Leaching behaviour based on diffusion test performed at long-term on recycled concrete made with precast concrete rejects.

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1. Introduction

Recent years have set challenges to the recycling industry marked by ongoing concerns of contamination, climate change and green policies. The innumerable types of wastes generated daily worldwide challenges the scientific community. It is necessary to implement measures that facilitate their recycling and recovery. Many of these wastes have been deeply studied, being generated new alternatives for them and granting a second life cycle. Wastes as recycled aggregates from Construction and Demolition Waste (CDW), can be applied to engineering infrastructures. Its incorporation in manufacturing recycled concrete has provided a specific effect on the properties of fresh and hardened concrete.

It is estimated that 850 million tons of CDW are generated in EU each year, which can be used legally after being treated properly, but unfortunately, in some cases are illegally dumped in landfills (Salesa et al., 2017). Although some countries such as Denmark and Germany achieve reuse ratios over 80%, other European countries have rates under 10%. The latest data from the National Institute of Statistics place the Spanish recycling rate at around 40%, below Italy (78%), Belgium (76%) and France (55%). (INE, 2019).

Different types of Recycled Aggregates (RA) can be obtained from CDW: mixed RA, asphaltic RA, concrete RA. Due to this high variety, sometimes it is difficult to find recycled aggregates with a proper tecnhical feasibility for a certain application type (road construction, concrete manufacturing, filling, etc) and the quality of an RA could be lower than the quality of natural aggregate. All over Europe, more than 5500 companies with around 8000 production plants are producing concrete precast products. Concrete precast producers consume large quantities of aggregates and generate voluminous amounts of concrete waste, generally about 1–2% of total production (Zengfenh et al., 2020).

The raw materials used to manufacture blocks could be virgin aggregate, but it is important to remark that also the precats concrete reject pieces (recycled materials from CDW) generated in the precast concrete plant can be reused. The present research work is focused in the environmental assessment of recycled concrete made with precast concrete rejects. In previous phases of the study, the optimisation of mix proportions (0%, 5%, 10%, 15%, 20% and 30%) based on mechanical properties was developed and in the final phases the pollutant potential of the recycled concrete prepared at 20% of recycled concrete which presented the best mechanical behaviour was analysed in order to: (i) determination of the maximum levels released by concrete specimens according to avalilability leaching test, (ii) identify most conflictive contaminants released by difussion processes in concrete monolithics according to normalised dymanic tank leaching test, (iii) study of the long-term behaviour of concrete specimens according to the dynamic tank leaching test.

2. Materials and methods

The concrete specimens were prepared with cement CEM I 52.5-R, natural aggregates: coarse gravel (4-10 mm), fine gravel (2-6) and sand (0-4 mm) with limestone nature. The recycled aggregate (RA) (0-10 mm) used came from the block rejects of an precast industry. In the laboratory, concrete casted through vibro compaction, and the incorporation of the recycled aggregate was done proportionally of each fraction of natural aggregates because of the similarity of the particle size distribution between the recycled aggregate and the combination of each fraction of natural aggregates.

About the experimental procedure for leaching assessment, the following tests were carried out: availability test NEN 7341: 2004 so as to determinate the maximum pollutant release from the tested materials, performed at pH 4 and pH 7; total content by elemental chemical analysis; and diffusion leaching tank test was performed on monolithic samples according to UNE-EN 7375:2004 of dynamic monolithic leaching test with periodic leachant renewal.

3. Results and discussion

For a complete characterisation of the leaching behaviour, the dynamic tank leaching test was performed to obtain different eluates over time. It allowed the determination of the diffusion coefficient: D_e, for each pollutant element released from concrete specimens, as well as, the effective diffusion coefficient, which assesses the long-term leaching behaviour for an element allowing the determination of its mobility. Table 1 shows the leaching data for the most conflictive elements detected according to the Landfill Directive (LD). Here, the results from specimens with 20% ratio incorporation are exposed.

Table 1. Leaching tank test parameters obtained by Annex D of NEN 7341:2004.

Element	Derived cumulative leaching over 64 days ε_{64} (mg/m^2)	Diffusion coefficient D_e (m^2/s)	Mobility Criteria: pD_e >12.5 (low); 11< pD_e <12.5 (avarage); pD_e <11 (high)
Cr	12.64	$8.17 \cdot 10^{-11}$	High
$SO_4^=$	20648.8	$6.07 \cdot 10^{-10}$	High
Cu	1.06	$6.87 \cdot 10^{-13}$	Average
Mo	5.96	$7.89 \cdot 10^{-12}$	Average
Ba	8.40	$1.50 \cdot 10^{-13}$	Low
Zn	1.98	$4.20 \cdot 10^{-14}$	Low

For a complete characterisation of the leaching behaviour of specimens to the long-term the release curves were plotted and the results of the chromium element and sulphate anion ($SO_4^=$), which presented the highest mobility, are shown in Figure 2. The higher data presented by the cumulative leaching than availability test were due the greater release of the elements in alkaline medium. The mechanisms of release detected in Cr were, firstly, surface wash-off and after, diffusion; in $SO_4^=$, just surface wash-off was identified, following the Annex E of NEN 7341:2004. At long term, it can be seen that Cr and $SO_4^=$ are close to the depletion of both elements.

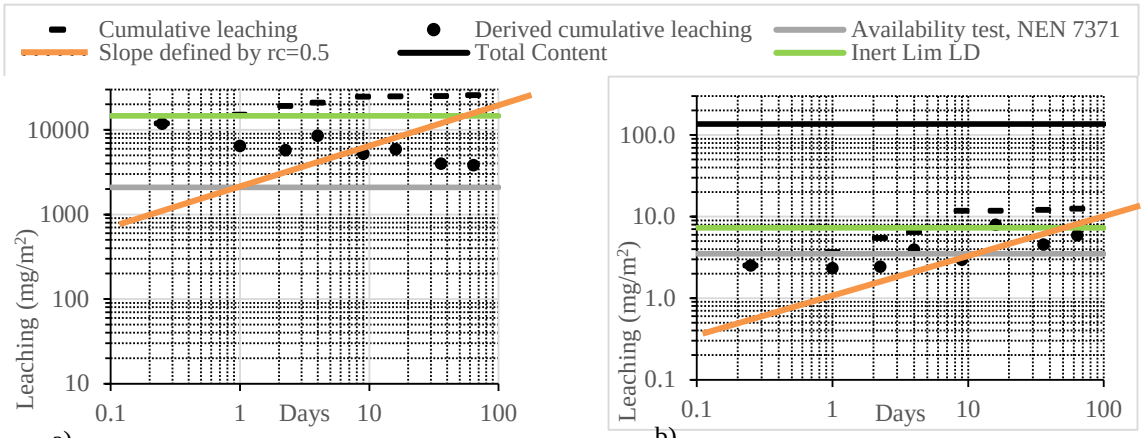

Figure 2. Release curves for Cr element (a) and $SO_4^=$ anion (b) following the Annex E of NEN 7341:2004.

4. Conclusions

This research deeps into the perfomance of the leaching in recycled concrete produced analogly to a precast concrete plant. The leaching results exhibited that the Cr and $SO_4^=$, which were classified as high mobility, exceeded slightly the limit to be classified as inert, but the tend of the leaching cumulative curve implies the depletion of them close to that limit. The study of leaching tank test at long-term leaching test on recycled concrete assesses its pollutant potential, providing valuable information about their behaviour.

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