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Trace elements leaching from cement mixtures containing fly ash

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Abstract

Fly ash can be utilized as a pozzolanic filler in cement mixtures used in various sub-surface applications. CLSM (Controlled Low Strength Material) and Grout are two types of cement/sand mixtures in which fly ash is added to the mixes.

CLSM is designed to fill cavities (trenches, pits, etc.) as a replacement for soil, fine quarry products or natural sand fillings and is composed of the same components as concrete, but their proportions are different. Due to the fine and globular particles that characterize ashes, their presence in the CLSM mixture increases workability, improves flow properties and reduces water consumption. Grout is designated to fill cracks in rocks and/or fill the gap between casted concrete and the. The difference between CLSM and Grout is in the content of the components of the mixture and especially the cement content. In infrastructure applications, CLSM and Grout may come into contact with runoff and even groundwater.

Therefore, the degree of contaminants leached from cement mixtures containing fly ash that are commonly used in Israel should be examined. Examination of these leachates and evaluation of the expected metal concentrations to be released will allow definition of criteria for fly ash usage in infrastructure applications.

Cubic blocks of 10 cm^3 of various cement mixtures of CLSM and reference cubes with no ash (Table 1) were manufactured and placed under controlled humidity and temperature conditions for curing periods of 7, 28 and 90 days. These periods were chosen for engineering reasons and are designed to enable the follow up of the strengthening of the concrete. Typically, strengthening of the concrete is completed after 28 days. If the concrete does not meet the required strength at this curing age, it does not disqualify the concrete, but it means that the concrete must be tested after 90 days of curing. Curing time of 7 days is minimal and represents immediate use of concrete before its strengthening.

The cubes were tested according to procedure EA NEN 7375:2004 (tank test) designed for determination of the extent of leaching of inorganic components from moulded or monolithic materials using the diffusion test. The contribution of the fly ash in the cement mixtures to the leachate is tested by comparison to mixtures without ash. The leaching procedure involves eight stages during a period of up to 64 days and was carried out in duplicates on identical cubes composition left for the three curing periods. The amount of water specified for the leaching test is 2 to 5 times the sample's volume (i.e., 2-5 L) and coverage should be at least 2 cm on each side and the water should not be mixed. The amount of water used during the test varied between 3 and 4 L. The test was conducted in eight stages in which each stage included: filling the container to the desired volume with ion-free water (distilled water), sealing the container and waiting until the end of the period of the given stage; emptying the water to another container, taking two filtered samples of 50 ml for

chemical analyses, measuring acidity and conductivity, draining the rest of the water and the test container is filled again.

The contents of the trace elements Ag, As, B, Ba, Be, Cd, Co, Cr, Cu, Hg, Mn, Mo, Ni, Pb, Sb, Se, Th, U, V, Zn were measured in the leachate of each stage. Concentrations were measured by Inductively Coupled Plasma Mass Spectrometry (ICPMS) except for mercury concentration that was measured by Atomic Fluorescence (AF). Determination of elemental concentration in each elution stage (μg/L) enables further calculations of the cumulative concentrations per unit area (mg/m^2) for each stage and for the entire test. These values can be compared with proposed limit values on outputs from monolithic treatment process (Guidance on sampling and testing of wastes to meet landfill waste acceptance procedures, 2005).

The ash chosen for testing (CMC-CerD from Colombia) contained a high quantity of ash characterized by a high concentration of contaminants and with a low pozzolanic activity (expected to release the highest contaminants concentration) and the cubes casted were left for 7, 28, and 90 days of curing totaling 12 cubes (Table 1). An additional empty container underwent all stages of leach to serve as a blank. As concentrations of this blank were all under limit of detection, all elemental concentrations measured in the leachates originate solely from the cubes.

Among the 20 measured elements, eight were below detection limit in all leachates (Ag, Be, Cu, Hg, Mn, Pb, Th & U) and another four have low and insignificant concentrations (B, Co, V & Zn). Among the remaining eight, three (Ba, Cd & Ni) reveal values that are below limit values. The cumulative concentrations for As and Cr are below the limit at seven curing days, while they are above at 28 days curing, while the concentrations for Mo, Sb and Se are 2 to 20 fold the limit values and they increase with curing time. Test of grout composition (Table 1) is in progress.

To summarise, in the tested CLSM by monolithic procedure, several elements were found to exceed limit values for landfill use. These elements are known to be in high concentrations in the coal. In order to permit the use of fly ash in cement mixtures, specific application oriented calculations will be made.

Table 1: Mixtures of CLSM and Grout prepared for the leaching tests (kg)

CLSM - total of 12 cubes: duplicate for each curing periods (7, 28 and 90 days)[1]

fly ash	cement	Sand[2]	water	total	Admixture[3]	7 d	28 d	90 d
400	120	1250	250	2020	1.0 kg/m^3	2	2	2
0	150	1500	300	1950	1.0 kg/m^3	2	2	2

Grout - total of 12 cubes: duplicate for each curing periods (7, 28 and 90 days)

fly ash	cement	Sand[2]	water	total	Admixture[3]
800	400	200	400	1800	0
0	800	650	300	1750	0

[1]An additional empty container with no cube served as procedural blank

[2]fine sand 0-4 mm

[3]air entrained agent