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Strength Properties of Ca-Based Alkali Activated Fly Ash System

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Abstract : Recently, the use of long-span precast concrete (PC) construction has increased in modular construction such as storage buildings and parking facilities. When applying long span PC member, reducing weight of long span PC member should be conducted considering lifting capacity of crane and self-weight of PC member and use of structural lightweight concrete made by lightweight aggregate (LWA) can be considered. In the process of lightweight concrete production, segregation and bleeding could occur due to difference of specific gravity between cement (3.3) and lightweight aggregate (1.2~1.8) and reducing weight of binder is needed to prevent the segregation between binder and aggregate. Also, lightweight precast concrete made by cementitious materials such as fly ash and ground granulated blast furnace (GGBFS) which is lower than specific gravity of cement as a substitute for cement has been studied. When only using fly ash for cementless binder alkali-activation of fly ash is most important chemical process in which the original fly ash is dissolved by a strong alkaline medium in steam curing with high-temperature condition. Because curing condition is similar with environment of precast member production, additional process is not needed. Na-based chloride generally used as a strong alkali activator has a practical problem such as high pH toxicity and high manufacturing cost. Instead of Na-based alkali activator calcium hydroxide [Ca(OH)2] and sodium hydroxide [Na2CO3] might be used because it has a lower pH and less expensive than Na-based alkali activator. This study explored the influences on Ca(OH)2-Na2CO3-activated fly ash system in its microstructural aspects and strength and permeability using powder X-ray analysis (XRD), thermogravimetry (TGA), mercury intrusion porosimetry (MIP). On the basis of microstructural analysis, the conclusions are made as follows. Increase of Ca(OH)2/FA wt.% did not affect improvement of compressive strength. Also, Ca(OH)2/FA wt.% and Na2CO3/FA wt.% had little effect on specific gravity of saturated surface dry (SSD) and absolute dry (AD) condition to calculate water absorption. Especially, the binder is appropriate for structural lightweight concrete because specific gravity of the hardened paste has no difference with that of lightweight aggregate. The XRD and TGA/DTG results did not present considerable difference for the types and quantities of hydration products depending on w/b ratio, Ca(OH)2 wt.%, and Na2CO3 wt.%. In the case of higher molar quantity of Ca(OH)2 to Na2CO3, XRD peak indicated unreacted Ca(OH)2 while DTG peak was not presented because of small quantity. Thus, presence of unreacted Ca(OH)2 is too small quantity to effect on mechanical performance. As a result of MIP, the porosity volume related to capillary pore depends on the w/b ratio. In the same condition of w/b ratio, quantities of Ca(OH)2 and Na2CO3 have more influence on pore size distribution rather than total porosity. While average pore size decreased as Na2CO3/FA w.t% increased, the average pore size increased over 20 nm as Ca(OH)2/FA wt.% increased which has inverse proportional relationship between pore size and mechanical properties such as compressive strength and water permeability.

Keywords : Ca(OH)2, compressive strength, microstructure, fly ash, Na2CO3, water absorption
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