The Effect of Fly Ash on the Flexible Strength Concrete and Concrete Temperature

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Abstract

Concrete is a construction material that is widely used in modern building structures. Concrete is obtained by mixing Portland cement, water, sand, gravel, and under certain conditions other admixtures can be used, one of which is using Fly Ash. The use of fly ash as a concrete forming material has a positive impact from an environmental perspective. Fly Ash is a very fine residue of burning coal. The fineness of the fly ash granules has the potential to cause air pollution. Handling of fly ash is currently still limited to stockpiling on vacant land. In this study, we will identify the benefits of fly ash as a substitute for cement in concrete. Identification of fly ash material focuses on the effect of using this material on the flexural strength of concrete and concrete temperature.

The purpose of this study was to determine the effect of using fly ash in what percentage with the best test results for flexural strength and workability of concrete. The percentage of fly ash used varies, starting from 10%, 15% and 20%. The concrete will be tested at 7, 14 and 28 days after curing. This study used 18 beam-shaped specimens where for each variation the addition of fly ash was made of 6 specimens.

Keywords: *fly ash, flexible strength, temperature, workability.*

INTRODUCTION

Concrete technology has been increasingly developed in the field of civil engineering. Many kinds of concrete have been developed and used in various ways. Concrete is a strong, fire-resistant and corrosion-resistant material. But the concrete is greatly influenced by the composition and quality of the concrete mix ingredients. Fly ash is the residue from burning coal. The elements contained in fly ash include Silica Oxide (SiO_2), Alumina Oxide (Al_2O_3), Iron Oxide (Fe_2O_3), and Sulfur Trioxide (SO_3). When chemically reacted with ordinary temperature it will form compounds that are binding.

The purpose of this study was to find out at what percentage the best, strongest and most effective fly ash mixture.

Fly Ash Concrete

Concrete is a construction material that is commonly used in the world of construction, both for buildings, bridges, dams, and others. Concrete is a homogeneous unit. Consists of a mixture of fine aggregate and coarse aggregate (sand, gravel, crushed stone, or other types of aggregate), with cement, which are held together by water in a certain ratio (Wuryati S. & Candra R, 2001).

Fly ashis a product of residual coal combustion commonly known as pozzoland material which can be used as a mixture of additives in concrete. Technological developments in fly ash have achieved new innovations regarding High Volume Fly Ash Concrete (HVFAC) which uses a fairly high fly ash content, namely above 50% as a constituent material and has a fas value of around 0.4 and the use of cement is lower than normal concrete (Thangaraj and Thenmozhi, 2012).

Reinforced concrete

Reinforced concrete is a composite material in which steel reinforcement is arranged into the concrete in such a way that it functions to withstand tensile forces on the structure. The two materials work together to withstand the forces acting on the element. The combination of the two materials makes reinforced concrete have very strong properties against compressive and tensile forces.

Based on SNI 2847:2013 (SNI, 2013) the steel reinforcement used must be deformed reinforcement, except for spiral reinforcement or prestressed steel, plain reinforcement is permitted. The rib reinforcement is installed as longitudinal or longitudinal reinforcement. Plain reinforcement does not have threads and is usually used to resist shear forces.

In general, concrete is a construction material consisting of several elements such as coarse aggregate (split) and fine aggregate (sand) which are bound by cement which reacts with water.

Portland cement

According to SNI 15-2049-2004 Portland cement on the market is divided into 5 types, namely:

1) Portland cement type I, for general use which does not require special requirements as required for other types.

2) Portland cement type II, which in use requires moderate resistance to sulfate or heat of hydration.

3) Portland cement type III, which in use requires high strength at the initial stage after bonding occurs.

4) Type IV Portland cement, which requires low hydration heat to be used.

5) Type V Portland cement, which in use requires high resistance to sulphate.

Aggregate

According to Tjokrodimuljo (2007), fine aggregate is rock that has a grain size between 0.15 mm-5 mm. Fine aggregate can be obtained from the soil, river bed or seaside.

Table 1 Fine aggregate gradation limits

Hole Sieve (mm)	Weight of grains passing through the sieve in percent			
	Rough	Rather Rough	Rather Fine	Fine
10	100	100	100	100
4,8	90-100	90-100	90-100	95-100
2,4	60-95	75-100	85-100	95-100

1,2	30-70	55-90	75-100	90-100
0.6	15-34	35-59	60-79	80-100
0.3	5-20	8-30	12-40	15-50
0.15	0-10	0-10	0-10	0-15

Source: Tjokrodimuljo, 2007

Fly Ash

According to ASTM C618 (ASTM, 1995:304) fly ash is defined as the fine grains of coal combustion residue or coal powder.

Table 2 Composition of type f fly ash based on the xrf test

Component	Percent (%)	Component	Percent (%)
SiO_2	52,2	K_2O	0.4
Al_2O_3	38,6	MgO	0.5
Fe_2O_3	2,9	SO_3	1,2
CaO	0.7	SO_2	-
Na_2O	0.5	LOI	1,4

Source: January & Quarter, 2011

Concrete Medicine (Additive)

Referring to the classification according to ASTM C494-82, there are 7 types of chemical admixtures including the following:

1) Type A (Water Reducer or plasticizer)

This material is used to reduce the need for water to be used. By using this material, a lower fas value will be obtained at the same value of the viscosity of the mixture.

2) Type B (Retader)

This material is used to slow down the concrete bonding process, usually used by ready mix concrete companies for project casting purposes.

3) Type C (Accelerator)

Chemicals to speed up the process of bonding and hardening of concrete. Usually used in casting below the surface of the water or in concrete structures that require immediate hardening.

4) Type D (Water Reducer Retader)

This type is necessary in connection with the reduction of water and slow down the bonding process.

5) Type E (Water Reducer Retarder)

This type is used to reduce water and to speed up the bonding process.

6) Type F (High Range Water Reducer/Superplasticizer)

This chemical serves to reduce the need for water to 12% or even more.

7) Type G (High Range Water Reducer)

This material has several uses, namely, reducing the need for water, speeding up the bonding process and hardening of concrete

Slump value

The slump value is used to measure the level of workability of a concrete mix, which affects the level of workability of the concrete. The greater the slump value, the thinner the concrete and the easier it is to work, conversely the smaller the slump value, the thicker the concrete and the more difficult it is to work.

Table 3 Determination of concrete mix slump values

Use of concrete (based on the type of structure made)	Slump Value(cm)	
	Maximum	Minimum
Walls, plate foundations and footings are reinforced	12.5	5
Unreinforced footings, caissons and underground structures	9	2,5
Slabs, beams, columns, walls	15	7,5
Road pavement	7,5	5
Mass concrete (mass concrete)	7,5	2,5

Source: Tjokrodimulyo, 2007

METHODOLOGY

The research method is the steps or methods used in researching a problem, case, symptom, issue or other in a scientific way to produce answers that can be accounted for. In a study, so that the expected goals can be achieved, it is necessary to take work steps that are coherent and orderly in order to get results and answers that are very rational and can be accounted for.

Concrete research was carried out at Waskita Karya Beton (WKB) Laboratory and Baching Plant, precisely in Krengseng Village, Gringsing Batang District

Material Properties

1) Fly Ash

a. Fill Weight= 1.599 kg/m3

b. Specific gravity = 2460 kg/m3

2) Fine Aggregate

a. An. Granules (Thirst Modulus)= 2.43 %

b. Fill Weight= 1.607 kg/m3

c. Sludge levels= 2.8 %

d. Water content= 1.611%

e. SSD Specific Gravity= 2.516 kg/m3

3) Coarse Aggregate

a. Fill Weight= 1.492 %

b. SSD Specific Gravity= 2.747 kg/m3

c. Sludge levels= 0.51 %

d. Water content= 3.55 %

Concrete Mix Design (Job Mix Design)

Aggregate amalgamation is an approach to obtain gradations according to certain specifications. This specification can be applied to fine aggregate only, coarse aggregate only or their alloys.

Table 4 Job mix concrete formula

No.	Description	Calculation	Score
1.	Required compressive strength	Defined	41.5 N/mm2 at 28 days defective part 5 %
2.	Standard deviation		3N/mm2
3.	Value added (margin)	Set	(K=1.64) 1.64 x 3 = 4.92 N/mm2
4.	Targeted average strength	(1) + (3)	41.5 + 4.92 = 46.42 N/mm2
5.	cement type	Set	Type 1 (Gresik)
6.	Fly Ash	Set	PLTU Tanjung Jati
7.	Aggregate type : Coarse Fine	Set	Machine break Well 7

8	Concrete Additive : Type D F type	Set	Fosrock RP 337 Fosrock SP264
9.	Free water cement factor		0.36
10.	Cement water factor max		0.36
11.	Slump		Slumps 60 – 100 mm
12.	Max aggregate size		20mm
13.	Free water content		(2/3 x 195)+(1/3 x225) = 205x75% = 150 liters
14.	The amount of cement	11:8 or 7	150 : 0.36 = 420 kg
15.	The arrangement of the fine aggregate grains		Zone 2 grain arrangement gradation area
16.	Fine aggregate percent of 4.8mm		39 %
17.	Aggregate relative specific gravity (surface dry)		2,657 known/presumed
18.	Specific gravity of concrete		2450kg/m3
19.	Combined aggregate content	19-12-11	2450 –420 – 150 = 1880 kg/m3
20.	Fine aggregate content	17-20	0.39 % x 1.880 = 733 kg/m3
21.	Coarse aggregate content	20-21	1.880 – 733 = 1.147 kg/m3

DATA and DISCUSSION

Concrete Temperature Check

1) Fly Ash 10%

In the results of the 10% fly ash concrete casting test, the concrete temperature was at 29°C, from the test results it can be concluded that the concrete temperature is still safe because it is still below <35°C.

2) Fly Ash 15%

In the results of the 15% fly ash concrete casting test, the concrete temperature was at 28.6°C, from the test results it can be concluded that the concrete temperature is still safe because it is still below <35°C.

3) Fly Ash 20%

In the results of the 20% fly ash concrete casting test, the concrete temperature was at 30.3°C, from the test results it can be concluded that the concrete temperature is still safe because it is still below <35°C.

Slump test

1) Fly Ash 10%

From the results of measurements with a meter the distance between the iron rods and the top of the concrete mix which had collapsed on the 10% fly ash concrete test obtained a slump value of 7.5 cm. If the average slump requested in the field is 8(+/-2) it means 6-10 cmthen the workability of the concrete is still safe and the concrete is ready to be used for casting in the field

2) Fly Ash 15%

From the results of measurements with a meter the distance between the iron rods and the top of the concrete mix which had collapsed on the 15% fly ash concrete test obtained a slump value of 7.5 cm. If the average slump requested in the field is 8(+/-2) it means 6-10 cmthen the workability of the concrete is still safe and the concrete is ready to be used for casting in the field.

3) Fly Ash 20%

From the results of measurements with a meter the distance between the iron rods and the top of the concrete mix which had collapsed on the 20% fly ash concrete test obtained a slump value of 7 cm. If the average slump requested in the field is 8(+/-2) it means 6-10 cmthen the workability of the concrete is still safe and the concrete is ready to be used for casting in the field.

Flexural Strength Test

a. Age 7 Days

Table 5 Calculation of the flexural strength of fly ash concrete aged 7 days

No	Fly Ash	Sample (Code/Mark)	Max Load(kN)	Strength (Kg)	Ratio (%)
1	10%	Fs45-01	28	38.08	84.6
2	10%	Fs45-02	29	39,44	87.6
3	15%	Fs45-01	30	40,8	90.7
4	15%	Fs45-02	31	42,16	93.7
5	20%	Fs45-01	29	39,44	87.6
6	20%	Fs45-02	30	40,8	90.7

Source: SNI 03-4154-1996

b. Age 14 Days

Table 6 Calculation of the flexural strength of fly ash concrete aged 14 days

No	Fly Ash	Sample (Code/Mark)	Max Load(kN)	Strength (Kg)	Ratio (%)
1	10%	Fs45-03	34	46,24	102.8
2	10%	Fs45-04	35	47,60	105.8
3	15%	Fs45-03	33	44.88	99.7
4	15%	Fs45-04	34	46,24	102.8
5	20%	Fs45-03	33	44.88	99.7
6	20%	Fs45-04	31	42,16	93.7

Source: SNI 03-4154-1996

c. Age 28 Days

Table 7 Calculation of the flexural strength of fly ash concrete aged 28 days

No	Fly Ash	Sample (Code/Mark)	Max Load(kN)	Strength (Kg)	Ratio (%)
1	10%	Fs45-05	39	53.04	117,9
2	10%	Fs45-06	41	55,76	123.9
3	15%	Fs45-05	40	54,40	120.9
4	15%	Fs45-06	38	51,68	114.8
5	20%	Fs45-05	39	53.04	117,9
6	20%	Fs45-06	37	50,32	111.8

Source: SNI 03-4154-1996

CONCLUSION

The results of the research on the effect of using fly ash concrete include:

1) Based on research testing, the more fly ash mixed, the lower the flexural strength results.

2) The effect of using fly ash in the concrete mix is that the more fly ash composition, the higher the concrete temperature, but from all the results of research tests it can be concluded that all concrete temperatures are still safe because they are still below 35°C.

3) The way to find out the difference in the effect of each percentage of fly ash used in the concrete mix in this study is by checking the temperature of each fly ash addition and the results of the concrete flexural strength test at 7 days, 14 days and 28 days.

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