CHAPTER 4
THE EFFECTS OF ALUMINIUM POWDER ON STRENGTH AND DENSITY OF AERATED CONCRETE WITHOUT AUTOCLAVED CURING

4.1 Introduction

The aerated concrete manufacturing process is a well-known micro-mortar matrix (i.e. cement, lime, sand and water) with the addition of aluminium powder as a pore-forming agent. It has been reported that the quantity of pores and pores distribution mainly influences the mechanical and physical properties of aerated concrete [52, 53]. Moreover, previous research undertaken by Cabrillac et al. (2006) [54] demonstrated that aerated concrete can be made without high steam pressure curing using different basic cement matrixes and aluminium powder dosages. The results found that the influence of aluminium powder has a relatively strong effect on the properties of aerated concrete compared with the other parameters. Although, the presence of aluminium powder in aerated concrete leads to a sharp decrease in the density and strength, both properties became constant at a concentration of aluminium powder of 0.5% by weight of binder. However, each mix proportion has its own suitable aluminium powder dosage.

In our study, the preliminary testing showed that the optimum mix proportion for making the aerated concrete was 45% OPC, 5% lime and 50% sand, which was used for the study. Therefore, this research focused on the determination of the optimum aluminium powder content for such mix proportion on the dry density and strength of aerated concrete without autoclaved curing. Following this, the optimum aluminium powder content was used to investigate the effect of the incorporation of RHA in aerated concrete with and without autoclaved curing.

4.2 Research Objective

This research aims to determine the optimum aluminium powder content for preparing aerated concrete

4.3 Methodology

The solid compositions (OPC lime and sand), as summarized in Table 3.4, were mixed with the aluminium powder at levels of 0, 0.3, 0.5, 0.7 and 0.9% by weight of binder (OPC+lime) and the addition of water dosage (determined by the flow table method) in the Horbart mixer for 2 min and 30 sec, as described in Section 3.3. The slurry was poured into 5 cm cube steel moulds and preheated at 40°C for 3 h for stabilization, and then removed from the moulds and cured in water for 7 days. The compressive strength and dry density analysis were examined.

4.4 Results and Discussion

This experiment was a primary test to determine the optimum aluminium dosage of aerated concrete on compressive strength and dry density. The contents of aluminium powder systematically studied were as follows (by % weight of binder): 0%, 0.3%, 0.5%, 0.7% and 0.9% and the samples were tested at 7 days. The compressive strength and dry density results are given in Table 4.1 and Figs. 4.1 and 4.2.

Table 4.1 Compressive strength and dry density results of aerated concrete with the various aluminium powder dosages at 7 days.

Content of Aluminium powder (%wt. Binder)	Compressive Strength (MPa)	Dry Density (kg/m^3)
0	31.9±2.6	1726±7
0.3	4.7±0.3	1132±12
0.5	2.3±0.1	1074±11
0.7	1.6±0.2	1044±7
0.9	1.7±0.4	1052±7

Figs. 4.1 and 4.2 show the relationship between aluminium dosages and dry density, and compressive strength, respectively. The introduction of aluminium powder

dosage caused to sharply decrease in strength and dry density. These results correlated with Cabrillac *et al.* (2006) [54] who concluded that a sharp decrease in the density (about 50%) was found when aluminium powder was added in the matrix. This phenomenon occurred from the high air voids in the matrix solid of the concrete by the expansion reaction. For doses greater than 0.5%, the dry density became constant, whereas strength decreased as the aluminium content increased. The strength loss compared to the reference (0%), was calculated as 85, 92, 95 and 95% for 0.3, 0.5, 0.7 and 0.9%, respectively. This indicates that the concentration of aluminium powder at 0.5% by weight of binder is an optimum.

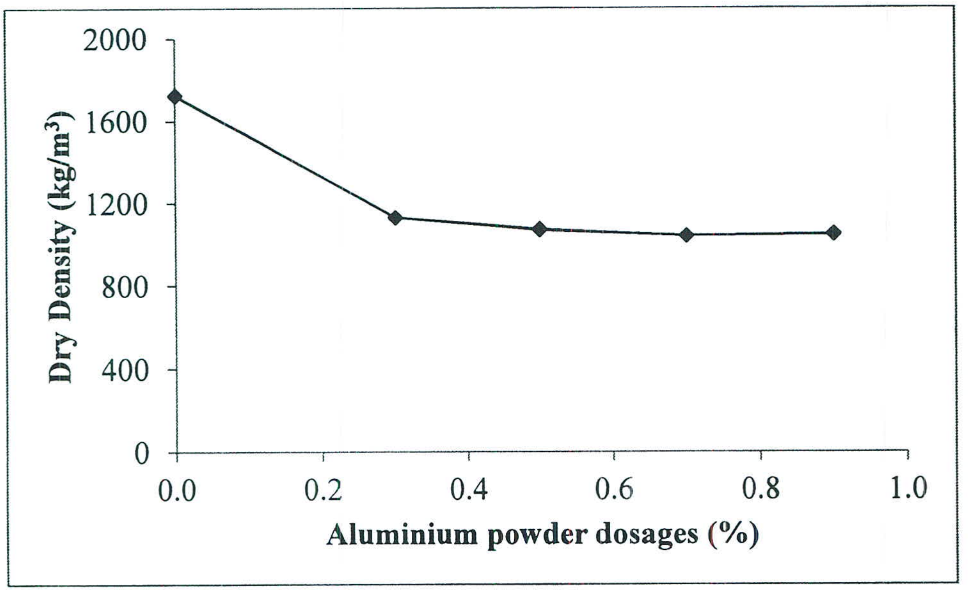

Figure 4.1 Relationship between dry density of aerated concrete and aluminium powder dosages at 7 days.

According to theory, the creation of air voids in aerated concrete reveals the reaction between lime and metallic aluminium; thus, the amount of lime was also considered. In this test, the lime was used to substitute OPC at the levels of 10, 15, 20 and 25% by weight. The results found that an increase in lime content greater than 10% has no significant effect on dry density, as given in Fig. 4.3. Although, with a specific gravity of lime (2.34) lower than OPC (3.13), the increase of lime cloud did not reduce the dry density. This is because when CaO reacts with water, it generates $Ca(OH)_2$ and heat, as shown in Eq. 4.1. Thus, amounts greater than 10% CaO could have hastened the reaction of the slurry to harden before creating bubble forms inside the concrete. It is well known that the dry density of aerated concrete depends on porosity and pore size distribution [18], in which higher porosity of aerated concrete has been established to be the consequence of the increase in macropore volume [55]. Cabrillac *et al.* (2006) [54], also reported that the reaction capacity of lime with the aluminium powder was less significant than that of cement. Therefore, the optimum mix proportion of this test was 45% OPC, 5% CaO, 50% sand and the addition of aluminium dosages at the level of 0.5 wt.% of binder, which was also used in the next research phase.

$$CaO + H_2O \rightarrow Ca(OH)_2 + heat \qquad (4.1)$$

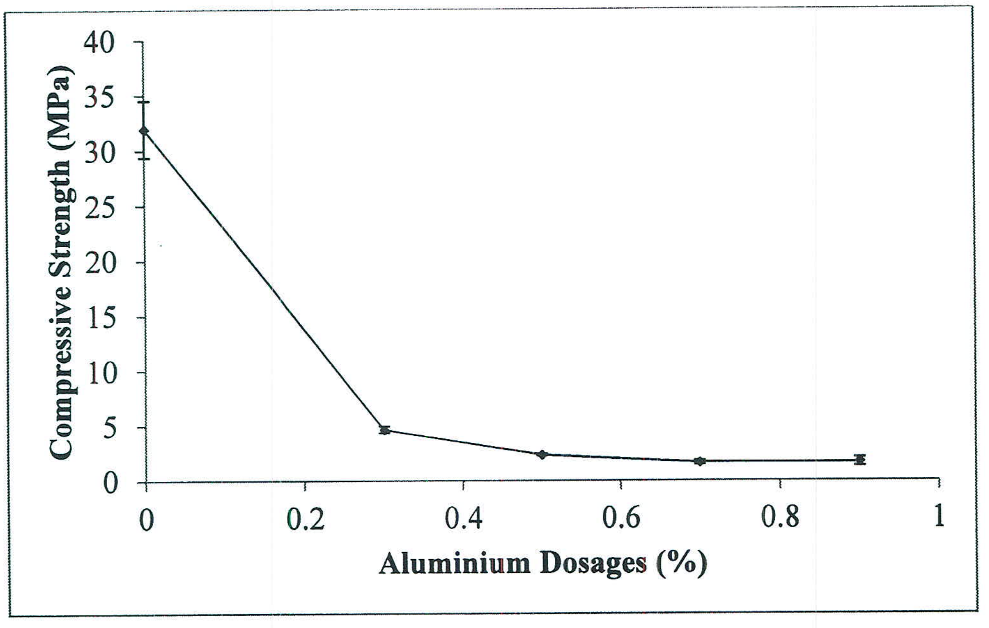

Figure 4.2 Relationship between compressive strength of aerated concrete and aluminium powder dosages at 7 days.

4.5 Conclusion

This study was a preliminary test to determine the optimum aluminium powder content, including mix proportion, for use in an investigation of aerated concrete incorporating RHA. The overall results indicate that the presence of aluminium powder has a strong effect on dry density and the corresponding strength of aerated concrete, in which the optimum aluminium powder content was 0.5% by weight of binder.

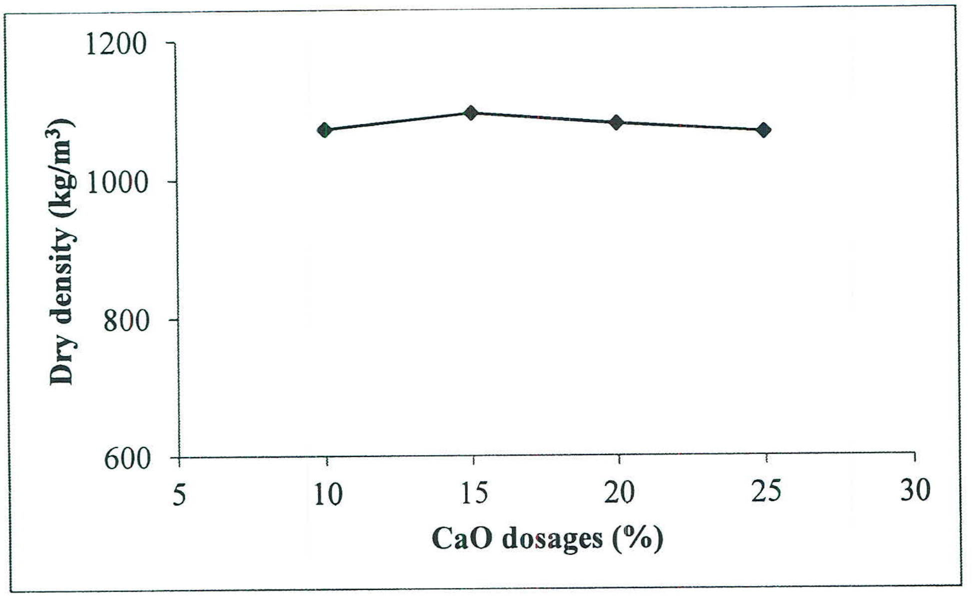

Figure 4.3 Relationship between dry density and CaO dosages at 7 days.