

Study of Paper Waste Based Paving Blocks on Compressive Strength and Water Absorption

Indah Handayasari and Gita Puspa Artiani

Department of Civil Engineering, Sekolah Tinggi Teknik PLN, West Jakarta, Indonesia 11750

Email: indahhalim22@gmail.com, indah.handayasari@sttpln.ac.id, gita_artiani@yahoo.com / gitapuspa@sttpln.ac.id

Abstract— As one of the products of the development of construction materials technology, paving blocks function for cover material and surface hardening that are very widely used for various purposes, ranging from simple needs to uses that require special specifications. In addition, now also the need for high quality but environmentally friendly building materials has become a demand given the large amount of waste that has not been optimally utilized. In this study, paper waste will be used as a subtle aggregate substitute material in the manufacture of paving blocks which are expected not only to provide alternative paving blocks that are environmentally friendly but also fulfill the required conditions where the use of waste paper-based paving blocks is intended as pavement on the archipelago considering the price and access to resources are quite expensive and the difficulty of bringing heavy equipment to the locations of islands is that most of them only have ports or docks whose capacity can only accommodate fishing boats. Other things obtained also when using building materials that have lighter weight can result in reduced weight of the construction material so that it is easier for transportation. Making test specimens is carried out by varying the composition of paper waste against fine aggregates of 0%, 2.5%, 5%, 7.5%, 10%, 12.5%. Test specimens were prepared for compressive strength testing by testing samples at 7 days, 14 days and 28 days. While the specimens for testing the absorption of water at the age of the block paving reached 28 days. Based on the results of testing using paper waste shows that the waste can be reused as a mixture of paving blocks so that it can optimize the use of waste but also as an effort to recycle waste into a product that provides higher economic value.

Index Terms—Paving blocks, waste, paper, compressive strength, water absorption

I. INTRODUCTION

One of the technological developments in construction materials is currently characterized by the increasing quality of building materials and the emergence of various new building materials that provide an alternative use of materials. The emergence of various new building materials along with the demands for the needs of building materials that have better quality than existing building materials. In addition to the need for building materials that have higher quality, lighter weight, more affordable prices, environmentally friendly building

materials also become alternative construction materials that can provide solutions to environmental problems and have a good effect on conservation and environmental protection. Other things obtained also when using building materials that have lighter weight can result in reduced weight of the construction material so that it is easier for transportation [1]–[2].

Among various kinds of alternative building material products that are used as cover or ground hardening, paving blocks are a product that is in great demand by consumers. This is because the paving blocks have advantages from other products in terms of shape, size, color and pattern and can be combined with other cover materials. In addition, as a cover material and surface hardening, paving blocks are very widely used for various purposes, ranging from hardening and beautifying road sidewalks, hardening of the parking area, and can even be used in special areas such as road hardening, especially in small islands remembering Indonesia is the largest archipelagic country in the world with the number of islands in 2018 with 16,056 islands where the coastline is 81,000 km with its sea area covering 5.8 million km² or about 70% of the total area of Indonesia. Besides that, paving blocks can also be done in a conventional way, and the constituent material is also easily available so that it is more beneficial to be seen from these situations and conditions. Another problem is paper waste that has not been optimally utilized. This encourages efforts to do better waste management and as much as possible can reuse the waste.

Considering the importance of using waste as a substitute for some of the constituent materials in paving blocks as an alternative environmentally friendly construction material, literature studies are needed in planning research to be carried out so that waste paper-based paving blocks that are of better quality than conventional paving blocks can be produced. Based on the research conducted by Argowi Pribadi [3] which utilizes newsprint as a coarse aggregate substitute material shows newspaper waste can be used as an alternative material for making papercrete mixtures. Papercrete material products that are environmentally friendly in light and non-structural structural elements can be used in the manufacture of partition walls, substitutes for block paving and floor concrete rebates.

In the research conducted by A. Yusuf Z, et al. [4] by utilizing solid waste (sludge) from paper processing Adiprima Suraprinta Company becomes a useful material and produces a mixture of alternative raw materials for making concrete blocks. The work starts from taking raw materials, testing materials and making mortar specimens measuring 5x5x5 cm³ from various mixed variations with the aim of finding optimal compositions. Mortar compressive strength test was carried out at 7.14 and 28 days. Mortar treatment is carried out by using fresh water. Weighing the dry weight of the mortar, then applied to the brick element size of 20x18x10 cm³. From the results of the evaluation it turns out that composition cement : 3.75 sand : 1.25 sludge of optimal and economic composition has a compressive strength of 28 days mortar specimens of 25.33 kg/cm² beyond the compressive strength of 20 kg/cm² used for simple home walls. Leach values of 28 and 60 days are 7.9% and 8.0%. The composition will be applied to the concrete block test results which have a compressive strength of 28 and 60 days at 22.33 kg/cm² and 23.67 kg/cm² beyond the compressive strength of 20 kg/cm² which has a usefulness for simple house walls. Research using paper pulp waste for concrete boards carried out by Andang Widjaja [5] resulted that concrete panels with a pulp mixture were lighter but water absorption and thermal coefficients were higher than normal concrete panels. Concrete boards with a weight ratio of sand and pulp 2.75 : 1.25 and 2.5 : 1.5 meet SII 0797-83. However, pulp has a disadvantage because it has the property of absorbing water so further research is needed by adding other ingredients so as not to trigger cracks and increase the value of compressive strength.

Based on several previous studies that used paper waste as a substitute material in a mixture of construction materials, in this study paper waste will be used as a subtle aggregate substitute material in the manufacture of paving blocks which are expected not only to provide alternative paving blocks that are environmentally friendly but also fulfill the required conditions.

II. RESEARCH METHODOLOGY

A. Paving Blocks Charatization

Paving blocks according to SNI 03-0691-1996 are defined as a composition of building materials made from a mixture of portland cement or similar hydraulic adhesives, water and aggregates with or without other additives which do not reduce the quality of the paving blocks. Quality standards that must be met by paving blocks for floors according to SNI 03-0691-1996 are as follows [6] :

1. Paving blocks must have a flat surface, there are no cracks and defects, the corners and ribs are not easily broken with the strength of the fingers.
2. The size of the paving block must have a minimum thickness of 60 mm with a tolerance of + 8%
3. Paving blocks must meet the requirements in the following Table I :

TABLE I. REQUIREMENTS OF PAVING BLOCKS (SNI 03-0691-1996)

Quality	Compressive Stregth (MPa)		Wear Resistance (mm/ second)		Water Absorpti on Max. (%)
	Averag e	Min.	Avererag e	Min.	
A	40	35	0,0090	0,103	3
B	20	17	0,1300	1,149	6
C	15	12,5	0,1600	1,184	8
D	10	8,5	0,2190	0,251	10

Description of its use:

- Quality A of paving blocks : used for roads
- Quality B of paving blocks : used for parking lots
- Quality C of paving blocks : used for pedestrians
- Quality D of paving blocks : used for parks and other uses

B. Paving Blocks Processing

In making paving block specimens with paper waste as a substitute for a portion of sand, paper waste must be processed first. Paper waste treatment proces shown in Fig. 1 are :

1. Paper waste is moistened with water then squeezed and torn into small pieces until it becomes pulp.
2. Paper pulp that has been dried in the sun to dry (approximately 24 hours).
3. The dried paper can be used as a substitute for sand in a mixture of paving blocks.



Figure 1. Paper waste treatment process

After all the materials used to make the paving blocks are ready, then all the ingredients are weighed according to the planned percentage variation. The process of making paper waste-based paving block specimens can be seen in Fig. 2. below:



Figure 2. The process of making paving block sample

The method used in making a mixture of paving block specimens with aggregate comparison between cement and sand is 1 : 4. The size of specimens used 20 cm x 10 cm x 8 cm with the average dry weight of paving blocks is 24000 gram. The making of paving blocks uses

conventional methods, which are carried out using molds and using the load of compaction of human power [7]-[8].

Paper based paving block test objects making test specimens is carried out by varying the composition of paper waste against fine aggregates of 0%, 2.5%, 5%, 7.5%, 10%, 12.5%. Each specimen was prepared 3 pieces for compressive strength testing by testing samples at 7 days, 14 days and 28 days. While the specimens for testing water absorption were prepared 3 pieces for the age of paving blocks reaching 28 days. After obtaining the test results data and then analyze and discuss and compare the value and nature of the compressive strength and water absorption of each of these data with the quality of the block paving that meets the requirements of SNI 03-0691-1996 [6].

III. RESULTS AND DISCUSSION

TABLE II. TEST RESULTS OF PAVING BLOCKS

Variations	Compressive Strength (MPa)	Water Absorption (%)	Requirements SNI 03-0691-1996		Quality
			Compressive Strength (MPa)	Water Absorption (%)	
Paving blocks normal	13.93	4.34	12.5	8	C
Paving blocks with 2.5% waste paper	12.64	7.05	12.5	8	C
Paving blocks with 5% waste paper	11.77	7.72	8.5	10	D
Paving blocks with 7.5% waste paper	10.79	9.43	8.5	10	D
Paving blocks with 10% waste paper	10.01	9.89	8.5	10	D
Paving blocks with 12.5% waste paper	9.29	11.03	8.5	10	-

The results of testing the compressive strength of paving blocks based on waste paper show that with the increase in the percentage of paper waste in the mixture it will comply with the value of compressive strength. From the test results showed on Fig. 3. that the highest compressive strength was found in normal paving blocks of 13.93 MPa for quality C by testing samples at 28 days.

However, the addition of paper waste to the paving block mixture showed that the highest compressive strength was in the mixture with 2.5% paper waste variation of 12.64 MPa and meets the requirements for minimum paving block compressive strength for quality C. Whereas for the variation of paper waste 5%, 7.5%, 10% and 12.5% the compressive strength of the paving blocks obtained is 11.77 MPa, 10.79 MPa, 10.01 MPa and 9.29 MPa. Where the compressive strength values for these three variations meet the minimum requirements for quality D. The following table and figures are the test results for compressive strength and water absorption of paving blocks sample at the age of 28 days:

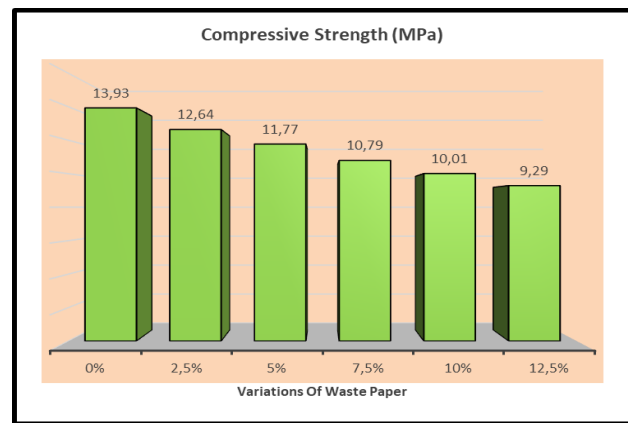


Figure 3. Test results for compressive strength of paving blocks

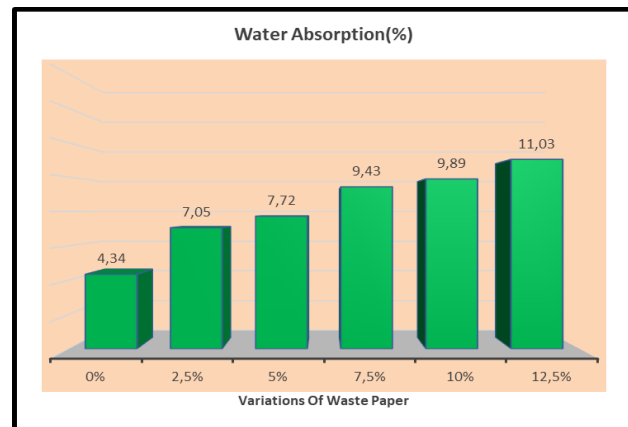


Figure 4. Test results for water absorption of paving blocks

Based on Table II and Fig. 3. show that the results of testing the compressive strength for all variations can meet the minimum requirements permitted according to the quality requirements of paving blocks on SNI 03-0691-1996. However, for variations of paving blocks with 12.5% of paper waste on the requirements the maximum percentage of water absorption on Fig. 4. shows results that exceed the maximum value required by SNI 03-0691-1996 while variations in paving blocks with other paper wastes can meet the specified requirements.

The results of testing waste paper based paving blocks with a variation of 2.5% paper waste as a fine aggregate substitute material provide optimum value and can be categorized into quality C which can be used as pavement for pedestrians. However, for variations of 5%, 7.5% and

10% of paper waste as fine aggregate substitutes which are categorized as D quality, they can also be used as gardening and other uses.

Based on the above, paper waste can be used as a substitute for some fine aggregates in a mixture of paving blocks and can be an alternative to environmentally friendly construction materials. Besides that, by reusing waste paper will provide added value to the waste itself and can maintain environmental sustainability.

IV. CONCLUSIONS

1. The use of paper waste as a substitute for fine aggregate in a mixture of paving blocks can reduce the compressive strength of the paving block along with the increasing percentage of paper waste used. In addition, the use of paper waste in paving blocks will also increase the percentage of water absorption
2. The optimum variation in the use of paper waste as a substitute for fine aggregates in paving blocks is in 2.5% of paper waste. Where the value of compressive strength obtained is 12.64 MPa and water absorption is 7.05%. These results meet the SNI 03-0691-1996 requirements for quality C paving blocks that can be used as pavement for pedestrians.
3. Based on the test results show that the use of paper waste as a substitute for fine aggregate in paving blocks is recommended to be maximum in a variation of 10% waste paper. This is indicated by the water absorption test results in variations of 12.5% of paper waste which cannot meet the maximum percentage requirements according to SNI 03-0691-1996.

CONFLICT OF INTEREST

The Author's declare that the submitted work has no conflict of interest.

AUTHOR CONTRIBUTIONS

Indah Handayasari in this study was tasked with compiling, planning, implementing, analyzed the data, making research reports and seminar journal papers. Gita Puspa Artiani conducted data processing. All authors had approved the final version.

REFERENCES

- [1] A. F. Sibuea, "Utilization of plastic bottle waste as eco plafond material (economic plastic fiber) in environmentally friendly concept paving blocks with press test, shock test and water absorption," *University of South Sumatera, Civil Engineering Journal of USU*, vol. 2, no. 2, pp. 1-8, 2013. [Online]. Available: <https://jurnal.usu.ac.id/index.php/jts/article/view/2877>

- [2] D. Rifany, K. M. Rizal, "Tilization of waste management results as an alternative to construction building materials," *Journal of SMARTek*, vol. 9, no. 1, pp 47-60, February, 2011, [Online]. Available: <http://jurnal.untad.ac.id/jurnal/index.php/SMARTEK/article/view/619>
- [3] A. Pribadi, "Utilization of newspaper waste as substitute material rough aggregates in papercrete mixtures and their applications for lightweight structure elements and non-environmentally friendly structures," *Al-Ard: Journal of Environmental Engineering*, vol. 1, no. 1, pp 1-10, September, 2015, Available: <https://doi.org/10.29080/alard.v1i1.28>
- [4] A. Yusuf Z., et al. "Utilization of waste paper sludge adiprima suraprinta company in making brick," *Journal of Application*, vol. 9, no. 1, pp 1-8, February, 2011, Available: <http://iptek.its.ac.id/index.php/jats/article/view/2709>
- [5] A. Widjaja, "Paper pulp waste for concrete boards, " *Civil Engineering Media*, vol. 8, no. 1, pp 1-8, January, 2008, Available: <http://puslit2.petra.ac.id/ejournal/index.php/mts/article/view/17711>
- [6] Information on http://infolpk.bsn.go.id/index.php/?sni_main/sni/detail_snieng/1009, SNI 03-0691-1996, *Bata Beton (Paving block)*, Badan Standarisasi Nasional, Indonesia.
- [7] T. F. R. R. Madya, A. Essy, T. Elly, *Study of the Mechanical Properties of Paving Blocks Made of Waste Concrete and Glass Powder*, University of Indonesia, Jakarta, Indonesia, 2012.
- [8] F. W. I. J. Satria, "Study of environmentally friendly paving blocks by utilizing plastic bottle waste and glass bottles as mixed substitutes," *Tecnical Collage of PLN*, Jakarta, Indonesia, 2018.

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Indah Hamdayasari, Indonesia 1977, graduated in Indonesia as civil engineering from University of Sriwijaya (1995-2000). Master's in pavement material and transportation management was obtained from Institute Technology of Bandung, Indonesia (2000-2002). She is a lecture at the Department of Civil Engineering at Tecnical Collage of PLN. Her area of expertise is Construction Engineering with interest in construction health and safety, material for pavement, transportaion management, data collection and analysis.



Gita Puspa Artiani, Indonesia 1981, graduated in Indonesia as civil engineering from Tecnical Collage of PLN (1999-2004). Master's in Construction Management was obtained from University of Trisakti (2011-2013). She is a lecture at the Department of Civil Engineering at Tecnical Collage of PLN. Her area of expertise is Construction Engineering with interest in construction management.