

UTILIZATION OF GYPSUM POWDER WASTE AS A SUBSTITUTE FOR PART OF CEMENT IN POROUS CONCRETE COMPRESSIVE STRENGTH

Aga Priatna¹, Yonas Prima Arga Rumbyarso², Gali Pribadi³

^{1,2,3}Civil Engineering Program, Faculty of Engineering, Krisnadwipayana University, Jakarta, Indonesia
Email : Priatnaaga@gmail.com

ABSTRACT

Porous concrete is used in infrastructure projects that require water absorption, supporting green cities and sustainable development. Its composition differs from conventional concrete because it has minimal or no fine aggregates, thus forming pores. This study aims to compare the compressive strength of normal porous concrete with porous concrete in which some of the cement is replaced with gypsum board waste powder. Testing was conducted at 7, 14, and 28 days to determine the effect of waste on concrete strength development. Compressive strength testing of porous concrete with varying amounts of gypsum powder waste showed that at 0% composition, the results at 7 and 14 days met the SNI 1974: 2011 standard. However, at 5% and 10% composition, the results at 7 days only partially met the standard, while at 14 days they were below the minimum limit of 88%. This indicates a decrease in compressive strength performance as the percentage of gypsum waste increases.

Keywords: Porous Concrete, Waste, Gypsum Powder, Compressive Strength, Substitute Material

INTRODUCTION

Porous concrete is widely used in infrastructure and stormwater management, supporting the concept of green cities and sustainable development. This concrete differs from conventional concrete in that it reduces fine aggregates to create voids that allow water to flow through. This study aims to test the compressive strength comparison between porous concrete with gypsum powder waste as a partial cement replacement and normal porous concrete with a planned compressive strength of 25 MPa (K-300). Tests were conducted at 7, 14, and 28 days to assess the effect of gypsum waste on concrete strength.

METHODS

This study was conducted using an experimental approach. The purpose of this study was to identify the causal relationship between the dependent variable and the independent variable. The dependent variable was a variation of normal concrete with a concrete quality of f'_c 25 MPa or equivalent to K-300, while the independent variable was a concrete sample containing gypsum powder waste as a substitute for part of the cement at a content of 5% and 10%.

Table 1. Total Number of Samples

No.	Test Sample (Gypsum Powder Waste)	7 days	14 days	28 days	Number of Test Items
1.	Compressive Strength Test Size 15 x 30 cm, Variation 0%	3	3	3	9
2.	Compressive Strength Test Size 15 x 30 cm, Variation 5%	3	3	3	9
3.	Compressive Strength Test Size 15 x 30 cm, Variation 15%	3	3	3	9
Number					27

Source: Research Data Processing, 2025.

In this study, the initial stage involved preparing materials such as sand, gravel, cement, water, and gypsum powder waste. Next, testing was carried out at the PT. Pionir Beton Plant Karawang laboratory, followed by the mix design process using Microsoft Excel software and a trial mix process. If the slump test results were as planned, the process continued with the manufacture of test samples molded using a Ø15 x 30 cm cylinder. After the concrete is removed from the cylinder mold for 24 hours, it is immediately immersed (cured) until the specified day. Once the concrete is ready on the specified day, it is subjected to a compressive strength test and the results are analyzed to draw conclusions.

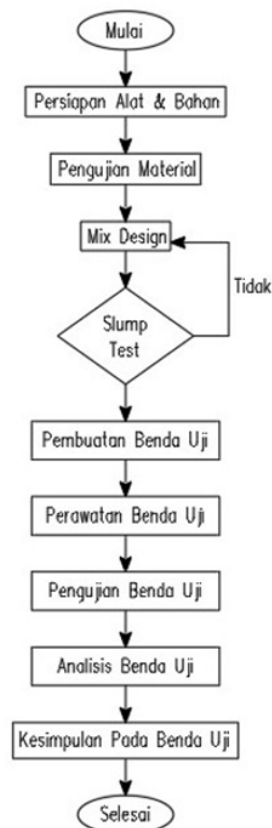


Figure 1. Research Flow Chart

Preparation of tools and materials consists of sieves, scales, measuring cups, ovens, cement spoons, concrete mixers, cylinder molds, concrete compressive strength testing machines, wheelbarrows, and slump test equipment. The stages of test specimen production consist of the mix design stage, the mixing stage, the slump test stage, the test specimen curing stage, and the concrete compressive strength test.

RESULTS AND DISCUSSION

The mix design used in this study was designed with the aim of achieving a slump value of 12 ± 2 cm, which indicates the workability of fresh concrete mix. This slump value was chosen so that the concrete would be easy to work with in the field without compromising structural quality. In addition, the specified planned compressive strength is $f'_c = 25$ MPa, which is known as K-300 in concrete quality units. This value indicates that the concrete is designed to withstand compressive loads of up to 25 MPa at 28 days after curing, which is the general standard for medium structural construction such as floors, columns, and building beams. The mix design planning includes the proportions of all the main components that make up porous concrete, namely cement, coarse aggregate (gravel or crushed stone), and water. The composition of these materials has been carefully calculated to achieve a balance between strength, durability, ease of workmanship, and material efficiency. The details of the concrete mix composition based on the mix design with the target slump and compressive strength can be seen in the table below:

Table 2 Total Number of Samples

No.	material	description	Volume	Unit
1.	cement	Indocement	330	Kg
2.	Coarse aggregate, maximum 2.5 cm	Rumpin	1334	Kg
3.	Water		165	Liter

From the results of the mix design calculations that had been carried out previously, the theoretical mixture proportions for each 1 m³ of concrete were obtained. These proportions included the measurements of each constituent material of the concrete, namely cement, coarse aggregate, and water, which were calculated carefully in order to produce concrete with the planned quality, namely $f'_c = 25$ MPa or equivalent to K-300 quality. The results of this mix design are then used as a reference in determining the material requirements for the volume of concrete to be used in making test specimens.

The volume of concrete mix required in this study is adjusted to the number and size of the test specimens to be made. The number of test specimens planned includes 27 cylindrical test specimens with dimensions of 15 cm in diameter and 30 cm in height. All test specimen sizes have been converted into meters to facilitate the calculation of the total volume of concrete required. Referring to these dimensions, the volume of each cylindrical test specimen is calculated using the cylinder volume formula, namely $\pi \times r^2 \times t$, while the volume of the block test specimen is calculated using the formula length $\times$ width $\times$ height.

After obtaining the individual volumes of each test specimen, the total volume of all test specimens was added up and then compared to the proportion of concrete mix per cubic meter. This step was intended to determine the exact amount of materials that had to be prepared on a laboratory scale, so that there would be no shortage or waste of materials during the mixing and molding process of the test specimens.

The calculation of the volume of normal porous concrete, variation 1, and variation 2 for cylindrical test specimens is as follows:

$$\begin{aligned}
 \text{Volume} &= 9 \text{ pieces} \times \text{cylinder volume} \\
 &= 9 \text{ pieces} \times (\text{circle area} \times \text{height}) \\
 &= 9 \text{ pieces} \times (1/4 \times \pi \times d^2 \times t) \\
 &= 9 \text{ pieces} \times (1/4 \times 3.14 \times 0.152 \times 0.3) \\
 &= 0.0477 \text{ m}^3
 \end{aligned}$$

Thus, the test mixture proportion is 0.0477 m³

Table 3 Mix Design for Normal Porous Concrete Cylinder Test Specimens

description	water	cement	coarse aggregate
Every 1 m ³	165 liter	330 kg	1334 kg
Every 0,0477 m ³	0,0477 m ³ x 165 liter = 7,8686 liter	0,0477 m ³ x 330 kg = 15,7373 kg	0,0477 m ³ x 1334 kg = 63,6168 kg

Table 4 Mix Design for Variation 1 Porous Concrete Cylinder Test Specimens

description	water	Filler		coarse aggregate
		(5%) gypsum powder	(95%) cement	
Every 1 m ³	165 liter	16,5 kg	313,5 kg	1334 kg
Every 0,0477 m ³	0,0477 m ³ x 165 liter = 7,8686 liter	0,0477 m ³ x 16,5 kg = 0,7869 kg	0,0477 m ³ x 313,5 kg = 14,9504 kg	0,0477 m ³ x 1334 kg = 63,6168 kg

Table 5 Mix Design for Variation 2 Porous Concrete Cylinder Test Specimens

description	Water	Filler		coarse aggregate
		(10%) gypsum powder	(90%) cement	
Every 1 m ³	165 liter	33 kg	297 kg	1334 kg
Every 0,0477 m ³	0,0477 m ³ x 165 liter = 7,8686 liter	0,0477 m ³ x 33 kg = 1,5737 kg	0,0477 m ³ x 297 kg = 14,1636 kg	0,0477 m ³ x 1334 kg = 63,6168 kg

Compressive strength testing of concrete is carried out when the concrete has reached 7 days, 14 days, and 28 days of age, which are important stages in evaluating the quality and performance of concrete under compressive loads.

**Figure 2. Process of Weighing Concrete Test Specimens****Figure 3. Concrete Compressive Strength Testing Process**

The results of the compressive strength testing of normal porous concrete in cylindrical form can be seen in Table 4 below.

Table 6 Normal Porous Concrete Compressive Strength

No.	Date		Age	Weight	Load	C. Strength	Remark	Rata-rata
	Casting	Test	(Days)	(Gram)	(kN)	(MPa)	%	(MPa)
1.	24 Jun 25	01 Juli 2025	7	10660	324,5	18,37	73,5	18,66
2.	24 Jun 25	01 Juli 2025	7	10340	329,6	18,66	74,6	
3.	24 Jun 25	01 Juli 2025	7	10460	335,2	18,97	75,9	
4.	24 Jun 25	08 Juli 2025	14	10660	397,0	22,47	89,9	22,60
5.	24 Jun 25	08 Juli 2025	14	10880	402,2	22,77	91,1	
6.	24 Jun 25	08 Juli 2025	14	10920	398,7	22,57	90,3	
7.	23 Jun 25	21 Juli 2025	28	10700	446,8	25,29	101,2	26,01
8.	23 Jun 25	21 Juli 2025	28	10720	461,4	26,12	104,5	
9.	23 Jun 25	21 Juli 2025	28	10760	459,3	26,00	104,0	

The results of the compressive strength test of porous concrete variation 1 in cylindrical form can be seen in Table 5 below

Table 7 Compressive Strength of Porous Concrete Variation 1

No.	Date		Age	Weight	Load	C. Strength	Remark	Rata-rata
	Casting	Test	(Days)	(Gram)	(kN)	(MPa)	%	(MPa)
1.	24 Jun 25	01 Juli 2025	7	10340	282,8	16,01	64,0	16,33
2.	24 Jun 25	01 Juli 2025	7	10400	279,0	15,79	63,2	
3.	24 Jun 25	01 Juli 2025	7	10460	303,9	17,20	68,8	
4.	24 Jun 25	08 Juli 2025	14	10680	355,8	20,14	80,6	20,38
5.	24 Jun 25	08 Juli 2025	14	10840	365,2	20,67	82,7	
6.	24 Jun 25	08 Juli 2025	14	10860	359,2	20,33	81,3	
7.	23 Jun 25	21 Juli 2025	28	10820	394,4	22,33	89,3	22,40
8.	23 Jun 25	21 Juli 2025	28	10900	394,9	22,35	89,4	
9.	23 Jun 25	21 Juli 2025	28	10960	397,9	22,52	90,1	

The results of the compressive strength test of porous concrete variation 2 in cylindrical form can be seen in Table 6 below

Table 8 Compressive Strength of Porous Concrete Variation 2

No.	Date		Age	Weight	Load	C. Strength	Remark	Rata-rata
	Casting	Test	(Days)	(Gram)	(kN)	(MPa)	%	(MPa)
1.	24 Jun 25	01 Juli 2025	7	10550	274,2	15,52	62,1	15,84
2.	24 Jun 25	01 Juli 2025	7	10580	284,5	16,10	64,4	
3.	24 Jun 25	01 Juli 2025	7	10320	281,1	15,91	63,6	
4.	24 Jun 25	08 Juli 2025	14	10800	361,8	20,48	81,9	20,57
5.	24 Jun 25	08 Juli 2025	14	10780	357,9	20,26	81,0	
6.	24 Jun 25	08 Juli 2025	14	10700	370,4	20,97	83,9	
7.	23 Jun 25	21 Juli 2025	28	10620	397,9	22,52	90,1	22,57
8.	23 Jun 25	21 Juli 2025	28	10720	408,2	23,11	92,4	
9.	23 Jun 25	21 Juli 2025	28	10600	390,1	22,08	88,3	

Dari hasil pengujian kuat tekan beton normal porous dengan f_c 25 MPa dan kuat tekan beton porous variasi limbah serbuk gypsum dengan mutu f_c 25 MPa dapat dilihat pada Gambar 4 dibawah ini.

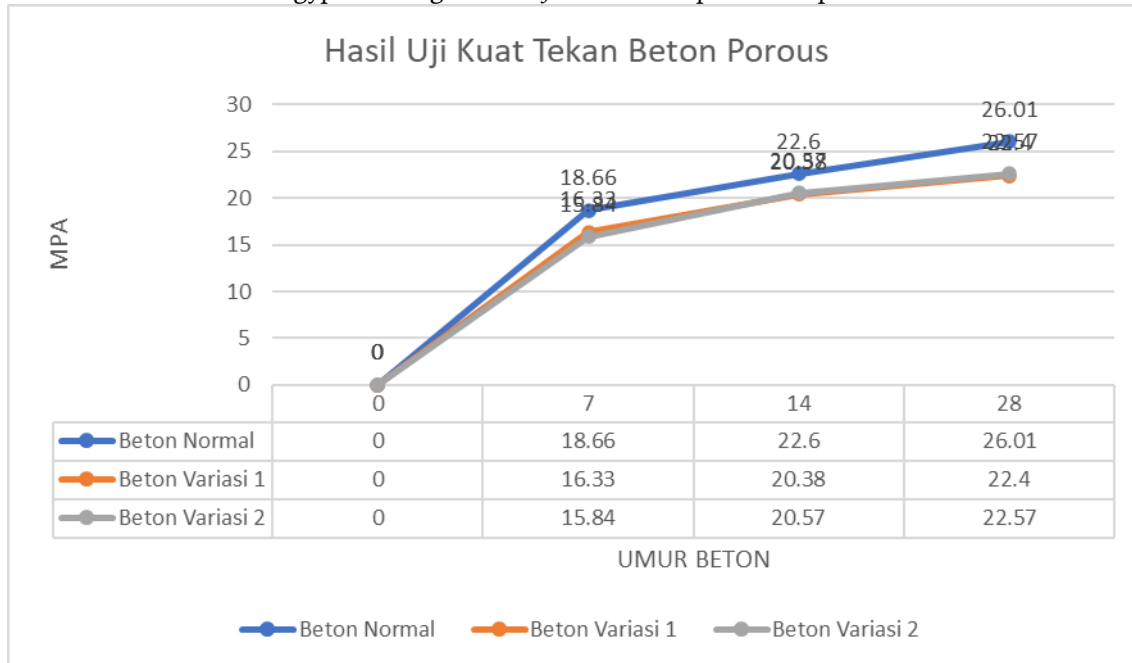


Figure 4. Porous Concrete Strength Test Results

When comparing the compressive strength of normal porous concrete with porous concrete that uses a mixture of gypsum board powder waste as a partial replacement for cement at 28 days of age, there is a decrease of:

- 1) Porous concrete using 5% gypsum board powder waste + 95% cement
 28 days = $\frac{25-22.40}{25} \cdot 100\% = 10.40\%$ (Decrease)
- 2) Porous concrete using 10% gypsum board waste powder + 90% cement
 28 days = $\frac{25-22.57}{25} \cdot 100\% = 9.72\%$ (Decrease)

The average compressive strength of normal porous concrete at 28 days is 26.01 MPa, exceeding the planned compressive strength of porous concrete, which is 25 MPa. while the average compressive strength of porous concrete using 5% - 10% gypsum board powder waste at 28 days is 22.40 MPa and 22.57 MPa, which does not reach the planned compressive strength of porous concrete, which is 25 MPa. Therefore, it can be concluded that the addition of gypsum board waste powder as a partial replacement for cement affects the decrease in the quality of the planned porous concrete.

CONCLUSIONS

Based on the research conducted, several conclusions were obtained, including the following:

- 1) Based on the compressive strength test table for normal porous concrete and gypsum powder waste as a partial filler replacement for a 0% composition, the average compressive strength of the concrete at 7 days was 18.66 MPa, at 14 days it was 22.60 MPa, and at 28 days it was 26.01 MPa. From this data, the percentage increase in compressive strength of concrete using gypsum board powder waste for a 0% composition was 74.66% on average, 90.43% on average at 14 days, and 103.23% on average at 28 days. These results exceed the concrete compressive strength

requirements according to SNI 2847:2019, which are a minimum limit of 65% for 7 days, 88% for 14 days, and 100% for 28 days.

- 2) Based on the compressive strength test table of normal porous concrete and gypsum powder waste as a partial filler replacement for a composition of 5%, the average compressive strength of concrete for 7 days was 16.33 MPa, for 14 days it was 20.38 MPa and for 28 days it was 22.40 MPa. From these data, the results of the percentage increase in concrete compressive strength using gypsum powder waste for a composition of 5% from the age of 7 days obtained an average of 65.33%, the age of 14 days obtained an average of 81.53% and the age of 28 days obtained an average of 89.60%, where the results of these data explain that at the age of 7 days the concrete compressive strength has exceeded the requirements for concrete compressive strength according to SNI 2847: 2019 for the age of 7 days the minimum limit is 65% but at the age of 14 days the average result of concrete compressive strength was obtained at 81.53% where this result did not reach the minimum limit required which is 88% and also at the age of 28 days the average result of concrete compressive strength was obtained at 89.60% where this result also did not reach the minimum limit required which is 100%..
- 3) Based on the compressive strength test table for normal porous concrete and gypsum powder waste as a partial replacement for filler for a composition of 10%, the average strength was obtained The concrete compressive strength at 7 days is 15.84 MPa, at 14 days it is 20.57 MPa and at 28 days it is 22.57 MPa. From these data, the results of the percentage increase in concrete compressive strength using gypsum board powder waste for a composition of 10% from the age of 7 days obtained an average of 63.36%, the age of 14 days obtained an average of 82.26% and the age of 28 days obtained an average of 90.27%, where the results of these data explain that at the age of 7 days the concrete compressive strength does not reach the concrete compressive strength requirements according to SNI 2847: 2019 for the age of 7 days the minimum limit is 65% and at the age of 14 days the average result of concrete compressive strength is 82.26% where this result does not reach the minimum limit required which is 88% and also at the age of 28 days the average result of concrete compressive strength is 90.27 where this result does not reach the minimum limit required which is 100%.
- 4) When comparing the compressive strength of normal porous concrete with porous concrete using a mixture of gypsum board powder waste as a partial cement replacement at 28 days, the decrease is as follows:
 Porous concrete using 5% gypsum board powder waste + 95% cement
 $28 \text{ days} = (25 - 22.40) / 25 \cdot 100\% = 10.40\% \text{ (Reduction)}$
 Porous concrete using 10% gypsum board powder waste + 90% cement
 $28 \text{ days} = (25 - 22.57) / 25 \cdot 100\% = 9.72\% \text{ (Decrease)}$
- 5) The average compressive strength of normal porous concrete at 28 days was 26.01 MPa, exceeding the planned compressive strength of 25 MPa. Meanwhile, the average compressive strength of porous concrete using 5%-10% gypsum board powder waste at 28 days was 22.40 MPa and 22.57 MPa, respectively, falling short of the planned compressive strength of 25 MPa. Therefore, it can be concluded that the addition of gypsum board powder waste as a partial cement replacement reduces the quality of the planned porous concrete.

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