Jurnal Kajian Ruang Vol 5 No 2
September 2025
http://jurnal.unissula.ac.id/index.php/kr

The Effect of Material Composition of Paving Blocks from Plastic Waste on Compressive Strength and Water Absorption

Fatma Nurkhaerani[1], Fransisca Debora[2], Gina Lova Sari[3], Eka Oktariyanto Nugroho[4*], Rani G. K. Pradoto[5], Hana Syakira[6]

[1] Civil Engineering, Universitas Singaperbangsa Karawang, Karawang, Indonesia
[2] Industry Engineering, Universitas Singaperbangsa Karawang, Karawang, Indonesia
[3] Environmental Engineering, Universitas Singaperbangsa Karawang, Karawang, Indonesia
[4] Water Resources Engineering Research Group, Bandung Institute of Technology, Bandung, Indonesia
[5] Construction Management and Engineering Research Group, Bandung Institute of Technology, Bandung, Indonesia
[6] Master's Program in Water Resources Management, Bandung Institute of Technology, Bandung, Indonesia
[*]E-mail: nugrohoeka@itb.ac.id

ABSTRACT

Waste volume in Karawang City that can be handled will only be 40% and the other 60% will be managed by waste banks and temporary shelter. Innovation in waste recycling is needed, one of which is making plastic waste as raw material for paving block production. This research aims to assess how using plastic waste as a material in making paving blocks affects their compressive strength and water absorption, with the potential to reduce overall plastic waste and explore alternatives to conventional materials. This research focuses on testing water absorption capacity and compressive strength based on SNI 03–0691–1996 standards for making paving blocks. The water absorption test results on PVG 1 and 2 are up to 38.46% larger than PVG 3 and 4 because there are many cavities in PVG 1 and 2 that making were below standard, and PVG 3 and 4 were at quality standard level B. The compressive quality test of PVG 1 and 2 have a more noticeable compressive quality regard with a typical regard of 6,075 MPa compared to clearing squares with a full plastic composition with an ordinary regard of 4,745 MPa. It happens since of insufficient and manual burning, but it can too be caused by an ought to utilize plastic waste and the got to age the clearing squares being attempted. When compared with the quality Indonesian National Standard (SNI 03 - 0691 – 1996), the compressive quality test of the clearing inside the examination did not meet the standard.

Keywords: Plastic Waste, Paving Block, Water Absorption Test, Compressive Strength

1. Introduction

The 2022 report on the World Population Review shows that 20 countries produce the most waste in the world, which is dominated by countries in Southeast Asia (Satispi & Aziz Samudra, 2022). Based on this report, Indonesia is ranked fifth, with the country producing the most waste at 64 million tons/year (Arumdani et al., 2021). Municipal solid waste (MSW) composition produced in Indonesia is dominated by organic waste and plastic (United Nations Environment Program, 2017). The ever-increasing amount of waste needs special attention from the government and society. Independent waste management starts from reducing waste accumulation from households as well as end-of-pipe solutions through the implementation of solid waste management (SWM) systems/technologies with full shared commitment (Aprilia A, 2021). The Indonesian government has been responsible for optimizing end-of-pipe solutions by making 1) sorting at the source, 2) waste policy, 3) establishing regional budget adjustments for waste management, 4) improving waste collection programs, and 5) implementing a system other SWM with various innovations (Undang-Undang Republik Indonesia Nomor 18 Tahun 2008 Tentang Pengelolaan Sampah, 2008).

Community participation in reducing waste can be done by sorting, reusing and managing waste into something that can add value (Dhokhikah & Trihadiningrum, 2012). One type of waste that is difficult to recycle is plastic waste. Different decomposition processes on a very complex scale make the recycling process of plastic waste still a complicated problem (Sonia

V, 2020). However, plastic waste has great potential for recycling and utilization into alternative materials by comparing the types of polymers and their environmental impacts (Hopewell et al., 2009). LDPE could be a thermoplastic, created by a free radical polymerization strategy beneath weight from 150–350 MPa and a temperature from 80–300 °C. The key characteristics of LDPE are low-temperature affecting sturdiness, low-temperature affecting resistance, great resistance to chemicals, and great crawl resistance (Salehi et al., 2004). New outlets for reused LDPE may be created in case their low mechanical properties are moved forward by including other materials. In truth, the reused LDPE has been broadly utilized with virgin polymers to move forward its mechanical properties. Typically, a successful way to reuse reused LDPE (Pham, 2021).

The potential for utilizing substitute materials for plastic squander as fabric for making clearing pieces is anticipated to diminish the sum of plastic squander and investigate the potential for utilizing plastic squander as a substitute or substitute for authoritative materials. This inquire about was carried out to investigate the impact of the composition of plastic squander as a fabric in making clearing squares on compressive quality and water assimilation tests.

2. Material and Method

2.1 Study Area

Karawang is part of a district in West Java Province, Indonesia. Based on Sectoral Statistics data from the Environmental Service for 2022, the Karawang Regency Environment and Hygiene Service reported a recapitulation of waste management in 2021 for 30 subdistricts where the total volume of waste was 526,379 tons/month, with the volume of waste handled only 210,600 tons/month. From this data, only 40% of the total waste has been handled. In comparison, the other 60% is managed in collaboration with the private sector through optimizing waste banks, Management Sites for Reuse, Reduce and Recycle (TPS3R), and Integrated Waste Management Sites (TPST) (Pemerintah Kabupaten Karawang PJBI, 2022).

2.2 Paving Block Process

The thing that underlies the implementation of this research is the implementation of research that has been carried out by several previous studies related to the use of waste, which can be used as paving blocks (Erdin et al., 2021), (Sudarno, 2021), (Burhanuddin et al., 2020), (Iswahyudi & Alfarisi M, 2024), (Dian W. Kurniawidi et al., 2021), (Debora et al., 2023), (Nazhif et al., 2024), (Nurkhaerani et al., 2024), (Sari & Nurkhaerani, 2024). The potential for waste in the Karawang area still really needs to be considered and utilized, one of which is by continuing to strive to improve the potential for utilizing plastic waste to be converted into paving block products. This research develops an innovative idea for making paving blocks

from plastic waste made from LDPE (Low-Density Polyethylene), which consists of plastic bottles, plastic bottle caps and plastic waste.

Table 1. Paving block composition.

No	Mark	Composition (%)		
		Sand	Plastic Waste	Cement
1	PVG 1	75	12,5	12,5
2	PVG 2	75	12,5	12,5
3	PVG 3		100	
4	PVG 4		100	

At this stage, literature studies and field studies were carried out related to several previous studies that have succeeded in utilizing plastic waste to convert it into paving blocks. The innovative idea given in this research is based on the material of the paving blocks used with square size (20 x 10 x 6 cm) and 100% raw material coming from plastic waste. These paving blocks will be compared with paving blocks made from a plastic mixture. The implementation process begins with the preparation of tools and materials that will be used in the process of making paving blocks from plastic waste. The following is the composition of the paving blocks used, as shown in Table 1.

2.2.1 Process Stage

In this study, two conditions were used, namely paving blocks mixed with plastic waste and paving blocks full of plastic waste.

1. Paving blocks mixed with plastic waste.

The first process for making paving blocks consists of a mixture of sand, plastic waste, and cement. This manufacturing is carried out manually using printing techniques and processes that still use human power. The method for making paving blocks is as follows:

1) Plastic waste is cut into small pieces (chopped), then cement, sand and chopped are mixed evenly with the ratio, namely plastic: sand: cement, 500 grams: 3000 grams: 500 grams (percentage = 12.5%: 75%: 12.5%).
2) The mixture is printed using a paving block mould measuring 20cm x 10cm x 6cm.
3) The final process is removing the paving block from the mold and drying it for approximately 7 days.

2. Paving blocks full of plastic waste

The overall material used is LDPE plastic waste, which consists of plastic bags. The choice of LDPE plastic material is because it is harder, stronger, opaque, and more resistant to high temperatures, so it will be impact resistant and has a resistance of up to 135ºC (Hakim, 2019). The equipment used is a large frying pan, paving mould, and manual press tool that functions as a paving press medium to form paving with the same shape and volume. The paving process is carried out in several stages, including:

1) Preparation of tools and materials will be carried out according to the needs of making paving blocks. Recommendations for the weight of chopped plastic to be used start from 3 - 5 kg of LDPE plastic waste per paving unit.
2) Plastic heating
3) The shredded plastic will be put into a heating pan when the pan temperature approaches 100ºC and will be heated in the temperature range of 150-200ºC.

4) Printing
5) Holding print results

Figure 1. The sample being tested for absorption capacity.

2.2.2 Water Absorption Test

The absorption capacity test was carried out at the Karawang Regency Main Waste Bank by immersing the paving blocks for 24 hours in completely submerged conditions. Before crocheting, the paving blocks are weighed first to determine their dry weight and then compared with their wet weight after soaking for 24 hours, as shown in Figure 1.

After getting the weight results in dry and wet conditions, the calculation is then carried out using the equation in SNI 03-0691-1996, which is as follows.

$$Water\ Absorption = \frac{Wet\ Weight - Dry\ Weight}{Dry\ Weight} \times 100\% \quad (1)$$

2.2.3 Compressive Strength Testing Stage

Compressive quality is the capacity of the test protest to get compressive drive per unit range. This test is prescribed for clearing pieces to degree the most extreme compressive stack the clearing can acknowledge. Clearing items of different sorts will be tried for compressive quality utilizing the Widespread Testing Machine at the Jakarta State Polytechnic (PNJ), as appeared in Figures 2 and 3. The usage of the compressive quality test is based on the SNI-03-0691-1996 standard as a quality necessity for concrete bricks (clearing pieces), which are classified into appearance, measure, physical properties, and resistance to sodium sulphate.

Compressive strength will be calculated using the following formula.

Figure 2. Compressive strength testing process.

$$Compressive\ strength\ (MPa) = \frac{Compressive\ load\ (N)}{Compression\ area\ (mm^2)} \quad (2)$$

Agreeing to worldwide units (SI), the weight unit is $N/m2$. The unit is called the Pascal (shortened as Dad). So, 1 $N/m2$ = 1 Dad, the Pascal unit is the weight applied by a unit drive of newtons on a surface zone of one square meter (Ahmad & Furqon, 2018). The comes about of the water retention capacity and compressive quality tests will be compared with the quality values in SNI 03-0691-1996 with respect to the physical properties that clearing pieces must have, to be specific as takes after, as appeared in Table 2.

Table 2. Physical properties of paving blocks.

Quality	Compressive strength (MPa)		Max average water absorption (%)
	Average	Min	
A	40	35	3
B	20	17,0	6
C	15	12,5	8
D	10	8,5	10

Source: SNI 03-0691-1996 [12].

The overall process of making paving blocks can be seen in the following flow chart, as shown in Figure 3.

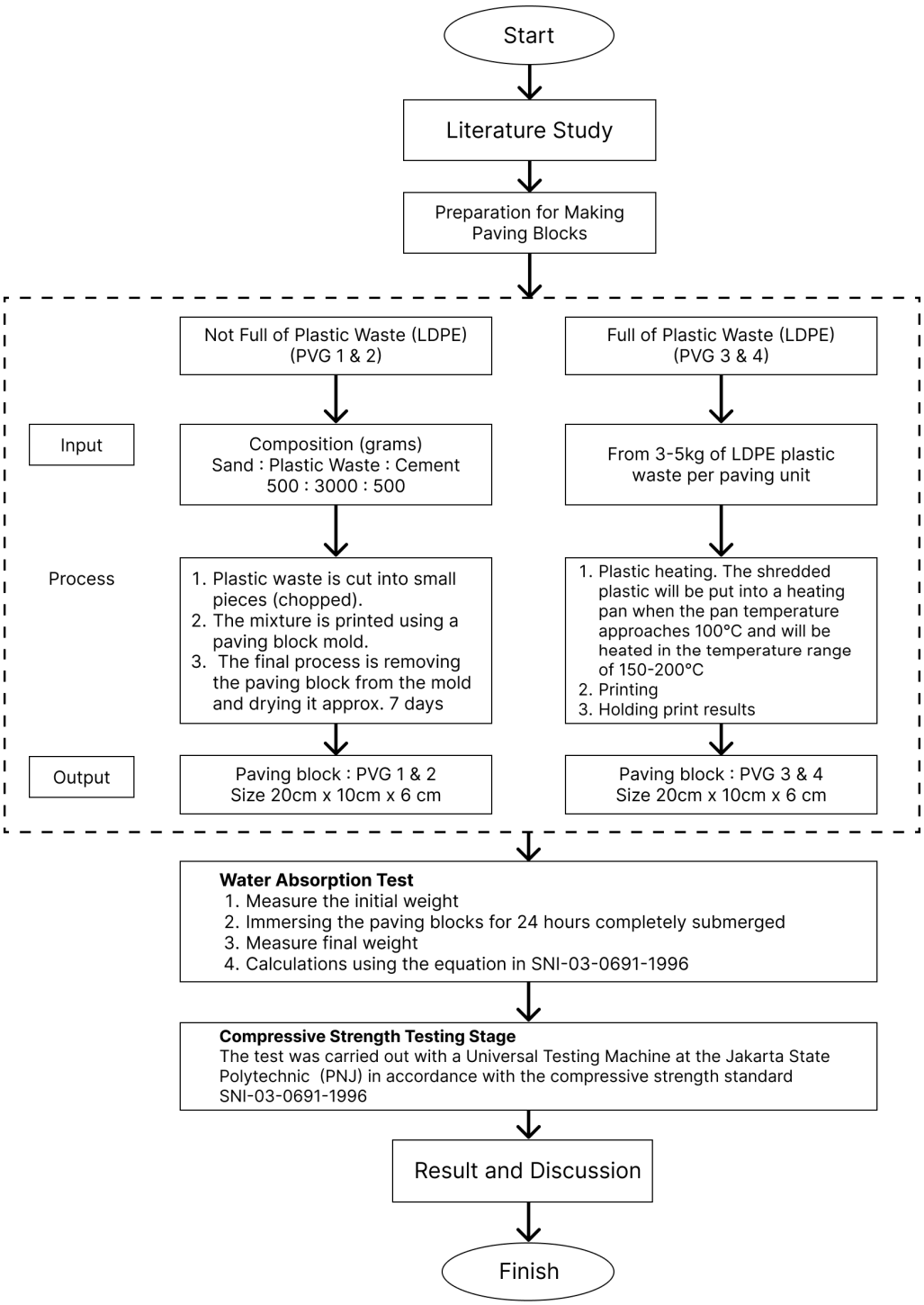

Figure 3. Research flow diagram.

3. Results and Discussion

The paving blocks made in this research consisted of two paving blocks mixed with plastic waste, cement, and sand and two paving blocks full of plastic waste. The plastic waste used is LDPE, namely plastic bags, considering the characteristics of the plastic-type as explained in Table 3. The size of all paving blocks is rectangular.

Table 3. Characteristics of types of plastic.

Polymer name	Characteristics (Desnia et al., 2024), (Hartono & Rachmat, 2022), (Ishaiba, 2015)	Frequently used virgin plastic (Rimantho D et al., 2012),(Siddique et al., 2008)	The breaking point (ºC) (Tempa et al., 2022)
Polyethylene Terephthalate (PET)	Lucid hard plastic that is fiber compatible	Bottles of soft drinks and mineral water, textile fibers, and filler for pillows and sleeping bags	80
High Density Polyethylene (HDPE)	Widely used material that is either white or coloured	Milk crates, heavy cream bottles, bottles for soap and cleansers, crinkly grocery bags, ziplocs, and bottles	75
Low-Density Polyethylene (LDPE)	Unless a colour is applied, milky white, soft, flexible plastic	Ice cream container lids, trash cans, rubbish bags, and black plastic sheets	70
Polypropylene (PP)	Flexible but tough plastic	Drinking straws, lunch boxes with hinges, potato chip bags, and ice cream containers	140

3.1 Water Absorption Testing

Water retention capacity testing was carried out at the Karawang Rule Squander Bank. Water retention ordinarily uncovers a material's rate porosity beneath a certain set of circumstances (Farhana et al., 2014). Most of the time, a material's durability is heavily influenced by its water absorption properties (Babafemi et al., 2018). A higher water absorption characteristic leads to poor structural performance because moisture causes the bond strength to weaken. Paving blocks are weighed to determine their dry weight. Next, the paving block is soaked in water for 24 hours and then weighed while wet. The weight contrast is at that point changed over into a rate. The taking after is the comes about of testing the water assimilation capacity of clearing squares, as appeared in Table 4.

Table 4. The test result of water absorption.

No	Mark	Weight (kg)			Percentage	Explanation
		Dry	Wet	Difference		
1	PVG 1	1,2	1,4	0,2	38,46%	Under Quality
2	PVG 2	1,3	1,8	0,5	16,67%	Under Quality
3	PVG 3	0,9	0,93	0,03	5,56%	Quality B
4	PVG 4	0,9	0,95	0,05	3,33%	Quality B

Based on Table 4, the test comes about on clearing pieces with a blended composition of plastic squander (PVG 1 and 2) have a more prominent water retention rate esteem than clearing pieces with a composition full of plastic squander (PVG 3 and 4). Clearing squares with a blended composition of plastic squander have a rate esteem of retention capacity of up to 38.46%. It can be caused by the huge number of cavities within the clearing squares, which can hold water in them longer than clearing squares with a composition full of plastic squander.

Moreover, the test comes about on water retention capacity are compared with SNI 03-0691-1996; clearing pieces with a composition full of plastic squander (PVG 3 and 4) can be included in quality B (Table 2) whereas clearing pieces with a blended composition of plastic squander don't meet the quality in SNI. It is additionally in line with inquire about that has been carried out with the comes about of the normal water assimilation of clearing pieces full of plastic squander not indeed coming to 1%, meaning that all the water retention values gotten from the least esteem to the most noteworthy esteem all drop into A quality necessities for clearing squares (Mustakim et al., 2023).

3.2 Compressive Strength Testing

Clearing squares with a blended composition of plastic squander and full plastic were tried to decide the compressive quality, as appeared in Figure 4.

Figure 4. Paving blocks sample.

Compressive strength is the most significant mechanical attribute in concrete technology. Any fresh concrete mixture must meet the minimal strength standards needed for structural use (Faraj et al., 2020). This test was carried out at the Jakarta State Polytechnic (PNJ) Civil Engineering Study Program Laboratory. Testing refers to SNI 03-0691-1996 concerning Paving Blocks with the following dimensions, as shown in Table 5.

Table 5. Paving block dimensions.

No	Mark	Surface Area (cm^2)	Size		
			Length (cm)	Width (cm)	Height (cm)
1	PVG 1	31.46	5.73	5.49	5.57
2	PVG 2	29.96	5.6	5.35	5.36
3	PVG 3	23.01	4.98	4.62	4.7
4	PVG 4	26.60	5.01	5.31	5.2

The key factor to consider when introducing a material to the building industry is strength. Compressive strength testing using UTM is required to determine this plastic paver's resistance to compression (Universal Testing Machine). For the load to be distributed uniformly, the paver block's surface needs to be flat on both sides. Finding compressive strength is crucial for determining the block's ability to support (Khuzairi M et al., 2020). The comes about of the clearing square compressive quality test can be seen within the taking after Table 6.

Table 6. Test results of compressive strength.

No	Mark	Test Result			Explanation
		Compressive Strength (Kgf/cm^2)	Compressive Strength (MPa)	Average (MPa)	
1	PVG 1	59.701	5.85	6.075	Under Quality
2	PVG 2	64.326	6.30		
3	PVG 3	41.031	4.02	4.745	Under Quality
4	PVG 4	55.812	5.47		

Based on the compressive strength test results, PVG 1 and 2, which are a mixture of plastic waste, have a compressive strength value that is greater than paving blocks with a full plastic composition. It can be caused by several things, including incomplete combustion during the process of making full plastic paving blocks because manual burning is used. Separated from that, it may too be caused by the need of plastic squander utilized and the need of age of the clearing squares tried. Based on investigate that has been carried out, the compressive quality of clearing pieces made from full HDPE plastic fabric matured 14 days comes to an normal esteem of 13.17 MPa, whereas at 28 days, it comes to an normal esteem of 16.56 MPa (Mustakim et al., 2023)

The compressive strength testing of all paving blocks did not meet SNI quality standards because the minimum value for minimum quality was 8.5 MPa, while all test results were below that value. Making paving blocks with a full composition of plastic waste must go through several studies, especially regarding the characteristics of each plastic waste. Investigate that has been carried out on clearing squares with the composition of mineral bottle squander, plastic packs and bottle caps moreover has comes about that are comparative to this inquire about. The

comes about of the normal compressive quality values for each clearing square variety were at that point compared with the quality necessities for clearing squares based on SNI 03 - 0691 - 1996. The result was that as it were 2 varieties passed the quality prerequisites out of a add up to of 7 varieties with diverse composition proportions (Burhanuddin et al., 2020).

4. Conclusion

The utilize of plastic squander can be turned into something with included esteem, one of which is by making it into clearing piece fabric. This inquiries about centers on making clearing pieces measuring (20 cm x 10 cm x 6 cm) with two sorts: 1) clearing pieces made from sand, plastic squander, and cement, in a proportion of 75: 12.5: 12.5, called PVG 1 and PVG 2; 2) clearing pieces made from totally liquefied plastic called PVG 3, and PVG 4. The clearing pieces that are made are tried for their receptiveness and compressive quality. The test comes about on clearing pieces with a blended composition of plastic squander (PVG 1 and 2) had a more prominent water retention rate esteem of up to 38.46% compared to clearing squares with a composition full of plastic squander (PVG 3 and 4) due to the expansive number of cavities within the clearing pieces. So PVG 1 and 2 are beneath quality, whereas PVG 3 and 4 are quality B based on SNI 03-0691-1996 benchmarks. The compressive quality test comes about of PVG 1 and 2 have a more prominent compressive quality esteem with a normal esteem of 6,075 MPa compared to clearing squares with a full plastic composition with a normal esteem of 4,745 MPa. It happens since of inadequate and manual burning, but it can too be caused by a need of utilize of plastic squander and a need of age of the clearing squares being tried. When compared with the quality standard SNI 03 - 0691 - 1996, the compressive quality test of the clearing within the investigate did not meet the standard. So, this investigate ought to be carried out within the future by deciding the sort of plastic and the fitting burning strategy for plastic squander.

References

Ahmad, A., & Furqon, H. M. (2018). Pengaruh Penambahan Ijuk Aren Terhadap Kuat Tekan Bata Merah. *TERAS*, *8*, 87–99.

Aprilia A. (2021). *Waste Management in Indonesia and Jakarta: Challenges and Way Forward*.

Arumdani, I. S., Puspita, A. S., & Budihardjo, M. A. (2021). MSW handling of top 5 leading waste-producing countries in Southeast Asia. *IOP Conference Series: Earth and Environmental Science*, *896*(1), 012003. https://doi.org/10.1088/1755-1315/896/1/012003

Babafemi, A. J., Šavija, B., Paul, S. C., & Anggraini, V. (2018). Engineering Properties of Concrete with Waste Recycled Plastic: A Review. *Sustainability*, *10*(11), 3875. https://doi.org/10.3390/su10113875

Burhanuddin, B., Basuki, B., & Darmanijati, M. (2020). PEMANFAATAN LIMBAH PLASTIK BEKAS UNTUK BAHAN UTAMA PEMBUATAN PAVING BLOCK. *Jurnal Rekayasa Lingkungan*, *18*(1). https://doi.org/10.37412/jrl.v18i1.20

Debora, F., Nugroho, E. O., Nurkhaerani, F., Sugiarto, A. R., Kusumawardhani, R. G., & Fasa, N. (2023). PELATIHAN PERHITUNGAN HARGA POKOK PRODUKSI PAVING BLOCK BERBAHAN LIMBAH PLASTIK NON EKONOMIS PADA BANK SAMPAH INDUK KABUPATEN KARAWANG. *MARTABE: Jurnal Pengabdian Masyarakat*, *6*(5), 1515–1522.

Desnia, E., Rosie, E., Hartono, S. B., Simanullang, W. F., Anggorowati, A. A., & Lourentius, S. (2024). Optimization of pyroliysis of polypropylene and polyethylene based plastic waste become an alternative oil fuel using bentonite catalyst. *E3S Web of Conferences*, *475*, 05006. https://doi.org/10.1051/e3sconf/202447505006

Dhokhikah, Y., & Trihadiningrum, Y. (2012). Solid Waste Management in Asian Developing Countries: Challenges and Opportunities. *Journal of Applied Environmental and Biological Sciences*, *2*(7), 329–335.

Dian W. Kurniawidi, Teguh Ardianto, Syamsuddin, Siti Alaa', Amrul Ikhsan, & Susi Rahayu. (2021). Pemilahan Sampah Plastik Untuk Mendukung Program Zero Waste Pada Pusat Daur Ulang Sampah Bajang Peripih Doro, Pringgarata, Lombok Tengah Tahun 2021. *Jurnal Pengabdian Magister Pendidikan IPA*, *4*(4), 402–409. https://doi.org/10.29303/jpmpi.v4i4.1159

Erdin, E. K. Z., Zainuri, & Soehardi, F. (2021). KUALITAS PAVING BLOCK DENGAN MENGGUNAKAN LIMBAH PLASTIK POLYPROPYLENE TERHADAP KUAT TEKAN. *JURNAL TEKNIK*, *15*(2), 185–190. https://doi.org/10.31849/teknik.v15i2.7435

Faraj, R. H., Hama Ali, H. F., Sherwani, A. F. H., Hassan, B. R., & Karim, H. (2020). Use of recycled plastic in self-compacting concrete: A comprehensive review on fresh and mechanical properties. *Journal of Building Engineering*, *30*, 101283. https://doi.org/10.1016/j.jobe.2020.101283

Farhana, Z. F., Kamarudin, H., Rahmat, A., & Al Bakri, A. M. M. (2014). The Relationship between Water Absorption and Porosity for Geopolymer Paste. *Materials Science Forum*, *803*, 166–172. https://doi.org/10.4028/www.scientific.net/MSF.803.166

Hakim, F. (2019). Pemanfaatan Bijih Plastik Jenis High Density Polyethylene (HDPE) Sebagai Subtitusi Agregat Pada Bata Beton (Paving Block). *DSP UII*, 1–11.

Hartono, E. F., & Rachmat, N. (2022). Klasifikasi Jenis Plastik HDPE, LDPE, dan PS Berdasarkan Tekstur Menggunakan Metode Support Vector Machine. *JATISI (Jurnal Teknik Informatika Dan Sistem Informasi)*, *9*(2), 1403–1412. https://doi.org/10.35957/jatisi.v9i2.2470

Hopewell, J., Dvorak, R., & Kosior, E. (2009). Plastics recycling: challenges and opportunities. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *364*(1526), 2115–2126. https://doi.org/10.1098/rstb.2008.0311

Ishaiba, A. (2015). *Mechanical Properties of Concrete Using Recycled Plastic*. The Islamic University-Gaza Research and Postgraduate Affairs.

Iswahyudi, Y. A., & Alfarisi M. (2024). Teknologi Tepat Guna Pengolahan Limbah Plastik Menjadi Paving Block Sebagai Alternatif Pemecahan Masalah Sampah. *Hum Care J*, 9–18.

Khuzairi M, Rosli BIN, Shahir M, Adnan BIN, Asyraf M, & Zaihaidi BIN. (2020). *Laporan Inovasi Pitex Sesi Jun 2020*.

Mustakim, M., Rahima, R., Muis, A., & Sulfanita, A. (2023). Studi Perbandingan Kuat Tekan Paving Block Berbahan Dasar Limbah Plastik. *Jurnal Ilmiah Rekayasa Sipil*, *20*(1), 41–50. https://doi.org/10.30630/jirs.v20i1.1022

Nazhif, A. A., Nugroho, E. O., Rusdy, N. F. P., Kardhana, H., Nuraeni, S., Pradoto, R. G. K., Kuntoro, A. A., Mohammed, B. S., Dharmowijoyo, D. B. E., Nurkhaerani, F., Wijaya, A. R., Fauzi, M. F., & Rayya, R. (2024). The effect of paving block from plastic waste material in the urban drainage: Study case in residential areas. *E3S Web of Conferences*, *479*, 03002. https://doi.org/10.1051/e3sconf/202447903002

Nurkhaerani, F., Sari, G. L., Debora, F., Nugroho, E. O., Hassalum, Z. D., & Ahmad, A. S. (2024). Analisis Paving Block berdasarkan Sifat Tampak dan Reduksi Limbah Plastik Multilayer, Limbah Keramik Sanitary, dan Limbah Karet Alas Sepatu. *Jurnal Pengendalian Pencemaran Lingkungan (JPPL)*, *6*(2), 91–97. https://doi.org/10.35970/jppl.v6i2.2391

Pemerintah Kabupaten Karawang PJBI. (2022). *Statistik Sektoral Dinas Lingkungan Hidup*.

Pham, N. T.-H. (2021). Characterization of Low-Density Polyethylene and LDPE-Based/Ethylene-Vinyl Acetate with Medium Content of Vinyl Acetate. *Polymers*, *13*(14), 2352. https://doi.org/10.3390/polym13142352

Rimantho D, Cahyadi B, & Dermawan D. (2012). Application Analytic Hierarchy Process (AHP): A Case Study of E-Waste Management in Surabaya, Indonesia. *Proceeding 8th Int. Semin. Ind. Eng. Manag*, 1–10.

Salehi, S. M. A., Mirjalili, G., & Amrollahi, J. (2004). Effects of high-energy electron beam on low-density polyethylene materials containing EVA. *Journal of Applied Polymer Science*, *92*(2), 1049–1052. https://doi.org/10.1002/app.20079

Sari, G. L., & Nurkhaerani, F. (2024). A study of the potential of non-economic plastic waste as a substitute for paving block to enhance domestic waste reduction. *Journal of Ecological Engineering*, *26*(1), 59–65. https://doi.org/10.12911/22998993/195270

Satispi, E., & Aziz Samudra, A. (2022). Study of Policy Implementation: Strategy of COVID-19 Plastic Waste Management in Indonesia. *Journal of Public Policy and Administration*, *6*(4), 155. https://doi.org/10.11648/j.jppa.20220604.11

Siddique, R., Khatib, J., & Kaur, I. (2008). Use of recycled plastic in concrete: A review. *Waste Management*, *28*(10), 1835–1852. https://doi.org/10.1016/j.wasman.2007.09.011

Sonia V, S. D. (2020). The State Liability Of Plastic Waste Dumping In Indonesia. *Utop y Prax Latinoam*, 493–505.

Sudarno, S. (2021). Pemanfaatan Limbah Plastik Untuk Pembuatan Paving block. *Jurnal Teknik Sipil Terapan*, *3*(2), 101. https://doi.org/10.47600/jtst.v3i2.290

Tempa, K., Chettri, N., Thapa, G., Phurba, Gyeltshen, C., Norbu, D., Gurung, D., & Wangchuk, U. (2022). An experimental study and sustainability assessment of plastic waste as a binding material for producing economical cement-less paver blocks. *Engineering Science and Technology, an International Journal*, *26*, 101008. https://doi.org/10.1016/j.jestch.2021.05.012

Undang-Undang Republik Indonesia Nomor 18 Tahun 2008 Tentang Pengelolaan Sampah, Pub. L. No. Nomor 18 Tahun 2008 (2008).

United Nations Environment Program. (2017). *Summary Report Waste Management*.