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Utilization of Carbide Welding Waste as an Alternative Cement Mixture for Concrete Compressive Strength

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Abstract

This research was conducted to investigate the utilization of carbide welding waste as a cement mixture on the compressive strength of concrete with a target quality of Fc 25 MPa. The test specimens were cylindrical, with a diameter of 15 cm and a height of 30 cm. Concrete mixtures incorporated carbide welding waste as a partial cement substitute, with variations of 5%, 7%, and 10%, compared to a conventional control mixture based on cement volume. A total of 16 cylindrical specimens were prepared. Compressive strength tests were conducted at 7 and 28 days. The designed concrete strength was Fc 25 MPa. The results showed that the use of carbide welding waste in concrete mixtures led to a decrease in compressive strength at 7 days compared to concrete without waste. However, at 28 days, compressive strength increased significantly, especially at certain percentages. At the optimal percentage, carbide welding waste was proven to improve the compressive strength compared to normal concrete, thus demonstrating its potential as an effective cement mixture.

Keywords

Concrete, Carbide Welding Waste, Compressive Strength, Cement Mixture

Introduction

Concrete has become one of the most dominant construction materials in modern civilization, being used in a wide variety of projects ranging from residential housing, commercial buildings, to large-scale infrastructure such as bridges, dams, and highways (Asrullah et al., 2021). The advantages of concrete include its ease of molding according to design, its ability to withstand high compressive loads, and its durability under various environmental conditions. In general, concrete consists of a mixture of cement, fine aggregate, coarse aggregate, and water, with cement acting as the main binder that ensures cohesion between aggregate particles (Wardana et al., 2025).

Nevertheless, behind its advantages, cement production has significant environmental impacts. The manufacturing process requires the calcination of limestone at very high temperatures (around

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1450°C), consuming vast amounts of energy and releasing large-scale carbon dioxide (CO_2) emissions. This condition encourages researchers to seek innovations to reduce cement usage, either by improving material efficiency, using supplementary cementitious materials (SCM), or applying the principles of sustainable construction (Pratama et al., 2025; Syahriadi et al., 2021; Wahyudi et al., 2022).

One such effort is the utilization of industrial waste as a partial cement replacement (Winarno & Juara, 2021). Carbide welding waste produced from acetylene gas welding processes is one type of waste with potential application in concrete technology. This waste appears as a fine, whitish-gray powder with a high calcium oxide (CaO) content (around 95%), which is similar to the main composition of Portland cement (Putra & Asfarina, 2024). Until now, carbide welding waste has often been disposed of carelessly in landfills or allowed to accumulate in work areas, which not only diminishes environmental aesthetics but also poses pollution risks (Anggraeni & Tarangga, 2020).

Previous studies (Erdiansyah Putra & Israjunna, 2023; Kahiriah et al., 2022; Somalinggi et al., 2020) revealed that the addition of carbide welding waste in specific proportions can influence the mechanical properties of concrete, particularly its compressive strength. The effects tend to depend on the concrete's age and the percentage of mixture. At early ages (for instance, 7 days), several studies reported a decrease in compressive strength due to the low initial reactivity of the waste. Based on this background, the present research aims to evaluate the influence of carbide welding waste as a cement mixture on the compressive strength of concrete with a planned quality of Fc 25 MPa.

Methodology

This study employed an experimental method at the PT Duta Bangsa Mandiri Laboratory, Malang, to examine the effect of partial substitution of cement with carbide welding waste (0%, 5%, 7%, and 10%) on the compressive strength of concrete with a target strength of Fc 25 MPa, in accordance with SNI 03-2834-2000, with a slump of 10 ± 2 cm. The materials used included Type I Portland cement, Lumajang sand (Zone II), gravel of 10–20 mm, clean water, and carbide welding waste containing approximately 95% calcium oxide.

After testing the quality of the materials, the mixtures were prepared following standard procedures: mixing, slump test, casting into cylindrical molds (15 × 30 cm), compaction with 25 blows per layer, curing for 24 hours, and immersion in water for 7 and 28 days. Compressive strength tests were conducted using a compression testing machine, and the values were taken as the average of two specimens for each variation at each age.

Results and Discussion

Concrete Material Analysis

Table 1. Results of Fine Aggregate Testing

Type of Test	Result	Unit
SSD Moisture Content	0,5	(%)
Loose Bulk Density	1870	(kg / m3)
Compacted Bulk Density	1920	(kg / m3)
Sieve Analysis	2 Zona	
Spesific Grafity	2,57	
Absorption	1,83	(%)
Silt Content	0,04	(%)

Fine aggregate testing was conducted to ensure the sand used met the technical criteria for concrete mixtures, especially in mixtures with partial cement substitution using carbide welding waste. The laboratory test results indicated that the sand possessed good physical characteristics and was suitable for use, with a Zone II gradation ideal for medium to high-strength concrete. The SSD water content was recorded at 0.5%, the loose bulk density was 1870 kg/m³, the compact bulk density was 1920 kg/m³, the specific gravity was 2.57, and the water absorption was 1.83%, all of which were within the acceptable standards. The silt content of 0.04% was also well below the maximum limit of 5% according to the Indonesian National Standard (SNI), ensuring it would not interfere with the cement bond. Overall, this fine aggregate was deemed to meet the requirements for normal concrete material and supported the validity of the research on the effect of carbide waste substitution on concrete compressive strength.

Table 1. Results of Coarse Aggregate Testing

Type of Test	Result	Unit
SSD Moisture Content	0,6	(%)
Loose Bulk Density	1460	(kg / m3)
Compacted Bulk Density	1450	(kg / m3)
Sieve Analysis	November 13	(mm)
Spesific Grafity	2,66	
Absorption	0,6	(%)
Silt Content	0,9	(%)

The coarse aggregate used was tested for water content, bulk density, specific gravity, silt content, and sieve analysis, and the results showed a quality that met the Indonesian National Standard (SNI) for concrete materials. The SSD water content was recorded at 0.6%, which served as a reference for correcting the water content of the mixture. A loose bulk density of 1460 kg/m³ and a compact bulk density of 1450 kg/m³ indicated a density level that affects the cement and water requirements. The SSD specific gravity was 2.66 gr/cm³, which is within the normal aggregate range (2.5–2.9 gr/cm³). The low water absorption was 0.6%. The silt content of 0.9% was still below the maximum limit of 1%, indicating the aggregate was clean. The sieve analysis indicated a particle size distribution that supported the concrete's strength and workability. In this study, SNI 03-2834-2000 was used to determine the concrete mixture composition. With a planned concrete quality of Fc 25 MPa, the resulting composition was as follows:

Table 3. Concrete Mix Composition per 1 m³ for Fc = 25 MPa

Material	Amount	Unit
Portland Cement (PC)	370	Kg
Water	185	Liter
Sand (**Fine Aggregate**)	977	Kg
Gravel 1/2" (**Coarse Aggregate**)	884	Kg
Slump	10 ± 2	Centimeter

Table 4. Design Mixture Composition with Waste Mixture (unit: kg)

Waste %	Sand (kg)	Gravel (kg)	Water (L)	PC (kg)	Waste (kg)
0%	21,50	19,44	4,07	8,14	-
5%	21,50	19,44	4,07	7,79	0,40
7%	21,50	19,44	4,07	7,58	0,56
10%	21,50	19,44	4,07	7,32	0,81

The compressive strength test results are shown in the following tables and graphs:

Table 5. Compressive Strength Test Results (MPa)

	0%		**5%**		**7%**		**10%**	
Sample	**I**	**II**	**I**	**II**	**I**	**II**	**I**	**II**
7 **Days**	26,57	25,99	21,37	23,10	22,53	24,26	24,26	25,41
28 **Days**	29,46	28,30	25,41	23,68	28,88	25,99	28,88	30,04

Table 6. Average Compressive Strength Test Results (MPa)

	0%	**5%**	**7%**	**10%**
7 Days	26,28	22,23	23,39	24,83
28 Days	28,88	24,54	27,43	29,46

Table 6 presents the average concrete compressive strength data at 7 and 28 days with varying percentages of carbide welding waste used as a partial cement substitute: 0%, 5%, 7%, and 10%. Based on the 7-day test results, the normal concrete mix (0%) showed the highest compressive strength value at 26.28 MPa. In contrast, concrete with added carbide welding waste experienced a decrease in compressive strength as the percentage of the mixture increased. The concrete compressive strength for the 5% variation was recorded at 22.23 MPa, then increased to 23.39 MPa for the 7% variation, and reached its highest point of 24.83 MPa at 10%. These results indicate that at an early age, the carbide welding waste did not show a significant contribution to the concrete's strength, likely due to its low initial reactivity, which prevented optimal hydration.

Conclusion

The results demonstrated that the utilization of carbide welding waste as a cement mixture can positively affect the compressive strength of concrete, particularly at 7% and 10% variations. The optimal substitution percentage was found at 10%, which achieved an average compressive strength of 29.46 MPa at 28 days, exceeding the control concrete (28.88 MPa).

These findings confirm the potential of carbide welding waste as an effective and environmentally friendly cement substitute, contributing to improved long-term concrete performance. Further research with wider substitution percentages and additional testing is recommended to ensure safety, compliance with quality standards, and alignment with hazardous waste management regulations for optimal and sustainable implementation in the construction industry.

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