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The Effect of Coarse Aggregate Size On Pervious Concrete Mixture

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Abstract

Along with the development progress in Indonesia, it causes the reduction of green areas. Coupled with the lack of public awareness of the environment is a problem that must be considered. Pervious concrete that be as one of the solutions in pavement construction, concrete sheet piles, retaining walls is a product that can be considered successfully in meeting expectations as an environmentally friendly construction. For road pavement, pervious concrete must have a strength of 30 MPa. Therefore, there is a need for research for the mix design of pervious concrete using the ACI 522R-10 Report on Pervious Concrete method with an initial design compressive strength of 25 MPa. The method is to vary the coarse aggregate used in the pervious concrete mixture. In this research, it is divided into 5 variations to find a mixture that is in accordance with the plan or which exceeds the initial plan, and its permeability still meets the requirements for pervious concrete. Testing of the specimens includes the volume weight test, compressive strength, split tensile strength, modulus of elasticity of concrete, porosity, absorption, and permeability. From the research, the results of the volume weight of pervious concrete are 1,974.14 - 2,187.83 kg/m^3 that pervious concrete is included in the lightweight concrete group due to it has a weight below 2,200 kg/m^3. The average compressive strength of pervious concrete is 20.089 – 46.978 MPa. The value of the split tensile strength of pervious concrete is 8,968-19,127 MPa. The average value of porosity is between 8,307 – 13,097%. The average value of absorption is between 3.452 – 5.444%. The average value of the permeability is between 0.0025-0.487 cm3/sec. From this research, it can be concluded that the use of different coarse aggregates size will produce pervious concrete with different compressive strengths. The compressive strength with aggregate size 0.5x0.5 without sieving, it closed to the initial plan of 27.72 MPa, whereas the highest compressive strength is for a mixed aggregate size of 1/1 and 0.5/0.5 cm with sieving that the compressive strength achieved 46.978 MPa.

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1. Introduction

Pervious concrete consists of agglomeration of single-sized coarse aggregate covered with a thin cement paste layer of about 1.3 mm (Neville and Brooks, 2010).

Based on ACI 522R-10 mix design for pervious concrete consists of: cement (270 - 415 kg), aggregate (1190 - 1480 kg), cement water factor (0.27 - 0.34), ratio of sand and gravel weight (0 to 1:1) by using chemical admixtures.

The addition of sand will reduce the pore content and increase the compressive strength. The use of non-sand concrete as a pavement material is very limited and has not been developed for certain applications. However, non-sand concrete has been widely used as a structural building material in Europe, Australia and the Middle East for more than 70 years (Harber, 2005). The earliest use of pervious concrete occurred in England in 1852 with the construction of two dwelling houses and a sea grove 61 m long and 2.15 m wide (Harber, 2005). The use of non-sanded concrete became much more widespread during the material shortage after World War II, for cast-in-place load-bearing walls for non-rise and multi-storey buildings.

The initial use of non-sand concrete was mainly for two-story structures, then it was developed for five-story buildings in the 1950s and continues to grow. In recent years, pervious concrete has been used as a load-bearing material in high-rise buildings of up to ten stories. The most remarkable use of pervious concrete was in Stuttgart, Germany where high-rise buildings were constructed using conventional concrete for the lower six floors and non-sand concrete for the remaining thirteen upper floors (Harber, 2005).

The specific gravity of pervious concrete is generally about 70% of conventional concrete if made with the same material. The specific gravity of pervious concrete using conventional aggregates varies from 1602 to 1922 kg/m^3. Clinker aggregate has been tested and the pervious concrete produces a specific gravity of 961 kg/m3 (Harber, 2005).

(Abadjieva and Sephiri, 2000) conducted a study of pervious concrete with a ratio of weight of aggregate to cement from 6 : 1 to 10 : 1. The compressive strength of pervious concrete at the age of 28 days varied from 1.1 to 8.3 MPa, depending on the ratio of aggregate to cement. , and the decrease occurred with increasing the ratio of aggregate to cement. The mixture with the ratio of aggregate to cement 6:1 is the strongest. The compressive strength of pervious concrete is lower than the compressive strength of conventional normal concrete due to an increase in porosity. The highest tensile strength and flexural strength occurred at the ratio of aggregate to cement 7:1 and the decrease occurred with increasing ratio of cement to aggregate. The tensile strength and flexural strength of pervious concrete are lower than conventional normal concrete (Ginting, 2015).

Non-sand concrete has several advantages, including (Kusuma, 2013):

- *Low Shrinkage*, the total shrinkage of non-sanded concrete when hardened/dry is about half that of solid concrete made with the same aggregate. The shrinkage rate is also much faster. The total shrinkage movement, it has been found that 50% to 80% occurs in the first 10 days, whereas for solid concrete only 20 to 30 percent will occur in the same period. This means that the danger of cracking is much less when compared to normal concrete.
- *Light Weight*, due to the use of lightweight aggregate, lightweight concrete is produced.
- *Thermal insulation*.
- *Eliminated segregation*.
- *Reduce cement demand*, the need for cement is small because it does not use sand, so the aggregate surface area is reduced.
- *Simple*, which means how to make it simple and faster.
- *Sound insulation*.
- *Environment Friendly*, easy to pass water, can be used as a material for making infiltration wells, thereby increasing infiltration into the soil.

Non-sand concrete has several disadvantages, some of which are (Kusuma, 2013):

- *Porous*, non-sand concrete is not recommended with reinforcing steel especially if it is in an aggressive environment, its pervious nature can accelerate the corrosion rate of the structure.
- *Low compressive strength*, due to its light weight, the compressive strength of non-sand concrete is very low so that the application is very limited.

Figure 1. a pervious concrete

This research aims to determine the effect of coarse aggregate size in the pervious concrete mixture that is designed.

2. Methodology and Literature Review

The research study is a literature study and an experimental study on pervious concrete. The research location is at the Materials and Construction Laboratory, Faculty of Engineering, Universitas Tanjungpura, Pontianak and a concrete workshop on Jalan Reformasi Untan.

2.1. Material

The materials used in the manufacture of pervious concrete are as follows:

1. The cement used is type PCC.
2. The stones used are 1/1 cm and 0.5/0.5 cm. Where is this stone, some are sieved and some are not sieved.
3. The water used is PDAM water with a PH of 6-7.
4. Superplasticizer with the trademark Sikamen LN issued by PT Sika.
5. The planned compressive strength is 25 MPa.
6. W/C used 0.26
7. Mixing standard based on ACI 522R-10
8. Mineral admixture that used is Sikafume.

2.2. Equipment

The equipment used in this test are a compressive testing machine, bearing block, compressometer, concrete cube, concrete cylinder, vibrating sieve machine (shieve sekker machine), material oven, weighing machine mixer, Los Angeles machine, slump tools, organic plates and other support tools.

2.3. Research Method

The research method is as follows:

1. *Material preparation and test*
    a. Collection of theoretical basis, previous research journals that support this research
    b. Preparation of materials and testing of materials
2. *Concrete mix design*. Calculation of the concrete mix design using ACI 522R-10 with a design compressive strength of 25 MPa. Calculation of the need for the manufacture of test specimens as many as 5 variations of specimens, five variations of specimens with gradation of coarse aggregate.

3. *Casting the test specimens*, is made in the form of a cube with a size of 15 x 15 cm and a cylinder with a diameter of 15 cm and a height of 30. The casting of the test object is assisted with a concrete mixer machine.
4. *Test object treatment*. Treatment of the test specimens is carried out by immersing it in a tub filled with water at room temperature. Treatment is carried out one day after casting to one day before testing.
5. *Volume weight test.* Testing the weight volume of the concrete cylinder using an electric scale with an accuracy of 0.05 kg at the age of 3, 7, 14, 21, 28 days of concrete.
6. *Compressive strength test*. Testing the compressive strength of concrete based on SNI 03-1974-2011, this research uses a compressive testing machine brand MTB with a capacity of 2,000 kN and an accuracy of 5 kN at the age of 3, 7, 14, 21, 28 days.
7. *Permeability Test*. Permeability testing is carried out to determine and measure the ease with which water can pass through the concrete. The test is carried out using a permeability tool
8. *Split tensile strength test*. Split tensile strength testing is based on SNI 03-2491-2002, this research uses a bearing block and a MTB brand compressive testing machine with a capacity of 2000 kN and an accuracy of 5 kN at the age of 28 days.

2.4. Analysis Method

1. Volume weight can be calculated by the formula :

$$W_c = \frac{m}{V} \quad \text{...(1)}$$

Where:

Wc	=	Volume weight (kg/m^3)
m	=	Concrete weight (kg)
V	=	Concrete volume (m^3)

Compressive strength can be calculated by the formula :

$$f_c = \frac{P}{A} \quad \text{...(2)}$$

Where;

f_c	=	compressive strenght (MPa)
P	=	maximum load test (N)
A	=	contact area (mm^2)

2. Permeability coefficient can be calculated by the formula :

$$K = \frac{\rho g L Q}{P A} \quad \text{...(3)}$$

Where:

K	=	permeability coefficient (cm^3/det)
ρ	=	density of water (kg/cm^3)
g	=	acceleration of gravity (cm/det^2)
L	=	length or height of sample (cm)
Q	=	flow rate of water (cm^3/det)
P	=	Water pressure (kg cm/det^2/cm^2)
A	=	contact area of sample (cm^2)

3. Split tensile strength can be calculated by the formula:

$$f'_{ct} = \frac{2P}{\pi t D} \quad \text{...(4)}$$

where :

f'_{ct}	=	split tensile strength of concrete (N/mm^2)
P	=	maximum compressive load when concrete cylinder split/collapsed (N)
π	=	phi (3,14)
t	=	height/length of concrete cylinder (mm)
d	=	diameter of concrete cylinder (mm)

2.5. Population and Sample

The population is all objects to be studied in this study, namely cylinders with a cylinder size with a diameter of 150 mm, and a height of 300 mm.

Table 1. List of Laboratory Specimens for Test Sample

No	Test Specimen	Compressive Test					Split Tensile Test	Porosity, permeability
		Day to					Day to -	Day to -
		3	7	14	21	28	28	28
Var 1	Cylinder	5	5	5	5	5	5	5
Var 2	Cylinder	5	5	5	5	5	5	5
Var 3	Cylinder	5	5	5	5	5	5	5
Var 4	Cylinder	5	5	5	5	5	5	5
Var 5	Cylinder	5	5	5	5	5	5	5
Total		**125**					**25**	**25**

Where:

Var 1	=	A mixture of cement, sieved stone 1/1 cm, water, SF and SP.
Var 2	=	A mixture of cement, 50% of 1/1 cm stone + 50% of sieved 0,5/0,5 cm stone, water , SF and SP.
Var 3	=	A mixture of cement, unsieved 1/1 cm stone, water, SF and SP.
Var 4		A mixture of cement, sieved 0,5/0,5 cm stone, water, SF and SP.
Var 5		A mixture of cement, unsieved 0,5/0,5 cm stone, water, SF and SP.

3. Results and Discussion

3.1. Material Testing

3.1.1. Cement

The elements contained in the PCC Conch cement used are as follows:

Table 2. Composition of PCC Conch cement

Element	(%)
Silicon Dioxide (SiO_2)	23,64
Alumunium Oxide (Al_2O_3)	8,4
Ferric Oxide (Fe_2O_3)	4,36
Calcium Oxide (CaO)	58,38
Magnesium Oxide (MgO)	1,91
Sulfur Trioxide (SO_3)	2
Lost Incand (LOi)	3,28
Free Lime	0,56
Undissolved part	8,96

3.1.2. Water

The water used is PDAM water with a PH of 7 and clean conditions because the water can be used for drinking water. This water data was obtained from the results of previous research on pervious concrete.

3.1.3. Chemical Admixture

Chemical admixtures are usually used in small amounts in pervious concrete mixture. The purpose of its use is to improve certain properties of the mixture, especially to speed up the drying process in pervious concrete.

In this study, Sikamen LN and Silica Fume were used as chemical admixtures to reduce the water level of the concrete specially formulated for the precast concrete element industry, to increase the initial strength of the concrete so that the formwork can be quickly released and can be used as much as possible so that the time used can be accelerated. So from these data it can be concluded that Sikamen LN is a type F chemical admixture with high initial strength and water reduction.

Sikamen LN is a dark brown liquid from PT Sika Indonesia. Using Sikaman LN will be able to reduce air by 20%, will result in a 40% increase in 28 days of compressive strength and an increase in airtightness. Its density is 1.22 ± 0.01 kg/L at 2+20 °C

Meanwhile, the usage limit of Sikamen LN is at a dose level of 0.30% - 2.0% of the total weight of cement material depending on the requirements regarding workability and strength. It is recommended that a trial mixture be carried out to determine the appropriate level of need. Typical dosage rates for use with silica sand are 0.30% - 1.20% by weight of cementitious materials.

Silicafume is an excellent and high-performance additive for concrete mixture, in order to produce high-performance concrete. The use of silicafume as much as 25% of the weight of cement is the most optimum silicafume content for the manufacture of concrete (*Wille, et al., 2011*)

3.1.4. Coarse Aggregate (split stone)

Split stone is a coarse aggregate used in this study as an ingredient in the manufacture of pervious concrete. The split stone used is the stone originating from West Kalimantan. For this study used 2 types of split stone sizes, namely split stone measuring 1/1 cm and split stone measuring 0.5 / 0.5 cm which is sieved sieve and not sieved with a sand.

3.1.4.1. Physical and mechanical data 1 cm/1 cm stone

The type of aggregate is distinguished in two conditions, namely the saturated surface dry (SSD) state and the absolute dry state or oven dry state. In this examination, the absorption value will also be obtained, namely the ratio between the weight of water absorbed by the aggregate in a saturated surface condition and the weight of the aggregate in an oven dry state.

Inspection of specific gravity aims to determine the specific gravity and percentage of water weight that can be absorbed by coarse aggregate (stone), calculated against dry weight. The results can be seen in the table below:

Table 3. Results of Examination of Coarse Aggregate Size 1/1

No	Type of Examination	Examination Result	Unit
1	Absorption	0,103	%
2	Volume weight	1.571	kg/m^3
3	Water content	1,6	%
4	Fineness Moduli	6,62	-
5	Aggreagate wea	9,1	%
6	Mud content	0,4	%
7	Specific gravity	1.780	kg/m^3

The value of fineness modulus for coarse aggregate (split) with a size of 1 cm / 1 cm is 2,919. This coarse aggregate is classified as good coarse aggregate because it has fineness modulus value between 2 - 8. So that it meets the requirements for use in concrete with a strength of 25 MPa.

3.1.4.2. Physical and mechanical data of stone size 0.5/0.5 cm

The type of aggregate is distinguished in two conditions, namely the saturated surface dry state (SSD) and the absolute dry state or oven dry state (oven dry). In this examination, the absorption value will also be obtained, namely the ratio between the weight of water absorbed by the aggregate in a saturated surface condition and the weight of the aggregate in an oven dry state.

Inspection of specific gravity aims to determine the specific gravity and percentage of water weight that can be absorbed by coarse aggregate (stone), calculated against dry weight. The results can be seen in the table below.

Table 4 Results of Examination of Coarse Aggregate Size 0.5 cm / 0.5 cm:

No	Type of Examination	Examination Results	Unit
1	Absorption	0,188	%
2	Volume weight	1.668	kg/m^3
3	Water content	0,272	%
4	Fineness Modulus	2,75	-
5	Aggregate wear	12,21	%
6	Mud content	2,4	%
7	Specific gravity	2.455	kg/m^3

The value of fine grain modulus (MHB) for coarse aggregate (split) with a size of 0.5/0.5 cm is 2.750. This coarse aggregate is classified as good coarse aggregate because it has an fineness modulus value between 2 - 8. So that it meets the requirements for use in concrete with a strength of 25 MPa.

3.1.5. Fine Aggregat

The type of aggregate is distinguished in two conditions, namely the saturated surface dry state

(SSD) and the absolute dry state or oven dry state (oven dry). In this examination, the absorption value will also be obtained, namely the ratio between the weight of water absorbed by the aggregate in a saturated surface condition and the weight of the aggregate in an oven dry state.

Inspection of specific gravity aims to determine the specific gravity and percentage of water weight that can be absorbed by fine aggregate (sand), calculated against dry weight. The results can be seen in the table below:

Table 5. Fine Aggregate Inspection Results

No	Type of Examination	Hasil Pemeriksaan	Unit
1	Absorption	0,08	%
2	Volume weight	1.668	kg/m^3
3	Water content	0,421	%
4	Fineness	2,002	-
5	Aggregate	2	warna
6	Mud content	5	%
7	Specific gravity	2.518	kg/m^3

The volume weight of the fine aggregate was checked in the loose and solid state. Analysis of the average volume weight obtained by sand is 1,668 kg/m^3.

3.2. Composition of Pervious Concrete Mixture with ACI 552R

From the material data obtained, a mix design for pervious concrete is made referring to the ACI 522R-10 Report on Pervious Concrete regulations, because at this time Indonesia does not yet have SNI for pervious concrete. From the analysis carried out, the data obtained are as follows;

Tabel 6 Total material requirement for $1m^3$

Material	Var1	Var2	Var3	Var4	Var5
			Kg		
Cement	382,61	382,61	382,61	382,61	382,61
Air	114,4	14,41	14,41	14,41	14,41
Coarse Aggregate 1/1 cm (sieved)	1480,73	740,365			
Coarse Aggregate 0,5/0,5 cm (sieved)		740,365		1480,73	
Coarse Agregat 1/1 cm (unsieved)			1480,73		
Coarse Aggregate 0,5/0,5 cm (unsieved)					1480,73
Selicafume	57,39	57,39	57,39	57,39	57,39
Superplasticizer	7,65	7,65	7,65	7,65	7,65

3.3. Pervious Concrete Analysis

Pervious concrete is the final subject of this study. The study of pervious concrete used a cylindrical specimen with a diameter of 15 cm and a height of 30 cm. Where for the material composition plan obtained from previous research, namely from journal materials using water cement ratio (w/c) 0.26.

3.3.1. Slump Test

Slump testing is very important to determine the level of workability and the resulting material. Where the slump test is carried out. The data from the research that has been done obtained the following data:

Tabel 7. Slump Test

No	Variasi	Slump Test (cm)
1	Var 1	19,5
2	Var 2	17
3	Var 3	17
4	Var 4	4,8
5	Var 5	4,5

From the table it can be seen that the slump test is obtained for an average of 45 – 195 mm. Based on the SNI regulations for concrete construction, it is required that the best concrete is with a slump of 25-100 mm. Thus, only Var4, and Var5 fulfill these conditions. For Var1, Var2 and Var3 too dilute. This is caused by using too much water or too much sikament. Thus it is necessary to reduce water by 10% with the addition of LN.

3.3.2. Volume Weight Test

The results of the average volume/content weight of the pervious concrete that have been tested for the sample size of the cylindrical sample with a diameter of 15 cm and a height of 30 cm from each variation of the mixture for each age obtained the following data:

Table 8. Volume Weight/content average age 3,7,14,21 and 28 days

Variation	Avarage Volume Weight (Kg/m³)				
	3 Days	7 Days	14 Days	21 Days	28 Days
Var1	2212,35	2180,29	2189,72	2184,06	2187,83
Var2	2030,08	2006,82	2018,77	2022,54	2014,37
Var3	1979,8	1962,2	1977,28	1972,26	1974,14
Var4	2155,78	2147,55	2133,15	2111,78	2099,84
Var5	2256,34	2250,68	2251,94	2245,03	2236,23

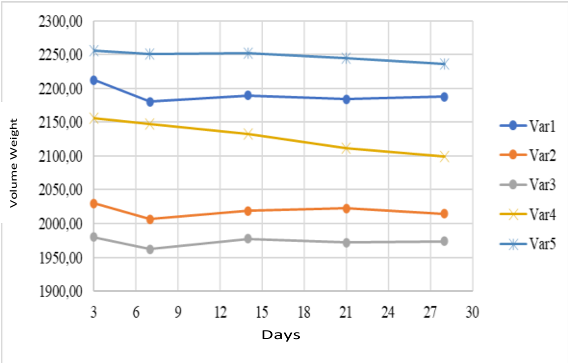

Figure 2. Graph of volume weight vs age of pervious concrete

From the table, it can be seen that the pervious concrete from each variation were taken from 15 specimens that had been made, which resulted in an average weight/volume weight of concrete between 1,974.14 – 2,236.23 kg/cm3 at the age of 28 days. It can be seen from this that the weight of pervious concrete is lighter than normal concrete in general and there is also the same where normal concrete is limited to a weight of 2,200-2,500 kg/cm3. The weight of this pervious concrete will decrease along with the increase in the age of the concrete.

3.3.3. Compressive Strength Test

The results of the compressive strength test of pervious concrete that have been tested for cylindrical specimens with a diameter of 15 cm and a height of 30 cm for each age obtained the following data:

Table 9 Average compressive strength by age

Variasi	Avarage Compressive Strength (MPa)				
	3 Hari	7 Hari	14 Hari	21 Hari	28 Hari
Var1	10	11,26	18,13	19,11	20,09
Var2	22,78	37,33	45,33	45,78	46,98
Var3	15,78	15,89	21,2	21,42	21,64
Var4	18,62	23,87	27,44	32,18	34,44
Var5	20,67	25,17	27,67	27,33	27,72

From the table it can be seen that the pervious concrete of each variation was taken from 15 specimens that had been made, which resulted in an average compressive strength of 28 days between 20.09 - 46.98 MPa. From the results obtained, the greatest compressive strength is the variation 2 by using mixed stone as much as 50% for stone 1/1 and 0.5/0.5. From the planning for 25 MPa which is close to the var5 variation, while for the var3 variation the compressive strength does not reach.
From the table above, we can see that with increasing age of the concrete, the compressive strength of the concrete will be stronger. This can be illustrated in the barcart image below.

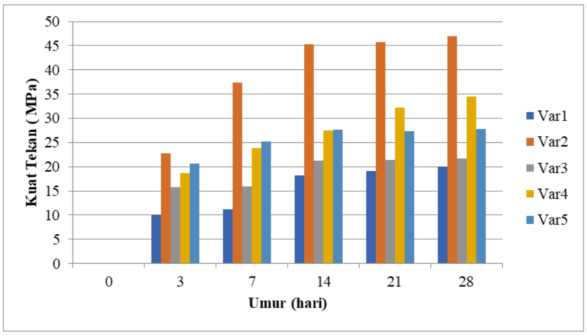

Figure 3. Barchart Compressive Strength Vs Age

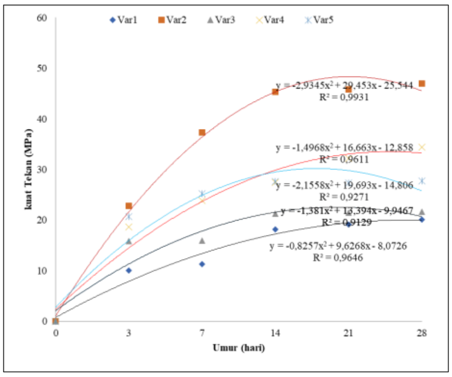

Figure 4. Graph of Compressive Strength Vs Age

For all variations that have been tested, the equation for the relationship between compressive strength and age is as follows:

Table 10. Equation of compressive strength vs. age of pervious concrete

Variation	Equition and Value R^2
Var1	$y = -1{,}381x^2 + 13{,}394x - 9{,}9467$ $R^2 = 0{,}9129$
Var2	$y = -2{,}9345x^2 + 29{,}453x - 25{,}544$ $R^2 = 0{,}9931$
Var3	$y = -0{,}8257x^2 + 9{,}6268x - 8{,}0726$ $R^2 = 0{,}9646$
Var4	$y = -1{,}4968x^2 + 16{,}663x - 12{,}858$ $R^2 = 0{,}9611$
Var5	$y = -2{,}1558x^2 + 19{,}693x - 14{,}806$ $R^2 = 0{,}9271$

where this is a strong relationship between y and x because R2 is close to 1 or the truth level is close to 1. From the above equation, we can use it as a reference to determine the strength of pervious concrete based on age.

3.3.4. Permeability Test

The results of the permeability test for pervious concrete that have been tested for cylindrical specimens with a diameter of 15 cm and a height of 30 cm for each variant obtained the following data:

Table 11. Permeability of the average age of 28 days

Variasi	Permeabilitas (cm^3/det)
	28 Hari (%)
Var1	0,1842
Var2	0,0973
Var3	0,4876
Var4	0,1148
Var5	0,0025

Based on the data from the table above, it was found that the permeability results were obtained in the Var3 variant, namely 1/1 cm stone without sieving with a permeability of 0.49 (cm^3/sec). For the smallest permeability is a mixture of stone size 0.5/0.5 cm without sieving.

3.3.5. Porosity Test

The results of the permeability test for pervious concrete that have been tested for cylindrical specimens with a diameter of 15 cm and a height of 30 cm for each variant obtained the following data:

Table 12. Porosity average age 28 days

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Variation	Porosity
	28 Days (%)
Var1	23,41
Var2	23,88
Var3	23,56
Var4	23,81
VVar5	23,24

Based on the data from the table above, it was found that the best proportion results were obtained in the Var2 variant, namely a mixed stone of 0.5/0.5 and 1/1 cm with a porosity of 23.88%. which is the more pervious the concrete will be easier to absorb and drain the water that remembers it.

3.3.6 Tensile split strength test

The results of the split tensile test of pervious concrete that have been tested for cylindrical specimens with a height of 30 cm and a diameter of 15 cm for each variant obtained the following data:

Table 13. The average split tensile test results based on the age of 28 days

Variation	Split tensile strength (MPa)
	28 Days
Var1	8,97
Var2	19,05
Var3	10,16
Var4	19,13
Var5	16,03

Based on the data from the table above, it was found that the best split tensile strength results were obtained in the Var4 variant, namely 0.5/0.5 cm stone filtered with a porosity of 19.13 MPa. Thus, for split tension in pervious concrete, the average split tensile strength is 40.55 -57.82 % of its compressive strength. Thus, this pervious concrete has met the requirements for split tensile strength where the minimum split tensile required is 40 % compressive strength.

4. Conclusion

a. From the material analysis that has been carried out, a mix design is made for pervious concrete with a planned compressive strength of 25 MPa using the ACI 522R-10 standard. The following mixture was obtained:

Tabel 14. Composition of pervious concrete

Cement vol	382,61	Kg/m³
Water weig	114,4	Kg/m³
Coarse agg	1480,73	Kg/m³
Silicafume 1	57,39	Kg/m³
Sikamen LN	7,65	Kg/m³
Total	2.027,86	Kg/m³

b. From above mixture above, the cylindrical with a diameter of 15 cm and a height of 30 cm with variations in the coarse aggregate used were manufactured and the results are as follows :

Table 15. Test Results for Pervious Concrete

No	Test Result	Variation				
		Var1	Var2	Var3	Var4	Var5
1	Slump (mm)	195	170	170	48	45
2	Volume weight (Kg/m³)	2,187.83	2,014.37	1,974.14	2,099.84	2,236.23
3	Permeability (cm³/det)	0.184	0.097	0.488	0.115	0.003
4	Compression strength (MPa)	20.089	46.978	21.644	34.444	27.722
5	Tensile strength (MPa)	8.968	19.048	10.159	19.127	16.032
6	Porosity (%)	23.413	23.876	23.563	23.808	23.242

c. From the data above, the best composition of physical and mechanical properties is Variation Var2 where by using a mixture of 0.5/0.5 stone and 1/1 cm stone each as much as 50%. These results were re-analyzed to obtain a modified mix design for pervious concrete based on ACI 522R-10.

d. From the data above, the best composition of physical and mechanical properties is the variation Var2 that using a mixture of 0.5/0.5 stone and 1/1 cm stone each as much as 50%. These results were re-analyzed to obtain a modified mix design for pervious concrete based on ACI 522R-10. This is due to the planned compressive strength of 25 MPa while the results obtained are 46.978, an increase of 187.912% from the initial plan.

e. The initial hypothesis which states that the variation of aggregate affects the physical and mechanical properties of pervious concrete has been verified with the results of the research obtained.

f. Good aggregate used in the manufacture of pervious concrete is stone with a mixture of 1/1 cm and 0.5/05 cm.

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