Reuse of Steel Industry Slag in a Landfill Top Cover

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Introduction

Recent EU legislation leads to the closure of many landfills in the member states of the EU. Only for Sweden, the required amount of material to cover these landfill sites is estimated at 100 millions of tons. The steel company Uddeholm Tooling AB in Hagfors/Värmland, Sweden, produces ladle slag (LS) and electric arc furnace slags (EAFS) that are potentially suitable materials for landfill cover liners. The municipal landfill at Hagfors has to be capped and the steelworks wastes could be a cost efficient alternative to natural materials. As LS shows cementitious properties, it is presumed to have a low hydraulic conductivity and thus perform well in the liner. However, the use of LS in construction raises practical problems such as it solidifies very fast after mixing with water whereby compaction properties change. The admixture of EAFS might decelerate the solidification.

The goal of this laboratory investigation was to find a blend of LS and EAFS that is applicable for a landfill cover liner with regard to permeability and workability properties. In addition, the acquired blend was tested under field conditions.

Material and Methods

One LS and four different EAFS, produced at different modes of operation in the EAF at Uddeholm Tooling AB, were investigated. First, laboratory tests were performed, namely hardening, proctor density and hydraulic conductivity tests. The hydraulic conductivity testing was designed according to a factorial design in order to investigate if and how the factors "time between water contact and compaction", "LS to EAFS ratio" and "water content" influence hydraulic conductivity. Second, a field test area of 1,700 m^2 was built on the Hagfors landfill to investigate the performance of one of the slag mixtures in the liner construction. Another one will be built during 2006.

Results

The hardening tests showed that the curing can be decreased by admixing EAFS to LS. When mixed with water and compacted, slag mixtures of LS and one type of EAFS reached a dry density up to 2.3 (t m^{-3}) at moisture contents between 10 and 12.6 wt.%. The density tended to be lower after longer intervals of time between the mixing with water and compaction. The hydraulic conductivity tests indicated that mixtures of LS and EAFS exhibit a very low hydraulic conductivity in the range of 1.4×10^{-8} and $< 2.2\times10^{-11}$ m s^{-1}. Among the studied factors, only "time between water contact and compaction" seemed to affect permeability. However, the derived model was statistically weak and thus not reliable. In some cases, the hydraulic conductivity decreased with time, being quite high at the beginning (up to 10^{-5} m s^{-1}) and decreasing to very low hydraulic conductivity (about 2×10^{-9} m s^{-1}) after a few weeks (figure 1). Under field conditions, however, e.g. cracking might occur which would increase the permeability of the liner. Two mixtures of LS and EAFS will therefore be tested under field conditions.

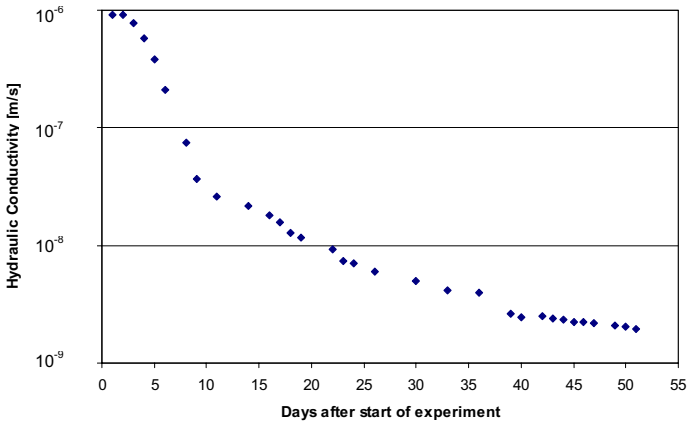

Figure 1: Development of hydraulic conductivity over time measured on a sample containing 35 wt.-% EAFS, 65 wt.-% LS and 9 wt.-% initial water content compacted after 24 hours after mixing with water

Conclusions

The admixture of EAFS to LS might improve its properties with regard to the application in a landfill liner. The tested materials probably fulfil the requirements with regard to compactibility and permeability as they reach a very high dry density up to 2.3 t m^{-3} and very low hydraulic conductivities in the range of 1.4×10^{-8} and $< 2.2\times10^{-11}$ m s^{-1}. However, when water is added to the material during construction, it should be compacted immediately as otherwise both the compaction and permeability properties deteriorate. The permeability may not be constant over time and the real amount of water percolating through the liner must be studied in the field.

The work was performed within MiMeR (Mineral and Metals Recycling Research Centre) at Luleå University of Technology and in co-operation with Uddeholm Tooling AB and Hagfors municipality.