

ANALYSIS OF CONCRETE COMPRESSIVE STRENGTH WITH PARTIAL SUBSTITUTION OF IRON POWDER WASTE AS FINE AGGREGATE

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ABSTRACT

This study evaluates the use of iron powder waste as a partial replacement of fine aggregate in concrete to reduce environmental impacts. By testing various percentages of iron powder (0%, 7.5%, and 12.5%), this study analyzed the compressive strength of concrete at the ages of 7, 14, and 28 days. The results showed that the addition of iron powder tended to reduce the compressive strength of concrete compared to normal concrete. Concrete with 7.5% iron powder had better compressive strength compared to 12.5%, but both had not reached the expected compressive strength. Further research is needed to find the optimal combination of iron powder and other additional materials.

Keywords: Concrete, Compressive Strength, Waste, Iron Powder, Fine Aggregate

INTRODUCTION

The construction industry plays a vital role in infrastructure development, with concrete as the primary material. Factors such as the constituent materials, mixing process, environmental conditions, and curing of concrete greatly affect the quality of concrete. However, the use of conventional materials such as natural aggregates has a negative impact on the environment. Iron powder waste, generated from the metal industry, has similar properties to fine aggregate and can be used as a substitute in concrete. The use of this waste can increase the strength of concrete while reducing dependence on natural resources and environmental impact.

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METHODS

This study uses an experimental method with a series of laboratory tests to evaluate and compare the results. The testing process in the study includes material analysis, preparation of a concrete mix plan, concrete viscosity testing through slump tests, making test samples, concrete curing, and concrete compressive strength testing. The implementation of the study is divided into several stages of implementation, including:

- 1) At this stage, the equipment and materials used in the implementation of the study are provided;
- 2) At this stage, testing is carried out on the concrete components such as:
 - a. Specific gravity testing on aggregates;
 - b. Testing to pass through the sieve.
- 3) Called the concrete mix planning stage (mix design) based on the SK SNI 03-2834-2000 method.
- 4) Making test objects or test object samples, the samples used in this test object consist of several comparison variations:
 - a. Normal concrete variation without the addition of plastic bottle waste;
 - b. Concrete variation with the addition of 3% plastic bottle waste;
 - c. Concrete variation with the addition of 6% plastic bottle waste.
- 5) Slump test refers to SNI 1972-2008;
- 6) Concrete treatment (curing) is carried out by immersion in water;
- 7) Concrete compressive strength testing is carried out after the concrete is 7 days, 14 days, and 28 days old;
- 8) At this stage, the data obtained from the test results will be analyzed to obtain the relationship between the variables studied;
- 9) The last stage is drawing conclusions, at this stage the data that has been analyzed must be made into a conclusion related to the research objectives.

Research Flowchart

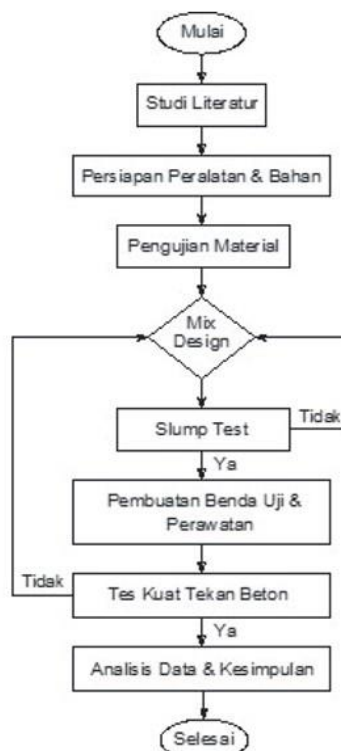


Figure 1. Research Flowchart

Before starting the research, it is necessary to prepare the tools and materials so that the process runs smoothly. The tools used must first be cleaned from dust or dirt that sticks. For example, the concrete cylinder must be cleaned to avoid bolts that get stuck or dragged when opening and removing. The walls of the concrete cylinder also need to be lubricated so that the concrete that has been poured and dried does not stick to the walls. Similar preparations are needed for other tools such as scales, ovens, and mixers. Materials need to be available in full from the beginning to the end of the research, including sand, crushed stone, water, and cement, to ensure there are no shortages. In addition, materials must be stored in a place protected from direct exposure to the weather to maintain their quality.

- 1) Slump testing on concrete is a measurement of the decrease in the height of the concrete that occurs immediately after the slump mold is lifted, according to SNI 1972-2008.
- 2) The concrete molding process is in accordance with SNI 2493-2011 which describes how to make and maintain concrete test objects in the laboratory. This process involves forming cylindrical concrete that will be tested for compressive strength;

RESULTS AND DISCUSSION

The proportion of the test specimen mixture with variations in the addition of some iron powder as a substitute for fine aggregate of 7.5% and 12.5%.

Table 1. Material Composition in 1 Concrete Cylinder

Volume Silinder (m3)	Variasi Serbuk Besi	Semen (kg)	Agregat kasar (kg)	Agregat halus (kg)	Air (kg)	Serbuk besi (kg)
0,0053	0%	2,07	5,97	3,36	0,98	0
0,0053	7,50%	2,07	5,97	3,11	0,98	0,25
0,0053	12,50%	2,07	5,97	2,94	0,98	0,42

The following is the calculation of the iron powder waste requirement for concrete variation 1 (one) and concrete variation 2 (two) for a cylindrical test object measuring 150 x 300 mm:

- 1) Iron powder waste used as a partial replacement of fine aggregate as much as 7.5%.
 $= 7.5\% \times \text{Sand weight} \times \text{Concrete cylinder volume}$
 $= 7.5/100 \times 633.6 \times 0.0053$
 $= 0.25 \text{ kg}$
- 2) Iron powder waste used as a partial replacement of fine aggregate as much as 12.5%.
 $= 12.5\% \times \text{Sand weight} \times \text{Concrete cylinder volume}$
 $= 12.5/100 \times 633.6 \times 0.0053$
 $= 0.42 \text{ kg}$

Concrete slump testing is carried out to measure the consistency or viscosity of the mixture of fresh concrete. To conduct a slump test, several tools are needed such as a slump cone (Abrams cone), a tamping rod, a flat and hard surface, and a fresh concrete mixture.

A low slump value indicates that the concrete is stiff and difficult to compact (not workable), while a high slump value indicates that the concrete is very workable and suitable for use in areas with dense steel reinforcement. The following are the results of the slump values obtained for 3 (three) concrete variations presented in the table below.

Table 2. Slump Analysis Test Results

Variasi Campuran	Nilai Slump	Satuan
Beton f_c '25 MPa.	9,8	Cm
Beton f_c '25 MPa variasi 7,5% limbah serbuk besi sebagai substitusi sebagian agregat halus	10	Cm
Beton f_c '25 MPa variasi 12,5% limbah serbuk besi sebagai substitusi sebagian agregat halus	8,5	Cm
Rata-rata	9,4	Cm

Based on the results of the slump test, the average slump value for 3 (three) concrete variations was 9.4 cm or 94 mm. The average slump value has met the slump value set in this study, which is 60-180 mm.



Figure 2. Results of Normal Concrete Slump Analysis Test



Figure 3. Results of Slump Analysis Test of Test Object Variation 1



Figure 4. Results of Slump Analysis Test of Test Object Variation 2



Figure 5. Diagram of Research Results on Concrete Compressive Strength at 7 Days



Figure 6. Graph of Concrete Compressive Strength Test Results at 7 Days of Age



Figure 7. Diagram of Research Results on Concrete Compressive Strength at 14 Days



Figure 8. Graph of Concrete Compressive Strength Test Results at 14 Days



Figure 9. Diagram of Research Results on Concrete Compressive Strength at 28 Days



Figure 10. Graph of Concrete Compressive Strength Test Results at 28 Days

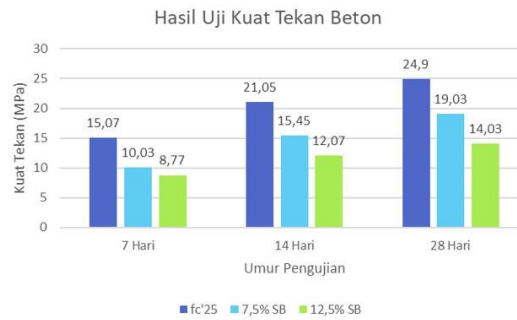


Figure 11. Combined Concrete Compressive Strength Test Results

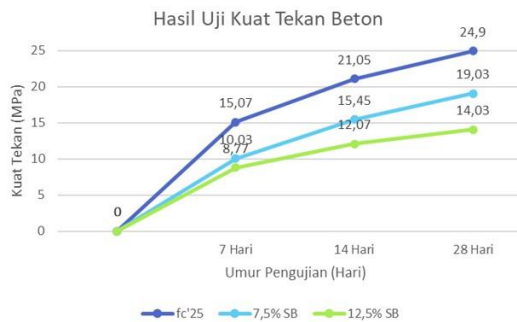


Figure 12. Combined Graph of Concrete Compressive Strength Test Results

CONCLUSIONS

The results of the average compressive strength test of normal concrete at the ages of 7, 14 and 28 days were 15.07 MPa, 21.05 MPa and 24.9 MPa, respectively. Based on these results, the compressive strength of the concrete has met the design compressive strength. The results of the average concrete compressive strength test of concrete variation 1 (one) with a mixture of iron powder waste of 7.5% at the ages of 7, 14 and 28 days were 10.3; 15.45 and 19.03 MPa. The average concrete compressive strength of variation 2 (two) with a variation of iron powder substitution of 12.5% at the ages of 7, 14 and 28 days were 8.77; 12.07 and 14.03 MPa, respectively. Based on the results of this compressive strength test, iron powder waste is not yet effective to be used as a substitute for fine aggregate because it does not meet the requirements of SNI 1974-2011 that the design compressive strength of concrete $fc'25$ at the age of 7 days is 65% with a value of 16.25 MPa, 88% at the age of 14 days with a value of 22 MPa and 100% at the age of 28 days with a value of 25 MPa. Based on the results of the compressive strength test conducted, both variations of concrete with a mixture of iron powder waste have not yet found the optimum variation that can achieve the design compressive strength of $fc' 25$ MPa. However, variations of concrete with a larger amount of iron powder waste substitution, the compressive strength results obtained tend to be lower.

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