the term 'regenerative,' which was first popularized by Robert Rodale in the context of organic farming and gardening. Rodale used the term to symbolize the continuous renewal of life in the soil without the use of harmful chemicals, highlighting a principle of ongoing self-renewal (Rodale, 1945). This concept of regeneration extends beyond agriculture and can be applied to various systems that support life, including architecture.

Later, in the mid-20th century, the broader sustainability movement gained momentum in response to growing environmental concerns. The concept of sustainability was popularized by the 1987 Brundtland Report, which defined sustainable development as meeting the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987).

In the realm of architecture, regenerative design emerged as a proactive response to these environmental challenges. Regenerative architecture seeks to shift away from the linear model of resource consumption and waste production towards a cyclical approach that mimics the regenerative processes found in nature (Orr, 2002). It entails a fundamental reimagining of the built environment, where buildings and landscapes are conceived not merely as isolated entities but as integral components of larger ecosystems (Lyle, 1994).

By embracing principles of integration, adaptability, and ecological restoration, regenerative architecture aims not only to minimize environmental impact but to actively contribute to the restoration and regeneration of natural systems (McDonough & Braungart, 2002). This design approach represents a paradigm shift in how we conceive, plan, and construct our built environment, emphasizing the interconnectedness of human and ecological systems in pursuit of a more sustainable and resilient future.

design hypotheses

In envisioning the transformation of Piyungan Landfill into an educational tourism hub for waste management, the design strategy proposes that architectural interventions can bridge the gap between waste processing and public awareness. By creating an immersive learning environment, the project aims to shift the landfill's perception from a waste disposal site to a center for sustainability education. The integration of interactive exhibition spaces, research labs, and hands-on recycling workshops will allow visitors to understand the waste lifecycle and innovative waste management technologies. These educational strategies aim to inspire behavioral change and promote responsible waste disposal practices within the broader community.

Beyond education, that waste management tourism can serve as a catalyst for environmental awareness and engagement. By incorporating eco-tourism elements such as composting gardens, upcycling workshops, and green innovation showcases, the project fosters an experiential learning approach that makes sustainability tangible. Visitors will have opportunities to witness real-time waste-to-energy conversion, material recovery processes, and ecological restoration efforts, making complex sustainability concepts accessible and engaging. This approach transforms waste education into a dynamic, participatory experience rather than a passive learning process.

At the core of the design philosophy is the belief that community involvement is crucial to fostering a culture of environmental stewardship. Public gathering spaces, sustainability markets, and collaborative maker-spaces will encourage knowledge exchange and innovation in waste management practices. By integrating regenerative design principles with active public participation, the project envisions Piyungan Landfill as a model for sustainable urban transformation, demonstrating how waste sites can evolve into educational and ecological assets. This initiative seeks to redefine the role of landfills, not as environmental burdens, but as centers for learning, research, and sustainable development that inspire long-term environmental responsibility.



originality and novelty

Title : Design of Piyungan Yogyakarta Waste Treatment Building
Author : Haidarullah Dhia Mu'afa Koesnoputro, 2021
Typology : Industrial building (for waste treatment)
Approach : Indoor air quality
Description : Discussing how to design a waste treatment facility with building skin design to decrease odor from the waste

Title : Pontianak Green Hub
Author : Muhammad Qaedi Zihni, 2022
Typology : Community center
Approach : Biophilic design
Description : Discussing how to design a green hub to solve environmental problems and empower the community

Title : Bantargebang Community Recycling Center
Author : Arganis Ellyza Putri Prabono, 2022
Typology : Community center
Approach : Ecological design
Description : Discussing how to design a community-based waste management center for scavengers and collectors

Title : Museum of Renewable Energy as a City Landmark in Bantul
Author : Agung Wahyu Hidayat, 2016
Typology : Museum
Approach : Green landscape
Description : Discussing how to design a museum of renewable energy as a city landmark

design excellence

The design excellence of the Piyungan Landfill 2.0 project lies in its holistic approach to urban sustainability and community development. Unlike existing research focused on specific aspects like waste treatment or community centers, this project integrates regenerative architectural principles to address multiple challenges concurrently. It aims to revolutionize waste management through advanced technologies, reducing waste volume and generating renewable energy to promote environmental sustainability and resource efficiency. Simultaneously, the project restores biodiversity by reclaiming landfill areas for native vegetation and wildlife habitats, enhancing ecological resilience and providing recreational spaces for community use.

Central to its design philosophy is the emphasis on community engagement and environmental education. By establishing a sustainability hub for interactive learning and cultural events, the project empowers residents with knowledge of sustainable practices. This approach fosters a sense of ownership and responsibility within the community, promoting long-term sustainability and resilience. Additionally, by prioritizing regenerative design principles such as adaptive reuse of materials and biomimetic innovations, the project ensures that its built environment aligns harmoniously with natural ecosystems, enhancing overall urban livability and environmental quality.

chapter 2

site analysis and context study

Site Information
Site Analysis
Site Context Study



site *information*

The Piyungan Landfill is a critical component of the waste management infrastructure in Yogyakarta, Indonesia. Situated within the region, it serves as the primary destination for the disposal of solid waste generated by residential, commercial, and industrial activities. The landfill accommodates various types of waste, including household garbage, construction debris, commercial waste, and other forms of non-hazardous solid waste.

One of the key functions of the Piyungan Landfill is to provide a designated and controlled environment for the disposal of waste materials. The site is engineered to minimize environmental impact by implementing measures to prevent groundwater contamination, leachate control, and methane gas emissions. Modern landfills incorporate liners and monitoring systems to contain and manage potential pollutants, ensuring that surrounding ecosystems and water sources remain protected.

Despite its vital role in waste management, the Piyungan Landfill faces several challenges. These challenges include limited capacity, as the landfill may reach its maximum storage capacity over time due to increasing waste generation rates. Additionally, inadequate infrastructure such as roads, drainage systems, and waste processing facilities may hinder the efficient operation of the landfill.

Environmental concerns also arise from the presence of a landfill in the vicinity. Improper waste disposal practices, such as open burning or illegal dumping, can result in air and soil pollution, as well as pose health risks to nearby communities. The visual impact of landfills on the surrounding landscape can also detract from the aesthetic appeal of the area and affect property values.



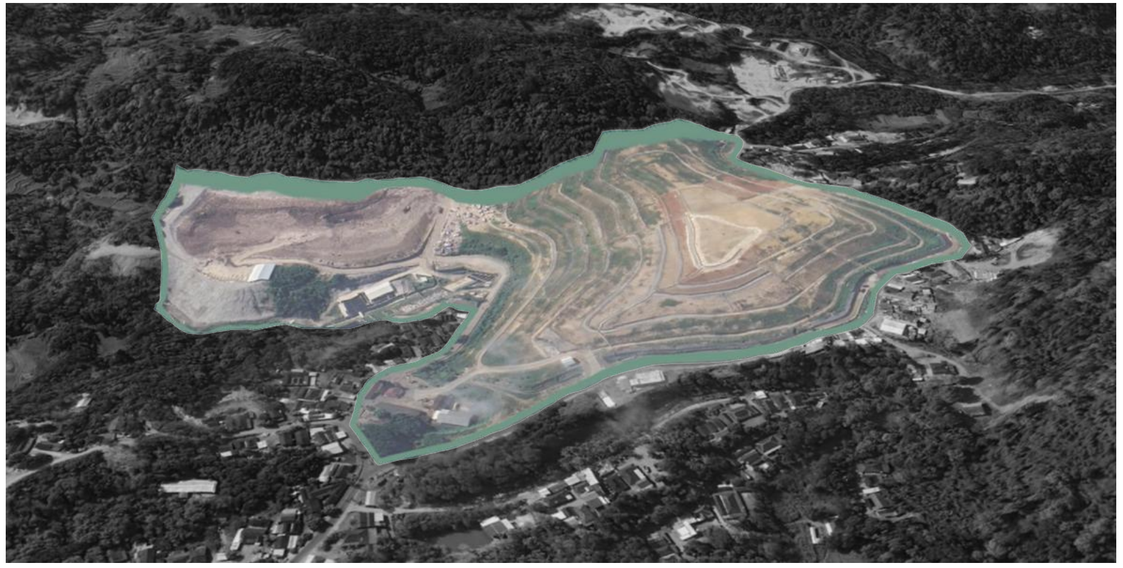
site *analysis*

Situated in Ngablak, Sitimulyo, Piyungan, within the Bantul Regency of the Special Region of Yogyakarta, the Piyungan Landfill occupies a prominent position in the region. Accessible from downtown Yogyakarta City, approximately 14 kilometers away, the landfill site is easily reachable within a short 30-minute drive. Characterized by its hilly terrain, the landfill area sits at an elevation of 1164 meters above sea level, offering expansive views of the surrounding landscape.

The climate in this region is tropical, with temperatures ranging from 24 to 31 degrees Celsius. Rainfall averages between 250 to 750 millimeters annually, while winds blow at speeds of up to 20 kilometers per hour. Humidity levels typically range from 70 to 95 percent, contributing to the area's lush vegetation and diverse ecosystem. Understanding the site's unique topography, climate conditions, and accessibility is crucial for informing thoughtful design decisions and sustainable development practices at the Piyungan Landfill.

In addition to its geographical and climatic characteristics, further site analysis of the Piyungan Landfill reveals recent improvements and initiatives aimed at mitigating environmental impacts and enhancing waste management practices. Supported by initiatives such as Indonesia's Green Sukuk program, the landfill has undergone significant transformations to become less odorous, better organized, and less prone to fires. These efforts include the implementation of advanced waste management systems, such as landfill gas capture and utilization, as well as the establishment of proper waste segregation and recycling facilities.

Additionally, enhanced operational procedures and community engagement initiatives have contributed to improved waste collection and disposal practices, reducing the landfill's overall environmental footprint. By considering these recent developments and ongoing efforts, designers can integrate sustainable design principles and best practices into future interventions at the Piyungan Landfill site, fostering environmental resilience and community well-being in the region.

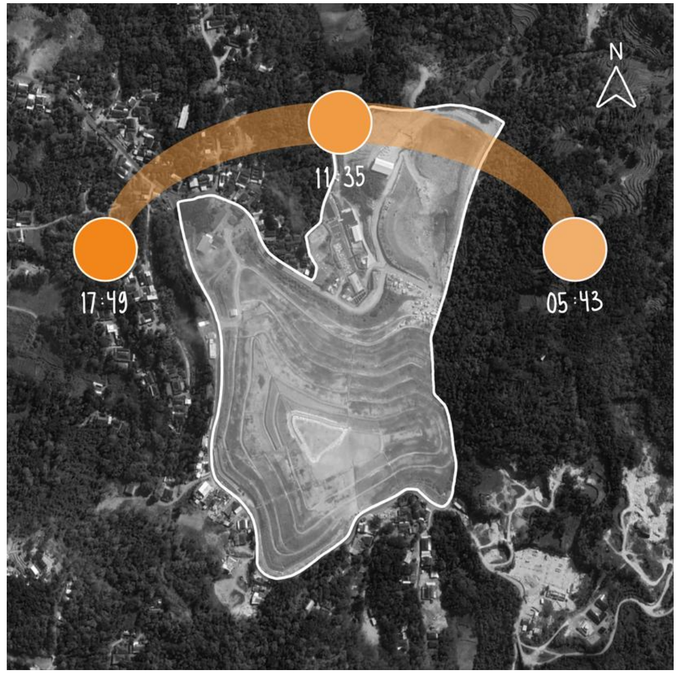






climate analysis

SUN PATH ANALYSIS



BUILDING

The architectural design of the building prioritizes optimal orientation to maximize natural daylighting and minimize solar heat gain. The building is ideally oriented with the main façade facing north or slightly northeast to capture diffused morning light and reduce direct sun exposure during peak hours. This orientation strategy effectively lowers energy consumption for cooling and lighting throughout the day. To complement this, appropriately sized roof overhangs and shading devices are integrated on windows facing east, south, and west to mitigate solar heat gain during midday, thereby reducing cooling loads and maintaining indoor comfort. Adjustable shading elements provide flexibility in controlling sunlight penetration based on time of day.

Natural ventilation and passive cooling strategies are integral to the building's design. Cross ventilation facilitated by openings on opposite sides and operable windows promotes airflow, facilitating the release of warm air and enhancing comfort without heavy reliance on mechanical cooling systems. Interior spaces are designed to maximize daylight penetration while minimizing glare using light shelves, reflective surfaces, and interior glazing.

Daylight-responsive lighting controls adjust artificial lighting levels based on available natural light, reducing energy consumption and enhancing occupant comfort and productivity. Sustainable materials with high thermal mass and insulation properties are utilized to improve building performance, aligning with regenerative principles. Additionally, a green roof atop the building provides insulation, reduces stormwater runoff, and enhances biodiversity, seamlessly integrating the building into its natural surroundings.

In summary, the building's design emphasizes orientation for optimal daylighting and solar heat management, integrates shading and overhangs to mitigate heat gain, and employs natural ventilation and passive cooling strategies. Interior spaces are carefully planned to enhance daylight penetration and reduce artificial lighting needs, while the use of sustainable materials and a green roof further enhances environmental performance and integration with the surrounding habitat sanctuary.

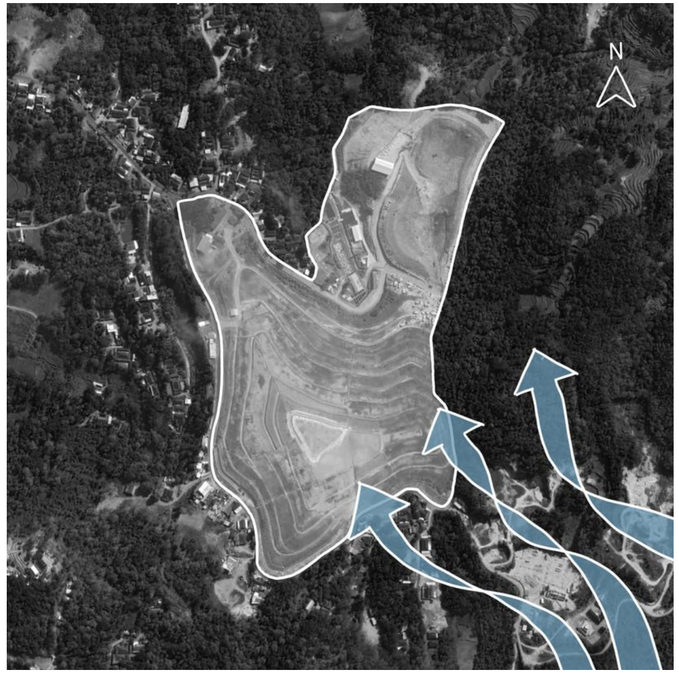
NON-BUILDING

The habitat sanctuary is meticulously planned to harmonize with the site's natural topography and sun path. Vegetation zones are strategically designated based on sunlight exposure, with east-facing slopes designated for species thriving in cooler morning temperatures and west-facing slopes for those resilient to afternoon heat and direct sun. This zoning approach optimizes plant health and ecological balance throughout the day. Natural and artificial shelters are integrated to offer refuge during extreme weather and create microclimates that provide shade and cooler temperatures during peak solar hours. Tree canopies, shrubs, and constructed habitats like rockeries contribute to diverse microhabitats supporting a variety of wildlife species.

Water features are strategically positioned to provide drinking water and habitat for aquatic species, utilizing rainwater harvesting systems to sustain irrigation across vegetation zones. Careful design minimizes sun exposure to reduce evaporation and maintain water quality. Wildlife corridors are designed to connect different vegetation zones, facilitating movement and promoting biodiversity. Vegetated buffers and green bridges ensure safe passage over potential barriers like roads, fostering habitat connectivity essential for ecological resilience. Native plant species are prioritized for their resilience and role in supporting local wildlife, complemented by educational signage to raise awareness about their importance in biodiversity conservation efforts.

A comprehensive monitoring program assesses habitat design effectiveness, tracking vegetation growth, wildlife presence, and water quality. This data informs adaptive management strategies, ensuring ongoing habitat sustainability. Regular maintenance and ecological restoration efforts are prioritized to uphold the sanctuary's long-term health and ecological integrity, reinforcing its role as a model of sustainable habitat management and conservation.

WIND DIRECTION ANALYSIS



BUILDING

The building's orientation is strategically planned to optimize natural ventilation and passive cooling. By aligning with prevailing northwest winds, the design positions main entrances, windows, and openings on the southeast or northeast sides to facilitate cross ventilation. This layout effectively harnesses cool breezes, promoting airflow throughout interior spaces and reducing reliance on mechanical ventilation. Operable windows and vents on both sides of the building further enhance cross ventilation, with louvers or adjustable vents providing control over airflow to maintain comfort even during strong gusts. Internal features like atriums or courtyards are designed as wind catchers, directing airflow into the building for natural cooling.

To mitigate solar heat gain, the design incorporates shading elements such as overhangs, awnings, or vegetated trellises on the west-facing façade. These elements protect against direct sunlight, maintaining comfortable indoor temperatures and minimizing energy consumption for cooling. Sustainable materials with high thermal mass are used for building envelopes to absorb and release heat gradually, enhancing overall thermal comfort and efficiency.

Outdoor spaces are carefully integrated into the design to provide comfortable gathering areas shielded from prevailing winds. Patios, verandas, and other outdoor features are strategically positioned to enhance visitor experience while mitigating wind effects. Landscaping elements such as windbreaks, hedges, and low walls create microclimates that further contribute to visitor comfort and environmental sustainability. Native vegetation is selected for its resilience to local climatic conditions, enhancing the site's natural aesthetics and biodiversity.

In conclusion, the building’s design strategy prioritizes orientation for natural ventilation, integrates passive cooling techniques, utilizes effective shading strategies, and designs outdoor spaces that enhance visitor comfort and environmental sustainability. These elements collectively create a harmonious balance between architectural functionality and ecological responsibility, ensuring a sustainable and enjoyable environment for occupants and visitors alike.

NON-BUILDING

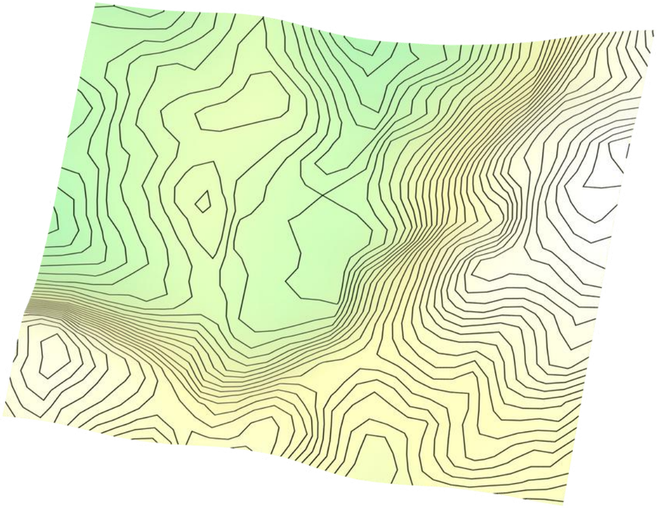
The design of the sanctuary incorporates natural windbreaks strategically placed along the northwest perimeter using vegetation like shrubs, trees, and dense planting. These windbreaks play a crucial role in creating sheltered microclimates within the sanctuary, protecting sensitive plants and offering refuge for wildlife from strong winds. By carefully integrating these natural barriers, the sanctuary enhances its resilience to harsh weather conditions while fostering a more stable habitat environment.

Planting design within the sanctuary is informed by the natural topography and prevailing wind patterns. Plant species are arranged in staggered rows or clusters to form layers of vegetation that effectively slow down and diffuse wind gusts. Taller plants and trees are strategically oriented to block prevailing winds, creating pockets of calm that reduce soil erosion and enhance habitat stability. This thoughtful arrangement not only mitigates the impact of wind but also promotes the establishment of diverse plant communities crucial for supporting local wildlife.

The sanctuary's wildlife habitat design incorporates natural features such as rockeries, brush piles, and log piles strategically placed to provide nesting sites, shelters, and wind protection for various species. Habitat corridors are designed to align with prevailing wind directions, facilitating wildlife movement and ensuring connectivity between different ecological zones. Additionally, water features such as ponds or streams are positioned in sheltered areas or behind windbreaks to minimize wind-driven evaporation and maintain stable water levels. Sustainable irrigation systems, including rainwater harvesting and recycled water, are implemented to support plant growth while preserving the sanctuary's ecological balance.

In summary, the sanctuary's design strategy emphasizes the creation of sheltered microclimates through natural windbreaks, strategic planting orientation, and thoughtful wildlife habitat design. By leveraging the natural landscape and wind dynamics, combined with sustainable water management practices, the sanctuary not only enhances its resilience to environmental stressors but also fosters a diverse and thriving ecosystem beneficial to both wildlife and visitors.

topography analysis



BUILDING

The integration of the building into the hilly terrain begins with embracing natural slopes and contours, minimizing excavation and disturbance while optimizing views and exposure to sunlight and prevailing winds. Strategic positioning enhances accessibility and reduces the need for extensive grading, preserving the natural landscape. The building's design focuses on flexibility and adaptation, employing terraced or stepped forms that follow the slope, blending harmoniously with the hillside. This approach not only reduces visual impact but also integrates the structure into its surroundings, offering panoramic vistas that enhance visitor experience and appreciation of the environment.

Sustainable construction techniques play a pivotal role in respecting the hilly terrain and minimizing environmental impact. Local sourcing of materials reduces transportation emissions, while passive solar design principles optimize natural light and heat gain. Green roofs and vegetated walls further enhance insulation and manage stormwater runoff, promoting ecological balance. Accessibility for all visitors is ensured through thoughtfully designed pathways, ramps, and entrances that follow natural contours. Outdoor terraces and viewing platforms at different levels provide resting areas and opportunities for scenic enjoyment, enhancing visitor engagement with the landscape.

Landscape integration focuses on preserving native vegetation and habitat corridors to support biodiversity and maintain ecological connectivity. Existing vegetation is conserved, and educational signage is incorporated to educate visitors about the landscape's significance and promote environmental stewardship. Resilience and adaptation strategies address challenges such as soil erosion, water runoff, and weather extremes inherent to hilly terrains. Erosion control measures, sustainable drainage systems, and resilient building materials are implemented to enhance durability and minimize maintenance, ensuring the building's long-term sustainability and environmental compatibility.

NON-BUILDING

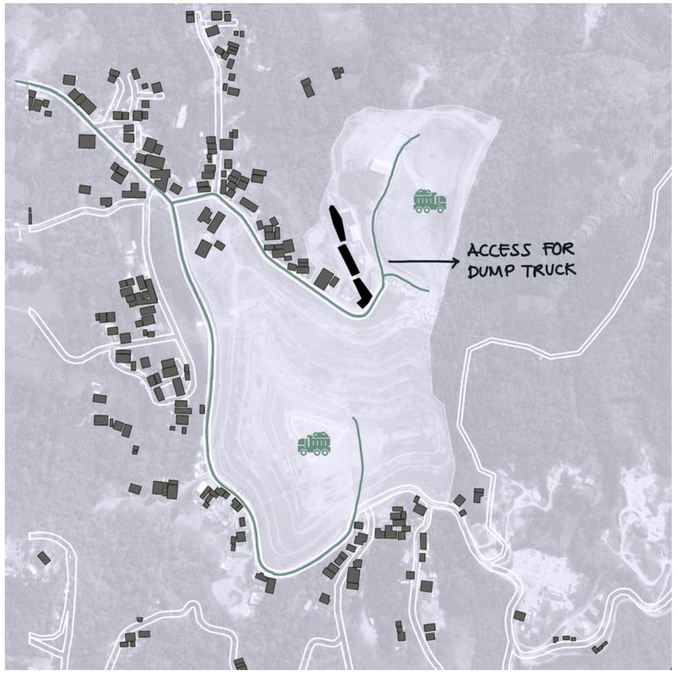
The habitat sanctuary is strategically divided into ecological zones that correspond to different elevations and microclimates shaped by the hilly terrain. Terracing techniques are employed to create level platforms or steps following natural contours, each supporting distinct vegetation and habitats. Lower, shaded terraces accommodate moisture-loving plants, while sun-exposed slopes host drought-tolerant species. This zoning approach optimizes habitat diversity and resilience, enhancing the sanctuary's ecological balance and supporting a variety of wildlife across varying environmental conditions.

To address common challenges of slope instability and erosion in hilly terrains, comprehensive measures are implemented for slope stabilization and erosion control. Techniques such as retaining walls, vegetated buffers, and erosion-control blankets are utilized to minimize soil movement and protect plant root systems. Native grasses, ground covers, and deep-rooted vegetation are strategically planted to anchor soil, enhance stability, and promote biodiversity. These practices not only mitigate erosion but also contribute to the sanctuary's overall ecosystem health and long-term sustainability.

Water management systems are designed to capitalize on the natural topography for rainwater harvesting and distribution. Swales, berms, and contour trenches are employed to capture and redirect runoff, encouraging infiltration and reducing erosion. Small ponds or wetlands in lower-lying areas enhance water retention and provide crucial habitats for amphibians and aquatic species. By integrating these features, the sanctuary fosters ecological resilience while supporting diverse wildlife populations through enhanced water availability and habitat connectivity.

In addition to ecological zoning and water management, the sanctuary incorporates wildlife corridors traversing different elevations to promote genetic diversity and facilitate safe movement across the landscape. Vegetated bridges or tunnels connect ecological zones, ensuring uninterrupted passage for wildlife while offering sheltered resting areas and varied vegetation. Natural and artificial shelters, such as rockeries, brush piles, and strategically placed vegetation, further create microhabitats that provide refuge, nesting sites, and protection from weather extremes for small mammals, birds, and reptiles. These design strategies enhance habitat suitability and ecological functionality, enriching the sanctuary's biodiversity and visitor experience alike.

accessibility

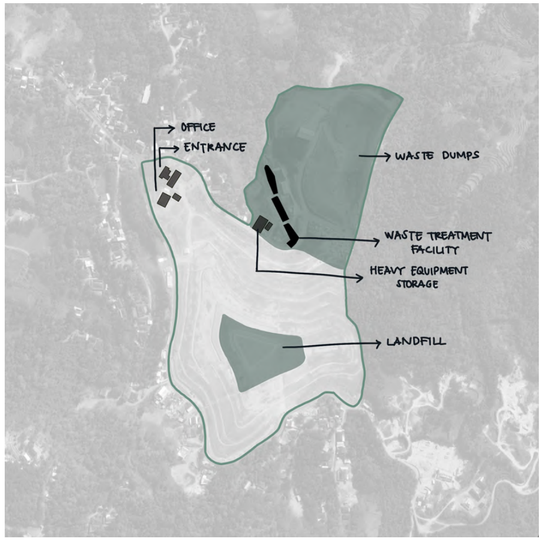


Road

Access for dump trucks

existing conditions

IN-SITU



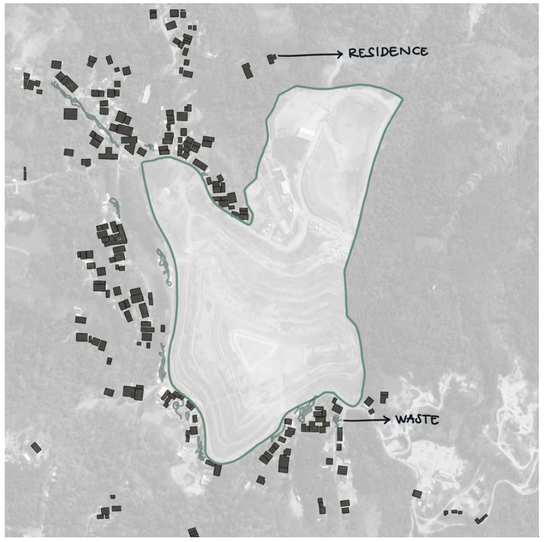
Site boundary

Landfill and waste dumps

Waste treatment facility

Office and heavy equipment storage

EX-SITU

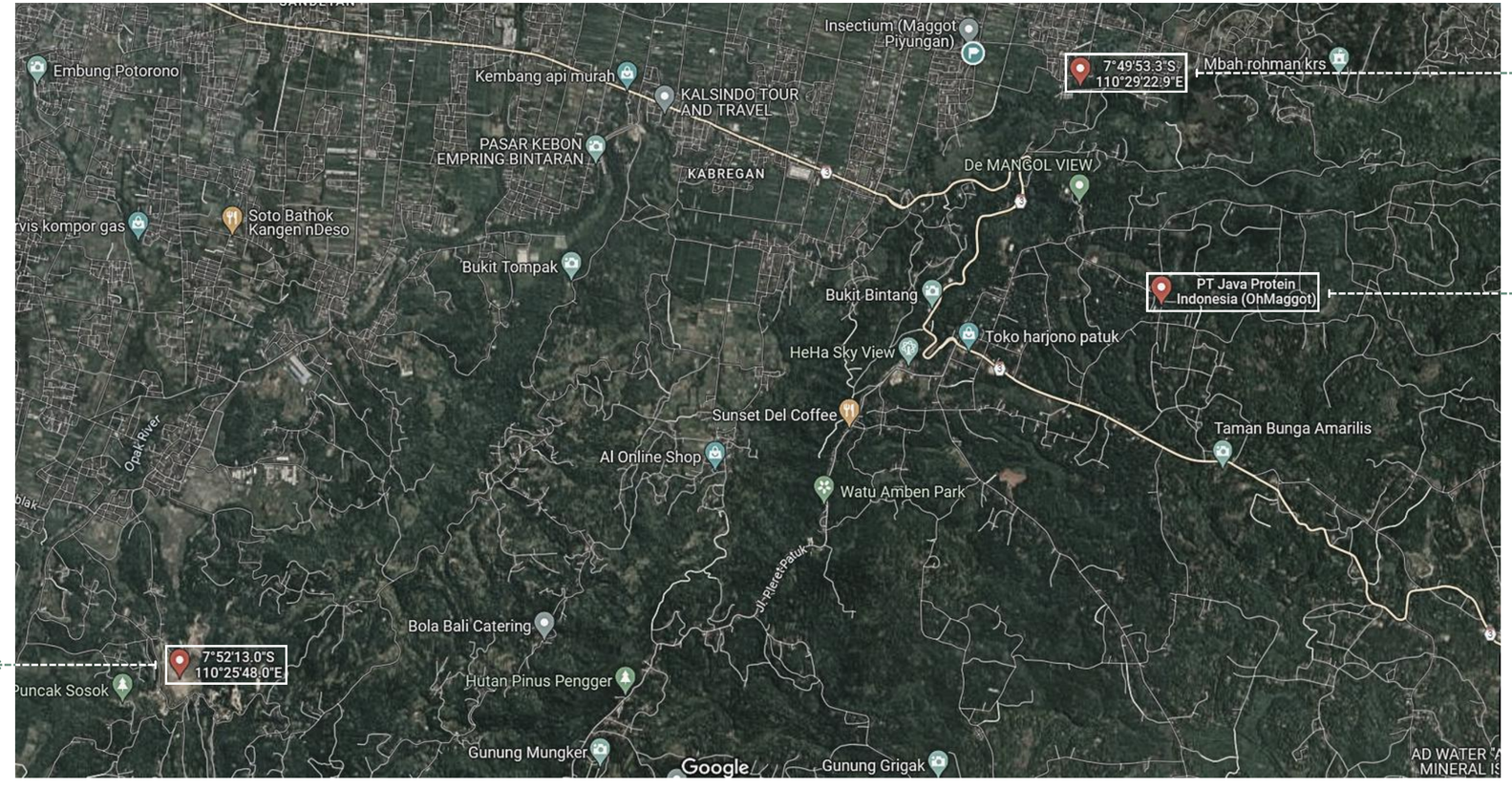


Site boundary

Waste

Residence

site surroundings



PIYUNGAN LANDFILL

TPS3R SRIMARTANI

Waste Processing Facility for Reduce-Reuse-Recycle serves for recyclable waste materials to be sorted, processed, and treated to minimize waste sent to landfills, as well as composting organic waste.

OHMAGGOT

A pioneering maggot business specializing in producing maggot-based products, utilizing organic waste processed as a primary resource for maggot feedstock, fostering a sustainable closed-loop system where waste is transformed into valuable protein-rich feed for livestock. With its innovative methods, OhMaggot showcases the synergy between waste management and agricultural ventures, championing the principles of circular economy and sustainable development.

menjadi berarti OhMaggot

site context *study*

the closure of piyungan landfill

On 23 July 2023, the Piyungan Landfill experienced its first temporary closure, marking the beginning of significant challenges for waste management in Yogyakarta. This closure was a response to environmental concerns and the need to address the growing waste crisis in the region. However, the closure was only temporary, lasting until 5 September 2023, according to the same source.

Subsequently, based on official statements from the Yogyakarta Provincial Government, it was announced that the Piyungan Landfill would be permanently closed in April 2024. This decision came after careful consideration of environmental and public health concerns associated with the landfill's operation.

The closure of the Piyungan Landfill in April 2024 marked a significant turning point in waste management practices in Yogyakarta. One of the primary causes leading to the closure was the environmental degradation and health hazards associated with the landfill's operation. The accumulation of waste resulted in soil and water contamination, air pollution, and the spread of disease vectors, posing significant risks to public health and the environment.

Additionally, the closure was worsened by the increasing volume of waste generated in Yogyakarta, outpacing the landfill's capacity to accommodate it. The unsustainable waste management practices contributed to the landfill's overloading and required the exploration of alternative waste disposal methods.



Source: LPM Himmah UII, 2022

The closure of the Piyungan Landfill had significant effects on waste management operations and the community. It raised immediate concerns about waste disposal and sanitation, as there was no acceptable alternative for managing the large quantities of waste generated daily. The absence of proper waste management infrastructure and practices worsened the waste crisis, leading to overflowing landfills, illegal dumping, and environmental degradation.

In response to the closure, the Yogyakarta Provincial Government announced plans for decentralization in waste management. Decentralization aims to empower local governments and communities to take more active roles in waste management and find localized solutions to waste disposal challenges. This approach involves the development of community-based waste management systems, waste-to-energy initiatives, and the promotion of recycling and composting practices at the local level.









The waste management cycle at the Piyungan Landfill follows several key stages:

WASTE COLLECTION

Waste is collected from households, businesses, and industries within the area served by the Piyungan landfill. Collection may be carried out by municipal waste management services or private waste collection companies.

TRANSPORTATION

Collected waste is transported to the Piyungan landfill site using waste collection vehicles such as trucks or compactors. Proper transportation methods ensure that waste is safely transported to the landfill without causing environmental pollution or health hazards.

DISPOSAL

At the landfill site, waste is disposed of in designated areas according to its type and characteristics. Waste disposal may involve compacting and spreading waste layers to maximize landfill capacity and minimize environmental impact.

COMPACTION AND COVERING

Waste is regularly compacted using heavy machinery to reduce its volume and create space for additional waste deposition. After each layer of waste is deposited, it is covered with soil or other materials to control odor, minimize litter, and prevent the attraction of pests.

LEACHATE AND GAS MANAGEMENT

Landfills generate leachate, a liquid formed by the decomposition of organic waste and rainwater percolating through the waste layers. Leachate is collected and treated to prevent contamination of groundwater and surface water bodies. Additionally, landfills produce landfill gas, primarily methane and carbon dioxide, which is collected and either flared off or utilized as a renewable energy source through landfill gas-to-energy projects.

MONITORING AND MAINTENANCE

The landfill site is regularly monitored to ensure compliance with environmental regulations and to assess potential environmental impacts. Monitoring activities may include groundwater monitoring, surface water monitoring, gas monitoring, and inspections of landfill infrastructure.

CLOSURE AND POST-CLOSURE CARE

Once the landfill reaches its capacity or is no longer in operation, it undergoes closure procedures to minimize environmental risks. Closure measures may include installing final cover systems, grading the landfill slopes, and implementing erosion control measures. Post-closure care involves continued monitoring and maintenance activities to ensure the long-term environmental integrity of the site.









chapter 3

design problem studies

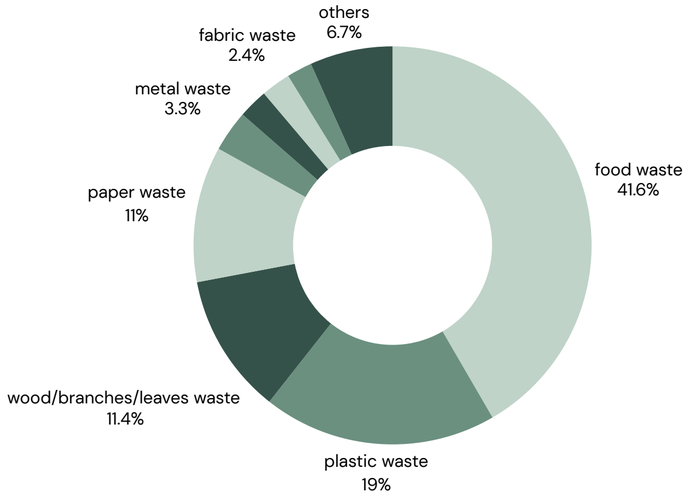
Design Theme Studies
Building Typology & Function Studies
Precedent Studies
Space Requirements

design theme *study*

waste management

Based on “Capaian Kinerja Pengelolaan Sampah” (Ministry of Environment and Forestry, 2023) the total waste generation amounted to 18,081,278.88 tons annually across 112 districts in Indonesia. Of this, a reduction of 16.18% was achieved, equivalent to 2,925,025.53 tons per year, showcasing efforts in waste reduction. Furthermore, waste handling reached 50.74%, managing 9,174,646.60 tons yearly. Managed waste constituted 66.92% of the total, amounting to 12,099,672.13 tons annually, while the remaining 33.08% remained unmanaged, totaling 5,981,606.75 tons per year. These statistics underscore the progress made in waste management practices across Indonesia, highlighting areas of success and opportunities for further improvement nationwide.

The composition of waste based on waste types is as follows: food waste comprises 41.6% of the total, followed by plastic waste at 19%, wood/branches/leaves waste at 11.4%, paper/cardboard waste at 11%, metal waste at 3.3%, glass waste at 2.4%, fabric waste at 2.4%, rubber/leather waste at 2.1%, and other waste types at 6.7%. These statistics provide insights into the distribution of waste materials, highlighting the prevalence of organic waste, plastics, and various other materials in the overall waste stream. Understanding the composition of waste is crucial for implementing effective waste management strategies and promoting recycling and resource recovery initiatives tailored to specific waste types.



FOOD WASTE

In Indonesia, food waste poses significant environmental and economic challenges. According to data, food waste is the largest component of municipal solid waste. The disposal of food waste contributes to greenhouse gas emissions, soil and water pollution, and the depletion of landfill capacity.

PLASTIC WASTE

Plastic waste is a pervasive environmental issue in Indonesia, constituting approximately 19% of the total waste stream. The improper disposal of plastic waste leads to widespread pollution of terrestrial and marine ecosystems, threatening wildlife and human health. Indonesia is one of the world's largest contributors to marine plastic pollution, with plastic debris clogging waterways, contaminating beaches, and harming marine life.

WOOD/BRANCHES/LEAVES WASTE

Organic waste, including wood, branches, and leaves, accounts for 11.4% of Indonesia's waste composition. Improper disposal of green waste can lead to environmental degradation, soil erosion, and habitat destruction.

PAPER WASTE

Paper waste represents 11% of the total waste generated in Indonesia. The disposal of paper waste contributes to deforestation, habitat loss, and air pollution from incineration. Inadequate recycling infrastructure and low recycling rates exacerbate the environmental impacts of paper waste, leading to increased demand for virgin fiber and forest resources.

METAL WASTE

Metal waste accounts for 3.3% of Indonesia's waste composition and presents challenges for waste management and recycling efforts. Improperly disposed metal waste can contaminate soil and water sources, posing risks to human health and the environment. Metal recycling processes may release harmful pollutants if not conducted properly.

GLASS WASTE

Glass waste comprises 2.4% of Indonesia's waste composition and presents challenges for recycling and waste management. Improperly disposed glass waste can pose safety hazards and contribute to environmental pollution, particularly in coastal areas.

FABRIC WASTE

Fabric waste, including textiles and clothing, accounts for 2.4% of Indonesia's waste composition. The disposal of fabric waste contributes to landfill overcrowding and environmental pollution.

RUBBER/LEATHER WASTE

Rubber and leather waste represent 2.1% of Indonesia's waste composition and present challenges for disposal and environmental management.

OTHER WASTE

This category may include inert materials, construction debris, electronic waste, and miscellaneous items, posing challenges for waste management and recycling due to their diverse nature and disposal requirements.

The waste management cycle in Indonesia typically involves several key stages, although the effectiveness and implementation may vary across regions due to differences in infrastructure, regulations, and resources.

WASTE GENERATION

Waste is generated from various sources, including households, businesses, industries, and institutions, contributing to the overall municipal solid waste (MSW) stream. The composition of waste varies, with significant portions being organic material, plastics, paper, and other recyclables. Rapid urbanization and population growth have increased the quantity of waste generated, posing a significant challenge for waste management systems.

COLLECTION

Waste collection is carried out by municipal authorities. Once collected, it is transported from various collection points to transfer stations or disposal sites using a range of methods, including trucks, carts, and informal means of transport. Informal waste collectors, known as "scavengers" or "pemulung," play a crucial role in the collection and sorting of waste, particularly recyclables, which they sell to recycling facilities or middlemen (Sembiring & Nitivattananon, 2010).

RECYCLING AND RECOVERY

Recycling and recovery efforts in Indonesia are limited but growing. Informal waste pickers significantly contribute to collecting recyclable materials from waste streams, which are then sold to recycling facilities or middlemen. These informal activities are crucial for recycling efforts but are often unregulated and lack formal support.

DISPOSAL

Waste disposal in Indonesia primarily involves landfilling, with most waste ending up in open dumps or poorly managed landfills. Proper waste disposal practices, such as landfill lining and leachate management, are often lacking in many areas. These practices lead to environmental pollution, groundwater contamination, and health hazards. Open dumping and uncontrolled landfilling are common due to inadequate infrastructure and funding.

Indonesia's waste management system faces significant challenges, characterized by inadequate infrastructure, limited funding, and poor waste disposal practices. The country struggles with widespread littering, open dumping, and uncontrolled waste accumulation, particularly in urban areas where population density exacerbates the issue. Insufficient waste collection and transportation services contribute to the proliferation of waste in streets, water bodies, and natural environments, posing threats to public health, environmental integrity, and economic development.

Efforts to improve waste management in Indonesia have been underway with varying degrees of success. Public awareness campaigns, led by government agencies, NGOs, and community groups, aim to educate citizens on the importance of responsible waste practices and environmental conservation. Additionally, national and local regulations govern waste management, including laws on waste reduction, recycling, and environmental protection. However, enforcement and compliance with these regulations remain major challenges, limiting their effectiveness in addressing the country's waste management issues.

Waste processing encompasses various methods and technologies for treating and transforming waste materials into reusable resources, energy, or safe final disposal products. Its goals are to minimize the environmental impact of waste, recover valuable materials, and reduce the volume of waste that requires final disposal. Key aspects of waste processing include several critical components.

RECYCLING

Recycling involves sorting and processing waste materials to extract and purify valuable components such as metals, plastics, paper, and glass. This process, known as material recovery, allows these materials to be reused rather than discarded. Once recovered, these materials can be remanufactured into new products. For example, recycled plastics can be made into new containers, and recycled paper can become new paper products. Recycling not only conserves natural resources but also reduces the environmental impact of waste disposal (Tchobanoglous & Kreith, 2002).

ANAEROBIC DIGESTION

Anaerobic digestion involves the breakdown of organic waste by microorganisms in the absence of oxygen. This process produces biogas, a mixture of methane and carbon dioxide, and digestate, a nutrient-rich byproduct. Biogas can be used as a renewable energy source for electricity, heating, and vehicle fuel, while digestate can be used as a fertilizer. Anaerobic digestion not only provides a sustainable way to manage organic waste but also contributes to renewable energy production (Weiland, 2010).

COMPOSTING

Composting is the aerobic decomposition of organic waste, such as food scraps and yard waste, by microorganisms in the presence of oxygen. This process produces compost, a nutrient-rich soil amendment that can be used in agriculture, gardening, landscaping, and soil restoration. Composting helps reduce the volume of organic waste that ends up in landfills, thereby minimizing methane emissions from anaerobic decomposition in landfills and contributing to soil health (Diaz et al., 2007).

INCINERATION

Incineration is the process of burning waste at high temperatures to reduce its volume and produce energy in the form of heat and electricity. While incineration can significantly decrease the amount of waste that needs to be landfilled, it also produces ash, which must be managed and disposed of safely. Additionally, emissions from incineration must be controlled to meet environmental standards, making it a method that requires careful regulation and advanced technology (Niessen, 2010).

CHEMICAL TREATMENT

Chemical treatment is used to neutralize or detoxify hazardous waste, making it safer for disposal or further processing. This method involves the use of chemicals to transform harmful substances into less dangerous ones. Chemical treatment is commonly applied to industrial waste, medical waste, and contaminated soils, helping to mitigate the risks associated with hazardous materials and ensuring that they do not pose a threat to human health or the environment (LaGrega et al., 2010).

MECHANICAL BIOLOGICAL TREATMENT (MBT)

Mechanical biological treatment (MBT) involves two main stages. First, waste undergoes mechanical processing to separate recyclables and reduce the size of waste materials. Then, the organic fraction of the waste undergoes biological treatment, such as composting or anaerobic digestion, to stabilize and reduce its volume. MBT is an integrated approach that enhances resource recovery and minimizes the amount of waste sent to landfills (Velis et al., 2009).

LANDFILL GAS RECOVERY

Landfills equipped with gas collection systems can capture methane and other gases produced by the decomposition of organic waste. This process, known as landfill gas recovery, allows these gases to be used to generate electricity or heat, reducing greenhouse gas emissions. By harnessing landfill gas, waste management facilities can mitigate the environmental impact of landfills and contribute to renewable energy production (Bogner et al., 2008).

THERMAL TREATMENT

Thermal treatment methods, such as pyrolysis and gasification, involve heating waste at high temperatures in the absence or presence of limited oxygen. Pyrolysis breaks waste down into gases, liquids, and solid residues, which can be used as fuel or chemical feedstocks. Gasification partially oxidizes waste to produce syngas, a mixture of hydrogen and carbon monoxide, which can be used for energy production or as a chemical feedstock. These methods offer a way to convert waste into valuable resources while reducing its volume (Arena, 2012).

E-WASTE PROCESSING

Electronic waste (e-waste) processing involves dismantling and recycling electronic devices to recover valuable components such as metals, plastics, and rare earth elements. Hazardous materials, such as lead and mercury, are safely removed and treated to prevent environmental contamination. Proper e-waste processing not only recovers valuable resources but also ensures that toxic substances do not harm the environment or human health (Widmer et al., 2005).

Effective waste management is a critical component of sustainable development, addressing the pressing need to manage the increasing amounts of waste generated by urbanization, industrialization, and population growth. Traditional methods of waste disposal, such as open dumping and poorly managed landfills, pose significant risks to public health and the environment, contributing to pollution, greenhouse gas emissions, and resource depletion. In response to these challenges, innovative waste management strategies have been developed to minimize waste, recover valuable resources, and mitigate environmental impacts.

Among these strategies, the 3R approach—Reduce, Reuse, Recycle—forms the cornerstone of sustainable waste management practices. This hierarchy prioritizes waste reduction at the source, promotes the reuse of materials, and enhances recycling efforts to convert waste into new products. Additionally, emerging solutions like maggot farming leverage biological processes to efficiently manage organic waste, converting it into valuable resources for agriculture and animal feed.

These strategies, supported by policy frameworks, technological innovation, and community engagement, are essential for creating resilient and sustainable waste management systems. By integrating these approaches, societies can reduce the environmental footprint of waste, recover valuable materials, and move towards a circular economy where waste is viewed as a resource rather than a burden.

MAGGOT FARMING FOR CIRCULAR ECONOMY

Maggot farming involves using black soldier fly larvae (BSFL) to decompose organic waste. The larvae can convert organic waste into high-quality protein and fat, which can be used as animal feed, and their frass (waste) can be used as fertilizer.

Application in the design:

- Maggot Farming Facility

Establishing a dedicated area for maggot farming where organic waste from the community and facility is processed.

- Community Integration

Educating and involving the local community in maggot farming, providing them with training and resources to set up small-scale maggot farms at home.

- Byproduct Utilization

Using the protein-rich larvae as feed for livestock or fish farming and the frass as a nutrient-rich organic fertilizer for agricultural gardens and green spaces.

ZERO WASTE INITIATIVES

Zero waste initiatives aim to eliminate waste by redesigning products and processes to ensure that all materials are reused or recycled back into the system.

Application in the design:

- Zero Waste Policy

Adopting a zero-waste policy for the facility, aiming to minimize waste generation and maximize recycling and reuse.

- Community Programs

Developing community programs to promote zero-waste practices, such as repair cafes, swap shops, and upcycling workshops.

- Product Design

Encouraging and supporting the design of products that are easy to disassemble, repair, and recycle.

COMPOSTING AND VERMICULTURE

Composting is the process of decomposing organic matter into nutrient-rich soil amendments. Vermiculture uses earthworms to enhance the composting process, producing high-quality vermicompost.

Application in the design:

- Community Composting Stations

Setting up composting stations where community members can bring their organic waste. Incorporating vermiculture to improve compost quality.

- Educational Programs

Implementing educational programs to teach residents and visitors about composting and its benefits.

- Soil Enrichment

Using the produced compost and vermicompost to enrich soil in agricultural gardens, botanical gardens, and other green spaces within the facility.

UPCYCLING AND CREATIVE REUSE

Upcycling involves transforming waste materials into new, higher-value products, extending the life cycle of materials and reducing waste.

Application in the design:

- Upcycling Workshops

Creating workshops where community members can learn to upcycle materials into useful or artistic items.

- Facility Integration

Using upcycled materials in the construction and decoration of the facility, such as furniture, art installations, and landscaping elements.

- Market Development

Supporting local artisans and entrepreneurs who use upcycled materials in their products.

habitat restoration and conservation

Habitat restoration and conservation are critical efforts aimed at repairing damaged ecosystems and protecting biodiversity. These practices ensure the survival of various species, maintain ecological balance, and provide essential services to humans and the environment.

Key principles of habitat restoration and conservation:

LAND RESTORATION

Land restoration focuses on reclaiming and rehabilitating degraded or contaminated lands to restore their ecological functions and values.

Application in the design:

- Soil Remediation

Implementing techniques such as phytoremediation, bioremediation, and soil amendments to remove contaminants and restore soil health. This is essential for supporting plant growth and creating a stable foundation for habitats.

- Regrading and Stabilization

Reshaping the land to prevent erosion and stabilize slopes, creating suitable conditions for plant and animal life.

- Hydrological Restoration

Restoring natural water flow patterns by removing barriers, re-establishing wetlands, and improving drainage systems to enhance water availability and quality.

ANIMAL HABITAT RESTORATION

This involves creating and enhancing habitats to support wildlife populations, ensuring they have the resources needed for survival and reproduction.

Application in the design:

- Habitat Creation and Enhancement

Designing and implementing habitats such as wetlands, grasslands, forests, and aquatic systems tailored to the needs of specific animal species. Including features like nesting boxes, ponds, and shelter areas.

- Corridors and Connectivity

Establishing wildlife corridors that connect fragmented habitats, allowing animals to move freely and safely between different areas. This is crucial for genetic diversity and species migration.

- Species Reintroduction

Reintroducing native species that have been extirpated from the area, following careful planning and monitoring to ensure their successful adaptation and survival.

PLANT CONSERVATION AND RESTORATION

Plant conservation and restoration aim to protect native plant species, reintroduce vegetation, and create diverse plant communities that support overall ecosystem health.

Application in the design:

- Native Plant Reintroduction

Using native plant species in restoration projects to ensure ecological compatibility and support local wildlife. Native plants are adapted to local conditions and provide essential resources for native animals.

- Invasive Species Management

Identifying and controlling invasive plant species that threaten native biodiversity through mechanical removal, chemical treatment, or biological control methods.

- Seed Banks and Nurseries

Establishing seed banks and nurseries to propagate and preserve native plant species, ensuring a steady supply of plants for restoration efforts.

ENVIRONMENTAL IMPROVEMENT

This principle focuses on enhancing the overall environment to support ecosystem functions and human well-being.

Application in the design:

- Water Quality Improvement

Implementing measures such as constructed wetlands, vegetative buffers, and natural filtration systems to improve water quality by removing pollutants and enhancing aquatic habitats.

- Air Quality Enhancement

Increasing vegetation cover through afforestation and urban greening to sequester carbon, produce oxygen, and filter air pollutants.

- Climate Resilience

Designing restoration projects with climate change in mind, selecting species and strategies that enhance ecosystem resilience to changing climate conditions, such as increased temperatures, altered precipitation patterns, and extreme weather events.

regenerative architecture

Regenerative architecture goes beyond sustainability by not only aiming to minimize environmental impact but also actively seeking to restore and regenerate the natural environment. It involves designing buildings and spaces that contribute positively to the ecosystem, support biodiversity, enhance social well-being, and create resilient communities. The ultimate goal of regenerative architecture is to create systems that are harmonious with nature, promoting a regenerative cycle of use, reuse, and renewal.

Key principles of regenerative architecture:

ECOLOGICAL RESTORATION

A core principle of regenerative architecture is ecological restoration, which involves actively restoring and enhancing degraded ecosystems through design interventions. This principle focuses on repairing damage caused by past human activities and supporting the recovery of natural habitats and biodiversity.

Application in the design:

- Restoration of Landfill Areas

Converting the existing landfill areas into green spaces, such as parks, habitat sanctuaries, and botanical gardens. Using native plant species to restore local biodiversity and create habitats for wildlife.

- Soil Remediation

Implementing soil remediation techniques to remove contaminants and restore soil health, making the land suitable for vegetation and wildlife.

CLOSED-LOOP SYSTEMS

Instead of relying on a linear model of resource extraction and waste production, regenerative architecture aims to create closed-loop systems where resources are reused and recycled. This principle involves designing systems where the outputs of one process become the inputs for another, minimizing waste and maximizing resource efficiency.

Application in the design:

- Waste to Energy and Water Treatment Integration

Designing the waste management facility to convert waste into energy and treat wastewater, ensuring that the outputs of these processes (energy and clean water) are reused within the facility or the community.

- Use of Recycled Waste as Building Material

Incorporating construction materials made from recycled waste into the design of the buildings and infrastructure, promoting the reuse of waste materials within the project.

- Nutrient Cycling

Using the byproducts of the waste treatment processes, such as compost from organic waste and treated sludge, to fertilize agricultural gardens and green spaces.

INTEGRATION WITH NATURE

Regenerative architecture emphasizes the harmonious integration of buildings and landscapes into their natural surroundings. This principle involves designing in a way that enhances the natural environment, rather than depleting it. Buildings are designed to work with natural processes, such as water flow, solar energy, and natural ventilation, to reduce energy consumption and enhance the ecological health of the site.

Application in the design:

- Restoration of Landfill to Green Area and Habitat Sanctuary

Transforming the areas currently filled with waste into vibrant green spaces. This includes creating habitat sanctuaries for local wildlife, agricultural gardens, botanical gardens, and aviaries. Using techniques such as phytoremediation to clean contaminated soils and reintroduce native plant species to restore ecological balance.

- Natural Water Management

Designing wetlands to naturally treat wastewater, manage stormwater, and provide habitats for aquatic species. Using permeable surfaces and bioswales to enhance groundwater recharge and reduce flooding.

COMMUNITY ENGAGEMENT

Regenerative architecture emphasizes the importance of engaging with local communities and stakeholders throughout the design and implementation process. This principle ensures that projects are responsive to the needs and aspirations of the people who will use and be affected by them, fostering a sense of ownership and stewardship.

Application in the design:

- Educational and Recreational Facilities

Developing a sustainability hub with educational exhibits about waste management, renewable energy, and biodiversity. Creating recreational areas such as parks and gardens that encourage community use and engagement.

- Participatory Design Workshops

Involving the local community in the planning and design process through workshops and public meetings to gather input and ensure the project meets local needs and values.

ADAPTABILITY AND RESILIENCE

Buildings and communities designed with regenerative principles are adaptable and resilient, capable of responding to changing environmental conditions and potential disruptions. This principle involves designing structures that can evolve over time, incorporating flexibility in use and function to accommodate future needs and challenges.

Application in the design:

- Flexible Spaces

Designing buildings and spaces that can be easily adapted for different uses over time, ensuring long-term viability and usefulness.

- Resilient Construction

Using pre-processed and stabilized waste materials like recycled aggregates and geopolymer concrete to provide structural integrity and durability, and implement advanced waste management systems to control and neutralize environmental hazards such as gasses and leachates. Additionally, incorporating proper ventilation, insulation, and biofiltration systems to maintain indoor air quality and mitigate any residual odors.

typology *study*

landfill

A landfill is a designated site for the disposal of waste materials by burial. It is the oldest and most common method of waste management, designed to minimize environmental impacts by isolating waste from the surrounding environment, particularly groundwater. Modern landfills are engineered to manage waste effectively and safely, incorporating systems for waste containment, leachate management, gas collection, and environmental monitoring.

Functions:

WASTE CONTAINMENT AND LINER SYSTEMS

The primary function of a landfill is to contain waste in a manner that prevents contamination of the surrounding environment. This is achieved through a system of layers, including a bottom liner made of clay or synthetic materials to prevent leachate from seeping into the ground. The liner system is crucial for protecting groundwater and soil from potential pollutants.

LEACHATE COLLECTION AND TREATMENT

Leachate is the liquid that percolates through waste material, potentially carrying harmful substances. Modern landfills are equipped with leachate collection systems, which consist of pipes and drainage layers above the liner to capture and divert leachate to treatment facilities. This system is essential for preventing groundwater contamination and managing wastewater effectively.



GAS COLLECTION AND MANAGEMENT

As waste decomposes, it produces landfill gas, primarily composed of methane and carbon dioxide. Landfills incorporate gas collection systems, which involve a network of pipes that collect gas and transport it to a processing or flaring system. Proper gas management helps reduce greenhouse gas emissions and can even provide a source of renewable energy when the gas is utilized for power generation.

COVER AND CAPPING SYSTEMS

To minimize odor, pests, and exposure to the elements, landfills use daily cover materials such as soil or synthetic tarps. Upon reaching capacity, a final capping system is applied, consisting of multiple layers designed to seal the landfill and promote surface water runoff. The cap also supports vegetation, which can aid in erosion control and enhance the site's visual appeal.

ENVIRONMENTAL MONITORING AND CONTROL

Continuous environmental monitoring is critical to ensure the landfill operates safely. This includes monitoring groundwater, surface water, air quality, and landfill gas emissions. Monitoring systems are strategically placed around the landfill to detect any potential environmental impacts, allowing for prompt corrective actions if necessary.

Key points for architectural design:

SITE PLANNING AND LAYOUT

Optimize the site planning and layout to ensure efficient waste management operations and minimize environmental impact. Design access roads, waste deposition areas, and functional zone

AESTHETIC AND COMMUNITY INTEGRATION

Integrate the landfill into the surrounding environment aesthetically and functionally. Employ landscaping strategies, natural barriers, and architectural treatments to mitigate visual impact and improve community acceptance. Design administrative and public spaces that blend harmoniously with the landscape.

SUSTAINABILITY AND ENVIRONMENTAL DESIGN

Incorporate sustainable design principles to minimize the landfill's environmental footprint. Utilize eco-friendly materials, design energy-efficient buildings, and integrate renewable energy sources where feasible. Focus on water management, erosion control, and habitat restoration to enhance environmental stewardship.

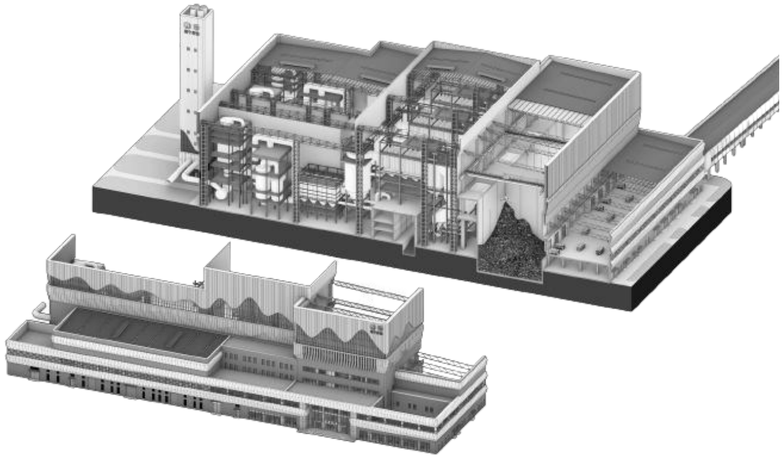
PUBLIC ENGAGEMENT AND EDUCATIONAL FACILITIES

Create engaging spaces for public interaction and education within the landfill site. Design visitor centers, observation points, and educational trails that inform visitors about waste management practices, environmental conservation, and the role of the landfill in the community. Foster positive community relations through accessible and informative architectural interventions.

waste-to-energy plant

Waste-to-energy (WTE) plants are advanced facilities designed to convert municipal solid waste into usable forms of energy, such as electricity and heat, through processes like incineration, gasification, and anaerobic digestion. These plants play a crucial role in modern waste management by reducing the volume of waste that ends up in landfills while simultaneously generating renewable energy. Moreover, waste-to-energy plants contribute significantly to reducing greenhouse gas emissions. By diverting waste from landfills, these plants minimize methane emissions, a potent greenhouse gas released during the decomposition of organic waste in landfills. Additionally, the energy generated from WTE plants can offset the use of fossil fuels, further lowering the overall carbon footprint. Besides environmental benefits, WTE plants provide a reliable and local source of energy, enhancing energy security and supporting local economies. Through their multifaceted roles, waste-to-energy plants not only manage waste efficiently but also contribute to sustainable energy solutions, making them vital for advancing environmental sustainability and combating climate change.

Key processes:
1. Incineration (Burning waste at high temperatures to produce heat, which is then used to generate electricity)
2. Gasification (Converting waste into syngas (synthetic gas) through a controlled process involving heat, oxygen, and steam)
3. Pyrolysis (Decomposing organic waste materials at high temperatures in the absence of oxygen to produce oil, gas, and char)
4. Anaerobic Digestion (Breaking down organic waste through microbial processes in the absence of oxygen to produce biogas)



Functions:

RECEPTION AND PRE-TREATMENT AREA

The reception and pre-treatment area of a waste-to-energy (WtE) plant is where waste is delivered, sorted, and prepared for processing. This area requires a design that accommodates heavy vehicular access, large storage spaces, and efficient sorting mechanisms. Odor control is crucial to prevent unpleasant smells from affecting the surrounding area. Architects must integrate this facility with existing infrastructure, ensuring smooth logistics and minimal disruption to the local environment.

COMBUSTION OR PROCESSING AREA

The combustion or processing area is the core of the WtE plant, where waste undergoes incineration, gasification, or anaerobic digestion to convert it into energy. This section demands high-temperature resistant materials, effective ventilation systems for heat and fumes, and robust safety measures. The structural design must support heavy machinery and withstand high operational stress, ensuring safety and efficiency in the energy conversion process.

ENERGY RECOVERY AREA

In the energy recovery area, turbines, generators, and heat exchangers convert the heat or gas produced from waste processing into usable electricity or other forms of energy. Architectural considerations include providing ample space for large equipment, implementing noise reduction measures, and designing maintenance-friendly layouts. Ensuring efficient energy transfer and minimizing losses are key goals in this part of the plant.

EMISSION CONTROL SYSTEMS

Emission control systems are critical for minimizing the environmental impact of WtE plants. This area includes scrubbers, filters, and other technologies designed to control and reduce emissions from the combustion process. Architects must integrate tall stacks and allocate space for pollution control equipment, ensuring the plant complies with stringent environmental regulations while minimizing its ecological footprint.

ADMINISTRATIVE AND CONTROL BUILDINGS

The administrative and control buildings house offices, control rooms, laboratories, and staff facilities. Architects should focus on creating comfortable and functional workspaces, incorporating modern control systems, and providing amenities for staff. These buildings should facilitate efficient management and monitoring of plant operations, contributing to overall productivity and safety.

STORAGE AND TRANSPORT

Storage and transport facilities are essential for handling waste, ash, and other by-products. These areas require durable flooring, easy access for transport vehicles, and efficient waste flow management. Architects must design these spaces to ensure seamless operations, minimizing downtime and optimizing the handling and transfer of materials within the plant.

Key points for architectural design:

SITE PLANNING AND LAYOUT

Effective site planning and layout are crucial for the smooth operation of a WtE plant. The design will integrate the plant seamlessly within the local environment and infrastructure. This includes considering access routes for waste delivery and by-product removal, ensuring efficient logistics, and positioning buildings to optimize the flow of materials. Proper site planning helps in reducing operational costs and improving overall efficiency.

DESIGN AESTHETICS AND COMMUNITY ACCEPTANCE

The visual impact of a WtE plant is a significant concern for the surrounding community. Designing an aesthetically pleasing facade can help in gaining community acceptance. This involves innovative architectural designs that blend with the local landscape or feature modern, sleek appearances that reduce the industrial look of the plant. Incorporating elements like green walls, vertical gardens, or artistic facades can also enhance the visual appeal.

BUILDING FACADE DESIGN

The design of the building facade plays a critical role in defining the plant's appearance and its integration with the environment. Facade designs will include the use of sustainable materials, energy-efficient glazing, and cladding systems that not only improve aesthetics but also contribute to energy savings. Innovative facade treatments, such as incorporating solar panels or living walls, can highlight the plant's commitment to sustainability and environmental stewardship.

SUSTAINABILITY AND GREEN DESIGN

Sustainability is a core consideration in designing WtE plants. The design will incorporate sustainable building materials, renewable energy sources like solar panels, and green roofs to enhance the plant's environmental performance. Designing with natural light and ventilation in mind can reduce energy consumption, while landscaping can help mitigate the plant's ecological footprint. Emphasizing sustainability can also improve public perception and support for the facility.

FUNCTIONAL DESIGN

Functional design focuses on creating spaces that enhance the workflow and operational efficiency of the WtE plant. While architects may not design the technical interiors, they can influence the layout and connectivity of various plant sections, ensuring easy access and smooth operations. Functional designs should also consider future-proofing, allowing the plant to adapt to technological advancements and changes in waste management practices.

PUBLIC ENGAGEMENT SPACES

Incorporating public engagement spaces, such as visitor centers or educational facilities, can enhance community relations and increase public awareness about waste management and energy production. These spaces can be designed to be welcoming and informative, using interactive displays and educational programs to engage visitors.

wastewater treatment plant

A wastewater treatment plant (WWTP) is a facility designed to treat wastewater from residential, commercial, and industrial sources to remove contaminants and pollutants before releasing the treated effluent back into the environment or reusing it for various purposes. The primary functions of a WWTP include physical, chemical, and biological processes to remove solids, organic matter, nutrients (such as nitrogen and phosphorus), and pathogens from wastewater. This ensures that the discharged water meets environmental and health regulations.

Functions:

TREATMENT PROCESSES AND EQUIPMENT

WWTPs are equipped with various treatment processes and equipment tailored to different stages of wastewater treatment. These include preliminary treatment (screens and grit chambers to remove large solids), primary treatment (settling tanks to remove suspended solids), secondary treatment (biological processes like activated sludge or trickling filters to remove dissolved organic matter), and tertiary treatment (advanced processes like filtration or disinfection to remove remaining contaminants). Each process requires specialized equipment and infrastructure to operate efficiently and effectively.

CONTROL ROOMS AND MONITORING SYSTEMS

Control rooms house the operational control systems and monitoring equipment essential for overseeing the treatment processes. These rooms are equipped with control panels, computers, and sensors that monitor flow rates, chemical dosing, oxygen levels, and other parameters critical to the treatment process. Operators use these systems to adjust process variables and ensure optimal performance of the plant.



CHEMICAL STORAGE AND HANDLING FACILITIES

Chemical storage and handling facilities are integral to WWTPs for storing and dosing chemicals used in the treatment process, such as coagulants, flocculants, disinfectants, and pH adjusters. These facilities include storage tanks, dosing pumps, and safety equipment to handle hazardous chemicals safely. Proper design of these facilities ensures efficient chemical management, minimizes risks to operators, and prevents environmental contamination.

ADMINISTRATIVE AND LABORATORY BUILDINGS

Administrative buildings accommodate offices, meeting rooms, and staff facilities for administrative and managerial personnel overseeing plant operations. Laboratory buildings house analytical laboratories where water quality tests are conducted to monitor effluent quality and ensure compliance with regulatory standards. These buildings are designed to provide comfortable and functional workspaces for staff involved in plant management and operations.

MAINTENANCE AND WORKSHOP AREAS

Maintenance and workshop areas are essential for performing routine maintenance, repairs, and equipment servicing within the WWTP. These areas include workshops equipped with tools, spare parts storage, and maintenance bays for servicing pumps, motors, and other mechanical equipment. Well-designed maintenance areas support efficient plant operation, prolong equipment lifespan, and ensure timely response to maintenance needs.

Key points for architectural design:

INTEGRATION OF TREATMENT PROCESSES

Effective architectural design involves integrating treatment processes into a coherent and efficient layout that facilitates the flow of wastewater through different stages of treatment. This includes designing clear pathways for wastewater flow, optimizing the spatial arrangement of treatment units to minimize piping lengths and operational inefficiencies, and ensuring accessibility for maintenance and operation personnel throughout the plant.

SAFETY AND ERGONOMICS

Architectural design plays a crucial role in ensuring safety and ergonomics within the WWTP environment. This includes designing buildings and pathways with clear signage, adequate lighting, and non-slip surfaces to minimize hazards and promote safe movement for personnel. Ergonomic considerations involve designing control rooms and workstation layouts that support comfortable and efficient operation, reducing operator fatigue and enhancing productivity.

ENVIRONMENTAL CONSIDERATIONS

Architects contribute to minimizing the environmental impact of WWTPs through sustainable design practices. This includes incorporating energy-efficient building materials and systems, designing for natural ventilation and lighting to reduce energy consumption, and integrating renewable energy sources like solar panels or wind turbines. Designing landscapes with native vegetation and green spaces can enhance biodiversity and provide natural habitats within the WWTP site.

COMMUNITY INTEGRATION AND AESTHETICS

Architectural design can enhance community acceptance of WWTPs by integrating aesthetic considerations and mitigating visual and odor impacts. This involves designing buildings with architectural features that blend harmoniously with the surrounding landscape or urban context, using screening and landscaping to conceal treatment units from public view, and implementing odor control measures to minimize nuisance odors.

FUTURE-PROOFING AND FLEXIBILITY

Designing WWTPs with future-proofing in mind involves creating flexible layouts and infrastructure that can accommodate technological advancements and changes in treatment processes. This includes designing modular buildings and adaptable spaces that can easily accommodate upgrades or expansions, ensuring the WWTP remains efficient and responsive to evolving regulatory requirements and community needs.

wetlands

In the context of waste treatment, constructed wetlands are engineered systems designed to mimic the natural processes of wetlands to treat wastewater or manage certain types of waste. These systems utilize wetland vegetation, soil, and microorganisms to remove pollutants and improve water quality. Constructed wetlands can be used for treating domestic sewage, agricultural runoff, industrial effluents, and even landfill leachate. They function through physical, chemical, and biological processes, where plants and microorganisms uptake nutrients, sedimentation removes solids, and microbial activity degrades organic matter, ultimately purifying water before it enters natural water bodies or recharges groundwater.

Functions:

TREATMENT CELLS AND PONDS

Constructed wetlands typically consist of treatment cells or ponds arranged in series or parallel flow configurations. Each cell is designed to facilitate specific treatment processes, such as sedimentation, filtration, adsorption, and microbial degradation of contaminants. Ponds may vary in depth and surface area to accommodate different flow rates and retention times, optimizing treatment efficiency.

VEGETATION AND ROOT ZONES

Vegetation plays a crucial role in constructed wetlands by providing habitat for beneficial microorganisms and promoting nutrient uptake. Plants such as cattails, reeds, and bulrushes are commonly used for their ability to absorb nutrients and pollutants from water through their roots. Architectural design focuses on selecting appropriate vegetation species and designing planting zones to maximize pollutant removal and enhance the ecological functions of the wetland.



SUBSTRATE AND MEDIA

The substrate or media within constructed wetlands provides support for plant growth and microbial activity while enhancing treatment efficiency. Common substrates include gravel, sand, and organic materials that provide surface area for microbial colonization and facilitate physical filtration and chemical adsorption of contaminants. Architectural design involves selecting and arranging substrate materials to optimize hydraulic conductivity, nutrient retention, and pollutant removal capacity within the wetland.

HYDRAULIC STRUCTURES AND FLOW CONTROL

Hydraulic structures such as weirs, baffles, and inlet/outlet structures are essential for controlling water flow and distribution within constructed wetlands. These structures regulate hydraulic retention times, maintain optimal water levels, and prevent short-circuiting of wastewater flow through the wetland. Architectural design focuses on designing robust and efficient hydraulic systems that ensure uniform distribution of wastewater across treatment cells while minimizing energy consumption and operational costs.

MONITORING AND CONTROL FACILITIES

Constructed wetlands require monitoring and control facilities to oversee treatment processes, water quality parameters, and operational conditions. Monitoring stations equipped with sensors and data acquisition systems measure parameters such as dissolved oxygen, pH, temperature, and nutrient concentrations. Architectural design includes designing accessible and secure facilities for housing monitoring equipment, control panels, and operator workstations to ensure accurate data collection, analysis, and decision-making for optimizing wetland performance.

Key points for architectural design:

INTEGRATION WITH SURROUNDING ENVIRONMENT

Architectural design integrates constructed wetlands seamlessly into the surrounding landscape and urban fabric. This includes selecting site locations that optimize natural topography and drainage patterns, using native vegetation for ecological enhancement, and incorporating landscape features like trails and observation points that engage and educate the community about wetland functions and benefits.

SUSTAINABLE AND RESILIENT DESIGN PRACTICES

Designing for sustainability involves implementing green building strategies and minimizing environmental impacts. Architects incorporate energy-efficient building materials, passive heating and cooling systems, and renewable energy technologies like solar panels. Sustainable design enhances the ecological integrity of constructed wetlands while reducing operational costs and promoting long-term environmental stewardship.

COMMUNITY ENGAGEMENT AND EDUCATION

Architectural design enhances community acceptance and involvement in wetland projects by creating visitor centers, interpretive displays, and educational facilities within or adjacent to the site. These spaces provide opportunities for public engagement, environmental education, and recreational activities, fostering community stewardship and appreciation for wetland ecosystems.

FLEXIBILITY AND ADAPTABILITY

Designing for flexibility allows constructed wetlands to accommodate future modifications and improvements. This approach ensures that constructed wetlands remain effective, efficient, and resilient over time, adapting to evolving environmental conditions and regulatory requirements.

precedent *study*

wasit natural reserve visitor centre

HABITAT CREATION

Just as it focused on creating habitats for local flora and fauna, the transformation of Piyungan Landfill can involve the establishment of diverse habitats suitable for native species. This may include the creation of wetlands, forests, grasslands, and other ecosystems that support biodiversity.

MONITORING AND RESEARCH

Integrating facilities for wildlife monitoring and research within the nature reserve allows for the systematic study of ecological processes and species dynamics. Continuous monitoring enables adaptive management strategies to be implemented, ensuring the effectiveness of restoration efforts and the long-term resilience of the ecosystem.

WETLAND RESTORATION

If feasible, restoring wetland ecosystems within Piyungan Landfill can enhance biodiversity and ecosystem services. Implementing sustainable water management practices and creating artificial wetlands can attract water-dependent species and improve overall habitat quality.

NATIVE PLANT PROPAGATION

Establishing native plant nurseries on-site can provide a sustainable source of vegetation for habitat restoration efforts. By propagating indigenous plant species adapted to local conditions, the nature reserve can support ecosystem regeneration and enhance landscape aesthetics.



INTERPRETIVE TRAILS

Developing interpretive trails and boardwalks throughout the reserve allows visitors to explore the diverse habitats and learn about local flora and fauna. Interpretive signage and educational exhibits along the trails provide opportunities for environmental education and awareness.

SUSTAINABLE DESIGN PRACTICES

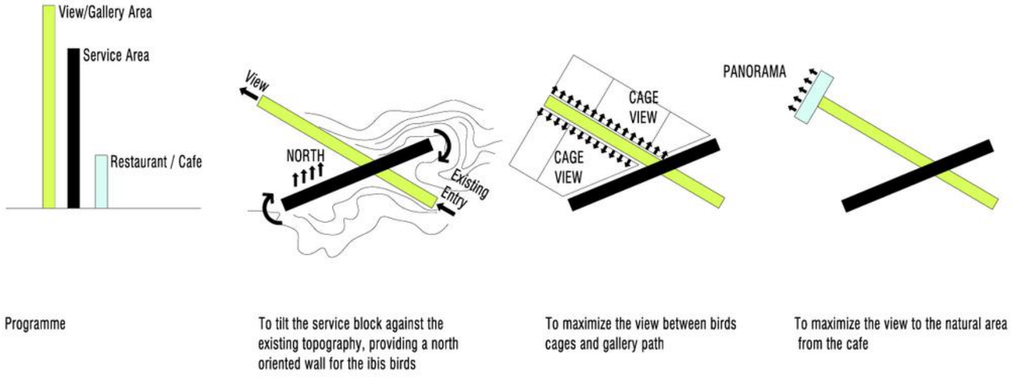
Integrating sustainable design practices into the development of infrastructure and buildings within the nature reserve promotes environmental stewardship and resource efficiency. Utilizing renewable energy sources, incorporating green building materials, and implementing water conservation measures minimize the ecological footprint of human activities within the reserve.

VISITOR FACILITIES

Providing visitor facilities such as visitor centers, observation decks, and picnic areas enhances the recreational experience and encourages public engagement with nature. These facilities can serve as hubs for educational programs, guided tours, and community events focused on environmental conservation.

COMMUNITY ENGAGEMENT

Engaging local communities in the planning, design, and management of the nature reserve fosters a sense of ownership and stewardship. Collaborative decision-making processes, volunteer programs, and citizen science initiatives empower residents to contribute to conservation efforts and build social cohesion.



Programme

To tilt the service block against the existing topography, providing a north oriented wall for the ibis birds

To maximize the view between birds cages and gallery path

To maximize the view to the natural area from the cafe

herman miller greenhouse

The Herman Miller GreenHouse is a pioneering example of regenerative architecture in a manufacturing context. Designed by William McDonough + Partners and completed in 1995, this facility embodies principles of sustainability and regenerative design that go beyond merely minimizing environmental impact. The GreenHouse was conceived as a model of how industrial buildings could function in harmony with their natural surroundings, contributing positively to the ecosystem and the well-being of its occupants.

DAYLIGHTING AND NATURAL VENTILATION

The design of the GreenHouse maximizes the use of natural light and ventilation, significantly reducing the need for artificial lighting and mechanical cooling. The building features large windows, skylights, and strategically placed openings that allow daylight to penetrate deep into the interior spaces. This not only reduces energy consumption but also creates a pleasant and productive working environment for employees.

ENERGY EFFICIENCY

The GreenHouse employs a variety of energy-efficient technologies and strategies. The building's orientation and design take advantage of passive solar heating, while high-performance insulation and glazing minimize heat loss. The integration of energy-efficient lighting systems and controls further reduces the building's energy demand. According to Kibert, these measures contribute to the GreenHouse consuming significantly less energy compared to conventional industrial buildings.

WATER MANAGEMENT

Water conservation is a critical component of the GreenHouse's design. The facility includes rainwater harvesting systems that collect and store rainwater for use in landscaping and non-potable applications. Additionally, efficient plumbing fixtures and a greywater recycling system reduce the overall water footprint of the building. These measures ensure that the GreenHouse operates within the natural hydrological cycle, reducing its impact on local water resources.

MATERIAL SELECTION AND WASTE REDUCTION

In line with regenerative principles, the GreenHouse was constructed using materials that are non-toxic, sustainably sourced, and have low environmental impacts. The design prioritized the use of recycled and recyclable materials, and the construction process emphasized waste minimization and material reuse. The facility also incorporates a comprehensive waste recycling program, ensuring that waste generated during manufacturing is diverted from landfills and repurposed wherever possible.

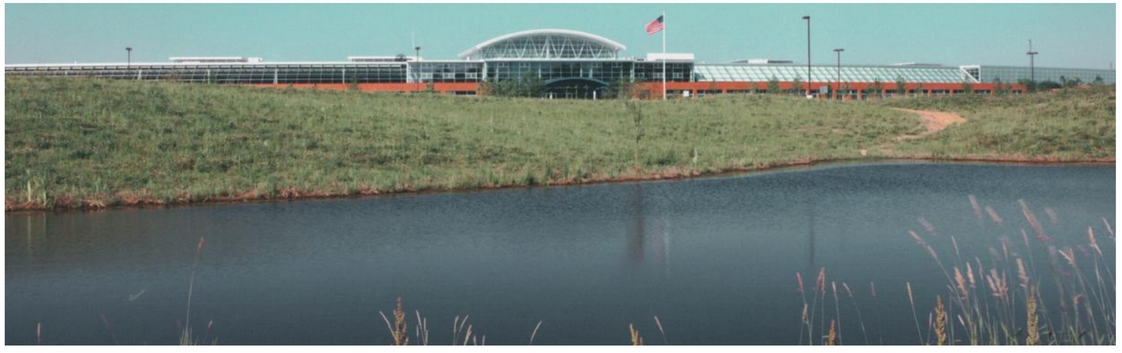
INDOOR ENVIRONMENTAL QUALITY

The GreenHouse was designed with a strong focus on indoor environmental quality, recognizing the importance of a healthy indoor environment for employee well-being and productivity. The building features low-emitting materials to reduce indoor air pollutants, advanced ventilation systems to ensure a constant supply of fresh air, and thoughtful spatial design to enhance comfort and connection to nature.

LANDSCAPE INTEGRATION

The surrounding landscape of the GreenHouse was carefully designed to enhance biodiversity and support local ecosystems. Native plants and adaptive species were used in the landscaping to create habitats for local wildlife and reduce the need for irrigation and chemical fertilizers. The integration of green spaces and outdoor areas provides employees with opportunities to connect with nature, further promoting well-being and productivity.





house & restaurant

The House & Restaurant project by Junya Ishigami is an located in Ube, Japan (Junya Ishigami + Associates, 2022). Completed in 2022, this project exemplifies Ishigami's innovative approach to design, which often blurs the boundaries between built and natural environments. The building serves as both a private residence and a public restaurant, creating a unique space that harmonizes with its surroundings and provides a new interpretation of living and dining experiences.

INTEGRATION WITH NATURE

The House and Restaurant embraces its natural surroundings, with a design that blurs the boundaries between indoor and outdoor spaces. Large openings and expansive glass facades create a sense of continuity with the surrounding landscape, allowing occupants to feel connected to nature at all times. The use of natural materials, such as wood and stone, further enhances this integration, reinforcing the building's relationship with its environment.

SPATIAL FLUIDITY AND FLEXIBILITY

Ishigami's design prioritizes spatial fluidity and flexibility, allowing for a seamless transition between different areas of the building. Open floor plans and minimalistic partitions create an airy and expansive interior, while movable elements and modular furniture enable users to adapt the space according to their needs. This approach fosters a sense of freedom and exploration, inviting occupants to engage with the architecture in a dynamic and interactive way.



NATURAL LIGHT AND VENTILATION

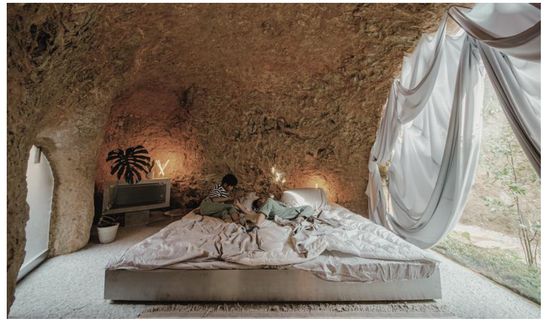
The House and Restaurant maximizes the use of natural light and ventilation to create a comfortable and sustainable indoor environment. Generous glazing and skylights allow ample sunlight to penetrate deep into the interior spaces, reducing the need for artificial lighting and creating a warm and inviting atmosphere. Cross-ventilation strategies, such as operable windows and ventilation louvers, promote natural airflow and thermal comfort, minimizing the reliance on mechanical systems.

HARMONY WITH CONTEXT

The House and Restaurant pays homage to its cultural and historical context, drawing inspiration from traditional Japanese architecture while incorporating contemporary design elements. The building's low-profile silhouette and organic forms echo the natural topography of the site, seamlessly blending into the surrounding landscape. At the same time, innovative construction techniques and advanced materials push the boundaries of traditional building practices, showcasing the possibilities of modern architecture in a traditional setting.









chapter 4

preliminary development

Functional Zoning
Space Requirements
Design Requirements
Architectural Concept
Materiality and Construction Method
Design Result

functional *zoning*



Waste Management Eco-Vision Center Habitat Restoration

WASTE MANAGEMENT SECTION



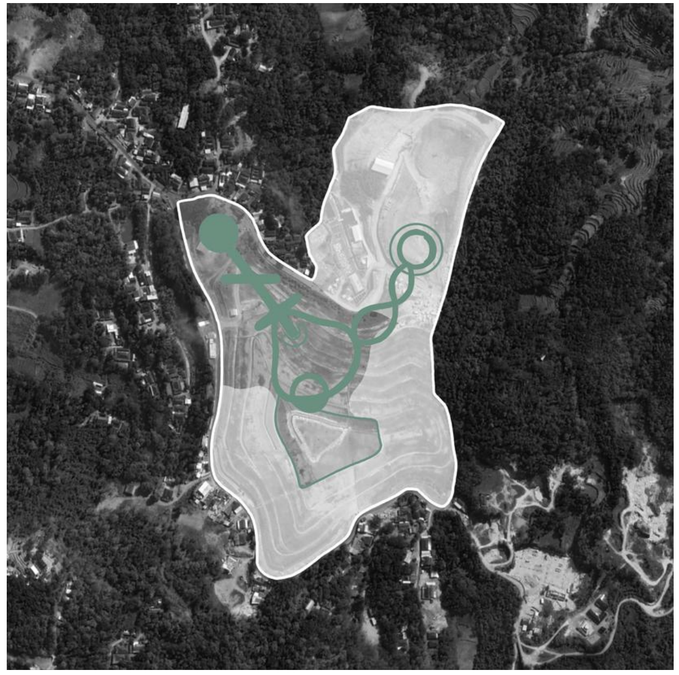
The waste management section is situated at the northeast part of the site, strategically placed to minimize its impact on nearby residential areas. By locating it away from residences, the project aims to mitigate potential nuisances such as odor, noise, and visual disruption associated with waste handling activities. This area also accommodates the relocation of the existing landfill and waste dump, enabling the implementation of modern waste management technologies and recycling facilities. Placing these facilities here supports the project's goal of sustainable waste management practices while ensuring the comfort and quality of life for nearby communities.

HABITAT RESTORATION SECTION

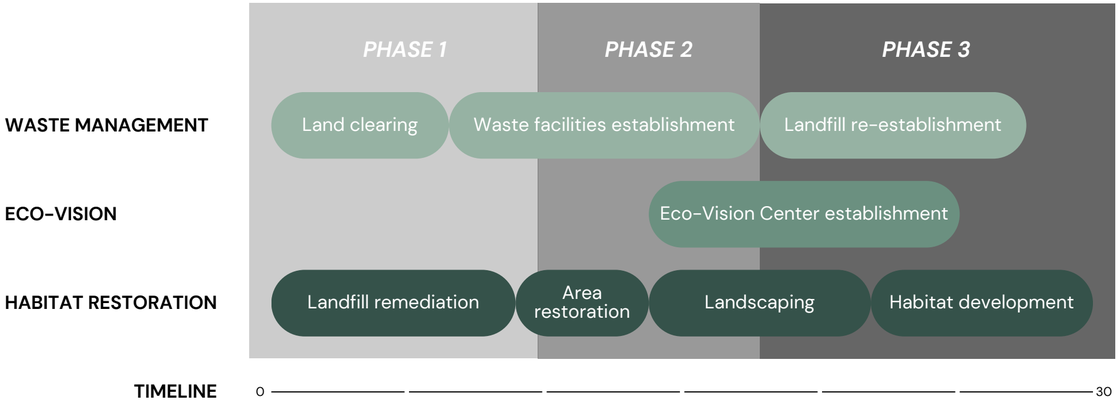


Nestled at the bottom side the site, the habitat restoration section spans a significant area, emphasizing its role in reclaiming green spaces and fostering biodiversity. This central location facilitates the restoration of native flora and fauna habitats, creating interconnected ecosystems that support local wildlife. By integrating with existing nature and green areas, this section provides seamless connections that enable wildlife to move freely and naturally, promoting ecological resilience and enhancing overall biodiversity within the site. Its central position ensures that habitat restoration efforts have maximum impact in revitalizing the site's natural environment.

ECO-VISION CENTER



Positioned at the center of the green area, Eco-Vision serves as a focal point for education, research, and community engagement on environmental stewardship. This strategic location ensures easy accessibility from various parts of the site, encouraging interaction and learning opportunities related to sustainable practices. Integrated within the restored habitats, the hub symbolizes the project's commitment to environmental sustainability by showcasing green building technologies, renewable energy sources, and sustainable materials. Its placement amidst thriving ecosystems not only educates visitors but also inspires a deeper appreciation and adoption of sustainable lifestyles, reinforcing the project's holistic approach to environmental conservation.



SECTION	ARCHITECTURAL SOLUTION	NON-ARCHITECTURAL SOLUTION
Waste Management	Landfill Relocation	New Way of Managing the Waste
	Waste-to-Energy Plant	New Waste Management Policy
	Wastewater Treatment Plant	More Involvement from the Government and Community
Eco-Vision	Community Education Spaces	Education about Waste Management, Biodiversity, and Sustainability
	Community Engagement Spaces	In-depth Research about Waste Management and Biodiversity
	Offices & Labs	Collaboration between Community, Government, and Organizations
Habitat Restoration	Landscape	Environmental Remediation
	Habitat Features	Community Involvement
	Wildlife Corridors	Monitoring and Maintenance



space *requirements*

	Space	Setting	Function Flexibility	Activities	Space per Person (sqm)	Capacity (people)
Public-Education	Gallery & Exhibition	Indoor & Outdoor	Semi-permanent	Visit themed exhibition about waste management process, strategies, impacts, history of Piyungan Landfill, and habitat restoration with waste art installations	1.5 - 2	200
	Workshops	Indoor & Outdoor	Semi-permanent	Workshop on waste management strategy by communities & organizations	3 - 5	20
	Auditoriums	Indoor	Non-permanent	Attend lectures by communities, organizations, or government and discuss	0.6 - 0.75	50
	Garden & Recreation	Outdoor	Non-permanent	Discover native plants, try edible plants, and just have a relax	3 - 5	50
Specialized	Offices	Indoor	Permanent	Office for the workers, staffs, and managers of the existing and future Piyungan Landfill	7 - 10	75
	Laboratories	Indoor	Permanent	Research on waste, biodiversity, and sustainability	7 - 10	20
	Community Rooms	Indoor	Semi-permanent	Base for the communities and organizations involved	2 - 3	10
Service	Lobby	Indoor	Semi-permanent	Reception and information center	1.5 - 2	25
	Cafe	Semi-outdoor	Semi-permanent	Enjoy healthy and eco-conscious refreshments and meals	1 - 1.5	75
	Eco-market	Indoor	Semi-permanent	Explore eco-conscious products promoting sustainable living practices	1 - 1.5	25
Amenities	Restrooms	Indoor	Permanent	Toilet use and personal hygiene	0.8 - 1	20
	Mushola	Indoor	Permanent	Pray	0.8 - 1	20
	Storage	Indoor	Permanent	Store essential supplies for exhibition, cafe, and shop operational needs	-	-
	Utility & Maintenance	Indoor	Permanent	Utility service & maintenance	-	-
	Parking Area	Indoor & Outdoor	Semi-permanent	Vehicle parking	-	-

design *requirements*

Designing a waste management education and tourism center requires a holistic approach that integrates functionality, sustainability, and visitor experience. The site's context and surroundings play a crucial role in shaping the design, ensuring a seamless transition from a former landfill to an eco-educational destination. The architecture should blend with the regenerated landscape, respecting the site's ecological restoration while minimizing further environmental impact. Accessibility is also key, incorporating clear signage, ramps, elevators, and interactive information points to accommodate diverse visitors, including students, researchers, tourists, and local communities.

Sustainability and regenerative principles should be at the core of the design. The center should utilize recycled and locally sourced materials, renewable energy systems such as solar and biogas, rainwater harvesting, and constructed wetlands for wastewater treatment. Green roofs, living walls, and permeable surfaces will enhance the site's environmental performance while reinforcing the theme of waste management and circular economy. The architectural approach should demonstrate sustainable building solutions, making the facility itself an educational tool. Visitors should be able to experience sustainability in action, from energy-efficient buildings to zero-waste operational systems that showcase responsible resource use.

The spatial organization should cater to an immersive educational experience, ensuring that visitors gain both knowledge and hands-on exposure to waste management solutions. The center must include an interactive exhibition area, showcasing the journey of waste from collection to recycling, processing, and transformation into new products or energy. Hands-on learning zones will allow visitors to engage in activities like recycling, composting, and upcycling workshops. A research and innovation hub will provide a platform for students, professionals, and environmentalists to develop and test waste management solutions. Additionally, outdoor demonstration areas, including restored landfill sections, constructed wetlands, and community gardens, will provide visitors with tangible examples of sustainable land rehabilitation. Supporting facilities such as a sustainable café and eco-shop will promote locally produced, upcycled, and eco-friendly goods, reinforcing the project's message of waste reduction and resource conservation.

Flexibility in design is essential to accommodate a wide range of educational programs, eco-tourism activities, and community events. Multi-functional spaces should allow for seminars, sustainability festivals, interactive workshops, and guided landfill tours. As waste management technologies evolve, the center should be designed to support future expansions, ensuring it remains a leading hub for sustainability education. Digital integration, including interactive displays, augmented reality experiences, and real-time waste tracking systems, will further enhance visitor engagement and provide cutting-edge learning opportunities.

Finally, community involvement and cultural relevance are essential in ensuring the center's long-term success. Engaging local waste workers, artisans, and sustainability advocates in the design and operation of the facility will create a sense of ownership and authenticity. The center should reflect Yogyakarta's cultural and historical connection to environmental stewardship, integrating traditional ecological knowledge with modern innovations. By fostering a participatory approach, the project will empower the community, promoting long-term behavioral change towards responsible waste management.

architectural *concept*

The Eco-Vision Center is designed as a regenerative educational tourism facility, seamlessly blending sustainability with an engaging architectural form. The concept is rooted in regenerative architecture, ensuring that the building not only minimizes its environmental impact but actively contributes to the site's ecological and social revitalization. The design integrates the natural contours of the site, utilizing different levels to create a dynamic visitor experience while respecting the site's topography. This adaptive approach allows the facility to minimize land excavation, enhance water drainage, and provide diverse perspectives of the surrounding regenerated landscape.

The architectural form consists of two primary geometric elements, intersecting linear structures and a circular core. The intersecting lines represent the movement of visitors, guiding them through the educational journey of waste management, sustainability, and environmental conservation. These linear elements house the main visitor-oriented spaces, such as galleries, exhibition halls, workshops, and seminar areas, facilitating an immersive and sequential learning experience. The lines also symbolize the connection between past and future, transforming a once-degraded landfill into an inspiring space for sustainability education.



At the heart of the design, the circular core serves as the center for research, administration, and laboratories. The circular shape signifies continuity, regeneration, and the closed-loop cycle of sustainable waste management, reinforcing the principles of a circular economy. It acts as the operational and intellectual hub of the facility, where researchers, educators, and environmentalists collaborate to advance sustainable waste management solutions. This core also provides a sense of stability amidst the dynamic movement of visitors, creating a harmonious balance between exploration and research.

The interplay between the intersecting lines and the circular core influences the flow of circulation within the facility. Visitors are intuitively guided along the linear pathways, experiencing an evolving narrative as they move from interactive exhibitions and demonstration areas to outdoor experiential zones. The different levels, shaped by the site's natural contours, provide varied viewpoints and perspectives, enriching the learning experience. As visitors ascend or descend, they gain new insights into waste transformation, regenerative landscapes, and sustainable living practices.

The architectural form also enhances visitor engagement through its spatial arrangement. The openness of the intersecting lines allows for visual and physical connections between spaces, fostering curiosity and interaction. Large openings and terraces provide seamless transitions between indoor and outdoor learning environments, reinforcing the interconnectedness of waste management, ecology, and community involvement. The adaptive levels further create a sense of discovery, where visitors encounter new aspects of the educational journey as they navigate through the facility.

Through this architectural approach, Eco-Vision transforms waste management education into an experiential and memorable journey. By merging regenerative principles with a purposeful geometric composition, the design embodies the transformation of waste into knowledge, disorder into structure, and degradation into renewal. It serves as both an educational landmark and a symbol of sustainable progress, inspiring visitors to rethink waste and embrace a regenerative future.



growing concept

The growing concept in the Eco-Vision Center is a long-term ecological restoration strategy that ensures the gradual transformation of the site into a self-sustaining ecosystem. This approach aligns with regenerative architecture principles, allowing nature to reclaim and flourish over time while fostering community involvement. In the initial phase (Development 1), the foundational infrastructure is completed, integrating waste management systems, research facilities, and educational tourism spaces. Simultaneously, early reforestation efforts and wetland restoration are initiated to lay the groundwork for biodiversity regeneration. A crucial element in this process is the tree-planting workshops, where local communities, visitors, and researchers actively participate in restoring green spaces.

As the ecosystem matures (Development 2), the planted trees and vegetation begin to flourish, creating denser green corridors, improving air quality, regulating the microclimate, and enhancing water retention. The once-degraded landfill starts to transform into a resilient natural landscape, attracting more wildlife and strengthening ecological interactions. By Year 10 (Development 3), the site has evolved into a self-sustaining sanctuary, where mature trees provide extensive canopy coverage and wetlands function as natural water purifiers. This gradual growth not only enhances the aesthetic and ecological value of the site but also ensures that the Eco-Vision Center remains adaptable to climate conditions. Through continuous community participation and adaptive management, this project serves as a living model of regenerative design, demonstrating how degraded land can be revitalized into a biodiverse and climate-responsive environment that benefits both nature and society.

response to climate

The Eco-Vision Center's response to climate is designed to address the challenges of Yogyakarta's tropical environment, which is characterized by high humidity, intense solar radiation, and heavy rainfall. To mitigate excessive heat and reduce energy consumption, the building integrates moss-covered facades and roofs, acting as a natural sun filter. Moss helps regulate indoor temperatures by providing shade, absorbing heat, and reducing surface temperatures, contributing to a cooler and more comfortable interior without reliance on artificial cooling. Additionally, the moss layer enhances air quality and moisture retention, fostering a microclimate that supports biodiversity while reinforcing the building's connection with nature.

However, given the tropical climate's high humidity, there is a concern that the building's interior could feel damp due to moisture retention from the moss-covered surfaces. To counter this, the design incorporates passive ventilation strategies, such as cross-ventilation, stack effect principles, and breathable materials like autoclaved aerated concrete (AAC) blocks, which regulate humidity and prevent excessive dampness. The integration of porous walls and well-placed openings ensures continuous airflow, maintaining a dry and comfortable indoor environment while still benefiting from the moss's thermal regulation and aesthetic appeal. This approach balances climate adaptation and indoor comfort, demonstrating how buildings in tropical regions can work with nature rather than against it, creating spaces that are resilient, energy-efficient, and ecologically integrated.



DEVELOPMENT 1 — AFTER ESTABLISHMENT



DEVELOPMENT 2 — YEAR 5 AFTER ESTABLISHMENT

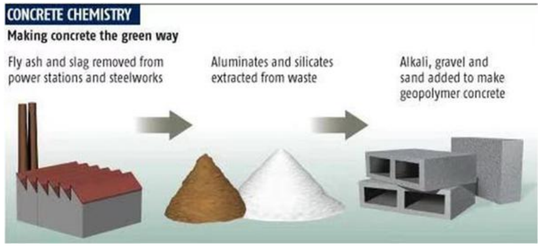


DEVELOPMENT 3 — YEAR 10 AFTER ESTABLISHMENT

materiality and *construction methods*

The Eco-Vision Center integrates sustainable and innovative construction techniques to align with regenerative architecture principles. The material selection prioritizes eco-friendly, locally sourced, and waste-derived materials, ensuring that the building itself becomes an example of sustainable waste transformation. The two primary materials used for construction are lightweight autoclaved aerated concrete (AAC) blocks for the main structural walls and geopolymer shotcrete for the building's outer facade, green walls, and roof system.

Autoclaved aerated concrete (AAC) blocks are chosen for the primary wall structure due to their lightweight properties, high insulation value, and sustainability benefits. Compared to traditional concrete or brick, AAC significantly reduces the structural load, enhances thermal efficiency, and minimizes material consumption. This material also contributes to energy efficiency by reducing the need for artificial cooling and heating, creating a more sustainable indoor environment. Additionally, AAC blocks are fire-resistant, soundproof, and durable, making them an ideal choice for an educational tourism facility that requires both safety and comfort.



For the outer facade, green wall, and roof system, geopolymer shotcrete is applied as a finishing layer. This shotcrete is uniquely formulated using geopolymer concrete produced from the waste-to-energy plant's residue, reinforcing the center's commitment to waste repurposing. The geopolymer shotcrete serves multiple functions: it enhances structural durability, provides a natural and organic aesthetic, and supports biophilic design elements. This layer acts as the foundation for moss growth, vertical gardens, and a green roof, transforming the building into a living structure that actively participates in ecological restoration. The porous and adaptable nature of geopolymer shotcrete allows for optimal moisture retention and plant adhesion, creating a self-sustaining ecosystem that absorbs carbon dioxide, enhances biodiversity, and regulates microclimate conditions.

In terms of construction methodology, the process begins with AAC block installation, ensuring that the lightweight walls align with the structural grid and provide thermal insulation. Once the primary wall structure is in place, the geopolymer shotcrete is sprayed onto the outer surfaces, forming a seamless, sculpted facade that integrates with the contours of the site. This monolithic application method minimizes material waste and reduces construction time, making it a highly efficient and low-carbon construction technique.

The combination of AAC blocks and geopolymer shotcrete allows the Eco-Vision Center to function as an energy-efficient, environmentally responsible, and aesthetically harmonious space. The result is a building that not only teaches sustainability but also embodies it, demonstrating how waste materials can be transformed into innovative architectural solutions that restore the environment, inspire visitors, and redefine the future of green architecture.

The use of autoclaved aerated concrete (AAC) blocks and geopolymer shotcrete in the Eco-Vision aligns with the principles of regenerative architecture, ensuring sustainability, ecological restoration, and long-term resilience. These materials contribute to environmental restoration by minimizing resource depletion and repurposing industrial waste. AAC blocks are lightweigh, while geopolymer shotcrete is produced from waste-to-energy plant residue, reducing landfill waste and promoting a closed-loop system where by-products are reintegrated into the building process. This approach significantly lowers carbon emissions, exemplifying a sustainable construction model that turns waste into a valuable resource.

Beyond sustainability, these materials enhance thermal efficiency and energy conservation. AAC blocks provide superior insulation, minimizing heat gain and reducing the need for artificial cooling, while the geopolymer shotcrete facade, integrated with moss and green walls, further enhances passive climate control. By incorporating living systems into the building envelope, the project fosters natural cooling, and improves air quality, creating a comfortable and energy-efficient environment. This harmonization between built and natural elements ensures that the building remains responsive to environmental changes over time.

The integration with nature is further emphasized through the green facade and moss-covered roof, where the geopolymer shotcrete surface is designed to support vegetation growth. The design not only enhances aesthetic and environmental performance but also supports water retention and air purification, contributing to a self-sustaining system that regenerates rather than depletes natural resources. This biophilic approach ensures that architecture works collaboratively with nature, turning the building into an active contributor to the surrounding ecosystem rather than a disruptor.

Lastly, the Eco-Vision plays a crucial role in community engagement and education by demonstrating innovative sustainable building practices. The use of waste-derived construction materials showcases the potential of circular economy principles, inspiring visitors to rethink waste and sustainability. Additionally, AAC blocks allow for flexible construction, enabling future modifications and expansions without excessive material waste, ensuring the building remains adaptable to future needs. By incorporating durable, low-maintenance materials that educate, engage, and regenerate, the Eco-Vision becomes a model for future sustainable architecture, one that restores, sustains, and evolves with its environment.

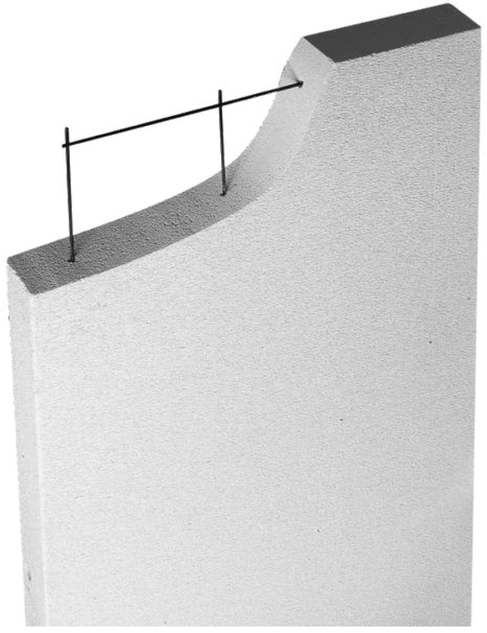


Autoclaved Aerated Concrete (AAC) is a highly sustainable and lightweight alternative to conventional building materials, offering significant environmental and structural benefits. It is manufactured through a precise process that involves mixing cement, lime, sand, water, and an expansion agent, typically aluminum powder. This reaction creates a porous structure, giving AAC its distinct lightweight properties while maintaining structural integrity. The material is then cured under high-pressure steam in an autoclave, which enhances its strength and durability. Due to its low density and thermal insulation properties, AAC is widely used in energy-efficient and sustainable construction projects, reducing energy consumption while maintaining high performance.

One of the key advantages of AAC is its high strength-to-weight ratio, making it an excellent choice for load-bearing and non-load-bearing applications. Despite being significantly lighter than traditional concrete, AAC provides adequate compressive strength, usually ranging between 3 to 5 MPa, making it suitable for walls, partitions, and floors. Its flexural and tensile strength are also comparable to conventional masonry materials, allowing it to perform well under structural loads while reducing the overall weight of buildings. Additionally, AAC offers exceptional fire resistance, with the ability to withstand fire for up to four hours or more, making it an ideal material for fire-prone regions and high-safety building applications.

AAC exhibits superior thermal insulation and soundproofing capabilities, making it highly energy-efficient and comfortable for occupants. The porous structure acts as a natural thermal barrier, reducing heat transfer and minimizing the need for artificial heating and cooling systems. This contributes to lower energy consumption, aligning with regenerative architecture principles by promoting passive design strategies. Moreover, the material's acoustic properties enhance indoor comfort by reducing noise pollution, making AAC an ideal choice for urban environments where noise reduction is essential.

Compared to traditional clay bricks and concrete blocks, AAC provides substantial environmental benefits by using less raw material while offering higher performance. The production process requires significantly less water and emits lower CO_2 emissions, contributing to a reduced carbon footprint. Additionally, AAC is fully recyclable, aligning with closed-loop systems in sustainable construction. However, its production must be carefully managed to maintain consistency in quality, strength, and moisture content. AAC's ability to integrate with other sustainable materials, such as geopolymer shotcrete for green facades, further enhances its potential for eco-friendly and regenerative architectural applications.





Geopolymer concrete (GPC) is a sustainable alternative to conventional Portland cement concrete, offering significant environmental and performance benefits. It is formed by activating aluminosilicate materials, such as fly ash, slag, or metakaolin, with an alkaline solution, typically a combination of sodium or potassium hydroxide and sodium or potassium silicate. This innovative concrete technology is gaining attention due to its potential to reduce carbon emissions while delivering excellent structural properties.

One of the primary strengths of geopolymer concrete lies in its high compressive strength, which often ranges between 40 to 80 MPa and can even exceed these values depending on the mix design. The strength development of GPC is rapid, with significant gains achieved within the first seven days. It is also known for superior performance at elevated temperatures, making it particularly suitable for fire-resistant applications.

In terms of flexural and tensile strength, GPC performs similarly to conventional concrete. The flexural strength typically accounts for 10-15% of the compressive strength, while tensile strength remains lower, necessitating the use of reinforcement in structural applications. However, geopolymer concrete stands out for its durability, especially in harsh environments. It exhibits better resistance to chemical attacks, sulfate and chloride exposure, acid attack, freeze-thaw cycles, and carbonation, thanks to its lower calcium content and denser microstructure.

The curing method plays a significant role in the strength development of GPC. Elevated temperature curing, typically between 60°C to 90°C, accelerates the geopolymerization process, leading to higher early strength. While ambient curing is also possible, it may result in slower strength gains compared to heat-cured geopolymer concrete. The composition of the materials, including the source (fly ash, slag, etc.) and the type of alkaline activator, also critically influences the final strength and performance of the concrete.



When compared to conventional Portland cement concrete, GPC offers substantial environmental benefits, producing significantly lower CO_2 emissions. It also demonstrates faster early strength development, particularly when heat-cured, and outperforms traditional concrete in aggressive environments due to its enhanced resistance to chemical and chloride attacks. However, geopolymer concrete does face challenges, such as variability in workability and setting time, the need for more standardized guidelines, and potential cost and availability issues related to raw materials like fly ash.

Geopolymer concrete has already found applications in infrastructure projects, precast elements, and environments requiring enhanced durability, such as marine structures, sewage pipelines, and fire-resistant buildings. While it holds great promise due to its high strength, durability, and environmental benefits, successful application requires careful consideration of its mix design, curing conditions, and local material availability.



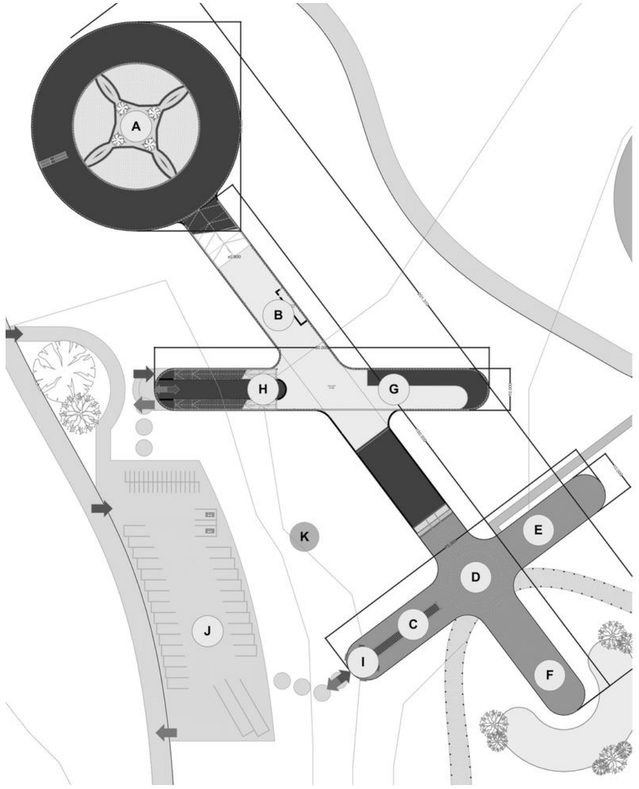
design *result*

SITUATION PLAN



A	Eco-Vision Visitor Center
B	Waste-to-Energy Plant
C	Wastewater Treatment Plant
D	New Landfill
E	Wetlands
F	Buffer Zone
G	Reclaimed Green Area
H	Existing Landfill
I	Parking Area
J	Plant Nursery Area
K	Inner Forest
L	Boardwalk

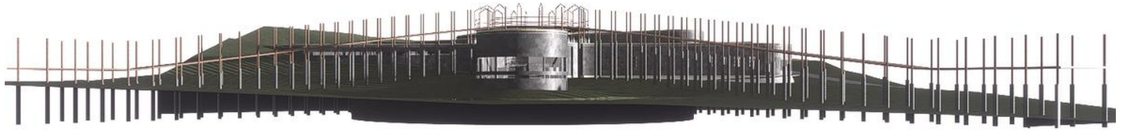
SITE PLAN

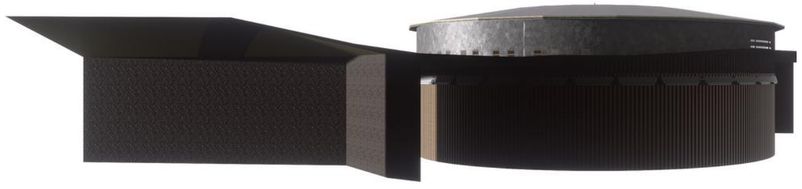


A	Office & Laboratory	+2.000
B	Reception & Indoor Gallery	±0.000
C	Community Rooms	-4.000
D	Eco-market & Workshop	-4.000
E	Cafe & Public Spaces	-4.000
F	Viewing Gallery	-6.000
G	Service Area	-4.000
H	Entrance to Reception	±0.000
I	Entrance to Eco-market	-4.000
J	Parking Area	+4.000
K	Assembly Points	+3.850

SITE ELEVATIONS





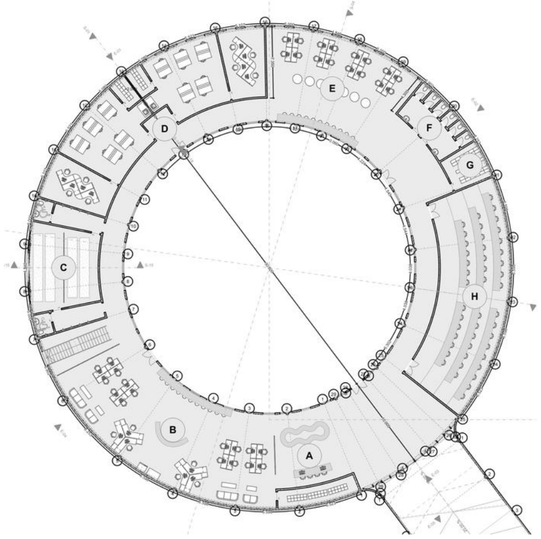


SITE SECTIONS



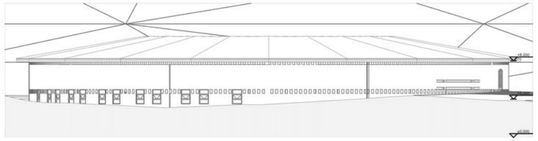


OFFICE & LAB PLAN

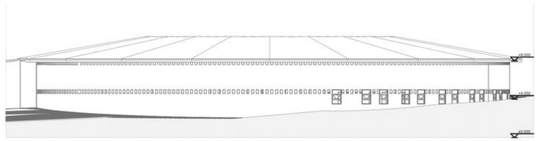


A	Reception	+2.000
B	Office 1	+2.000
C	Mushola	+2.000
D	Laboratory	+2.000
E	Office 2	+2.000
F	Restroom	+2.000
G	Storage	+2.000
H	Meeting Room	+2.000

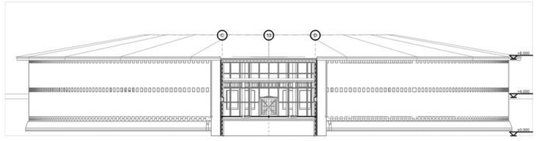
OFFICE & LAB ELEVATIONS



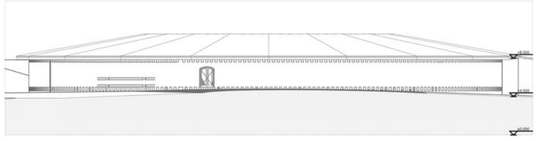
E-01 Office & Lab North Elevation 1:300



E-02 Office & Lab East Elevation 1:300

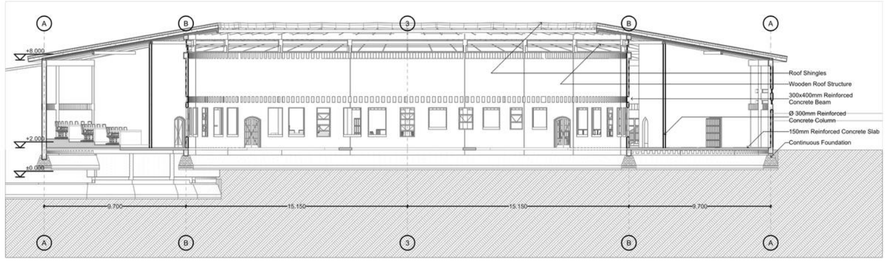


E-03 Office & Lab South Elevation 1:300

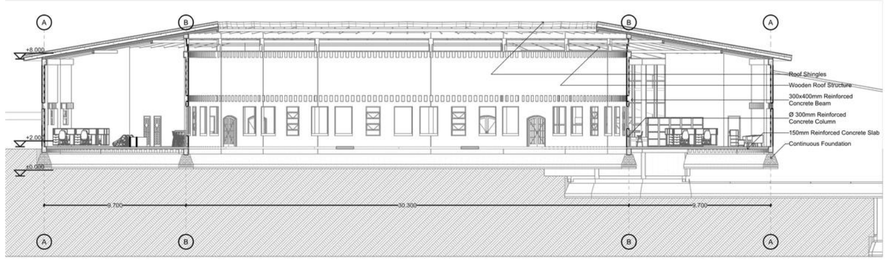


E-04 Office & Lab West Elevation 1:300

OFFICE & LAB SECTIONS

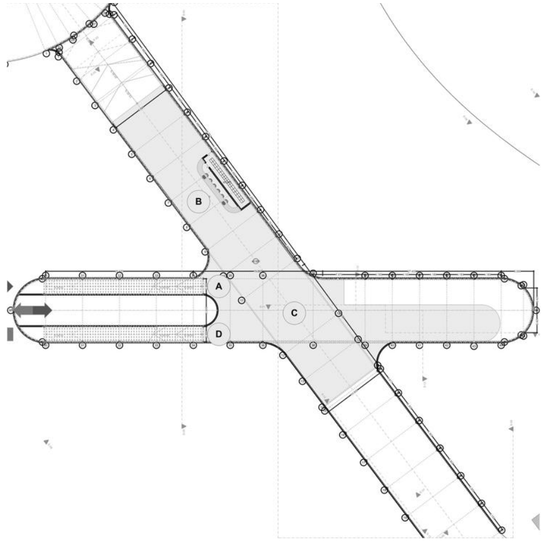


S-03 Office & Lab Section A-A' 1:200



S-04 Office & Lab Section B-B' 1:200

RECEPTION & GALLERY PLAN



A	Entrance	±0.000
B	Reception	±0.000
C	Gallery	±0.000
D	Exit	±0.000

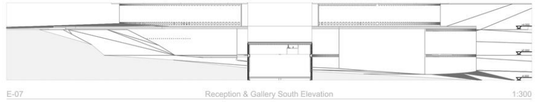
RECEPTION & GALLERY ELEVATIONS



E-05 Reception & Gallery North Elevation 1:300



E-06 Reception & Gallery East Elevation 1:300

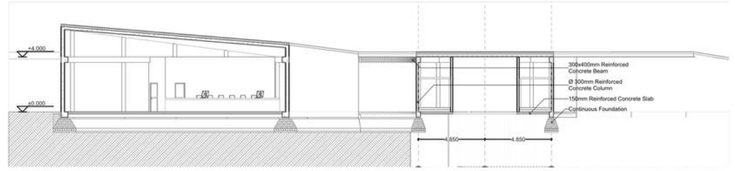


E-07 Reception & Gallery South Elevation 1:300

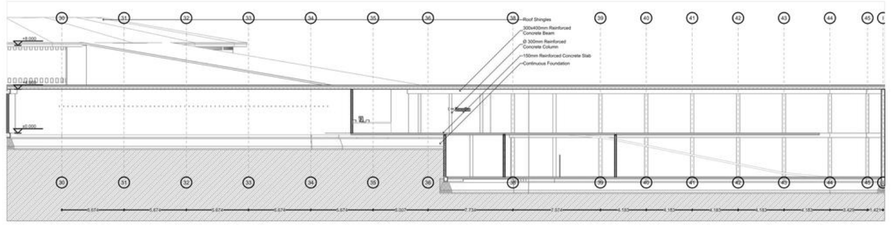


E-08 Reception & Gallery West Elevation 1:300

RECEPTION & GALLERY SECTIONS

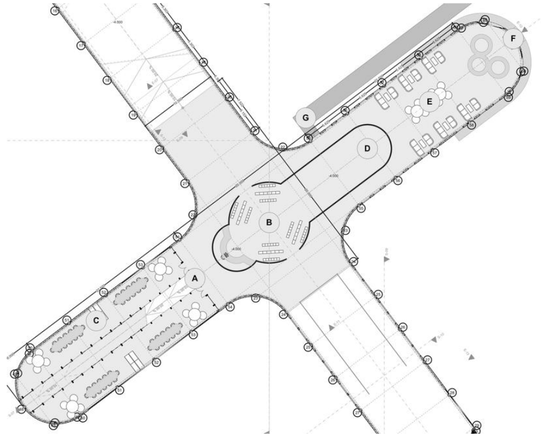


S-05 Reception & Gallery Section A-A' 1:200



S-06 Reception & Gallery Section B-B' 1:250

CAFE, SHOP, & WORKSHOP PLAN



A	Entrance & Exit
B	Eco-market
C	Community Rooms
D	Recycling Workshop
E	Cafe & Public Space
F	Exit to Outdoor
G	Clean Plastic Loading Deck

CAFE, SHOP, & WORKSHOP ELEVATIONS



E-09 Cafe, Shop, & Workshop North Elevation 1:250



E-10 Cafe, Shop, & Workshop East Elevation 1:250

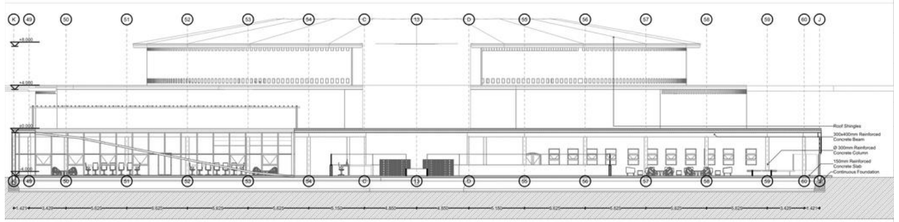


E-11 Cafe, Shop, & Workshop South Elevation 1:250

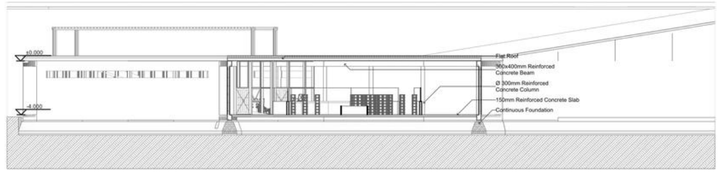


E-12 Cafe, Shop, & Workshop West Elevation 1:250

CAFE, SHOP, & WORKSHOP SECTIONS

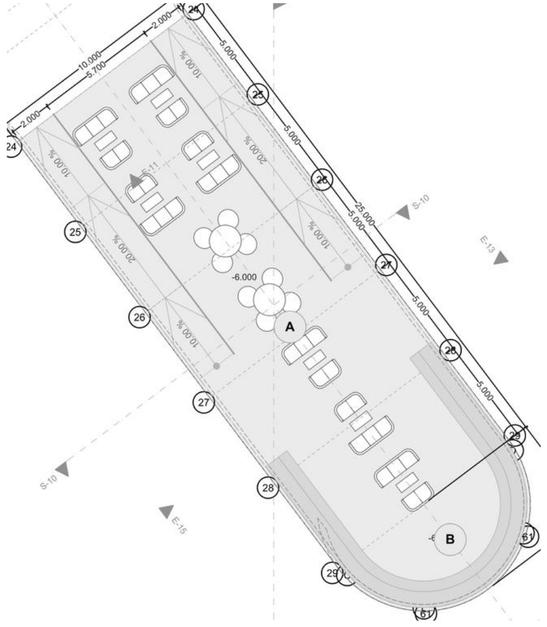


S-07 Cafe, Shop, & Workshop Section A-A' 1:250



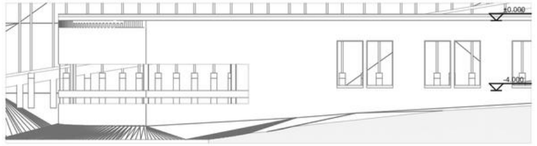
S-08 Cafe, Shop, & Workshop Section B-B' 1:200

VIEWING GALLERY PLAN

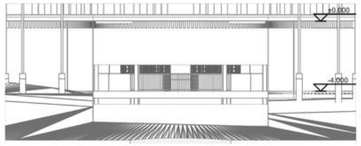


A	Cafe	-6.000
B	Viewing Area	-6.000

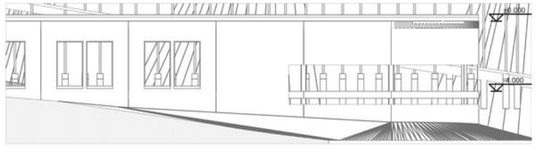
VIEWING GALLERY ELEVATIONS



E-13 Viewing Gallery East Elevation 1:200

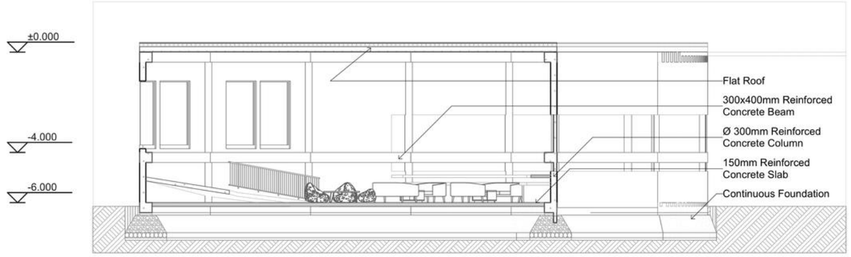


E-14 Viewing Gallery South Elevation 1:200

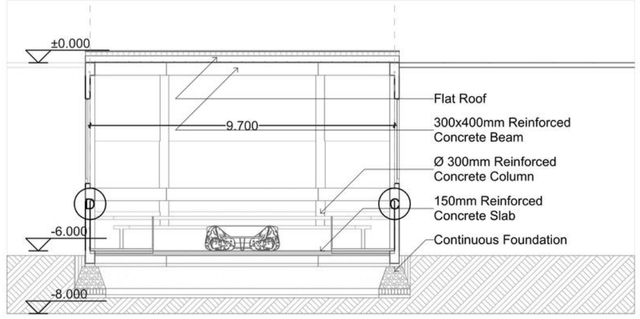


E-15 Viewing Gallery West Elevation 1:200

VIEWING GALLERY SECTIONS

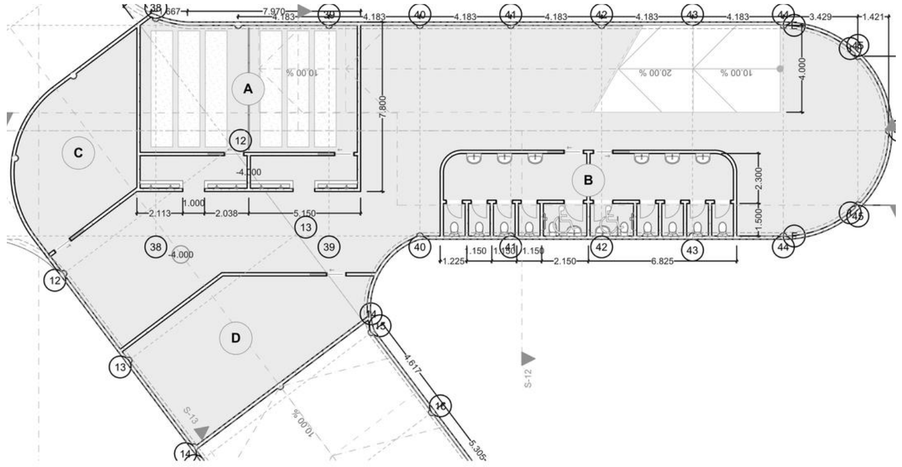


S-09 Viewing Gallery Section A-A' 1:125



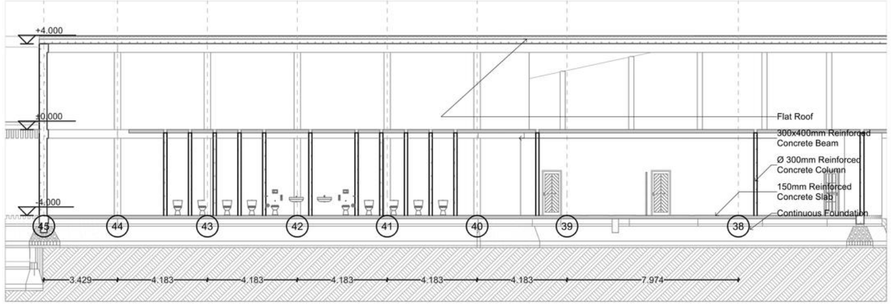
S-10 Viewing Gallery Section B-B' 1:100

SERVICE AREA PLAN

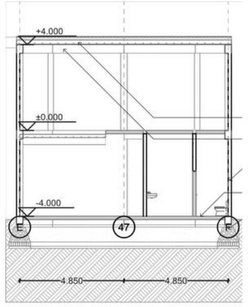


A	Mushola	-4.000
B	Restroom	-4.000
C	Water Plant	-4.000
D	Curator's Room	-4.000

SERVICE AREA SECTIONS

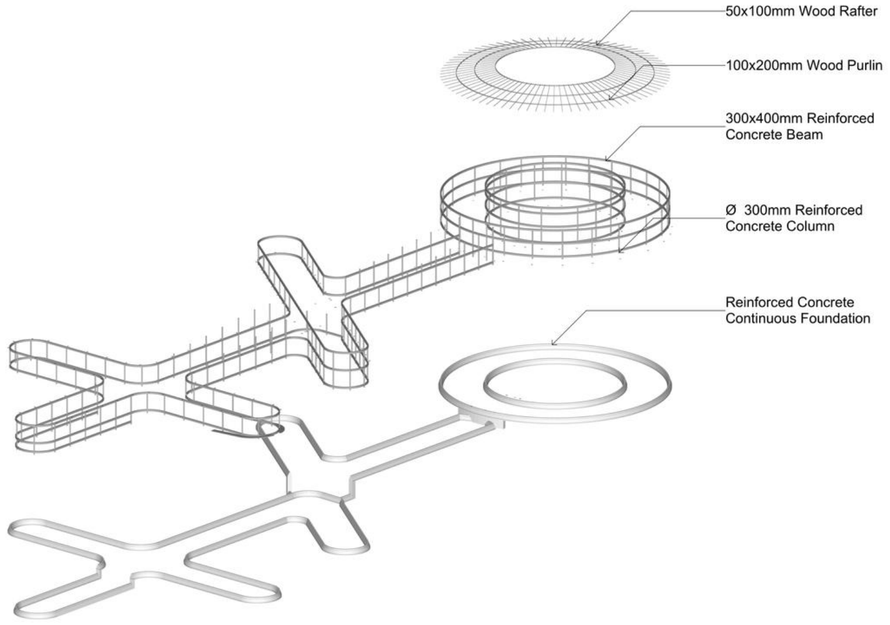


S-11 Service Area Section A-A' 1:150

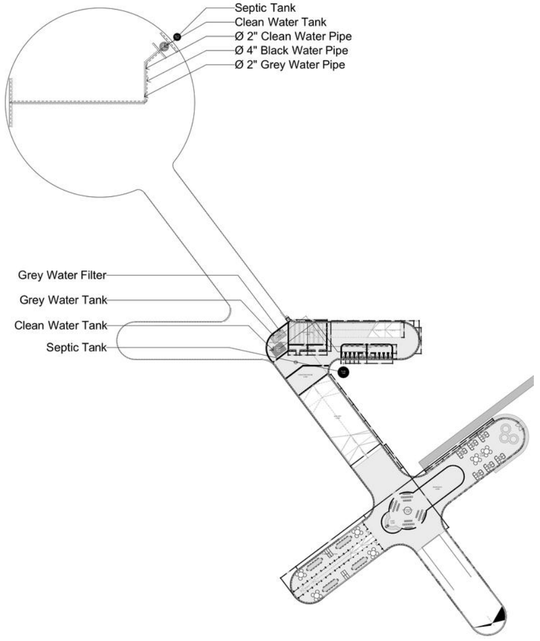


S-12 Service Area Section B-B' 1:150

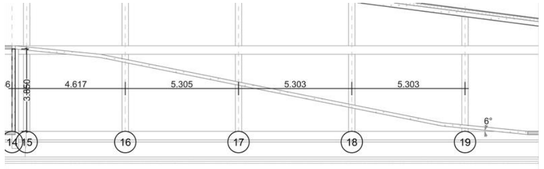
STRUCTURE AXONOMETRIC



PLUMBING SYSTEM

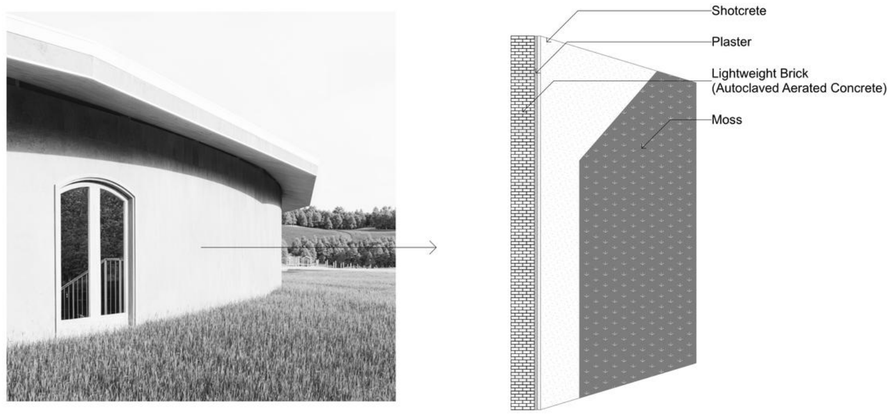


BARRIER FREE DETAILS



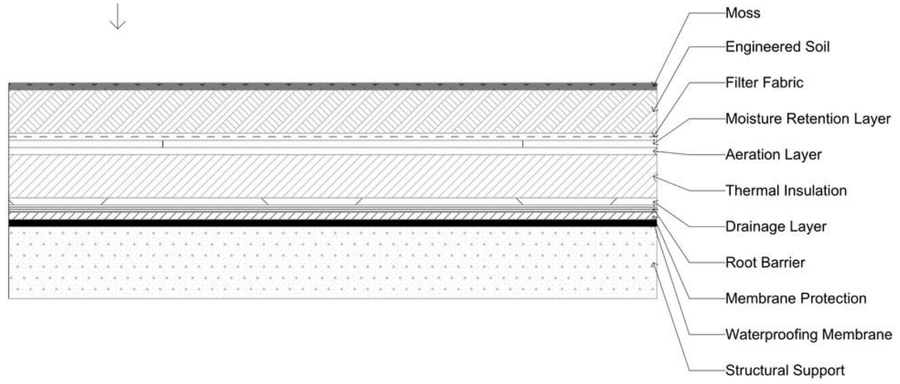
A barrier-free plan ensures accessibility for all users, including people with disabilities, by eliminating physical obstacles within a building. Using ramps throughout the entire building replaces or complements stairs, allowing smooth circulation for wheelchair users, strollers, and those with mobility challenges. The ramps are designed with gentle slopes, handrails, and non-slip surfaces to ensure safety and ease of movement. This approach not only meets universal design principles but also promotes seamless and inclusive navigation, making the building more functional and welcoming for everyone.

FACADE DETAILS



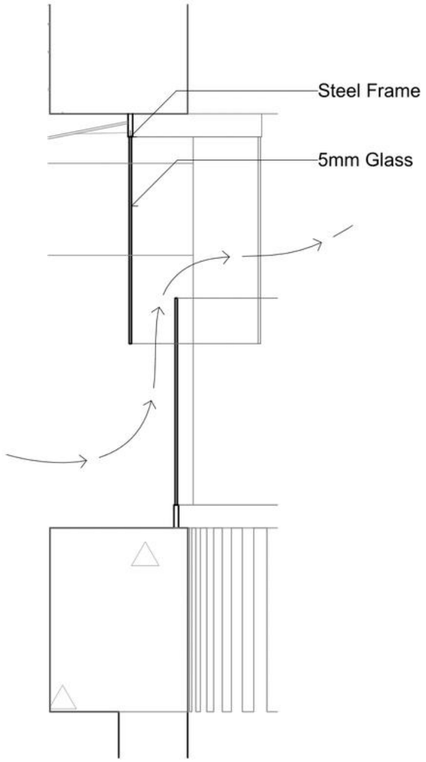
Shotcrete forms the sculptural facade and roof, applied in layered, irregular textures to create a porous, organic surface. This rough texture enhances water absorption, allowing rain to flow naturally down the structure. Over time, this process encourages moss to grow in the small gaps, gradually softening the raw concrete with a living, evolving patina. As the moss spreads, the facade blends seamlessly with its surroundings, reinforcing the concept of a building that exists in harmony with nature rather than standing apart from it.

GREEN ROOF DETAILS

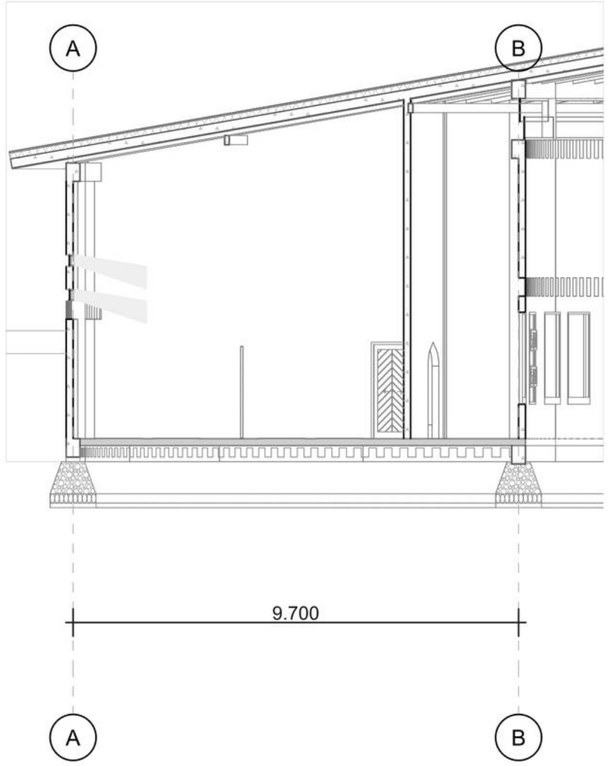


A green roof is a sustainable roofing system that integrates vegetation, soil layers, and drainage components to manage water, reduce heat, and improve environmental performance. It retains rainwater within its multiple layers, including moisture retention, aeration, and drainage systems, allowing slow absorption and evaporation. A rainwater harvesting system enhances this process by capturing runoff, filtering it, and redistributing it to sustain plant growth, reducing water waste and promoting self-sufficiency. This aligns with regenerative architecture by creating a closed-loop water system, where rainwater continuously cycles through the roof, supporting moss growth that further absorbs moisture, regulates temperature, and integrates the building with its natural surroundings.

PASSIVE AIR COOLING SYSTEM DETAILS



NATURAL LIGHTING DETAILS

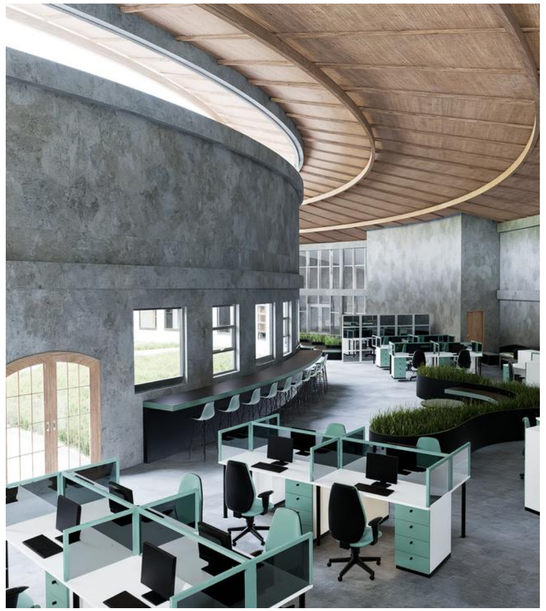


ODOR REDUCTION STRATEGY



An odor reduction strategy integrates multiple natural and technological solutions to maintain air quality and create a comfortable environment. In outdoor areas like boardwalks, jasmine plants are used for their natural fragrance, which masks unpleasant odors while also improving air quality. Green walls and roofs further enhance odor control by absorbing airborne pollutants and filtering gases, reducing the spread of unwanted smells. Inside the building, activated carbon filters in the HVAC system trap odor-causing molecules, while a biofiltration system processes and neutralizes organic compounds, ensuring that air circulating within the building remains fresh.

INTERIOR DETAILS



The interior design incorporates materials made from plastic waste, aligning with the closed-loop system by repurposing discarded plastics into functional and aesthetic elements. Recycled plastic is used for furniture, reducing reliance on virgin materials while diverting waste from landfills. These materials are durable, low-maintenance, and customizable, allowing for a visually appealing yet sustainable interior. By reintegrating waste into the design process, the building promotes a regenerative approach, where materials continuously circulate within the system, minimizing environmental impact and supporting a more sustainable future.























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attach*ments*

SIMILARITY CHECK REPORT

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Assalamualaikum Wr. Wb.

Dengan ini, menerangkan Bahwa:

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Nomor Mahasiswa	: 20512177
Pembimbing	: Assoc. Prof. Arif Budi Sholihah, S.T., M.Sc., Ph.D
Fakultas / Prodi	: Teknik Sipil dan Perencanaan/ Arsitektur
Judul Karya Ilmiah	: RESEARCH AND EDUCATIONAL TOURISM CENTER IN PIYUNGAN LANDFILL 2.0 REVITALIZATION PROJECT USING REGENERATIVE ARCHITECTURE PRINCIPLES

Karya ilmiah yang bersangkutan di atas telah melalui proses cek plagiasi menggunakan **Turnitin** dengan hasil kemiripan (*similarity*) sebesar **2 (Dua) %.**

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Wassalamualaikum Wr. Wb.

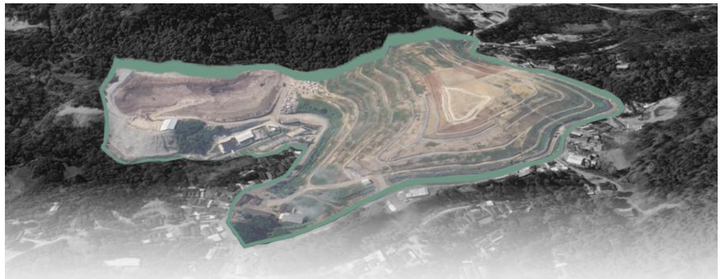
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Direktur

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DIREKTORAT PERPUSTAKAAN
YOGYAKARTA

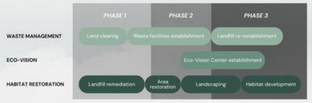
Muhammad Jamil, SIP.

ARCHITECTURAL PRESENTATION BOARD









SECTION	ARCHITECTURAL SOLUTION	NON-ARCHITECTURAL SOLUTION
Waste Management	Landfill Relocation	New Way of Managing the Waste
	Waste-to-Energy Plant	New Waste Management Policy
	Wastewater Treatment Plant	More Involvement from the Government and Community
Eco-Vision	Community Education Spaces	Education about Waste Management, Biodiversity, and Sustainability
	Community Engagement Spaces	In-depth Research about Waste Management and Biodiversity
	Offices & Labs	Collaboration between Community, Government, and Organizations
Habitat Restoration	Landscape	Environmental Remediation
	Habitat Features	Community Involvement
	Wildlife Corridors	Monitoring and Maintenance





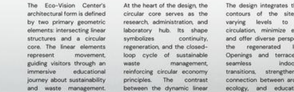




The Eco-Vision Center's architectural form is defined by two primary geometric elements intersecting linear structures and a circular core. The linear elements represent movement, guiding visitors through an immersive educational journey about sustainability and waste management. These structures house key visitor-oriented spaces, such as exhibition halls, galleries, and workshops, fostering interaction and exploration.

At the heart of the design, the circular core serves as the research, administration, and laboratory hub. Its shape symbolizes continuity, regeneration, and the closed-loop cycle of sustainable waste management, reinforcing circular economy principles. The contrast between the dynamic linear pathways and the stable circular core creates a balanced spatial experience, intuitively directing visitors while providing a sense of stability.

The design integrates the natural contours of the site, utilizing varying levels to enhance circulation, minimize excavation, and offer diverse perspectives of the regenerated landscape. Openings and terraces create seamless indoor-outdoor transitions, strengthening the connection between architecture, ecology, and education. This geometric composition embodies a transformation—turning waste into knowledge and degradation into renewal—while making sustainability an engaging spatial experience.



An odor reduction strategy integrates multiple natural and technological solutions to maintain air quality and create a comfortable environment. In outdoor areas like boardwalks, jasmine plants are used for their natural fragrance, which masks unpleasant odors while also improving air quality. Green walls and roofs further enhance odor control by absorbing airborne pollutants and filtering gases, reducing the spread of unwanted smells. Inside the building, activated carbon filters in the HVAC system trap odor-causing molecules, while a biofiltration system processes and neutralizes organic compounds, ensuring that air circulating within the building remains fresh.



ODOR REDUCTION STRATEGY



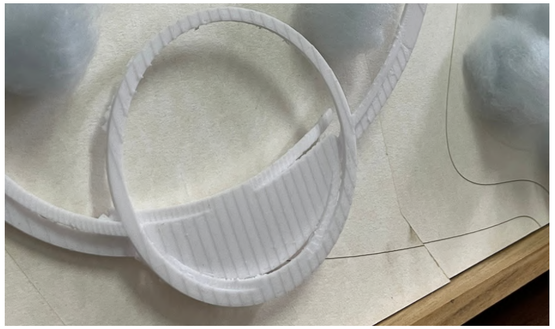
INTERIOR DETAILS

The interior design incorporates materials made from plastic waste, aligning with the closed-loop system by repurposing discarded plastics into functional and aesthetic elements. Recycled plastic is used for furniture, reducing reliance on virgin materials while diverting waste from landfills. These materials are durable, low-maintenance, and customizable, allowing for a visually appealing yet sustainable interior. By reintegrating waste into the design process, the building promotes a regenerative approach, where materials continuously circulate within the system, minimizing environmental impact and supporting a more sustainable future.

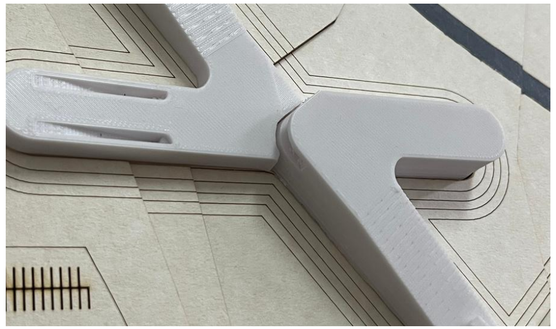



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FINAL ARCHITECTURAL DESIGN STUDIO 2025
THE DESIGN OF ECO-VISION
RESEARCH AND EDUCATIONAL TOURISM CENTER IN PYUNGAN LANDFILL 2.0
REVITALIZATION PROJECT USING REGENERATIVE ARCHITECTURE PRINCIPLES
PUTRI KINANTI SHINTA PRATIWI – 20512177
Supervised by Assoc. Prof.
Arif Budi Shalihah, S.T., M.Sc., Ph.D
REKA
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3D MODEL











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