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The Compressive Strength of Geopolymer Concrete Based on the Fineness Level of Fly Ash

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Abstract: Utilization of fly ash as cement substitution that serves as the connective material has the potential to be used in the manufacture of concrete material. Engineered fly ash becomes an adhesive by a chemical reaction with an activator contains siliceous produces a new type of material called a geopolymer. Geopolymer concrete production allows the full replacement of the cement in concrete construction applications. The aim of this study is to determine the optimum composition mixture and the behavior of the compressive strength of geopolymer concrete due to the fineness of fly ash. F-type fly ash which comes from the power plant Tanjung Enim is filtered into 4 zones before it used. It produces the level of fineness based on fall zone. NaOH and Na_2SiO_3 used as the activators. The research activities carried out with the manufacture of the cylinder and use the combined activator solution of NaOH and Na_2SiO_3. The ratio of the activator to the fly ash is 0.25, 0.35 and 0.45. Compaction method with stabbing and curing for the ambient temperature without any special treatment are used for the producing of geopolymer concrete. Effect of fineness level of fly ash based on zones falls (0, 1, 2 and 3) and the ratio of activator/fly ash to conduct compressive strength of geopolymer concrete contribute in increasing the compressive strength of geopolymer concrete maximum of 191.42%.

Key words: Fineness, geopolymer, fly ash, compressive, utilization, Tanjung Enim

INTRODUCTION

The research which develops 100% of cement substitution with fly ash showed good results in the development of concrete material. Fly ash is engineered to become a binder by chemical reaction by using the activator which contains siliceous form a new material called geopolymer. The characteristic of the fly ash makes it possible to substitution (Fernandez-Jimenez and Palomo, 2003). Utilization of fly ash as a replacement for the whole cement and serves as a connective material has the potential to be used in the manufacture of concrete material (Hardjito and Rangan, 2005; Neville, 2000; Palomo *et al*., 1999). Fly ash is engineered to be an adhesive through a chemical reaction with an activator type siliceous material produces a new type called a geopolymer (Abdul Aleem and Arumairaj, 2012).

The type and characteristics of fly ash used in the manufacture of geopolymer concrete allows for the replacement of the entire cement in concrete construction applications. Initial studies on the effect of the fineness level of fly ash to the compressive strength of geopolymer mortar showed that the characteristics of fly ash based on the level of fineness obtained from filtering and differentiated treatment in accordance with the fall zone of influence the compressive strength of mortar (Firdaus, 2015). This study is a follow-up research aimed to determine the effect of the fineness of fly ash to the compressive strength of geopolymer concrete and determine the composition of the optimum mixture ratio of activator use of Sodium Silicate and Sodium Hydroxide (Potassium) against fly ash content on the mechanical properties of geopolymer concrete compressive strength.

MATERIALS AND METHODS

The variables in this study, consisted of 4 fly ash fineness levels, 3% of activators and 4 test ages. All the variables were compared according to the parameter of compressive strength. Each of the variables is listed in Table 1.

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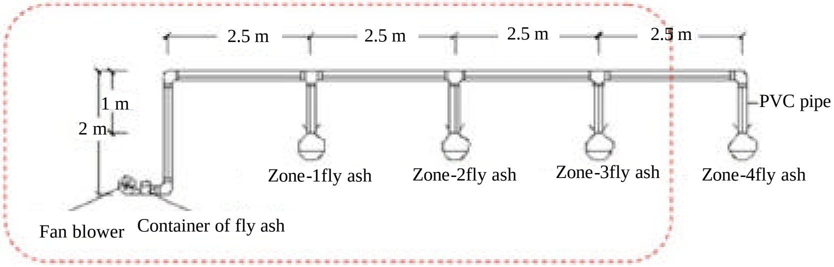

Fig. 1: Fly ash filterung based on fall zone

Table 1: Variables and parameter of the specimens

Fly ash fineness level	Percentage of activator	Type of specimens	Quantity	Total quantity of specimens
Z0	0.25 (P1)	Z0-G1-P1	3	9
	0.35 (P2)	Z0-G1-P2	3	
	0.45 (P3)	Z0-G1-P3	3	
Z1	0.25 (P2)	Z1-G1-P1	3	9
	0.35 (P3)	Z1-G1-P2	3	
	0.45 (P4)	Z1-G1-P3	3	
Z2	0.25 (P2)	Z2-G1-P1	3	9
	0.35 (P3)	Z2-G1-P2	3	
	0.45 (P4)	Z2-G1-P3	3	
Z3	0.25 (P2)	Z3-G1-P1	3	9
	0.35 (P3)	Z3-G1-P2	3	
	0.45 (P4)	Z3-G1-P3	3	

Tabel 2: Geopolymer concrete mixture proportions

	Rasio aktivator (%)		
Materials	0.25	0.35	0.45
Fly ash (gr)	1101.60	1101.60	1101.60
Sand (gr)	688.50	688.50	688.50
Coarse agregate	2257.66	2257.66	2257.66
Sodium silicate (Water glass); (gr)	123.18	168.02	221.60
Sodium hydroxide (Potasium); (gr)	48.10	66.90	87.90
Air (gr)	275.40	275.40	275.40
Super plastizer (gr)	4.54	4.54	4.54

Fly ash obtained from the source is not used directly as a mixture of concrete but do fall within the parameters based treatment that affects the fineness level of fly ash. The type and the treatment of fly ash on the last study (Firdaus, 2015) used in this research as well. It was treated based on the fall-zone parameter which indicates the fineness of the fly ash. Moreover, the fly ash fall zone parameter was modified with fly ash filtered tools (Fig. 1).

In this research, the fineness of fly ash samples was determined by 4 equally divided fall zones based on distance. Furthermore, fly ash which fell on each of the zones was used as an ingredient in the mixing of different geopolymer concrete specimens.

The previous study which used 5 zones of fly ash to produce the compressive strength of mortar, showed the relatively identical (not increase significantly) for the Zone 4 and 5. Therefore, this research on the geopolymer concrete is determined by using 4 of fall zones. Three mixtures of geopolymer mortar were prepared with the composition of each mixture, differentiated only by the amount of activator used. The composition of the mixtures can be seen in Table 2.

RESULTS AND DISCUSSION

Compressive strength tests were conducted on the geopolymer concrete cylinder specimens with the type of activator sodium silicate and sodium hydroxide (Potassium) with a ratio to the fly ash content of 0.25, 0.35 and 0.45% and the level of fineness of fly ash divided into Z0, Z1, Z2 and Z3. The compressive strength of geopolymer concrete was measured by the testing at 28 days and the average value can be seen in Table 3.

Figure 2 shows a graph of the average compressive test results of geopolymer concrete. The use of the ratios of Sodium Silicate and Sodium Hydroxide (Potassium) as the activators mixed with the fly ash based on the level of fineness (Z) show the effects of the compressive strength. It can be seen clearly that the compressive strength of geopolymer concrete with P1(ratio 0.25%) has a compressive strength, respectively for 10.49, 4.45, 5.89 and 10.19 MPa at the fineness level Z0, Z1, Z2 and Z3. Comparing with the concrete of Zone 0, the compressive strength of the each zone of concrete decrease significantly with a decline of 57.58, 43.85, 2.86%, respectively.

The higher of ratio activator to the fly ash gives a better compressive strength value. The ratio of activator to the fly ash of 0.35 and 0.45% demonstrate the higher compressive strength at each of fineness level. An increasing of 150 and 134%, respectively for the Z2 and Z3 for the ratio of 0.35, 106 and 183%, respectively for the Z2 and Z3 for the ratio of 0.45%.

Table 3: Compressive strength of geopolymer concrete

	Compressive strength (MPa); Rasio of activator (%)		
	0.24	0.35	0.45
Fineness levels	P1	P2	P3
Z0	10.49	9.10	10.80
Z1	4.45	6.79	6.57
Z2	5.89	22.76	22.23
Z3	10.19	21.33	30.57

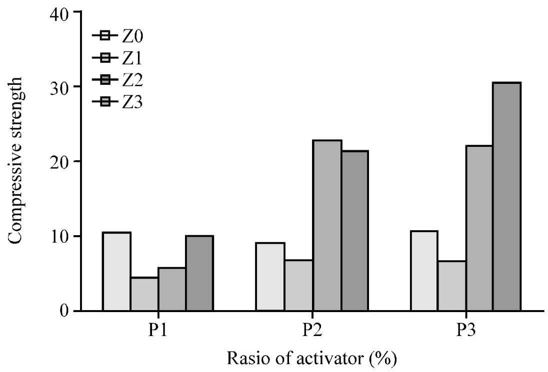

Fig. 2: The compressive strenght geopolymer concrete

On the contrary, the compressive strength of the Z1 in each of ratio of the activator to the fly ash decreases significantly. The fly ash of Z1 is provided from the closest zone, accordingly, it consists of homogeny gradation of the coarser particles. Comparing with the Zone 0 which consist of the good gradation the zone 1 is worse. This may cause, the compressive strength of the Zone 1 concrete decreased. However, the farther zone produce the finer particles and the finer has the good reactivity, therefore the trend of the compressive strength at each of mixture of ratio increases.

Overall, based on the ratio of activator, the trend of compressive strength is increasing due to the reactivity of activator and reactivity of the finer fly ash.

CONCLUSION

The fineness of fly ash which is determined based on the fall zone of filtering process influence the compressive strength. The further fall zone which shows the finer fly ash increases the compressive strength. Consequently, the maximum compressive strength is achieved by a mixture of concrete Z3-P3 of 30.57 MPa with an increase of 183.06% from the original mix with fly ash (Zone 0) with a specimen code Z0-P3.

The higher of ratio activator to the fly ash gives a better compressive strength value. Due to the increasing ratio of the activator sodium silicate and sodium hydroxide (Potassium) and the finer fly ash affect the compressive strength of geopolymer concrete, it can be concluded that the amount of activator and the reactivity of the finer fly ash affect the compressive strength.

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REFERENCES

Abdul Aleem, M.I. and P.D. Arumairaj, 2012. Optimum mix for the geopolymer concrete. Indian J. Sci. Technol., 5: 2299-2301.

Fernandez-Jimenez, A. and A. Palomo, 2003. Characterisation of fly ashes. Potential reactivity as alkaline cements. Fuel, 82: 2259-2265.

Firdaus, Y.I., 2015. Pemanfaatan Fly ash Berdasarkan Tingkat Kehalusan Dalam Rekayasa Mortar Beton Geopolimer. Konferensi Nasional Teknik Sipil ke-9. Makasar, Indonesia.

Hardjito, D. and B.V. Rangan, 2005. Development and properties of low-calcium fly ash-based geopolymer concrete. Master Thesis, Curtin University, Perth, Western Australia.

Neville, A.M., 2000. Properties of Concrete. Prentice Hall, Upper Saddle River, New Jersey, USA.,.

Palomo, A., M.W. Grutzeck and M.T. Blanco, 1999. Alkali-activated fly ashes: A cement for the future. Cem. Concr. Res., 29: 1323-1329.