

UTILISATION OF CS-CONTAMINATED FUKUSHIMA SOIL AS NATURAL POZZOLAN FOR EMBEDDING INTO K-ALKALI ACTIVATED MATERIALS

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Following the 2011 accident at the Fukushima Dai-ichi Nuclear Powerplant (FDNPS), Japan, it has been found that the soil in the surrounding area is heavily contaminated with radioactive cesium-137 (Cs-137), which has a half-life of 30 years. This led to the removal of approximately 106,000 m³ of soil, which is currently being stored at an interim disposal site. The Japanese government has promised the Fukushima prefecture that by 2045, a final repository will be built outside the prefecture for the disposal of Cs-contaminated soil. In order to construct a realistic repository, it is crucial that the overall volume of contaminated soil be minimised by effective soil utilisation. Low-radioactive soils (less than 8,000 Bq/kg) can serve as filling material for land reclamation, road construction, and various other applications. However, highly contaminated soils cannot be used and must be disposed of appropriately.

Here, Cs-contaminated soil was utilised as a natural pozzolan by amorphising it by grinding and then blending it with K-alkali-activated materials to efficiently encapsulate highly contaminated wastes. In general, metakaolin was used as a natural pozzolan for K-alkali-activated materials (K-AAM); however, in this study, Cs-contaminated soil was replaced for metakaolin since it was more cost-effective and produced less volume. Various K-alkali activator recipes were applied to Cs-contaminated soils (derived from basalt and granite rocks) with <75 µm particle size, at which point the Cs were significantly adsorbed. The manufacturing process was carried out in a smaller size of 8.8 cm², which was then tested for compressive strength using a thumb press. The specimens with the highest hardness and flowability during the production process were used for the Cs leaching test, which was conducted for 19 days. ICP-MS was utilised to measure the amount of Cs that had been leached from the specimen. Electron microscopy techniques (FE-EPMA, SEM-EDX, and TEM) were applied to the solid sample before and after leaching to examine the Cs retention mechanism, the hardening mechanism, and the presence of secondary phases. It was effectively hardened with high flowability and achieved a uniaxial compressive strength (UCS) of more than 1.47 MPa, which was the standard minimum required UCS from the Atomic Energy Society of Japan for low radioactive concrete wastes. Soil activation with a K-alkali activator led to the formation of K-AAM, which served as a coating bridging between the larger particles that had not been completely dissolved. Only a small amount of the Cs was leached away, while the rest was immobilised in K-AAM and other clay minerals (such as weathered biotite and vermiculite). In conclusion, activated soil with K-alkali activator was highly possible without adding any additive binder to form a hard concrete, demonstrating the high Cs-immobilisation, very practical, and low cost, and potentially useful as an adsorbent from removing hazardous materials in mining or industrial activities.