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An Experimental Study on the Thermal Conductivity of Concrete Containing Coal Bottom Ash Aggregate

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1 Introduction

Thermal conductivity plays a significant role in efficient energy usage, especially in the construction field. In fact, low thermal conductivity is recommended because lower thermal conductivity will increase the thermal insulation provided by the concrete and reduce the heating and cooling costs for residential and commercial buildings. To resolve this challenge, porous materials can be considered for use in concrete. Additionally, many researchers have had challenges producing high-strength concrete with low thermal conductivity.

Currently, coal-fired thermal power plants are creating a substantial amount of bottom ash and fly ash. Bottom ash is industrial waste produced at the bottom of coal furnaces. Concrete with low thermal conductivity can provide efficient energy utilization. Hence, an experimental study to investigate the effects of partial or total replacement of crushed fine aggregates with coal bottom ash (CBA) on the thermal properties of CBA concrete is vitally necessary.

In this experimental study, the thermal conductivity and mechanical properties of high-strength concrete specimens containing 25, 50, 75, and 100% replacement of crushed fine aggregates with CBA were investigated at a curing age of 28 days. The compressive strength, unit weight, and thermal conductivity of the specimens were measured.

Table 1. Physical properties of fine, coarse and coal bottom ash aggregates.

	Fineness modulus	Water absorption (%)	Unit weight (g/cm^3)
Crushed fine aggregate	3.17	0.69	2.60
Coarse aggregate	6.77	1.44	2.61
CBA	3.83	6.87	1.84

The physical properties of the fine, coarse and coal bottom ash aggregates are presented in Table 1. The concrete mix was designed with a target compressive strength of 60 MPa at a curing age of 28 days.

At a curing age of 28 days, the thermal conductivities of the CBA mixtures decreased as the CBA content increased. The thermal conductivities of the CBA concrete mixtures CBA25, CBA50, CBA75 and CBA100 were 6.4, 11.7, 14.2, and 22.5% less than that of the control concrete mixture (1.87 W/m·K), respectively, as shown in Figure 1. These test results imply that the decreased thermal conductivity in CBA concrete could increase the thermal insulation and reduce the heating and cooling costs for buildings.

The thermal conductivities of the CBA concrete increased with increasing compressive strength, as shown in Figure 2. A similar trend was found in the test results of Wongkeo *et al.* (2010) and Zhang *et al.* (2015).

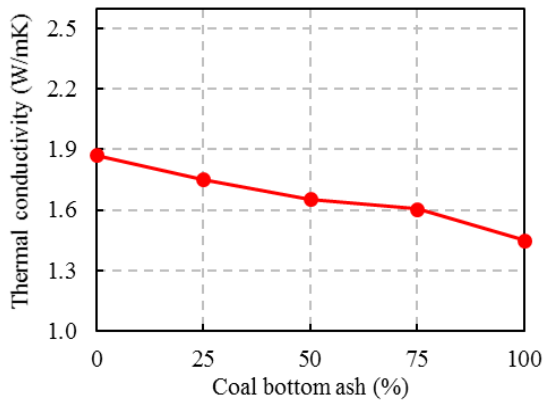

Figure 1. Effect of CBA replacement on thermal conductivity.

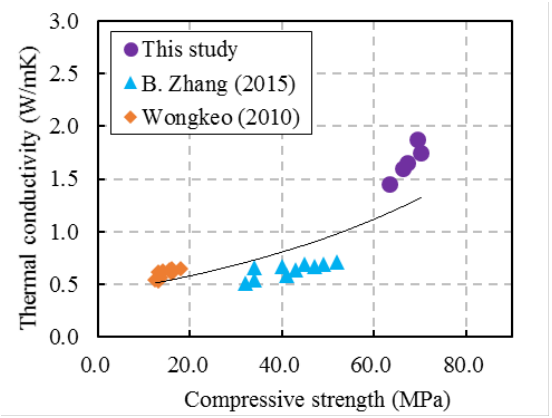

Figure 2. Relationship between the thermal conductivity and compressive strength.

As the CBA content increased, the thermal conductivity of the CBA concrete decreased gradually. Remarkably, when replacing all the crushed fine aggregate with CBA, the thermal conductivity of the CBA concrete (mixture CBA100) was 22.5% less than that of the control concrete at a curing age of 28 days.

Coal bottom ash could be utilized effectively for partial or total replacement of fine aggregates for fabricating high-strength concrete with a compressive strength of approximately 60 MPa; this concrete could achieve low thermal conductivity that could reduce the energy consumption of buildings.

References

Wongkeo, W. and Chaipanich, A. (2010). Compressive strength, microstructure and thermal analysis of autoclaved and air cured structural lightweight concrete made with coal bottom ash and silica fume. *Materials Science and Engineering A, 527*, 3676-3684.

Zhang, B. and Poon, C.S. (2015). Use of furnace bottom ash for producing lightweight aggregate concrete with thermal insulation properties. *Journal of Cleaner Production, 99*, 94-100.