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ABSTRACT

STABILIZATION/SOLIDIFICATION PROCESSES FOR THE TREATMENT OF CONTAMINATED SOIL AND WASTE

PROCESSI DI STABILIZZAZIONE/SOLIDIFICAZIONE PER IL TRATTAMENTO DI SUOLI E RIFIUTI CONTAMINATI

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ABSTRACT

Recovering industrial waste and contaminated soil is one of the main objectives in environmental management. Nowadays in Italy, landfilling is responsible for up to 40% of total soil contamination and up to 50% of the used remediation techniques involves excavation and disposal. On the other hand, the European Legislation has set key drivers to improve waste management, as setting recycling targets and limiting the use of landfilling with its rising cost. In this scenario, new technologies to reduce the toxicity of contaminated soil and hazardous waste before their disposal or to reuse them as aggregates are of great interest.

Stabilisation/solidification (S/S) is a treatment for wastes and soils which mainly uses cementitious or pozzolanic binders to produce a solid monolith that incorporates the contaminants. This process is particularly effective on heavy-metals contaminated soils. Other additives/fillers can also be used during a pre-treatment phase to amend adverse chemical and physical characteristics, e.g. high moisture content. Alternative methods to treat contaminated waste and soil exploited the application of accelerated carbonation to cement-based S/S. This process can improve the characteristics of the stabilized products in terms of leaching, strengths or pH.

Accelerated carbonation (ACT) is an enhanced form of natural carbonation that has been developed during the last years at industrial scale for the treatment of contaminated soil and industrial wastes. Accelerated carbonation induces a rapid reaction exposing the mineral or the reactive waste to a controlled atmosphere containing CO_2 and promotes rapid hardening of the product. The resultant precipitation of calcium carbonate reduces the porosity of the material, and leads to further changes at the microstructure, aiding the retention of contaminants and improving the mechanical properties. The pH is also lowered with the result of reduced solubility of many heavy metals.

Waste can be formed into aggregate by agglomeration. If the two processes are combined, it is feasible to produce hardened aggregate. The final product can be reused as aggregate in engineering fill or in concrete production.

The aim of the research project conducted during the Ph.D. programme is the development of an innovative approach for the enhancing of stabilization/solidification treatment of contaminated soils and wastes. The research aimed at the identification of innovative formulation using cement and thermal wastes for heavy-metals contaminated soil treatment and at the investigation of the effect of the accelerated carbonation applied to cement-based stabilization/solidification.

Tests of cement-based stabilization/solidification using Portland cement and the effect of accelerated carbonation on metals mobility were investigated on artificial heavy-metals contaminated soil at the *Sanitary Environmental Engineering Division* (SEED) at the University of Salerno. The process was assessed with further investigations on *soil washing residues* blended with thermal ashes and cement for the production of lightweight recycled aggregate. This part was conducted within the LLP Erasmus Placement Programme at the *Centre for Contaminated Land Remediation* (CCLR) of the University of Greenwich (UK). The process investigated entailed the mixing of soil washing residues with paper incineration ashes, reactive to carbon dioxide, or sewage sludge ashes followed by accelerated

carbonation to produce the aggregate. Portland cement was used as the binder, which also has an ability to combine with CO_2.

The effect of accelerated carbonation on the cemented contaminated soil was evaluated by mineralogical and structural properties. Chemical stability was measured by leaching of heavy metals from the raw materials and the final products. The aggregates produced showed comparable strength to commercially lightweight aggregates. Accelerated carbonation increased the strength and the density of the aggregate compared to the hydrated one. Heavy metals leaching were substantially unaffected by carbonation, apart for copper and barium. Further investigation tested the aggregates for using in lightweight concrete block and for green roofing. The use of a synthetic CO_2 flue gas lead to a capture of the carbon dioxide leading to a "low carbon" product. The study showed the applicability of the process for manufacturing lightweight aggregates from soil washing residues and ashes by enhanced cement based S/S as a good alternative for a wide range of civil engineering applications. The effect of accelerated carbonation has to be further explained. Future investigations are needed to enhance the process based on the variability of the wastes. Other waste and alternative carbon dioxide reactive fillers can be considered to be treated by the process.