【論文の内容の要旨】

With the development of industry and society of countries all over the world, global production and consumption of cement and related carbon dioxide emission has been increasing sharply. Meanwhile, the attendant massive pile of industrial waste not only seriously polluted the living environment but also caused the waste of resources. Generally, as the industrial waste, the mineral admixtures such as fly ash, ground blast furnace slag and coke residue can replace cement and be effectively used to improve the property of concrete, which can not only reduce the content of cement production and related CO₂ emissions. It has far-reaching significance for turning waste into treasure. Considering the composition of raw materials of concrete, if the electrolyzed water can be used to prepare the concrete and improve the properties as mixing water, this will provide another effective way to save the amount of cement, which has good environmental and economic benefits.

In this paper, considering the composition of concrete raw materials, the maximum reduction of cement content and related CO₂ emission could be achieved through three ways, which are single-added and multi-added different mineral admixture as well as electrolyzed cathode water used as mixing water in mortar or concrete.

Chapter 1 introduced the background, major research solution approach, the significance of the research as well as the construction of thesis.

Chapter 2 arranged and discussed the related research all over the world on properties and effect factors of high volume mineral admixture concrete, the current use of desulfurization petroleum coke residue as well as the electrolysis preparation and application of electrolyzed water.

Chapter 3 researched the threshold value of effective replacement ratio of single-added
high-volume mineral admixture mortar based up on the effect of different curing temperatures and replacement ratios on property of mineral admixture mortar. In addition, the optimum replacement ratio of single-added by-product petroleum coke residue in mortar was also obtained by strength test and XRD analysis. The threshold values of effective replacement ratio were different depend on curing temperature. For the high-volume fly ash mortar, the threshold values of effective replacement ratio were 40% at 20°C, 30% at 30°C, 20% at 50°C curing temperature. For the high-volume slag mortar, the threshold values of effective replacement ratio were 70% at 20°C, 60% at 50°C curing temperature, respectively. The threshold value moved forward with the curing temperature. From the obtained threshold value, the reaction efficiency of mineral admixture in mortar increased with curing temperature, the efficiency coefficient and ineffective content (%) of mineral admixture in mortar could be obtained at different curing temperature. According to the linear relationship equation between curing temperature and replacement ratio under the condition of same target strength, the maximum cement saving amount of concrete at different temperature zones of season a year can be calculated. Based on this research, the effective utilization maximization of mineral admixtures could be realized in the practical application at the different temperature of seasons. From the results of comprehensive analysis of strength, durability and XRD test, 10% was the optimum replacement ratio of single-added coke residue used in concrete at 20°C.

Chapter 4 researched the optimum replacement ratios of multi-added mineral admixture mortar and concrete, which were divided into fly ash-slag series, fly ash-coke residue series and slag-coke residue series at 20°C curing temperature. The mix proportions were designed based up on the threshold values of effective replacement ratio of single-added mineral admixture in mortar of Chapter 3. At 20°C, the threshold value of effective replacement ratio for fly ash and slag are 40% and 70%, respectively. When the cement content in the mortar is over than 60% or less than 30%, the Ca(OH)₂ amount of mortar would be superfluous or inadequate. The cement contents in mortar were designed as 40% and 50%, and the total mineral admixture contents were taken as 60% and 50% in this part. The results showed that the optimum replacement ratio was 20% fly ash, 30% slag and 50% cement in mortar without the loss in strength for fly ash-slag series. Moreover, the results of coke residue series showed that combining the 10% coke residue and 40% slag together in concrete can effectively improve the strength, the internal structure was more dense and compact, and the durability of 10% coke residue-slag concrete was better. The strength of combining fly ash and coke residue was relatively worse, far lower than that of ordinary cement mortar. Therefore, combining the 10% coke residue, 40% slag and 50% cement in concrete was the best way to use the mineral admixtures and save the cement content effectively.

Chapter 5 researched the effect of many kinds of electrolyzed water with different pH and ORP (Oxidation-Reduction Potential) values on the strength improvement and hydration promotion of mortar and concrete, the maximum cement saving amount of concrete could be calculated. The
Electrolyzed water is a kind of high-activity water, the alkaline electrolyzed water is generated on the cathode, and the acidic electrolyzed water is generated on the anode of electrolytic cell. In the first part, the effect of single (K⁺) and compound (Na⁺-K⁺) electrolyzed cathode water on the strength and hydration improvement of concrete was researched. The results showed that single and compound electrolyzed cathode water can both promote and stimulate the hydration reaction of concrete to produce more Ca(OH)₂ amount, leading to a higher strength of concrete. The growth ratio of strength of single and compound electrolyzed water concrete was not different without the AE admixture, both increased by about 18% at 91d than that of ordinary concrete. To a certain extent, the additive of AE admixtures has some impeditive or delayed effect on the role of electrolyzed water in concrete, increased by only 13.5% and 8.0% at 91d, respectively. In the second part, many kinds of electrolyzed water with different pH and ORP value was used to prepare the concrete. The results showed that the strong alkalies would be easy to cause a certain harm to the human body in experimental or construction, the pH value of electrolyzed water should be controlled below 10. When the PH value of water is below 10, the strength of electrolyzed water concrete increased with PH value, the strength reached to the top at 10 of pH value. The strength of electrolyzed water concrete decreased overall with ORP value. The appropriate ORP value of electrolyzed water should be controlled around 200 considering the range of pH value. In addition, the economic and environmental appraisal of using the electrolyzed cathode water in concrete was conducted and the predicted possible reduction cost per 1m³ concrete could be calculated.

Chapter 6 summarized the research results and overall conclusions of each chapter.