Equivalent: Jurnal Ilmiah Sosial Teknik
Volume 8, Issue 1, 161-181
e_ISSN: 2775-0833
https://jurnalequivalent.id/index.php/jequi/index
DOI: doi.org/10.59261/jequi.v8i1.268

Comparative Analysis of Concrete Compressive Strength Using OPC Cement and PCC Cement with A Mix of Concrete Additives

***Anugrah**
Universitas Pakuan Bogor, Indonesia

Hamka Wakkang
Universitas Muhammadiyah Parepare, Indonesia

Suwardi Setiawan
Universitas Fajar Makassar, Indonesia

***Corresponding author:**
Anugrah, Universitas Pakuan Bogor, Indonesia.
✉ anugrah@unpak.ac.id

Article Info :
Article history:
Received: December 01, 2026
Revised: January 05, 2026
Accepted: February 02, 2026

Keywords:
betonMix; concrete; opc; pcc cement

Abstract

Background: Concrete is one of the most essential construction materials widely used in infrastructure development. In recent years, the cement industry has introduced environmentally friendly products such as Portland Composite Cement (PCC) as an alternative to Ordinary Portland Cement (OPC).
Objective: This study aims to analyze the comparative compressive strength and split tensile strength of concrete using OPC and PCC cement, as well as to determine the effect of BetonMix additives on the mechanical performance of concrete.
Methods: The research employed an experimental laboratory method. Concrete mix design referred to *SNI* 7656:2012 with a planned compressive strength of 25 MPa. Mix variations consisted of normal concrete, OPC concrete, OPC + 500 ml BetonMix, and PCC + 500 ml BetonMix. Slump testing followed *SNI* 1972:2008, while compressive strength testing used cylindrical specimens based on *SNI* 1974:2011.
Results: The findings indicate differences in compressive and split tensile strength between OPC and PCC concrete. The addition of BetonMix improved concrete workability and contributed positively to strength development. The highest compressive strength was achieved by OPC concrete with BetonMix, while PCC with BetonMix also demonstrated good and more economical performance.
Conclusion: Both OPC and PCC are suitable as structural binders; however, BetonMix additives enhance mechanical performance. This study provides a practical reference for selecting cement types and additives to produce strong, efficient, and economical concrete.

To cite this article: Anugrah., Wakkang, H., & Setiawan, S. (2026). Comparative analysis of concrete compressive strength using OPC cement and PCC cement with a mix of concrete additives. *Equivalent: Journal Social Engineering Science*, 8(1), 161-181. https://doi.org/10.59261/jequi.v8i1.268

INTRODUCTION

Concrete is a very important material used extensively in infrastructure development. Concrete construction can be found in the building of dams, rigid pavements, bridges, pipelines, and skyscrapers (Asthana & Khare, 2022; Luchko et al., 2022; Sharma et al., 2022). The need for concrete will continue to increase in line with current development. The important role of concrete in construction demands high-quality concrete, so that the use of concrete with high compressive strength requires adequate materials that are, of course, economical (Chamasemani et al., 2023; Pang et al., 2024).

From a material engineering perspective, concrete is a mixture of coarse aggregate, fine aggregate, cement, and water, as well as added substance additives if required. One of the main ingredients in manufacturing concrete is cement (Dong et al., 2022; Susanto et al., 2019). The cement industry has now produced environmentally friendly products without reducing the quality of the concrete, namely Portland Composite Cement (PCC). PCC cement is currently widely used by construction consumers, while Ordinary Portland Cement (OPC) is seldom used because it is more expensive and less environmentally friendly compared to PCC cement.

The construction sector accounts for approximately 8% of total CO_2 emissions, with cement production alone contributing nearly 7% of global carbon dioxide releases (Andrew, 2019). The environmental burden of OPC production stems from the calcination of limestone and the subsequent clinkering at temperatures exceeding 1450°C, as well as the clinker grinding process, which are highly energy-intensive and carbon-emitting operations (Ying, 2022). In response to mounting sustainability pressures and international climate commitments under the Paris Agreement, the cement industry has undergone paradigm shifts toward blended cements incorporating supplementary cementitious materials (SCMs) such as fly ash, slag, and pozzolans, which partially replace clinker content and thereby reduce embodied carbon (Samad & Shah, 2017).

Chemical admixtures, particularly water-reducing agents and plasticizers, offer promising pathways to mitigate PCC's early-age strength deficiencies while enhancing workability and durability characteristics (Barbhuiya et al., 2025). Fatema (2021) demonstrated that high-range water reducers (superplasticizers) significantly improve concrete workability and compressive strength by optimizing water-cement ratios, enabling denser particle packing and accelerated hydration kinetics.

Based on SNI-15-2049-2015 concerning Portland cement specifications, PCC as a hydraulic binder results from milling together Portland cement clinker and gypsum with one or more inorganic materials, or the result of mixing between Portland cement powder with other inorganic material. Inorganic materials include pozzolan, silicate compounds, and limestone, with a total inorganic ingredient content of 6–35% of the cement mass (Hansted et al., 2023). From the description, PCC is categorized under special blended cement, which has specifications different from those of OPC cement.

OPC is a hydraulic cement produced by grinding Portland cement clinker, particularly those consisting of calcium silicates that are hydraulic, milled together with the addition of one or more crystalline compounds of calcium sulfate, and may include other additional materials. Concrete Mix is a clear, multipurpose fluid used to improve the quality of concrete mixtures. In the form of a ready-to-use fluid, Concrete Mix is beneficial for reducing water usage, increasing mixture plasticity, and accelerating concrete hardening (concrete aged 7–14 days becomes equivalent to concrete aged 28 days) (Fapohunda et al., 2017).

Several previous studies have examined the comparative performance of Ordinary Portland Cement (OPC) and Portland Composite Cement (PCC) as well as the role of admixtures in improving concrete properties. A study by Aprianti (2015) reported that composite cements such as PCC, which contain pozzolanic materials, can enhance concrete durability and reduce the heat of hydration, although their early compressive strength may be lower than OPC under certain conditions.

Meanwhile, research conducted by Wang (2024) demonstrated that the addition of chemical admixtures, particularly water-reducing additives, significantly improves concrete workability and compressive strength by optimizing the water–cement ratio. However, most prior studies tend to examine cement type and admixture effects separately, or do not simultaneously analyze compressive strength and splitting tensile strength within a single controlled experimental design. Therefore, the novelty of this research lies in its integrative comparative approach, which evaluates the mechanical performance of OPC- and PCC-based concrete concurrently with the incorporation of BetonMix admixture at measured proportions.

The purpose of this study is to comparatively examine the compressive strength and splitting tensile strength of concrete produced using Ordinary Portland Cement (OPC) and Portland Composite Cement (PCC). The study further aims to analyze the effect of adding BetonMix chemical admixture on the improvement of both compressive and splitting tensile strength of concrete made with each cement type. Through this comparative approach, the research seeks to identify differences in mechanical performance between OPC-based and PCC-based concrete mixtures, as well as to evaluate the extent to which BetonMix contributes to enhancing structural strength characteristics.

To provide research direction, the scope and limitations of this study cover the use of OPC and PCC cement, with OPC cement sourced from PT Semen Tonasa, Pangkajene and the Islands Regency, South Sulawesi. The concrete mix design refers to SNI 7656:2012 with a planned compressive strength of 25 MPa, incorporating BetonMix chemical admixture across four mix variations: normal concrete, OPC cement, OPC cement + BetonMix 500 ml, and PCC cement + BetonMix 500 ml. Testing was carried out on cylindrical specimens with a focus on concrete compressive strength in accordance with SNI 1974:2011, while slump testing follows SNI 1972:2008 with a slump value of 75–100 mm.

The benefits of this study are expected to provide a picture and empirical evidence regarding the ease of use and relative economy of OPC and PCC cement in concrete mixtures, to contribute knowledge related to the influence of BetonMix admixture addition on concrete compressive strength, to enrich the development of knowledge and technology in the field of construction, and to serve as a reference for future studies that will address a comparative analysis of concrete compressive strength through the combined use of OPC and PCC cement with admixtures.

METHOD

The type of research used in this study was quantitative research, which is a research method that requires extensive use of numbers, starting from data collection and interpretation of the data to the display of results accompanied by images, tables, or graphs. The research data were then analyzed in accordance with laboratory testing procedures. This study employed an experimental research method, namely by comparing four (4) variations: Normal Concrete, OPC Cement, OPC cement mixture + BetonMix, and PCC cement mixture + BetonMix, in order to determine the compressive strength of the concrete. The manufacture, curing, and testing of the test specimens were carried out at the Civil Engineering Laboratory, Faculty of Engineering, Muhammadiyah University of Parepare, and the research was conducted over a period of four months from July to October 2023.

Data were obtained through experiments conducted in the Civil Engineering Structures and Materials Laboratory, Muhammadiyah University of Parepare. This research focused on four mix variations: normal concrete, OPC cement, OPC cement + BetonMix 400 ml, and PCC cement + BetonMix 500 ml. The number of samples required for each variation is presented in Table 1.

Table 1. Mixture variations for compressive strength

Variation Concrete Mix	Concrete Age				Amount
	Compressive Strength			Split Tensile Strength	
	7	14	28	28	
Normal Concrete	3	3	3	2	11
OPC Cement	3	3	3	2	11
OPC+Betonmix Cement 400ml	3	3	3	2	11
PCC Cement+ Betonmix 500ml	3	3	3	2	11
Total					44

Secondary data as supporting material provided an overview of the study area. Secondary data collection was data collection not conducted directly from the source or object. Data were obtained from written sources such as theoretical books, report books, regulations, and documents originating from related agencies and the results of literature reviews.

The data analysis technique used in this study was descriptive parametric analysis. The concrete compressive strength test results were obtained by dividing the maximum load of the test specimen by the cross-sectional area of the test specimen. The data were then presented in tabular or graphical form. The steps taken were: (1) the test specimen was weighed before testing was conducted; (2) the test specimen was placed on the Universal Testing Machine; (3) the Universal Testing Machine was switched on, and the test specimen was subjected to an incrementally increasing load so that the compressive strength could be read as indicated by the manometer; and (4) the test specimen cracked once the applied load reached the maximum limit that the test specimen could withstand. At the point of cracking, the manometer needle stopped at the maximum value that the test specimen was able to sustain.

RESULTS AND DISCUSSION

Results

Planning Concrete Mix (Mix Design)

Planning mixture concrete counted use SNI 7656:2012 method with data results are:
Given material data:
Concrete quality = 25 Mpa
Slump = 75 – 100 mm
Size aggregate maximum = 20
Oven dry weight of aggregate rough = 1.773
Specific gravity of cement without addition air = 3.08
Fineness modulus aggregate smooth = 2.95
Specific gravity (SSD) of aggregate smooth = 2.56
Specific gravity (SSD) of aggregate rough = 2. 69
Aggregate water absorption smooth = 1.45 %
Aggregate water absorption rough = 3.04 %
Aggregate Water Content smooth = 2.46 %
Aggregate Water Content rough = 1.28 %
Specific Gravity of OPC cement = 3.18
Calculation
Strong and strong plan:
Fc' = 25 Mpa
= $25x$ 9.81
= 245,250 Kg/cm ^{2}

1. Margin

Count strong average concrete pressure, with strong the required average pressure and margin value depends from level supervision quality.

The margin value (m) is set with use formula:

Margin = 1.64×Sd

Table 2. Table of values deviation (kg/cm ^{2}) for various work volumes and qualities implementation in the field

Volume of work		**Quality of implementation**		
Classification	**m ^{3}**	**Very well**	**Good**	**Enough**
Small	<.1000	45 < s ≤ 55	55 < s ≤ 65	65 < s ≤ 85
Currently	1000-3000	35 < s ≤ 45	45 < s ≤ 55	55 < s ≤ 75
Big	>3000	25 < s ≤ 35	35 < s ≤ 45	45 < s ≤ 65

(Source: SNI 03-2834-2000)

Standard deviation (Sd) = 60
Margin =1,64 × Sd
= 1.64 x 60
= 98.4 Kg/cm ^{2}

2. Concrete strength plan (fcr)

$$fcr = fc' + m$$=fc^'+m

$$= fc' + (1{,}64 \times Sd)$$

$$= 245.250 + 98{,}4$$

$$= 343.64 \quad \text{Kg/cm}^2$$

$$fc = \frac{fcr}{g}$$=fcr/g

$$= \frac{343.64}{10}$$

$$= 35{,}03 \text{ Mpa}$$

3. Volume of water required per m3 stir concrete

   As for the table of water volume required per m3 stir concrete

Table 3. Volume of water required per m3 stir concrete for various mark slump and size aggregate maximum

Water (kg/m3) for the maximum aggregate nominal size of crushed stone								
Slump (mm)	9,5 mm*	12,7 mm*	19 mm*	25 mm*	37,5 mm*	50 mm+*	75 mm +	150 mm++
Concrete without additional sound								
25-50	207	199	190	179	166	154	130	113
75-100	228	216	205	193	181	169	145	124
150-175	243	228	216	202	190	178	160	-
> 175*	-	-	-	-	-	-	-	-
Amount of air in concrete (%)	3	2,5	2	1,5	1	0,5	0,3	0,2
Concrete with additional sound								
25-50	181	175	168	160	150	142	122	107
75-100	202	193	184	175	165	157	133	119
150-175	216	205	197	184	174	166	154	-
> 175*	-	-	-	-	-	-	-	-
The recommended amount of air for exposure levels is as follows: mild (%)	4,5	4,0	3,5	3,0	2,5	2,0	1,5**	1,0**
moderate (%)	6,0	5,5	5,0	4,5	4,5	4,0	3,5**	3,0**
Weight (%)	7,5	7,0	6,0	6,0	5,5	5,0	4,5**	4,0**

(Source: SNI 7656:2012)

When tabulated No data found then done calculation interpolation based on size aggregate maximum and slump values with size aggregate maximum namely 20 which are between 19-25 mm

Interpolation formula:

$$x = x1 + \frac{(y-y1)}{y2-y1}(x2 - x1)$$

Water needs

It is known that:

X =? Y = 20

X1 = 193 Y1 = 25

X2 = 205 Y2 = 19

Water

25	193	From the table
20	?	
19	205	From the table
x=	203	Kg

Air

25	1.5%
20	?
19	2%
x =	1.9%

$$x\ (air)\ = 193 + \frac{(20-25)}{19-25}(205-193)$$
$$= 203\ \text{Kg}$$
$$x\ (udara) = 1{,}5\% + \frac{(20-25)}{19-25}(2\% - 1{,}5\%)$$
$$= 1{,}9\ \%$$

Determination water cement factor (FAS)

Table 4. Water cement factor (ltr/kg cement) for various types of construction and weather conditions

Concrete strength age 28 days, MPa*	Water-cement ratio (weight)	
	Concrete without additional air	Concrete with air additives
40	0,42	-
35	0,47	0,39
30	0,54	0,45
25	0,61	0,52
20	0,69	0,60
15	0,79	0,70

(Source: SNI 7656:2012)

It is known that:

X = ? Y = 35.03

X1 = 0.42 Y1 = 40

X2 = 0.47 Y2 = 35

FAS

40.0	0.4 2
3 5.03	?
3 5.0	0.47
x=	0.4 70

$$x\ (FAS)\ = 0{,}47 + \frac{(35{,}03-40)}{35-40}(0{,}47-0{,}42)$$
$$= 0{,}470\ \text{Kg}$$

4. Cement weight per 1 m3 of concrete

   W water = 203Kg

   W cement $= \frac{W\ air}{FAS}$ $= \frac{203}{0{,}470}$ = 432.20kg/m ^{3}

   $= \frac{w\ Semen}{1000}$ $= \frac{432{,}20}{1000}$ = 0.4 32 tons

   Cement volume $= \frac{W\ cement\ (ton)}{Specific\ gravity\ of\ cement}$ $= \frac{0.43219611}{3{,}08}$ = 0.1 40 m ^{3}

5. Gravel weight every 1 ^{m3} concrete

Table 5. Aggregate volume per unit volume of concrete mix (Source: SNI 7656:2012).

Maximum aggregate nominal size (mm)	Aggregate volume Oven dry coarse* per unit volume of concrete for various modulus of fineness of fine aggregate			
	2,40	2,60	2,80	3,00
9,5	0,50	0,48	0,46	0,44
12,5	0,59	0,57	0,55	0,53
19	0,66	0,64	0,62	0,60
25	0,71	0,69	0,67	0,65
37,5	0,75	0,73	0,71	0,69
50	0,78	0,76	0,74	0,72
75	0,82	0,80	0,78	0,76
150	0,87	0,85	0,83	0,81

a. Gravel A

It is known that:

X =?	Y = 20
X1 = 0.62	Y1 = 19
X2 = 0.67	Y2 = 25

b. Gravel B

It is known that:

X =?	Y = 20
X1 = 0.60	Y1 = 19
X2 = 0.65	Y2 = 25

c. Gravel A and B

It is known that:

X =?	Y = 3.0
X1 = 0.608	Y1 = 2.95
X2 = 0.620	Y2 = 2.80

A		B		A and B	
19	0.62	19	0.60	3.00	0.608
20	?	20	?	2.95	?
25	0.67	25	0.65	2.80	0.620
x=	0.628	x=	0.608	x=	0, 611

$$x\ (gravel\ A) \quad = 0,62 + \frac{(20-19)}{25-19}(0,67-0,62)$$

$= 0,628$ Kg

$$x\ (gravel\ B) \quad = 0,60 + \frac{(20-19)}{25-19}(0,65-0,60)$$

$= 0,608$ Kg

$$x\ (gravel\ AB) \quad = 0,608 + \frac{(3,0-2,95)}{2,80-3,0}(0,620-0,608)$$

= 0,611 Kg

dry weight (SSD) = 1.773

W Gravel = Volume × SSD

= 0.611 × 1.773 = 1.083 tons

= W Gravel × 1000

= 1.083 × 1000 = 1083 kg

V Gravel $=\frac{Gravel\ mass}{Gravel\ density} = \frac{1,083}{2,69}$ = 0.4 0 3 m^3

6. Absolute weight of 1 m^3 of sand concrete

Water Volume = 203kg

$= \frac{Water\ mass}{Water\ density}$

$= \frac{203\ kg}{1000\ kg/m^3}$ = 0.203 m^3

Solid cement volume = 4 32 kg

$= \frac{Cement\ mass}{Cement\ density \times 1000}$

$= \frac{432}{3,08 \times 1000}$ = 0.1 4 0 m^3

Vol. absolute Ag. Coarse =11 11 kg

$= \frac{Ag.coarse\ mass}{Ag.coarse\ density \times 1000}$

$= \frac{1083}{2,69 \times 1000}$ = 0.403 m^3

Entrapped air volume =1.9%

= 1 m^3 × 1.9% = 0.019 m^3

Total solid volume besides Ag. fine

Vtot = Vol. water + vol. cement + vol. ag. Coarse + vol. air
= 0.203 + 0.140 + 0.40 3 + 0.019
= 0.766 m^3

Vol. Ag. Fine
= 1 – Total volume
= 1 – 0.766
= 0.234 m^3

Fine Ag Weight dry
= Vol. Ag. Fine × (BJ Ag. Fine × 1000)
= 0.234 × (2.56 × 1000)
= 601.2 kg

7. Estimation heavy sand every 1 m^3 concrete

Table 6. Aggregate volume

Aggregate Maximum Nominal Size (mm)	**Preliminary Estimate of Concrete Weight (kg/m^3)**	**Concrete Without Air Additives (kg/m^3)**	**Concrete With Air Additives (kg/m^3)**
9,5	2280	2280	2200
12,5	2310	2310	2250
25	2350	2350	2275
37,5	2410	2410	2310
50	2450	2450	2350
75	2530	2530	2400
150	2600	2600	2500

It is known that:

X = ? Y = 20
X1 = 2380 Y1 = 25
X2 = 2345 Y2 = 19

Concrete Weight 1 m^3

25	2380
20	?
19	2345
x=	2350

$$x\ (beton) = 2380 + \frac{(20-25)}{19-25}(2345-2380)$$
$$= 2350 \quad \text{Kg}$$

Based on the data above so estimation heavy concrete is 2350

So that:

Water (Net weight) =203
Cement = 4 32
Aggregate rough = 1083 +
Total = 1 7 19
Then the weight of Ag. Fine is =2350 – 17 19
= 631 kg

8. Correct to water content

Note: Testing water content of the material is carried out before want to carry out the mixing process for testing water content can be seen in SNI 03-1971-1990

Water content obtained:

Ag. Gross = 1.28 %
Ag. Fine = 2.46 %

So that weight (mass) adjustment based on water content is
Coarse Ag (Wet) = Coarse Ag (Wet) × Moisture Content of Coarse Ag
= 1.28% × 1083
= 13,890 kg
Fine Ag (Wet) = Fine Ag (Wet) × Water Content of Fine Ag
= 2.46% × 630
= 15,524 kg

Water absorbed No become part from the mixing water and must issued from adjustment in the added water. Then:

Water given by Ag. Coarse = Water absorption of Ag. Coarse × Ag. Coarse (Wet)
= 1.45 % x1083.94
= 15,731
Water given by Fine Ag = Water absorption of Fine Ag × Fine Ag (Wet)
= 3.04 % x630.863
= 19,176
With thus added water requirements is as following
Correction water = Water – Total weight mass + Total water absorption
= 203.0 –29.4 + 34.908
= 208,494 kg
So the estimate is 1 m ^{3} concrete is as following
Correction water = 208,494 kg
Cement = $\frac{Air}{FAS} = \frac{208.494}{0{,}470}$ = 443,893 kg

Ag. Crude = Weight of crude ag. + weight water content ag. crude – weight coarse ag absorption
= 1083,940 + 13,890 – 15,731
= 1082.099kg

Fine Ag. = Fine Ag. Weight + Weight water content of fine aggregate – weight fine ag absorption
= 6 30,863 + 15,524 – 19,176
= 627.211kg

Amount = Water + Coarse Ag + Fine Ag
= 208,494 + 1082,099 + 627,211
= 2361.697 kg

9. Need mixture material for 1 m ^{3} concrete

Table 7. mixture material for 1 m ^{3} concrete

	Based on Correction to water content (kg)	Based on estimation mass concrete (kg)	Based on absolute volume (kg)
Water (weight clean)	208.5	203.0	203.0
Cement	443.9	432.2	432.2
Ag. Rough (dry)	1082.1	1083.9	1083.9
Ag. Fine (dry)	627.2	630.9	601.2

Comparison weight = W cement: W sand: W gravel: W water

1	1.39	2. 51	0.47

10. Material Requirements for Making Cylindrical Test Objects Concrete:

Need 1 cylinder concrete
Diameter (d) = 0.15 m
Height (h) = 0.3 m
Volume of 1 cylinder $= \frac{1}{4}\pi d^2 h$
$= \frac{1}{4} 3{,}14 \times 0{,}15^2 \times 0{,}30$

= 0.0053014m ^{3}

Total volume of cylinder = Volume of 1 cylinder ×- Number of concrete cylinders

= 0.0053014 m ^{3} × 12

= 0.06361725 m ^{3}

To avoid a shortage of materials, it is necessary to increase the cylinder volume by 15%.

Additional volume = vol. 1 2cylinder x 15%

=0.06361725 m ^{3} x 15%

= 0.00954259 m ^{3}

Total volume = Total cylinder volume + Additional volume

= 0.06361725 m ^{3} + 0.00954259 m ^{3}

= 0.07315984m ^{3}

Table 8. Need material for 1 2 cylinder concrete

	Based on Correction to water content (kg)		**Based on estimation mass concrete (kg)**		**Based on absolute volume (kg)**	
W cement	26.91	Kg	29.96	kg	29.96	kg
W sand	47.25	Kg	45.82	kg	36.43	kg
W gravel	81.37	Kg	81.29	kg	81.29	kg
W water	13.34	Kg	14.85	kg	14.85	kg

1. Need PCC cement and OPC cement Object Test:

a. need 1 cylinder concrete

Diameter (d) = 0.15 m

Height (h) = 0.3 m

Volume of 1 cylinder = $\frac{1}{4}\pi d^2 h$

= $\frac{1}{4}3{,}14 \times 0{,}15^2 \times 0{,}30$

=0.0053014m ^{3}

In order not to happen lack material so required increase in cylinder volume by 15%

Additional volume = vol.1 cylinder x 15%

= 0.0053014 m ^{3} x 15%

= 0.000795m ^{3}

Total volume of 1 cylinder = Volume of 1 cylinder + Additional Volume

= 0.0053014 m ^{3} + 0.000795 m ^{3}

= 0.006096m^3

Table 9. Need material for normal concrete

	Need one by one cubic concrete		**Need one by one cylinder concrete**		**Needs 1 2 cylinder**	
W cement	432.20	kg	2.87	kg	31.62	Kg
W sand	630.86	kg	4.20	kg	46.15	Kg
W gravel	1083.9	kg	7.21	kg	79.30	Kg
W water	203.00	kg	1.35	kg	14.85	Kg

b. For variation OPC cement

Limestone powder volume requirements

OPC cement volume = V. cement x BJ. OPC cement

= 0.140 m3x3.18

= 445.717 m3

Table 10. Need material for variation OPC cement

	need one by one cubic concrete		need one by one cylinder concrete		12cylinder requirement	
W OPC cement	445.72	kg	2.96	kg	32.61	kg
W sand	601.18	kg	4.00	kg	43.98	kg
W gravel	1083.9	kg	7.21	kg	79.30	kg
W water	203.00	kg	1.35	kg	14.85	kg

b. For variation OPC cement + Concrete Mix 500 ml

1) OPC cement volume requirements

OPC cement volume = V. cement x BJ. OPC cement
= 0.140 m3x3.18
= 445.717 m3

Need Concrete Mix

$$\text{Vol. Concrete Mix} = \frac{\text{Kebutuhan BM}}{\text{1 zak semen (40 kg)}}$$

$$= \frac{500\ ml}{40\ kg}$$

= 1.3 ml

Water needs

Water weight = 75% of total water requirements
= 203 kg × 75%
= 152.3k g

Table 11. Need material for variation OPC cement and concrete mix

	need one by one cubic concrete		need one by one cylinder concrete		12cylinder requirement	
W OPC cement	445.7	kg	2.96	kg	32.61	kg
W sand	601.2	kg	4.00	kg	43.98	kg
W gravel	1084	kg	7.21	kg	79.30	kg
W water	152.3	kg	1.01	kg	11.14	kg
W BetonMix	5.57	l	0.04	l	0.41	l

For variation PCC cement and Concrete Mix 500 ml

PCC cement volume requirements

Vol. PCC cement =V. semen x BJ. PCC cement
= 0.140 m3 x 3.08
= 432.196 m3

Need Concrete Mix

$$\text{Vol. Concrete Mix} = \frac{\text{BM need}}{\text{1 cement pack (40 kg)}}$$

$$= \frac{500ml}{40\ kg}$$

= 13 ml

Water Needs

Water weight = 80% of total water requirements
= 203 × 80%
= 162.40 kg

Table 12. Need material for variation PCC cement and concrete mix

	need one by one cubic concrete		need one by one cylinder concrete		12 cylinder requirement	
W PCC cement	432.2	kg	2.87	kg	31.62	kg
W sand	601.2	kg	4.00	kg	43.98	kg
W gravel	1084	kg	7.21	kg	79.30	kg
W water	162.4	kg	1.08	kg	11.88	kg
W BetonMix	5.40	l	0.04	l	0.40	l

Slump Value

Testing mark *Slump test* done with use cone *Abrams,* with wet cone *Abrams* moreover formerly Then place it on a flat surface. Then filled with fresh concrete in 3 layers, each layer filled 1/3 of the cone volume *Abrams* and stabbed as many as 25 times and stabbing done until reach part lower from every layer after filling cone finished part above it leveled. In time about 30 seconds cone lifted straight vertical in a way slowly, then determine mark *slump* with method measure tall mixture difference with tall cone.

Table 13. Slump test results

NO	Variation Mixture concrete	Mixing time (minutes)	*Slump* plan (mm)	Average field *slump (mm)*
1	B eton normal	±10	75 – 100	80.0
2	OPC			85
3	OPC+ BM 500 ml			88.3
4	PCC + BM 500ml			88.3

(Source: Laboratory results 2023)

Based on table 13 on give explanation about comparison mark *Slump test* between each variation*.* Where in the four variations of concrete *the slump test* value obtained meets the requirements *slump* plan.

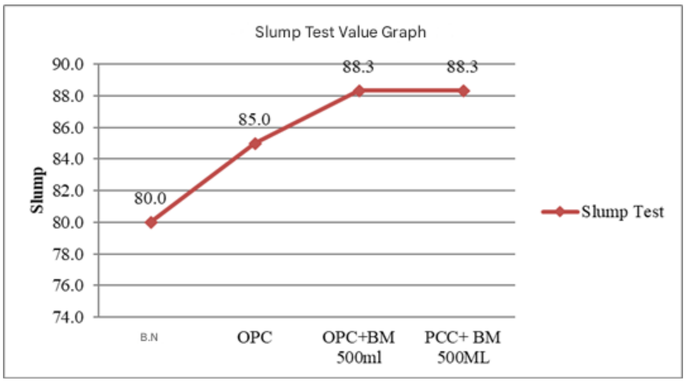

Figure 1. Comparison of *slump* values for each variation

From Figure 1, the OPC condition of concrete causes an increase in *workability*. This is because OPC has a regular surface texture and is not hollow, so that when mixing is carried out, the cavities in the OPC fill each other or bind each other so that the *slump value* or workability of the concrete mixture increases.

Discussion

Strong Determination

After fabricating and curing the test specimens, compressive strength testing was then conducted. Compressive strength testing was performed when the test specimens were aged 7 days, 14 days, and 28 days, with a total of 12 samples consisting of 4 mixture variations, namely normal concrete, OPC cement, OPC cement + 500 ml Mixed Concrete, and PCC cement + 500 ml Mixed Concrete. For each mixture variation, 3 cylindrical samples were made for the compressive strength test, with a specimen size of 150 × 300 mm. Before performing the concrete compressive strength test, the specimens were first weighed for each variation that would be used as test samples.

The results of the compressive strength testing — consisting of normal concrete, OPC cement, OPC cement + 500 ml Mixed Concrete, and PCC cement + 500 ml Mixed Concrete — with 3 days of curing are as follows:

1. Normal concrete

Based on research results, the average compressive strength of normal concrete obtained in 7, 14, and 28 day tests is as follows:

Table 14. Summary of normal concrete compressive strength results

No.	Age	Weight (Kg)	Load (KN)	Compressive Strength f'c (MPa)
1	7 Days	12.2 08	309	15.66
2	14 Days	1 2,392	358	20.31
3	28 Days	12. 413	4 62	2 6.16

On testing test sample with normal concrete with cylinder size 15 x 30 cm with amount sample 3 pieces obtained strong press with an average of 15.66 MPa for 7 days old, 20.31 MPa for 14 days old, and 2 6.16 MPa for 28 days old.

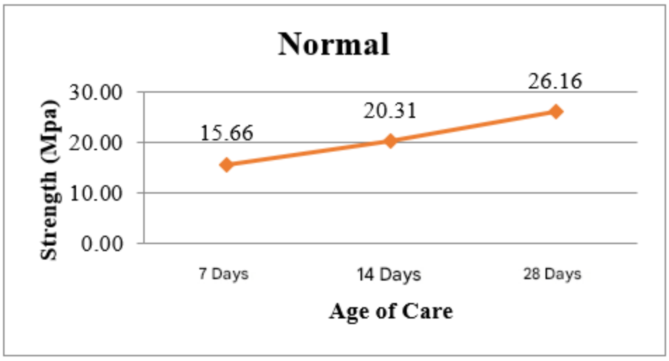

Figure 2. Normal concrete compressive strength test graph

Figure 2 explains that normal concrete experiences an increase in compressive strength from 7 days to 14 days of 4.65 Mpa, while from 14 days to 28 days of 5.85 Mpa.

2. OPC Cement

Based on the research results, the average compressive strength of OPC cement concrete obtained in the 7, 14 and 28 day tests is as follows:

Table 15. Summary of concrete compressive strength results for OPC cement variations

No.	Age	Weight (Kg)	Load (KN)	Compressive Strength f'c (MPa)
1	7 Days	12,435	390.00	22.08
2	14 Days	12,350	448.33	25.38
3	28 Days	12,588	563.33	29.44

On testing test sample with OPC cement with size 15 x 30 cm with amount sample 3 pieces obtained strong press with an average of 22.08 MPa for 7 days old, 25.38 MPa for 14 days old, and 29.44 MPa for age 28 day, fulfill strong planned press with chart in figure 3.

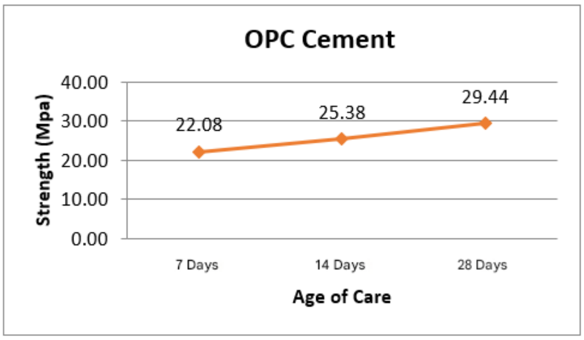

Figure 3. OPC cement compressive strength test chart

On the graph on can explained that concrete normal to experience improvement strong press from 7 days old to 14 days old as big as 3.30 Mpa whereas for 14 days old 28th day experience improvement strong press as big as 4.06 MPa.

3. OPC Cement + Concrete Mix 500ml

Based on the research results, the average compressive strength of OPC cement + 500ml Concrete Mix obtained in the 7, 14 and 28 day tests:

Table 16. Summary of compressive strength results of OPC Cement + 500ml Concrete Mix

No.	Age	Weight (Kg)	Load (KN)	Compressive Strength f'c (MPa)
1	7 Days	12,465	416	23.59
2	14 Days	12,652	451	25.57
3	28 Days	12,840	533	30.20

On testing test sample with OPC cement + Concrete Mix 500ml with size 15 x 30 cm with amount sample 3 pieces obtained strong press with an average of 23.59 MPa for 7 days old 25.57 MPa for 14 days old and 30.20 MPa for 28 days old, meets strong planned press with chart.

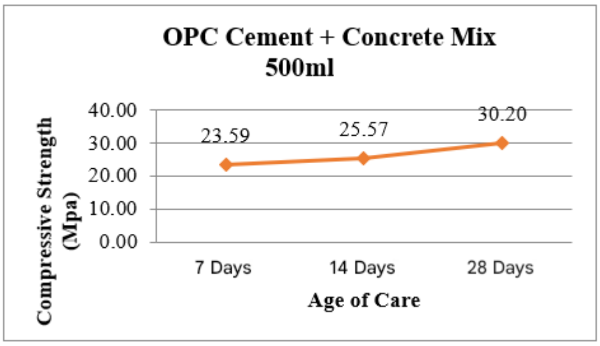

Figure 4. Concrete compressive strength test graph
OPC cement + Concrete Mix 500ml

On the graph on can explained that concrete with OPC cement + Concrete Mix 500ml experience improvement strong press from 7 days old to 14 days old as big as 2.83 MPa while for 14 days old 28th day experience improvement strong press as big as 4.63 MPa.

4. PCC Cement + Concrete Mix 500ml

Based on the research results, the average compressive strength of PCC Cement + Concrete Mix 500ml obtained in the 7, 14 and 28 day tests.

Table 17. Summary table of compressive strength results of PCC cement + 500ml Concrete Mix

No.	Age	Weight (Kg)	Load (KN)	Compressive Strength f'c (MPa)
1	7 Days	12,478	386	21.89
2	14 Days	12. 278	424	24.01
3	28 Days	12,342	496	28.12

On testing test sample with PCC Cement + Concrete Mix 500ml with size 15 x 30 cm with amount sample 3 pieces obtained strong press with an average of 21.89 MPa for 7 days old, 24.01 MPa for 14 days old and 2 8.12 MPa for 28 days old, meets strong planned press with chart.

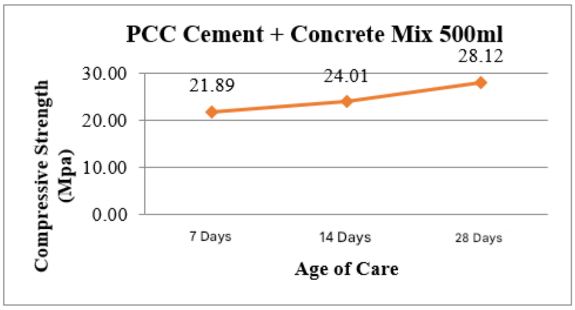

Figure 5. Graph PCC cement testing + 500ml Concrete Mix

From the graph, PCC cement + Concrete Mix 500 mL experienced an increase in compressive strength from 7 days to 14 days of 2.12 MPa, whereas from 14 days to 28 days, the compressive strength increased by 4.11 MPa.

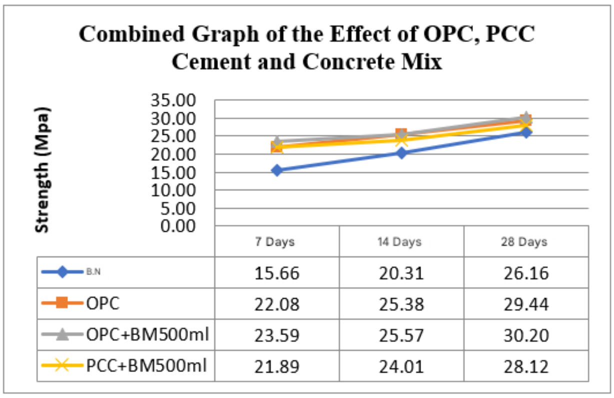

Figure 6. Combined graph of OPC and PCC cement usage

Figure 6 shows that 7-day-old concrete experienced an improvement in compressive strength from the normal concrete of 6.42 MPa on OPC cement, then an improvement of 1.51 MPa, while OPC + Betonmix 500 ml experienced a decline of 1.70 MPa compared to PCC + Betonmix 500 ml. For 14-day-old concrete, the compressive strength increased from the normal concrete of 5.07 MPa on OPC cement, 0.19 MPa at OPC + Betonmix 500 ml, and experienced an improvement of 1.56 MPa at PCC + Betonmix 500 ml. For 28-day-old concrete, the compressive strength increased from the normal concrete of 3.28 MPa on OPC cement, then an increase of 0.76 MPa in OPC + Betonmix 500 ml and 2.08 MPa on PCC + Betonmix 500 ml.

From the explanation above, it can be concluded that both cements can increase the compressive strength of concrete beyond the planned or normal concrete compressive strength. The addition of Betonmix 500 ml to concrete with OPC cement can increase the compressive strength of concrete by 0.76 MPa. This is caused by the role of the concrete mix additive in strengthening the concrete. The addition of Betonmix 500 ml to concrete with PCC cement can increase the compressive strength of concrete by 2.08 MPa. As for the decline in compressive strength, this is caused by an imperfect compaction process, resulting in a larger volume of entrapped air within the concrete. The larger the volume of air in the concrete, the lower the compressive strength tends to be, due to the presence of unfilled air voids. Therefore, it can be concluded that the use of OPC and PCC cement with added admixtures can increase the quality of concrete.

Split Tensile Strength of Concrete

After completing the manufacturing and curing process of the test specimens, splitting tensile strength testing was then conducted on the test specimens. Splitting tensile strength testing was carried out at 28 days of age using cylindrical test specimens measuring 30 cm in length and 15 cm in diameter, with 8 samples in total, consisting of normal concrete, OPC, OPC+BM 500 ml, and PCC+500 ml. Each test specimen was weighed prior to the splitting tensile strength test being performed. The results of the splitting tensile strength testing at 28 days of curing for normal concrete, OPC, OPC+BM 500 ml, and PCC+500 ml are presented as follows.

1. Normal concrete

From the research results, the testing of normal concrete was carried out when the test specimens were 28 days old.

Table 17. Recapitulation results testing strong pull split normal concrete

No.	Age	Weight (Kg)	Load (KN)	L (mm)	D (mm)	Compressive Strength (MPa)	f'c
1	28 Days	12, 570	1779.19	300	150	5, 66	

Here is the proofread and corrected passage:

In testing the split tensile strength of normal concrete, an average split tensile strength value of 5.66 MPa was obtained. Based on the source, the split tensile strength value ranges between 9–15% [of the compressive strength]. Therefore, the tested split tensile strength value is already in accordance with the theoretical split tensile strength value. From the results of split tensile strength testing on the test specimens, no segregation (uneven distribution of aggregate in concrete) was observed, as the aggregates in the test specimens were spread evenly throughout the mix.

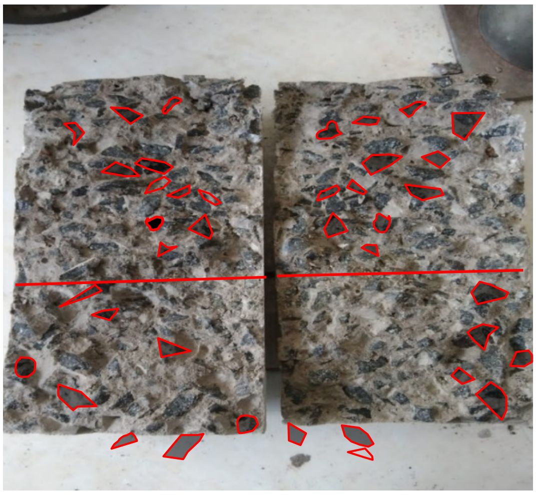

Figure 7. Normal split tensile image

From the splitting tensile strength test fracture face of the test specimen, the distribution of aggregate in concrete can be determined based on the following calculation:

a. Distribution aggregate part on

% Distribution aggregate $=\frac{S.Top\ Aggregate}{Total\ aggregate} \times 100$

$=\frac{9}{20} \times 100$

= 4 5 %

b. Distribution aggregate part lower

% Distribution aggregate $= \frac{S.Bottom\ Aggregat}{Total\ aggregate} \times 100$

$= \frac{11}{20} \times 100$

= 5 5 %

Can be seen from results calculation above, comparison distribution aggregate part top and bottom lower amounting to 4 5 %: 5 5 %. So that can concluded that distribution aggregate in concrete evenly.

2. OPC

From the research results, testing of the OPC variation concrete was carried out when the test specimen was 28 days old.

Table 18. Summary of the results of split tensile strength testing of Opc variation concrete

No.	Age	Weight (Kg)	Burden (KN)	L (mm)	D (mm)	Compressive Strength f'c (MPa)
1	28 Days	12,745	1803.96	300	150	7,556

On testing strong pull split concrete for concrete variation Opc obtained mark strong average pressure 7.556 MPa.

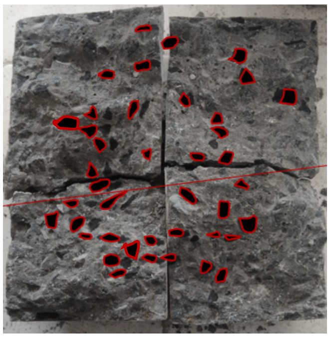

Figure 8. Split pull image OPC

From the figure 8 testing strong pull split on the test object, spreading aggregate in concrete can formulated based on from calculation following:

a. Distribution aggregate part on

% Distribution aggregate $= \frac{S.Top\ Aggregate}{Total\ aggregate} \times 100$

$= \frac{18}{38} \times 100$

= 47.36 %

b. Distribution aggregate part lower

% Distribution aggregate $= \frac{S.Bottom\ Aggregate}{Total\ aggregate} \times 100$

$= \frac{21}{34} \times 100$

= 55.26 %

Can be seen from results calculation above, comparison distribution aggregate part top and bottom lower by 55.26 %: 4 7.36 %. So can concluded that distribution aggregate in concrete evenly.

3. OPC + Betonmix 500ml Variation

OPC + Betonmix500ml concrete variation was carried out when the test specimen was 28 days old.

Table 19. Summary of the results of the split tensile strength test of the Opc + Betonmix500ml concrete variation

No.	Age	Weight (Kg)	Burden (KN)	L (mm)	D (mm)	Compressive Strength f'c (MPa)
1	28 Days	12,575	1779.90	300	150	8,444

On testing strong pull split concrete for concrete variation OPC + Betonmix 500ml obtained mark strong average pressure 8.44 MPa.

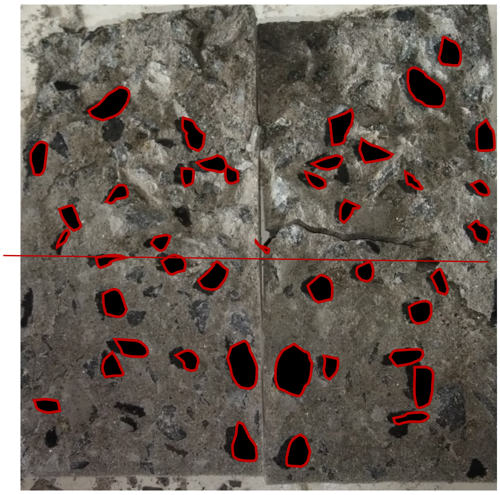

Figure 9. Split pull image
OPC + Betonmix 500ml

From figure 9 testing strong pull split on the test object, spreading aggregate in concrete can formulated based on from calculation following:

a. Distribution aggregate part on

% Distribution aggregate $= \frac{S.Top\ Aggregate}{Total\ aggregate} \times 100$

$= \frac{22}{42} \times 100$

$= 52.38\ \%$

b. Distribution aggregate part lower

% Distribution aggregate $= \frac{S.Bottom\ Aggregate}{Total\ aggregate} \times 100$

$= \frac{20}{42} \times 100$

$= 47.61\ \%$

Comparison distribution aggregate part top and bottom lower as big as 52.38 %: 47.61 %. So can concluded that distribution aggregate in concrete evenly.

4. PCC Variation + Betonmix 500ml

From the research results, testing of the PCC + Betonmix500ml concrete variation was carried out when the test specimen was 28 days old.

Table 20. Summary of the results of the split tensile strength test of concrete variations PCC + Betonmix500ml

No.	Age	Heavy (Kg)	Burden (KN)	L (mm)	D (mm)	Compressive Strength f'c (MPa)
1	28 Days	12,385	1753.01	300	150	7,333

On testing strong pull split concrete for concrete variation PCC + Betonmix 500ml obtained mark strong average pressure 7.33 MPa.

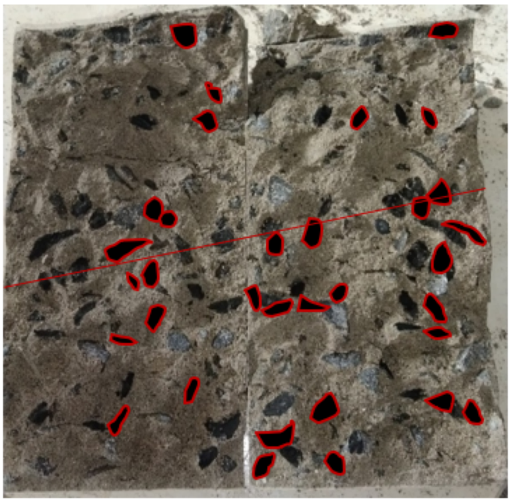

Figure 10. Split pull image
PCC + Betonmix 500ml

From f testing figure 10 strong pull split on the test object, spreading aggregate in concrete can formulated based on from calculation following:

a. Distribution aggregate part on

% Distribution aggregate $= \frac{S.Top\ Aggregate}{Total\ aggregate} \times 100$

$= \frac{15}{33} \times 100$

$= 45.45\ \%$

b. Distribution aggregate part lower

% Distribution aggregate $= \frac{S.Bottom\ Aggregate}{Total\ aggregate} \times 100$

$= \frac{18}{33} \times 100$

$= 54.54\ \%$

Can be seen from results calculation above, comparison distribution aggregate part top and bottom lower as big as 45.45 %: 54.54 %. So can concluded that distribution aggregate in concrete evenly. Figure 11 is influence use OPC, PCC and Betonmix to strong pull split concrete:

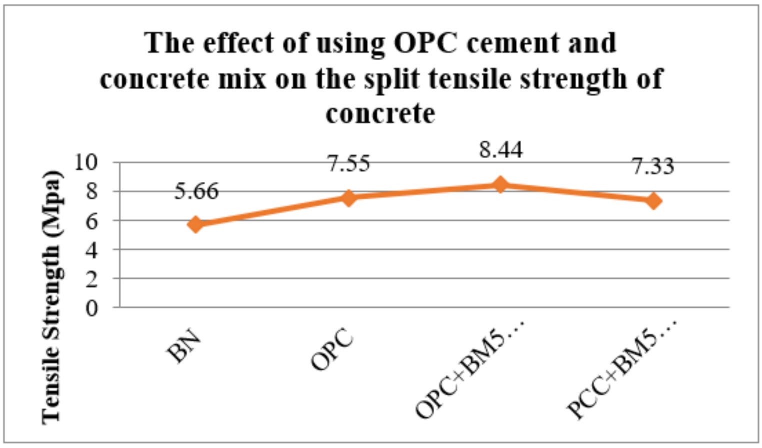

Figure 11. Graph influence use OPC, PCC and Betonmix to strong split pull

Figure 11 explained that on concrete characteristics experience improvement strong pull split from normal concrete of 1.89 M P a in concrete variation OPC improvement strong pull split from normal concrete of 2.78 Mpa in concrete variation OPC + Betonmix 500ml and reduction strong pull split from normal concrete of 1.67 Mpa in concrete variation PCC + Betonmix 500ml.

CONCLUSION

Based on the research results, variations in OPC and PCC cement mixtures with the addition of Betonmix have a significant influence on the compressive strength and splitting tensile strength of concrete. At 28 days, normal concrete has an average compressive strength of 26.16 MPa, while concrete with OPC cement reaches 29.44 MPa, OPC + Betonmix 500 ml at 30.20 MPa, and PCC + Betonmix 500 ml at 28.12 MPa, which shows that OPC cement provides a greater improvement in compressive strength compared to PCC due to its faster nature in reaching the target concrete quality. In splitting tensile strength testing, normal concrete has an average value of 5.66 MPa, while OPC is 7.55 MPa, OPC + Betonmix 500 ml is 8.44 MPa, and PCC + Betonmix 500 ml is 7.33 MPa. The addition of Betonmix 500 ml is proven to increase the compressive strength of concrete in both OPC and PCC mixtures, with increases of 0.79 MPa and 2.08 MPa respectively, so that overall, the use of OPC and PCC cement with the addition of Betonmix can reach the planned compressive strength and is declared worthy of use in construction.

ACKNOWLEDGEMENT

The authors would like to express their sincere gratitude to the Civil Engineering Laboratory, Faculty of Engineering, Muhammadiyah University of Parepare, for providing facilities, technical support, and laboratory equipment necessary for conducting this experimental research. The authors also appreciate the support from Universitas Pakuan Bogor, Universitas Muhammadiyah Parepare, and Universitas Fajar Makassar for their institutional encouragement and academic environment that facilitated the completion of this study. Special thanks are extended to all laboratory assistants and technical staff who contributed to specimen preparation, testing procedures, and data documentation. Their assistance and cooperation were invaluable in ensuring the accuracy and reliability of the experimental results.

AUTHOR CONTRIBUTION STATEMENT

All authors contributed substantially to the development and completion of this research. Anugrah contributed to conceptualization of the research framework, experimental design development, mix design calculation based on SNI standards, data analysis, manuscript drafting, and final revision as the corresponding author. Hamka Wakkang contributed to laboratory experimentation, specimen preparation and curing supervision, data collection, compressive and split tensile strength testing, and preliminary data interpretation. Suwardi Setiawan contributed to methodological validation, statistical analysis, critical review of experimental procedures, literature review strengthening, and manuscript refinement. All authors have read and approved the final version of the manuscript.

REFERENCES

Andrew, R. M. (2019). Global CO 2 emissions from cement production, 1928–2018. *Earth System Science Data*, *11*(4), 1675–1710.

Aprianti, E., Shafigh, P., Bahri, S., & Farahani, J. N. (2015). Supplementary cementitious materials origin from agricultural wastes–A review. *Construction and Building Materials*, *74*, 176–187. https://doi.org/10.1016/j.conbuildmat.2014.10.010

Asthana, B. N., & Khare, D. (2022). Construction Aspects of Dams. In *Recent Advances in Dam Engineering* (pp. 305–338). Springer. https://doi.org/10.1007/978-3-030-32278-6_14

Barbhuiya, S., Das, B. B., & Adak, D. (2025). Effects of chemical admixtures on the properties of concrete. In *Binding Materials for Sustainable Construction* (pp. 329–362). Elsevier.

Chamasemani, N. F., Kelishadi, M., Mostafaei, H., Najvani, M. A. D., & Mashayekhi, M. (2023). Environmental impacts of reinforced concrete buildings: Comparing common and sustainable materials: A case study. *Construction Materials*, *4*(1), 1–15. https://doi.org/10.3390/constrmater4010001

Dong, Z., Tan, H., Yu, J., & Liu, F. (2022). A feasibility study on Engineered cementitious Composites mixed with coarse aggregate. *Construction and Building Materials*, *350*, 128587. https://doi.org/10.1016/j.conbuildmat.2022.128587

Fapohunda, C., Akinbile, B., & Shittu, A. (2017). Structure and properties of mortar and concrete with rice husk ash as partial replacement of ordinary Portland cement–A review.

International Journal of Sustainable Built Environment, *6*(2), 675–692. https://doi.org/10.1016/j.ijsbe.2017.07.004

Fatema, K., Sarker, M. A., Habib, A., & Alam, M. A. (2021). Effect of high range water reducing (HRWR) super plasticizer on compressive strength of sand cement solid block. *Int J Eng Technol*, *8*(1), 7–14.

Hansted, F. A. S., Mantegazini, D. Z., Ribeiro, T. M., Gonçalves, C. E. C., & Balestieri, J. A. P. (2023). A mini-review on the use of waste in the production of sustainable Portland cement composites. *Waste Management & Research*, *41*(4), 828–838. https://doi.org/10.1177/0734242X22113524

Luchko, J., Nazarevich, B., & Kovalchuk, V. V. (2022). *Degradating concrete and reinforced concrete building structures and long-term structures*. https://doi.org/10.31650/2415-377X-2022-86-35-46

Pang, Y., He, T., Liu, S., Zhu, X., & Lee, C. (2024). Triboelectric nanogenerator-enabled digital twins in civil engineering infrastructure 4.0: a comprehensive review. *Advanced Science*, *11*(20), 2306574. https://doi.org/10.1002/advs.202306574

Samad, S., & Shah, A. (2017). Role of binary cement including Supplementary Cementitious Material (SCM), in production of environmentally sustainable concrete: A critical review. *International Journal of Sustainable Built Environment*, *6*(2), 663–674. https://doi.org/10.1016/j.ijsbe.2017.07.003

Sharma, R., Jang, J.-G., & Hu, J.-W. (2022). Phase-change materials in concrete: Opportunities and challenges for sustainable construction and building materials. *Materials*, *15*(1), 335. https://doi.org/10.3390/ma15010335

Susanto, D., Djauhari, Z., & Olivia, M. (2019). Karakteristik Beton Portland Composite Cement (PCC) Dan Silica Fume Untuk Aplikasi Struktur di Daerah Laut. *Jurnal Rekayasa Sipil (JRS-Unand)*, *15*(1), 1–11. https://doi.org/10.25077/jrs.15.1.1-11.2019

Wang, X.-H., Fang, Z.-C., & Zheng, L. (2024). Effect of dose and types of the water reducing admixtures and superplasticizers on concrete strength and durability behaviour: a review. *Journal of Civil Engineering and Management*, *30*(1), 33–48. https://doi.org/10.3846/jcem.2024.20145

Ying, F. Y. (2022). *Calcined Soiled Waste: Performance, Cost and Energy Efficient Pozzolan in Cementitious Building Material*. National University of Singapore (Singapore).