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Use of Fly Ash PLTU Holtekamp Jayapura in The Manufacture of Self Compacting Concrete (SCC)

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ABSTRACT

Self-Compacting Concrete (SCC) is a concrete that is able to compact itself with a fairly high slump. In the process of placing in the formwork volume (placing) and its compaction process (compaction), SCC does not require a vibration process like normal concrete. Self-Compacting Concrete must use additional materials compared to normal concrete. The use of fly ash as a concrete forming material is based on the properties of this material which are similar to the properties of cement. The similarity of these properties makes fly ash a substitute material to reduce the amount of cement as a concrete constituent material. The purpose of this study was to obtain workability behavior using Self-Compacting Concrete (SCC) with the addition of fly ash and the compressive strength value of SCC concrete at the ages of 3, 21, and 28 days. Based on the research conducted, the compressive strength values of concrete at 0%, 20%, 25%, 30% and 35% at the age of 3 days were 28.8 MPa, 29.5 MPa, 16.0 MPa, 25.3 MPa, 16.0 MPa. At the age of 21 days, 41.8 MPa, 33.0 MPa, 19.3 MPa, 33.9 MPa, and 16.4 MPa. At the age of 28 days, 35.9 MPa, 44.5 MPa, 33.5 MPa 28.8 MPa, and 26.6 MPa where the maximum load with 5 variations of fly ash occurred at a variation of 20% fly ash with a curing age of 28 days of 44.5 MPa.

1. INTRODUCTION

Concrete is a material consisting of a mixture of cement, coarse aggregate, fine aggregate, water and additives (admixture) when needed. Generally, the concrete that is widely used in the construction process is normal concrete. In addition to the relatively easy manufacturing process because it does not require additional materials (admixture), normal concrete is also considered more economical. However, it is not uncommon in the normal concrete casting process to often experience obstacles due to the distance between the reinforcements that are too tight. As a result, there is a separation between fine aggregates, cement, and water with coarse aggregates (segregation). Therefore, in the process, normal concrete continues to undergo changes that are adjusted to existing construction needs. One of them is the development of Self Compacting Concrete (SCC) type of concrete.

Self-Compacting Concrete (SCC) is concrete that is able to self-compact with a fairly high slump. In the process of placing the formwork volume (placing) and the compaction process, SCC does not require a vibration process like in normal concrete. SCC has high flowability so that it is able to flow, meet formwork, and achieve its own highest density (EFNARC 2005).

In Indonesia, the development of Self Compacting Concrete has not been like in Japan. In Indonesia, there is still a limit to the mix design method that will be on the concrete. Unlike normal concrete, Self Compacting Concrete must require additional materials compared to normal concrete (Okamura and Ouchi, 2003).

The use of fly ash material as a concrete forming material is based on the properties of this material which has similarities with the properties of cement. The similarity of these traits can be reviewed from two main traits, namely physical and

chemical. Physically, fly ash material is similar to cement in terms of the fineness of its grains. According to ACI Committee 226, fly ash has a fairly fine grain, which passes the sieve No. 325 (45 millimicrons) 5-27% with a specific gravity between 2.15-2.6 and is blackish-gray in color. The chemical properties possessed by fly ash are silica and alumina with a percentage of 80%. The similarity of these properties makes fly ash a substitute material to reduce the amount of cement as a constituent material for concrete.

The use of fly ash as a concrete forming material has a positive impact when viewed from an environmental perspective. Fly Ash is a very fine coal burning residue. The fineness of these fly ash granules has the potential to affect air pollution. In addition, the handling of fly ash is currently still limited to stockpiling on vacant land. For this reason, we conducted a study on "Characteristics of Self Compacting Concrete (SCC) that uses fly ash as a substitute for cement".

2. LITERATURE REVIEW

2.1. Theoretical Foundations

Self-Compacting Concrete or commonly abbreviated as SCC is fresh concrete that is very plastic and flows easily because its own weight fills the entire mold because the concrete has the properties to self-compact without the help of a vibrator for compaction. According to (Tjaronge et.al 2006 and Hartono, et.al 2007) good SCC concrete must remain homogeneous, cohesive, without segregation, blocking, and bleeding. Self-Compacting Concrete is a concrete that when it is still in the form of fresh concrete it is able to flow through the reinforcement and fill the entire space in the mold solidly without the help of manual compaction or mechanical vibration

2.2 SCC (Self Compacting Concrete) Concrete Preparation Material

2.2.1 Aggregate

Aggregate is a single material that is used together with a binding medium to form concrete with an amount of around 75% of the volume of concrete. Based on the grain size, Aggregate is divided into 2 types, namely fine aggregate and coarse aggregate.

a. Fine Aggregate

Fine aggregate is natural sand as a result of natural desynthesis of rocks or sand produced by rock breakers and has a grain size smaller than 3/16 inch or 5 mm (passed sieve no. 4).

b. Coarse Aggregate

Coarse aggregate is gravel as a result of natural desintegration of rocks or gravel produced by rock breakers and has a grain size smaller than 5 - 40 mm (held in sieve no. 4).

2.2.2 Cement

Cement is an adhesive material that has the property of being able to bind solid materials into a compact and strong whole. Cement itself can be divided into two types, namely non-hydraulic cement and hydraulic cement.

Non-hydraulic cement is cement that cannot harden with water, but needs air to be able to harden, the main example of a type of non-hydraulic cement is lime. As for hydraulic cement has the ability to bind and harden in water, hydraulic cement includes, but is not limited to, the following materials: Hydraulic lime, patio cement, slag cement, natural cement, Portland cement.

2.2.3 Water

Water is a very important basic material in the manufacture of concrete. Water is needed to react with cement and become a lubricant between the aggregate grains so that it is easy to compact. In its use, water should not be too much because it will cause a decrease in the strength of perforated concrete bricks.

2.3.3 Fly Ash

Currently, the use of coal among coal-fired power plants (Steam Power Plants), especially in Holtekamp coal-fired power plants, is increasing in volume, because the price is relatively cheap compared to the price of fuel oil for industry. The use of coal as an energy source to replace fuel, on the one hand, is very profitable, but on the other hand it can cause problems. The main problem of the use of coal is coal ash which is a by-product of coal combustion. A certain amount of coal use will produce coal ash of around 2-10%. At this time, the management of coal ash waste is only limited to stockpiling in the Holtekamp PLTU area.

2.4. Material Characteristics

Material characteristics are the ability and behavior of a material or material when receiving a certain loading pattern. This is done to find out the properties and characteristics of the material whether it meets the requirements or not. In addition, the results of this test will be used as data for the design of concrete mixtures (Mix Design).

2.4.1 Aggregate Water Content

Aggregate moisture content testing can be calculated using the formula:

$$\text{Moisture content} = (C-E)/E \times 100\% \quad (1)$$

Where:
C = Weight of the test piece (gr)
E = Oven dry specimen weight (gr)

2.4.2. Aggregate Sludge Content

Testing of aggregate sludge content can be calculated using the formula:

$$\text{Sludge Level} = C/A \times 100\% \quad (2)$$

Where:
A = Weight of the test piece
C = Weight of the test piece – the weight of the dry test piece of the oven (gr)

2.4.3. Volume Weight

The aggregate volume weight is used to determine the proportion of aggregate used in the mixture. It can also be interpreted as a comparison between the weight of dry material and its volume.

The volume of the bohler can be calculated using the formula:

$$(V) = 1/4 \, .\pi \, . \, D^2 \, . \, T. \quad (3)$$

Where:
π = 3,14
d = Bohler diameter
t = Bohler height

2.4.4. Sieve Analysis

The weight of the soil held in each sieve is calculated and the cumulative percentage of the weight of the soil that passes through each sieve is calculated in weight.

Sieve analysis can be calculated using the following formulas:

$$\% \text{ Retained per sieve} = \frac{D}{A} \times 100\%$$

$$\% \text{ Cumulative pass} = \frac{C-B}{A} \times 100\%$$

$$\text{Modulus of Fineness (Fr)} = \frac{100\% - \text{Komulatif Tertahan}}{100\%}$$

Where:

A = Weight of the test piece (gr)
B = Weight of the Sieve in empty condition (gr)
C = Weight of the filter and its contents (gr)
D = Weight of the test specimen held on each sieve (gr)

2.4.5. Specific Gravity and Absorption

Specific Gravity Aggregate is the comparison between the weight of aggregate volume and volume of water. While Absorption is the percentage of water weight that can be absorbed by pores so that the SSD condition is achieved. The aggregate specific gravity is divided into three, namely:

1. Dry specific gravity is the comparison between the weight of dry aggregate and the weight of distilled water whose content is the same as the content of aggregate in a saturated state at a certain temperature.
2. The specific gravity of saturated surface dry aggregate (SSD) is the comparison between the weight of saturated surface dry aggregate and the weight of distilled water whose content is the same as the aggregate content in a dry state at a certain temperature.
3. Apparent specific gravity is the comparison between the weight of dry aggregate and the weight of distilled water whose content is the same as the content of aggregate in a dry state at a certain temperature.

3. RESEARCH METHODOLOGY

3.1 Location and time of research

The research was carried out at the Civil Engineering Laboratory of Yapis Papua University which is located on Jl. Dr.Samratulangi No.11 Dock V on Jayapura City, Papua Province. This research is planned to be carried out for 3 months, from March 2021 to May 2021, starting from aggregate testing to concrete compressive strength testing and followed by the preparation of the final report.

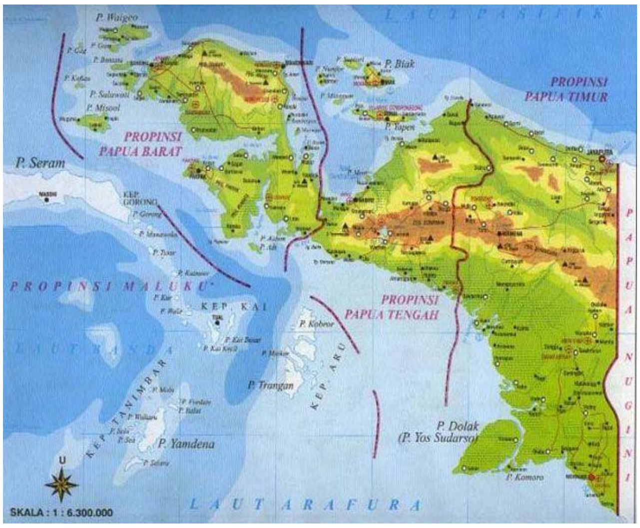

Figure 1. Concrete Testing Sites
Source : Google Map 2024)

3.2 Research Flow Diagram

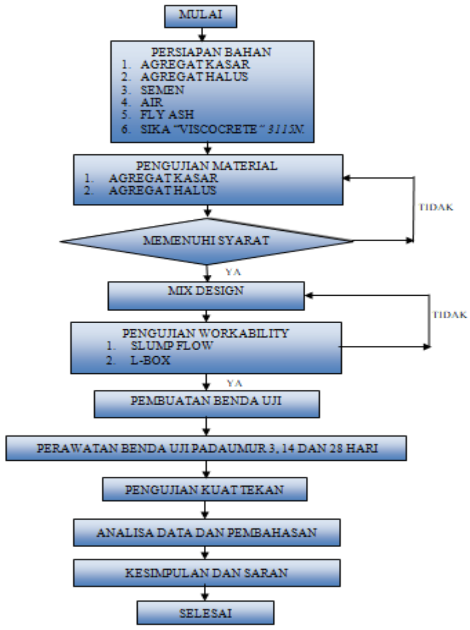

Figure 2. Research Flow Diagram.

4. MATERIAL CHARACTERISTICS

4.1 Material Characteristics Testing

The materials used in this study consist of natural aggregates, namely fine aggregates (sand) and coarse aggregates (broken stone) from the village of Harapan Sentani. Based on the implementation of aggregate examinations at the Civil Engineering Laboratory of Yapis Papua University, the results of the examination of material characteristics were obtained

4.1.1 Fine Aggregate (Sand) Characteristic Examination

Table 1. Results of Fine Aggregate (Sand) Characteristic Inspection

No.	Aggregate Characteristics	Interval	Result Examination	Information
1	Modulus of Fineness	2,3 – 3,1	2,990	Meet
2	Weight Volume : a. Dense b. Loose	- -	1,862 1,743	- -
3	Moisture Content	-	0,25 %	-
4	Sludge Content	5 %	0,16 %	Meet
5	Specific Gravity and Absorption : a. Real BJ b. BJ Dry Base c. BJ Surface Dry d. Water Absorption	1,6 – 3,3 1,6 – 3,3 1,6 – 3,3 0,2% – 2%	2,830 2,691 2,740 1,833%	Meet Meet Meet Meet

Source : (Engineering Laboratory Test Results Civil of Yapis University of Papua 2024)

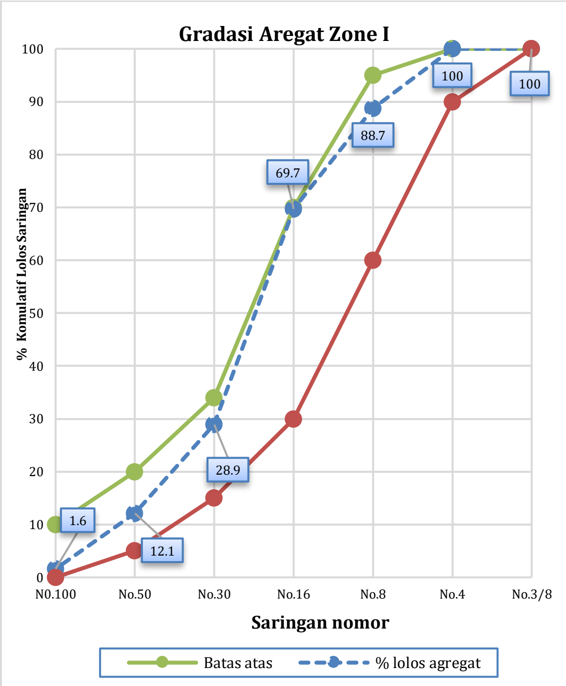

Figure 3. Fine Aggregate Gradation Chart

The Fine Aggregate (Sand) gradation graph in the figure above shows that the Fine Aggregate (Sand) used is sand with a zone I gradation with a fine modulus of aggregate grains of 2.990.

4.1.2 Examination of Characteristics of Coarse Aggregate (Broken Stone)

Table 2. Results of Examination of Characteristics of Coarse Aggregate (Pebbles)

No.	Aggregate Characteristics	Interval	Result Examination	Information
1	Modulus of Fineness	6,0 – 7,1	6,926	Meet
2	Weight Volume : a. Dense b. Loose	- -	1,389 1,404	- -
3	Moisture Content	-	1,382 %	-
4	Sludge Content	1 %	1.0 %	Meet
5	Specific Gravity and Absorption : a. Real BJ b. BJ Dry Base c. BJ Surface Dry d. Water Absorption	1,6 – 3,3 1,6 – 3,3 1,6 – 3,3 0,2% – 4%	2,859 2,705 2,759 1,989	Meet Meet Meet Meet

Source: (Engineering Laboratory Test Results Civil of Yapis University of Papua 2024)

The results of the coarse aggregate sieve analysis were then plotted on the graph of the incoming gradation limit on the aggregate gradation of a maximum size of 20 mm.

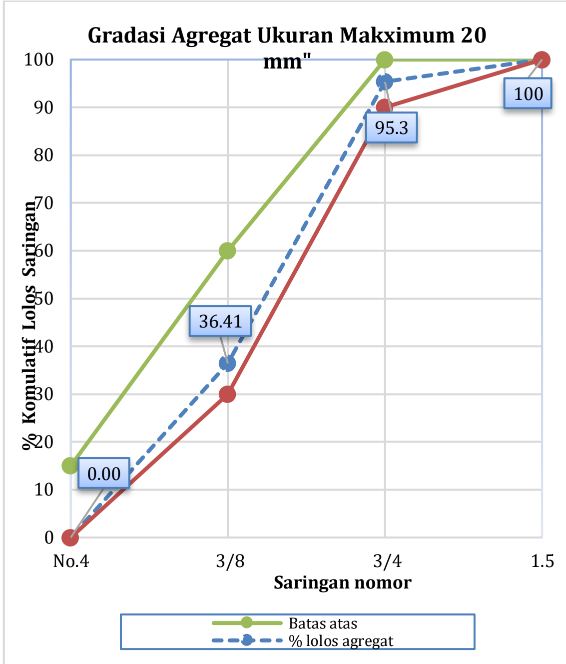

Figure 4. Coarse Aggregate Gradation Chart

4.1.3 Addictive Materials (Superplasticizer)

The additive additive used in this study is Viscocrete 3115-N. Mixing Viscocrete 3115-N scythe is added to the measured water, where 1% of the weight of the cement is 0% fly ash (FA) variety concrete.

Figure 5. Viscocrete 3115-N from PT. Sika Indonesia

4.1.4 Fly Ash Test Results

Table 3. Fly Ash Test Results

No.	Parameters	Unit	Test Result of *Fly Ash Sample*
1	SiO2	%wt	12,9
2	Al2O3	%wt	8,94
3	Fe2O3	%wt	11,71
4	TiO2	%wt	0,66
5	CaO	%wt	27,07
6	MgO	%wt	6,56
7	Cr2O3	%wt	0,01
8	K2O	%wt	0,31
9	Na2O	%wt	0,99
10	SO3	%wt	2,45

Source: (ITS Geopolymer Research Consortium Indonesia 2018)

4.2 Mix Design Concrete

The design of the concrete mixture carried out in this study uses the D.O.E (Development Of Environment, Building Research Enstability, Britime) method. Planning by DOE is used as a planning standard by the Department of Public Works in Indonesia and is contained in the standard book No. SK. SNI T-15-1990-03 with the title of his book Procedures for Making Normal Concrete Manufacturing Designs. The required concrete compressive strength (concrete quality) is targeted Fc = 35 Mpa.

Table 4. Composition of Concrete Mix 3 Samples

Variations	0%	20%	25%	30%	35%	Unit
Cement	9.200	7.36	6.90	6.44	5.98	Kg
Fly Ash	0	1.84	2.30	2.76	3.22	Kg
Water	3.660	3.660	3.660	3.660	3.660	Ltr
Ag. Soft	8.350	8.350	8.350	8.350	8.350	Kg
Ag. Rough	20.490	20.490	20.490	20.490	20.490	Kg
Addictive 1%	0.092	0.092	0.092	0.092	0.092	Ltr

4.3 SCC Fresh Concrete Testing (Workability)

4.3.1 Slump Flow Test

Table 5. Slump Flow Test

Fly Ash (%)	D1 (cm)	D2 (cm)	Average (mm)	Condition (mm)	Ket
0	605	607	606	550-850	Yes
20	601	590	595.5	550-850	Yes
25	572	584	578	550-850	Yes
30	552	563	557.5	550-850	Yes
35	536	525	530.5	550-850	It

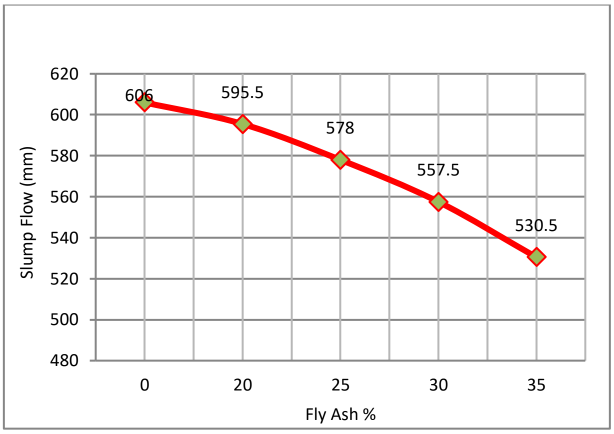

Figure 6. Slum Flow Graph

4.3.2 L-Box

This test is carried out for SCC concrete mixtures using the L-Box tool to determine the ability to pass certain rebar conditions (Passing Ability). The L-Box used uses plain iron with 3 reinforcements with a size of D12.

Table 6. L-Box Test Results

L-BOX Reinforcement 3 D12					
Fly Ash (%)	**H1 (cm)**	**H2 (cm)**	**Ration**	**Condition**	**Ket**
0	11.4	11.3	0.99	0.8 - 1.0	Yes
20	12.3	10.0	0.81	0.8 - 1.0	Yes
25	20.5	6.7	0.32	0.8 - 1.0	It
30	22.0	6.0	0.27	0.8 - 1.0	It
35	23.5	4.8	0.20	0.8 - 1.0	It

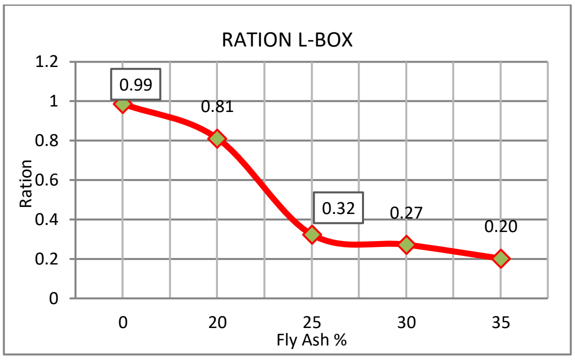

Figure 7. L-Box Ration Chart

4.4 Compressive Strength of Concrete

Perhitungan kuat tekan beton dengan variasi Fly Ash 0%

Gaya Tekan	3 Hari	=	507.9	KN	507900	N	
	21 Hari	=	738.6	KN	738600	N	
	28 Hari	=	634.8	KN	634800	N	
Luas Bidang		=	0.25	x	3.14	x	22500
		=	17662.50	mm²			
	3 Hari	=	Kuat Tekan / Luas Bidang				
		=	507900	:	17662.50		
		=	28.8	Mpa			
	21 Hari	=	Kuat Tekan / Luas Bidang				
		=	738600	:	17662.50		
		=	41.8	Mpa			
	28 Hari	=	Kuat Tekan / Luas Bidang				
		=	634800	:	17662.50		
		=	35.9	Mpa			

Table 7. Results of SCC concrete compressive strength test with fly ash variation.

Fly Ash	Age	Heavy	Broad	Burden	Compressive Strength
(%)	(Day)	(Kg)	(mm2)	(KN)	(Mpa)
0	3	12,741	17662.5	507.9	28.8
	21	12,771	17662.5	738.6	41.8
	28	12,721	17662.5	634.8	35.9
20	3	12,824	17662.5	521	29.5
	21	12,668	17662.5	583.7	33.0
	28	12,713	17662.5	785.3	44.5
25	3	12,813	17662.5	283.4	16.0
	21	12,948	17662.5	340.5	19.3
	28	12,816	17662.5	591.2	33.5
30	3	12,996	17662.5	447.5	25.3
	21	13,048	17662.5	598.7	25.3
	28	12,988	17662.5	508.4	33.9
35	3	12,884	17662.5	283.1	16.0
	21	12,95	17662.5	289.2	16.4
	28	12,879	17662.5	469.6	26.6

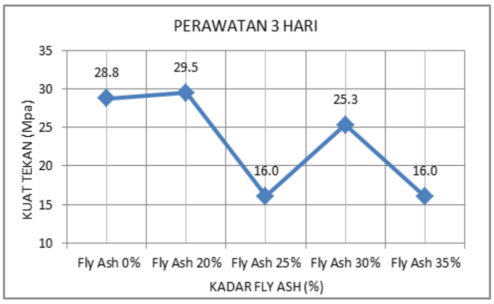

Figure 8. 3-day life care graph, concrete compressive strength relationship, various variations of fly ash.

From graph 8. We can see that the optimum compressive strength occurs at a 3-day maintenance age at a 20% fly ash variation of 29.5 Mpa.

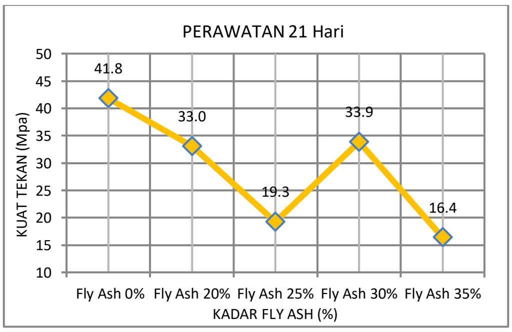

Figure 9. 21 days of age care for concrete pressure huat relationships various variations of fly ash.

From graph 9. We can see that the optimum compressive strength occurs at a 21-day treatment age at a 0% fly ash variation of 41.8 Mpa.

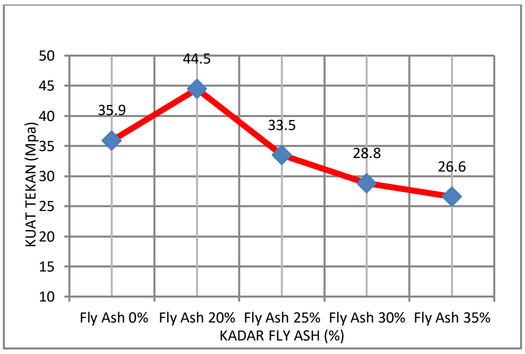

Figure 10. 28-day life-span care for concrete pressure huat relationships various variations of fly ash.

From graph 10. We can see that the optimum compressive strength occurs at a 28-day treatment age at a 20% fly ash variation of 44.5 Mpa.

5. COVER

5.1 Conclusion

Based on the discussion that has been described, the following conclusions can be drawn:

1. Based on the results of workability testing on Self Compacting Concrete (SCC) with the addition of fly ash as a substitute for cement, the standard that meets the requirements of SCC concrete based on the workability properties of slump flow testing and L-Box variation of 0% and 20% addition rates, slump flow value of 0% fly ash content of 606 mm with L-Box ration value of 0.99 and slamp flow value of 20% fly ash content of 595.5 mm with L-Box ration value of 0.81
2. Based on the results of the tests carried out, the effect of the compressive strength value of concrete on the addition of fly ash as a substitute for cement in SCC concrete was obtained, the optimum compressive strength value at the immersion age of 28 days with the addition of 20% fly ash as a substitute for cement of 44.5 Mpa. fly ash in 0% concrete mixture of 47.2 Mpa.

5.2 Suggestion

Based on the results of the research that has been carried out, as a material for consideration, several suggestions are proposed as follows:

1. It is recommended that at the time of further research, it is hoped that the number of test pieces will be increased to obtain the influence of fly ash substitution on SCC concrete.
2. It is necessary to pay attention to the compaction process at the time of making the test piece because it affects the compressive strength of the concrete.

REFERENCES

1) American Society for Testing Material (ASTM) C 307-03,1953, " Standard Test Method for Tensle Strength of Chemical-Resistant Mortar, Grouts, and Monolithic Surfacings "
2) Anonymous. 2002. Annual Book of ASTM Standarts 2020. Volume 04.3. USA : ASTM International.
3) National Standardization Agency, SNI 03-2834-2000 on "Procedures for Making Normal Concrete Mixture Plans."

4) Efendi, Yusuf. 2006. Review of Permeability and Shrinkage of Concrete with a Mixture of Methacrylate, Red Cement and Quenched Lime as a Partial Substitute for Seman. Final Project. Department of Civil Engineering, Faculty of Engineering, Sebelas Maret University, Surakarta.
5) L.J. Murdock and K.M. Brook (Translated by Stepanus Hendarko). 1991. Concrete Materials and Practices. Jakarta: Erlangga
6) Wonda, E. (2024, July). Analisa Sifat Fisis Dan Mekanis Tanah Untuk Menetukan Daya Dukung Tanah. In *Prosiding Seminar Nasional Teknik Sipil* (Vol. 2, No. 1, pp. 440-452).
7) Mulyono, Tri, 2003, Concrete Technology, Andi, Jakarta
8) Nugroho, Eko. 2010. Analysis of Porosity and Permeability of Concrete with Fly Ash Additives for Rigid Pavement. Final Project. Department of Civil Engineering, Faculty of Engineering, Sebelas Maret University, Surakarta.
9) Rochmawati, R. (2023, June). Perbandingan Hasil Uji Kuat Tekan Beton Menggunakan Compresion Testing Machine Dengan Hammer Test Menggunakan Agregat Kali Doyo. In *Prosiding Seminar Nasional Teknik Sipil* (Vol. 1, No. 1, pp. 131-135).
10) Sulistiar, F., & Wantoro, M. (2024, July). Penggunaan Pasir Pantai Sebagai Agregat Halus Dalam Pembuatan Beton Scc. In *Prosiding Seminar Nasional Teknik Sipil* (Vol. 2, No. 1, pp. 333-341).
11) Tjokrodimulyo Kardiyono, 1992, Concrete Technology, Publishing Bureau, Yogyakarta.
12) Ministry of Public Works and Housing, 2017, Special Specification - Interim SKh-1.7.23 Self Compacting Concrete.
13) Kukun Rusyadi, 2012, Self-Compacting Concrete Tightening with the Addition of Fly Ash and Structuro.