MERCURY AND CADMIUM IMMOBILIZATION IN POTASSIUM-ACTIVATED GEOPOLYMER: THE EFFECT OF MIXING DESIGN AND HEAVY METALS CONCENTRATION

Pramesti Prihutami, Graduate School of Engineering, Hokkaido University, Sapporo 060-8628, Hokkaido, Japan
prihutami.pramesti.l5@elms.hokudai.ac.jp
Chaerun Raudhatul Islam, Graduate School of Engineering, Hokkaido University, Sapporo 060-8628, Japan
Yusuke Ohya, Graduate School of Engineering, Hokkaido University, Sapporo 060-8628, Hokkaido, Japan
Ryosuke Kikuchi, Faculty of Engineering, Hokkaido University, Sapporo 060-8628, Hokkaido, Japan
Tsubasa Otake, Faculty of Engineering, Hokkaido University, Sapporo 060-8628, Hokkaido, Japan
Tsutomu Sato, Faculty of Engineering, Hokkaido University, Sapporo 060-8628, Hokkaido, Japan

Key Words: cadmium, immobilization, mercury, metakaolin geopolymer, potassium activator

Industrial activities produce solid waste (e.g. fly ash) and wastewater typically containing heavy metals. These heavy metals are prone to contaminate the environment and are hazardous for their toxic behavior. Mercury and cadmium, for example, can damage the skeleton, liver, kidney, and nervous system. A potential technique to prevent heavy metal release is solidification/stabilization. Several studies have discovered that sodium-activated geopolymer is a promising binder candidate for this confinement process. However, there is still a gap in understanding heavy metals immobilization mechanisms in geopolymer matrix made using potassium activator. In this study, 0.5% of mercury and cadmium-doped geopolymer were made by four different mixing designs while keeping the K_2O:SiO_2:H_2O ratio of 1:1:13 then cured at 40°C for 24 hours and another 24 hours at 25°C. The mixing designs are: 1) solid mixing of heavy metal salt and metakaolin, followed by potassium activator addition; 2) mixing of dissolved heavy metal with metakaolin, thenceforward potassium activator addition; 3) dissolution of heavy metal salt in potassium activator, followed by metakaolin addition; and 4) mixing of dissolved heavy metal with potassium activator, thenceforth metakaolin addition. The second mixing design was also used to manufacture geopolymers in a range of heavy metal concentrations, from 0.02% to 5%. The results from various mixing designs showed that the initial speciation of mercury and cadmium, whether ions or salts, affects the characteristics of heavy metal-doped geopolymers. Geopolymers made by ions incorporation appear to be more homogeneous with mercury mostly existing as HgO in the above concentration range. On the other hand, salts introduction produced geopolymers with segregation at the upper and lower parts of containers, in which HgO or $Cd(OH)_2$ is concentrated at the bottom. Different heavy metal concentration also holds an effect on geopolymer characteristics. The incorporation of low heavy metal concentrations resulted in apparently more homogeneous geopolymers. Meanwhile, concentrations exceeding the heavy metal salt (heavy metal-chloride) solubility limit produced geopolymers with either HgO or $Cd(OH)_2$ and KCl observed at the bottom. This study shows that mercury and cadmium speciation in geopolymer depend on their initial species solubility.