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資源工程研究所

碩士學位論文

碳酸化對燃煤飛灰無機聚合材料特性
影響之研究

A Study on the Properties of Coal Fly Ash
Geopolymer Affected by Carbonation

研究生：盧子威

指導教授：柯明賢

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摘要

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研究生：盧子威 指導教授：柯明賢

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本研究使用燃煤飛灰與氫氧化鈉溶液合成之無機聚合物材料進行碳酸化實驗，以探討無機聚合物材料於二氧化碳氣氛下其特性之變化，利用燃煤飛灰與氫氧化鈉溶液以固定之液固比製成粒徑為 1.5×3.0 cm 之柱狀與 0.8cm 之粒狀無機聚合物材料，並分別進行室溫養護與溫度 200°C 、水氣組成 40%、二氧化碳組成 60% 之碳酸化養護，之後分別取養護 7 天、14 天與 28 天之試體進行各項特性分析，以探討碳酸化對於無機聚合物材料於養護階段其特性變化之影響。另外，本研究亦將室溫養護 28 天後之試體進行 28 天之碳酸化實驗，並進行各項特性分析，以探討碳酸化對於無機聚合物材料特性之影響。

由結果可發現柱狀試體在碳酸化養護下於 7 天時其抗壓強度遠高於室溫養護，而到了第 14 天時其抗壓強度驟降，低於室溫養護之試體。由試體切片之 SEM 發現在試體外層形成較為緻密之結構，而由 pH 值分析可發現 7 天至 14 天之碳酸化養護之試體的 pH 值為 11，到了 28 天時其 pH 值降至 10。又碳酸化養護 28 天試體之抗壓強度及熱重分析與碳酸化養護 14 天之試體均無明顯差異，顯示碳酸化養護之試體其無機聚合反應到了 14 天之後可能受碳酸化之影響而停止。本研究進一步將室溫養護 28 天後之柱狀無機聚合物材料試體再進行溫度 200°C 、水氣組成 40%、二氧化碳組成 60% 之碳酸化實驗，由結果可發現在經過室溫養護 28 天後之試體在經過碳酸化其抗壓強度僅略微下降，顯示柱狀之無機聚合物材料其抗壓強度不受碳酸化影響，而由

熱種分析結果顯示室溫養護後之無機聚合材料可作為二氧化碳之吸收材，值得進一步探討。

而由粒狀無機聚合材料的研究結果可發現在碳酸化養護下於 7 天時其抗壓強度遠高於室溫養護，而到了第 14 天時其抗壓強度雖驟降，但仍高於室溫養護之試體，直到第 28 天其抗壓強度才較室溫養護之試體為低。而由 pH 值分析可發現碳酸化養護之試體在第 7 天時之 pH 值約為 11，而到了第 14 天後其 pH 值下降至 10.8，且到了 28 天後其 pH 值約為 10.4。之後進一步將室溫養護 28 天後之粒狀無機聚合材料進行溫度 200°C、水氣組成 40%、二氧化碳組成 60%之碳酸化實驗，由抗壓強度分析結果可發現在 28 天碳酸化養護後無機聚合材料之抗壓強度由 25Mpa 上升到 30MPa，顯示粒狀無機聚合材料在碳酸化後其抗壓強度有上升的趨勢。

綜合本研究結果可發現，無機聚合材料如要得到早期高抗壓強度，可於二氧化碳氣氛下進行碳酸化養護，不僅於 7 天內可得到較高之抗壓強度，亦兼具二氧化碳之吸收作用。而經 28 天室溫養護後之無機聚合材料則會有較佳之二氧化碳吸收能力，且碳酸化對其抗壓強度不會產生顯著的影響。

ABSTRACT

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The aim of this study was to utilize coal fly ash and NaOH solution to prepare 1.5×3.0 cm pillared and 0.8cm granular geopolymer, and the carbonation test would be used to investigate the effects of carbonation on the properties of geopolymer. The both geopolymers were respectively cured in the atmospheric and carbonation(temperature 200 °C, 40% H₂O, 60% CO₂) conditions. Besides, another carbonation test(temperature 200 °C, 40% H₂O, 60% CO₂) was performed after 28 days atmospheric curing. To analyze the compressive strength, pH and TG of geopolymer cured after 7, 14, 28 days was used to evaluate the effects of carbonation on geopolymer.

The results indicated that the compressive strength of pillared geopolymer curing with carbonation was higher than curing with atmosphere after 7 days. The compressive strength of geopolymer curing with carbonation after 14 days decreased with curing time and was lower than curing with atmosphere. The SEM photographs showed that the outer layer microstructures of geopolymer became more compact. Furthermore, the pH analysis showed that the pH of geopolymer was 11 after 7~14 days and the pH decreased to 10 after 28 days. The compressive strength and TG analysis of geopolymer cured after 28 days did not obviously change compared with cured after 14 days. It implied that the

geopolymerization of geopolymer could shut down due to the carbonation after 14 days. Besides, the carbonation of geopolymer cured with atmosphere after 28 days was also performed. The results indicated that the compressive strength of pillared geopolymer was not affected by carbonation and the cured geopolymer was a good absorption material of CO₂.

The results indicated the compressive strength of granular geopolymer curing with carbonation was higher than curing with atmosphere after 7 days. The compressive strength of geopolymer curing with carbonation after 14 days decreased with curing time but was still higher than curing with atmosphere. The compressive strength of geopolymer curing with carbonation after 28 days was lower than curing with atmosphere. Furthermore, the pH analysis showed that the pH of geopolymer was 11 after 7 days and the pH respectively decreased to 10.8 after 14 days and 10.4 after 28 days. Besides, the carbonation of geopolymer cured with atmosphere after 28 days was also performed and the results indicated that the compressive strength of granular geopolymer would become higher

Based on the results of this study, it implies that the compressive strength of geopolymer in the carbonation curing would reach higher than in the atmosphere curing after 7 days. The geopolymer curing in the atmosphere condition after 28 days would have the better absorption capacity of CO₂ and the compressive strength of geopolymer curing in the atmosphere condition after 28 days was not obviously affected by the carbonation.

