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SPENT FOUNDRY SAND VALORIZATION IN CONSTRUCTION SECTOR THROUGH THE VALIDATION OF HIGH-PERFORMANCE APPLICATIONS

Erika Garitaonandia [1]*, Clara Delgado [1], Lucia Unamunzaga[1], Antonio Martínez Puche[2], Iñaki García[3], Javier Ríos[4]; Jose Luis Rodríguez [5]

[1] *IK4-AZTERLAN, Aliendalde Auzunea 6, 48200-Durango, Spain*
[2] ACCIONA CONSTRUCIÓN S.A., Valportillo II, nº8, 28108 – Alcobendas, Spain
[3] FUNDICIONES DEL ESTANDA, S.A., Antzitzar 17, 20200 – Beasain, Spain
[4] GAIKER-IK4, Parque Tecnológico Bizkaia, Ed.202, 48170 – Zamudio, Spain
[5] ONDARLAN, S.L., Txirrita-Maleo nº10, 20100 – Renteria, Spain
* *e-mail: egarita@azterlan.es*

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One of the most pressing problems facing the metal casting industry nowadays is the disposal of Spent Foundry Sand (SFS). Despite having high silica content and good engineering properties, this waste is typically landfilled. Foundry sand could be beneficially reused in the construction sector, if the presence of residual organic compounds from binders and metals from casting are below critical limits.

In the current study, 20 different SFS samples and their leachates have been analyzed. Results indicate that just a few parameters tend to exceed the limit values for inert waste, typically Dissolved Organic Carbon and fluorides in leachate. Regarding physical-chemical specifications for fine aggregates, contents of organic matter, fines and soluble salts in SFS seem to be the most critical.

This paper describes the activities performed in the framework of the ongoing project LIFE ECO-SANDFILL, regarding the integration of a novel mechanical SFS reclamation system in a Spanish foundry, in order to reach the required quality in reclaimed sand for their validation technically and economically in three pilot construction applications.

INTRODUCTION

SFS generation represents more than 80 % of the total solid waste generated in foundries. With more than 3 000 active foundries in Europe [1], this waste amounts to about 9 Mt annually, being less than 40 % of the SFS generated valorized, mainly in cement industries.

The physical and chemical characteristics of SFS depend on the type of casting process and binders used. It consists of a morphologically uniform sand, with an average particle size between 300-500 µm, sub angular-spherical shape and a high content (80-95 %) of valuable silica. Therefore, SFS is potentially recoverable as secondary raw material in diverse applications, in substitution of natural silica sand, provided that applicable environmental and technical requirements are met.

DETERMINATION OF CRITICAL PARAMETERS FOR SFS VALORISATION IN CONSTRUCTION SECTOR

Use of SFS as secondary fine aggregates in a material-intensive sector such as construction offers promising valorization options. The sand must meet relevant technical specifications for each application and, additionally, fulfil several environmental conditions for unbound uses, where the sand is directly in contact with the soil.

Currently, SFS reuse in construction sector is not specifically addressed in any regulation at European or local level. For this reason, regulations existing for valorization of other waste streams have been used as a reference: the quality criteria selected in LIFE ECO-SANDFILL pilot experiences stem from the construction and demolition waste legislation in the Basque Country (Spain) [2], which stipulates that recycled aggregates intended for unbound applications must fulfil leachate limit values for inert waste landfilling [3] and meet contaminant concentration limit values stated in soil pollution regulation [4], whereas no environmental conditions are given to hydraulically bound applications.

SFS (green and chemically bonded sand) generated in 20 ferrous foundries in Spain have been characterized, to identify the parameters in the full set of specifications that are most critical for SFS to comply with limits, from both an environmental and a technical point of view.

Regarding the contaminants content in sand, all the 20 SFS samples studied are below the regulated limits for soil pollution. However, pollutant limits in leachate are exceeded in several samples. 60% of the samples analyzed fail to meet the leaching limits for fluoride and Total Dissolved Solids (TDS) and 70% exceed the content limit for Dissolved Organic Carbon (DOC). The measured values of other leachate parameters such as Zn content and phenol index, in samples from a few foundries, have been found to be around the limits.

Those experimental results suggest that only 5, out of the more than 125 chemical substances of environmental concern for unbound construction applications, may require close monitoring and correction measures in SFS. Table 1 lists the environmental acceptance criteria stablished on them for SFS to be used in LIFE ECO-SANDFILL project.

Table 1. Critical environmental parameters of SFS for use in construction unbound applications

Component in leachate	Limit Value (mg/kg). Inert Waste
Zinc	<4
Total Dissolved Solids (TDS)	4000
Fluoride	<10
DOC	<500
Phenol Index	<1

Considering technical requirements stablished for aggregates, SFS must meet the criteria requested either to the fine aggregates and to the final product, which might vary from one application to another. Table 2 shows the critical parameters defined for sand as an aggregate for bound [5] and unbound [6] applications in Spanish regulations:

Table 2. Critical technical parameters of SFS for use in construction applications

Component in sand	Unbound App.	Bound App.
Organic Matter	< 2%	< 3.5 %
Soluble salts	< 1%	-
Fines	-	< 6%

In this sense, fines and organic matter contents may influence the setting time and mechanical resistance of concrete and mortars, as well as the bearing capacity of embankments. In general, green sand shows values above the limit set for both parameters. Similarly, high values of some soluble salts as sulfates can cause swelling in bound applications and volumetric instability in unbound ones. Furan bonded sand has shown higher values of sulfates than other SFS types.

SFS RECLAMATION TECHNIQUE

The new reclamation equipment integrated and tested in a foundry located in Northern Spain consists on scrubber style reclamation with centrifugal force, in which the sand is rubbed together and against the walls in a closed system, removing effectively impurities from the surface of the silica sand.

An intensive characterization program has been carried out onto sand samples taken from the inflow and outflow of the reclamation equipment, to help define the operation regime that allows achieving the quality required for foundry and construction applications.

THREE PILOT EXPERIENCES

After the adequate reclamation treatment in the equipment, a flow of quality sand, environmentally safe, has been obtained and used in 3 eco-innovative construction applications. Those full-scale case studies have been implemented in the construction works for the High-Speed Train in Spain:

- Embankment: Unbound application. Reclaimed SFS used: ca. 700 t (400 m^3).
- Flowable mortars: Bound application. Reclaimed SFS used: ca. 150 t (100 m^3).
- CLSM (Controlled Low Strength Material): Bound application. Reclaimed SFS used: ca. 10 t (6 m^3).

CONCLUSIONS

Aggregates in hydraulically bound construction applications appears as a promising valorization option for SFS. However, most of the studied SFS samples fail to meet certain environmental limit values for their use in unbound applications and, therefore, need to undergo some conditioning treatment in order to achieve the quality criteria. The trends below have been observed in SFS samples:

- ✓ Regarding environmental compliance, leaching limit values for fluorides, DOC and TDS are exceeded in more than 60% of the samples. These parameters are especially sensitive in unbound applications, since the sand is directly in contact with the soil, but are not critical in bound applications, where the sand is enclosed in a cementitious matrix and the risk of leaching is low.
- ✓ As for technical aspects, parameters such as fines, organic matter and soluble salts contents are considered critical for both bound and unbound applications. The highest percentages of fine and organic matter have been found in green sand samples. In the case of sulfates, the highest values have been measured in furan resin sand.

The characterization carried out over 20 SFS samples from different foundries and the results obtained with the new reclamation process suggest that the new mechanical reclaiming technology enables SFS to reach the acceptance criteria for reusing foundry sand in different construction applications.

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