Journal of Social Research
P-ISSN: 2827-9832
E-ISSN: 2828-335x
http://ijsr.internationaljournallabs.com/index.php/ijsr

THE POTENTIAL UTILIZATION OF PLASTIC WASTE AS A BUILDING MATERIAL

Sang Kompiang Rizki Putra Atmaja[1], Warmadewanthi, IDAA[2*]
[1,2]Departement of Environmental Engineering, Institut Teknologi Sepuluh Nopember
[*] warma@its.ac.id

ABSTRACT

One of the innovations in utilizing plastic waste is to process it into Plastic Blocks for Wall Pairs (BPBPD). This research aimed to analyze the temperature required in melting used plastic and cooking oil for making BPBPD mixtures. Variations in the research are temperature under the range 180°C, 200°C, and 220°C. Comparison of the proportions of the mixture of plastic, oil, and coarse aggregate 5-10 mm, namely 1.5:1:0.5, 1:1:0.5, and 1:1:0.25. The types of plastic used are plastic bags, aluminum-coated plastic, and mica plastic. The parameters in this study are the compressive strength value, the initial rate of suction (IRS) value, the porosity value, and the water absorption rate. The study results showed that the minimum temperature for melting plastic bags and aluminum is 180°C, and for melting mica plastic is 220°C. The recommended proportion for making this BPBPD is a ratio of 1.5:1:0.5. The results of the IRS test on the plastic bags BPBPD ranged from 0.037-0.057 Kg/m2, the aluminum plastic BPBPD 0.030-0.057 Kg/m2, and the mica plastic BPBPD 0.033-0.043 Kg/m2. The water absorption rate for plastic BPBPD ranges from 0.233-0.378%, aluminum plastic BPBPD 1.644-4.233%, and mica plastic BPBPD 1.233-2.756%. Porosity results from the plastic bag BPBPD ranged from 0.355-0.931%, the aluminum plastic BPBPD 10.83-12.1%, and the mica plastic BPBPD 2.25-3.9%. In general, the compressive strength of BPBPD plastic bags, both without and with immersion, meets the minimum average compressive strength according to BSN 1989 with quality IV with the highest value in the 1.5:1:0.5 mixture of 38.2 Kg/cm^2.

Keywords: *utilization, plastic waste, building material*

INTRODUCTION

The waste problem is crucial. In fact, waste can be said to be a cultural problem because its impact affects various aspects of life, especially in big cities of Indonesia such as Jakarta, Semarang, Surabaya, Bandung, Palembang, and Medan. The most sources of waste are those from settlements, the composition of which is 75% consisting of organic waste and the rest is inorganic waste (Patwa et al., 2020). Organic waste is widely used as material for making compost, briquettes, and biogas, but inorganic waste is still minimally managed. Inorganic waste is very difficult to degrade or even cannot be degraded by nature at all, therefore a very wide landfill is needed to offset the production of this type of waste. The most common inorganic waste in society is plastic waste (Lucien, 2022).

Likewise, community involvement in reducing the use and recycling of plastic is still very minimal. Usually, plastic is burned to destroy it from view. Plastics are widely used in various kinds of human life needs. Starting from food packaging materials to automotive material needs. Plastic is the most popular and most widely used material for making automotive components besides metal in the form of iron (Alqahtani et al., 2015). The main problem with plastic is plastic waste, which cannot be decomposed naturally. It takes a very long time to clean up plastic waste from the face of the earth (Stafford & Jones, 2019).

Plastic pollution has also been identified as one of the world's top ten environmental threats, causing significant and widespread impacts on the world's ecosystems and wildlife, despite the increasing amount of non-packaged agri-plastic waste and the uncertainty around its impact on the environment by reducing the use of single-use agricultural plastics (Kaščak et al., 2021). The results of research on plastic waste management can be carried out using an executive management strategy with community representatives to deal with environmental pollution.

METHOD

Materials

The materials used are used thin plastic obtained from TPS3R Bumi Daup Lestari. The types are crackle plastic, aluminum-coated plastic, and mica plastic. The selection of these plastics is based on their light and thin characteristics (classified as LDPE types) so they are easier to melt. In the making process, the sample is mixed using different types of plastic, with used cooking oil, and used an aggregate of concrete. The desired sample characteristics are in accordance with the physical properties of solid concrete as shown in Table 1.

Table 1 Solid Concrete Brick Physical Requirements

Physical Requirements	Unit	Solid Concrete Quality Level			
		I	*II*	*III*	*IV*
Min. Average Compressive Strength	Kg/cm^2	100	70	40	25
Gross Press Strength	Kg/cm^2	90	65	35	21
Average Water Absorption, Max	%	25	35	-	-

Preparation and Mix Design

This research was conducted with the purpose of knowing the minimum temperature for melting plastic, knowing the recommended proportions, and BPBPD characteristics such as Initial Rate of Suction (IRS), water absorption rate, porosity, and compressive strength (Patwa et al., 2020). The first step that needs to be prepared is to prepare tools and materials, namely used cooking oil, chopped plastic, and used concrete aggregate. Specific gravity and viscosity tests were carried out for used cooking oil, plastic specific gravity tests, and used concrete aggregates as well as abrasion tests for aggregates (Toruan et al., 2013).

The next step is to determine the proportions of the material, using the composition according to Table 2 which explains the proportions of the used cooking oil mixture, the type of plastic, and the used concrete aggregate (Safi et al., 2013).

Table 2 Mixed Proportions

Temperature	Proportion (Plastic + Oil + Aggregate)		
	I	*II*	*III*
180^oC	1,5: 1: 0,5	1: 1: 0,5	1: 1: 0,25
200^oC	1,5: 1: 0,5	1: 1: 0,5	1: 1: 0,25
220^oC	1,5: 1: 0,5	1: 1: 0,5	1: 1: 0,25

The proportion in mixture I consists of 350 grams of plastic: 250 grams of oil: 100 grams of aggregate, for mixture II 300 grams of plastic: 300 grams of oil: 100 grams of aggregate, and in mixture III 325 grams of plastic: 325 grams of oil: 50 grams of aggregate. Of these three types of proportions, different types of plastic are used in the mixture, using plastic bags, aluminum-coated plastics, and mica plastics (Siddique et al., 2008).

After the mix design is made, the sample is then poured into a cube-shaped mold with dimensions of 10 x 10 x 8 cm. The sample is then allowed to stand for about 3-5 minutes before applying a pressure of 106.87 kg using a press with the aim of minimizing the presence of cavities in the BPBPD test object and flattening its surface.

Figure 1 Press Tool

Figure 2 BPBPD Specimen

Testing Method

Initial rate of suction (IRS)

The purpose of this test is to determine the amount of water absorption of the test object, so that later it can determine whether the block of plastic material needs to be soaked first or not when bonded with sand and cement mortar.

$$IRS = \frac{(W.wet - W.after\ curring)}{A}$$

Where, IRS = initial absorption rate (Kg/m^2.minute), Wwet = weight after being immersed in water as high as 3 mm for 1 minute (Kg), Wdry = weight of dry sample, A = area submerged in water (m^2)

Water Absorpption Rate

Tests for water absorption levels are carried out with the aim of knowing the level of absorption by the test object, namely blocks of plastic material, where the percentage of water absorption from blocks of plastic material must not exceed the maximum water absorption limit according to the level of each physical quality (Sikalidis et al., 2002). The percentage of water absorption on the test object based on the volume ratio is calculated by the following formula:

$$Abs = \frac{Ww - Wd}{Wd}\ x\ 100\%$$

Where, Abs = water absorption (%), Ww = specific gravity of the sample after submerging (gr), Wd = dry sample weight.

Porosity

Porosity is a condition in which an object becomes porous so that liquid can escape, or the ability of a block of plastic material to allow water to pass through. Porosity calculation is carried out based on the total weight of the mixture with the following formula (Krebs & Walker, 1971)

Porosity (%) = void in mix or void in mix (VIM)

$$\text{Porosity (P) \%} = \frac{SG_{mix} - D}{SG_{mix}} = \left(1 - \frac{D}{SG_{mix}}\right) x100\% \text{ to the bulk sample volume}$$

Where, P = porosity (%), D = sample density (gr/m^3), Sgmix = max mix density (gr/cm^3), a,b,c = percentage of material from the components of the mixture.

Compressive Strength Test

In the BPBPD compressive strength test, the compressive load (P) received per unit area (A) causes the specimen to be crushed. The test object is used in its original form. An illustration of the BPBPD compressive strength test can be seen in the following figure.

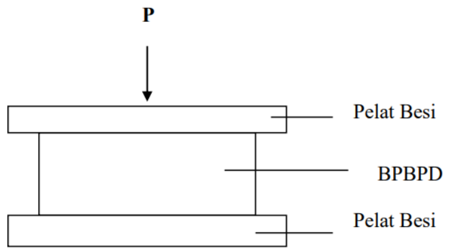


Figure 3 Compressive Strength Test BPBPD

BPBPD compressive strength is calculated using the following formula:

$$\sigma^1 bp = \frac{P}{A}$$

Where, F = compressive strength (Kg/cm^2), P = maximum load (Kg), A = compressive area (cm^2).

RESULTS AND DISCUSSION

Material Physical Properties Test

Based on the specific gravity test of plastic and used cooking oil is presented in Table 3 as follows.

Table 3 Results of Examination of Weight of Plastic and Used Cooking Oil

Inspection	Plastic Type			Cooking Oil
	Crackle (A)	*Aluminium Plated (B)*	*Mica (C)*	
Specific Gravity (SG)	0,91	0,89	0,92	0,918

To find out the viscosity of used cooking oil, it was tested using the Saybolt Furol tool and made a comparison between used cooking oil and new oil (Calero et al., 2014). The viscosity value is obtained from the flow time (seconds) of a certain amount (60 ml) of oil correlated with the Kinematic Viscosity Value (SNI 06-06721-2002). The test results are presented in Table 4, where used cooking oil has a thinner consistency than new cooking oil.

Table 4 Oil Viscosity Check Results

No	Test Material	Temperature (Celcius)	Flow Time (Second)	Viscosity (Centistokes)
1	Cooking Oil	30°	219	46,8
2	Oil	30°	244	52

Next inspection of the aggregate material, to determine the specific gravity of the aggregate, is carried out by a sieving process with the aggregate retained on the No. sieve. 4 (4.75 mm) to find the weight in water and the aggregate SSD weight (Arafa et al., 2017). Then an abrasion test was carried out using a Los Angeles machine.

Table 5 Aggregate Specific Gravity Inspection Results

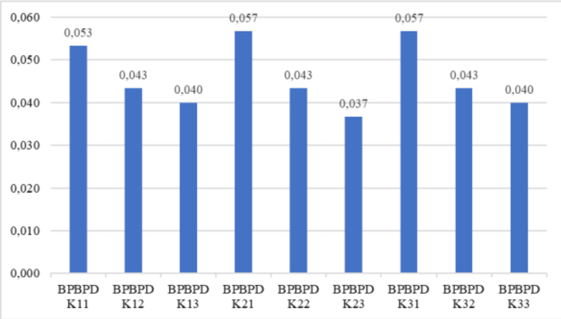
Materials	Specific Gravity			Water Absorption (%)
	Bulk	***SSD***	***Pseudo***	
Aggregate	1,987	2,205	2,541	10,968

Table 6 Aggregate Wear (Abrasion) Inspection Results

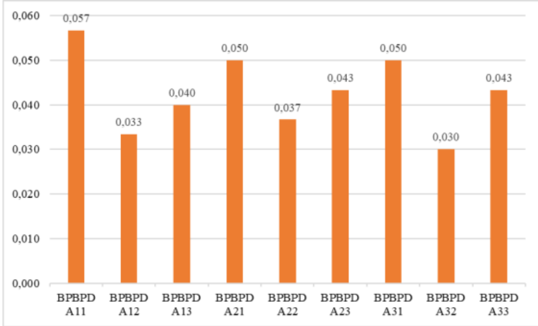
Materials	Wear (Abrasion) (%)
Aggregate	35,248

Initial Rate of Suction (IRS) Test Result

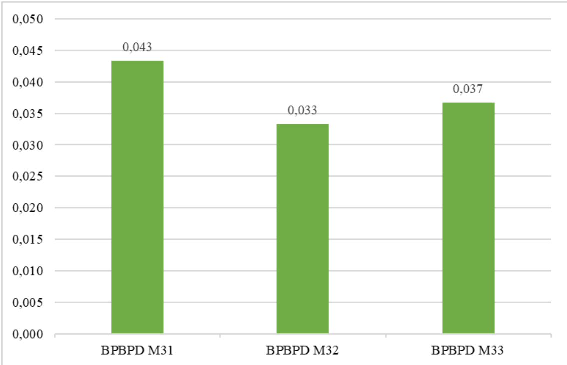
The results of the Initial Rate of Suction (IRS) test of the three types of specimens with different temperatures, proportions, and types of plastic can be seen in Figure 4 with (A) BPBPD with the type of plastic bag, (B) BPBPD with the type of aluminum-coated plastic, and (C) BPBPD with a type of mica plastic.



(A)



(B)



(C)

Figure 4 *Initial Rate of Suction* (IRS) Test Result

Based on the results of the IRS test, the three types of BPBPD have a value that is smaller than the range determined based on research results (Adam, 2020), therefore BPBPD does not need to be soaked before bonding with sand and cement mortar.

Water Absorption Test Results

The results of the water absorption test for the three types of specimens can be seen in Figure 5 with (A) BPBPD with plastic bag types, (B) BPBPD with aluminum-coated plastic types, and (C) BPBPD with mica plastic types.

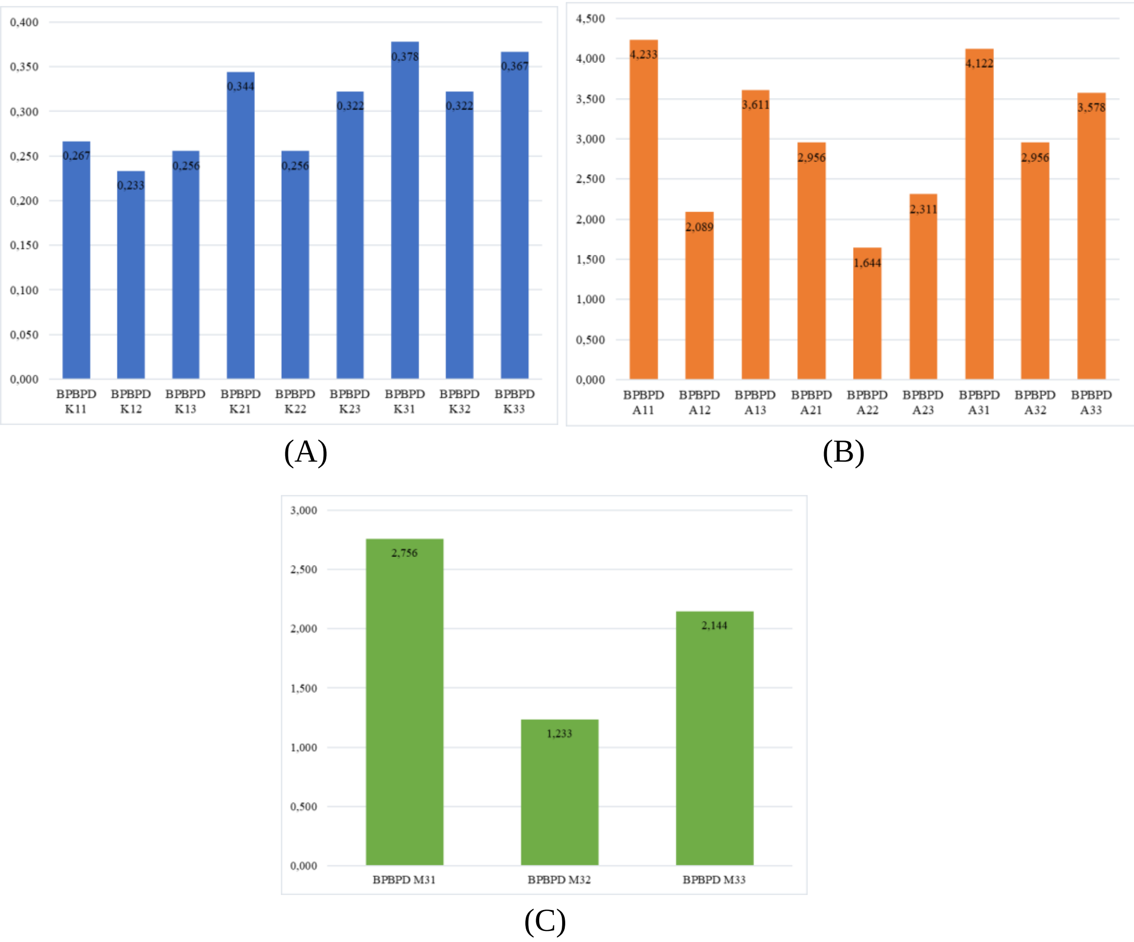
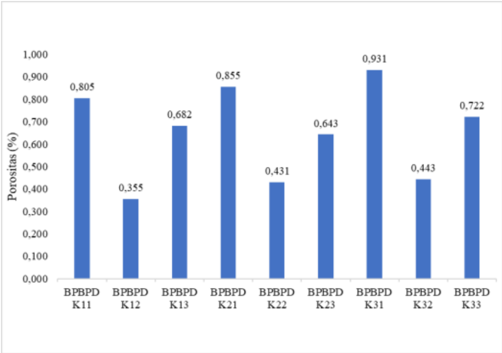


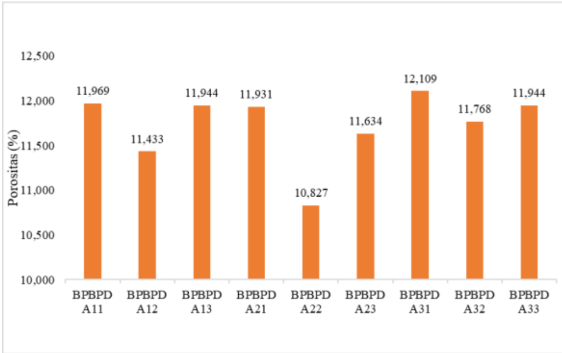
Figure 5 Water Absorption Test Result

Based on these results it can be concluded that BPBPD (B) has a greater water absorption capacity than BPBPD (A) and (C) this is due to the presence of more pores in BPBPD (B) than other BPBPDs.

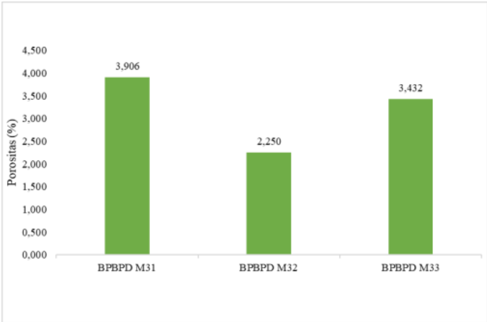
Porosity Test Result

The following results of the porosity test of the three types of specimens are presented in Figure 6 with (A) BPBPD with plastic bag types, (B) BPBPD with aluminum-coated plastic types, and (C) BPBPD with mica plastic types.





(A) (B)



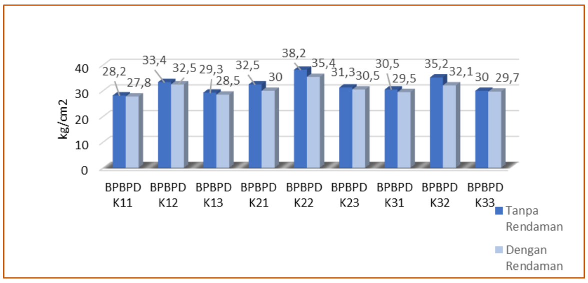
(C)

Figure 6 Porosity Test Result

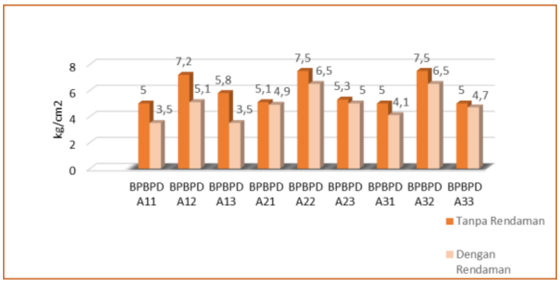
Based on the test results, it can be concluded that the higher the water absorption rate produced by the BPBPD, the higher the porosity value of the BPBPD in general.

Compressive Strength Test Results

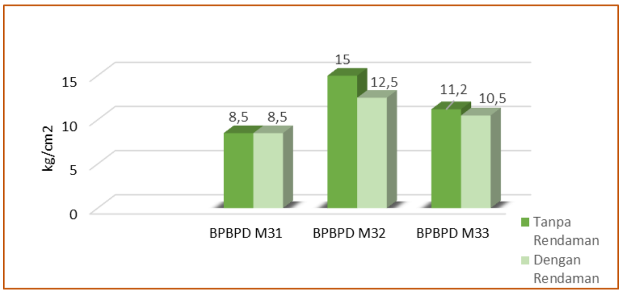
The compressive strength test was carried out under the condition that the BPBPD was completely submerged in water for 1 day and without being soaked (Karthick et al., 2022). The results of the compressive strength test are presented in Figure 7 with (A) BPBPD with the crackle plastic type, (B) BPBPD with the aluminum-coated plastic type, and (C) BPBPD with the mica plastic type.



(A)



(B)



(C)

Figure 7 Compressive Strength Test Result

Based on the results of the compressive strength test both with and without immersion, the results of BPBPD (A) have a compressive strength that is in accordance with the minimum standard average compressive strength of solid concrete bricks (Thanaya et al., 2020). Categorized as quality IV. Meanwhile, BPBPD (B) and (C) have compressive strength values lower than 25 Kg/cm^2.

CONCLUSION

Based on the analysis that has been done, the following conclusions can be drawn. The minimum temperature for melting plastic bags and aluminum plastic is 180°C, while mica plastic requires a minimum temperature of 220°C. The recommended proportion for making BPBPD is a ratio of 1.5: 1: 0.5, in which the mixed proportion consists of 350 grams of plastic, 250 grams of oil, and 100 grams of aggregate. Characteristics of the Plastic Block Wall Mount Material which is made from a mixture of plastic used cooking oil, and coarse aggregate namely:

a. The IRS value of each BPBPD produces an IRS value that is less than the IRS standard that has been set. So BPBPD does not need to be soaked before it is glued with mortar.
b. The highest water absorption rate was found in mica plastic BPBPD with an absorption rate of 13.867%, while the plastic bag and aluminum BPBPD were 0.378% and 4.233%. This is due to the pore factor found in BPBPD, the more pores there are, the higher the level of water absorption.
c. The BPBPD with the highest porosity value was found in the aluminum plastic BPBPD with a porosity value of 12.109%, while for the plastic bags and mica plastic BPBPD the porosity values were 0.931% and 3.906%.
d. The highest unsoaked compressive strength values were produced from plastic bags BPBPD, aluminum plastic BPBPD, and mica plastic BPBPD respectively at a mixture proportion of 1.5: 1: 0.5, namely 38.2 Kg/cm^2, 7.5 Kg/cm^2, and 15 Kg/cm^2. The highest

immersion compressive strength values were produced from plastic bags BPBPD, aluminum plastic BPBPD, and mica plastic BPBPD respectively, namely 35.4 Kg/cm^2, 6.5 Kg/cm^2, and 12.5 Kg/cm^2.

REFERENCES

Adam, A. M. (2020). Sample size determination in survey research. *Journal of Scientific Research and Reports*, *26*(5), 90–97.

Alqahtani, F. K., Ghataora, G., Khan, M. I., Dirar, S., Kioul, A., & Al-Otaibi, M. (2015). Lightweight Concrete Containing Recycled Plastic Aggregates. *Proceedings of the 2015 International Conference on Electromechanical Control Technology and Transportation*. https://doi.org/10.2991/icectt-15.2015.101

Arafa, M., Tayeh, B. A., Alqedra, M., Shihada, S., & Hanoona, H. (2017). Investigating the Effect of Sulfate Attack on Compressive Strength of Recycled Aggregate Concrete. *Journal Of Engineering Research And Technology, JERT*, *4*(4).

Calero, J., Luna, D., Sancho, E. D., Luna, C., Bautista, F. M., Romero, A. A., Posadillo, A., & Verdugo, C. (2014). Development of a new biodiesel that integrates glycerol, by using CaO as heterogeneous catalyst, in the partial methanolysis of sunflower oil. *Fuel*, *122*. https://doi.org/10.1016/j.fuel.2014.01.033

Karthick, K., Kumar, S. S., Karthik, T., Lokesh, K., Harris, T. M. A., Jegan, A. M. A., & Raja, S. (2022). Use of recycled plastic waste in concrete composites - A review. *AIP Conference Proceedings*, *2527*. https://doi.org/10.1063/5.0108652

Kaščak, J., Gašpár, Š., Paško, J., Knapčíková, L., Husár, J., Baron, P., & Török, J. (2021). Design of an atypical construction of equipment for additive manufacturing with a conceptual solution of a printhead intended for the use of recycled plastic materials. *Applied Sciences (Switzerland)*, *11*(7). https://doi.org/10.3390/app11072928

Krebs, R. D., & Walker, R. D. (1971). *Highway Materials*. McGraw-Hill Book Company.

Lucien, J. A. (2022). Innovative Management of Plastic Waste and Utilisation of Green Practices: Towards Preservation of Environment and Social Welfare. *International Journal of Innovative Science and Research Technology*, *7*(2).

Patwa, A., Parde, D., Dohare, D., Vijay, R., & Kumar, R. (2020). Solid waste characterization and treatment technologies in rural areas: An Indian and international review. In *Environmental Technology and Innovation* (Vol. 20). https://doi.org/10.1016/j.eti.2020.101066

Safi, B., Saidi, M., Aboutaleb, D., & Maallem, M. (2013). The use of plastic waste as fine aggregate in the self-compacting mortars: Effect on physical and mechanical properties. *Construction and Building Materials*, *43*. https://doi.org/10.1016/j.conbuildmat.2013.02.049

Siddique, R., Khatib, J., & Kaur, I. (2008). Use of recycled plastic in concrete: A review. *Waste Management*, *28*(10). https://doi.org/10.1016/j.wasman.2007.09.011

Sikalidis, C. A., Zabaniotou, A. A., & Famellos, S. P. (2002). Utilization of municipal solid wastes for mortar production. *Resources, Conservation and Recycling*, *36*(2). https://doi.org/10.1016/S0921-3449(02)00018-6

Stafford, R., & Jones, P. J. S. (2019). Viewpoint–Ocean plastic pollution: A convenient but distracting truth? *Marine Policy*, *103*, 187–191.

Thanaya, I. N. A., Mataram, I. N. K., & Rimbawa, I. W. E. A. (2020). Blok Bahan Pasangan Dinding (BBPD) dari Bahan Bekas Bongkaran Bangunan Dengan Perekat Lateks. *JST (Jurnal Sains Dan Teknologi)*, *9*(2), 143–152.

Toruan, A. L., Kaseke, O. H., Kereh, L. F., & Sendow, T. K. (2013). Pengaruh Porositas Agregat Terhadap Berat Jenis Maksimum Campuran. *Jurnal Sipil Statik*, *1*(3).