Clays from the Westerwald area as a source for high reactive main cement constituent

C. J. Piribauer[1], R. Diedel[1], H. Knapp[1], W. Heuser[1], M. Schellhorn[1]

[1]Steaphan Schmidt Group,
e-mail: christoph.piribauer@stephan-schmidt.group

The cement and concrete industry are currently in a state of transition due to high CO_2 emissions. According to a study of the vdz (Deutscher Verband der Zementindustrie), there are three main levers to lower the emissions: alternative fuels, CCS / CCU and clinker reduced cements. As most of the emissions are so called process emissions and the potential for CCS / CCU is limited in a close range to the cement producers, there is a strong focus on the development and usage of clinker reduced cements. Calcined clays play an important role here as a substitute for the cement clinker made from limestone. To meet the decarbonisation targets of the German cement industry, 6.8 to 7.5 million tonnes/a of clay will be needed by 2030 (Basten, 2022). In order to cover this very high demands for clays, waste clays from treatment processes, such as filter cakes and clays from sludge ponds, are considered in addition to conventionally mined clays. As these secondary raw materials occur only in relatively small quantities with strongly varying compositions, they are likely to play only a minor role in the future due to the strong influence of the mineralogical-chemical composition on the calcination conditions and therefore on the resulting reactivities and technological properties.

Figure 1. Mine Wimpsfeld 3, white kaolinitic-illitic clays with an overburden of bentonites and basalt. – Picture: Stephan Schmidt Group

Stephan Schmidt KG operates 20 open-cast clay mining operations in Germany, 16 in the Westerwald area. From these deposits, more than 100 clays were selected for a screening process not only focussing on their basic suitability for calcination, but also with regards to a long-time availability for a constant material supply of a calciner. In a first screening step, the carbonate content (< 5 mass-%), the sulphide concentration (< 1.5 mass-%) and the clay mineral/quartz ratio (> 50 %) were assessed. Clays that met these requirements were calcined at 750 °C and subjected to a test for pozzolanic properties. The Surana method (Surana and Joshi, 1990) was chosen to determine the pozzolanicity. By chemically treating the calcinates after Surana, the available reactive Si and Al ions could be determined via ICP-OES. At a concentration >80,000 ppm (Al+Si), suitability as a clinker substitute is ensured, comparable to the performance of blast furnace slag and fly ash (Schulze and Rickert, 2019). Next to this information, also the influence of the calcined clays on the early strength can be estimated, as a higher Al content leads to the formation of CA phases. The final step in the evaluation of calcined clays involves the testing of CEM I cements (activity index/EN 450-1; water demand/EN 196-3; compressive strength/EN 196-1), in which 25 % of the cement clinker phase is replaced by calcined clays.

Based on this knowledge, 2 main supply areas have been identified. While the raw material mixture from Arbon/Wimpsfeld 3 (Fig. 1) has a high smectite content, the Sedan mixture is kaolinitic-illitic dominated. Each site allows the delivery of 250,000 t clay/a, which corresponds to the production of 200,000 t/a of calcinate.

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