学　位　論　文　内　容　の　要　旨

博士の専攻分野の名称　　博士（工学）　　氏名　李　闖

学　位　論　文　題　名

Hydration and durability characteristics of a new composite cementitious binder containing of slag and calcite

(スラグとカルサイトを含む新しい複合セメントバインダーの水和と耐久性に関する研究)

Cement is produced by burning limestone to a temperature over 950 degrees. Meanwhile, $CO_2$ could be discharged out. On average, each 900 kg $CO_2$ is discharged to the atmosphere for producing one ton of cement, which means around 5% to 7% $CO_2$ are occurred by cement product. In case of control the global warming, as well as energy saving, in this work, a new composite cementitious binder containing of slag and calcite without cement has been developed. However, the hydration behavior, including its hydration products, porosity, chemical shrinkage etc. of this new composition is not clear. The mechanisms need to be understood. Moreover, its long-term performance depends on the interaction with the service environment. Therefore, its durability also needs to attract attentions.

In chapter 3, the influence of the filler content, filler fineness and water to powder ratio (W/P) on hydration kinetics and microstructure behaviour of a new clinker-free material made of calcium hydroxide, blast furnace slag (BFS), calcite and expansive agent are explored in this study. The hydration characteristics of the proposed material were investigated by multiple experimental programmes including X-ray diffraction (XRD), TG-differential thermal analysis (DTA), selective dissolution measurement and mercury intrusion porosimetry (MIP). The experimental results revealed that slag reaction degree is enhanced by increasing the filler content and fineness of the filler in high W/P ratio. However, the filler fineness does not show significant improvement in the hydration degree of slag with low W/P ratio in later curing period due to the reduced amount of available water for the hydration reaction. Another interesting finding of this study is that the hemicarboaluminate which is thermodynamically unstable than monocarboaluminate, stably formed even at the later age of hydration reaction in the presence of calcium carbonate. The amended thermodynamic model also well agreed with the tendency of the experimental results in terms of hydration products and porosity of the hardened matrix as a function of curing period.

In chapter 4, specimens were covered by epoxy resin except for the bottom of the circular surface which will face to to 500 mL 0.5M NaCl solution for up to 12 months after a hydration period of 28 days to test its chloride ingress profiles. The chloride penetration characteristics of the proposed material were investigated by multiple experimental programmes including XRD, titration, ion chromatography, TG-DTA methods. The amount of chemical bound chloride in Afm phases, physical bound chloride in C-S-H, and free chloride in pore solution are established as a function of immersion period, as well as a function of the distance from the exposed surface. The experimental results show that the amount of free chloride in pore solution is enhanced by increasing the fineness of the calcite filler, as well as the addition rate. The filler fineness does not give a significant influence in chemical bound chloride in

Afm phase. Also, the production of Friedel' s salt and the disappear of hemicarboaluminate show the possibility that the hemicrboaluminate transfer to Friedel' s during immersion. Besides, immersion period does not give a significant influence on the chloride penetration distance.

Since carbonation causes numerous chemo mechanical changes in the binder, most notably changes in strength, porosity, pore size distribution, and chemistry. Furthermore, it can cause shrinkage and cracking of the cementitious matrix. Carbonation behaviour is also required to be explored. In chapter 5, the carbonation behaviour of this new composite under an environment of 5% $CO_2$ and 60% humidity, especially phase changes and content changes as a function of carbonation period are carried out through XRD and TG test. The experimental results confirm the disappear of ettringite, hemicarboaluminate, portlandite and the formation of calcite during carbonation. The fineness of calcite filler does now show a significant influence of carbonation behaviour. However, a high addition rate of calcite filler shows a high carbonation speed under $CO_2$ environment and a longer carbonation period makes more part of the specimens lost its characteristics due to the neutralization.

In chapter 6, which is the last chapter of this research, the hydration and durability characteristics of this new composite cementitious binder are summarized, and future issues were discussed. From the hydration and durability behavior of this new composite, a considerable reduction in emitting the carbon dioxide gas during the manufacturing process of the material can be obtained by using the proposed new material as an alternative binder for OPC in the construction industry.