Notice of the Final Oral Examination
for the Degree of Master of Applied Science
of
RANDALL WU
BEng (University of Victoria, 2018)

“Cement-Based Stabilization/Solidification of Zinc-Contaminated Kaolin Clay with Graphene Nanoplatelets”

Department of Civil Engineering

Thursday, May 13, 2021
10:00 A.M.
Remote Defence

Supervisory Committee:
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Abstract

Heavy-metal contamination in soils has become a serious environmental problem. Among all metals, excessive amount of zinc was released to soils over the years. Zinc is not only toxic to human being, but also to plants. High concentration of zinc is extremely phytotoxic. Currently, the most popular method to remediate heavy-metal contaminated soils is stabilization/solidification (S/S) technique as it is cheaper, faster and more effective to remediate heavy metals than other remediation methods. Portland cement is the most-used binder in S/S technique. However, the production of Portland cement has released a significant amount of carbon dioxide, which strongly contributes to global warming. In addition, zinc retards the setting and hydration of Portland cement, which would require more Portland cement to remediate zinc-contaminated sites. Therefore, researchers are looking for new materials to improve the performance of Portland cement in zinc-contaminated soils.

In recent years, the application of graphene-based materials in concrete had proved to be effective. Due to relative cost-effectiveness and comparable properties, multi-layer graphene, known as graphene nanoplatelets, may show a promising potential in construction. Moreover, research has reported that graphene nanoplatelets can be exfoliated from graphite and potentially scaled up for full-scale applications. At present, there is no application of graphene nanoplatelets in the S/S of contaminated soils and the roles of graphene nanoplatelets in cement-stabilized zinc-contaminated clay remained unknown. In this research, graphene nanoplatelets were dispersed in solution with a high-shear mixing apparatus. Dispersed graphene nanoplatelets solution was then applied to zinc-contaminated soil along with cement. To evaluate the efficacy of this S/S method, various influencing factors such as mixing sequence, graphene nanoplatelets content, zinc content, cement content, and curing time were studied. An optimum graphene nanoplatelets content was determined through the unconfined compressive strength (UCS) of the stabilized/solidified samples. It was found that at the optimum content, the unconfined compressive strength of cement-stabilized zinc-
contaminated clay was improved by 22.3% with the addition of graphene nanoplatelets. Also, graphene nanoplatelets were effective at moderate zinc content and low cement content. Graphene nanoplatelets accelerated cement hydration effectively at early ages. Microstructural analyses indicated that more hydration products were developed in samples with graphene nanoplatelets. At current stage, it is still expensive to apply graphene nanoplatelets in S/S technique; however, it is possible to exfoliate graphite into graphene nanoplatelets in future research.

Keywords

High-Shear Mixing; Graphene Nanoplatelets; Portland Cement; Stabilization/Solidification Technique; Unconfined Compressive Strength; Zinc-Contaminated Kaolin Clay