FLY ASHES FROM CELLULOSE INDUSTRIES AS SECONDARY RAW MATERIALS IN AUTOCLAVED AERATED CONCRETE

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Cellulose industries produce several thousand tons of fly ashes by waste combustion which have to be disposed. They contain considerable amounts of free lime and sulphate, two components which are needed in the production of autoclaved, aerated concrete (AAC). Based on detailed investigations on composition and properties of the fly ashes, experiments in laboratory scale were carried out using fly ashes as a substitute for primary raw materials in AAC mixtures. Mineralogical as well as mechanical properties of the autoclaved samples were determined.

(1) Lime-sulphate-ashes are composed mainly of free CaO and anhydrite while (2) Al-bearing ashes contain less lime and anhydrite but considerable amounts of low reactive calcium silicates and highly reactive calcium aluminates. Other compounds are low crystalline calcite, portlandite, quartz and hydroxyl-ellestadite. Due to coated surfaces, elevated contents of sulphate and alkalis, the reactivity of CaO in the ashes against water is significantly lower compared to commercial lime as it is used for AAC (HAUSER, 1995).

In laboratory scale, a series of reference mixtures composed of quartz sand, lime, cement and sulphate with variable lime/sand-ratio was produced. Analogous mixtures were obtained by replacing lime and sulphate with ashes. After addition of water and Al-powder as pore forming agent, the pastes were autoclaved in saturated steam atmosphere at 200°C for 6 hours.

Mineralogical investigations of the autoclaved samples were performed by X-ray diffraction (XRD). Additionally, the method of dissolving SiO_2 in hot and cold HCl was applied to quantify the crystallinity of CSH phases (SOCIETY OF CHEMICAL INDUSTRY, 1964; FLORENTIN, 1926). For the reference series both methods indicate increasing proportions of well crystallised tobermorite with increasing lime/sand-ratio of the mixture. Minor amounts of xonotlite and portlandite occur in the lime rich mixture. The opposite behaviour can be observed in series with lime-sulphate-ashes. The proportion of semi-crystalline CSH increases with increasing ash/sand-ratio, indicating a retarding effect on the formation of well crystallised tobermorite from semi-crystalline CSH. XRD patterns of samples with Al-bearing ashes display strongly increasing peak intensities for basal reflections of tobermorite while SiO_2 solubilities imply lower crystallinities with increasing ash contents. These apparently contradicting results indicate that different degrees of crystallisation are developed with respect to different crystallographic directions (CRENNAN et al., 1972; DYCZEK & TAYLOR, 1971; STADE & WIEKER, 1982). The uptake of Al_2O_3 in the lattice of CSH produces high XRD intensities parallel to the c-axis. Furthermore, retarding effects on the condensation of the silicate structures within the ab-plane are expected. The occurrence of scawtite was only observed in mixtures with high ash contents. Low crystalline calcite is considered to be the source of CO_2.

The compressive strength of AAC is related to the content and kind of CSH phases. With increasing lime/sand- and ash/sand-ratio, respectively, increasing amounts of CSH phases are formed which correlates with increasing compressive strength. At highest lime/sand-ratios of the reference series the formation of xonotlite affects compressive strength negatively while in series with ashes at high ash/sand-ratios the lower crystallinity of the silicate structure of the CSH seems to control the drop in compressive strength.

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