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by Sri Wiwoho Mudjanarko

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Cite as: AIP Conference Proceedings **2020**, 020029 (2018); https://doi.org/10.1063/1.5062655
Published Online: 05 October 2018

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Optimization of Standard Mix Design of Porous Paving Coconut Fiber and Shell for the Parking Area

A. D. Limantara[1, a)], S. Winarto[1], E. Gardjito[1], B. Subiyanto[1], D. Raharjo[1], A. Santoso[1], H. L. Sudarmanto[1] and S. W. Mudjanarko[2, b)]

[1]*Department of Civil Engineering, Kadiri University, Selomangleng 1, Kediri, Indonesia.*
[2]*Department of Civil Enginering, Narotama University, Arief Rachman Hakim 51, Surabaya, Indonesia.*

[a)]arthur.daniel@unik-kediri.ac.id
[b)]sri.wiwoho@narotama.ac.id

Abstract. The pavement in the parking area is usually concrete paving with class B quality with a flat surface appearance, no cracks, and defects, minimum thickness of 60 mm with a tolerance of ± 8%. The condition of parking area infrastructure which in the rainy season occurred water puddles which is a common problem that arises this is due to high rainfall is also not able to absorb rainwater runoff into the soil. The use of natural materials for pavement construction is a must in supporting the achievement of green roads. This paper aims to obtain the most optimal mixture of standard design strengths using coconut fibers and coconut shell as a coarse aggregate with a ratio of 10%, 20%, 30%, 50%, 100% and the parameters used in this study are a compressive strength, permeability, and porosity resulting from the test object. The research methodology used refers to ACI 522.1-08, ACI 522R-10, ASTM C33-78. 2010, SNI 03-0691-1996, and SNI 03-2847-2002. Based on data processing of laboratory test results obtained from this study, the optimum value of the combination of 21% has a compressive strength of 17.1 MPa, permeability 0.5 cm/sec, and 23% porosity.

INTRODUCTION

Growth in the number of motor vehicles in Indonesia from 2014 to 2015 is 6.29%, where the number of cars in 2015 is 121.390 million units. Java Island itself ranks first in the number of vehicles that is equal to 51.24% or 62.20 million units of vehicles. This makes big cities like Jakarta and Surabaya have problems providing enough parking space. [1]

The pavement in the parking area is usually a concrete paving with the requirements of the quality of concrete brick must meet the class B quality (17.0 MPa) which is intended for a parking lot with flat looking surface properties, no cracks, and defects, the minimum thickness of 60 mm with tolerance ± 8%. [2]

But now many conditions of parking area infrastructure that in the rainy season is not adequate as many puddle which is a common problem that occurs in almost all major cities in Indonesia is due to high rainfall is also due to the closed land that is not able to absorb rainwater runoff to in the soil as shown in figure 1. This puddle over time can lead to damage to paving the parking area.

The solution is to create environmentally friendly porous paving concrete, which not only functions as infrastructure but also serves as a water catchment area. For material selected using the equipment for standard mix design combine fiber waste and coconut shell that can be obtained quickly and many environments around us (Figure 2).

Advances in Civil Engineering and Science Technology
AIP Conf. Proc. 2020, 020029-1–020029-7; https://doi.org/10.1063/1.5062655
Published by AIP Publishing. 978-0-7354-1738-0/$30.00

FIGURE 1. Flooding in the parking area.

FIGURE 2. Waste coconut fiber and coconut shell.

The specific objective of this research to find alternatives substitute of fine and coarse aggregates on paving blocks using coconut fiber and shell so that it can raise some issues such as how many percentages of mixed substitution is needed to achieve the compressive strength as the minimum standards allowed for the parking area, and percentage permeability and porosity. Knowing whether the selection of fibers and coconut shell as coarse aggregate can replace the main material is a fine aggregate (sand), and coarse aggregate (gravel) on the mix design paving blocks up to 100%.

MATERIALS

Concrete brick (paving block) is a mixed composition between portland cement or other hydraulic cement, fine aggregate, coarse aggregate, and water, with or without other additives that do not reduce the quality of the concrete brick. The physical properties of the quality of concrete brick areas in Table 1: [2]

Table 1. Physical Properties.

Quality	Compressive Strength (MPa)		Wear Resistance (mm/minute)		Maximum water absorption (%)
	Average	Min	Average	Min	
A	40	35	0,090	0,103	3
B	20	17,0	0,130	0,149	6
C	15	12,5	0,160	0,184	8
D	10	8,5	0,219	0,251	10

Remarks:
Quality A = used for road
Quality B = used for parking
Quality C = used for pedestrians
Quality D = used for parks and other uses

Porous concrete is concrete that has pores or cavities in its structure, allowing the fluid to flow through the holes contained in the concrete. The aggregates used are only coarse aggregates or with slightly fine aggregates. The cement water factor must be maintained in such a way that once the concrete is hardened the pores are formed not covered by a mixture of hardened cement paste. Also, the control of the cement water factor also aims to make aggregate grains strongly bonded to each other. [3]

Aggregates are the most critical component of concrete in determining magnitude. In concrete, there is usually about 70% to 75% aggregate volume. This aggregate must be graded in such a way that the entire mass of the concrete can function as a whole, homogeneous, and dense object, in which small aggregates serve as fillers of gaps between large aggregates. [4]

The coarse aggregates in this study consisted of coconut shells in which the aggregate properties also affected the attachment between the totals and the water requirements of the mixers. Aggregates that have smaller grain sizes have the potential to produce high strength concrete. A good roughly aggregate gradient constraint according to [5] is shown in Table 2:

TABLE 2: Gradation of Aggregate Natural Coarse Standard.

Sieves Diameter	Percentage of Passed
25,4 mm (1")	100
19,0 mm (3/4")	95 – 100
9,50 mm (3/8")	20 – 55
4,75 mm (No. 4)	0 – 10
2,36 mm (No. 8)	0 – 5

Fine aggregates typically are sand, either natural and obtained directly from the river or quarry, or from the breakdown of rocks. Its size varies between the number 4 and number 100 US standard sieve. Good fine aggregate must be free of organic material, clay, particles smaller than 100 sieve numbers or other materials that can damage the concrete mix. Fine aggregate was natural sand as a result of the disintegration of the 'natural' rock or sand produced by stone crushers industries and has the largest grain size 5.0 mm. [6]

In the cement porous concrete mixture used should be a type I portland cement by the specifications provided by the Colorado Ready Mixed Concrete Association version 1.2 (CRMCA) on guidelines for the design of porous concrete pavement.

The use of water plays an important role in the process of making porous concrete, where the use of water or water-cement factor needs to be carefully controlled to produce a good mixture of concrete paste. Pore concrete that has too much water will cause the pores of the concrete to be covered by a liquid paste. Meanwhile, if too little water will make the pavement becomes brittle because the stickiness of cement with aggregate becomes less perfect, so the strength of the porous concrete will decrease. In ACI 522R-10 the best water-cement factor in the manufacture of porous concrete should be between 0.26-0.45%.

Is part mesocarp (blanket) in the form of coarse fibers of coconut. The fibers are usually referred to as waste that is only stacked under the stands of the coconut plant then left to rot or dry and is often only used as a substitute for firewood.

Coconut shell is waste (waste processing) from restaurant or household using coconut as the primary material of food supplement. Its existence is widely available to us, and its utilization is usually used for handicraft and wood fuel substitute.

METHODOLOGY

Porous concrete has a relatively low compressive strength when compared to conventional concrete compressive strength. According to ACI 522R-10, the average compressive strength of pore concrete ranges from 2.8-28 MPa. So the use of pore concrete is only suitable to be applied to road pavement that has traffic load intensity such as sidewalks, parking lots, pedestrian paths, residential streets, and parks. The concrete strength of porous concrete in this study was targeted at 17 MPa at 28 days, where the determination of compressive strength was based on the minimum quality standard paving concrete by SNI 03-0691-1996.

Porosity is a ratio between the volume of air cavities to the total amount of the entire pore concrete test specimen. The magnitude of the porosity value generated by the pore concrete will significantly depend on the size of the air cavity produced.

The larger the cavity or the pores of the concrete, the porosity value is also higher which means that the pore concrete can drain the water quickly. However, a negative impact with the magnitude of the pore will make the compressive strength of the concrete to be reduced due to the decrease of the bonds between aggregates with cement.

However, with good and correct porous concrete preparation planning, it is still possible to obtain minimum compressive strength value in accordance with the limits of the conditions already planned according to its use.

Porosity testing is done by a soaking method in water, so the porosity value of porous concrete can be calculated by using the equation: [7]

$$P = \left\{ \frac{(W_b - W_k)}{V_b} x \left(\frac{1}{pair} \right) \right\} x100\% \tag{1}$$

with:

P	=	porosity (%)
W_b	=	wet mass of specimen after soaking (gr)
W_k	=	dry mass of specimen (gr)
V_b	=	volume of the specimen (cm^3)
Pair	=	mass of water type (gr/cm^3)

Permeability is a capability possessed by rocks to pass fluid or fluid through interlocking pores or cavities. The permeability values of porous concrete obtained ranged from 0.14 to 1.22 cm/sec. To know the value of permeability can be determined by testing using the principle of high energy down (Falling Head Meter). The final value of water permeability in porous concrete can be calculated by [7].

$$k = \frac{A}{t} \tag{2}$$

with:

k	=	coefficient of permeability (m/s)
A	=	coefficient of surface area (m)
t	=	time (s)

TABLE 3: Matrix Test Specimens.

Cement (kg)	Course Agregate				Fine Agregate (kg)	Water (kg)	Number of Sample
	Gravel (kg)	Coconut Shell		Coconut Fiber 5%			
		%	kg	kg			
538	1080	10	60	60	33	258	3
538	960	20	180	60	33	258	3
538	840	30	300	60	33	258	3
538	600	50	540	60	33	258	3
538	0	100	1140	60	33	258	3

RESULT OF COMPRESSIVE STRENGTH TEST

The results of compressive strength test on the concrete paving machine compressive strength test at 28 days of all samples combination of shell and coconut fibers such as mix design matrix (Table 3) are shown in Table 4 and Figure 3 is shown a blend of shell and coconut fibers with the mean concrete paving average compressive strength at 28 days and minimum standards for compressive strength of concrete paving for parking areas.

TABLE 4: Compressive Strenght Test of Paving Concrete.

% of Coconut Fiber and Coconut Shell	No	Date Testing	Weight of sample (gr)	Strenght of 28 days (kg/cm²)	Strenght of 28 days (MPa)	Average of Strenght of 28 days (MPa)
10	1	15/04/2018	7,6	249,7	24,5	22,4
	2	15/04/2018	7,3	225,3	22,1	
	3	15/04/2018	7,6	211,0	20,7	
20	1	15/04/2018	7,2	177,4	17,4	17,8
	2	15/04/2018	7,4	181,4	17,8	
	3	15/04/2018	7,3	185,5	18,2	
30	1	15/04/2018	6,7	107,0	10,5	10,6
	2	15/04/2018	6,7	109,1	10,7	
	3	17/04/2018	6,6	108,1	10,6	
50	1	17/04/2018	5,8	78,5	7,7	7,5
	2	17/04/2018	5,2	84,6	8,3	
	3	17/04/2018	5,7	66,3	6,5	
100	1	17/04/2018	4,4	35,5	3,0	2,6
	2	17/04/2018	4,2	31,1	2,6	
	3	17/04/2018	4,5	26,6	2,3	

At the intersection point average compressive strength test results at 28 days with the minimum standards for the compressive strength of concrete paving for parking areas obtained optimal value combination of shell and coconut fiber mixture of 21% (Figure 3).

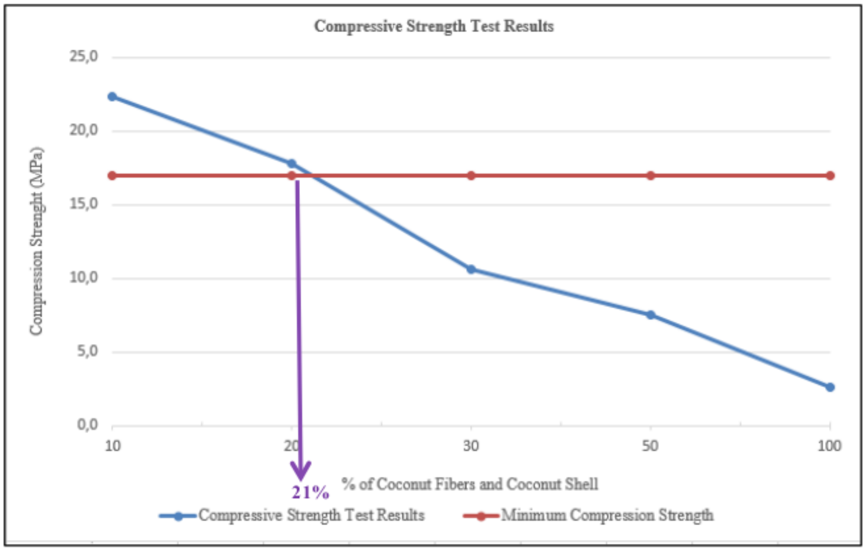

FIGURE 3. Compressive strength test result.

The optimal value of 21% is used to find the optimal values of permeability and porosity by utilizing graphics permeability and porosity values in combination with a mixture of shell and coconut fibers as shown in Figure 4, the optimal value obtained permeability of 0.5 cm/sec and a porosity value of 23 %.

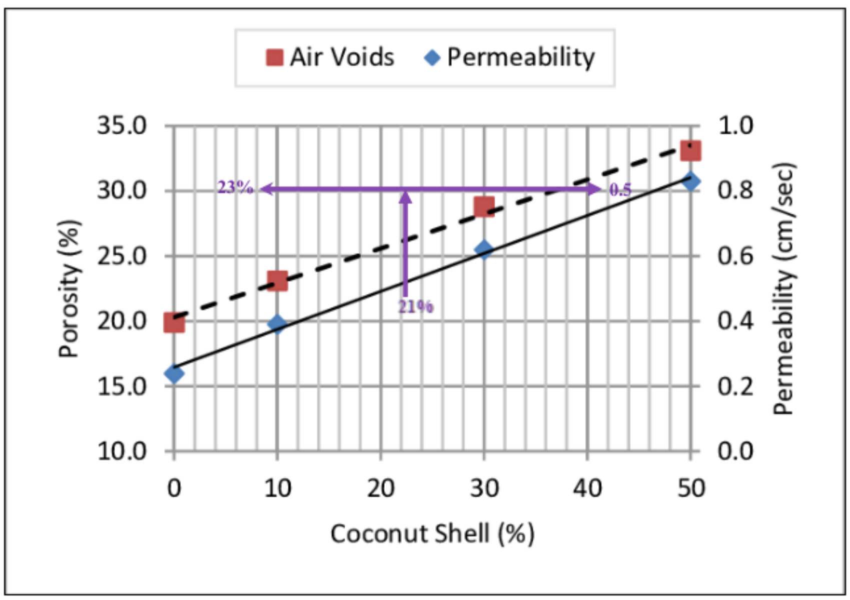

FIGURE 4. Permeability and porosity result.

CONCLUSION

- The percentage of fibers and coconut shells combined in mixed paving design has a tendency to decrease the compressive strength of paving, the more the rate will reduce the compressive strength.
- While the higher the percentage of the addition of fibers and coconut shell will be the higher the value of permeability and porosity.
- The use of coconut fiber and coconut shell material on mixed design paving block with the minimum qualifications for the parking area is 21% with a compressive strength of 17,1 MPa, permeability equal to 0,5 cm/min and porosity equal to 23%.

ACKNOWLEDGMENTS

A big thank you to the CEO of the University of Kadiri on the support so that this research can be successful and the sponsorship has been a lot of help regarding finance as well as several colleagues, Mr. Edy Gardjito, Mr. Bambang Subiyanto and Mr. Hery Lilik Sudarmanto.

REFERENCES

1. A. D. Limantara, Y. C. S. Purnomo, and S. W. Mudjanarko, "Pemodelan Sistem Pelacakan Lot Parkir Kosong Berbasis Sensor Ultrasonic dan Internet of Things (IoT) Pada Lahan Parkir Diluar Jalan," Pros. Semnastek 2017, November, pp. 1–10.
2. SNI 03-0691, "Bata Beton (Paving Block)," Badan Standar Nasional Indonesia, 1996.
3. E. P. Pratomo and A. Setyawan, "Pengaruh gradasi terhadap porositas dan kuat tekan beton berpori," September, pp. 723–731, 2016.
4. A. D. Limantara, A. Widodo, S. Winarto, L. D. Krisnawati, and S. W. Mudjanarko, "Optimizing the use of natural gravel Brantas river as normal concrete mixed with quality fc = 19.3 Mpa," IOP Conf. Ser. Earth Environ. Sci. 2018, pp. 0–8.
5. ASTM C33-78, "Standard Specification for Concrete Aggregates 1," 2010, pp. 1–11.
6. SNI 03-2834-2000, "Tata Cara Pembuatan Rencana Campuran Beton Normal," Badan Standar Nasional Indonesia 2000, pp. 1–34.
7. L. Hanta and A. Makmur, "Studi eksperimental pengaruh bentuk agregat terhadap nilai porositas dalam campuran beton berpori pada aplikasi jalur pejalan kaki," p. 10, 2015.
8. S. Mohammed, B. Mohamed, Y. Ammar, "Pervious Concrete: Mix Design, Properties and Applications", RILEM Technical Letters (2016) 1: 109 – 115,
9. P. Thushara, J. Thilak, D. Ranjith, "Pervious Concrete: A Sustainable Choice in Civil Engineering and Construction", Innovation & Application Center of Holcim (Lanka) Limited, (2014), pp. 1-7.
10. R. Rabiah, L.T. Susan, N. Jodi, H. Vimy, Annual Conference of The Transportation Association of Canada Vancouver, British Columbia, (2009), pp. 1-18.

Prosiding Sri Wiwoho Mudjanarko 3

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