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THE INFLUENCE OF MODIFIED FLY ASH PARTICLES BY HEATING ON THE COMPRESSIVE STRENGTH OF GEOPOLYMER MORTAR

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1. Introduction

Every day, the world is generated large quantities of waste materials, such as: water, oils, solvents and solid waste (fly ash, glass, stone powder, mine tailings, etc). Fly ash has emerged as a material with high potential applications in construction because it has a chemical composition similar to Portland cement, cheep material, low density, good dispersion and fluidity[1,2]. However, the scope application of fly ash is very limited due to fly ash is grey or black in color; using only to product where color is not important. For this reason, a heating method was necessary to be developed to increase the whiteness of fly ash.

The purpose of this research is whitening the fly ash to compete with other filler materials. And compared the influence of adding fly ash before and after modified by high temperature in order to obtain the compressive strength and the hardness of geopolymer mortar is investigated. Experimental results show that high temperature is effective method to purify fly ash, high whiteness of the particle which increased with the calcination temperature and slightly reduced the hardness of geopolymer mortar.

2. Experimental

Geopolymer mortar prepared by mixing from calcined shale fly dust from rotary kiln as binder (Si/Al ratio of 2.0) with alkali activator containing NaOH and Na_2SiO_3 with modulus 1.50–1.95. Next the mixture was mixed with fine sand and fly ashes as filler[3]. Compressive strength testing of mortar was performed as per AS 1012.9 using (ø 50 × 100) mm diameter cylindrical moulds.
Fly ashes used in this study came from different sources in Czech Republic. The fly ashes were already classified into 2 names of city and coded such as: OPE (Elna Opatovice), PRT (Pražská Teplárenská).

Fly ashes are heated to improve the whiteness at certain temperature using a furnace. Around 1 kg fly ashes was heated in a furnace to 200 °C, 400 °C, 600 °C, 800 °C and 1000 °C at a heating rate of 5 K/min and with a soak time of 1 hour at the maximum temperature and finally annealed down to room temperature. The exact weight of fly ashes before and after heating was measured by using an analytical balance with a resolution of 0.1 mg. Fig. 1 shows that the weight loss of fly ash samples at temperature below 200 °C is small (less than 0.2 %), it indicates that as-received fly ash samples are relatively dry. When fly ash samples are further heated, the weight loss will be increased and the maximum of weight loss is at around 1000 °C. Fig. 2 shows fly ash particles before and after heating at 1000 °C.

Fly ash particles are generally spherical in shape and range in size from 1 μm to 20 μm. Figs. 3 and 4 show the SEM photographs and corresponding energy spectrum of fly ash OPE, PRT before and after heating at 1000 °C. After heating at high temperature, fly ash particles may suffer sever degradation, pitting, buckling, and breakage, which all can eventually regress the mechanical property of matrix. Tab. I shows the summary chemical composition of fly ashes.

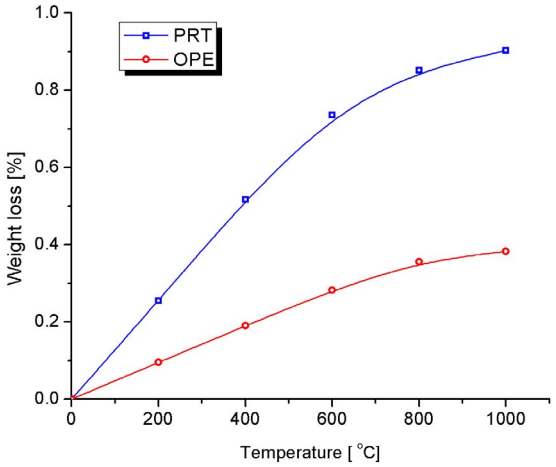

Fig. 1. **The weight loss as a function of heating temperature**

Fig. 2. **The photograph of fly ash OPE, PRT before (grey) and after heating at 1000 °C (brown)**

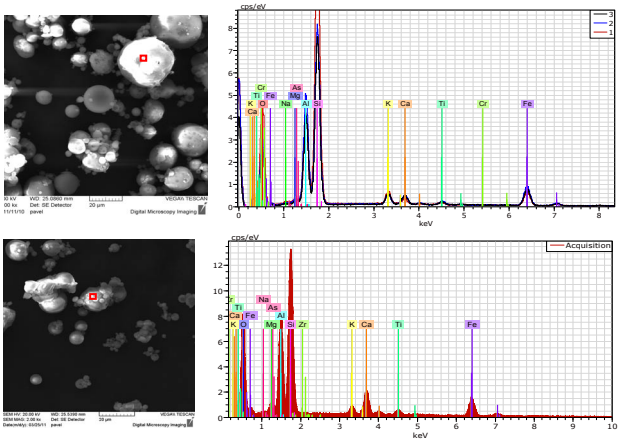

Fig. 3. **SEM photographs and corresponding energy spectrum of fly ash OPE before (above) and after heating at 1000 °C (under)**

Table I
The calcination dependent composition of fly ashes

Atomic [%]	PRT	PRT 1000 °C	OPE	OPE 1000 °C
Na	0.77	0.63	0.47	0.61
Mg	1.17	0.70	0.43	0.53
Al	10.89	4.50	12.64	13.88
Si	25.17	33.56	28.54	22.47
K	1.70	0.83	1.27	1.42
Ca	0.93	1.06	0.97	4.64
Ti	0.53	0.50	0.41	1.06
Fe	3.68	1.76	2.44	8.78
As	0.10	0.03	0.11	1.29
Cr	-	-	0.08	0.08
O	55.06	56.43	52.65	45.24

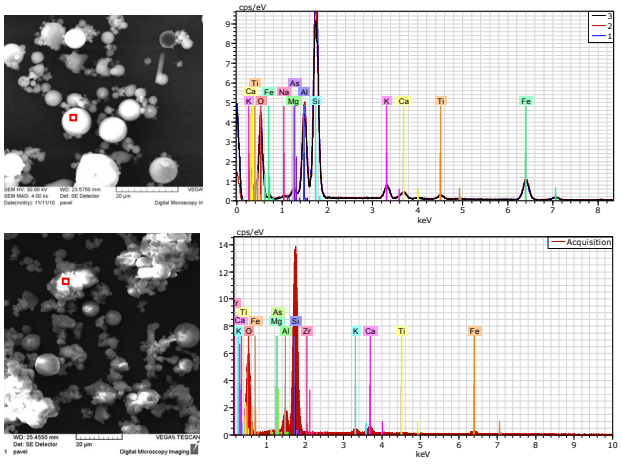

Fig. 4. **SEM photographs and corresponding energy spectrum of fly ash PRT before (above) and after heating at 1000 °C (under)**

3. Results

The obvious color difference can be observed by a naked eye for samples in Figs. 5–7.

This high processing temperature can have significant influence on the final properties of the geopolymer mortar.

Fig. 5. **The photograph of geopolymer mortar based on fly ash OPE, PRT before (grey) and after heating at 1000 °C (brown)**

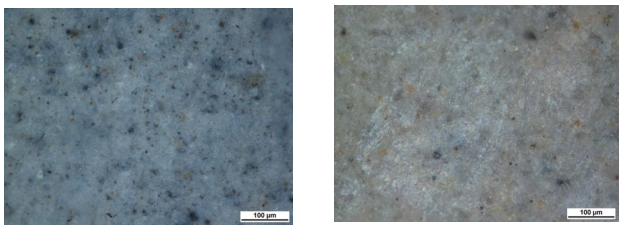

Fig. 6. **SEM photographs geopolymer mortar based on fly ash OPE before (left) and after heating at 1000 °C (right)**

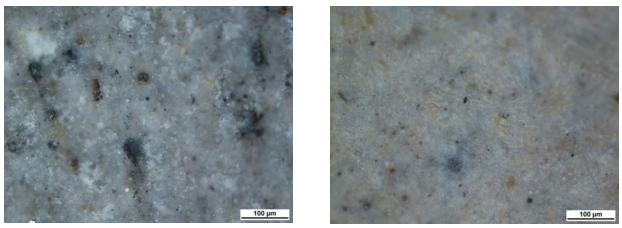

Fig. 7. **SEM photographs geopolymer mortar based on fly ash PRT before (left) and after heating at 1000 °C (right)**

Tabs. II and III present the hardness and density of geopolymer mortar based on fly ashes PRT, OPE before and after modified particles by heating at 1000 °C.

After heating fly ash particles at 1000 °C, the hardness and compressive strength of samples can be reduced slightly but not much in Figs. 8 and 9.

4. Conclusions

The purpose of this research is using the method of calcination temperature to whitening the fly ash to compete with other filler materials. It is evident from the above

Table II
Properties of geopolymer mortar before and after heating PRT fly ash (FA) particles at 1000 °C

Water/fly ash [%]		0.25	0.33	0.37	0.40
Original FA	Density [g/cm^3]	1.75	1.62	1.47	1.53
	Hardness [HV]	353±7	279±5	198±6	146±3
FA at 1000 °C	Density [g/cm^3]	1.73	1.56	1.42	1.46
	Hardness [HV]	346±7	249±7	163±6	132±3

Table III
Properties of geopolymer mortar before and after heating OPE fly ash (FA) particles at 1000 °C

Water/fly ash [%]		0.21	0.33	0.35	0.42
Original FA	Density [g/cm^3]	1.77	1.67	1.53	1.51
	Hardness [HV]	312±9	282±9	231±6	141±6
FA at 1000 °C	Density [g/cm^3]	1.54	1.54	1.36	1.38
	Hardness [HV]	247±4	267±8	189±3	125±4

observations that the high temperature has considerable effect on the surface morphology and pitting of the fly ash particles. The study are used fly ash particles as filler, the particles after heated at high temperature will soften and may have adverse effect on the structural and reduced mechanical properties of the geopolymer mortar. Thus, authors recommend this method use in fine art sculpture, architecture, especially where color is more important than the mechanical properties.

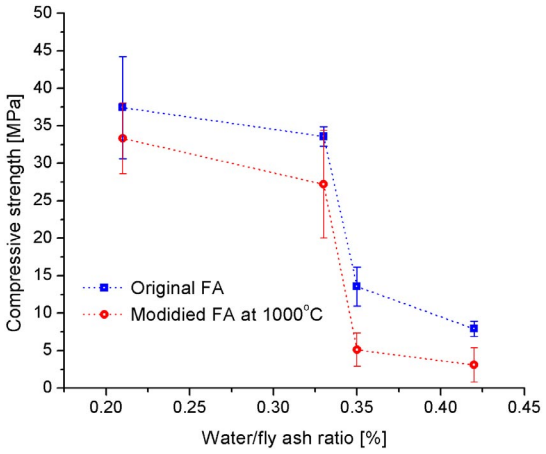

Fig. 8. **Compressive strength of geopolymer mortar based on fly ash PRT**

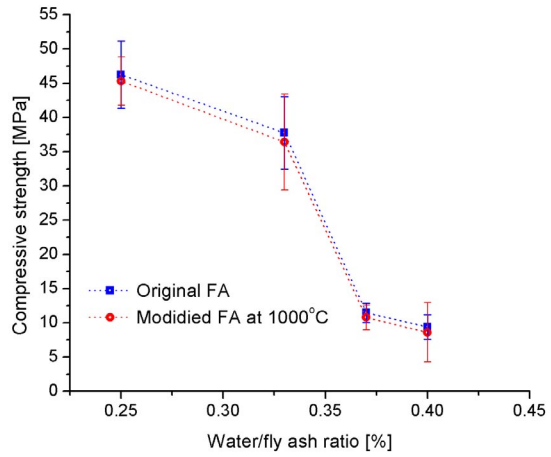

Fig. 9. **Compressive strength of geopolymer mortar based on fly ash OPE**

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N. Xiem, P. Louda, D. Kroisová, N. Trung, and N. Thien *(Department of Material Science, Faculty of Mechanical Engineering, Technical University of Liberec, Czech Republic):* **The Influence of Modified Fly Ash Particles by Heating on the Compressive Strength of Geopolymer Mortar**

In this study, 2 types of fly ash from Czech Republic power plants were investigated with respect to composition. Fly ashes particles are heated at high temperature up to 1000 °C to remove the contaminant (unburnt carbon) and the color become brighter can be observed by a naked eye. However, the high processing temperatures can slightly influence on the final properties of the fly ash and geopolymer mortar. After heating fly ash particles at 1000 °C, the compressive strength of samples can be reduced slightly when comparing with original fly ash.