Layout guide for *EES: Conference Series* using Microsoft Word Porous Concrete Filter (FBP) Design for Water Filtration

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Abstract. Water plays an important role in sustainable development, socio-economic development, energy and food production, healthy ecosystems and for human survival today and in the future. Water is also central to adaptation to climate change, serving as an important link between society and the environment. Laboratory experimental methods were carried out to find the composition of cement and fine aggregate (retained by sieve no. 50) as a constituent of porous concrete filters (PCF). The comparisons used in this study are 1:5, 1:7, and 1:9 with a thickness of 10 cm. Water with a high level of turbidity was filtered using PCF to obtain water with a turbidity level <25 NTU. PCF with a composition of 1: 9 can optimally reduce water turbidity levels up to 95% and produce the largest discharge, which is 0.072 l/s. Therefore, the smaller the fine aggregate composition used, the better the PCF's ability to reduce turbidity levels, but reduce the resulting discharge capacity. In other words, it will be inversely proportional to the turbidity level and directly proportional to the water discharge.

Keywords: *Water, PCF, Turbidity Level, Discharge.*

Introduction

Water is the primary requirement for world society. Therefore, one of the SDGs targets is to improve the quality and availability of water in 2030 to ensure the availability and management of water and sustainable sanitation for all. The achievement of adequate access to clean water in Indonesia is currently only 72.55% and is still far below the SDGs target of 100% (1). A total of 33.4 million people lacked clean water and 99.7 million shortfall improved sanitation facilities (1). This is due to limited infrastructure and clean water treatment technology that is evenly distributed in Indonesia (2).

The development of water treatment techniques is growing. A simple technique that is commonly used is to draw up a specific material per layer with a certain thickness which is considered to improve water quality. Several water treatment techniques such as chemical processing, ultrafiltration technology and Reverse Osmosis (RO) have also been widely applied in various fields.

In this decade, separation technique with membrane technology has also developed and is widely applied in the water treatment industry as an alternative to conventional treatment such as; coagulation, sedimentation, and filtration with fine aggregate media. Membrane technology for water treatment is increasing and using different material combinations to get optimal results, however synthetic membranes made from polymers such as cellulose acetate, ethyl cellulose, polyvinyl alcohol, methyl polymethacrylate require relatively high costs. A method that is simpler and easier to apply to the public is needed but its function is almost the same or equivalent to a membrane, namely the Porous Concrete Filter (PCF).

Generally, porous concrete is a uniformly graded material consisting of cement, coarse aggregate, little or no fine aggregate, added materials, and water (3). This type of concrete has a high porosity that allows the water above it to flow into the lower layer. This when applied to construction project reduces runoff directly and increases groundwater recharge (4). This concrete is generally used in parking areas, areas that have light or low traffic volume roads, residential roads, on sub bases for conventional concrete pavements and pedestrian sidewalks (5). In this study, the permeability of porous concrete is used for water filtration through concrete pores (6). These pores are useful for refining suspensions and emulsions but can still pass water. Porous concrete is modified with cement and fine aggregate as the base material for PCF.

Water treatment with PCF is still rarely used in Indonesia even though its use is more efficient in operation and energy needs (7). The right composition of PCF constituent materials can separate suspensions and emulsions (8). In addition, the PCF manufacture cheaper price and operating pressure required is smaller and thus require support tool utility fewer (7).

Taghizadeh *et al.*, (2007); Kamulyan, (2014); Jeswani *et al.*, (2014) have proved that the function PCF is almost the same or equivalent to membrane technology, which can reduce the turbidity level of the water to <5 NTU (6,8,9). PCF also have filtration capability against contaminating bacteria (*Escherichia coli* and *coliform*) to 100% (7). Ong *et al.* (2016) examined the physical/chemical characteristics and water flow of various porous concrete mixtures made of various concrete materials and their effectiveness in reducing water pollution (10). This study proves that porous concrete with a mixture of fly ash and limestone powder can reduce pollutants by about 30% of the influent naphthalene concentration. The mixture with pure cement removes 10% of the influent naphthalene concentration, while the mixture with slag removes only 0.5% of the influent naphthalene concentration. Porous concrete with smaller aggregate size and higher cavity content has a better ability to remove Phosphorus and Nitrogen (11). Porous concrete can also increase the PH of water (12,13). Faisal, et al. (2020) reported that porous concrete can reduce COD and BOD by 61% and 79% respectively (14).

This study aims only to design the most optimal PCF in the water filter in reducing water turbidity level.

Methodolgy

The research method used was experimental in the Laboratory of the Department of Civil Engineering, Faculty of Engineering, University of Gorontalo.

Materials and Tools

The materials used in making Porous Concrete Filters (PCF) are portland cement and fine aggregate with various compositions (1:5, 1:7,1:9) and 10 cm thick. The tools used are sieve no.30, sieve no.50 sieve no. 200, scales, ovens, bohlers, measuring glass, dryers, trays, sieve shakers, compacting sticks, pycnometers, and cone molds.

Method

The method this study as follows.

Design and build the PCF test model (Figure 1).

Preparation of equipment used.

Preparation of PCF composition materials as follows:

Portland cement tested; fineness level filtered on filter no.200; specific gravity; and volume weight.

Fine aggregate tested: The test passes sieve no. 30 and is stuck with sieve no.50; specific gravity test; and volume weight test. The fine aggregate used is in the SSD (Saturated Surface Dry) condition.

PCF printing in pipe. 5" according to the composition (Figure 2). Each material is mixed evenly and poured into the pipe. It ensures that no air is trapped in it by gently poking and tapping the pipe until it is even. Furthermore, PCF is soaked for 3 days for curing so that the heat of the hydration of the cement is lost. After soaking, the PCF was removed and dried.
Install dry PCF to the test model (Figure 2).
Taking water samples for testing the physical parameters of water samples.
The PCF model test is carried out by filling the inlet reservoir with water samples whose turbidity parameters have been tested.
Taking samples of infiltrated water through PCF, the turbidity level is tested and the resulting water discharge is measured.
Comparison of the results of filtered water samples by PCF and analysis of the effectiveness of PCF on turbidity parameters.
Repeat steps (2) - (9) for a different cement and fine aggregate composition.

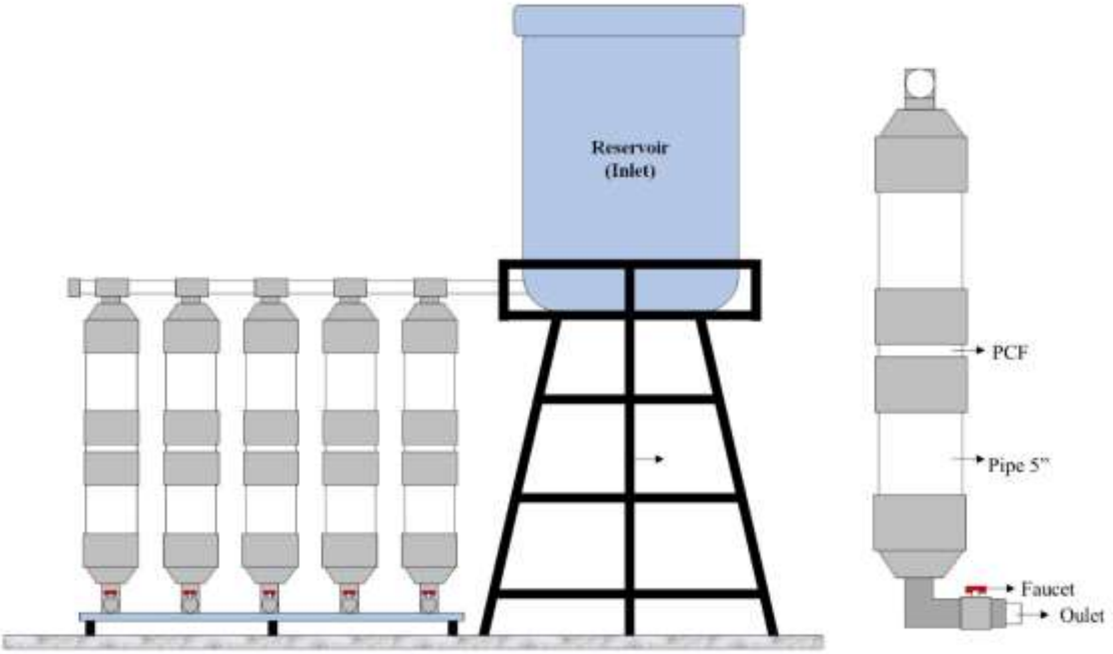

Figure 1. PCF test model

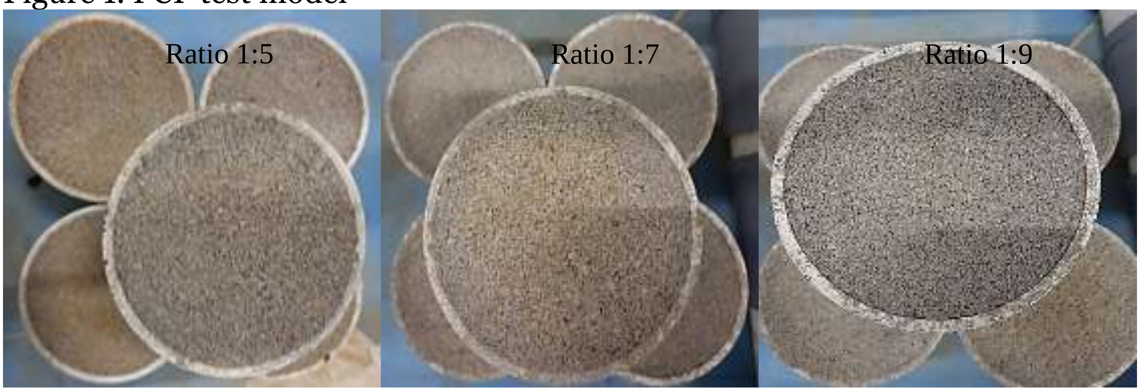

Figure 2. PCF

Results and Discussions

In this study, the PCF used consisted of 3 compositions of cement and fine aggregate, namely 1:5, 1:7, and 1:9. The water samples used had different levels of turbidity for each composition, namely 391.8 NTU each; 210.9 NTU; and 396.3 NTU. The three samples were flitrated using PCF with the composition above to see how effectively PCF can filter water. The results obtained for each PCF composition can be seen in Figure 3. It shows that PCF with each composition can reduce water turbidity levels to

99.59% (average 1.61 NTU from 391.8 NTU) for PCF 1:5, 94.42% (average 12.18 NTU from 210.9 NTU) for PCF 1:7, and 95.31% (average 18.61 NTU 396.3 NTU) for PCF 1:9. The three results of PCF filtration are in accordance with quality standards based on the Regulation of the Minister of Health of the Republic of Indonesia Number 32 of 2017 concerning Environmental Health Quality Standards and Water Health Requirements for Sanitation Hygiene Needs, Swimming Pools, *Solus per aqua*, and Public Baths. The quality standard for the level of turbidity based on the Environmental Health Quality Standard for Water Media for Sanitation Hygiene Purposes is <25 NTU.

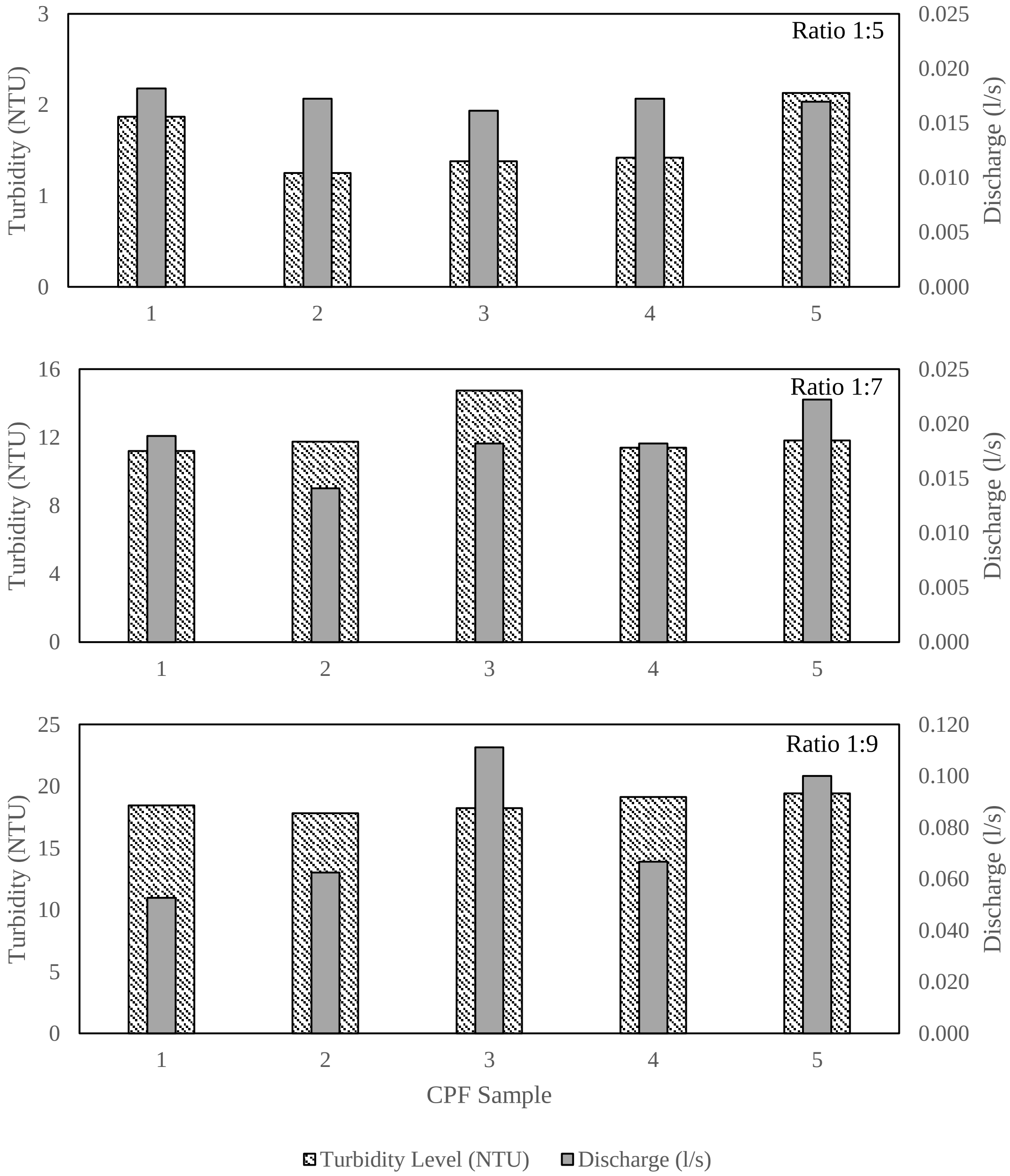

Figure 3. The level of turbidity after filtering water and discharge passing through the PCF

Figure 3 also shows that the average water discharge generated by each PCF composition is 0.017 l/s respectively; 0.018 l/s; and 0.072 l/s. These results prove that the smaller the composition of the fine aggregate used, the better the ability of PCF to reduce turbidity levels, but reduce the resulting discharge capacity. This means that the composition of fine aggregate to cement will be inversely proportional to the turbidity level and is directly proportional to the volume of water discharge. Therefore, it can be concluded that PCF with a composition of 1:9 is the most optimal for use, because it can reduce water turbidity levels to 95% or <25 NTU and produce the largest discharge, which is 0.072 l/s. The size of the pores in the concrete filter is divided into three, namely pores that are smaller than the size of the suspension and the emulsion is called gel pores with a size of 0.5-5 nm, capillary pores with a size of 5-5000 nm and macro pores with a size of > 5000 nm. The relationship between the capillary pores that form the filtration pathway can filter suspensions and emulsions because they are segmented by gel pores (typical gel path travelers). The thicker the filter, the greater the chances of typical gel path traveled occurring.

Conclusions

In this study, the evaluation of the physical characteristics of the PCF samples, and the influence of water cement and fine aggregate ratio are investigated. According to the current experimental work, the following conclusions are be observed:

The PCF Sample showed the best removal for suspense of approximately 99.59 % when the ratio 1:5 was used, as compared with that of 1:7 and 1:9.

The PCF Sample showed the highest discharge of approximately 0.072 l/s when the ratio 1:9 was used, as compared with that of 1:5 and 1:7.

The smaller the cement and fine aggregate ratio used, the better the PCF's ability to reduce turbidity levels, but reduce the water discharge. In other words, it will be inversely proportional to the turbidity level and directly proportional to the water discharge.

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References

1. BPS. Statistik Air Bersih 2012- 2017. BPS Indonesia. Jakarta; 2018.
2. Sukartini NM, Saleh S. Akses Air Bersih di Indonesia. J Ekon Kuantitatif Terap. 2016;9(2):89–98.
3. Sandy D, Tonapa SR, Tanan B, Febriani L. Experimental Study of Porous Concrete with Addition of Fiber Variations. Int J Eng Sci Appl. 2017;4(1):69–76.
4. Shreyas K. Porous Concrete & Its Characteristics With Mineral Admixtures. J Emerg Technol Innov Res. 2018;5(7):1359–64.
5. Xu G, Shen W, Huo X, Yang Z, Wang J, Zhang W, et al. Investigation on the properties of porous concrete as road base material. Constr Build Mater [Internet]. 2018;158:141–8. Available from: https://doi.org/10.1016/j.conbuildmat.2017.09.151
6. Taghizadeh MM, Torabian A, Borghei M, Hassani AH. A study of feasibility for water purification using vertical porous concrete filter. Int J Environ Sci Technol. 2007;4(4):505–12.
7. Maadji R. Karakteristik Filtrasi dan Cuci balik Filter Beton untuk Air Minum. Universitas Gadjah Mada; 2018.
8. Kamulyan B. Karakteristik Hidraulik Filtrasi Dan Cuci balik Filter Beton. Universitas Gadjah Mada; 2014.
9. Jeswani H, Oke N, Choksi P, Naik A, Mahapatra N, Sayed R. Use of pervious concrete as gravity filter. In: 21st Century Watershed Technology Conference and Workshop 2014: Improving Water Quality and the Environment. Waikato: ASABE; 2014. p. 155–63.

10. Ong SK, Wang K, Ling Y, Shi G. Pervious Concrete Physical Characteristics and Effectiveness in Stormwater Pollution Reduction [Internet]. Iowa; 2016. Available from: http://lib.dr.iastate.edu/intrans_reports/197
11. Park SB, Tia M. An experimental study on the water-purification properties of porous concrete. Cem Concr Res. 2004;34(2):177–84.
12. Ju Lee M, Gin Lee M, Huang Y, Liang Chiang C. Purification Study of Pervious Concrete Pavement. Int J Eng Technol. 2013;5(5):532–5.
13. Bhuiyan TA. Pervious Concrete and Water Quality. University of Georgia; 2015.
14. Faisal GH, Jaeel AJ, Al-Gasham TS. BOD and COD reduction using porous concrete pavements. Case Stud Constr Mater [Internet]. 2020;13:e00396. Available from: https://doi.org/10.1016/j.cscm.2020.e00396