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ECOBRICKS AS A SUSTAINABLE SOLUTION: DESIGNING AN ECO-FRIENDLY READING GARDEN TO REDUCE PLASTIC WASTE

Dwi Ariyani*, Resti Nur Arini, Rini Trisno Lestari, Fadli Kurnia

Department of Civil Engineering, Universitas Pancasila

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***Corresponding author**
Dwi Ariyani
Email:
dwi.ariyani@univpancasila.ac.id

Abstract

The increasing population from year to year has led to a rising demand for housing. Alongside this population growth, there has been a concurrent increase in waste production, particularly plastic waste discarded into the environment. In order to achieve SDG Goal 11, community engagement activities are being conducted. These activities occur within the Ecovillage Karawang community, a network dedicated to environmental preservation and plastic waste recycling. The methods employed include surveys, literature reviews, and the application of Ecobricks. Previously, community engagement activities involved providing tools for plastic shredding and Ecobrick production, but these were limited to residual plastic bottles and hard plastics. This community engagement project (PKM) aims to design and construct a 2.5m x 2.5m reading garden using Ecobricks as a building material. The aim of this PKM program is to provide multiple benefits through a single activity, specifically the application of Ecobricks as a construction material and the reduction of plastic waste through the reuse of ecobricks. This PKM project determined that 105 kg of plastic waste, including wrappers from candies, beverage sachets, plastic bags, and packaging, were used in constructing the reading garden. It, of course, contributes significantly to reducing plastic waste in the environment.

Keywords: *Ecobrick; Literacy; Plastic Bottle; Reading Garden; Reuse*

INTRODUCTION

To achieve SDG's 11, Sustainable Cities and Communities, with a target achievement by 2030 (Sutopo et al., 2014). In order to reduce the per capita environmental impact in urban areas, particularly concerning air quality and municipal waste management, special attention is needed to address the detrimental impact of plastic waste on the environment. To achieve SDG 11, community engagement activities are carried out. These activities are conducted within the Ecovillage Network (Jangkar) community in Karawang, which is dedicated to environmental conservation and recycling plastic waste. However, a challenge arises from the lack of knowledge among Ecovillage members regarding proper plastic waste recycling. Typically, they separate plastic waste with economic value from non-recyclable plastic waste, such as used plastic bags and other types of plastic that cannot be recycled. Therefore, further technology is required to make this waste beneficial to the community (Wijaya et al., 2021), possibly as eco-friendly building materials. Another issue in this area is the absence of a library due to the distance of schools from the community, where most parents work as scavengers. As a result, there is a lack of interest in reading books.

The Community Partnership Program (PKM) will be implemented in the EcoVillage of Tanjung Mekar, located in Tanggul Jaya Village, Karawang West District, Karawang Regency, approximately 65 km from Pancasila University. Tanjung Mekar District is near the Citarum River, which is internationally renowned for being the fourth most polluted river in the world, posing significant environmental challenges (Idris et al., 2019). The waste polluting the Citarum River consists mostly of inorganic or non-biodegradable materials, such as plastic, bottles, beverage containers, food packaging plastic, and

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so on. Plastic waste is extremely difficult to decompose, taking more than 100 years to break down fully. Incinerating plastic waste will only worsen the situation due to the toxic dioxins produced. Therefore, the appropriate method to address plastic waste is the Ecobrick method (Antico et al., 2017), Which uses plastic waste as a building material. (Dhanalaxmi et al., 2019; Wulandari et al., 2023). Waste management requires active participation from the community (Nalhadi et al., 2020; Ristanto et al., 2022; Suminto, 2017). Through this understanding, the community can assist in waste sorting, reduce the use of single-use plastics, and engage in education and campaigns that promote environmentally friendly behaviors (Widyowanti et al., 2022). With their active involvement, we can effectively address the waste issue.

The EcoVillage Tanjung Mekar is an environmentally conscious community located in a scavenger area where a waste bank has already been established. The EcoVillage Tanjung Mekar area has land donated by local residents for the productive and environmentally beneficial development of waste processing. As mentioned in summary, in a previous Community Partnership Program (PKM), EcoVillage Tanjung Mekar received a grant in the form of ecobrick production equipment, including plastic shredders and semi-automatic presses for making ecobricks with dimensions of 20 cm x 20 cm. Because there is only one type of mold, the produced products are of a single variety. Therefore, molds with different shapes or dimensions are needed to diversify ecobrick production. Previous research on eco-brick materials has shown that plastic waste, such as plastic bottles filled with plastic, sand, or soil, results in a stronger material compared to other building materials on the market (Ariyani et al., 2021). Other research has also indicated that waste Polyethylene Terephthalate (PET) bottles packed with other dry solid waste or sand and soil have been successfully used in several countries worldwide and are more sustainable (Antico et al., 2017; Chaudhary et al., 2017; Muyen et al., 2016). Developing building materials utilizing plastic waste is crucial for a better environment. Another equally important issue is that most local residents work as scavengers, and the surrounding community highly appreciates the presence of a waste bank and the EcoVillage Tanjung Mekar area. Many children are actively participating in scavenging or assisting their parents in sorting waste in EcoVillage Tanjung Mekar. Children have more leisure time, especially with 50% of schools being conducted online. Therefore, there is a need for beneficial activities that can enhance these children's knowledge during their free time. The partner's facility includes land that can be used for a reading garden, which the community has donated. Research related to the role of community reading gardens has shown that they play a vital role in developing an interest in reading (Nalhadi et al., 2020; Septiarti et al., 2020). In line with the utilization of ecobricks and the community's need for meaningful activities while in EcoVillage Tanjung Mekar, along with their parents, it is proposed to create a reading garden measuring 3m x 2m. This reading garden would be equipped with bookshelves and knowledge-based reading materials for children. Importantly, the reading garden would utilize ecobricks as one of its building materials.

METHOD

The implementation method involves both the approach and design stages, including creating ecobricks (Figure 1). In the site survey and mapping phase, there are two survey agendas. The first survey aims to determine the development needs of ecobrick products concerning the required dimensions. This survey seeks detailed information regarding the types of ecobrick products that are in high demand within the community. The second survey is conducted to identify the location and land area that will be used for setting up the reading garden, as well as the placement of ecobricks around the garden area. For the ecobrick building design, measurements are taken to determine the actual dimensions and area that can be constructed. The design of the reading garden includes the design of spaces for interacting with books, entrance design, the surrounding environment utilizing ecobricks, and the overall landscaping around the reading garden. In the creation of ecobricks, used plastic bottles and non-recyclable plastic waste, such as candy wrappers, plastic bags from reading materials, and other types of plastic are used.

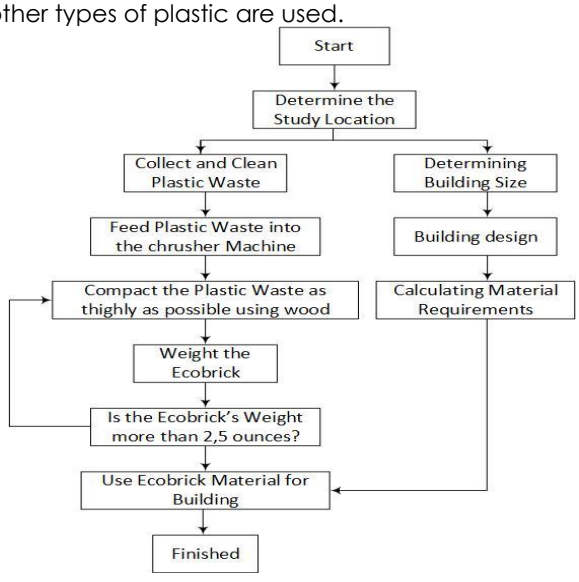

Figure 1. Flowchart of implementation method

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RESULT AND DISCUSSION

Reading Garden Design

In the previous Community Partnership Program (PKM), there were already tools for shredding and making ecobricks. The team from Pancasila University's Civil Engineering department provided direct guidance and experimented with various methods and compositions involving plastic, cement, sand, and water to assess the strength of ecobricks compared to those without plastic. Various mold samples were subjected to laboratory testing, and research comparing the strength of ecobricks with conventional building materials available in the market was also conducted (Ariyani et al., 2021).

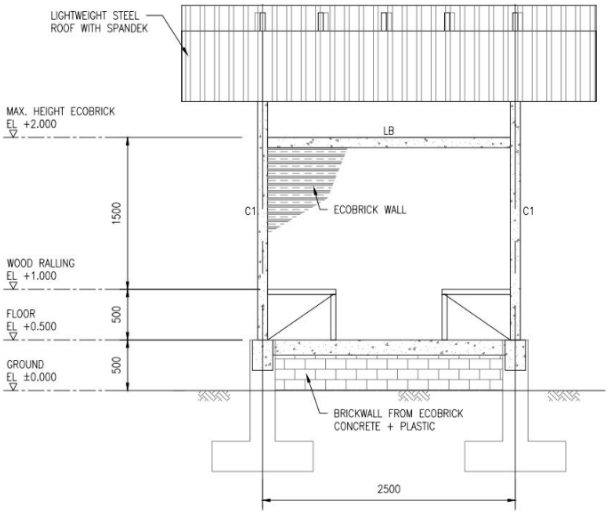

Figure 2. Front view of the reading garden building design using ecobricks

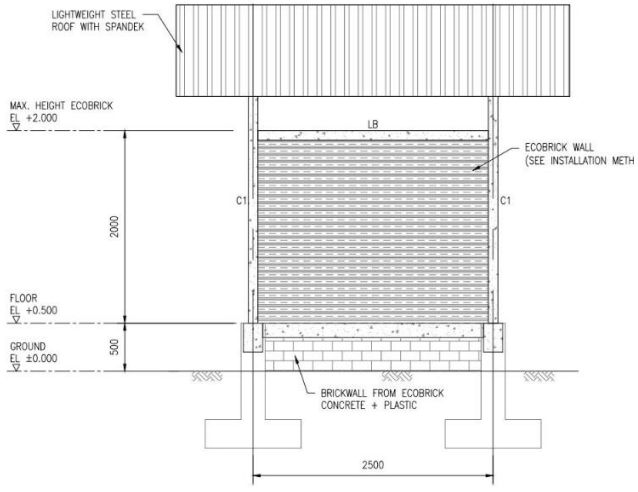

Figure 3. Back view of the reading garden building design using ecobricks

Based on the actual design, the reading garden is planned to have dimensions of 2.5 x 2.5 meters (Figure 2, Figure 3, and Figure 4). The arrangement method of ecobrick bottles can be seen in Figure 5. Utilizing the wood available in the surrounding environment. High-quality wood will be selected for construction to ensure that the building lasts for at least 15 years. If the existing wood is insufficient, additional wood may be purchased from outside or within the vicinity of EcoVillage Tanjung Mekar. Student involvement will include assisting with building construction, particularly in crucial stages such as lifting, wood joining, and roof construction.

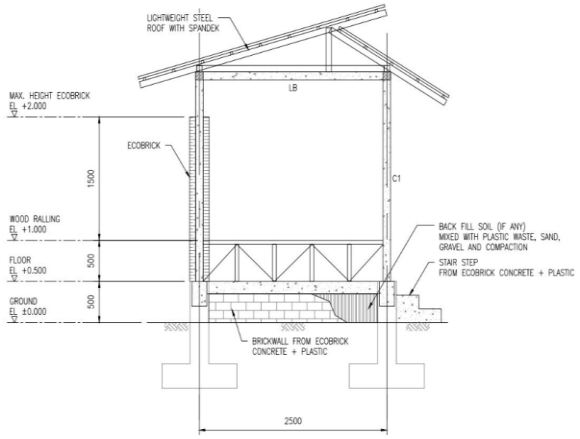

Figure 4. Side view of the reading garden building design using ecobricks

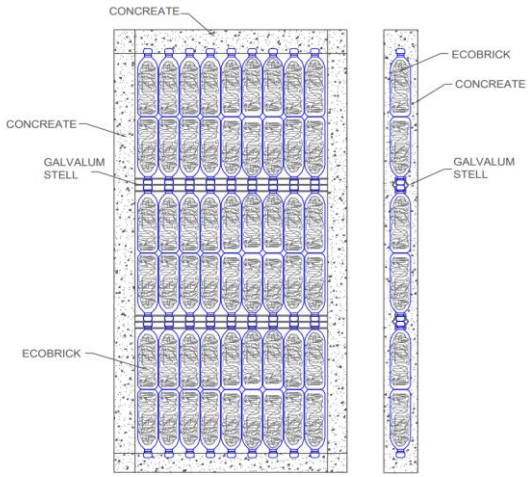

Figure 5. The arrangement method of ecobrick bottles

Structural Calculation

The design of the modeling frame is shown in Figure 6. The frame analysis is conducted using a supporting program, and the obtained force values are shown in Table 1. The modelling results show that the maximum force occurs in bar 41, which experiences a compressive force of -8738.66 N. Based on the design data, control will be performed on the bending of bar 41.

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Table 1. The values of bar forces

Bar frame	Bar Force (N)	Bar Frame	Bar Force (N)
19	-8738.64	41	-8738.66
20	-6213.43	42	-6213.41
20	-754.79	43	2907.74
21	2907.74	44	-3735.19
22	-3735.19	45	0.002388
23	0.002388	46	-3204.79
24	-3204.79	47	0.001017
25	0.001017	48	-294.63
26	-294.63	56	-337.91
		58	-213.17

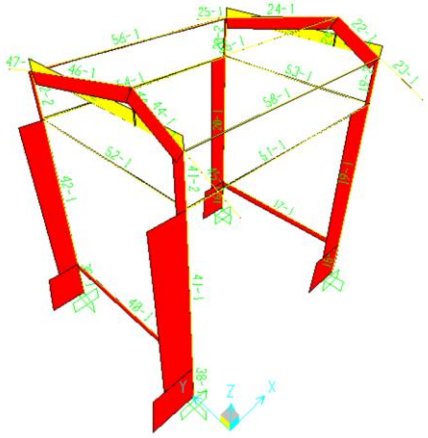
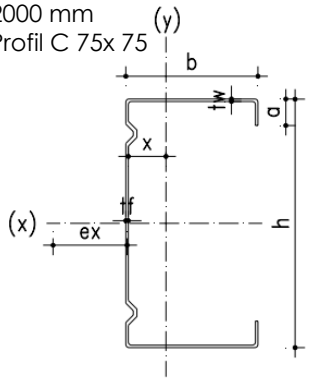


Figure 6. Frame modelling

Compression Bar Analysis

Bar Force (P) : -8738,66 N
length of the bar. : 2000 mm
design profile : Profil C 75x 75



Profile Data:
h = 74,14 mm
b = 39,28 mm
a = 10,38 mm
t = 0,73 mm
A = 124,494 mm²
Ix = 115618,946 mm⁴
Iy = 27791,423 mm⁴
Fy = 500 MPa
E =203000 MPa

Buckling check in the Y-direction against axial force

$$Py_{cr} = \frac{\pi^2 . E . I_y}{(K_y . L_y)^2}$$

$$Py_{cr} = \frac{3{,}14^2 x 203000 x 27791{,}423}{(1.2000)^2} = 13906{,}1249\ N$$

$$Fe_y = \frac{Py_{cr}}{Ae}$$

$$Fe_y = \frac{13906{,}1249}{139{,}03} = 100{,}022\ MPa$$

$$Fp_y = 0{,}833(Fe_y)$$

$$Fp_y = 0{,}833(100{,}022) = 83{,}319\ MPa$$

$$Conditions: Fp_y \leq {}^{Fy}/_{2}$$

$$Conditions: 83{,}319 \leq 250$$ (Fay=Fpy)

$$Cr_y = \emptyset . A_e . F_{ay}$$

$$Cr_y = 0{,}9x139{,}03x83{,}319 = 10425{,}422$$

$$Cr_y > P_{load}$$

$10425{,}422 > 8783{,}6$ (Safe)

The bending force in the Y-direction is expressed as **SAFE**

Buckling check in the X-direction against axial force

$$Px_{cr} = \frac{\pi^2 . E . I_x}{(K_x . L_x)^2}$$

$$Py_{cr} = \frac{3{,}14^2 . 203000 . 115618{,}946}{(1.2000)^2} = 57852{,}795\ N$$

$$Fe_x = \frac{Px_{cr}}{Ae}$$

$$Fe_x = \frac{57852{,}795}{139{,}03} = 416{,}117\ MPa$$

$$Fp_y = 0{,}833(Fe_y)$$

$$Fp_x = 0{,}833(416{,}117) = 346{,}626\ MPa$$

$$Condition: Fp_y \leq {}^{Fx}/_{2}$$

$$Condition: 346{,}626 \geq 250\ (Fa_x\ counted)$$

$$Fa_x = Fy - \left(\frac{Fy^2}{4.Fp_x}\right)$$

$$Fa_x = 500 - \left(\frac{500^2}{4x346{,}626}\right) = 319{,}690$$

$$Cr_x = \emptyset . A_e . F_{ax}$$

$$Cr_x = 0{,}9x139{,}03x319{,}690 = 40001{,}883$$

$$Cr_x > P_{load}$$

$40001{,}883 > 8783{,}6$ (Safe)

Bending force in the X-direction is stated to be **SAFE**

Making Ecobrick

Once the land area has been determined and the community has been educated on the proper method of making ecobricks (Figure 7 and Figure 8), the next step is to guide the installation of ecobricks around the reading garden. In collaboration with the local community, the PKM team will offer assistance in installing ecobricks around the reading garden (Figure 9). Testing has been conducted on ecobricks compared to concrete bricks and red bricks, and the results indicate that the highest compressive strength is 41.2 MPa for plastic bottles. It surpasses the compressive strength of red bricks, 27 MPa, and concrete bricks, 38 MPa (Ariyani et al., 2021). Ecobricks are a recycling method that transforms plastic bottles into solid, sturdy bricks or blocks. (Kamble & Karad, 2017; Sakuntalawati & Ibad, 2021). These ecobricks can then be used in various construction or design projects (Muyen et al., 2016; Sari et al., 2023; Yusuf et al., 2020).

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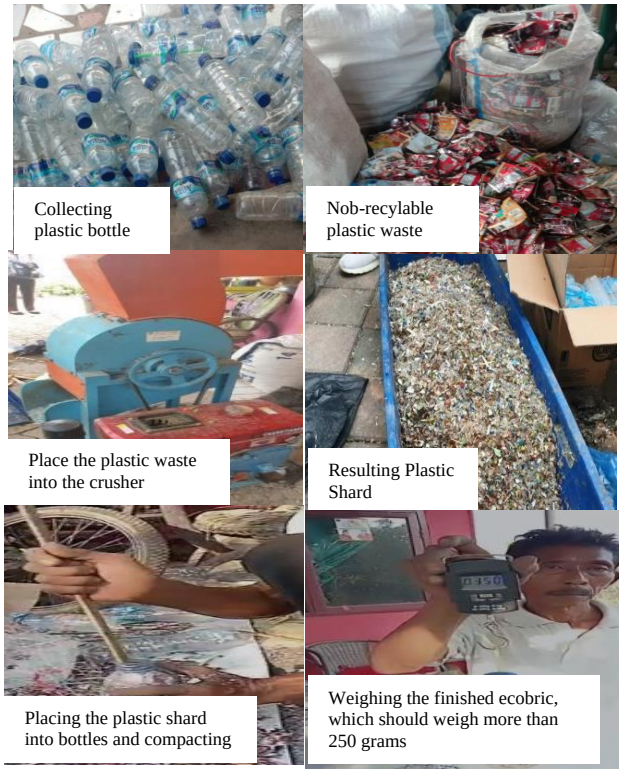

Figure 7. Steps in making ecobricks

Figure 8. Ecobrick results for the reading garden

Figure 9. Ecobricks that have already been applied for the reading garden

From the results of this PKM activity, it is known that the amount of plastic waste used to construct the reading garden includes 300 used 600ml Aqua plastic bottles and 100 kg of plastic waste in the form of candy wrappers, sachet drink packaging, plastic bags, and other plastic types, with an average weight of 350 grams per ecobrick. Therefore, the total weight of plastic waste used to build the reading garden is 105,000 grams or 105 kg of plastic waste.

Partner Assessment

The evaluation of the Ecobrick Implementation program is conducted by considering several indicators: (1) The number of people directly involved, from the time of education and mentoring to the construction phase, the number of people involved during the socialization phase is 15, two of whom are instructors from Pancasila University. In the construction phase, there are 5 individuals involved, including landowners, village officials, and 3 craftsmen. (2) Assessing the community's ability to implement the established Standard Operating Procedures (SOP). At least 60% of the trained individuals are expected to implement the SOP effectively for making ecobricks (Mumtaz et al., 2017). (3) Understanding the benefits of ecobricks in reducing plastic waste in the surrounding community. (4) The comprehension, perception, and participation of children in the Tanjung Mekar Ecovillage area regarding the presence of the Reading Garden. The evaluation is carried out by direct observation during trials, training, and education on the SOP for ecobrick production. Additionally, surveys are distributed to the local community and children in the Tanjung Mekar Ecovillage environment. The overall solutions and changes resulting from the community engagement activities are shown in Table 2 and Table 3.

Table 2. Solutions and service

Problem	Solution	Outcome
Limited skills and knowledge regarding recycling within the ecovillage community lead to non-recyclable waste ending up in landfills, increasing the waste burden.	Providing guidance and support for creating ecobric materials that can be easily made and applied within th community using non-recyclable plastic waste, such as candy wrappers and packaging materials.	The composition of ecobrick materials, whether with a mixture of cement or full plastic, using recycled plastic bottles.

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Table 3. Changes resulting from community engagement activities

No	Initial Condition	Intervention	Change
1	Lack of knowledge about recycling non-recyclable plastic waste	Providing knowledge about eco-friendly building materials that can reduce non-recyclable plastic waste	Increasing community awareness of how to utilize non-recyclable plastic waste
2	Lack of equipment for making and molding ecobricks	Adding new ecobrick molding equipment, previously with dimensions of 20 cm x 20 cm x 6 cm, now expanded to include dimensions of 20 cm x 10 cm x 6 cm	Producing building materials derived from plastic waste tailored to the design needs of buildings, making them easy to apply to structures of various designs
3	Low awareness and skills among the community in recycling waste	Providing skills to the local community on how to create sturdy ecobricks based on previous compression strength tests	Equipping the community with the skills to transform plastic waste into other economically valuable forms that can be easily applied in the local environment for building purposes
4	Limited community capacity to design reading garden buildings using ecobricks	Designing environmentally-friendly reading garden buildings that the local residents can use	Creating environmentally friendly reading garden structures by utilizing plastic waste from the surrounding environment

CONCLUSION

The increasing population from year to year has led to an increased demand for housing and has also increased the amount of waste, especially plastic waste, discarded into the environment. To achieve Sustainable Development Goal (SDG) 11, which is Sustainable Cities and Communities, special attention is needed to environmentally harmful plastic waste, and one of the solutions is to use ecobricks as building materials. Community engagement activities are carried out in the Jaringan Kerja (Jangkar) Ecovillage Karawang community to recycle plastic waste into ecobricks. Assistance is provided in creating ecobricks from non-recyclable plastic waste, such as candy wrappers and plastic bags. In addition to addressing the plastic waste problem, this program aims to build a reading garden using ecobricks as building materials, providing dual benefits. From the results of this community engagement activity, it is known that a total of 105 kg of plastic waste was used in constructing the reading garden, including candy wrappers, sachets, plastic bags, and packaging materials. This initiative can undoubtedly reduce the amount of plastic waste in the environment and increase income. The program evaluation encompasses the number of community members involved, their ability to implement ecobrick production, the community's understanding of the benefits of using ecobricks, and children's participation in the reading garden project. This community engagement is a physical project and a long-term investment in social, economic, and sustainable environmental development in the Tanggul Jaya Village, Tanjung Mekar Subdistrict, West Karawang. This program provides a solution to reduce the negative impact of plastic waste on the environment. This activity can reduce about 20% of the plastic waste in the environment, with approximately 105 kg of plastic waste being used to create a reading garden, while also increasing community knowledge and involvement in environmental conservation, while also increasing community knowledge and involvement in environmental conservation. Through community service activities, it is hoped that there is an awareness that non-recyclable plastic waste can be utilized to create other more useful forms with economic value. For the next activity to be carried out, we will conduct a trial using different types of plastic waste to be used as building materials and assess the strength of the resulting material, making it safe and widely usable by the general public.

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