DEVELOPMENT OF ONE-PART GEOPOLYMERS BASED ON INDUSTRIAL WASTE

Rebecca Willson-Levy, Department of Earth and Environmental Science, Ben-Gurion University of the Negev, Beer-Sheva, Israel
Alva Peled, Department of Civil and Environmental Engineering, Ben-Gurion University of the Negev, Beer-Sheva, Israel
Ofra Klein-BenDavid, Department of Earth and Environmental Science, Ben-Gurion University of the Negev, Beer-Sheva; Nuclear Research Center Negev (NRCN), Beer-Sheva, Israel
Gabriela Bar-Nes, Department of Civil and Environmental Engineering, Ben-Gurion University of the Negev, Beer-Sheva; Nuclear Research Center Negev (NRCN), Beer-Sheva, Israel

Utilization of waste-based geopolymers as building materials presents an alternative path towards reduction of the negative environmental impacts of conventional ordinary Portland cement. Moreover, one-part geopolymers, activated by solid alkali-activators, can potentially replace conventional cement in in-situ applications.

This research aims to develop one-part geopolymers based on local Israeli carbonate industrial and mining wastes to produce Ca and Mg based solid alkali-activators. Dolomite and limestone quarry dust and calcite industrial byproduct were thermally activated at 950℃, transforming carbonates into Ca and Mg oxides. Thermal activation reduced particle size and raised effective surface area contributing to material reactivity. Applicability of various binders including metakaolin and waste-based binders (Oil shale ash, Fly ash and Blast furnace slags) were tested for one-part geopolymer synthesis. Mix design and synthesis condition were studied.

One-part geopolymers were cast, utilizing the Ca and Mg oxides as solid activators, premixed with the binders. Geopolymerization and hydration were initiated upon water addition to the dry mix. Ambient temperature curing was applied to reduce environmental impact.

For metakaolin based geopolymers, the optimal mix design was 6-8 Molar activator content and water to solid ratio of 1.1-1.2, resulting from high water demand of Ca-Mg based solid activators and metakaolin. These geopolymers yielded fair compressive strength of 16-20 MPa (at 40 days, figure 1 left) with Stratlingite as the main crystalline binding phase formed, illustrated in needle-like morphology by SEM imaging (figure 1 right). Highest initial temperature evolution was obtained by the calcite CH - 6M system, leading to the highest compressive strength of 20 MPa. Results for waste-based binders will be presented as well. This study illustrates activated carbonate waste materials may be used as sustainable solid activators for one-part geopolymer synthesis.

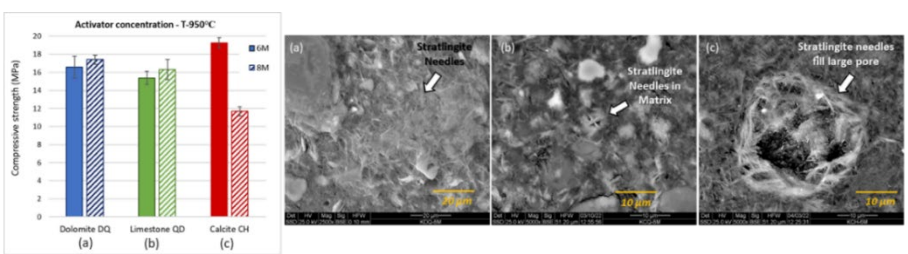

Figure 1. SEM Imaging (right) of metakaolin based 'one-part geopolymers': Dolomite DQ (a), Limestone CQ (b) and Calcite CH (c). Compressive strength at 40 days (left graph) comparing 6M and 8M activator concentrations.