

Analysis of the Effect of Battery Powder as Cement Additive on the Mechanical Properties of Concrete

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Abstract— Disposable primary battery waste can be classified into the Hazardous and Toxic Materials (B3) category. So there is a need for innovation to deal with these problems. This research aims to determine the effect of adding battery powder on cement weight and what is the optimal percentage of battery powder on the mechanical properties of 25 MPa concrete with variations in battery powder of 0%, 1%, 3% and 5%. Mix Design planning refers to SNI Concrete Planning 03-2834-2000. The results of the research showed a consecutive increase in compressive strength for the 0% variation: 25,233 Mpa, 1%: 27,350 Mpa, 3%: 31,064 Mpa, and 5%: 33,193 Mpa, an increase in splitting tensile strength for the 0% variation: 2,145 Mpa, 1% : 2,545 Mpa, 3%: 3,017 Mpa, and 5%: 3,088 Mpa, and an increase in variation strength of 0%: 2,799 Mpa, 1%: 2,953 Mpa, 3%: 3,518 Mpa, and 5%: 3,826 Mpa in concrete. So it can be concluded that the optimum variation is found in the 5% battery powder variation.

Keywords— Concrete, battery powder, compressive strength, split tensile strength, flexural strength.

I. INTRODUCTION

Concrete is a material that contains Portland cement and aggregate. Fine aggregate (sand), coarse aggregate (gravel), air-porous water. The large use of concrete in construction results the increasing demand for concrete materials has given rise to the field of construction materials technology. There is a need for innovation in the development of concrete materials. Battery powder is waste from batteries that can no longer be used and is generated after the battery is processed through several recycling stages. Currently, several studies have been conducted to utilize battery powder as a raw material in various applications such as cement additives in concrete and the manufacture of metal alloys, so as to provide economic and environmental benefits.

Before running this research, there are still many similar studies that can support this research process, for example, conducted by Denie Chandra with the title "Analysis of the Effect of Potassium Activator and Material Conditions on Geopolymer Concrete from Coal Fly Ash B3 Waste Against Compressive Strength". According to the tests carried out, it is illustrated that potassium hydroxide (KOH) activator in oven drying conditions and SSD material conditions does not really affect the compressive strength of 28-day-old geopolymer concrete, even lower than potassium. It is possible that in previous studies, the quality of 30 MPa f_c geopolymer concrete has not been achieved so further research needs to be done to achieve the quality of 30 MPa f_c geopolymer concrete based on fineness and fly ash activity.[1].

A study conducted by Mardewi Jamal with the title "Analysis of Cement Content Variations on the Compressive Strength of Pumice Aggregate Lightweight Concrete and Local Materials" The pressure strength of pumice aggregate concrete with normal cement content provides an average pressure strength of 9.7 MPa. The pressure strength of concrete using pumice aggregate with 300 kg/cm³ cement content created an average pressure strength of 12.80 MPa. The compressive

strength of concrete using pumice aggregate with cement content of 350 kg/cm³ created an average compressive strength of 13.24 MPa. The compressive strength of concrete using pumice aggregate with a cement content of 400 kg/cm³ created an average compressive strength of 13.44 MPa. The compressive strength of concrete using pumice aggregate with a cement content of 450 kg/cm³ created an average compressive strength of 15.09 MPa. This increase in pressure strength is due to the increased cement content and additives used in the lightweight concrete mix.[2]. From Tri Mulyono's research entitled "Lime as an Additive for Normal Concrete". The predicted compressive strength at 28 days is 20 MPa using the cylinder test method with a standard deviation of 5.25 MPa. Variations in the amount of lime added to conventional concrete mixes are based on the percentage of cement by weight with variations of 0%, 10%, 20%, 30%, 40%, 50%, 60% and 70%. Tests on fresh concrete were conducted only to check for slump to determine workability. In hardened concrete, the compressive strength and internal weight of the material were tested. [3]. Based on the results of research by Muhammad et al entitled "Correlation of Concrete Compressive Strength and Sulfate Resistance in Normal Concrete with the Addition of Kaolin as a Partial Substitution of Cement". The conclusion obtained is the relationship of concrete compressive strength with the addition of kaolin is as follows: The higher the replacement ratio of kaolin to cement, the lower the compressive strength of concrete. Similarly, for sulfate resistance, the higher the degree of replacement of cement with kaolin in conventional concrete, the lower the sulfate resistance of the concrete.[4]. Irzal Agus' study titled "Utilization of Carbide Welding Waste Against Concrete Compressive Strength Values", Carbide welding waste used as a partial replacement for cement affects the strength of concrete pressure, this can be seen from the results of the pressure strength test on day 28, where normal concrete is valued at 253.93 kg/cm², while carbide welding waste with a 10% variation is 259.70 kg/cm² on day 28.[5]. Research conducted

by Nuryasin Abdillah with the title "Utilization of Silica Sandblasting Waste as a Substitute for Fine Aggregates for Concrete Mixtures". According to the test results, it is known that the effect of using sandblasting waste as a substitute for fine aggregate in concrete mixes has increased for the value of concrete pressure strength, even the pressure strength obtained is higher than planned. This takes place due to the physical properties of sandblasting waste which is rather fine so that the fine grains can fill the pores in the concrete which can make the compressive strength increase.[6]. The research conducted by Dahlia Patah entitled "The Effect of Concrete Waste as a Substitute for Coarse Aggregates on Concrete Strength". The study results obtained, used concrete can be used in concrete mixtures to increase the strength and usability of used concrete. The strength of concrete increases when using used concrete with an optimal coarse aggregate replacement ratio of 10 with a compressive strength of 40.03 MPa after 28 days with a percentage increase of 16.4 compared to frequent concrete. Thus, concrete mixtures containing up to 40% concrete waste were only able to achieve strength levels of 93.7% to 98.5%, almost equal to the compressive strength of conventional concrete of 34.39 MPa.[7]. According to Bobby and Zulkifli's research titled "The Effect of Addition of B3 Waste on the Strength of K-175 Quality Concrete". The conclusion of this test is that in the process of making carbide residue mixed concrete, the average compressive strength of 5% carbide residue is 249.69 kg/cm², an increase of 1.77% compared to normal concrete, so that the average compressive stress is 245.34 kg/cm². [8]. Research conducted by Eka et al with the title "Testing the Pressure Strength of Concrete Using Sikacim Tamabah Material". The test results of normal concrete pressure strength amounted to 36.472 MPa. While the concrete pressure strength using Sika with 10% water reduction on day 28 of concrete mixing amounted to 38.087 MPa, the pressure strength of the Sika concrete mixture with 20% water reduction on day 28 reached 44.476 MPa. The experimental results show that the concrete pressure strength in the addition of 10% Sika increased by 1.074, in the addition of 20% Sika increased by 1.2% so that the compressive strength of normal concrete. [9]. The study conducted by Ega Rismana using the title "Test of Pressive Strength of Concrete Bricks for Wall Pairing with Styrofoam (Expanded Polystyrene) Waste Mix". The optimum flexural strength is achieved in bricks mixed with polystyrene foam at a 30% change ratio with an average flexural strength of 0.962 N/mm² and in accordance with the requirements of the average flexural strength of SNI 03-2156 -1991 involving lightweight cellular structures. concrete block) with autoclaving. The optimal compressive strength was obtained from concrete blocks mixed with polystyrene foam at a variable ratio of 20% with an average compressive strength of 44.28 kg/cm² and included in level 3 of SNI 030349-1989 related to concrete blocks for wall installation. [10]

II. RESEARCH METHODOLOGY

1. Location of Research Materials

Disposable primary battery powder was taken from waste battery stones at Antang landfill and surrounding neighborhoods, Makassar, South Sulawesi.



Figure 1. Where to get research materials



Figure 2. Battery Powder

2. Equipment and Materials

The instruments used in this research are digital scales that have a focus of 1 kg with a load capacity of 150 kg, scales with an accuracy of 1 gram, ovens, sieves, scissors, cones, etc. A set of slump testing machine, stirring machine (mol/mixer), mold, soaking tank and compressive strength testing machine. The materials used in this test are Portland cement, coarse aggregate, fine aggregate, fibers, silica fume and water.

3. Material Characteristics

TABLE 1. Specification of Coarse aggregate Characteristics

No.	Testing	Results	Interval	Description
1	Water Content	1,482%	0,5% – 2,0%	Qualified
2	Sludge Content	0,929	0,2% – 1,0%	Qualified
3	SSD Specific gravity	2,667	1,60 – 3,20	Qualified
4	Absorption	0,664%	0,20% – 2,00%	Qualified
5	Solid Volume Weight	1606,429	1400 – 1900 kg/m ³	Qualified
6	Loose Volume Weight	1463,571	1400 – 1900 kg/m ³	Qualified
7	Modulus of Fineness	7,073	5,50 – 8,50	Qualified

TABLE 2. Specification of Fine Aggregate Characteristics

No	Testing	Results	Interval	Description
1	Water Content	3,5%	3,0% – 5,0%	Qualified
2	Sludge Content	3,736%	0,2% – 6,0%	Qualified
3	SSD Specific gravity	2,681	1,60 – 3,20	Qualified
4	Absorption	1,113%	0,20% – 2,00%	Qualified
5	Solid Volume Weight	1488,994	1400 – 1900 kg/m ³	Qualified
6	Loose Volume Weight	1437,107	1400 – 1900 kg/m ³	Qualified
7	Modulus of Fineness	2,597	2,20 – 3,10	Qualified
8	Organic Substances	1	< No. 3	Qualified

4. Mix Design with SNI Method

From the results of testing the properties of materials and calculating the composition of the mixture for making test objects according to the SNI 03-2834-2000 mixture design method.

5. Trial Mix

A trial mix was conducted to see the specified composition achieve a planned compressive strength (f'_c) of 25 Mpa, which was carried out for 7 days of testing.

TABLE 3. Trial Mix Test Results

Concrete Age (Day)	Maximum Load (kN)	Actual Compressive Strength (MPa)	Age Factor	28-day Conversion Compressive Strength (MPa)	Average
7	290	16,404	0.65	25,237	25,237
	280	15,838		24,367	
	300	16,970		26,107	

6. Test Process for Concrete Compressive Strength, Split Tensile Strength and Flexural Strength

a. Pressure Strength Test Process

Concrete pressure strength tests were processed during hardening in retention times of 7, 21 and 28 days.

b. Splitting Tensile Strength Test Process

The split pull test was conducted on the 28th day sample according to SNI 03-2491-2002.

c. Concrete Flexural Strength Test Process

The sample flexural strength test was processed at 28 days of concrete age based on SNI 4431:2011.

III. TEST RESULTS AND RELATIONSHIP OF MECHANICAL PROPERTIES OF CONCRETE

a. Test Result of Mechanic Properties

1) Concrete Pressure Strength

Concrete compressive strength testing is carried out when the concrete is 7, 21 and 28 days old using a compression testing machine to determine the maximum compressive strength of concrete when it gets a compressive load (P) expressed in kN units. The addition of battery powder with a percentage variation of 0%, 1%, 3% and 5% by weight of cement produces different compressive strengths.

From Figure 3, the actual concrete compressive strength graph shows that the addition of 5% battery powder increases the percentage of concrete compressive strength against 0% normal concrete by 31.848%.

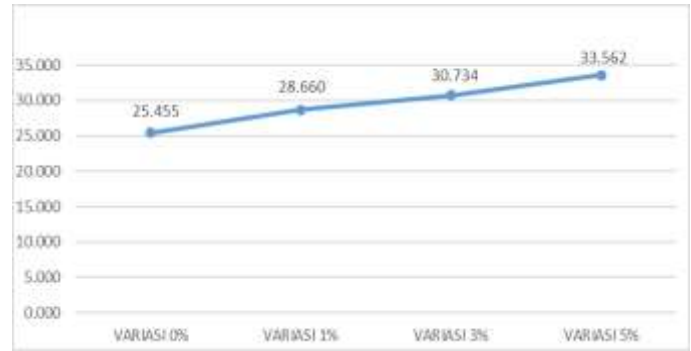


Figure 3: Actual compressive strength graph of concrete

2) Tensile Strength of Concrete

The test of tensile strength of concrete is carried out when the specimen is 28 days old using a compression testing machine in order to know the maximum pull force of concrete separated by the time of the load received (P) which is expressed in units of kN.

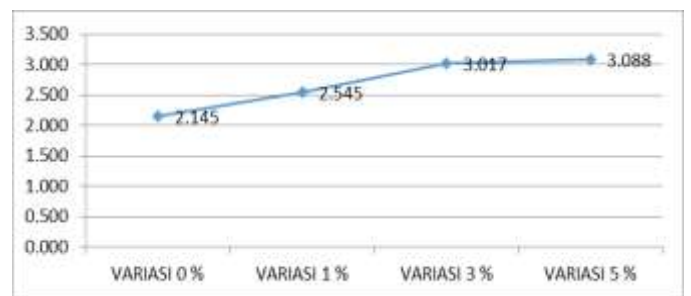


Figure 4: Concrete split tensile strength graph

From Figure 4, the graph of tensile strength of concrete with the addition of battery powder variations of 0%, 1%, 3% and 5% shows that the greater the addition of battery powder variations, the tensile strength of concrete increases. The test results show that the addition of 5% battery powder increases the percentage of concrete split tensile strength by 43.963% against normal concrete of 0% variation.

3) Flexural Strength of Concrete

This test was carried out when the specimens were 28 days old, the specimens were in the form of beams with a size of 60 cm × 15 cm × 15 cm, using a bending tester that has two loading points.



Figure 5: Flexural strength graph of concrete

The flexural strength graph shows that the flexural strength

of concrete increases with the increase of battery powder percentage. The addition of 5% battery powder increases the percentage of concrete strength by 36.692% against 0% normal concrete.

b. Relationship of Mechanical Properties of Concrete

1) Relationship of Concrete Pressure Strength / Concrete Split Tensile Strength

TABLE 4. Relationship between split tensile strength and compressive strength

Substitution Variation	Average (MPa)		Ratio Value
	Compressive Strength	Split Tensile Strength	
0%	25,455	2,145	8,4%
1%	28,660	2,545	8,9%
3%	30,734	3,017	9,8%
5%	33,562	3,088	9,2%

Based on the table above, the ratio between compressive strength (f'_c) and split tensile strength (f_t) for the 0%, 1%, 3% and 5% components is 8.4%, 8.9%, 9.8% and 9.2%. The percentage has complied with the predetermined standard of 7%-11%. (Agus Setiawan: 2016).

2) Relationship between Concrete Pressure Strength and Concrete Flexural Strength

TABLE 5. Relationship between Pressure Strength and Flexural Strength

Substitution Variation	Average (MPa)		Correlation Coefficient Value (x)
	Compressive Strength	Flexural Strength	
0%	25,455	2,799	0,555
1%	28,660	2,953	0,552
3%	30,734	3,518	0,635
5%	33,562	3,826	0,660

Table 5 shows that the coefficient of correlation between the flexural strength of concrete (f_r) for the percentage of concrete compressive strength (f'_c) at 0%, 1%, 3% and 5% variation is $0,555 \sqrt{f'_c}$, $0,552 \sqrt{f'_c}$, $0,635 \sqrt{f'_c}$ and $0,660 \sqrt{f'_c}$. This shows that the relationship between compressive strength and flexural strength with battery powder additives to the weight of cement obtained good results because there was an increase in the coefficient of correlation of the flexural strength of concrete for the percentage of concrete pressure strength.

IV. CONCLUSIONS

- The effect of adding battery powder as cement additive can increase the value of pressure strength, split tensile strength and flexural strength of concrete as the percentage of battery powder increases.
- The addition of 5% battery powder can significantly increase the pressure strength, tensile strength and flexural strength of concrete. So it can be concluded that the optimum value of the addition of battery powder is 5% of the variation of the addition of battery powder by 0%, 1%, 3% and 5%.

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