Jurnal Pijar MIPA
https://jurnalfkip.unram.ac.id/index.php/JPM

ISSN 1907-1744 (Print)
ISSN 2460-1500 (Online)

The Effect of Substitution of LDPE Plastic, Coconut Fiber, and Seashell as Mixed Raw Materials for Paving Blocks

Kania Ratnawati[1*], Firda Ainun Nisah[2], Yona Tasya Azizie[2]

[1]Enviromental Engineering Program, Faculty of Engineering, Universitas Singaperbangsa Karawang, Karawang, West Java, Indonesia
[2]Industrial Engineering Program, Faculty of Engineering, Universitas Singaperbangsa Karawang, Karawang, West Java, Indonesia
*E-mail: kania.ratnawati@ft.unsika.ac.id

Received: December 30, 2023. Accepted: January 20, 2024. Published: January 29, 2024

Abstract: Human life is inseparable from the use of plastic in everyday life. LDPE plastic significantly impacts the environment as it is difficult to decompose naturally. On the other hand, natural waste such as seashells and coconut fiber are often found without further processing needs to recycle. To overcome this issue, there must be an effort to recycle these wastes. This research aims to determine the substitution effects of recycled products (LDPE plastic, seashells, coconut fiber) in producing paving blocks. The paving block is made with 2 main variations: a mixture of LDPE plastic and seashells (X1 and X2) and a mixture of LDPE plastic and coconut fiber (Y1 and Y2). The results show that paving block X has a higher compressive strength than paving block Y. The best paving block mixture is variation X2, which has a maximum load of 11 kN, a compressive strength of 46.797 kgf/cm^2, and a maximum water absorption capacity of 4,8 %. The compressive strength values from the variations of the produced paving blocks are below the quality requirements set by SNI03-060292-1996. However, producing paving blocks with LDPE plastic, seashells, and coconut fiber can positively address waste issues in the Karawang Regency community through recycling practices.

Keywords: Coconut Fiber; Environment; LDPE Plastic; Paving Block; Seashell.

Introduction

In the current era, waste issues have become a serious challenge faced by various regions worldwide. One of the most concerning types of waste is Low-Density Polyethylene (LDPE) plastic waste. The extensive daily use of LDPE plastic led to increased LDPE plastic waste production that is difficult to decompose in the soil even after being buried for years [1]. Karawang, as a coastal area, faces additional problems related to coconut fiber and seashell waste. Coconut fiber is a by-product of the coconut industry, and seashells originate from seafood consumption waste, both commonly encountered and not effectively utilized.

In construction, paving blocks are commonly used for various building projects. Typically, paving blocks are made from sand, cement, and water [2]. On the other hand, coconut fibers have several advantages, including a tensile strength of 46.67 N/m^2, making them resistant to decay, lightweight, and elastic [3]. One approach is to use LDPE plastic waste (Low-Density Polyethylene), seashells, and coconut fibers as raw material mixtures. LDPE plastic has a simple polymer chemical structure, making it easy to produce [4]. Seashells can also be employed as a mixture for making paving blocks because they share the same chemical compound as sand [5]. Seashell powder contains pozzolanic chemical compounds containing lime (CaO), alumina, and silica compounds, making it suitable for paving block raw material [6]. Utilizing these three materials is expected to result in paving blocks with improved properties, especially in terms of compressive strength and water absorption capacity, and as a solution to address waste issues.

LDPE (Low-Density Polyethylene) is a type of plastic with the code 4 commonly found in plastic bags or plastic wraps for food packaging [7]. LDPE has a low density, approximately 0.742 g/ml, viscosity of 0.78 grams/ml, a melting point of 115°C, and high chemical resistance, but it easily dissolves in benzene and tetrachlorocarbon (CCl4) [8]. The unique characteristics of LDPE, with its high chemical resistance, make it a beneficial material in various applications.

Previously, research on substituting raw materials for paving block production has been conducted by several researchers with significant results. Research using a mixture of plastic and coconut fibers in paving block production has an average compressive strength of about 9-12 Mpa [9] and an average water absorption rate of about 2.45% [10]. On the other hand, research on using a mixture of plastic with shells has also been conducted, yielding an average compressive strength of about 12.8 Mpa [11] and an average water absorption rate ranging from 3.53% to 4.89% [12]. None of these studies precisely specify the type of plastic used, necessitating a more specific examination.

This study examines the influence of using LDPE waste, coconut fibers, and seashells as raw material mixtures in paving block production. Thus, this research also significantly reduces the negative impact of LDPE plastic waste and utilizes the untapped potential of coconut fiber and seashell waste more optimally. In other words, this study

How to Cite:
Nisah, F. A., Ratnawati, K., & Azizie, Y. T. (2024). The Effect of Substitution of LDPE Plastic, Coconut Fiber, and Seashell as Mixed Raw Materials for Paving Blocks. *Jurnal Pijar Mipa*, *19*(1), 168–172. https://doi.org/10.29303/jpm.v19i1.6392

contributes to sustainable solutions in the construction industry by supporting more efficient waste management.

Research Methods

This research employs an experimental method to examine the production of paving blocks using LDPE plastic waste, seashells, and coconut fiber. All these compositions will undergo physical tests, including compressive strength and water absorption tests on the produced paving blocks. The results of these tests will be compared with the SNI 03-0691-1996 standard.

This study combines the use of LDPE plastic waste and organic waste in producing environmentally friendly materials, potentially reducing the use of conventional materials such as bricks or paving blocks that require significant natural resources.

The paving block production research using LDPE plastic and coconut fiber waste was conducted from June 18 to June 24, 2023. The results of this research are expected to yield paving blocks as an environmentally friendly solution for managing plastic waste and reducing organic waste.

Preparation

Producing paving blocks from recycled materials such as LDPE plastic, seashells, and coconut fiber is an environmentally friendly innovation. The first step in making paving blocks is preparing the tools and materials. The tools used include scales, mixers, presses, paving block molds, cloth, scissors, buckets, LDPE plastic, seashells, coconut fiber, cement, sand, and water.

The following process is material sorting, where the primary materials are prepared. LDPE plastic is taken from the Karawang Waste Bank, paying attention to the type of plastic collected. Meanwhile, seashells are obtained from Pasir Putih Cilamaya Beach, Karawang, and coconut fiber is collected from the waste of the Nata de Coco factory.

After sorting, the next step is chopping LDPE plastic, seashells, and coconut fiber. The chopping process aims to facilitate the mixing of these materials. Each step ensures that all required materials are prepared in optimal conditions and recycled correctly.

Figure 1. Chopping of Ingredients

Implementation

After preparing the necessary tools and materials, the next step is to carry out the process of making paving blocks. This process plays a crucial role in testing the potential use of these materials in producing paving blocks with improved properties, especially in terms of compressive strength and water absorption.

The materials are mixed according to the specified composition. The mixing process is done sequentially and according to predetermined proportions to create a well-mixed combination and balanced contribution to the final properties of paving blocks. Once all the materials are uniformly mixed, the next step is to pour the mixture into paving block molds with 20 x 20 cm dimensions, then compact it by pressing. The final step is the drying process, where the paving blocks, either molded or finished, are dried under direct sunlight.

Table 1. Comparison of Paving Block Material Composition

Code	Comparison of Paving Block Material Composition (g)			
	LDPE Plastic	Seashell	Cement	Sand
X1(1:2:4:21)	175	375	750	3750
X2(2:1:4:21)	375	175	750	3750
Code	Comparison of Paving Block Material Composition (g)			
	LDPE Plastic	Coconut Fiber	Cement	Sand
Y1(1:3:1:2)	350	750	1500	2500
Y2(3:1:1:2)	750	350	1500	2500

Figure 2. Drying of Paving Blocks

Testing

The dried paving blocks undergo compressive strength testing and water absorption testing. Compressive strength testing was conducted on September 4, 2023, at the Infrastructure Technology Center Laboratory (PUTI) of the Department of Civil Engineering, Jakarta State Polytechnic. Meanwhile, water absorption testing is carried out at the dedicated laboratory of Singaperbangsa University Karawang.

Results and Discussion

In the implementation, the chopping process aims to reduce the size of the materials to ensure even mixing [13]. Mixing the materials ensures that each component contributes evenly, creating a homogeneous mixture supporting the paving block's final property [14]. Subsequently, the drying process helps eliminate excess water content, ensuring that the paving blocks achieve the desired strength and properties [15].

Compressive strength testing will provide an overview of how the raw material mixture consisting of LDPE plastic, coconut fiber, and seashells can affect the durability and strength of the resulting paving blocks. The paving blocks to be tested are prepared as standardized blocks measuring 20 x 20 cm. Each variation of the raw material mixture is uniformly placed on the prepared compression testing device. This is done to ensure that the testing yields accurate and reliable results.

Paving blocks have been made with LDPE plastic, seashells, and coconut fiber. The variations include the mixture of LDPE plastic and seashells (X), namely X1 with more seashells than X2. The variation of LDPE plastic and coconut fiber (Y), namely Y1, has more coconut fiber than Y2. These variations are created to determine the paving block mixture with the highest strength.

Looking at the visible properties of paving blocks with a mixture of LDPE plastic-seashells (X) and LDPE plastic-coconut fiber (Y), they have nearly the same smooth surface, without cracks or defects, visible fibers, and the corner parts are not easily cut with finger strength. Although both have nearly the same smooth surface, the presence of fibers and additional material structures can give different characteristics to the two variations of paving blocks. Variation X shows that seashell particles on the surface of the paving block are barely visible; this is similar to what was done by Yuliana et al. (2021) in making seashell composites [16]. Meanwhile, variation Y still shows coconut fiber's texture on the paving block's surface.

Figure 3. The mixture of LDPE Plastic, Seashell, and Coconut Fiber Paving Blocks

Another physical property to consider in paving blocks is resistance to pressure (compressive strength) and its ability to absorb water (water absorption). Compressive strength measures how well paving blocks can withstand pressure or loads applied to them without excessively burdening the structure underneath [17]. This compressive strength refers to the SNI 03-0692-1996 mentioned earlier. The compressive strength results of the four variations of paving blocks produced are shown in Table 2.

Table 2. Paving Block Compressive Strength Test Results

Mark	Max Load (kN)	Test Results Compressive Strength (Kgf/cm^2)	(mPa)
X1	6	34.446	3.378
X2	11	46.797	4.5892
Y1	5	28.357	2.7809
Y2	5	27.119	2.6595

Table 2 shows that paving blocks with LDPE plastic and seashells (X) have higher compressive strength than those with LDPE plastic and coconut fiber (Y). This could be because seashells tend to have a hard and dense texture, so when mixed with LDPE plastic, they can function as a natural reinforcement [18]. Additionally, the powdered form of seashells can thoroughly mix with the composition of other paving block materials, namely cement and sand. The similarity in the physical form of all raw materials in variation X enhances the bonding between the existing materials, resulting in a stronger bond. On the other hand, coconut fiber has looser and lighter fibers, which can reduce the compressive strength of the mixture [19]. The distinct coconut fiber form, presented as strands, differs from the shape of other raw materials in variation Y. This distinction weakens the bonding between the paving block constituents, leading to a lower compressive strength than variation X.

The compressive strength value for the LDPE plastic and seashells mixture, namely X2 (46.797 Kgf/cm^2), is much larger than X1 (46.797 Kgf/cm^2), proving that the amount of LDPE plastic plays a significant role in the strength of the paving block.

The compressive strength values for both variations of LDPE plastic with coconut fiber (Y1 and Y2) are almost the same, with values of 28-27 Kgf/cm^2 and a maximum load of 5 kN. This result indicates that the amount of LDPE plastic and coconut fiber does not affect the compressive strength of the paving block.

SNI Standard 03-0349-1989 sets the minimum requirements for the compressive strength of paving blocks at 35 kgf/cm^2 [20]. By achieving a maximum compressive strength of 46.797 kgf/cm^2, variation X2 demonstrates excellent quality, providing confidence that this paving block meets and even exceeds the established quality standards. This indicates that the strongest material for paving blocks comes from a mixture of seashells and LDPE plastic with a higher composition. Higher compressive strength is one of the factors ensuring that paving blocks can be used in applications requiring higher mechanical durability.

The next test is water absorption. Water absorption measures how much water paving blocks can absorb to reduce the risk of cracking due to trapped freezing water [20]. When water is trapped inside paving blocks and subsequently freezes, it expands, causing pressure and enlarging its volume. This process can damage the structure of paving blocks because the generated pressure may result in cracks or even serious structural damage. Therefore, low water absorption can reduce the risk of cracking due to freezing, preserve the structural integrity of paving blocks, and enhance the quality and durability of the material. Here is the table comparing the physical test results on paving blocks.

Table 3. Paving Block Water Absorption Test Results

Mark	Size (cm)	Thickness (cm)	Dry Weight (Kg)	Wet Weight (Kg)	Water Absorption (%)
X1	20x20	5.5	4.40	4.55	3.4
X2	20x20	5.5	3.95	4.15	4.8
Y1	20x20	5.5	3.05	3.15	3.27
Y2	20x20	5.5	3.05	3.15	3.27

The table above shows that the LDPE plastic and seashells mixture (X) has an average water absorption of around 3.4% - 4.8%, while the LDPE plastic and coconut fiber mixture (Y) has an average water absorption of around 3.27%. The water absorption of paving blocks with a mixture of LDPE plastic and seashells is higher than that of paving blocks with a mixture of LDPE plastic and coconut fiber. This occurs because seashells tend to have a more porous nature with many microscopic cavities, whereas coconut fibers have a denser fiber structure with fewer cavities or pores [21]. Pores or microscopic cavities in seashells allow for higher water absorption. Conversely, the denser fiber structure in coconut fibers can reduce water absorption.

Paving blocks with more LDPE plastic and seashells (X1) at 4.81% have the highest water absorption among the block variations, indicating the highest risk of cracking. Conversely, paving blocks with less LDPE plastic and coconut fiber (Y2) at 3.17% have the lowest water absorption, indicating the lowest risk of cracking for use.

Compressive strength and water absorption testing in paving blocks can be referred to according to the Indonesian National Standard (SNI) for paving blocks with the number 03-0692-1996. In this SNI list, the quality of paving blocks is divided into several categories depending on how strong the compressive strength of the paving block is. Quality requirements according to SNI 03-0692-1996 are written in the following table.

Table 4. Quality Requirements for Paving Blocks According to SNI 03-060292-1996

Quality	Compressive strength (mPa)		Max Water Absorption (%)	Classification
	Average	Min		
A	40	35	3	For roads
B	20	17.0	6	For parking facilities
C	15	12.5	8	For pedestrians
D	10	8.5	10	For parks and other uses

Based on the results, the water absorption value is excellent, around 3%, which meets the quality standard A according to SNI 03-060292-1996. However, the compressive strength values obtained from the variations of paving blocks produced are below the quality requirements set by SNI. Nevertheless, paving blocks made from a mixture of LDPE plastic, seashells, and coconut fibers can contribute positively to addressing waste issues.

Conclusion

Paving blocks have been produced with a mixture of LDPE plastic, seashells, and coconut fibers, showing potential for creating environmentally friendly materials. Paving blocks made from LDPE plastic and seashell (X) mixture show higher compressive strength than those with a mixture of LDPE plastic and coconut fiber (Y). In testing, variation X2 has a maximum compressive strength of 11 kN and a compressive strength of 46.797 kgf/cm^2. Meanwhile, water absorption in paving blocks with a mixture of LDPE plastic and coconut fiber (Y) is lower than in paving blocks with a mixture of LDPE plastic and seashell. Variation Y2 shows the lowest water absorption at 3.17%, indicating a more negligible risk of cracking and good usability. Therefore, variation X2, a mixture of LDPE plastic and seashells, provides the best substitution effect. This is demonstrated by having the highest compressive strength, maximum load, and a sufficiently good maximum water absorption capacity. From the test results, the water absorption value meets the excellent quality standard A of around 3%, by the provisions of SNI 03-060292-1996. Nevertheless, the compressive strength values from the variations of the produced paving blocks are still below the quality requirements set by SNI. However, paving blocks with a mixture of LDPE plastic, seashells, and coconut fiber can positively address waste issues in the Karawang Regency community through recycling practices. In the subsequent research, an exploration can be conducted on utilizing coconut fibers by transforming them into powder form. Additionally, it is recommended to create a more extensive range of variations to be more specific in determining the most suitable substitution material.

Acknowledgements

The Research Team expresses gratitude to Bank Sampah Karawang for providing guidance in the paving block-making process, ensuring the smooth and successful implementation of the project.

References

[1] Qomariah, N., & Nursaid, N. (2020). Sosialisasi pengurangan bahan plastik di masyarakat. *Jurnal Pengabdian Masyarakat Manage*, *1*(1), 43-55.

[2] Ruswanto. (2017). Pengaruh Penambahan Abu Pembakaran Serbuk Kayu Jati Terhadap Kuat Tekan Dan Serapan Air Pada Paving Block. Jurnal Hasil Kajian, Inovasi, dan Aplikasi Pendidikan Fisika, 1.

[3] Ramadhani, S. (2011). Pengaruh Penambahan Serat Sabut Kelapa Terhadap Parameter Kuat Geser Tanah Berpasir. SMARTek, 9(3), 187-195.

[4] Aprilianti, A. (2019). Pemanfaatan Bijih Plastik Jenis PP (Polypropylene) Sebagai Subtitusi Agregat Pada Bata Beton (Paving Block). Yogyakarta: Universitas Islam Indonesia.

[5] Ichsan, & Fadil, M. (2019). Analisa Pemanfaatan Limbah Kulit Kerang sebagai Bahan Campuran pada Pembuatan Paving Block Ditinjau dari Nilai Kuat Tekan dan Serapan Air (Doctoral dissertation, Universitas Medan Area).

[6] Siregar, S. M. (2009). Pemanfaatan Kulit Kerang dan Resin Epoksi Terhadap Karakteristik Beton Polimer. Medan: Tesis Universitas Sumatera Utara.

[7] Brizi, M. R. A., Rakhmawati, A., & Arnandha, Y. (2021). Pemanfaatan Limbah Plastik Ldpe Sebagai Bahan Campuran Pembuatan Bata Beton (Paving Block). *Jurnal Rekayasa Infrastruktur Sipil*, *1*(2), 2-7.

[8] Nugroho, A. S. (2020). Pengolahan Limbah Plastik LDPE dan PP Untuk Bahan Bakar Dengan Cara Pirolisis. *Jurnal Litbang Sukowati: Media Penelitian Dan Pengembangan*, *4*(1), 91-100.

[9] Listriyana, A., & Silviyanti, N. A. (2023, September 2). Pengaruh Penambahan Serabut Kelapa Terhadap Kuat Tekan Plasbut (Plastik Serabut) Paving Block. SIPIL SAINS, 13(2), 92-99.

[10] Ardhiansyah, M. D., & Sarwidi. (2018). Pengaruh Pemanfaatan Sabut Kelapa Sebagai Material Serat Terhadap Kuat Tekan dan Daya Serap Beton.

[11] Handayasari, I., & Artiani, G. P. (2019). Perbandingan Kuat Tekan Paving Block Ramah Lingkungan Berbasis Limbah Botol Plastik Kemasan Air Mineral Dengan Limbah Cangkang Kerang Dan Limbah Botol Kaca Sebagai Bahan Substitusi Terhadap Semen. Construction and Material Journal, 1(1), 21-27.

[12] Hidayat, A. (2021). *Pengaruh Penambahan Limbah Cangkang Kerang Sebagai Campuran Terhadap Kuat Tekan dan Daya Serap Air Pada Paving Block* (Doctoral dissertation, Universitas Islam Riau).

[13] Ma'rifat, Monalisa, & Bismantara. (2017). Rancang Bangun Mesin Pencacah Sampah Organik Sebagai Bahan Dasar Pupuk Kompos. (Doctoral dissertation, Institut Teknologi Sepuluh Nopember).

[14] 123dok. (2021). Proses Mixing. Dipetik Desember 28, 2023, dari https://123dok.com/article/proses-mixing-pengadukan-dan-pencampuran.zpvolmrz

[15] Rahayoe, S. (2017, October 28). Teknik Pengeringan.

[16] Utami, A. V. The Effect of The Ratio of Blood Shells (Andara Granosa) and Natural Fibers to The Bending Strength of The Composite. *ROTASI*, *23*(1), 1-5.

[17] Oktavianita, Y., Syamsudin, R., & Zacoeb, A. (2015). Perbandingan Kuat Tekan dan Tegangan-Regangan Bata Beton Ringan dengan Penambahan Mineral Alami Zeolit Alam Bergradasi Tertentu Dengan dan Tanpa Perawatan Khusus. Jurnal Mahasiswa Jurusan Teknik Sipil, 1, 1-8.

[18] Nayan, A., & Hafli, T. (2022). Mahasiswa Undip Menyulap Limbah Plasik Menjadi Genteng. (manunggal) Retrieved Desember 28, 2023, from https://manunggal.undip.ac.id/mahasiswa-undip-menyulap-limbah-plastik-menjadi-genteng/

[19] Ifa, L. (2018). Pemanfaatan Sabut Kelapa Sebagai Bioadsorben Logam Berat PB (II) Pada Air Limbah Industri. *Journal Of Chemical Process Engineering (JCPE)*, *5*(1), 54-60.

[20] Badan Standardisasi Nasional. (1996). Bata beton (Paving block). Diambil kembali dari BSN: https://www.bsn.go.id/

[21] Hidayat, F., & Melinda, A. P. (2022, September 3). Studi Eksperimental Pemanfaatan Abu Cangkang Lokan Terhadap Kekuatan Beton. Journal of Civil Engineering and Vacational (CIVED), 9(3), 268-275.