DEVOTION Journal of Community Service

Volume 3, Number 4, February 2022
e-ISSN: 2797-6068 and p-ISSN: 2777-0915

UTILIZATION OF COAL COMBUSTION WASTE (FLY ASH) FOR GEOPOLYMER CONCRETE AS GREEN CONCRETE

Nugroho Arie Putranto

PT. Indah Karya (Persero)
nugroho.arie@indahkarya.co.id

KEYWORDS
Coal combustion waste, Fly ash, Geopolymer, Concrete

ARTICLE INFO
Accepted: January, 26th 20222
Revised: February, 13th 2022
Approved: February, 14th 2022

ABSTRACT

The use of Portland Cement as a paste in conventional concrete is still often the primary/favourite choice in civil engineering construction. In time, cement production will cause harm to the environment, especially in the production process, and the availability of natural raw materials in cement production will dwindle. Therefore, it is necessary to find an innovative alternative to replace cement utilization. From the test matrix that has been carried out, it can be concluded that the waste from burning coal (fly ash), can be used as a substitute for Portland cement, and also at the composition of 16 moles – the ratio of sodium silicate to sodium hydroxide of 1.5 has a strong quality much better compression than the composition when using a 100% Portland cement mixtureFrom the test matrix that has been carried out, it can be concluded that the waste from burning coal (fly ash), can be used as a substitute for Portland cement, and also at the composition of 16 moles – the ratio of sodium silicate to sodium hydroxide of 1.5 has a strong quality. much better compression than the composition when using a 100% Portland cement mixture.

INTRODUCTION

Basically, this research has the aim of utilizing Soda Ash waste into usable goods that can be used as a substitute for the use of Portland Cement as a building material for construction and other infrastructure development.

So far, concrete is known as the most popular building material (Meyer, 2005). This is because the basic ingredients are easily found and relatively cheap, and the technology used in the manufacturing process is relatively simple. However, lately the use of concrete has been receiving criticism more often, particularly from among those who care about the environment (Müldür, n.d.). The spotlight of attention is the emission of gases such as carbon dioxide (CO2) produced from the calcination process of limestone and combustion in cement production processes, requiring high temperatures in the production.

On the other hand, as the demand for construction materials such as concrete rises, the demand for cement raw materials also increases. Growth in Indonesian market show that cement consumption for the first half of 2008 increased by 21.1 percent from 15.5 million tons as of June 2007 to 18.8 million tons in June 2008. It is estimated that the cement consumption until the end of this year will reach 20.4 to 21.3 million tons. Production of one ton of portland cement will produce one ton of CO2 which is released into the atmosphere, which will in turn lead to the effects of global warming. CO2 contribution to global warming itself is approximately 65% (Davis & Gertler, 2015). Increased production of cement will increasing the amount of CO2 released into the atmosphere so that it will also accelerate the global warming process (Huntzinger & Eatmon, 2009).

In allusion to the contribution of the cement industry of to the total CO2 emissions, then we need to exert more efforts to reduce gas production rates that trigger a global warming, due the fact that the percent contribution of CO2 will continue to increase along with the increasing amount of cement production. Therefore it is important to find ways to replace cement in the concrete manufacturing process, or totally replace it with another material that is more environmentally friendly.

In this study fly ash is used with the following considerations:

1. Uses materials or waste materials resulting from coal combustion Geopolymer concrete is environmentally friendly because it uses waste materials that can pollute the environment and reduces CO_2 emissions from cement production (Davidovits, 1991).
2. Reduces the amount of cement consumption, so that geopolymer concrete is expected to have cheaper production costs compared to conventional concrete in which the amount of CO_2 emissions released into the air which is comparable to the amount of cement produced (Davidovits, 1991). This circumstance was what mostly encouraged us to find alternative materials to replace cement in concrete making.
3. Fly Ash is already a familiar material in the manufacture of concrete.

METHOD RESEARCH

The type of research carried out is by conducting trial error on each material composition. The test is carried out in a concrete laboratory and carried out an analysis of the sample as a whole.

Materials

a. Fly Ash

The researcher use material from coal combustion (fly ash) as cement replacement material. The fly ash used is from Paiton.

b. Portland Cement

In this case the cement is used as a comparison between conventional concrete and geopolymer concrete

c. Sand

d. Gravel

e. NaOH (*Sodium Hidroxyde*)

Sodium hydroxide is largely sold in the market. The form is solid and white and appears slightly dewy on the surface. Sodium hydroxide absorbs water and carbon dioxide from the air. In the event of direct contact with the skin, it will give heat and burns (causing skin irritation). In the manufacture of geopolymer concrete, sodium hydroxide is used as an alkaline activator (Hardjito, Wallah, & Rangan, 2004). As an alkaline activator, sodium hydroxide is used to react the elements Al and Si that are contained in the fly ash so as to produce a strong polymer bond

f. Na_2SiO_3 (Sodium Silicate)

Sodium silicate gel is like as a blob of glass with a greenish color. If left in the open air, this gel will eventually harden and look like glass. Therefore, sodium silicate is often referred to as water glass. Sodium silicate has a viscosity (thickness) between 0.4 - 600 000 cps (centi poise). This gel also has a pH between 3-9. In making this geopolymer concrete, sodium silicate has the function to accelerate the polymerization reaction occurring within the concrete. (Hardjito et al., 2004).

Synthesis

Techniques Data analysis is done by making a matrix of specimens with various compositions of mixtures of materials (Chung, 1974) (can be seen in the table below) and testing according to the duration of the sample life of each mixture.

a. Preparation of the research matrix specimen:

Table 1. Research Matrix Specimen

Type	Test Day 7	Test Day 14	Test Day 28	Test Day 56	XRD	Total
12 mol – ratio.0,5	3	3	3	3	3	15
12 mol - ratio.1,0	3	3	3	3	3	15
12 mol - ratio.1,5	3	3	3	3	3	15
12 mol - ratio.2,0	3	3	3	3	3	15
12 mol - ratio.2,5	3	3	3	3	3	15
14 mol - ratio.0,5	3	3	3	3	3	15
14 mol - ratio.1,0	3	3	3	3	3	15
14 mol - ratio.1,5	3	3	3	3	3	15
14 mol - ratio.2,0	3	3	3	3	3	15
14 mol - ratio.2,5	3	3	3	3	3	15
16 mol - ratio.0,5	3	3	3	3	3	15
16 mol - ratio.1,0	3	3	3	3	3	15
16 mol - ratio.1,5	3	3	3	3	3	15
16 mol - ratio.2,0	3	3	3	3	3	15
16 mol - ratio.2,5	3	3	3	3	3	15

b. Molar concentration used in the research were 12 mol, 14 mol, dan 16 mol

c. Composition of sodium silicate to sodium hydroxyde are 0,5 ; 1,0 ; 1,5 ; 2,0 ; 2,5

d. Sand and gravel used for making samples are treated the same for all variations

e. First shaped test specimens using mortar 50mm x 50mm.

f. Specimen test at age 7, 14, dan 28

Data collection is collected from the results of trials on the list of matrix data so that conclusions can be made which composition is the best that can be applied.

Analysis

In carrying out the analysis, the author uses several references or methods of conducting sample tests/trials based on the following standards:

1. Fine Aggregate
   a) Weight of sand (*ASTM C128-93*)

b) Humidity of sand (*ASTM C 556-89*)
c) Water infiltration in the sand (*ASTM C128-93*)
d) Weight of sand volume (*ASTM C 29 / C29M – 91*)
e) Cleaning of sand on organic materials (*ASTM C 40 – 92*)
f) Cleanliness of sand to mud (*ASTM C 117 – 95*)
g) Analysis of the filter (*ASTM C136 – 95A*)

2. Coarse Aggregate
   a) Humidity of gravel (*ASTM C 556-89*)
   b) Weight of gravel (*ASTM C 127 – 88 Reapp 93*)
   c) Water infiltration in the gravel (*ASTM C 127 – 88 Reapp 93*)
   d) Weight of gravel volume (*ASTM C 29/C 29 M – 91a*)
   e) Cleanliness of gravel to mud (*ASTM C 117 – 95*)
   f) wear tests of coarse aggregate (*ASTM C 131 – 89*)
   g) Analysis of the filter (*ASTM C1366 – 95A*)
3. The Specimens
   a) Slump test of concrete (*ASTM C 143 -78*)
   b) Concrete Porosity (*AFNOR NF B 49104*)
   c) compressive strength of concrete (*ASTM C 823 – 75*)
   d) splitting tensile strength (*ASTM C 496– 94*)

RESULT AND DISCUSSION

Table 2. Compressive Strength Results (Mortar)

Type	Age 7				Age 14				Age 28			
	1	2	3	rata-rata	1	2	3	rata-rata	1	2	3	rata-rata
PC 100%	256,37	256,55	256,08	256,333	288,4	287	287,9	287,767	Not Yet	Not Yet	Not Yet	Not Yet
12 mol - ratio.0,5	256,77	261,08	260,41	259,42	289,9	292,11	292,03	291,347	Not Yet	Not Yet	Not Yet	Not Yet
12 mol - ratio.1,0	262,73	261,88	262,41	262,34	301,18	301,2	301,28	301,22	Not Yet	Not Yet	Not Yet	Not Yet
12 mol - ratio.1,5	279,81	279,47	279,66	279,647	316,72	317	316,92	316,88	Not Yet	Not Yet	Not Yet	Not Yet
12 mol - ratio.2,0	263,41	261,96	262,36	262,577	303,21	303,14	303,5	303,283	Not Yet	Not Yet	Not Yet	Not Yet
12 mol - ratio.2,5	256,85	255,91	256,54	256,433	294,67	294,31	294,44	294,473	Not Yet	Not Yet	Not Yet	Not Yet
14 mol - ratio.0,5	268,91	269,12	269,03	269,02	309,79	310,11	310,1	310	Not Yet	Not Yet	Not Yet	Not Yet
14 mol - ratio.1,0	274,98	275,54	275,6	275,373	321,44	322,19	322,27	321,967	Not	Not	Not	Not Yet

									Yet	Yet	Yet	
14 mol - ratio.1,5	291,33	292,61	292,59	292,177	337,61	339,43	338,88	338,64	Not Yet	Not Yet	Not Yet	Not Yet
14 mol - ratio.2,0	280,67	279,98	279,9	280,183	324,47	324,39	323,99	324,283	Not Yet	Not Yet	Not Yet	Not Yet
14 mol - ratio.2,5	270,11	270,21	270,15	270,157	310,87	309,96	309,98	310,27	Not Yet	Not Yet	Not Yet	Not Yet
16 mol - ratio.0,5	294,51	296,77	296,55	295,943	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet
16 mol - ratio.1,0	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet
16 mol - ratio.1,5	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet
16 mol - ratio.2,0	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet
16 mol - ratio.2,5	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet	Not Yet

Unit : kg/cm2

Discussion

Coal combustion waste, in this case Fly Ash, can be used as a substitute for cement, so that with the addition of an alkaline silicate to the reactor a strong bond will be formed, and geopolymer can be used for making concrete. This technology is known as geopolymer concrete. Basically, this research has the aim of utilizing Soda Ash waste into usable goods that can be used as a substitute for the use of Portland Cement as a building material for construction and other infrastructure development. The research method used in this research is to use a sampling test method with various compositions of materials, that is using different levels of molarity (ranging from 12 moles, 14 moles, 16 moles), the ratio of sodium silicate to sodium hydroxide is 0.5; 1.0; 1.5; 2.0; 2.5, then for each composition a 50mm x 50mm mortar mold sample was made and the compressive strength of the mortar was tested at the age of the specimens at 7,14 and 28 days.

Coal combustion waste, in this case Fly Ash, can be used to replace Portland cement material (sodium silicate and sodium hidroxyde mixed into the mix design), where the production of cement can increase the amount of CO2 released into the atmosphere, and thus accelerate the global warming process. NaOH (Sodium Hidroxyde), sodium hydroxide is used as alkaline activator, wich is used to react Al and Si contained in the fly ash so as to produce a strong polymeric bond. Na2SiO3 (Sodium Silicate), sodium silicate is used to accelerate the polymerization reaction occurring within the concrete. From the compresive strength result, it can be seen that the Geopolymer concrete is better than conventional concrete Geopolimer concrete is represents an innovation in concrete technology and can be ascribed as Green concrete (“enviromental friendly”).

CONCLUSION

Coal combustion waste, in this case Fly Ash, can be used to replace Portland cement material (sodium silicate and sodium hidroxyde mixed into the mix design), where the production of cement can increase the amount of CO2 released into the atmosphere, and thus accelerate the global warming process.

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