Slag Cement Optimization on Flexture Strength of High Quality Concrete with Various Treatment

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Keywords: Slag Cement, Flexure Test, Concrete.

Abstract: Concrete technology to date continues to grow. The need for efficient constructions that are often viewed interms of concrete mechanical behavior, on-the-filed application, to the estimated cost of its implementation increasing lyrequire construction actors to optimize construction engineering materials, especially concrete engineering materials. Various types of concrete now a days have been developed according to its needs, one of which is high quality concrete.In designing high quality concrete, it should be noted that several factors will affect the achievement of the quality of the plan, which is cement. Environmental issues are now a national and international issue in every establishment and operation of the company that is about CO2 emissions from cement production and the existence of B3 waste from steel production. In this research the use of slag cement from PT.Indocement Indonesia as a substitute for the type I Portland cement in the substituted concrete mixture to create an environmentally friendly high quality concrete with high initial durability and strength. The use of slag cement optimization is coupled with the use of the Master Ease 3029 superplasticizer. This research aims to compare slag cement-based high-quality concrete and high-quality concrete with conventional mixture. From the result of the research which has been done on the concrete of 28 days of age, the average of absorption of slag cement concrete that happened at PDAM water, sea water, acid water, and compound curing compared to normal concrete is 13,952%, 13,724%, 18,835% and 47,511 %. The increase of slag cement concrete modulus on PDAM water, seawater, and acid water curing compared to normal concrete break modulus is 11,333%, 6,517%, and 10,858%. However, the fracture modulus of slag cement concrete of compound curing decreased by 1.670% compared to the normal concrete of compound curing. The maximum deflection is owned by high quality concrete with PDAM water treatment that is on the slag cement concrete of 0.77168926 mm and in the normal concrete of 0.168302511 mm. The result of crack pattern observation during the test can be concluded that the crack pattern that occurs on the concrete beam with various curing that is formed is in the middle of the beam between the load point which is 1/3 of the effective length of the beam. The slump value of both concrete showed results that did not give a significant effect due to the use of superplasticizer.

1 INTRODUCTION

Based on the Indonesian National Standard 03-6468-2000, high quality concrete is a concrete that has characteristics as a solid material unity with a compressive strength greater than 41.4 MPa. Often people think that to produce high quality concrete requires a lot of cement. However, the use of cement in large quantities will increase the heat of hydration. The high heat of hydration causes shrinkage and cracking in the beginning of the hardening process of concrete which can reduce the strength and durability of the concrete.

Environmental problems are now a national and international issue in every establishment and operation of the company that is about CO2 emissions and the existence of waste products from every activity.

Cement production produces CO2 emissions of about 7% of total CO2 emissions. Sources of CO2 emissions in cement production come from 50-55% calcined limestone (CaCO3), 40-50% fuel combustion and 0-10% of electric power. It is difficult to replace cement in producing concrete, but can be minimized by using supplementary cementitious materials such as Granulated Blast Furnace Slag (GBFS). (Gidion, 2013).

In Indonesia, many industries engaged in steel smelting and refining, including PT Krakatau Steel in West Java, which produces at least 150 tons of

Karolina, R., Syahrizal, ., Handana, M. and Syafitri, A.
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DOI: 10.5220/0010094203280331
In *Proceedings of the International Conference of Science, Technology, Engineering, Environmental and Ramification Researches (ICOSTEERR 2018) - Research in Industry 4.0*, pages 328-331
ISBN: 978-989-758-449-7

slag every day. Every ton of steel production produces 20 percent of slag waste. Slag by-products resulted from the steel smelting and refining companies can be utilized to be a more valuable materials through waste co-processing. If not utilized, the waste is included in the category of toxic and hazardous waste (B3). (PuslitbangJalandanJembatan, 2011).

In September 2017, two of Indonesia's largest cement companies developed technology and industrial waste utilization from other companies as raw materials to become a more valueable products and provide efficiency benefits to the company. One of the industrial waste companies that can be utilized for raw materials for cement-making is slag. (Keputusan Menteri Negara Lingkungan Hidup Nomor 231 Tahun 2010).

In good fineness, slag cement exhibits the same or higher quality compared to portland cement (type I) and has the "Low Heat Hydration" property that produces low hydration heat and CO2 emissions produced when the production is very low. Therefore, , can replace portland cement function with a certain mass comparison ratio. Various replacement levels (Substitutions) starts from 30% - 70%. (Semen Indonesia, 2017).

2 MANUSCRIPT PREPARATION

Slag cement is the result of *Granulated Blast Furnace Slag* addition which has a slag / clinker property into a final mill of cement at the finish mill as an additional substitution material. The content of the dominant chemical composition in slag contains iron oxide and silicate. The physical and chemical composition of the slag is similar to a blast furnace slag or clinker.

Production of Ground Granulated Blast Furnace Slag requires a little extra energy compared to the energy needed for Portland cement production. The replacement of Portland cement with GGBFS will lead to significant reductions in carbon dioxide emissions. Therefore, construction materials are environmentally friendly. GGBFS with modern technology can replace as much as 30% to 80% of Portland cement used in concrete.

GGBFS has better water impermeability characteristics as well as improved resistance to corrosion and sulfate attacks. GGBFS can increase lower hydration heat which reduces the risk of cracking. In addition, it has a higher resistance to the sea and sulfate, workability, reduce permeability, which helps in making, placing and compacting. And fix the final settlement and give a bright color on the concrete. The chemical element content in the slag cement can be seen in table 1 below.

Table 1 Chemical elements in *stell slag*

Oxide	% Weight
CaO	51,68
SiO_2	29,59
Al_2O_3	10,05
Fe_2O_3	2,59
MgO	2,11
S^{2-}	0,22
as Na_2O	0,44
SO_3	2,31
LOI	0,21
IR	0,95
If Cao	0,18
Cr^{6+}	0,52

Source : Indocement, 2017

Table 2 Slag cement physical characteristics

Description	Test Result
Water content, %	5,4
Blaine, Fineness, m^2/kg	388
Residue 45 mm, %	5,9
Autoclave Expansion, %	0,00
Shrinkage, 28 days	0,08
Compressive Strength :	
3 Days, kg/cm^2	107
7 Days, kg/cm^2	161
28 Days, kg/cm^2	358
Normal Consistency, %	26,13
Time of Setting, Vicat Test:	
Initial Set, min	260
Final Set, min	238
False Set, %	87
Heat Hydration:	
7 Days, cal/g	50
28 Days, cal/g	57

Source: Indocement, 2017

2.1 Fine Aggregate

Fine aggregate (sand) is derived from the natural disintegration of natural rocks or artificial sand resulted from stone crusher and has a 5 mm grain size. The fine aggregate to be used shall meet the specifications set by ASTM. If all the existing specifications have been met, then it can be said that the aggregate is a good quality.

2.2 Coarse Aggregate

Coarse aggregate (gravel / split) are derived from natural disintegration of natural rocks or in the form of split produced by stone crusher, and has grain size between 5-40 mm.

2.3 Water

Water is needed on the manufacture of concrete to trigger cement chemical processes, moisturize aggregates and provide ease in concrete work. Water containing harmful compounds, contaminated with salt, oil, sugar, or other chemicals, when used in concrete mix, it will degrade the quality concrete, can even change the properties of the resulted concrete.

2.4 Superplasticizer

Superplasticizer used in this high quality concrete mix is *Master Ease 3029*. *Master Eease 3029* is a type of *high range water reducesuperplasticizer* produced by BASF. Master Ease is designed to provide high rheological properties in fresh concrete thus enhancing the ease of placement and completion of concrete, as well as concrete pumping for all construction activities.

2.5 Concrete Treatment (curing)

This treatment is done so that the next hydration process is not disturbed. If this happens, the concrete will crack due to the rapid loss of water. The treatment is done at least 7 days and the high initial strength concrete is minimum for 3 days and must be maintained in humid conditions, unless it is done with an accelerated care. (PB, 1989: 92). Concrete treated for 7 days will be stronger about 50% than the untreated concrete. (Paul Nugraha, 2007). In concrete treatment the means and materials and equipments used will determine the properties of hard concrete made, especially in terms of strength. In this test, two different ways of treatment are soaked (PDAM water, seawater, acid water) and compound curing.

2.6 Crack

If the new concrete dries quickly, the surface will experience a tensile stress higher than its tensile strength. This will cause cracks. Cracking may also occur when there is a high temperature difference (up to 200c) between the inner and outer part of the concrete, due to the difference of expansion.

2.7 Durability

The amount of damage that arises depends heavily on the quality of concrete, although in extreme conditions, even a well-protected concrete will be destroyed. Extremely dangerous outer material attacks usually can not be avoided completely due to natural conditions and also increase the cost of making concrete. Protection against attacks can be done by improving the quality of concrete so as to provide defense of the concrete significantly.

3 CONCLUSIONS

Based on the research that has been done, it can be concluded that:

- *Slump flow test* between normal concrete and *slag cement* concrete did not show any significant effect on *workability.*
- Concrete absorption value of normal concrete of PDAM water, acid water and compound curing decreased compared to normal concrete of sea water curing that is equal to 24,114%, 186,888%, 53,144%. While concrete absorption value of slag cement concrete of PDAM water, acid water and compound curing decreased compared to slag cement concrete of sea water curing that is equal to 24,363%, 200,685%, 98,642%.
- The absorption average decrease of slag cement concrete occurring in PDAM water, sea water, acid water, and compound curing compared to normal concrete is 13,952%, 13,724%, 18,835% and 47,511%.
- Based on the results of absorption test with different water PH treatments showed that the higher PH water used in concrete treatment will also result in a high absorption value.
- The fracture modulus of normal concrete of seawater, acidic water, and compound curing has been decreased compared to the normal concrete of PDAM water curing which is 12.343%, 9.554%, 29.331%. While the slag cement concrete fracture modulus of seawater, acid water, and compound curing also decreased compared to slag cement concrete of PDAM curing that is respectively 17,423%, 10,023% and 46,364%.
- The magnitude of the increasing fracture modulus of slag cement concrete on PDAM water, sea water, and acid water curing compared to normal concrete fracture

modulus is 11.333%, 6.517%, and 10.858%. However, the slag cement concrete fracture modulus is decreased by 1.670% compared to the normal concrete of compound curing.

- Concrete treatment with PDAM water has a greater maximum moment compared to other concrete treatments. In addition, the maximum moment of high quality concrete with slag cement concrete is higher compared to high quality concrete with normal concrete with various treatments that has been done.
- The result of crack pattern observation during the test can be concluded that the crack pattern that occurs in the concrete beam with various treatments (curing) formed is in the middle span of the beam between the load point that is 1/3 of the effective length of the beam.

The maximum deflection is owned by high quality concrete with PDAM water treatment that is on the slag cement concrete of 0.77168926 mm and on the normal concrete of 0.168302511 mm.

ACKNOWLEDGEMENTS

Thank you to KEMENRISTEK DIKTI for funding this research.

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