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ECONOMIC ANALYSIS AND COMPRESSIVE STRENGTH OF CONCRETE, COST AND UTILIZATION TIME OF CARBON-SULFUR AND DIRTY SULFUR SOLID WASTE

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Abstract
This study aims to analyze whether carbon-sulfur and dirty sulfur solid waste added materials can be used for concrete manufacturing, obtain and analyze the formulation of a 2% carbon sulfur mixture with concrete compressive strength, and the cost value. This research is experimental where this study aims to determine the relationship between concrete compressive strength and compression testing machine tools. The test specimen made in this experiment is a concrete cylinder. The data form of this study is numeric. The conclusions that can be drawn from the discussion for carbon-sulfur and dirty sulfur solid waste research are as follows: Carbon sulfur &; dirty sulfur from the results of the laboratory test determination shows that the toxicity characteristics leaching procedure (TCLP) value and total concentration (TK) have not exceeded the Category B threshold according to PP22 of 2021.

Keywords: Concrete, Economics, Waste

INTRODUCTION

PT Vale Indonesia Tbk (PTVI) is a nickel mining industry located in Sorowako, South Sulawesi. The product produced by PTVI is nickel matte. As a major industry that applies environmentally sound technology, PTVI carries out careful environmental management intending to minimize its impact on the environment (Timur, n.d.). Waste produced by PTVI can be in the form of solid, gas, or liquid waste. The solid waste produced by PTVI is carbon-sulfur and dirty sulfur. Solid waste, carbon sulfur, and dirty sulfur are PTVI's priority agenda for handling due to limited storage land. Considering the urgent need related to limited land, it is necessary to conduct a study on the use of carbon-sulfur and dirty sulfur waste.

Based on the Regulation of the Minister of Environment and Forestry Number 6 of 2021 concerning Procedures and Requirements for Hazardous and Toxic Waste Management, the determination of B3 waste status is carried out through characteristic tests which include explosive, flammable, reactive, infectious, corrosive and/or toxic. TCLP Test, LD50 Toxicology Test, and Sub Chronic Toxicology Test (Hidup & Nomor, 6AD). Were carried out to determine the toxic properties of B3 waste. Carbon

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sulfur and dirty sulfur are designated as non-B3 waste based on TCLP test results so that further processing and utilization can be carried out (Indonesia, n.d.).

There are two advanced processing options, namely solidification for final disposal and cement / concrete manufacturing for road bases or other concrete products. Processing with stabilization or solidification aims to move solid waste or relocate it to be stored in the landfill area. Processing into cement or concrete aims to utilize solid waste as material for civil engineering purposes, for example in terms of road pavements (road bases) and concrete products (paving blocks, bricks, canteens, and barriers) (Juliardi AR, 2022).

Admixtures are ingredients added to the concrete mixture during or during mixing. The function of this material is to change the properties of concrete to make it more suitable for a particular job, or to save costs. Admixture or added material defined in Standard Definitions of terminology Relating to Concrete and Concrete Aggregates (Agustian & Ilham, 2021) and Cement and Concrete terminology (ACI SP-19) is as a material other than water, aggregate, and hydraulic cement mixed in concrete or mortar added before or during stirring. Added materials are used to modify the properties and characteristics of concrete e.g. to be easily machined, accelerate hardening, increase compressive strength, savings, or for other purposes such as energy saving. Added ingredients are usually given in relatively small quantities, and must be with close supervision so as not to overdo it which will worsen the nature of beton (Ramadhan & Khuljanna, 2021).

This study aims to analyze whether carbon-sulfur and dirty sulfur solid waste added materials can be used for concrete manufacturing, obtain and analyze the formulation of a 2% carbon sulfur mixture with concrete compressive strength, and the cost value. The benefits of this study provide knowledge and information on whether carbon-sulfur and dirty sulfur solid waste can be utilized and can increase the compressive strength of concrete. Provide recommendations to PT. Vale Indonesia in terms of cost and time due to the addition of carbon-sulfur and dirty sulfur solid waste materials.

Identification The problems of this research are (a) The existence of solid waste produced by PTVI is carbon-sulfur and dirty sulfur which needs to be utilized due to limited land for storage. (b) That carbon-sulfur and dirty sulfur waste classified as non-B3 waste can be further utilized. (c) Further utilization of carbon-sulfur and dirty sulfur waste may be in the form of solidification for final disposal and cement/concrete manufacturing for road bases or other concrete products. (d) In terms of the economic aspect, solid waste can provide benefits for PTVI and the community environment.

The formulation of this research problem is; (1) Can carbon sulfur &; dirty sulfur be used as additives to increase the compressive strength of concrete? (2) How is the relationship between the formulation of the 2% carbon sulfur mixture and the compressive strength of concrete and the cost value? (3) How is the relationship between the formulation of the 4% carbon sulfur mixture and the compressive strength of concrete and the cost value?

RESEARCH METHODS

This research is experimental where this study aims to determine the relationship between concrete compressive strength and compression testing machine tools. The test specimen made in this experiment is a concrete cylinder. The data form of this study is numeric. This research will be carried out systematically following scientific rules that have been obtained previously.

The author will conduct research and sampling at PT. Vale Indonesia Sorowako city, South Sulawesi, and conducted concrete compressive strength experiments at PT. WIKA Pratama Learning Centre Cibubur. The object of research is to formulate added materials with carbon-sulfur &; dirty sulfur materials and material costs arising from aggregate substitution, the use of concrete mix design, and the concrete encroachment time.

Research data is a set of information or information from something obtained through observations or also searches to certain sources where the data obtained before being processed and analyzed can become a fact or assumption. The data used in this study are concrete compressive strength test data and material-specific gravity data. The correct data collection technique will produce data that has high credibility, and vice versa. This stage of data collection must not be wrong and must be carried out carefully according to procedures and qualitative descriptive research.

The collection of data carried out in this study, especially for primary data collection includes the following steps; (a) The first stage is to ensure that the sample used has been tested using the TCLP and LOI methods to find out that the sample is non-B3 waste. (b) The next stage is the sample aggregation process according to the filter number to be used and calculating the specific gravity and material properties of the sample. (c) The formulation Stage is the stage where researchers formulate formulates formula formulas using a mixture of Cs &; Ds and the substitution of concrete-forming materials. (d) (d) The next stage is to justify the compressive strength of the normal sample (Fc) without any added ingredients to be used as a comparison. (e) The next stage is the manufacture of concrete samples with formulations determined based on the number of carbon-sulfur and dirty sulfur samples carried. Optimization of sample use is needed at this stage so that there are not many samples left. (f) The next stage is the concrete compressive strength test with a grinding period of 7,14,28,54 and 90 days. (g) The next stage is to analyze the data from the test results of compressive strength testing of concrete with carbon-sulfur and dirty sulfur with normal concrete. (h) The next stage is to analyze the costs incurred due to aggregate substitution to the permeation time. (i) The next stage is to analyze the potential utilization of waste with a predetermined formulation. (j) The last stage is to calculate the economic value of this sulfur waste.

Data collection in this study is the formulation of added materials, compressive strength of concrete, and the price of materials used in the mix design process. Research conducted at the WIKA Pratama Learning Center Cibubur Testing Lab.

The research variables that will be observed and become primary data are as follows: (1) Formulation of carbon-sulfur-added ingredients. (2) Formulation of dirty sulfur additives. (3) Formulation of carbon-sulfur + dirty sulfur additives. (4) Aggregation of filter additives no.30, 50, 100, and 200. (5) The specific gravity of fine aggregate. (6) Specific gravity of coarse aggregate. (7) Specific gravity of Portland cement. (8) Normal concrete compressive strength 7, 14, 28, 54, and 90 days (without added materials). (9) Compressive strength of concrete life 7, 14, 28, 54, and 90 days (with added materials). (10) Price of cement material. (11) Price of sand material. (12) The material price of fine aggregate. (13) Coarse aggregate material price. (14) Economic value of waste.

In this study, experiments were carried out in the testing laboratory which was carried out using concrete compressive testing equipment (Compression Testing machine) Data obtained from testing test objects by measuring the compressive strength value of concrete. The data analysis method used is a comparative analysis using tabulations and graphs. The data analysis process of each test result data will be tabulated based on the number of samples of each formulation and calculate the costs incurred due to the addition of carbon-sulfur and dirty sulfur materials.

The stages of the data analysis process are as follows: a) Normal concrete compressive strength of the amount of load per unit area that causes concrete test specimens to disintegrate when loaded with certain compressive forces generated by the pressing machine. b) Compressive Strength of concrete due to the addition of carbon-sulfur and dirty sulfur then a comparative analysis is carried out using tabulations and graphs according to their respective formulations. c) Each formulation has a different grammation related to its constituent factors i.e. cement, fine aggregate, coarse aggregate, and water. From this variable incur costs and are adjusted based on the specific gravity of loss and normality. d) Cost calculation using the AHSP method (Unit Price Analysis of Work) point A.4.1.1.10. Making 1 m^3 of concrete quality f'c = 26.4 Mpa (K300). e) Derivatives of formulations and costs are the amount of waste material used and will be analyzed using rigid pavement models to obtain the required grams and costs incurred for each formulation. f) Calculate the economic value of the AHSP calculation results.

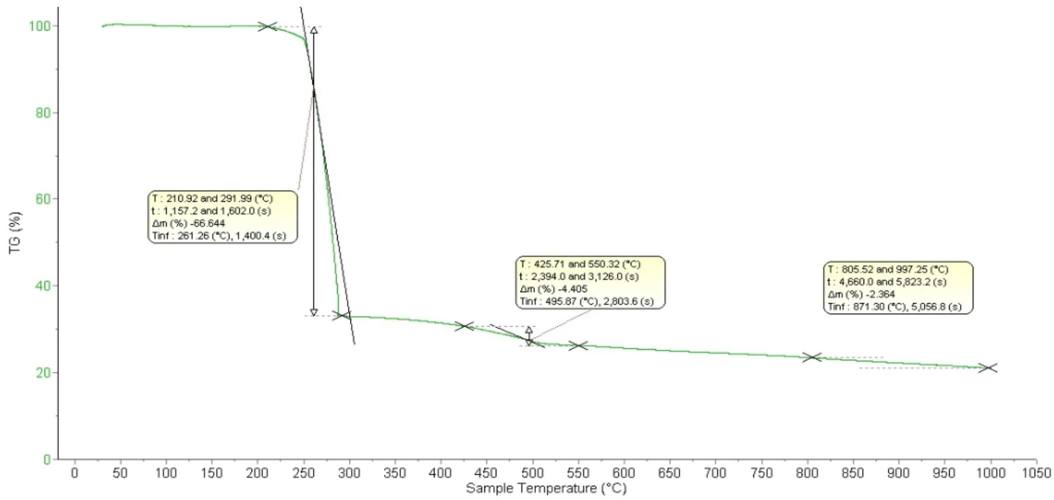
RESULTS AND DISCUSSION

A. Testing Carbon Sulfur and Dirty Sulfur as Non-B3 Waste

Thermogravimetric analysis techniques are carried out by measuring changes in the weight of the screw (sample) along with heating on the stagger. This technique can measure, among others, thermal stability parameters, volatile component fraction, water loss, solvent loss, plasticizer loss, decarboxylation (removal of carbon dioxide from amino acids), pyrolysis (combustion in an oxygen-free environment), oxidation, decomposition, charge rate, amount of metal catalyst residue on carbon, nanotubes, and ash percentage weight (Ragaert, Delva, & Van Geem, 2017). All these scalable applications are often made in the industry. However, there are some tests where information can be obtained through the cooling process after heating. There are two types of graphs in this analysis process, namely: (a) Rajah (plot) sample weight against temperature. (b) Cedar (usually in %) mass loss.

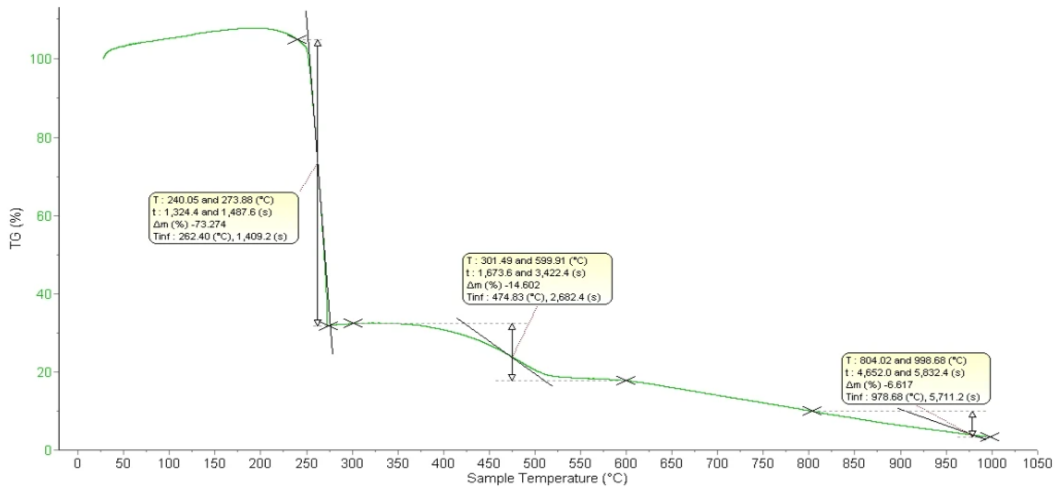
TGA figures for carbon sulfur can be seen in Figure 1 and dirty sulfur in Figure 2 both in the temperature range of 25-1000 oC. The estimated loss of ignition (LoI) after the removal process for carbon-sulfur and dirty sulfur is less than 10%.

Figure 1
TGA Diagram for Terok Carbon sulfur



Source: BRIN Research (2022) (Nevola et al., 2022)

Figure 2
TGA Figure for Terok Dirty Sulfur



Source: BRIN Research (2022) (Nevola et al., 2022)

B. Total Concentration and TCLP

The results of determining the total concentration (TK) and toxicity characteristic leaching procedure (TCLP) for carbon-sulfur and dirty sulfur are presented following Government Regulation No. 22 of 2021 concerning the Implementation of Environmental Protection and Maintenance (Annex XIII) and State Minister of Environment Regulation No. 6 of 2021 concerning Procedures and Requirements for B3 Waste Disposal. presented in Table 1 TK and TCLP values for both carbon-sulfur and dirty sulfur are below the total concentration of B (TK B). Even TCLP and TK for carbon sulfur are below TK C.

However, for dirty sulfur, there is one parameter, namely nickel, whose value is above TCLP C, and three other parameters, namely nickel, TPH C10-C36, and total PCBs whose value is above TK C. The TCLP value of dirty sulfur for Nickel is 2.86 mg / L (threshold TK C = 1.4 mg / L). While the total value of dirty sulfur concentration for nickel, TPH C10-C36, and total PCBs respectively are 123, 1040, and 0.04 mg/kg whereas the threshold values of TK Care are 60, 1000, and 0.02 mg / k respectively.

C. LOI and TCLP Test Results

The results of the determination of laboratory tests show that the toxicity characteristics leaching procedure (TCLP) value and total concentration (TK) have not exceeded the Category B threshold according to PP22 of 2021. Thus, carbon-sulfur and dirty sulfur waste have the potential to be utilized Based on TGA analysis, the incandescent loss value for carbon-sulfur and dirty sulfur waste is less than 10% if the calculation is carried out after the sulfur evaporation stage from the waste matrix. Therefore, to avoid confounding the presence of sulfur against LoI, it is necessary to conduct TGA analysis on products formulated by CS and DS both for solidification/stabilization and concrete filler road base.

D. Formula Job Mix Design Beton

Waste carbon-sulfur (CS) and dirty sulfur (DS) are used as fillers and substitutes in fine aggregates of concrete-forming materials. The effect of adding carbon sulfur and dirty sulfur to the concrete mixture was observed with a squeeze period of 7, 14, 28, 54, and 90 days. Table 1 shows the design mix plan of CS, DS, and CS and DS mixtures. The percentage variation of the mixture used is 2%, 4%, and 6% respectively. CS and DS are 5%, 10%, and 15%. This percentage refers to the number of samples brought from PT. Vale Indonesia has as much as 425 kg with a combination of Cs of as much as 200 kg and Ds of as much as 225 kg.

Tabel 1
Mix Design Formulasi Beton F'c 25.

Formulasi	Semen	Agregat Halus	Agregat Kasar	Air	Cs Filler	Cs Agregat Halus	Ds Filler	Ds Agregat Halus
	Kg	Kg	Kg	Liter	Kg	Kg	Kg	Kg
Beton Normal F'c 25	366	700	1.047	205	0	0		
Beton + Cs 2%	366	686	1.050	205	7	14		
Beton + Cs 4%	366	671	1.049	205	15	28		
Beton + Cs 6%	366	656	1.047	205	22	42		
Beton + Ds 2%	366	693	1.050	205			7	7
Beton + Ds 4%	366	671	1.048	205			15	15
Beton + Ds 6%	366	661	1.047	205			22	39
Beton + (Cs + Ds 5%)	366	685	1.050	205	6,1	7	12,2	7
Beton + (Cs + Ds 10%)	366	672	1.048	205	12,2	14	24,4	14
Beton + (Cs + Ds 15%)	366	654	1.047	205	18,3	21	36,6	21

Source: Data Processing (2023)

CS and DS waste are aggregated first before mixing. As shown in Table 2 each waste will be filtered using filters No. 30, 50, 100, and 200.

Table 2
CS and DS fillers restrained by sieves No. 30, 50, 100 and 200

Sieve size		Retained weight			
		Carbon sulfur		Dirty Sulfur	
Number	Diameter (mm)	medical history	%	medical history	%
30	0,6				
50	0,3	10,053	15	15,046	27
100	0,15	9,109	13	21,366	39
200	0,075	49,000	72	19,000	34

Source: Test Results (2023)

E. Normal Concrete Formulation

This normal concrete formulation becomes a control formulation for other formulations, as well as for other sample test results. This normal concrete formulation is also a reference for compressive strength analysis and cost per m3. The details of the formulation and the results of the compressive strength test are as follows;

Semen: 366 kg
Pasir: 700 kg
Split/Coarse aggregate: 1047 kg
Air: 205liter
Slum Rencana : 12 cm
Slump Aktual : 10 ± 2 cm

Table 3
Normal Concrete Compressive Strength Test Results

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Laboratorium Penguji
LP-1216-IDN

HASIL UJI KUAT TEKAN BETON SILINDER
(SNI 1974:2011)

Pemohon : Vian Marantha - BRIN
Proyek : PENELITIAN EFEK PENAMBAHAN MATERIAL CS & DS
Kontraktor : PT WIJAYA KARYA (Persero) Tbk
Suhu Ruangan : 27,4 °C Kelembaban : 54 %

No. Laporan : WIKA/LAB.031.A.BT/11/2022
Tanggal : 06 November 2022
Mutu Beton : *F 25 Mpa*

No.	No Urut Benda Uji	Tanggal Pembuatan	Tanggal Pengujian	Umur (hari)	Kode	Slump (cm)	Tinggi H (cm)	Diameter D (cm)	Luas Penampang (A) (cm²)	Berat (G) (gr)	Berat Isi (gr/cm³)	Beban (P) kN	Tegangan Benda Uji Ø (kg/cm²)	Tegangan Benda Uji Ø Mpa	Remarks
1	0.NOR.	7-Sep-22	14-Sep-22	7	KOMPOSISI NORMAL	-	30	15	176,625	11578	2,185	218,0	125,80	12,34	
2	0.NOR.	7-Sep-22	14-Sep-22	7		-	30	15	176,625	11774	2,222	224,3	129,43	12,70	
3	0.NOR.	7-Sep-22	14-Sep-22	7	SEMEN : 366 KG	-	30	15	176,625	11772	2,222	210,0	121,18	11,89	125,47
4	0.NOR.	7-Sep-22	21-Sep-22	14	PASIR : 700 KG	-	30	15	176,625	11865	2,239	216,1	124,70	12,24	
5	0.NOR.	7-Sep-22	21-Sep-22	14	SPLIT : 1047 KG	-	30	15	176,625	11785	2,224	240,6	138,84	13,62	
6	0.NOR.	7-Sep-22	21-Sep-22	14	AIR : 205 LT	-	30	15	176,625	11780	2,223	221,3	127,70	12,53	130,41
7	0.NOR.	7-Sep-22	4-Oct-22	28	SL RA : 10±2 CM	-	30	15	176,625	11885	2,243	274,4	158,34	15,54	
8	0.NOR.	7-Sep-22	4-Oct-22	28	SL RI : 12 CM		30	15	176,625	11976	2,260	259,7	149,86	14,71	
9	0.NOR.	7-Sep-22	4-Oct-22	28		-	30	15	176,625	11939	2,253	289,4	167,00	16,39	158,40
10	0.NOR.	7-Sep-22	30-Oct-22	54		-	30	15	176,625	11827	2,232	290,4	167,57	16,44	
11	0.NOR.	7-Sep-22	30-Oct-22	54			30	15	176,625	11830	2,233	253,7	146,40	14,37	
12	0.NOR.	7-Sep-22	30-Oct-22	54		-	30	15	176,625	11778	2,223	271,6	156,72	15,38	156,90
13	0.NOR.	7-Sep-22	5-Nov-22	90		-	30	15	176,625	11890	2,244	323,2	186,50	18,30	
14	0.NOR.	7-Sep-22	5-Nov-22	90			30	15	176,625	12013	2,267	285,1	164,51	16,14	
15	0.NOR.	7-Sep-22	5-Nov-22	90		-	30	15	176,625	12790	2,414	210,3	121,35	11,91	157,46

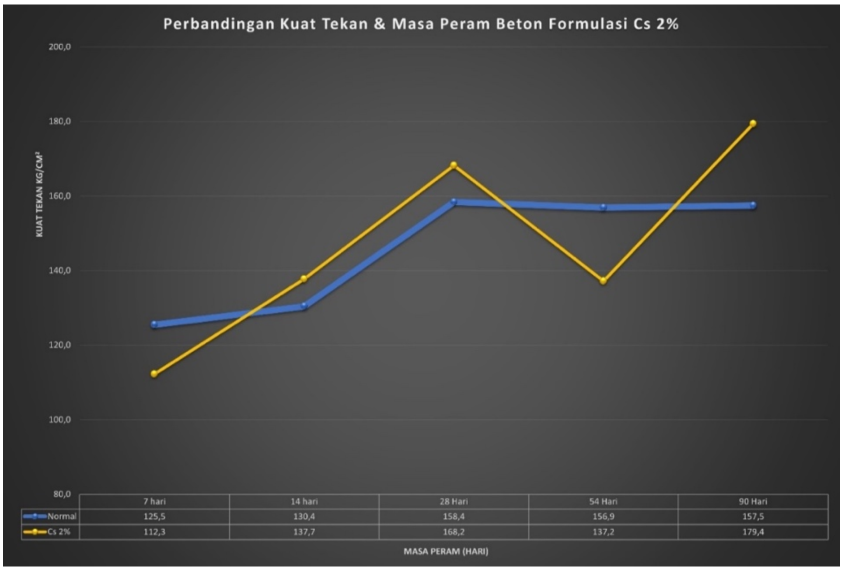
Source: Wika Beton Test Results 2023 (Muhajir & Yuamita, 2023)

Based on Table 4.6 the 15 samples that have been prepared are categorized into 5 param periods, namely 7, 14, 28, 54, and 90 days, for every 2 strong params prepared 3 samples are to be tested, this is to see the pattern of concrete characteristics and the treatment process between sample 1 and others, besides that, it also serves as a sample backup if the concrete treatment process is not following the applicable terms and conditions.

F. Formulasi Beton + Cs 2%

Making concrete with the addition of 2% carbon sulfur has the following material composition: (a) Cement: 366 kg. (b) Sand: 686 kg. (c) Split: 1050 Kg. (d) Water: 205 liters. (e) Cs as filler: 7 kg. (f) Cs fine aggregate substitution: 14 kg. From the composition of the concrete mix design with the addition of 2% cs, a curing process of up to 90 days is carried out, and compressive strength results are obtained as in Figure 4.10 below.

Figure 3
Comparison of compressive strength of normal concrete with 2% Cs composition



Based on Figure 3, you can see a graph of the increase in compressive strength of concrete according to the length of the coating period carried out. On day 7 the compressive strength of concrete with a Cs composition of 2% was still below normal concrete, entering days 14 and 28 there was an increase in compressive strength of 5.36% and 6.31%. Entering the 54th day, there was a significant decrease in compressive strength by 14.35%, and rose again in the 90-day compressive period by 13.9% from the compressive strength of normal concrete. From the composition of the addition of 2% cs, it can be seen that the content of Cs can increase the compressive strength of concrete on days 14, 28, and 90 days. For details of the test results of each 2 sample can be seen in Table 4 below.

Table 4
Compressive Strength Test Results of Concrete Formulation Cs 4%

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Laboratorium Penguji
LP-1216-IDN

HASIL UJI KUAT TEKAN BETON SILINDER
(SNI 1974:2011)

Pemohon	: Vian Marantha - BRIN	No. Laporan	: WIKA/LAB.031.A.BT/11/2022
Proyek	: PENELITIAN EFEK PENAMBAHAN MATERIAL CS & DS	Tanggal	: 08 November 2022
Kontraktor	: PT WIJAYA KARYA (Persero) Tbk	*Mutu Beton*	*: F 25 Mpa*
Suhu Ruangan :	27,4 °C	Kelembaban :	54 %

No.	No Urut Benda Uji	Tanggal		Umur	Kode	Slump	Tinggi H	Diameter D	Luas Penampang (A)	Berat (G)	Berat Isi	Beban (P)	Tegangan Benda Uji		Remarks
		Pembuatan	Pengujian	(hari)		(cm)	(cm)	(cm)	(cm²)	(gr)	(gr/cm³)	kN	Ø (kg/cm²)	Ø Mpa	
1	1.CS	9-Sep-22	16-Sep-22	7	KOMPOSISI + CS 2 %	-	30	15	176,625	11607	2,191	176,1	101,62	9,97	
2	1.CS	9-Sep-22	16-Sep-22	7		-	30	15	176,625	11728	2,213	231,8	133,76	13,13	
3	1.CS	9-Sep-22	16-Sep-22	7	SEMEN : 366 KG	-	30	15	176,625	11746	2,217	175,7	101,39	9,95	112,25
4	1.CS	9-Sep-22	23-Sep-22	14	PASIR : 686 KG		30	15	176,625	11604	2,190	205,5	118,58	11,64	
5	1.CS	9-Sep-22	23-Sep-22	14	SPLIT : 1050 KG		30	15	176,625	11700	2,208	243,6	140,57	13,79	
6	1.CS	9-Sep-22	23-Sep-22	14	AIR : 205 LT		30	15	176,625	11764	2,220	267,0	154,07	15,12	137,74
7	1.CS	9-Sep-22	6-Oct-22	28	SL RA : 10±2 CM		30	15	176,625	11824	2,231	306,2	176,69	17,34	
8	1.CS	9-Sep-22	6-Oct-22	28	SL RI : 12 CM		30	15	176,625	11730	2,214	284,0	163,88	16,08	
9	1.CS	9-Sep-22	6-Oct-22	28	CS FIL : 07 KG		30	15	176,625	11705	2,209	284,2	164,00	16,09	168,19
10	1.CS	9-Sep-22	2-Nov-22	54	CS PSR : 14 KG	-	30	15	176,625	11437	2,158	229,0	132,14	12,97	
11	1.CS	9-Sep-22	2-Nov-22	54		-	30	15	176,625	11601	2,189	229,9	132,66	13,02	
12	1.CS	9-Sep-22	2-Nov-22	54		-	30	15	176,625	11640	2,197	257,8	148,76	14,60	137,86
13	1.CS	9-Sep-22	7-Nov-22	90		-	30	15	176,625	11762	2,220	323,4	186,62	18,31	
14	1.CS	9-Sep-22	7-Nov-22	90		-	30	15	176,625	11768	2,221	359,4	207,39	20,35	
15	1.CS	9-Sep-22	7-Nov-22	90		-	30	15	176,625	11460	2,163	249,9	144,20	14,15	179,40

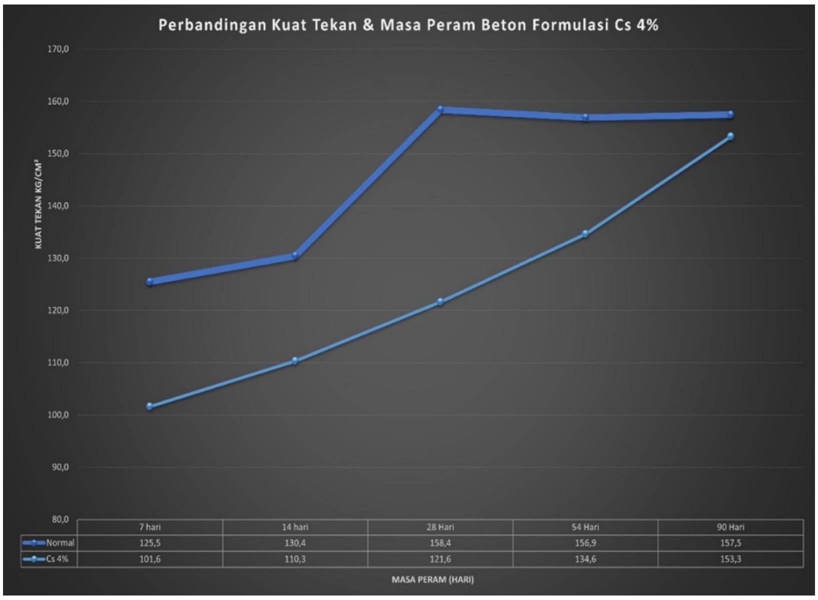
Source: Wika Beton Test Results (2023)

The next calculation after the formulation is determined is to calculate the costs incurred, for characteristic K, this term is no longer used in the world of concrete mix design. Currently, the term Fc' has been used following SNI. A significant difference lies in the type of concrete test specimen used. If previously the term K 300 was used to refer to PBI 1971, now the term fc' = 25 MPa is used following SNI 2847-2013. This quality concrete is usually used in construction projects for the manufacture of two-story buildings and is one type of ready-mix concrete that is often used. Table 4.8 is the cost of concrete forming following AHSP PU obtained as a result of a substitution of fine aggregate substitute material for the 2% Cs formulation has a concrete forming price of Rp 1,123,728, -.

G. Concrete Formulation + Cs 4%

The manufacture of concrete with the addition of 4% carbon sulfur has the following material composition: (a) Cement: 366 kg**.** (b) Sand: 671 kg**.** (c) Split: 1049 Kg**.** (d) Water: 205 liters**.** (e) Cs as filler: 15 kg**.** (f) Cs fine aggregate substitution: 28 kg. From the composition of the concrete mix design with the addition of 4% Cs, a curing process of up to 90 days is carried out, and compressive strength results are obtained as in Figure 5 below.

Figure 5
Comparison of compressive strength of normal concrete with 4% Cs composition



Based on Figure 5, the compressive strength graph using a 4% Cs composition seems to continue to increase according to the length of the boiling period, but it is still far from the normal concrete compressive strength required even though there is waste absorbed. This shows that the more Cs waste added, the resulting compressive strength results will decrease compared to the 2% Cs composition.

Table 5 shows details of all compressive strength test results performed up to 90 days. This composition uses quite a lot of waste material for m3 units of concrete, but the compressive strength is never above the compressive strength of normal concrete.

Table 5
Test Results of Compressive Strength of Concrete Formulation Cs 4%

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Komite Akreditasi Nasional
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LP-1216-IDN

HASIL UJI KUAT TEKAN BETON SILINDER
(SNI 1974:2011)

Pemohon	: Vian Marantha - BRIN	No. Laporan	: WIKA/LAB.031.A.BT/11/2022
Proyek	: PENELITIAN EFEK PENAMBAHAN MATERIAL CS & DS	Tanggal	: 10 November 2022
Kontraktor	: PT WIJAYA KARYA (Persero) Tbk	*Mutu Beton*	*: F 25 Mpa*
Suhu Ruangan :	27,4 °C	Kelembaban :	54 %

No.	No Urut Benda Uji	Tanggal		Umur	Kode	Slump	Tinggi H	Diameter D	Luas Penampang (A)	Berat (G)	Berat Isi	Beban (P)	Tegangan Benda Uji Ø	Tegangan Benda Uji Ø	Remarks
		Pembuatan	Pengujian	(hari)		(cm)	(cm)	(cm)	(cm^2)	(gr)	(gr/cm^3)	kN	(kg/cm^2)	Mpa	
1	2.CS	11-Sep-22	18-Sep-22	7	KOMPOSISI + CS 4%	-	30	15	176,625	11747	2,217	180,1	103,93	10,20	
2	2.CS	11-Sep-22	18-Sep-22	7		-	30	15	176,625	11742	2,216	169,9	98,04	9,62	
3	2.CS	11-Sep-22	18-Sep-22	7	SEMEN : 366 KG	-	30	15	176,625	11587	2,187	178,2	102,83	10,09	101,60
4	2.CS	11-Sep-22	25-Sep-22	14	PASIR : 671 KG	-	30	15	176,625	11678	2,204	185,7	107,16	10,52	
5	2.CS	11-Sep-22	25-Sep-22	14	SPLIT : 1049 KG	-	30	15	176,625	11802	2,227	182,8	105,48	10,35	
6	2.CS	11-Sep-22	25-Sep-22	14	AIR : 205 LT	-	30	15	176,625	11705	2,209	205,0	118,29	11,61	110,31
7	2.CS	11-Sep-22	8-Oct-22	28	SL RA : 10±2 CM	-	30	15	176,625	11677	2,204	217,6	125,56	12,32	
8	2.CS	11-Sep-22	8-Oct-22	28	SL RI : 11 CM	-	30	15	176,625	11603	2,190	206,3	119,04	11,68	
9	2.CS	11-Sep-22	8-Oct-22	28	CS FIL : 15 KG	-	30	15	176,625	11535	2,177	208,4	120,26	11,80	121,62
10	2.CS	11-Sep-22	4-Nov-22	54	CS PSR : 28 KG	-	30	15	176,625	11524	2,175	223,6	129,03	12,66	
11	2.CS	11-Sep-22	4-Nov-22	54		-	30	15	176,625	11567	2,183	239,4	138,14	13,56	
12	2.CS	11-Sep-22	4-Nov-22	54		-	30	15	176,625	11513	2,173	236,9	136,70	13,42	134,62
13	2.CS	11-Sep-22	9-Dec-22	90		-	30	15	176,625	11599	2,189	304,5	175,71	17,24	
14	2.CS	11-Sep-22	9-Dec-22	90		-	30	15	176,625	11448	2,161	230,0	132,72	13,02	
15	2.CS	11-Sep-22	9-Dec-22	90		-	30	15	176,625	11472	2,165	262,3	151,36	14,85	153,26

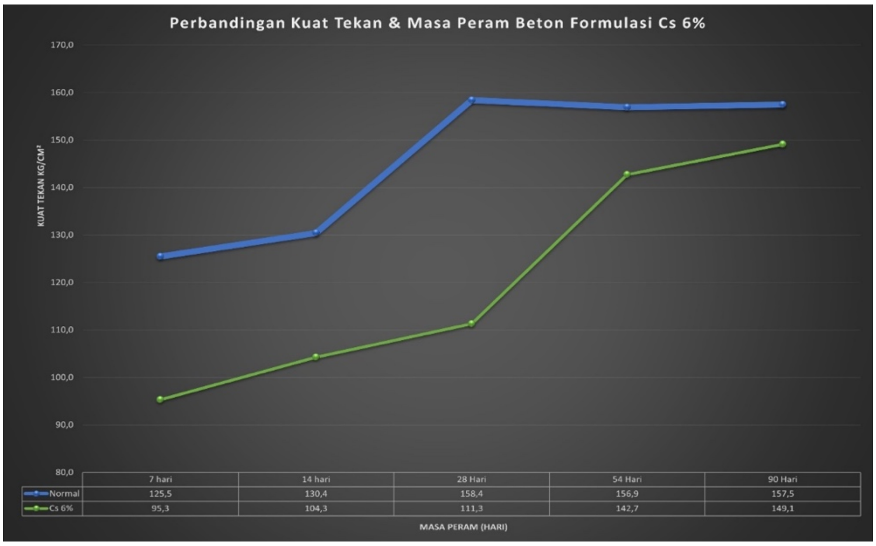
Source: Wika Beton Test Results 2023

Table 5 Cost of Concrete Forming with 4% Cs Composition consists of several variables that have been determined following AHSP guidelines from the Ministry of Public Works, namely (1) Power which includes masons, head builders, handymen, and supervisors, this item as a constant in the calculation because it is fixed for all formulations that have been determined. (2) Materials which include Portland cement, sand, split, and water, this item changes their coefficient depending on the test results of normal aggregate and cornered aggregate. This coefficient changes based on the specific gravity calculated when the mixture is mixed with Cs. In this case, the coefficient for coarse aggregate is 0.766 and for fine aggregate is 0.355. (3) Equipment that includes the price of the equipment used or the rental of the equipment used for the formation of the beton.

H. Concrete Formulation + Cs 6%

Making concrete with the addition of 6% carbon sulfur has the following material composition; (a) Cement: 366 kg. (b) Sand: 656 kg. (c) Split:1047 Kg. (d) Water: 205 liters. (e) Cs as filler: 22 kg. (f) Cs fine aggregate substitution: 42 kg. From the composition of the concrete mix design with the addition of 6% Cs, a curing process of up to 90 days is carried out, and compressive strength results are obtained as in Figure 6 below.

Figure 6
Comparison of compressive strength of normal concrete with 6% Cs composition



In Figure 6, the 6% Cs composition also gets results that are not much different from the 4% composition. With a trend of compressive strength that continues to increase but cannot match or exceed the compressive strength of normal concrete as the compressive strength control. It can be concluded that the addition of carbon-sulfur of more than 2% does not make the compressive strength of the resulting concrete much better. Table 4.10 shows compressive strength details with a 6% Cs formulation with a shelf life of up to 90 days. At 90 days old, the composition of this formula reaches a compressive strength of 149.11 Kg/cm², there is a difference of 5.33% from normal concrete.

Table 6
Results of Formulation Concrete Compressive Strength Test Cs 6%

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HASIL UJI KUAT TEKAN BETON SILINDER
(SNI 1974:2011)

Pemohon : Vian Marantha - BRIN
Proyek : PENELITIAN EFEK PENAMBAHAN MATERIAL CS & DS
Kontraktor : PT WIJAYA KARYA (Persero) Tbk
Suhu Ruangan : 27,4 °C Kelembaban : 54 %

No. Laporan : WIKA/LAB.031.A.BT/11/2022
Tanggal : 14 November 2022
Mutu Beton : *F 25 Mpa*

No.	No Urut Benda Uji	Tanggal		Umur	Kode	Slump	Tinggi H	Diameter D	Luas Penampang (A)	Berat (G)	Berat Isi	Beban (P)	Tegangan Benda Uji		Remarks
		Pembuatan	Pengujian	(hari)		(cm)	(cm)	(cm)	(cm²)	(gr)	(gr/cm³)	kN	Ø (kg/cm²)	Ø Mpa	
1	3.CS	15-Sep-22	22-Sep-22	7	KOMPOSISI + CS 6%	-	30	15	176,625	11765	2,220	183,5	105,89	10,39	
2	3.CS	15-Sep-22	22-Sep-22	7		-	30	15	176,625	11720	2,212	158,0	91,17	8,95	
3	3.CS	15-Sep-22	22-Sep-22	7	SEMEN : 366 KG	-	30	15	176,625	11590	2,187	154,1	88,92	8,73	95,33
4	3.CS	15-Sep-22	29-Sep-22	14	PASIR : 656 KG	-	30	15	176,625	11627	2,194	176,2	101,67	9,98	
5	3.CS	15-Sep-22	29-Sep-22	14	SPLIT : 1047 KG	-	30	15	176,625	11835	2,234	184,2	106,29	10,43	
6	3.CS	15-Sep-22	29-Sep-22	14	AIR : 205 LT	-	30	15	176,625	11783	2,224	181,7	104,85	10,29	104,27
7	3.CS	15-Sep-22	12-Oct-22	28	SL RA : 10±2 CM		30	15	176,625	11775	2,222	181,7	104,85	10,29	
8	3.CS	15-Sep-22	12-Oct-22	28	SL RI : 12 CM		30	15	176,625	11815	2,230	221,9	128,05	12,57	
9	3.CS	15-Sep-22	12-Oct-22	28	CS FIL : 22 KG	-	30	15	176,625	11785	2,224	175,1	101,04	9,92	111,31
10	3.CS	15-Sep-22	8-Nov-22	54	CS PSR : 42 KG		30	15	176,625	11680	2,204	228,4	131,80	12,93	
11	3.CS	15-Sep-22	8-Nov-22	54			30	15	176,625	11771	2,221	242,7	140,05	13,74	
12	3.CS	15-Sep-22	8-Nov-22	54		-	30	15	176,625	11741	2,216	270,8	156,26	15,33	142,70
13	3.CS	15-Sep-22	13-Dec-22	90			30	15	176,625	11671	2,203	261,3	150,78	14,80	
14	3.CS	15-Sep-22	13-Dec-22	90			30	15	176,625	11605	2,190	274,3	158,28	15,53	
15	3.CS	15-Sep-22	13-Dec-22	90			30	15	176,625	11579	2,185	239,6	138,26	13,57	149,11

Source: Wika Beton Test Results (2023)

Table 6 Cost of Concrete Forming with 6% Cs Composition consists of several variables that have been determined by AHSP guidelines from the Ministry of Public Works, namely (1) Power which includes masons, head builders, handymen, and supervisors, with coefficients of each head handyman (0.028), masonry (0.275), worker (1.650), and supervisor (0.083) this item as a constant in the calculation because it is fixed for all predetermined formulations. (2) Materials which include Portland cement, sand, split, and water, this item changes their coefficient depending on the test results of normal aggregate and cornered aggregate. This coefficient changes based on the specific gravity calculated when the mixture is mixed with Cs. In this case, the coefficient for coarse aggregate is 0.764 and for fine aggregate is 0.347. (3) Equipment which includes the price of tools used or rental of tools used for concrete forming.

I. Concrete Formulation + Ds 2%

Making concrete with the addition of 2% dirty sulfur has the following material composition: (a) Cement: 366 kg. (b) Sand: 693 kg. (c) Split: 1050 Kg. (d) Water: 205 liters. (e) Cs as filler: 7 kg. (f) Cs fine aggregate substitution: 7 kg. From the composition of the concrete mix design with the addition of 2% Ds, a curing process of up to 90 days is carried out, and compressive strength results are obtained as in Figure 7 below.

Figure 7
Comparison of compressive strength of normal concrete with 2% ds composition

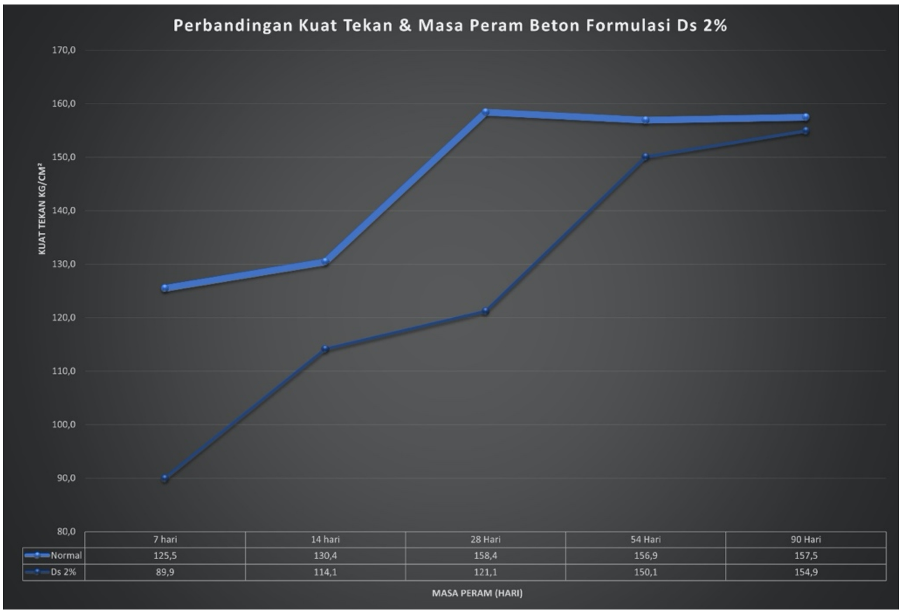

Figure 7 shows that the compressive strength trend in the 2% Ds formulation increases according to the length of the 7-day to 90-day press period, but the compressive strength yield never exceeds the required concrete compressive strength. At 90 days, the compressive strength of the 2% Ds formulation is almost close to the compressive strength of normal concrete of 154.9 Kg/cm2.

Compressive strength at the age of 7 days has a difference of up to 28.36% lower while at the age of 28 to 90 days it is almost close to normal concrete figures. At the age of 90 days, the difference in compressive strength is 1.7%. Table 7 shows detailed variations in concrete compressive strength test numbers that vary with increasing trends but never exceed the required normal compressive strength of concrete.

Table 7
Compressive Strength Test Results of Ds 2% Formulation Concrete

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(SNI 1974:2011)

Pemohon	: Vian Marantha - BRIN	No. Laporan	: WIKA/LAB.031.A.BT/11/2022
Proyek	: PENELITIAN EFEK PENAMBAHAN MATERIAL CS & DS	Tanggal	: 16 November 2022
Kontraktor	: PT WIJAYA KARYA (Persero) Tbk	*Mutu Beton*	*: F 25 Mpa*
Suhu Ruangan :	27,4 °C	Kelembaban :	54 %

No.	No Urut Benda Uji	Tanggal		Umur	Kode	Slump	Tinggi H	Diameter D	Luas Penampang (A)	Berat (G)	Berat Isi	Beban (P)	Tegangan Benda Uji		Remarks
		Pembuatan	Pengujian	(hari)		(cm)	(cm)	(cm)	(cm²)	(gr)	(gr/cm³)	kN	Ø (kg/cm²)	Ø Mpa	
1	4.DS	17-Sep-22	24-Sep-22	7	KOMPOSISI + DS 2 %	-	30	15	176,625	11780	2,223	143,9	83,04	8,15	
2	4.DS	17-Sep-22	24-Sep-22	7		-	30	15	176,625	11800	2,227	147,8	85,29	8,37	
3	4.DS	17-Sep-22	24-Sep-22	7	SEMEN : 366 KG	-	30	15	176,625	11795	2,226	175,5	101,27	9,94	89,86
4	4.DS	17-Sep-22	9/31/2022	14	PASIR : 693 KG		30	15	176,625	11763	2,220	238,5	137,62	13,51	
5	4.DS	17-Sep-22	9/31/2022	14	SPLIT : 1050 KG		30	15	176,625	11636	2,196	187,5	108,20	10,62	
6	4.DS	17-Sep-22	9/31/2022	14	AIR : 205 LT		30	15	176,625	11497	2,170	167,1	96,42	9,46	114,08
7	4.DS	17-Sep-22	14-Sep-22	28	SL RA : 10±2 CM		30	15	176,625	11777	2,223	210,3	121,35	11,91	
8	4.DS	17-Sep-22	14-Oct-22	28	SL RI : 13 CM		30	15	176,625	11598	2,189	212,4	122,56	12,03	
9	4.DS	17-Sep-22	14-Oct-22	28	DS FIL : 07 KG		30	15	176,625	11634	2,196	207,1	119,51	11,73	121,14
10	4.DS	17-Sep-22	10-Nov-22	54	DS PSR : 07 KG	-	30	15	176,625	11636	2,196	248,6	143,45	14,08	
11	4.DS	17-Sep-22	10-Nov-22	54			30	15	176,625	11670	2,202	286,8	165,50	16,24	
12	4.DS	17-Sep-22	10-Nov-22	54		-	30	15	176,625	11516	2,173	244,7	141,20	13,86	150,05
13	4.DS	17-Sep-22	15-Nov-22	90			30	15	176,625	11549	2,180	264,7	152,74	14,99	
14	4.DS	17-Sep-22	15-Nov-22	90			30	15	176,625	11514	2,173	264,3	152,51	14,97	
15	4.DS	17-Sep-22	15-Nov-22	90			30	15	176,625	11621	2,193	276,3	159,44	15,65	154,90

Table 7 Cost of Concrete Forming with 2% Ds Composition consists of several variables that have been determined following AHSP guidelines from the Ministry of Public Works, namely (a) Power which includes masons, head builders, handymen, and supervisors, with coefficients of each being head masonry (0.028), masons (0.275), workers (1.650), and supervisors (0.083) this item as a constant in the calculation because it is fixed for all formulations that have been determined. (b) Materials including Portland cement, sand, split, and water, these items change their coefficients depending on the test results of normal aggregates and cornered aggregates. This coefficient changes based on the specific gravity calculated when the mixture is mixed with Cs. In this case, the coefficient for coarse aggregate is 0.766 and for fine aggregate is 0.357. (c) Equipment which includes the price of tools used or rental of tools used for concrete forming.

CONCLUSION

The conclusions that can be drawn from the discussion for carbon-sulfur and dirty sulfur solid waste research are as follows: Carbon sulfur &; dirty sulfur from the results of laboratory test determination shows that the toxicity characteristics leaching procedure (TCLP) value and total concentration (TK) have not exceeded the Category B threshold according to PP22 of 2021.

Based on TGA analysis, the incandescent loss value for carbon-sulfur and dirty sulfur waste is less than 10% if the calculation is carried out after the sulfur evaporation stage from the waste matrix. Thus, carbon-sulfur and dirty sulfur waste have the potential to be utilized and used to increase the compressive strength of concrete.

BIBLIOGRAPHY

Agustian, Aldy, & Ilham, Dimas Muhammad. (2021). *Pengaruh Penambahan Kawat Bendrat Galvanis Pada Campuran Beton Terhadap Kuat Tekan Beton*. Politeknik Negeri Sriwijaya.

Hidup, Peraturan Menteri Lingkungan, & Nomor, Kehutanan. (6ad). Tahun 2021 Tentang Tata Cara Dan Persyaratan Pengelolaan Limbah Bahan Berbahaya Dan Beracun. *Jakarta (Id): Sekretariat Negara*.

Indonesia, A. Sumber Daya Alam. (N.D.). Upaya Pemanfaatan Serta Pengelolaan Kawasan Pantai Maupun Pesisir Di Indonesia. *Kata Pengantar*, 204.

Juliardi Ar, Naniek Ratni. (2022). *Teknologi Pengelolaan Kesehatan Masyarakat*. Sasanti Institute.

Muhajir, Sayid Muhammad, & Yuamita, Ferida. (2023). Analisis Total Productive Maintenance Dengan Menggunakan Metode Overall Equipment Effectiveness Pada Mesin Mixing Batching Di Pt. Wijaya Karya Beton Tbk Boyolali. *Jurnal Inovasi Dan Kreativitas (Jika)*, *3*(1), 1–9.

Nevola, Riccardo, Russo, Antonio, Scuotto, Samuel, Imbriani, Simona, Aprea, Concetta, Abitabile, Marianna, Beccia, Domenico, Brin, Chiara, Carusone, Caterina, & Cinone, Francesca. (2022). Non-Invasive Respiratory Support In Sars-Cov-2 Related Acute Respiratory Distress Syndrome: When Is It Most Appropriate To Start Treatment? *Respiratory Research*, *23*(1), 327.

Ragaert, Kim, Delva, Laurens, & Van Geem, Kevin. (2017). Mechanical And Chemical Recycling Of Solid Plastic Waste. *Waste Management*, *69*, 24–58.

Ramadhan, Muhamad, & Khuljanna, Tiara Novia. (2021). *Analisa Kuat Lentur Beton Memadat Sendiri Dengan Superplasticizer-Concrete Admixture Type F*. Politeknik Negeri Sriwijaya.

Timur, Perkebunan Kabupaten Luwu. (N.D.). *Pelaksanaan Program Corporate Social Responsibility (Csr) Pt. Vale Indonesia Tbk Pada Sektor Pertanian Dan*.

Anggraeni, N. (2020). Analisis Mutu Dan Biaya Beton Berpori Menggunakan Limbah Botol Plastik Pet Untuk Trotoar. Universitas Islam Negeri Sunan Ampel.

Annual Report Pt. Vale Indonesia. (2021). Annual Report Pt. Vale Indonesia Tahun 2021. Jakarta. Retrieved From Www.Vale.Com/Indonesia

Apriwelni, S., & Bintang Wirawan, N. (2020). Kuat Tekan Beton Mutu Tinggi Dengan Memanfaatkan Fly Ash Dan Bubuk Kaca Sebagai Bahan Pengisi High Quality Concrete Compressive Strength By Using Fly Ash And Glass Powder As Filler. Jurnal Saintis, Volume 20, 61–68. Doi: 10.25299/Saintis2020.Vol20(01).4846

Astm. (2003). Astm C 702 - 98 2003 Standard Practice For Reducing Samples Of Aggregate To Testing Size.

Bsn, B. S. N. (2000a). Sni 03 - 2834 - 2000 Tata Cara Pembuatan Rencana Campuran Beton Normal.

Bsn, B. S. N. (2000b). Sni 03 - 6468 - 2000 Tata Cara Perencanaan Campuran Tinggi Dengan Semen Portland Dengan Abu Terbang.

Bsn, B. S. N. (2002). Sni 03 - 2847 - 2002 Tata Cara Perhitungan Struktur Beton Untuk Bangunan Gedung.

Bsn, B. S. N. (2004a). Sni 15 - 2049 - 2004 Semen Portland. Ics 91.100.10.

Bsn, B. S. N. (2004b). Sni 15 - 7064 - 2004 Semen Portland Komposit.

Chandra, D. (2021). Analisa Pengaruh Aktivator Kalium Dan Kondisi Material Pada Beton Geopolymer Dari Limbah B3 Fly Ash Batubara Terhadap Kuat Tekan. Jurnal Rekayasa, 11(01), 1–16.