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Possibility of Coal Combustion Product Conditioning

Tomasz Z. Błaszczyński[1], Maciej R. Król[2]

[1]Technical University of Poznań, Piotrowo 5, 60-965 Poznań, Poland
[2]Technical University of Koszalin, Śniadecki 2, 75-453 Koszalin, Poland

Abstract. This paper is focused on properties of materials known as green binders. They can be used to produce aluminium-siliceous concrete and binders known also as geopolymers. Comparing new ecological binders to ordinary cements we can see huge possibility of reducing amount of main greenhouse gas which is emitted to atmosphere by 3 to even 10 times depending of substrate type used to new green material production. Main ecological source of new materials obtaining possibility is to use already available products which are created in coal combustion and steel smelting process. Most of them are already used in many branches of industry. They are mostly civil engineering, chemistry or agriculture. Conducted research was based on less popular in civil engineering fly ash based on lignite combustion. Materials were examine in order to verify possibility of obtaining hardened mortars based of different factors connected with process of geopolymerization, which are temperature, amount of reaction reagent and time of heat treatment. After systematizing the matrices for the basic parameters affecting the strength of the hardened mortars, the influence of the fly ash treatment for increasing the strength was tested.

1. Introduction

Need of new binders searching is strictly connected with problem of climate changes. Process of temperature rising which effect on climate change, and state of environment is without doubt undesirable process. Derivative of temperature rise is amount of carbon dioxide in the atmosphere [1]. Cement industry is being responsible on up to 9 % of global anthropogenic CO_2 emission (data for year 2016) [2, 3]. Lately this amount had risen from 3 in year 2000 [4]. Future perspectives for reduction are not looking acceptable. In some ways, cement industry has been doing more to the green agenda than other great producers of greenhouse gasses like fossil fuel energy companies or large utilities. Cement companies owners have signed up to voluntary emissions reductions, reassured they will do more than in last years to produce the materials needed for a low carbon environment. It is strictly connected with building hydropower dams or fixing wind turbines. In less than 15 years from now even the fact of stopping acceleration of cement production and introducing technologies of CO_2 emission like carbon capture and storage (CCS) [5], speculation about amount of cement production due to worlds carbon dioxide production does not look satisfactorily (figure 1).

Possibilities of making the cement industry more economical and at the same time ecological are plural. Unfortunately, not all treatments offer significant reductions in greenhouse gas emissions. Relative reduction of energy consumption, transport and its use in the process and maintenance of the industry in the form of electricity, even by 20 or 30% will reduce the total reduction by only 2-3%. In addition, the calcination-related production process, which cannot be changed, does not provide the opportunity to reduce almost half of the CO_2 value attributed to clinker cement.

Future possibilities of reducing carbon dioxide production are limited. Three different forecast describing future possibilities of reducing emission have been introduced (figure 2). Carbon share projections have been developed on the basis of predicted cement production data for years 2017-2030. The carbon dioxide emissions per 1t of cement produced were set at 2016. Global production has assumed a constant emission from fossil fuels. Forecast I does not include significant introduction of geopolymer binders. Their share is limited to the production of specialized materials and production by small companies already using the technology of geopolymer cements.

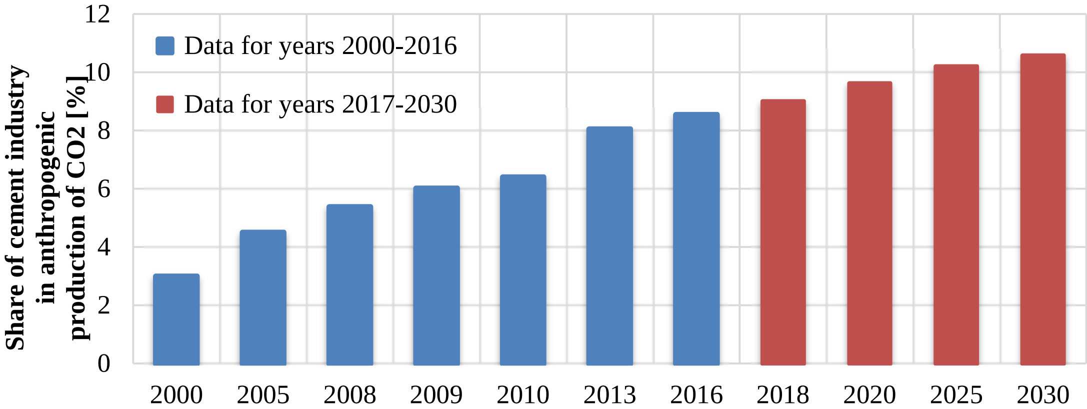

Figure 1. Actual and perspective of future share of cement industry in anthropogenic production of CO_2 [2- 4, 6].

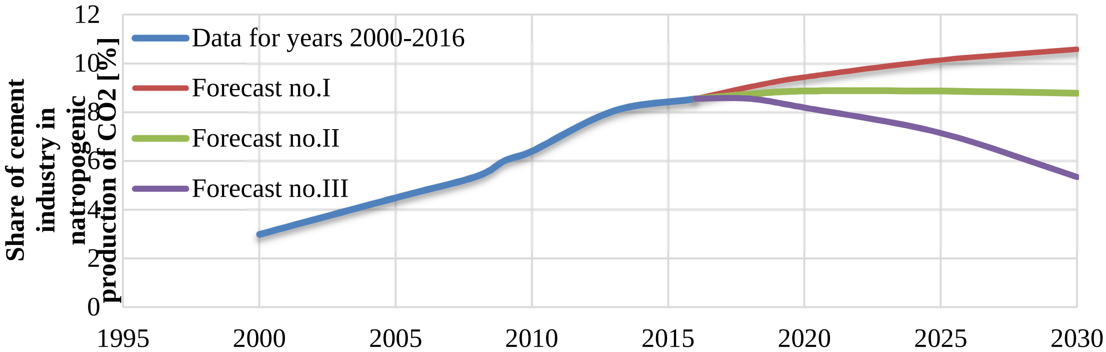

Figure 2. Actual and perspective of future share of cement industry in anthropogenic production of CO_2 with forecasts assuming replacing Portland cement by green binders [2-6].

Forecast concept II takes into account the replacement of 25% of clinker cement produced with green binder produced from waste substances such as fly ashes and blast furnace slags from current production. Concept III assumes that at least half of cement production will be replaced by geopolymer binder produced both from waste materials and dedicated material, i.e. produced specifically for the production of geopolymers. As can be seen from forecast II, the growth of carbon dioxide production is halted, while in forecast III, the value of greenhouse gas emitted into the atmosphere, despite huge quantities of cement produced, is significantly declining.

2. Research base

The fly ash derived from the combustion of lignite with significant calcium content was used for the study. In the samples identified, the CaO content ranged from 8 to 15%. Samples were not cleaned of unburned carbon, which was in the composition of about 3 to 5% (table 1). The only treatment for ash was the reduction of grain size by ash grinding. During the grinding process, a noticeable change in the screening curve was observed (figure 3).

Table 1. Chemical content of subjected for research calcium fly ash.

SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MgO	CaO	Na_2O	K_20	Ignition loss
44,17	21,79	4,58	1,85	1,49	21,06	0,23	0,19	4,64

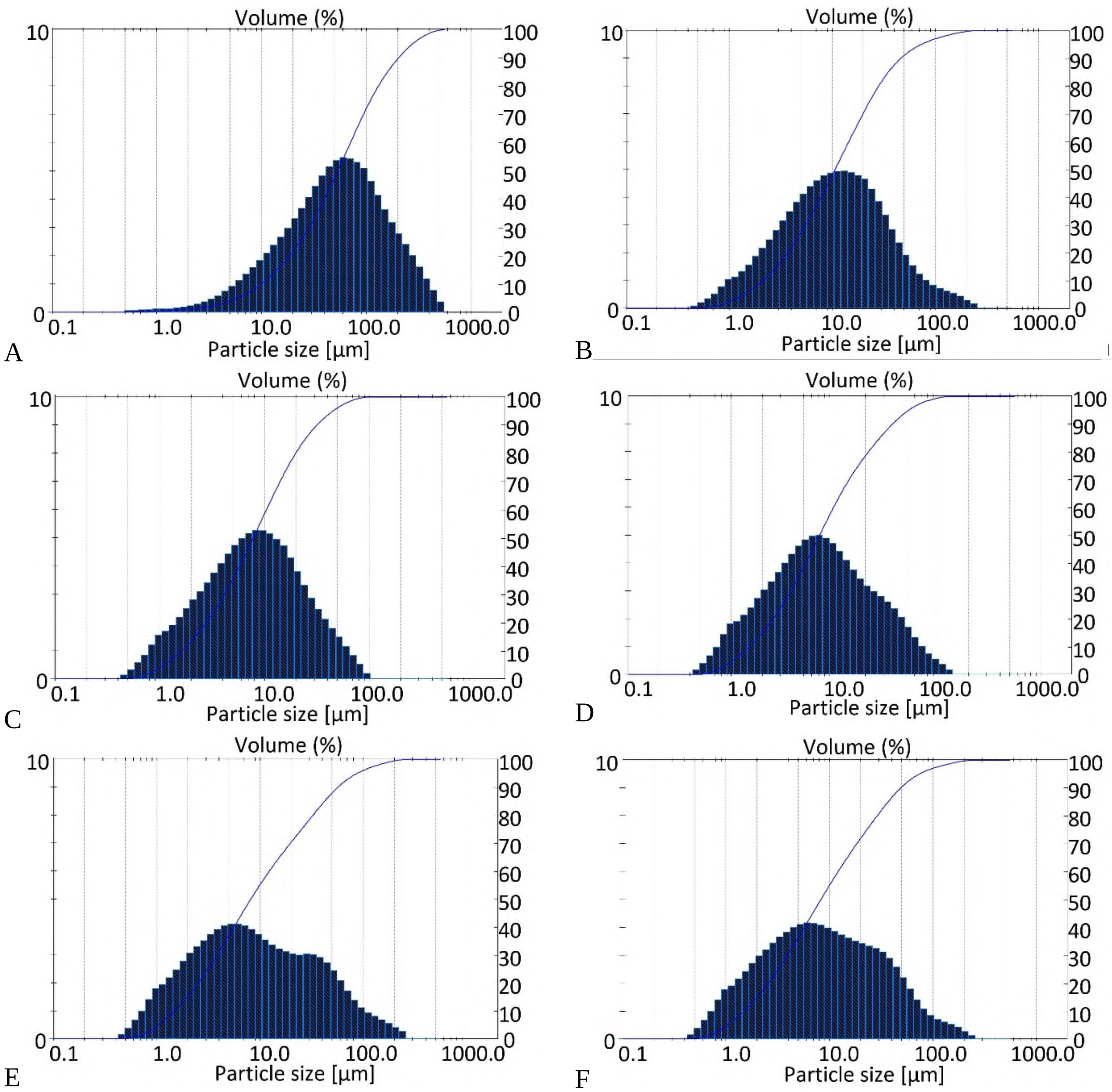

Figure 3. Graphs of grinded and subjected to ultrasound wave fly ash used for research A) original, not subjected to grinding sample., B) sample grinded for 30 s., C) sample grinded for 60 s., D) sample grinded for 120 s., E) sample grinded for 180 s., E) sample grinded for 240 s.

Most preferred in terms of maximum fragmentation was milling in time of 60 seconds. In the course of fractions it gives the highest ash content of less than 45 microns. A further increase in grinding time resulted in the opposite effect, in the material began to form agglomerates. The next stage of treatment was to subject the material to an ultrasound wave that broke up the formed agglomerates, making the sample the most crushed to be the sample milled by 120 seconds. The degree of fragmentation described by the specific surface in this case corresponded to the obtained compressive strength of the test samples.

3. Results

Grounded fly ash was used to create geopolymer binders. Activation took place with aqueous NaOH solution. The binder was used to form beams 40x40x160 mm. The most optimal water-binder ratio was W/B = 0.50 and the molar concentration of NaOH in water was 8M. For the first 12h of maturation, they were placed in a low temperature furnace at 85 °C, then after 24 hours they were disassembled and subjected to testing. Rest of samples assigned for subsequent tests, were placed in air-dry conditions with a relative humidity of 50% and a temperature of 20 °C. According to conducted earlier tests (figure 4)

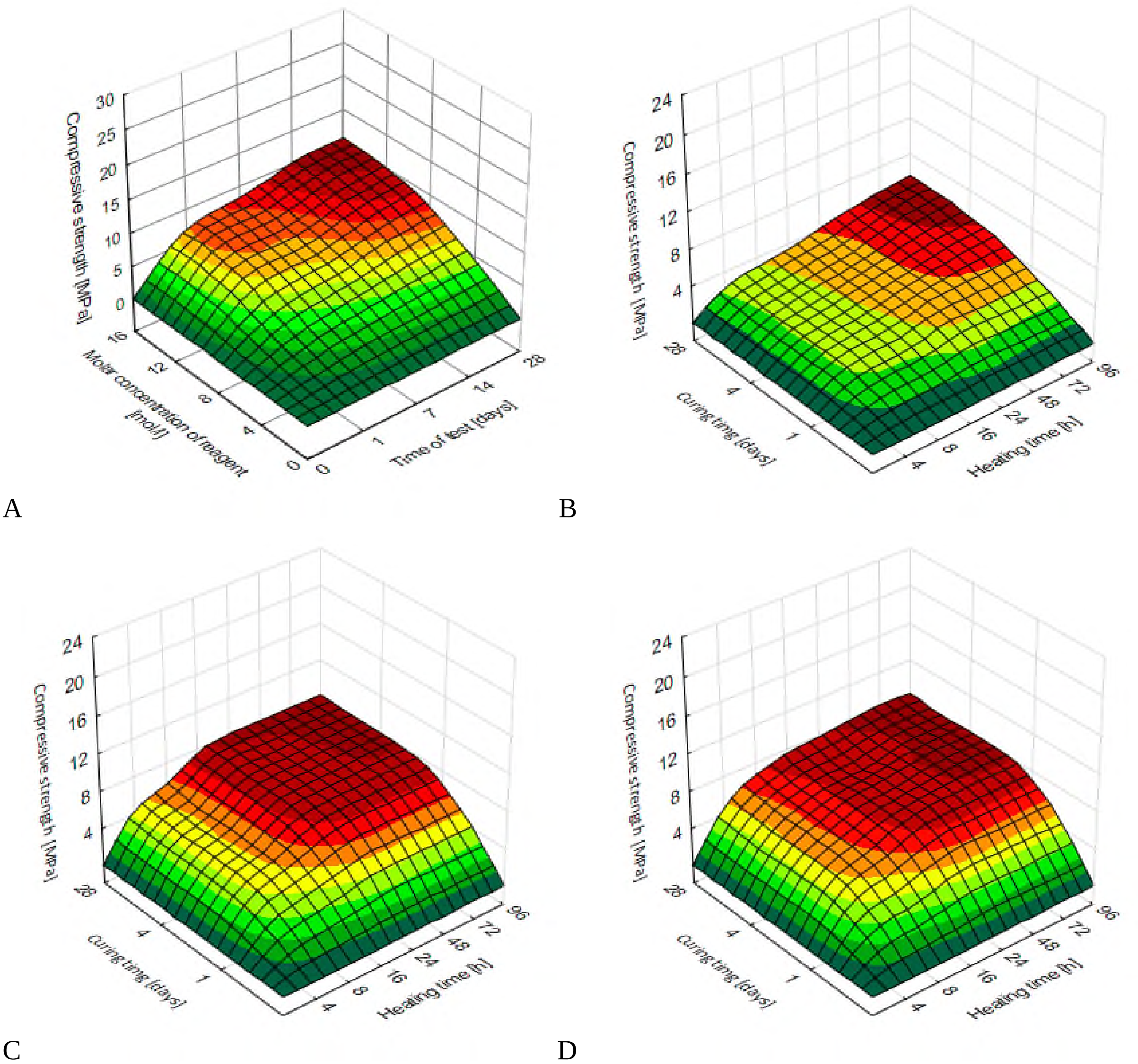

Figure 4. Influence of A) molar concentration, B) temperature 65^{0}C, C) temperature 80^{0}C, D) temperature 95^{0}C, at the compressive strength of tested calcium fly ash.

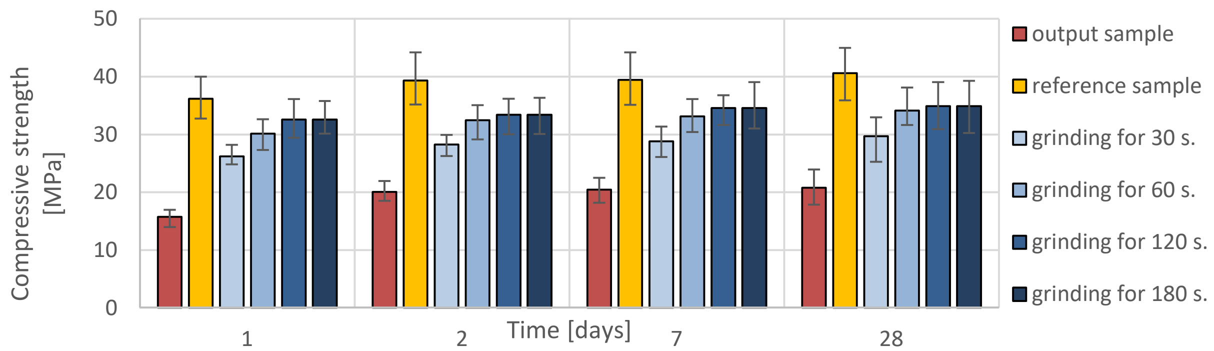

Figure 5. Compressive strength of grinded fly ash.

Together with the reduction of grain size, both compression strength and bending tensile strength were simultaneously increased. Significant increase in the tensile strength of the reference sample, which was the mixture of 50% of the milled material for 120 seconds and 25% of the milled material for 30 and 240 seconds respectively. The material obtained after mixing these components was characterized by relatively the smallest particle size, with a particle size less than 10 [µm] in relation to the amount of material less than 45 [µm], and the most even distribution of grain sizes in the range of 10-45 µm. This allowed the polymerization reaction to be more uniform, depending on the grain size. This has a positive effect on the compressive strength to flexural tensile strength ratio (figure 5, 6).

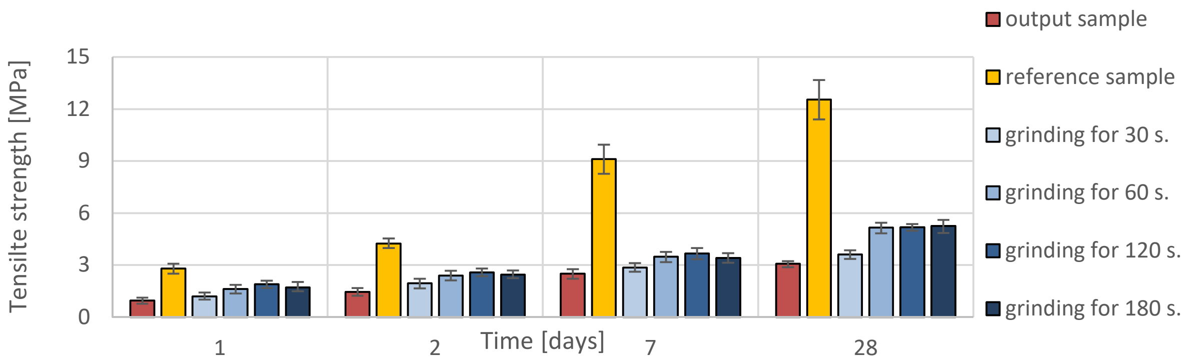

Figure 6. Compressive strength of grinded fly ash.

In comparison to ordinary cements highly specialized materials based on alumino-silicate binders can easily reach equal strength and much better physical properties than Portland cements [7,].

4. Conclusions

At the Paris climate summit which was held in 2015, one of the biggest cement company and 16 other cement manufacturers went further and promised to decarbonise their production by 2030. This exertion will lead to an even 10 percent worldwide reduction in carbon dioxide emissions connected with cement production. As we can see (figure 1, 2) this already taken into consideration amount of CO_2 reduction won't be enough to bring level of greenhouse gasses emission to proper level. Additional resources introduced on global, national and even local fields would really accelerate research that is needed to perform new green binders implementation. Till then we will need to believe that a lots of work that has been spent on environment awareness will spill in social effect [9].

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