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THE INFLUENCE OF ADDITION CARBIDE WELDING WASTE ON THE COMPRESSIVE STRENGTH OF MORTAR

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***Abstract*— Technological developments in the infrastructure sector are currently being balanced with innovations in the materials that make up concrete. Cement is one of the building blocks of concrete. Cement functions as a bonding agent between aggregates in concrete. The research aimed to determine the influence of additional carbide welding waste on the compressive strength of mortar. The effect of carbide waste as a partial substitute (substitution) and also cement additives in mortar on the strength of mortar planned with SNI 03-6825-2002 on Portland Cement Mortar Compressive Strength Testing Methods for Civil Works and SNI 03-6882-2002 on Mortar Specifications for Pair Unit Work through material tests.**

Carbide waste has a chemical composition of 60% calcium (CaO), 1.48% SiO2, 0.09% Fe2O3, and 9.07% Al2O3. The main constituent of cement is calcium, which comes from limestone, so in this research, carbide waste is used as a cement substitute. and added materials so that it is hoped that the compressive strength of the mortar will increase when compared to mortar without added materials. The test object used is a cube-shaped mortar with dimensions of 5cm x 5cm x 5cm according to SNI 03-6882-2014 with a design mix ratio of cement to sand of 1:3 and FAS 0.5. Variations in adding carbide waste: 0%; 0.5%; 1%; 1.5%; 2%; 2.5%; and 3% of cement. Mortar compressive strength tests were carried out at ages 7, 14, 21, and 28 days. The results obtained in this research show that the optimum compressive strength value for using carbide waste as a cement substitute is at a level of 2% with a compressive strength value of 13 MPa, while for carbide waste as a material addition, it is at a level of 0.5% with a compressive strength value of 17.60 MPa.

Keywords: *Carbide Welding Waste, Compressive Strength, Mortar*

I. INTRODUCTION

There is now a rise in infrastructure development. Infrastructure development encompasses many facets of facilitating economic progress, with the building industry being one such example. The construction industry encompasses several sectors such as building construction, road infrastructure, dam construction, and other ancillary structures. Construction structures can take the form of wooden, steel, or reinforced concrete structures.

Reinforced concrete structures are highly favored due to its excellent longevity, ease of construction, and fire resistance. Concrete is a composite material consisting of water, cement, and a combination of fine and coarse aggregate. Cement is an exhaustible natural substance. Cement is crucial in the creation of concrete as it acts as a binding agent between aggregates [1].

As the need for concrete increases, there are many innovations about concrete binders other than cement. Portland cement is a hydraulic cement, which is cement that when mixed with cement will form a solid and hard mass. In general, the 4 most important main components of cement are tricalcium silicate (3CaO.SiO2), dicalcium silicate (2CaO.SiO2), tricalcium aluminate (3CaO.Al2O3) and tetracalcium aluminoferrite (4CaO.Al2O3.Fe2O3)[1].

Materials that have similar content and properties as cement are called pozzolan. Pozzolan can be used as a substitute for cement or as an additive to cement in certain percentages, either from natural or artificial materials.

In this research, the effect of adding carbide from welding waste as a substitute or additive to cement will be studied. The reason is because currently the industrial sector in the welding sector is also increasing. The welding activity will produce industrial waste in the form of carbide waste. According to [2] carbide waste has a chemical composition of 60% Calcium (CaO), 1.48% SiO2, 0.09% Fe2O3, 9.07% Al2O3. The addition of carbide waste is an effort to increase the calcium element needed in the pozzolanic reaction when mixed with SiO2 in carbide waste.

The components of a mortar mix consist of cement, fine aggregate and water. As an adhesive, Portland cement is one of the most important mortar ingredients. However, the price of Portland cement is also increasing over time. Therefore, as many different materials that have the same properties as portland cement are sought to replace or at least slightly reduce the cement composition in mortar while still meeting the feasibility requirements. In this research, mortar is used because the focus of the research is the effect of the addition of carbide welding waste on compressive strength, if using concrete will incur more costs.

The objectives of this research include:

1. Knowing the effect of carbide waste as a partial substitute (substitution) and also cement additives in mortar on the strength of mortar planned with SNI 03-6825-2002 on Portland Cement Mortar Compressive Strength Testing Methods for Civil Works and SNI 03-6882-2002 on Mortar Specifications for Pair Unit Work through material tests.
2. Knowing the level of carbide waste to get the optimum compressive strength.

In SNI 03-6825-2002, mortar is defined as a mixture of materials consisting of fine aggregate (sand), water, and Portland cement with a certain composition.

There are several other functions of mortar, namely to increase adhesion and durability with construction parts, as a brick binder, plastering work and ceramic binder and aesthetically, mortar provides color and texture to the wall [3].

In SNI 15-2049-2004, hydraulic cement is produced by grinding portland cement slag mainly consisting of hydraulic calcium silicates and ground together with added ingredients in the form of one or more crystalline forms of calcium sulfate compounds and may be added with other added ingredients.

Carbide waste is a B3 waste derived from the acetylene gas (C2H2) production process. The chemical composition of Carbide waste includes; SiO2 compounds 1.48%, CaO 59.98%, Fe2O2 0.09%, Al2O3 9.07%, MgO 0.67% and others 28% [4]. The chemical reaction equation of Calcium Carbide with water is:

$$CaC_2 + 2H_2O \rightarrow C_2H_2 + Ca(OH)_2$$

II. METHOD

The method used in this research is qualitative. The dependent variable and the independent variable refer to the SNI. The variables to be sought in this research are as follows:

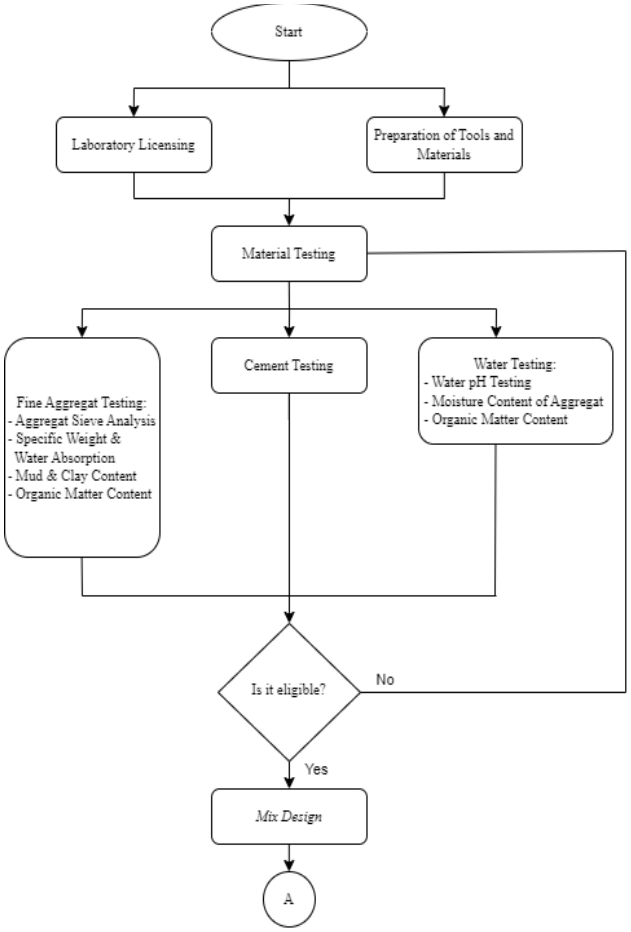
1. The dependent variable is the ratio between the volume of cement and sand is 1:3. The FAS (Faktor Air Semen) used is 0.5.
2. The independent variables are cement and carbide waste as partial substitution of cement in mortar mix.
3. Control variables are material test and compressive strength.

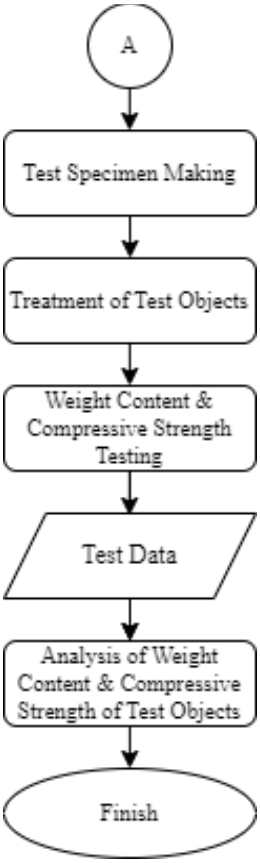
The carbide waste used in this research was taken from one of the welding workshops located in Pangkalan Village, Plered District, Cirebon and then processed by pounding it into powder. The percentage levels of partial substitution and cement additives in the mortar mixture are normal mortar 0%; 0.5%; 1%; 1.5%; 2%; 2.5%; and 3% by weight of cement. The test specimens used were mortar cubes with dimensions of 5cm x 5cm x 5cm, 3 specimens each for each variation. The compressive strength of mortar was tested at 7, 14, 21 and 28 days. The mortar constituent materials used were; fine aggregate used from River Sand (Cirebon), Tiga Roda Cement and water from the Materials Technology Laboratory of the Faculty of Engineering, Swadaya Gunung Jati University.

The research location; selection, sorting, material testing, mixing, manufacturing, maintenance and testing of test cubes were carried out at the Materials Technology Laboratory, Faculty of Engineering, Universitas Swadaya Gunung Jati Cirebon.

Testing the basic ingredients of mortar includes testing the fine aggregate including mud content, organic matter content, specific gravity and sieve analysis.

The flowchart of this research is as follows:





FIGUR 1. FLOWCHART RESEARCH

The compressive strength of concrete and mortar is the maximum force per unit area acting on concrete and mortar test specimens. The mortar compressive strength test was conducted based on SNI 03-6825-2002 (BSN 2002b). The test specimen is placed on the pressing machine then the test specimen is pressed until the test specimen breaks. At the time of rupture and the needle on the tool stops moving then the maximum compressive force that works is recorded. The compressive strength of concrete and mortar can be obtained with the following equation.

$$f'c = \frac{P}{A}$$

Description :

f'c : The compressive strength (MPa)

P : Maximum load (N)

A : Cross section of the area of the material resisting the load (mm^2)

III. RESULTS AND DISCUSSION

TABLE I. FINE AGGREGATE TESTING RESULT

Description	Test Result		Requirements		Results
	Value	*Test Standard*	value	Test Standard	
Grading Zone	II	-	-	-	-
Fineness Modulus	2,832	SNI 03-1968-1991	2,00-3,00	SNI 03-1968-1991	Qualify
Bulk Spesific Gravity	2,522	SNI 1969;2008	2,50-2,70	SK SNI T-15-1990-03	Qualify
Bulk Spesific Gravity (SSD)	2,537				
Apparent Spesific Gravity	2,560				
Absorption %	0,578		-	-	-
Water Content %	5,823	SNI 03-1971-1990	-	-	-
Silt And Clay Content %	3,000	SNI 03-4142-1996	≤5,00	SK SNI S-04-1989-F	Qualify
Organic Matter Content %	No. 1	SNI 03-2816-1992	No.1, 2, or 3	-	Qualify

TABLE II. WATER TESTING RESULT

Description	Test Result		Requirements		Results
	Value	*Test Standard*	value	Test Standard	
Water Condition	Clear	SNI 7974:2013	Clear	SNI 7974:2013	-
Water Flavor	Tasteless		Tasteless		Qualify
Water Smell	No Odor		No Odor		Qualify
Ph of Water	8,00	SNI 7974:2013	4,5-8,5	Contruction and building manual, book 4	Qualify

TABLE III. WEIGHT CONTENT OF MORTAR WITH CARBIDE WASTE AS CEMENT SUBTITUTE

Mix Variation	Weight of Content (gram)			
	7 Day	Day 14	Day 21	Day 28
Mortar 0% Carbide	2,33	2,33	2,27	2,33
Mortar 0,5% Carbide	2,40	2,47	2,42	2,26
Mortar 1% Carbide	2,35	2,45	2,39	2,24
Mortar 1,5% Carbide	2,43	2,41	2,49	2,29
Mortar 2% Carbide	2,44	2,42	2,42	2,48
Mortar 2,5% Carbide	2,39	2,42	2,45	2,44
Mortar 3% Carbide	2,47	2,42	2,40	2,43

TABLE IV. WEIGHT CONTENT OF MORTAR WITH CARBIDE WASTE AS CEMENT ADDITIVE

Mix Variation	Weight of Content (gram)			
	7 Day	Day 14	Day 21	Day 28
Mortar 0% Carbide	2,33	2,33	2,27	2,33
Mortar 0,5% Carbide	2,38	2,26	2,44	2,45
Mortar 1% Carbide	2,41	2,24	2,41	2,42
Mortar 1,5% Carbide	2,54	2,29	2,48	2,41
Mortar 2% Carbide	2,44	2,51	2,49	2,48
Mortar 2,5% Carbide	2,44	2,44	2,38	2,43
Mortar 3% Carbide	2,43	2,45	2,43	2,45

TABLE V. AVERAGE COMPRESSIVE STRENGTH OF MORTAR WITH CARBIDE WASTE AS CEMENT SUBSTITUTE

Variasi Campuran	Average Compressive Strength (MPa)			
	Day 7	Day 14	Day 21	Day 28
Mortar 0% Carbide	6,27	12,27	13,47	13,07
Mortar 0,5% Carbide	5,33	10,40	11,40	12,60
Mortar 1% Carbide	6,20	11,20	11,47	12,20
Mortar 1,5% Carbide	7,40	12,60	14,40	11,33
Mortar 2% Carbide	8,20	13,07	14,60	13,00
Mortar 2,5% Carbide	6,13	10,93	12,00	11,00
Mortar 3% Carbide	4,80	8,60	9,40	8,80

TABLE VI. AVERAGE COMPRESSIVE STRENGTH OF MORTAR WITH CARBIDE WASTE AS CEMENT ADDITIVE

Mix Variation	Average Compressive Strength (MPa)			
	Day 7	Day 14	Day 21	Day 28
Mortar 0% Carbide	6,27	12,27	13,47	14,40
Mortar 0,5% Carbide	8,80	13,47	17,00	17,60
Mortar 1% Carbide	5,20	9,40	9,80	14,40
Mortar 1,5% Carbide	6,80	10,67	14,00	12,80
Mortar 2% Carbide	5,40	11,00	13,47	11,60
Mortar 2,5% Carbide	10,00	13,20	13,60	12,67
Mortar 3% Carbide	6,00	12,20	12,20	11,33

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aggregates in mortar, it can be seen that the compressive strength value of mortar when compared to normal mortar has decreased. The compressive strength of normal mortar at the age of 28 days is 13.07 MPa.

Table 6 and Figure 3 above show that mortar with carbide waste as an additive to cement shows the optimum value at a percentage of 0.5%, namely 17.60 MPa, but along with the increase in carbide waste has decreased. The following mortar compressive strength values at 1%, 1.5%, 2%, 2.5% and 3% variations are 14.40 MPa, 12.80 MPa, 11.60 MPa, 12.67 MPa and 11.33 MPa, respectively. When compared to normal mortar, the mortar with the addition of carbide waste as an additive to cement increased by 22.22%. The compressive strength value of normal mortar is 14.40 MPa.

The use of carbide waste in this research can be projected based on the proportion in the mortar mixture which has an impact on the characteristics of the mortar. The parameter that determines the proportion that can be used is the result of the compressive strength value. The compressive strength value required in SNI 6882: 2014 which adopts ASTM C270 is grouped on the type of mortar specified. The following is a table of mortar property specifications in figure 7.

Mortar	Tipe	Kekuatan tekan rata-rata pada umur 28 hari, min, MPa (psi)	Retensi air, min, %	Kadar udara, maks, %[B]	Rasio agregat (diukur dalam kondisi lembab, lepas)
Semen-kapur	M	17,2 (2 500)	75	12	
	S	12,4 (1 800)	75	12	
	N	5,2 (750)	75	14[C]	
	O	2,4 (350)	75	14[C]	
Semen mortar	M	17,2 (2 500)	75	12	Tidak kurang dari 2¼ dan tidak lebih dari 3½ jumlah dari volume-volume terpisah dari material sementisius
	S	12,4 (1 800)	75	12	
	N	5,2 (750)	75	14[C]	
	O	2,4 (350)	75	14[C]	
Semen pasangan	M	17,2 (2 500)	75	18	
	S	12,4 (1 800)	75	18	
	N	5,2 (750)	75	20[D]	
	O	2,4 (350)	75	20[D]	

FIGURE 2. MORTAR PROPERTIES SPESIFICATION

In this research according to the results of the mortar compressive strength test in table 5 and table 6, the classification of mortar with carbide waste as a substitute or additive to cement belongs to type N cement mortar because the lowest compressive strength is 8.8 MPa in mortar with carbide waste as a substitute for cement with a percentage of 3%.

IV. CONCLUSIONS

The utilization of carbide waste is a solution to the abundant handling of carbide waste and an innovation for construction material technology. This research focuses on the utilization of carbide waste as a substitute and added material to cement, the ratio of cement and sand and the water factor of cement are made fixed so that this research can obtain pure changes in characteristics due to variations in carbide mixture. Based on the research that has been carried out, the conclusions can be drawn as follows:

1. From the results of the content weight test, the normal mortar values obtained at ages 7, 14, 21 and 28 were 2.33; 2.33; 2.27; and 2.33 grams, respectively. These values are for reference for each day age and other mix variations. The content weight values at other ages and mix variations experienced inconsistent increases and decreases due to uneven compaction.
2. The compressive strength of normal mortar at 28 days used as control was 13.07 MPa.
3. The optimum value of the percentage of carbide waste as a substitute for cement is at 2% with a compressive strength value at 28 days of age of 13 MPa. When compared with normal mortar, it decreased by 0.55%.
4. The Optimum value of the percentage of carbide waste as an additive to cement is at 0.5% with a compressive strength value of 17.60 MPa, after which the compressive strength value decreases. When compared with normal mortar, it increased by 22.22%.
5. The lowest compressive strength value was 8.8 MPa in the variation of carbide waste as a 3% cement substitution, so the classification of cement mortar in this research is Type N mortar.

From the research that has been done, some suggestions that can be given include:

1. Further research needs to be done related to the chemical properties of carbide welding waste.
2. Further research needs to be done related to the chemical properties of carbide welding waste.
3. Further research can be carried out by calculating the absorption capacity of mortar using carbide waste additives.

REFERENCES

[6] Tjokrodimuljo, Kardiyono (2007). Teknologi Beton. Biro Penerbit Jurusan Teknik Sipil Fakultas Teknik UGM, Sleman, Daerah Istimewa Yogyakarta.

[7] Mahendra, Pandu., dan Risdiato, Yogie, (2019). Pemanfaatan Limbah Carbide Sebagai Material Pengganti Semen Terhadap Kuat Tekan Beton Normal. Fakultas, Universitas, Teknik Surabaya, Islam, 2 No. 2, 1–7.

[8] Kusumah, Andi., Anita Setyowati Srle Gunarti dan Sri Nuryati. 2016. Perbandingan Kuat Tekan Mortar Menggunakan Air Saluran Tarum Barat dan Air Bersih. Jurnal Bentang. Vol. 4. No. 2. Hal: 30-37.

[9] Rajiman. (2015). Pengaruh Penambahan Limbah Carbide Dan Material Agregat Alam (Feldspart) Terhadap Sifat Fisik Beton. Tapak Vol. 4 No. 2 , 118-124

[10] Badan Standarisasi Nasional. 2002. SNI 03-6825-2002. Spesifikasi Agregat Halus Untuk Pekerjaan Adukan dan Plesteran Dengan Bahan Dasar Semen. Bandung.

[11] Badan Standarisasi Nasional. 2004. SNI 15-0302-2004. Semen Portland Pozolan. Jakarta.

[12] Novita, S., Rofaidah, S., dan Asro, M. 2010. Analisa Stabilisasi Tanah Lempung Organik Dengan Limbah Carbide Untuk Subgrade Pada Jalan. Politeknik Negeri Sriwijaya.

[13] ASTM Internasional. (2018) "Standart Specification for Masonry Cement". ASTM C91/C91M-18, West Conshohocken.

[14] ASTM Internasional. (2009) "Standart Specification for Portland Cement". ASTM C150-07, West Conshohocken.

[15] Aprida, L. F., Dermawan, D., & Bayuaji, R. (2015). Identifikasi Potensi Pemanfaatan Limbah Karbit dan Abu Sekam Padi sebagai Bahan Alternatif Pengganti Semen. Conference Proceeding on Waste Treatment Technology, 4(2), 13–16. Zuraidah, S. dan Jutmiko, R.A., 2007. Pengaruh Penggunaan Limbah Pecahan Batu Marmer Sebagai Alternatif Pengganti Agregat Kasar Pada Kekuatan Beton. Jurnal Teknik Sipil Universitas Dr. Soetomo. Surabaya.

[16] British Standart (BS) 3148:1980 tentang air dalam penyusunan beton.

[17] Kusumah, Andi., Anita Setyowati Srle Gunarti dan Sri Nuryati. 2016. Perbandingan Kuat Tekan Mortar Menggunakan Air Saluran Tarum Barat dan Air Bersih. Jurnal Bentang. Vol. 4. No. 2. Hal: 30-37.

[18] Suprobo, Joko. 2020. Studi Kuat Lentur Beton F'c 30 Mpa Dengan Limbah Karbit Sebagai Bahan Tambah Semen. Jurusan Teknik Sipil Fakultas Teknik Universitas Siliwangi Tasikmalaya

[19] Tira Roesdiana, 2007, Pengaruh Penambahan Pozzolan Terhadap Kuat Tekan Mortar, Skripsi, Program Studi Teknik Sipil, Fakultas Teknik, Universitas Teknik Sipil.

[20] Mayhutomo, Alpiyan, Bambang Setiawan, dan Noegroho Djarwanti. 2018. Pengaruh Kolom Karbit Sebagai Perbaikan Tanah Dasar Ekspansif Dengan Pengaliran Dari Tanah Ke Kolom. Jurnal Teknik Sipil Fakultas Teknik Universitas Sebelas Maret.

[21] Zulhijah, Dilla., Sri Handani., dan Sri Mulyadi. Pengaruh Variasi Ukuran Agregat Terhadap Karakteristik Beton Dengan Campuran Abu Sekam Padi. Jurnal Ilmu Fisika (JIF). Vol 7. No. 2. Hal: 50-55.