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BOOK OF
PROCEEDINGS

6th International Conference **WASTES** SOLUTIONS TREATMENTS OPPORTUNITIES

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HYDRAULIC BEHAVIOUR OF A NONWOVEN GEOTEXTILE SUBMITTED TO MECHANICAL DAMAGE TESTS WITH INCINERATOR BOTTOM ASH

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ABSTRACT

The municipal solid waste incineration process produces a residue (incinerator bottom ash) that has shown potential to be used as recycled aggregate in civil engineering applications, where it may come into contact with geotextiles. Like the aggregates typically used in these applications, incinerator bottom ash can cause damage to geotextiles during the installation process (placement and compaction operations). In this work, a nonwoven geotextile was submitted to mechanical damage tests with incinerator bottom ash and other aggregates: *tout-venant* and *corundum*. The effect of the mechanical damage tests on the hydraulic behaviour of the geotextile was evaluated. To that end, the geotextile was characterised, before and after the mechanical damage tests, by water permeability normal to the plane and characteristic opening size tests. The results allowed concluding that the mechanical damage tests did not cause changes in the hydraulic behaviour of the geotextile, regardless of using incinerator bottom ash or the other two aggregates.

Keywords: geotextiles, mechanical damage, recycled aggregates, incinerator bottom ash

INTRODUCTION

Incineration is a common waste treatment process, producing incinerator bottom ash (IBA) in large quantities. Over the years, studies have been conducted to find useful roles for IBA, namely: in the development of cementitious materials, in concrete as recycled aggregate, and in road construction, also as recycled aggregate [1]. In the latter case, IBA may come into contact with geotextiles (and/or other geosynthetics), making it important to assess the impact it may have on them.

The operations carried out during the installation of the geotextiles on site, namely their handling and placement, as well as the placement and compaction of aggregates over them, may damage these polymeric materials. Thus, the construction activities may induce unwanted changes in the properties of the geotextiles, which, if not properly accounted for during the design phase, can compromise their performance.

The evaluation of installation damage can be performed by field damage tests (installation under real conditions) or by laboratory tests. To assess the resistance of geosynthetics to mechanical damage under repeated loading, a laboratory method was developed – EN ISO 10722 [2]. This method has been used as an indicator of the resistance of geosynthetics to the placement and compaction of aggregates over them.

This work evaluated the mechanical damage induced by IBA (and other aggregates) on a nonwoven geotextile, namely on its hydraulic behaviour. The use of IBA as recycled aggregate (filling material) in road infrastructure (where geotextiles often perform functions of filtration, drainage or separation) requires that it has good compatibility with other materials, not having a negative impact on them (or, at least, not having a more negative impact than the aggregates it intends to replace). To enable the use of IBA (allowing its valorisation), there are other requirements that must be fulfilled. Examples include having adequate environmental behaviour and physical, mechanical and geotechnical properties compatible with those needed to act as filling material.

MATERIALS AND METHODS

Geotextile and aggregates

The geotextile submitted to mechanical damage (MD) under repeated loading tests (hereinafter MD tests) was manufactured from polypropylene fibres and had the following properties: mass per unit area – 379 g/m^2; thickness (under 2 kPa) – 3.07 mm; tensile strength – 23.5 kN/m; velocity index for a head loss of 50 mm (V_{H50}) – 39.1 mm/s; characteristic opening size (O_{90}) – 85 µm.

The aggregates used in the MD tests were IBA (resulting from the municipal solid waste incineration process) and, for comparison, *tout-venant* (well-graded untreated mixed aggregate) and *corundum* (aggregate used in EN ISO 10722 [2]). The particle size distribution of the aggregates (tests carried out according to EN 933-1 [3]) can be found in Fig. 1.

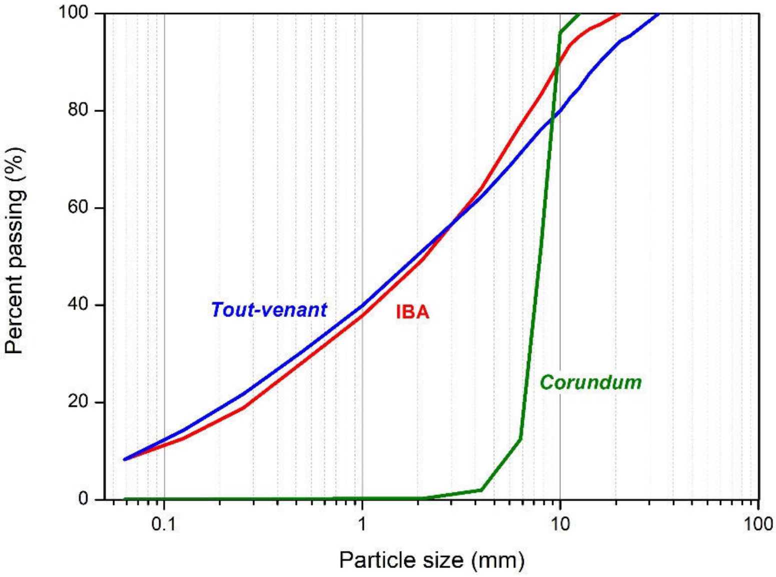

Figure 1 – Particle size distributions of IBA, *tout-venant* and *corundum*.

Mechanical damage tests

The procedures of the MD tests followed EN ISO 10722 [2]. The geotextile was placed between two layers of an aggregate (IBA, *tout-venant* or *corundum*) and subjected to cycling loading between 5 and 500 kPa at the frequency of 1 Hz for 200 loading cycles. A more detailed description of the MD tests can be found in Almeida *et al.* [1].

Damage evaluation

The impact of the MD tests on the geotextile was assessed by monitoring changes in its properties. Two characterisation tests were performed: determination of water permeability normal to the plane (EN ISO 11058 [4]) and determination of characteristic opening size (EN ISO 12956 [5]). The results of the water permeability tests included the flow velocity values at 20 ºC (v_{20}, in mm/s) for each head loss H tested (14, 28, 42, 56 and 70 mm) and the corresponding V_{H50} (in mm/s). O_{90} (in µm) was the output of the EN ISO 12956 [5] test. The values of v_{20} and V_{H50} resulted from the test of 5 specimens. O_{90} represents the mean value of 3 tested specimens. The V_{H50} and O_{90} values of the mechanical damaged samples are presented as percentage variations of the values obtained for the reference sample (undamaged): ΔV_{H50} and ΔO_{90}, respectively.

MAIN RESULTS AND DISCUSSION

The MD tests with IBA and *tout-venant* did not induce relevant visible damage on the geotextile. By contrast, the tests with *corundum* caused some fibre cutting and punctures. The velocity indexes v_{20}

of the reference and mechanical damaged samples can be found in Table 1 (the respective standard deviations are presented in brackets). Table 2 illustrates the impact of the MD tests in V_{H50} and O_{90}.

Table 1 – Velocity indexes v_{20} at different head losses H.

Sample	Velocity index v_{20} [mm/s]				
	$H14$	$H28$	$H42$	$H56$	$H70$
Reference	12.6 (0.6)	23.0 (1.6)	33.2 (2.5)	43.3 (3.2)	52.3 (4.0)
MD with IBA	12.9 (1.1)	23.5 (2.1)	33.8 (3.1)	43.6 (4.3)	53.3 (5.0)
MD with *tout-venant*	13.0 (0.9)	23.5 (1.4)	33.7 (2.2)	43.7 (3.0)	53.2 (3.4)
MD with *corundum*	12.1 (1.6)	23.1 (3.0)	33.6 (4.6)	43.6 (6.0)	53.0 (7.5)

Table 2 – Percentage variations in V_{H50} and O_{90}.

Sample	ΔV_{H50} [%]	ΔO_{90} [%]
MD with IBA	+1.5	-0.8
MD with *tout-venant*	+1.5	+1.3
MD with *corundum*	+0.8	-2.0

The MD tests with IBA did not induce relevant changes in the water permeability behaviour normal to the plane of the geotextile. Its characteristic opening size was also unaffected. Like the MD tests with IBA, the MD tests with *tout-venant* had no impact on the v_{20}, V_{H50} and O_{90} of the geotextile. Even the MD tests with *corundum* (which caused cuts in fibres and punctures, as mentioned above) did not result in changes in the hydraulic behaviour of the geotextile. As a side note, it can be mentioned that, although not affecting the hydraulic behaviour, the MD tests with *corundum* provoked changes in the tensile behaviour of the geotextile (e.g., reduction in tensile strength of about 25%). By contrast, the MD tests with IBA and *tout-venant* were significantly less impactful (reductions in tensile strength of 2-3%).

If IBA fulfils the requirements to be considered as a valid aggregate in civil engineering applications, its use will contribute to achieve a more sustainable construction. Indeed, it will allow reducing the use of natural resources and IBA will be valued, assuming a useful and noble role, which does not exist when its destination is landfill disposal.

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