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Design of an Educational Center for Recycling Inorganic Waste Using an Energy-Saving Architectural Approach

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Abstract—Environmental damage caused by waste occurs in Yogyakarta, starting with the closure of the Piyungan Final Disposal Site due to excess cargo that caused the city of Yogyakarta to experience an emergency condition rubbish. Responding to this, the Yogyakarta City government implementing zero inorganic waste rules starting January 2023. Where people are prohibited from throwing away inorganic waste and are encouraged to manage it independently or through a bank rubbish. However, in practice, society does not have it education about managing inorganic waste and waste banks has its own obstacles in managing inorganic waste. Through the Inorganic Waste Recycling Education Center, the aim is provide a formulation of the concept for designing public facilities serves to educate the public about recycling inorganic waste. Using data collection methods namely qualitative methods with the aim of this research being, to produced a concept for designing a Recycling Education Center Inorganic Waste that uses an Economical Architecture approach Energy to maximize the sustainability of life in the future will come. And help the government in efforts to reduce it waste volume in Yogyakarta City.

Keywords: education center; recycling; inorganic waste; energy saving.

1. Introduction

The waste problem is a challenge faced by every city, including Yogyakarta. The peak of the problem occurred due to the closure of the Piyungan Final Disposal Site in May 2022. The closure of the Piyungan Final Disposal Site resulted in the City of Yogyakarta experiencing a waste emergency because according to data from the Yogyakarta Environmental Service, Yogyakarta City is the district/city in DIY that produces the largest volume of waste. around 360 tons/day with a composition of 58% Organic Waste and 42% Inorganic Waste. Of the total waste of 360 tons/day, around 37,363 tons/day are managed by waste banks and pelapak, 100 tons are handed over to Piyungan Final Disposal Site. So the total unmanaged waste is 127 tons/day of organic waste and 95 tons/day of inorganic waste.

Table 1. Calculation of Unmanaged Waste

Trash Volume	Management Rubbish	Unmanaged Wasted
360 Tons/ Day	Waste Bank 37,37 Tons/ Day	Organic 127 Ton/Hari
	Piyungan 100 Tons/Day	Inorganic 96 Ton/Hari

Source: Sisnanto and Nurina, 2023

In response to this, the Yogyakarta City Government created a Movement for Managing Waste and Garbage with Biopori which is specifically for Organic Waste. The result is that organic waste is reduced by around 30%. Meanwhile, for Inorganic Waste, the government will implement a zero inorganic waste rule

starting in early January 2023. The rule is stated in the Yogyakarta Mayor's Circular Letter Number 660/6123/SE/2022 where the public is prohibited from throwing away inorganic waste, and must manage it independently or through a waste bank. However, in its implementation, the waste bank has not been able to educate the public at large about recycling inorganic waste and there is no place to accommodate the recycled work. And the community cannot manage their waste independently because of the lack of education about managing waste. Quoted from Lukas S. (2023, September 15) with resource person Yohanes Tola 'Trash, Sister City and Circular Economy' detikNews publication.

Looking at the problems above, a solution is needed, namely, presenting a facility that is able to provide management facilities in the form of education-based recycling of Inorganic Waste. Namely solid waste management strategy activities which consist of separation, collection, processing, distribution and manufacture of used products or materials and are the main components in modern waste management (Permadi, 2011). According to an article written by the Banten Province Environment and Hygiene Service entitled Inorganic Waste Management, several inorganic wastes that can be utilized through the recycling process are plastic waste, metal waste, glass or glass waste and paper waste.

When planning facilities in the form of buildings, it is necessary to pay attention to the negative impacts of development on the environment. Because buildings are objects that consume the most energy. The Energy Efficiency and Conservation Clearing House Indonesia in 2012 stated that the building sector absorbs 40% of the world's energy sources, even in Indonesia, this sector is responsible for 50% of total energy expenditure and more than 70% of overall electricity consumption. From this large amount of energy use, the building sector contributes to 30% of Green House Gas emissions in Indonesia.

So the development design will focus more on building energy conservation and efficiency efforts by implementing Energy Saving Architecture to create low energy buildings. Energy Efficient Architecture is an architectural typology resulting from the manifestation of Energy Conscious Design (Enggrila D. Magdalena and Linda Tondobala, 2016). Energy Saving Architecture is achieved by applying the principle of energy conservation through a design approach that can be divided into two, namely, Active Design where the building uses the help of technological tools that can control, reduce energy use and produce new energy and Passive Design where it relies on the building's own design capabilities. to be able to anticipate the external climate. This writing aims to create a design concept for the Inorganic Waste Recycling Education Center which accommodates educational facilities for inorganic waste recycling with an Energy Saving Architecture approach in an effort to reduce waste in the City of Yogyakarta and sustain life in the future.

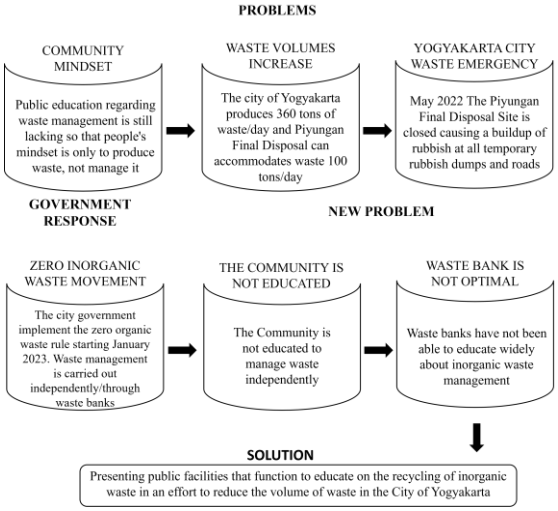


Figure 1. Background Scheme
Source: Sisnanto and Nurina, 2023

2. Methods

The method used in this writing is the data collection method using qualitative methods and discussion methods. The data collection is carried out by:

(1) Direct observation of final waste disposal site and waste banks as empirical examples of waste processing that has been carried out as well as observing the site or site that will be used for design, in order to obtain field data in the form of existing site conditions and be able to describe directly what the design concept is. both micro and macro.
(2) Conduct direct interviews with resource persons related to the waste collection community or waste bank managers to obtain information or obstacles and problems that occur during the work process.
(3) Collecting data by documenting the data that became the material for preparing this writing. How to document data by obtaining visual images from photos of conditions in the field
(4) Collecting data by studying literature obtained from various sources, including books, theoretical references, articles and the internet related to the topic of the Education Center for Recycling Inorganic Waste with an Energy-Saving Architectural Approach and building design standards.
(5) Data collection using Precedent Studies which is carried out through comparative studies or

comparisons of existing similar facilities, in order to obtain input that can be applied to the design and gain an understanding of the factors supporting the building's technical requirements.

The discussion method in this research was carried out in several stages, namely:

(1) Analysis stage, carried out with non-physical analysis, namely a general overview of the area and physical analysis, namely analysis and response to the site
(2) Concept Preparation Stage, namely the data and analysis results will be sorted and compiled into a planning concept which will be used as material and basis for making designs.

3. Results and Discussion

Existing Conditions

The site is on Jalan Batikan, Pandeyan Village, Umbulharjo District, Yogyakarta City. The site is empty land with an area of ± 9,100 m². Site boundary, North is bordered by Jl. Babaran and residents' houses. The east is bordered by a housing complex. The south is bordered by empty land and residents' houses. And to the west, it borders Jl. Batikan.

Figure 2. Existing Conditions
Source: Sisnanto and Nurina, 2023

The location selection is based on regulations in the Yogyakarta City Regional Spatial Planning Regulation for 2021 – 2041 concerning priority areas that must be prioritized for development and construction. For educational activity zones, the priority area is in Umbulharjo District with several land use functions, namely, trade and service zones, high density residential areas and medium density residential areas. So, in designing the construction of an Education Center in this zone, conditions are required in accordance with Yogyakarta Mayor Regulation No. 118 of 2021, namely:

a) Buildings are directed to implement the green infrastructure concept including the provision of green gardens on green roofs.
b) Buildings must not interfere with the function of Green Open Space (RTH) and must have access to the road.

Site Analysis

Site analysis was carried out to obtain super position mass and super position zoning concepts which are the result of combining the concepts of view response, solar response and wind response. Super position is used to determine a mass composition.

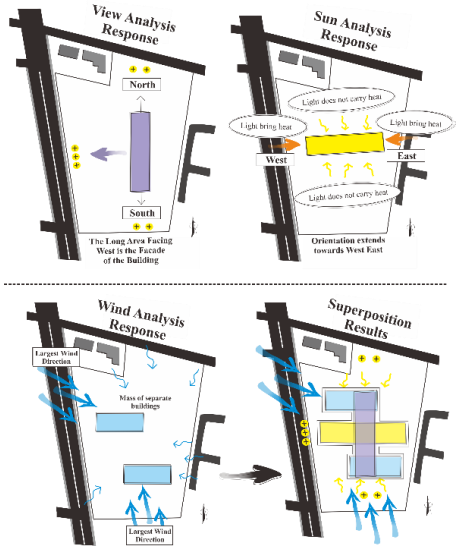


Figure 3. Super Mass Position
Source: Sisnanto and Nurina, 2023

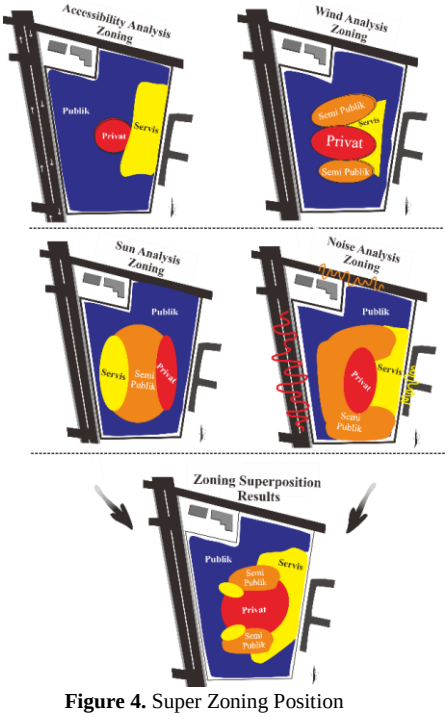


Figure 4. Super Zoning Position
Source: Sisnanto and Nurina, 2023

Mass Composition Concept

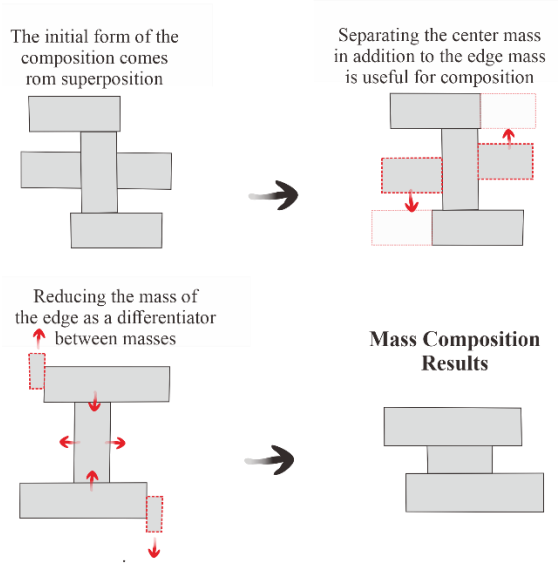


Figure 5. Mass Composition
Source: Sisnanto and Nurina, 2023

The resulting mass composition is given a volume with a central mass lower than the edge mass which is useful as a shade and adds a green rooftop in accordance with mayor regulations and in line with the concept of energy efficient buildings.

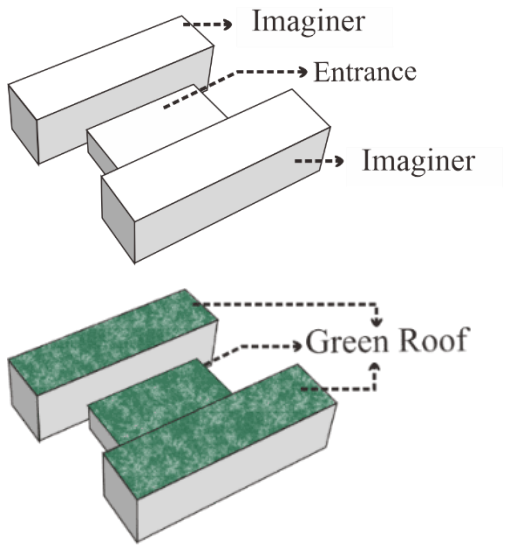


Figure 6. Mass Shape
Source: Sisnanto and Nurina, 2023

Space Program Concept

The participants in the activities at the Inorganic Waste Management Education Center are the general public and students. The required space is 8,950.77 m². To meet the space requirements, the building was made of more than one floor with reference to the Yogyakarta Regional regulations on the KDB and KLB sites. The main facilities in this building are exhibition space and workshop space.

Table 2. Space Program Concept

No	Types of Activity	Area
1.	Lobby Area	426,05 m²
2.	Educational Area	4.257,33 m²
3.	Recreation Area	1.366,15 m²
4.	Management Area	196,21 m²
5.	Service Area	954,9 m²
6.	Parking Area	1.750,14 m²
	TOTAL	**8.950,77 m²**

Source: Sisnanto and Nurina, 2023

Structure Concept

a) Lower Structure
The lower structure uses a footplate type of foundation because the site is in an urban area which has sandy soil. Footplates are installed at a depth of 2 m to reach hard ground, with footplate sizes of 150 x 150 cm², 120 x 120 cm² and 100 x 100 cm² which are based on footplate foundation calculations according to SNI-2847-2013.

b) Middle Structure
The middle structure uses a column and beam frame structure with plane elements using floor plates. Because the building has a length of 60 m² and the shape of the building is asymmetrical, a dilated column type is used to strengthen the structure which is placed at a distance of 30 m.

c) Upper Structure
The upper structure uses a concrete roof structure and steel frame with an extensive garden type green rooftop layer where the green roof is for plants or soft vegetation such as bushes, shrubs and grass.

Circulation Between Buildings

Circulation in the design of the inorganic waste recycling education center is divided into 2 circulations, namely:

a) General Circulation
In this circulation, users, namely car, motorbike and bus drivers, have different entry and exit access.

b) Service Circulation
In this circulation, service activities leading to the loading dock have the same entry and exit access as the 1-way route. Meanwhile, access for managers is via the main entrance.

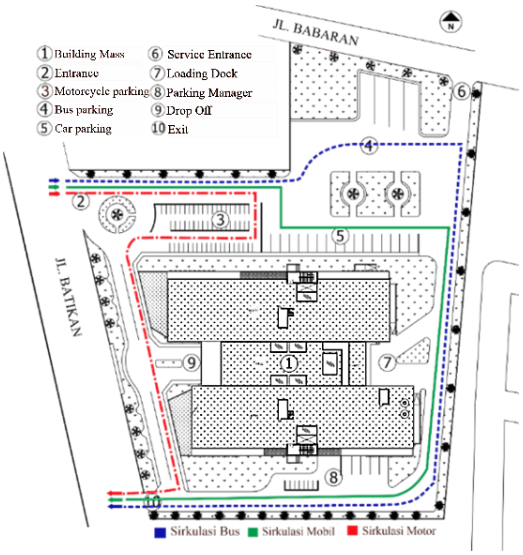


Figure 7. General Circulation Concept
Source: Sisnanto and Nurina, 2023

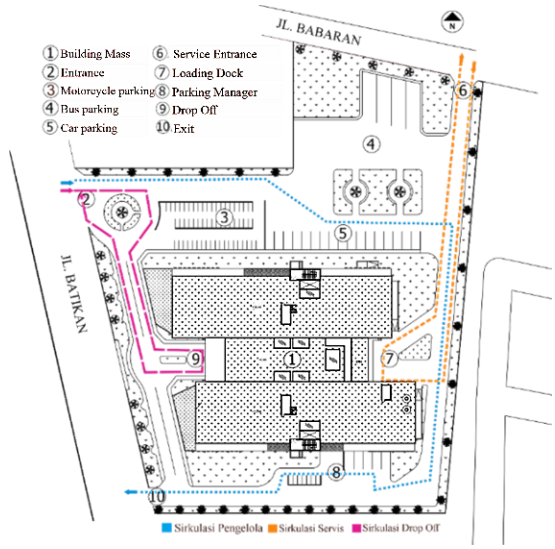
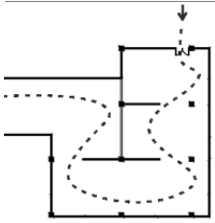


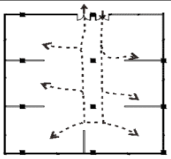
Figure 8. Servicel Circulation
Source: Sisnanto and Nurina, 2023

Interspace Circulation Concept

The circulation pattern between spaces used in the design of this building is Radial Organization. That is, users must pass through the lobby to get to other rooms in this building.

Table 3. Exhibition Hall Circulation and Interior

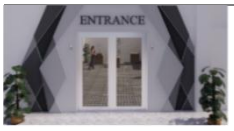
Exhibition Space Circulation	Exhibition Hall Interior
	

Paper Exhibition Hall Circulation	Interior of Paper Exhibition Hall
	

Source: Sisnanto and Nurina, 2023

The exhibition space in this building has directional signs for visitor circulation using texture and color at the entrance to the exhibition space.

Table 4. Exhibition Hall Entrance Concept

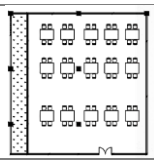
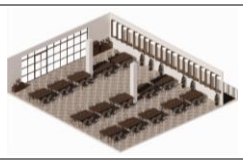
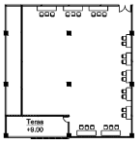
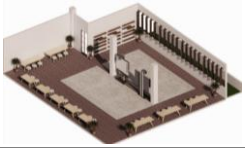
Plastic Waste Exhibition Hall	Paper Waste Exhibition Hall
	
Metal Waste Exhibition Hall	**Glass Waste Exhibition Hall**
	

Source: Sisnanto and Nurina, 2023

Workshop Space Layout Pattern Concept

The workshop room layout pattern in this building is divided into 2 patterns based on the type of activity, namely, the Rectangle layout pattern concept is used in the glass and metal workshop room which has activities with personal work space and little discussion. Meanwhile, the paper and plastic workshop room uses the Horse Shoe layout pattern because it has activities with a large work space and is carried out in groups.

Table 5. Workshop Space Layout Pattern Concept

Rectangle Layout Pattern	Rectangle Layout Interior
	
Horse Shoes Layout Pattern	**Interior Layout Of Horse Shoes**
	

Source: Sisnanto and Nurina, 2023

Energy Saving Architectural Approach Concept

In realizing buildings with energy saving principles, it is necessary to apply several design approaches. This building applies 2 designs, namely active design and passive design.

A. Active Design

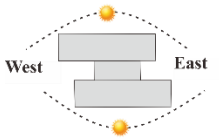
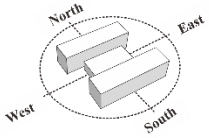
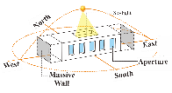
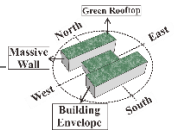
Table 6. Active Design Concept

Indicator	Design Concept
Artificial Lighting	Using LED type lights controlled by the Building Automation System
Artificial Ventilation	Using AC type X Daikin with Cop 4.71
Water Conservation	Recycle rainwater to flush toilets and water plants
	Applying magna tanks to facilitate the absorption and storage of water in the soil

Source: Sisnanto and Nurina, 2023

B. Passive Design

Table 7. Passive Design Concept

Indicator	Passive Design	
Mass	The long and slender building mass aims to evenly distribute light entering the building	
Orientation	The orientation of the building extends towards West East to prevent the building from being exposed to excessive sunlight	
Natural Lighting	Using transparent dividing walls	
	Apply light shelves for light distribution	
	Optimize openings towards North South	
	Applying Skylights to the roof of the building	
Heat Reduction	Applying Double Glazed Low E Glass with a U Value of 1.764	
	Applying building sheathing made of perforated aluminum	
	Apply shading to horizontal louvers screen type openings	
	Providing massive walls on the West and East sides	
	Applying a green roof as thermal insulation	

Source: Sisnanto and Nurina, 2023

Energy Saving Results

Through the EDGE application, the Inorganic Waste Recycling Education Center Building is able to save energy by 37.24% and is able to save water by 37.77% by implementing active design and passive design of the building.

Effectiveness of Building Functions

The function of the building, which is the Inorganic Waste Recycling Education Center, is expected to be able to reduce the volume of waste in the city of Yogyakarta by educating the public who visit this building. Data from SNI 19-3983-1995, the volume of waste per person/day for household classification is 0.4 kg. Meanwhile, it is assumed that 1,100 people/day visit the education center. Based on calculation results, 1,100 visitors to the education center building/day can reduce the volume of waste by around 440 kg/day or 0.44 tonnes/day.

4. Conclusion

The design concept for the Inorganic Waste Recycling Education Center with an Energy Saving Architectural Approach is focused on strategic location, functionality, and sustainability. The building is located on Jl. Batikan, Pandeyan Village, Umbulharjo District, Yogyakarta, occupying a land area of approximately 9,100 m² with a Building Coverage Ratio (KDB) of 80%, a Floor Area Ratio (KLB) of 3.5, and a Green Area Ratio (KDH) of 10%. It spans 8,950.77 m² and accommodates up to 1,100 users, including the general public and students,

offering three main facilities: exhibition space, workshop, and retail area. The structure consists of two and three floors with a single building mass and a green roof, aligning with local regulations and reflecting energy-efficient design principles.The foundation system utilizes a footplate structure with a depth of 2 m to adapt to the sandy soil conditions, incorporating column dilatation due to the asymmetrical building shape and its length of over 30 m. Energy savings are achieved through active and passive design strategies. Active measures include the implementation of LED lighting, a Central AC system with a COP of 4.71, and rainwater recycling. Passive strategies emphasize the use of a slender mass oriented longitudinally from west to east, with openings placed on the north and south sides. Transparent dividing walls, light shelves, and skylights enhance natural lighting, while double-glazed Low-E glass with a U-Value of 1.764, perforated aluminum envelopes on north-south openings, vertical shading, and massive walls on the west side minimize heat gain. Additional cooling effects are achieved through the use of a green roof, a vertical deep pool, and voids in the roof for thermal insulation and airflow. This energy-efficient design enables the building to save 37.42% of energy and 37.77% of water. Furthermore, it is estimated to reduce the volume of inorganic waste in Yogyakarta City by approximately 440 kg per day, equivalent to 0.44 tonnes per day.

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