OPTIMIZING THE UTILIZATION CEMENT SLAG AND FLY ASH OF CONCRETE QUALITY

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Abstract - Development of knowledge and technology in the field of Construction required a building material that has a better advantage than existing building materials so far. The use of concrete using slag and fly ash reduces the consumption of cement so that efficiency is expected in the construction world, but licensing the use of hazardous waste is not easy in Indonesia.The experimental method tested on the K100-700 concrete quality from laboratory testing with a percentage of 20% indicates a sufficiently favorable level of efficiency.In addition, the quality obtained is equivalent to standard concrete products. Utilization of hazardous waste can cut production costs, however, regulations related to the use of hazardous waste for raw materials of concrete should be facilitated since it can cut production costs, and it is also helping reduce environmental pollution.

Index Terms - Cement Slag , Fly Ash, Concrete Quality, Production Cost.

I. INTRODUCTION

In concrete planning is often known term of conventional concrete, namely concrete with the use of materials, technology and equipment are still simple. The value of compressive strength of the concrete can be known from the results of the compressive strength test against the cylindrical test object diameter 30 cm and height of 15 cm which is burdened with a certain compression force and gradually until the test object is destroyed (SK SNI M-10-1991-03). Slag Cement or included in GGBFS (ground granulated blast-furnace slag according to ACI 233R-95, is a high blast furnace slag of metal or iron with a temperature of about 1500^{o}C. In developed countries the use of Concrete Slag is already in use, however in Indonesia not all construction has implemented the waste of slag. Utilization of industrial waste in the field of construction is used to improve the quality and compressive strength of concrete as it contributes to reducing the use of natural resources. As it is well known that 70% of the material used in construction works is concrete therefore the more increase of the industry means increasing waste from the factory. According to [1]One of the biggest potential applications for reusing copper slag is on the production of cement and concrete. According to [2]The method of inserting slag in the normal smoothness of the concrete has an important influence on the properties of the concrete resistance.

Currently in developed countries slag cement has been utilized in every mixture of concrete and even the percentage reaches 30%, this is seen from the production of slag cement which continues to increase from year to year. From several experiments conducted and literature[3], Concrete mixtures were evaluated for workability, density, compressive strength, tensile strength, bending strength and durability. From several experiments conducted and literature [4]that concrete using slag cement has better properties than concrete using only portland cement, such as :

- Increasing workability
- Ease of finishing
- Increasing compressive strength and flexural strength
- Increase the stability
- More resistant to chemical hazards
- Consistency of concrete performance
- Brighter concrete colors

Fly ash is one of the mineral added materials in which the material contains silica or alumina silica and alumina which do not have binding properties such as cement, but in its fine form in the presence of water, the compounds will react with calcium hydroxide at normal temperature forming calcium silicate hydrate (CSH) compound with hydrolysis of calcium hydrate and having a low solubility rate. Fly ash is derived from residual combustion generated from Thermal Generating Station) Among them come from factories derived from power plant.Based on [5] fly ash has good potential for use in the construction industry and According to[6] The optimal amount of fly ash varies not only with application but also with the composition and proportion of all the ingredients in the concrete mix. Fly ash is derived from residual combustion generated from Thermal (Generating Station) among them come from factories derived from power plant. According to [7] Along with the increasing of production cost, hence need to look for alternative solution of mixture of raw material of concrete production. In this case the use of slag and fly ash has been applied in some developed countries can be considered as a solution to reduce the production cost. By using fishbone diagram, it can be seen the correlation of optimization of slag and fly ash to the quality of concrete quality and reduce production cost. Here is a fishbone diagram to unravel the issues raised in this study

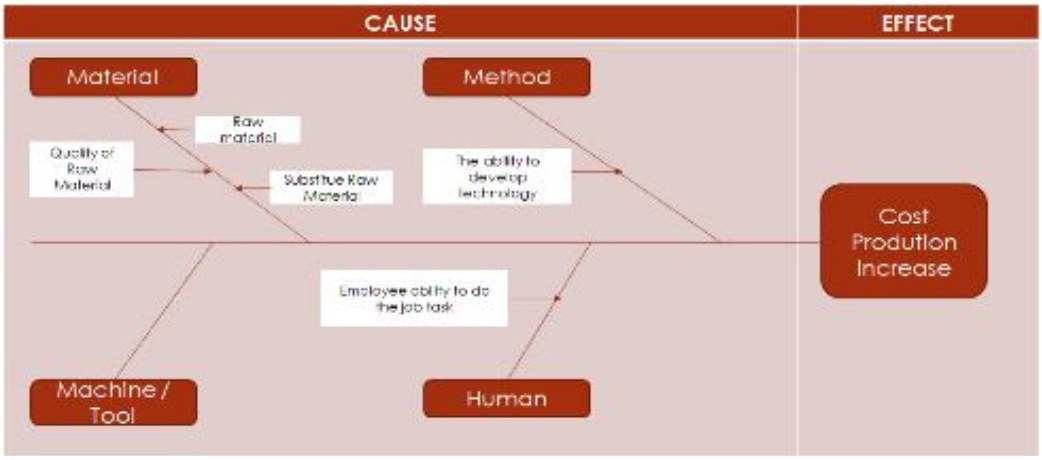


Fig. 1.Fishbond diagram utilization slag concrete & Fly Ash

Possible Roout Cause	Discussion	Root Cause ?
Raw Material	the stock of slag is abundant from the steel production so that the waste of it can be used	Yess
Substitues of Raw Material	the utilizing of substitues raw material isn't optimal yet since there are regulations in utilizing hazardous waste	Yess

Table 1 : Material Aspect

Possible Roout Cause	Discussion	Root Cause ?
Employee ability to do the job task	percentage of defect product	No

Table 2 : Human Aspect

Possible Roout Cause	Discussion	Root Cause ?
the ability to develop technology	improved the production quality by using substitute raw material	Yess

Table 3 :Method Aspect

The above Fishbone diagram can be seen that the production costs increased due to the utilization of raw materials slag and fly ash less optimal since the regulation of the utilization of hazardous waste cannot be arbitrary[8]. Although the amount is abundant but the use is still needed effort to get permit of hazardous waste utilization [9]. On one hand, it is economically very helpful to cut production costs and on the other hand helping utilize the use of hazardous waste so as to reduce environmental pollution. The purpose of this paper is :

- Knowing the quality of cement slag
- Determine standard of cement use for concrete mixture when using cement slag
- Utilize hazardous wasteand prevent environment destruction.
- Reduce production cost

II. DETAILS EXPERIMENT

A. Material and Procedures

In mortar research carried out by comparing Fly Ash Ex. PelabuhanRatu with cement slag. In a concrete experiment, it was conducted to find the correlation graph of w / c (cement water factor) to the compressive strength and to determine the need of cement, water and price for the concrete using the new materials. This experiment was conducted in laboratory using 5x5x5 cm mortar cube, which refers to ASTM-C.109 standard, "Standart Test Method for Compressive Strength of Hydraulic Cement Mortars. The composition for mortar experiment is as follows:

Material	Origin Material	Quantity	Fly Ash 20 Pelabuhan Ratu	Slag Cement 20
Cement 1	OPC INDOCEMENT	gram	592	592
Pozzolan 1	Fly Ash Pelabuhan Ratu	gram	148	0
Pozzolan 2	Slag cement	gram	0	148
Sand 1	BANGKA	gram	975	988

Table 4: Composition of the mixture of mortar experiments

At the time of experiment, it is conducted observation and test :

- Workability 9 slump
- Water requirements for the same workability
- Compressive strength of age 3.7 and 28 days

III. RESULT AND DISCUSSION

B. Result of Mortar Test

No Trial			N032	N033	N034	N035	N036	N037
Code			Bangka 100% + OPC INDO 80% + FA Suralaya 20%	Bangka 100% + OPC INDO 80% + SLAG SEMEN 20%	Bangka 100% + OPC Gresik 80% + FA Suralaya 20%	Bangka 100% + OPC INDO 80% + SLAG SEMEN 20%	Bangka 100% + OPC Gresik 80% + FA Suralaya 20%	Bangka 100% + OPC INDO 80% + SLAG SEMEN 20%
Composition Trial Mix			0,0010	0,0010	0,0010	0,0010	0,0010	0,0010
Cement 1	OPC Gresik	gram	592	592	592	592	592	592
Pozzolan 1	Suralaya	gram	148	0	148	0	148	0
Pozzolan 2	Slag Cement	gram	0	148	0	148	0	148
Pozzolan 3	Indobarat	gram	0	0	0	0	0	0
Sand 1	Bangka	gram	975	998	976	1002	979	1002
Water 1	Precast	gram	377	378	377	378	377	378
Testing Time	hours:minute		15:49	16:06	16:26	16:38	13:31	13:47
Slump	cm		19,50	19,00	19,50	19,00	19,50	19,00
Change of Water	lt/m^3		0,00	20,50	0,00	20,50	0,00	20,50
nitial Seting Time	minutes							
w/c			0,485	0,520	0,485	0,520	0,485	0,520
3 day	1	kg/cm^2	326	326	306	286	326	286
	2	kg/cm^2	347	286	326	306	306	286
	Average	kg/cm^2	337	306	316	296	316	286
7 day	1	kg/cm^2	469	428	469	428	449	428
	2	kg/cm^2	481	449	469	428	469	408
	Average	kg/cm^2	475	438	632	428	459	418
28 day	1	kg/cm^2	632	612	632	632	653	612
	2	kg/cm^2	653	612	645	612	632	632
	Average	kg/cm^2	642	612	638	622	642	622

Table 5 : . Mortar Fly ash Test Data with Cement Slag

Compressive Strength (kg/cm^2) as age	FA Suralaya 20%	Slag cement Jakarta 20%
Compressive Strength (kg/cm^2)		
3 day	323	296
7 day	468	428
28 day	641	619
percentage of comparison		
3 day		0,92
7 day		0,92
28 day		0,96
Realitation Data Trial Mix		
Realitation w/c	0,485	0,520
Change of water	0	20,50
Initial Seting Time		
Hours : minutes	04:40	03:35
Delta		01:05
Slump (cm)		
Slump Plain	19,50	19,00
Slump After 30'		
Developing Compresive Strength		
Age of day	% Compressive Strength after 28 days	
0	0	0
3	0,50	0,48
7	0,73	0,69
28	1,00	1,00

Table 6 : The average fly ash mortar test result with cement slag

C. Result of Concrete Test

Concrete experiments performed with the composition of Fly Ash 20% and 20% Cement Slag are as :

Compressive Strength (kg/cm^2) as age	W/C 0,3 FA 20	W/C 0,3 Slag cement 20	w/c 0,5 FA 20	W/C 0,5 Slag cement 20	W/C 0,7 FA 20	W/C 0,7 Slag cement 20
1 day	399	431	138	127	57	54
3 day	490	512	243	247	125	120
7 day	532	624	349	349	161	190
28 day	626	648	435	462	218	224
Precentace comparison						
1 day	1,00	1,08	1,00	0,92	1,00	0,96
3 day	1,00	1,05	1,00	1,02	1,00	0,96
7 day	1,00	1,17	1,00	1,00	1,00	1,18
28 day	1,00	1,04	1,00	1,06	1,00	1,03
Realitation of Trial Mix						
Realitation w/c	0,300	0,300	0,530	0,530	0,896	0,919
	1,000	1,000	1,000	1,000	1,000	1,026
Water diference (ltr	203	226	199	199	222	228
Water diference (%)	1,00	1,11	1,00	1,00	1,00	1,03
Initial Setting Time						
hour : minutes	05:04	04:13	05:32	05:17	07:43	07:41
Deviation		00:51		00:15		00:02
Slump (cm)						
Slump Plain	16	20	16	16	16	16
Develpoment Compressive Test						
Age of day	% Compressive Strength after 28 days					
1	0,64	0,66	0,32	0,27	0,26	0,24
3	0,78	0,79	0,56	0,53	0,57	0,54
7	0,85	0,96	0,8	0,75	0,74	0,85
28	1,00	1,00	1,00	1,00	1,00	1,00

Table 7 : Data of Fly Ash Concrete Test Results with Cement Slag

To know the quality of cement slag against fly ash, and observed from mortar and concrete experiment, then it is obtained the combination as follows :

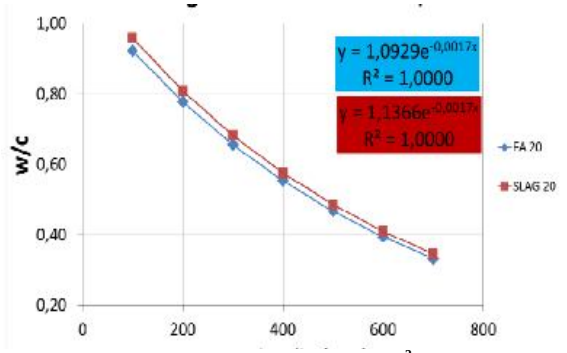


Fig.2. Correlation compressive strength to W/C

The graph shows a strong relationship between compressive strength with w / c, where the strength of cement slag is relatively the same as that of fly ash.

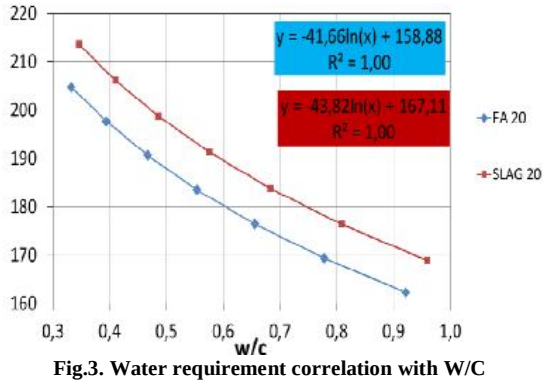


Fig.3. Water requirement correlation with W/C

The graph above shows the relationship of water demand, where with the use of cement slag requires more water than fly ash.From the relationship graph above can be obtained composition ratio w/c, use cementius is as follows :

Quality K	Goal kg/m^3	w/c		water (ltr/m^3)		Cementius (kg/m^3)	
		FA 20	Slag cement 20	FA 20	Slag cement 20	FA 20	Slag cement 20
100	149	0,808	0,840	168	175	208	208
200	249	0,681	0,709	175	182	257	257
300	349	0,575	0,598	182	190	316	317
400	449	0,485	0,504	189	197	390	391
500	549	0,409	0,426	196	205	479	481
600	649	0,345	0,359	203	212	589	590
700	749	0,291	0,303	210	219	722	725

Table 8 : Comparison of W/C composition, water (liter/m^3), sementius (kg/m^3)

From the table of comparison composition shown results to obtain the same quality in Semen Slag there is addition of water 8 liters / m3 to Fly Ash, and addition of cementius of 1kg/m^3.The influence of the addition of Granulated Blast Furnace Slag to the economic value can be known as follows.

The table below illustrates the impact on the economic value of a concrete product using a mixture of concrete slag and fly ash which is a hazardous waste can cut production costs.

The results obtained from the use of these materials are also not disappointing, equivalent of quality obtained from concrete that uses only raw materials of cement.

Quality K	Goal kg/m^3	w/c		water (ltr/m^3)		Cementius (kg/m^3)		Price (Rp/m^3)		Delta
		FA 20	Slag cement 20	FA 20	Slag cement 20	FA 20	Slag cement 20	FA 20 (IDR)	Slag cement 20 (IDR)	
100	149	0,808	0,840	168	175	208	208	416.733	408.383	-8.350
200	249	0,681	0,709	175	182	257	257	436.591	426.558	-10.033
300	349	0,575	0,598	182	190	316	317	462.529	450.506	-12.023
400	449	0,485	0,504	189	197	390	391	495.703	481.313	-14.390
500	549	0,409	0,426	196	205	479	481	537.544	520.324	-17.220
600	649	0,345	0,359	203	212	589	590	589.809	569.193	-20.616
700	749	0,291	0,303	210	219	722	725	654.645	629.943	-24.702

Table 9 : The effect of adding to the economic value

The addition of Blast Furnace Slag (BFS) seen from the economic review on the results of this study, BFS can provide the efficiency of production raw materials where the calculation of the above table can be seen there is an efficiency of 20% in using substitute raw material of cement produced[10]. While viewed from the environment with the utilization of BFS which is included as hazardous waste will reduce the impact of environmental pollution caused by hazardous waste.

CONCLUSION

From the results of the experiment can be concluded as follows :

- With the same W/C, compressive strength of cement slag is 20% bigger than FA 20% that is equal to 5%.
- To get the same workability the use of water, cement slag is 20% higher with an average of 8 liters/m^3.
- To get the same quality the use of cement slag using cementius average larger 1 kg/m^3.
- Initial setting time cement slag 20% average is faster 60 minutes compared to FA 20%.
- From an economical overview, the addition of blast furnace slag provides economic value, the more blast furnace slags being added the lower the cost of cement production.

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