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THE EFFICIENCY OF FLY ASH AND CEMENT SLAG TO DEVELOPMENT BUILDING

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ABSTRACT: In world construction, the construction of high-rise buildings almost entirely uses concrete. This study uses fly ash and cement slag as a cement substitute as a reduction in cement requirements. This is due to the limited amount of cement in the market and the binding function of cement and the increasing cement prices. The use of fly ash and cement slag is toxic hazardous waste material that must be handled so that it can be used properly. From the results of the age strength of concrete 1-3 days, the compressive strength of fly ash is higher than that of cement slag but from a mixture of 28 days, it reaches 100% in accordance with the specified standard. In this laboratory test for the use of fly ash and slag cement, 50%, in the future it is necessary to research that the use of fly ash and slag cement can be up to 70% so that the use of fly ash material and cement slag can replace the function of concrete mixed cement as a binder of coarse and fine material to get concrete compressive strength with specified standards. Production costs can be minimized so that if this applied can avoid the company from potential billions/year losses.

Keywords: Fly Ash, Cement slag, Compressive strength, Production cost, High rise building

1. INTRODUCTION

The construction of high-rise buildings currently demands good quality materials, almost 70% of the use of materials from the building is concrete so that to meet the construction of high-rise buildings will be demanded high-quality concrete[1]**.** It has been commonly known that the use of fly ash can be used for mixed use of concrete but what about the slag concrete in which both components are hazardous waste?. The results show that significantly improved workability and strength development are obtained at an increased admixture content[2]. Many research has been done to review the effect of added ingredients on improving the quality of concrete. One of the added ingredients that are often to be used in the mixed concrete mix is fly ash and cement slag. Due to their good performance and environmental friendliness, fly ash-based construction materials have great[3]. Fly-ash which is the remnants of coal combustion, flowed from the combustion chamber through the kettle in the form of smoke bursts, which is formed of fine particles and is an inorganic material formed from the change of mineral materials due to the combustion process of the coal combustion process on the generating unit steam (boiler) will form two kinds of ash that is fly ash (fly ash) and bottom ash (bottom ash). In Indonesia, the use of toxic hazardous waste such as cement slag, Fly Ash, bottom ash cannot be used directly but there must be waste management. Fly Ash-Bottom Ash is classified as hazardous waste so that any management in storage, transport, collection, utilization, management and stockpiling must be recorded and traceable as evidenced by the manifest document and each of the actors shall have a valid license and appropriate with designated it. Disposal of fly ash from coal-fired power plants causes economic and environmental problems. Violations of the provisions of hazardous waste management regulations result in administrative sanctions up to criminal sanctions in the form of prison confinement 1-5 years and a fine of 1-5 billion as stipulated in the Law of Indonesia No. 32 of 2009 on the management and protection of the environment. The purpose and objectives of this paper Innovation are as follows :

- Making Effective Management System which facilitates the process of data collection of coal ash in and out every day (First In First Out).
- Knowing the quality of Fly Ash and Cement Slag
- Determine standard of cement used for a concrete mix when using fly ash and cement slag with comparison 50%
- Knowing the level of efficiency of using fly ash waste and cement slag waste.

2. LITERATURE REVIEW

The production process of electricity of Coal Steam Power Plant produced side products which are Fly ash and bottom ash. Fly ash is a solid waste produced from coal-fired power plants[4]. From the results of fossil fuel combustion has been widely known from its emissions containing various heavy metals and gaseous substances[5]. The product is kept

in a big stack with the size of particles grains smooth [6]. From the waste can be used a a mixture of cement replacement for high rise building. According[7] to form an economical aggregate sand substitute to be used as a concrete filler product. Fly ash can be used for concrete mixed.

ASTM C.16 mentioned the use of fly ash in concrete mixes has various advantages :

- Improve workability of concrete mortar
- Reduce heat hydration
- Reduce the cost of concrete work
- Enhance resistant to sulfate attack
- Enhances resistance to alkali-silica reaction attack
- Heightening the age of the concrete
- Enhance concrete compressive strength
- High concrete durability
- Reduce depreciation
- Reduce porosity and water absorption in concrete

The disadvantage of use of fly ash in concrete mixtures:

a. The process of hardening and adding concrete strength is rather slow due to the pozzolanic reaction of fly ash
b. Quality control must be carried out more often because the quality of fly ash depends on the combustion process (temperature) and the type of coal.

In the utilization of waste can be compared to the other waste such as cement slag. Cement slag is a chemical reaction as one of popular activation method which is considered to fix hydraulic characteristic of the slag[8]. Recent studies have shown that mixing granular ground furnace slag with low calcium fly ash has a significant effect on the regulation and development of the initial strength of the system preserved at room temperature[9]. This work presents the chemical activation of blast-furnace slag-blended Portland cement. According to [10] a partial replacement of Portland cement (PC) by ground granulated blast furnace slag (GGBFS)is an effective method to improve the durability of concrete due to its lower diffusivity and higher chemical resistance compared to PC. The GGBS, which enhances the chloride ingress resistance, was utilized as a supplementary cementitious[11]. Both media will react to decrease production cost because the usage of cement relatively increases in every year. The production of cement, the primary ingredient in concrete[12]. The production cost pressed in order to get the highest advantage but still considered the quality without relieving the ingredients which cause bad quality in the development of high rise building.

ACI 233 [13] reported that concrete using cement slag has better properties than concrete using only portland cement, such as :

- Increases the strength an d durability of the concrete structure
- Reduces permeability
- Cement Slag gives a workable mix with progress good pumpable and compaction characteristics
- Increase sulfate attack resistance
- Decrease chloride penetration
- The heat of hydration is low
- Resisted the alkali-silica reaction
- More chemically stable
- Gives good surface finish and improves aesthetics
- The color is more even and light
- Lower chances of Florence
- Reduces the maintenance and repair cost
- Cement slag does not produce carbon dioxide, sulfur dioxide or nitrogen oxides.

The disadvantages of using cement slag are that it is not fulfilled limestone, which is results in weak cement in another hand the binding capacity of concrete is not massive.

Cement slag produced from several fires is not a failed product but is already a product that is ready to use. In the slag, there is limestone for bonding like cement. The results indicate that in a multi-blend cement of fly ash, GBFS, low-grade limestone, and clinker, up to 70 % of clinker can be replaced gainfully and the performance of resultant mortar samples prepared using multi blend cement containing cement-grade and low-grade limestone were comparable [14].

For concrete calculations in finding correlation graph, w/c (cement water factor) to compressive strength used exponential regression formula and in the calculation used MS Excell program.

$$Y = ae^{bx} \quad (1)$$

a = compressive strength (kg/cm^2)
b = w/c
e = exponential (2,718)
R = Coefficient (if close to 1 then the value is good)

As for determining the water requirement against w/c used the formula :

$$Y = a+bx \quad (2)$$

a = water requirement (ltr/m^3)
b = w/c

3. RESEARCH METHODOLOGY

In this research the methodology is used as follows :

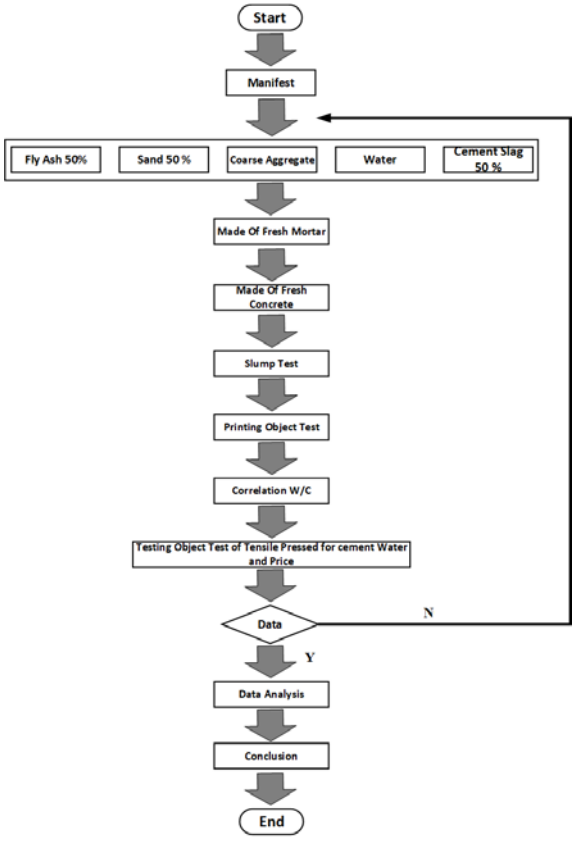

Fig.1 Flowchart Methodology

Starting from the management waste, it will be checked through the manifest. In this study, the waste that is being used must have passed the stage of distribution waste that is going to be used. During the experiment, it get observed and test such as workability (slump), the need of water for the same workability to seek the correlation graph of w/c toward tensile pressed at the age of 1,3,7 and 28 days and determined the need of cement, water and price for concrete which is using fly ash and cement slag. If it doesn't fulfill the standard criteria then it will be back to through mix design for making mortar and concrete, but if it meets the standard criteria the data will be processed for evaluation.

4. EXPERIMENTAL SETUP

The experiments performed on a laboratory scale include mortar cube experiments and concrete experiments using a small mixer.

Materials used in this experiment are as follow :

- Cement: Type I (OPC) Ex. PT. Indocement Tunggal Perkasa
- Fly Ash 50 %: Ex. Pelabuhan Ratu
- Source Fly ash took from this research including Fly ash ex. Surabaya Factory, Fly ash ex. Pindodeli and Fly ash ex. Indhobarat, Fly ash ex. Pelabuhan Ratu. Most of the usage of fly ash using fly ash ex. Suralaya 96%, the use of fly ash ex. Pindodeli 2% while Fly ash Indobarat 1%, therefore it is needed another source as alternative pozzolan as mineral add material in order to get appropriate quality and cost. Other fly ash alternatives are obtained from various sources that produce Fly ash, for example, the Jakarta cement slag.
- Cement Slag 50% : Ex. Semen Jakarta
- Stone: Coarse aggregate Ex. BCA Supplier Bangun Jaya
- Sand: Natural Sand Ex. Belitung
- Water: Well Foundry Precast Cibitung

5. RESULT AND DISCUSSION

5.1 Transportation of Hazardous waste

Fly ash and bottom ash are the dominant hazardous waste generated from Power Generation activities in PLTU Suralaya. Not all waste can be used for concrete mixes for construction buildings, but for coal waste can be used as well. The amount of ash produced depends on ash content in coal. Here is the hazardous Waste Distribution Flow.

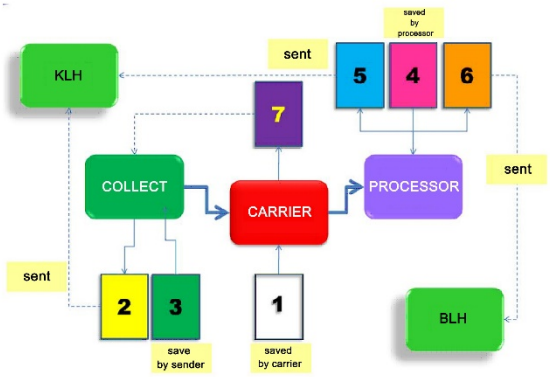

Fig.2 Process Flow of Hazardous Waste Manifest Distribution

The Manifest document consists of 7 sheets, with the final holder of the manifest for the 3rd and 7th sheets hold by the sender (producer), sheet 1 is held by the carrier, the 2nd and 5th sheets are held by the Ministry of the Environment, the 4th sheet is held by the recipient, the 6th sheet is held by the government which is delivered by the carrier.

5.2 Mortar Experiment Result

The use of mortar in construction works has been the fundamental of an ancient civilization where the mixtures were simply prepared using the combination of lime, sand, and water[15].

Fig.3 Laboratory Test Result on Mortar Fly Ash Comparison with Cement Slag

Fly ash and slag cement have been treated sustainable materials for the use of cement products for wastewater infrastructure due to their capabilities of corrosion resistance[16].

5.3 Concrete Experimental Result

The development of direct tensile strength of OPC and slag-cement concretes is similar to that of compressive strength [17].
Concrete experiments were performed with the composition of Fly Ash 50% and 50% cement slag are as follows :

Table 1. Test Result Data of Fly Ash Test with Cement Slag

Compressive Strength (kg/cm^2) a age	w/c 0,5 FA 50	w/c 0,5 SJ 50
1 day	104	101
3 day	219	229
7 day	330	353
Percentage of comparison		
1 day	1,00	0,97
3 day	1,00	1,05
7 day	1,00	1,07
28 day	1,00	1,07
Realitation Trial Mix		
Realitation w/c	0,500	0,500
	1,000	1,000
Change of water (ltr/m^3)	0	0
change of water (%)	1,000	1,000
Initial seting time		
hours:minutes	05.40	05.04
Delta		00.36
Slump (cm)		
Slump Plain	10	5
Slump After 30'	-	-
Developing Compressive strength		
Age of day	% Compressive Strength after 28 days	
1	0,45	0,41
3	0,95	0,94
7	1,44	1,44
28	1,00	1,00

In order to know the quality of Fly Ash and Cement Slag, and viewed from Mortar and concrete experiment then it is got the combination as follows:

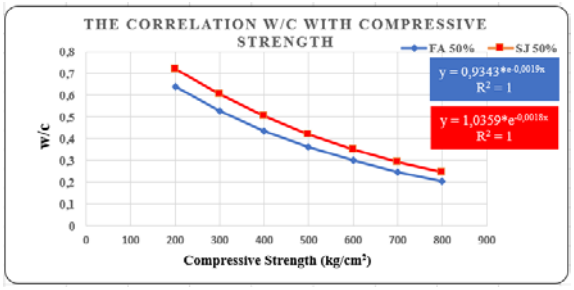

Fig.4 The relation of compressive strength against w/c.

Refer to Eq. (1), the above graph shows a compressive strength relationship to w / c, where the compressive strength of cement slag is relatively the same as that of fly ash. From the analysis of the exponential linear regression graph above can be seen near the scatter point or coefficient value R = 1.

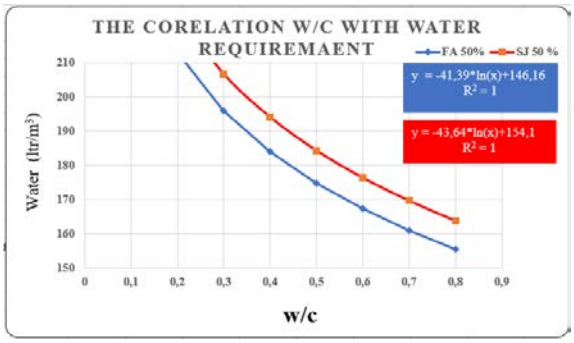

Fig.5 The relation of water requirement with w/c

Refer to Eq. (2), from the above linear regression graph analysis can be seen the value of R = 1 means good and can be used.

Fig.6 Distribution of Molen Truck for High Rise Building foundry with Fly Ash and Cement Slag

Nowadays, concrete is a material widely used to make high-rise buildings. Thus to meet the construction of high-rise buildings will be demanded high-grade concrete. But along with the increasing

human need for better infrastructure, then the concrete with high quality is much needed, for example for high rise buildings.

Fig.7 Floor and column concrete with concrete containing FA and cement slag

The development of construction in Indonesia occurred so fast, this research has been done to develop construction technology ranging from construction materials to technology used in the construction itself. The development of these construction materials can be seen from the many types of added materials used as additives in the normal concrete mortar. These added ingredients aim to improve the quality of concrete to be better and environmentally friendly. Alkali-activated fly ash-slag (AAFS) concrete is a new blended alkali-activated concrete that has been increasingly studied over the past decades because of its environmental benefits and superior engineering properties[16]. To know the quality of cement against fly ash, and evaluated from mortar and concrete experiment, it is got combination as follows :

Table 2 Comparison of composition for efficiency

Quality K	Goal kg/m^3	w/c		water (ltr/m^3)		Cementius		Price (IDR)	
		FA 50	Slag cement 50	FA 50	Slag Cement 50	FA 50	Slag cement 50	FA 50	Slag Cement 50
100	149	0,670	0,754	163	166	243	221	395.940	400.190
200	249	0,554	0,630	171	174	308	277	413.879	417.701
300	349	0,458	0,526	178	182	389	346	438.197	441.215
400	449	0,379	0,439	186	190	492	432	470.279	471.946
500	549	0,313	0,367	194	198	620	539	511.874	511.418
600	649	0,259	0,307	202	206	780	671	565.181	561.524
700	749	0,214	0,256	210	214	979	834	632.950	624.607

From the table above with the comparison of the composition between Fly Ash and Cement Slag 50% for high rise building, for example taken K300 with FA 438.197 (IDR) and cement slag 441.215 (IDR) whereas for normal production cost without the use of both materials with the same quality is about 470 thousand, so the difference is about 30 million (IDR). If the production cost per year, for example, 1million/m^3 than the efficiency can be generated is 1 million x 30 million = 30 billion, so with the utilization of fly as and cement slag it can avoid the company from potential loss of the billions/ year. The cost of production is the number of costs incurred by industry to process raw materials into finished goods. By optimizing the available production factors optimally in order to produce optimal output.

6. CONCLUSIONS

With the implementation of Innovation the use of Fly Ash and Cement Slag and by experimental method, it can be concluded that :

1. The use of Fly Ash and cement Slag is needed to replace the role of cement and sand, and build a world of construction with an environmentally friendly.
2. The cement water factor (water dement ratio = w /c) greatly affect the concrete compressive strength. With the same w/c of compressive strength cement slag 50% bigger than Fly Ash that is equal to 21%.
3. Concrete compressive strength is influenced by cement water factor (water-cement ratio = w / c), nature and type aggregate, mixture type, workability, concrete (curing) treatment and age of concrete. In order to get the same workability the water usage of cement slag 50% is larger with averages 4 liters / m^3
4. The bigger usage of fly ash and cement slag materials made smaller production cost which can help the need for the development in the future

7. ACKNOWLEDGMENTS

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