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著者(和文)	SIRIBUDHAIWANN
Author(English)	Norrarat Siribudhaiwan
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論 文 要 旨

THESIS SUMMARY

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学生氏名： Student's Name	Norrarat SIRIBUDHAIWAN	指導教員（主）： Academic Advisor(main)	Etsuo SAKAI
		指導教員（副）： Academic Advisor(sub)	Masahiro MIYAUCHI

要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

The use of blended cement is an alternative way of addressing an environmental concern of the cement industries. Greenhouse gases can be reduced and by-products can be utilized. Many by-products, such as blast furnace slag and FA, are widely used around the world. The amount of FA by-product available is expected to increase because of the increasing number of coal-fired power stations in Japan. It is therefore necessary to expand the use of FA blended cement; however, FA blended cement still has a weakness with respect to its use in construction, which is its low early-stage strength because of partial replacement of the cement component by supplementary materials. It is necessary to improve the initial strength of FA blended cement to enable it to become commonly used in construction. Our hypothesis is that the effect of a higher C_3S content in cement clinker can improve the early strength of FA-blended cement.

Analysis of the hydration reaction in the new blended cement system is necessary for material design. A new simulation hydration model for FA blended cement is proposed, based on a modification of Tomozawa's model. This new model considers the particle size distribution and different phase contents of the cement, and can be used to simulate the reaction or hydration of FA and each component of a cement. Using this model, the influences of the cement composition and the FA particle size on the reactions of FA blended cement are clarified. Increasing the C_3S content in clinker is necessary to improve the strength and extent of reaction in FA blended cement at its early stage. Increasing the fineness of the FA has been shown to improve reaction of the blended cement at the later stages, but FA blended cement performance was not improved during the early stage. The C_3S content in the clinker of FA blended cement is confirmed to be 65 to 70% to attain the same level of optimized performance as Ordinary Portland Cement (OPC) containing 55 to 60% C_3S. After getting the necessary amount of alite content from calculation, the cement containing a high C_3S content was synthesized at three different scales: in a laboratory electro-furnace; at a pilot-plant scale; and in an actual cement production plant. The maximum obtainable C_3S content in cement clinker is limited to about 70% in the synthesized cements. A free lime content of 3% or more remains in the cement when the C_3S in clinker exceeds 70%, indicating that calcination of the cement is insufficient. The grindability of high C_3S clinker is higher than that of OPC. This property of high C_3S clinker is related to its lower belite content and can contribute to lower energy consumption during the grinding process. Clinker containing about 70% C_3S was successfully synthesized at an actual cement production plant. The reaction ratio of C_3S in high C_3S cement is higher than that of OPC. The reaction ratio of FA in high C_3S cement is higher than that in OPC, indicating higher reactivity of the additive materials in the high C_3S blended cement system. A 20% replacement by FA resulted in the same level of heat liberation as in OPC when using high C_3S clinker. Heat liberation is related to the extent of the hydration reaction of the cement: this result therefore indicates that replacement of 20% FA or less can achieve the same or better reaction compared with that of OPC. The amount of hydrated products in the high C_3S blended cement system was higher than that of the OPC blended system and the amount of calcium hydroxide (CH) in the high C_3S cement with 20% FA replacement was the same as that of OPC at the early stage. The same CaO/SiO_2 ratio in calcium silicate hydrate (CSH) in hardened samples resulted as for OPC. This indicates that long-term hydration will not change; however, with higher amounts of CH in system, this cement may have higher resistance to carbonation and better durability compared with OPC. The study of mechanical properties was done by porosity and gel-space ratio calculation. Porosity is related to strength in hardened samples. The relationship between compressive strength and porosity is already well studied and many models have been proposed. In our research, porosity in hardened blended cement was measured by mercury intrusion porosimetry. This technique can, however, only show the pore size distribution—not the total pore volume—in hardened FA-blended cement samples. Upon analysis, it appeared that the pore system had been destroyed by the extreme pressure of this technique. Consideration of the gel–space ratio was therefore attempted using the simulation method proposed in Chapter 2 and the reaction ratio of high C_3S clinker with FA added at 20%. The gel–space ratio is directly related to the strength of hardened cement. The gel–space ratio of hardened high C_3S cement with 20% FA was determined to be the same as that of OPC. These calculations clearly confirm that high C_3S cement improves early strength while maintaining its long-term properties when compared with OPC in a blended cement system.

A method for the material design of a new FA blended cement is proposed based on simulation and a theoretical hydration model, and the optimum component content for a high C_3S cement is estimated. A special type of cement, containing about 70% C_3S, was successfully synthesized in an actual cement production factory. Using this cement, new FA blended cement was developed that has similar properties to those of OPC.

備考 ： 論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。
Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1copy of 800 Words (English).

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