Development of alkaline-activated lignite bottom ash for use as supplementary cementing materials

Salitta Prachumwan 650510110, Advisor: Associate Professor Dr. Kedsarin Pimraksa

Department of Industrial Chemistry, Faculty of Science, Chiang Mai University.

Abstract

This study investigated the utilization of lignite bottom ash, a by-product from Mae Moh Power Plant, as an alternative cementitious material. The lignite bottom ash was mechanically and chemically activated. Different grinding durations of 8, 10, and 12 hours were employed to obtain different fineness. 4 types of alkali solutions were also used to activate the starting material. The specimens were kept at the same condition; 60 ˚C for 7 days prior to compressive strength testing. The results showed that increasing the grinding duration reduced particle size and significantly improved compressive strength. Among the alkaline activators, alkali solution type 1 yielded the highest compressive strength. In addition, cement paste specimens were prepared by partially replacing ordinary Portland cement with lignite bottom ash ground for 12 hours and activated with each alkaline solution at a replacement level of 30% by weight. The cement paste incorporating sodium hydroxide type 1–activated lignite bottom ash exhibited the highest compressive strength. These findings demonstrate the potential of ground and alkali-activated lignite bottom ash as a supplementary cementitious material for sustainable construction applications.

Introduction

The Portland cement industry is a major source of CO_2 emissions according to equation (1) & (2) to produce main compound like 3CaO.SiO2, leading to increased interest in alternative materials derived from industrial by-products. Lignite bottom ash from coal-fired power plants to be used as a partial Portland cement replacement. This study investigates the effects of grinding duration and alkaline activators on the compressive strength and evaluates the potential use of lignite bottom ash as a partial replacement for ordinary Portland cement in the development of environmentally friendly construction materials.

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g) \quad (1)$$

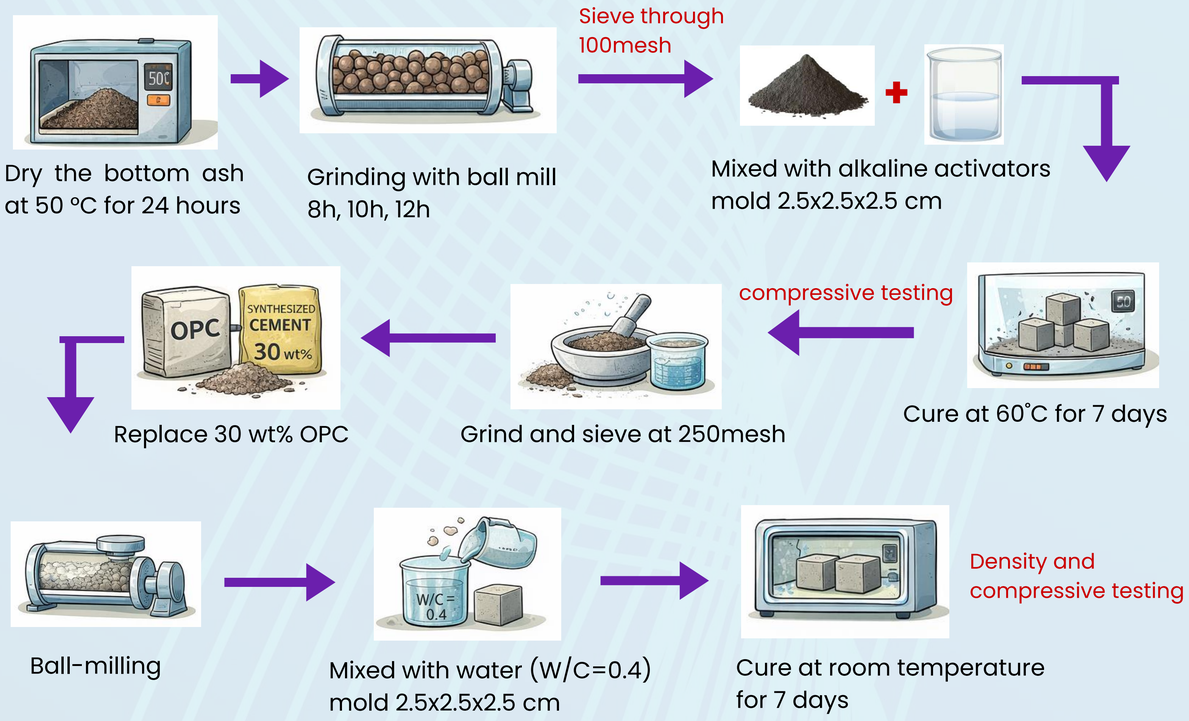
$$3CaO(s) + SiO_2(s) \rightarrow 3CaO{\cdot}SiO_2(s) \quad (2)$$



Objectives

1).To investigate the effects of grinding duration and alkaline activators on the compressive strength of lignite bottom ash–based materials.
2).To evaluate the potential of alkali-activated lignite bottom ash as a partial replacement for ordinary Portland cement in sustainable construction materials.

Experiments



Results

Table 1. Chemical composition of bottom ash determined by XRF

Chemical compositions (wt%)									
SiO2	CaO	Fe2O3	Al2O3	SO3	MgO	K2O	Na2O	TiO2	BaO
26.78	24.94	17.65	16.65	6.75	2.55	2.31	1.02	0.50	0.20

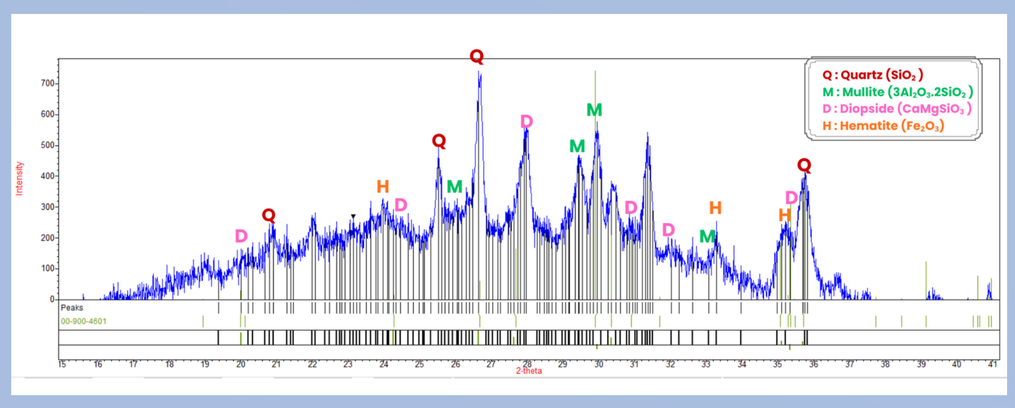


Figure 1. XRD pattern of bottom ash

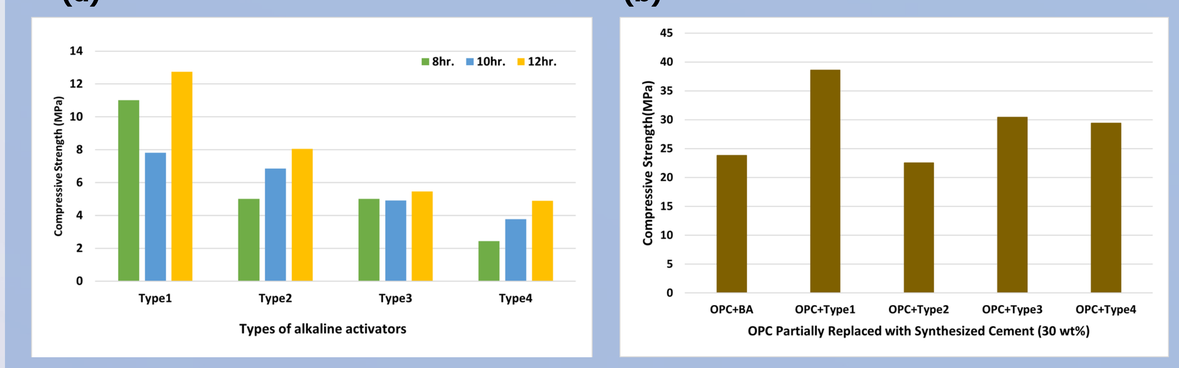


Figure 2. (a) Compressive strength of bottom ash at different grinding durations activated with alkaline activators
(b) Compressive strength of PC replaced with 30 wt% lignite bottom ash (12 h grinding)

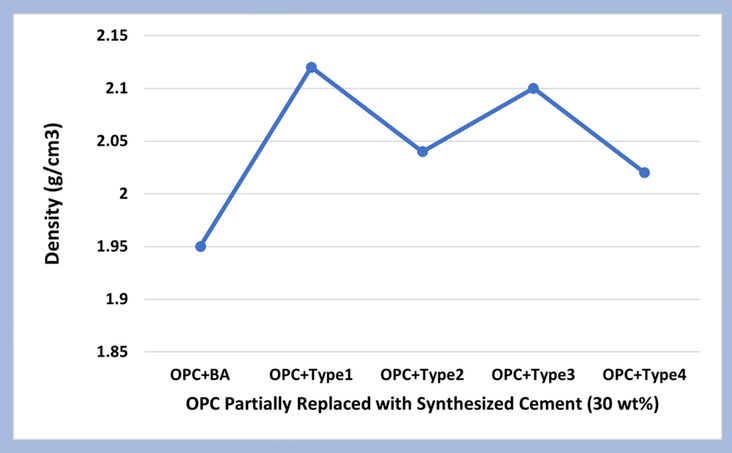


Figure 3. Density of PC replaced with 30 wt% lignite bottom ash (12 h grinding)

Conclusion

The results indicate that increasing the grinding duration significantly enhances the compressive strength of lignite bottom ash, with 12 hours of grinding yielding the highest strength. Sodium hydroxide type 1–activation resulted in the highest compressive strength among all activators.

Partial replacement of ordinary Portland cement with 30 wt% lignite bottom ash ground for 12 hours resulted in acceptable compressive strength and density, demonstrating its potential as a sustainable alternative cementitious material for environmentally friendly construction.

References

Choeycharoen, P., Sornlar, W., & Wannagon, A. (2022).
A sustainable bottom ash-based alkali-activated materials and geopolymers synthesized by using activator solutions from industrial wastes. Journal of Building Engineering, 54, 104659.