

Reactivity of calcined river sediments

Katja Traven¹, Barbara Horvat¹, Mark Češnovar^{1,2}, Mojca Božič³, Boštjan Gregorc³, Vilma Ducman¹

¹Slovenian National Building and Civil Engineering Institute, Dimičeva 12, 1000 Ljubljana, Slovenia

Phone: +386 1 2804 438

E-mail: vilma.ducman@zag.si

²International Postgraduate School Jožef Stefan, Jamova 39, 1000 Ljubljana, Slovenia

³Dravske elektrarne Maribor, Obrežna ulica 170, 2000 Maribor, Slovenia

Introduction: River sediment within hydro power plant systems affect the safety of dams, and reduce energy production, storage and discharge capacity and can effect river flow, consequently meaning that they must be regularly dredged. Depending on the chemical and mineralogical compositions of such dredged materials, as well as their particle size, they may be suitable to be used in the building sector as precursors for geopolymers (alkali activated materials) [1], for the production of cement clinker [2], bricks [3], lightweight aggregates [4], and concrete [5], or for other purposes. If dredged sediments are calcined and then rapidly cooled, the materials become more reactive due to an increase in the content of amorphous phase.

The aim of the present study was to evaluate the reactivity of sediment from the Drava River following calcination at various temperatures, and to evaluate the materials obtained for further use as supplementary cementitious materials (SCM) and/ or alkali activated precursors.

Methods: The sediments investigated were subjected to thermal exposure using a Porotherm furnace fired to 700, 750, 800, 850, 900 and 950 °C at a heating rate of 600 °C/h, using a dwelling time of 20 min at each selected temperature. Following the temperature exposure the sediments were quickly cooled in order to obtain the greatest possible amorphous phase content. Three different methods were applied to assess the reactivity of the calcined material: i) quantitative XRD analysis, ii) pozzolanic activity determined by lime consumption, and iii) determination of the strength activity index (SAI).

Amorphous phase was determined by XRD analysis, via Rietveld refinement using X'Pert High Score Plus diffraction software. Pozzolanic activity was determined following the procedure described in [6], where $\text{Ca}(\text{OH})_2$ consumption in the saturated lime solution-sediment suspension is analyzed at different ages. The modified method from EN 196-3 [7] was followed to determine SAI, for which prisms of $2 \times 2 \times 8 \text{ cm}^3$ were produced by partially replacing (25 %) cement with the calcined sediment studied.

Results: All three methods applied showed that reactivity depends on the calcination temperature. As can be seen in Fig 1., some phases (calcite, dolomite, zeolite) disappear after firing to 950 °C, and Rietveld analysis also reveals that the amount of amorphous phase is higher (9 and 31 % for sediment samples fired at 700 and 950 °C, respectively).

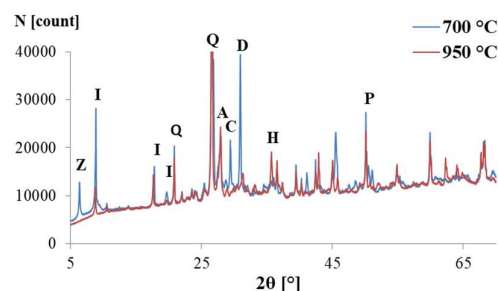


Fig. 1: X-ray diffractograms of sediment fired at 700 and 950 °C (A = albite; C = calcite; D = dolomite; H = hematite; I = ilite; P = periclase; Q = quartz; Z = zeolite).

Chemical analysis confirmed that the sample fired at at 850 °C exhibited the highest consumption of lime. Similarly, the SAI test also revealed that the drop in compressive strength after 28 days was lowest (compared to the reference sample CEM I) following calcination at 850 °C.

Discussion: Our results confirmed that increased reactivity after calcination, particularly evident after calcination above 850 °C, should open up the possibility of using calcined sediments such as these for SCM and/ or as precursors for alkali activated materials. Further analysis in this direction will be performed.

Acknowledgements: The authors would like to thank the Slovenian Research Agency (ARRS) for project grant L7-2629: “Evaluation and remediation of sediments for further use in building sector (READY4USE)”.

References: [1] Lirer et al. (2017) *J Environ Manage* **191**:1–7; [2] Anger et al. (2017) *Eur J Environ Civ Eng* **23**:957-970; [3] Slimanou et al. (2020) *J Build Eng* **28**:101085; [4] Wang et al. (2017) *Mar Georesour Geotec* **35**:472-480; [5] Junakova & Junak (2017) *Sustainability* **9**:852; [6] Tironi et al. (2013) *Cement Concrete Comp* **37**:319-327; [7] EN 196-3.