World Academy of Science, Engineering and Technology
International Journal of Civil and Environmental Engineering
Vol:17, No:02, 2023

Effects of Particle Size Distribution of Binders on the Performance of Slag-Limestone Ternary Cement

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Abstract : Using supplementary cementitious materials, such as blast-furnace slag and limestone, to replace cement clinker is a promising method to reduce the carbon emissions from cement production. To efficiently use slag and limestone, it is necessary to carefully select the particle size distribution (PSD) of the binders. This study investigated the effects of the PSD of binders on the performance of slag-limestone ternary cement. The Portland cement (PC) was prepared by grinding 95% clinker + 5% gypsum. Based on the PSD parameters of the binders, three types of ternary cements with a similar overall PSD were designed, i.e., NO.1 fine slag, medium PC, and coarse limestone; NO.2 fine limestone, medium PC, and coarse slag; NO.3. fine PC, medium slag, and coarse limestone. The binder contents in the ternary cements were (a) 50 % PC, 40 % slag, and 10 % limestone (called high cement group) or (b) 35 % PC, 55 % slag, and 10 % limestone (called low cement group). The pure PC and binary cement with 50% slag and 50% PC prepared with the same binders as the ternary cement were considered as reference cements. All these cements were used to investigate the mortar performance in terms of workability, strength at 2, 7, 28, and 90 days, carbonation resistance, and non-steady state chloride migration resistance at 28 and 56 days. Results show that blending medium PC with fine slag could exhibit comparable performance to blending fine PC with medium/coarse slag in binary cement. For the three ternary cements in the high cement group, ternary cement with fine limestone (NO.2) shows the lowest strength, carbonation, and chloride migration performance. Ternary cements with fine slag (NO.1) and with fine PC (NO.3) show the highest flexural strength at early and late ages, respectively. In addition, compared with ternary cement with fine PC (NO.3), ternary cement with fine slag (NO.1) has a similar carbonation resistance and a better chloride migration resistance. For the low cement group, three ternary cements have a similar flexural and compressive strength before 7 days. After 28 days, ternary cement with fine limestone (NO.2) shows the highest flexural strength while fine PC (NO.3) has the highest compressive strength. In addition, ternary cement with fine slag (NO.1) shows a better chloride migration resistance but a lower carbonation resistance compared with the other two ternary cements. Moreover, the durability performance of ternary cement with fine PC (NO.3) is better than that of fine limestone (NO.2).

Keywords : limestone, particle size distribution, slag, ternary cement
Conference Title : ICCCR 2023 : International Conference on Cement and Concrete Research
Conference Location : Paris, France
Conference Dates : February 06-07, 2023