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Implementation of Hospital Waste Replacing Stony Aggregates in Non-Structural Concrete Mixes of Low Resistance

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Abstract

A non-structural concrete mix was elaborated with a resistance of 14.5 Megapascals under the parameters indicated in the American Concrete Institute (ACI), ASTM and the Colombian Technical Standards (NTC). Six mixing cylinders were made with the concrete mix to test their mechanical resistance using the compressive resistance test, 3 were tested on day 7 and the 3 left were tested on day 28, the tests were performed in the IBERFEST machine, located in the laboratory of resistance of materials of the University Francisco de Paula Santander in the city of Cucuta, Colombia. The results were averaged to obtain the data of interest. Hospital solid waste was treated and processed in the Ecosteryl machine 250C, located in the environmental technology park Guayabal, Cucuta. The processes for the treatment of the waste material were performed under the established procedures in the Colombian decree 2676 of 2000. Taking particles, no bigger than 20mm of waste material, 2.5, 5 and 7.5% of the total stony aggregate used for the elaboration of the non-structural concrete was replaced, each of the 3 percentages were used for the elaboration of the 6-cylinder mixes (2 of each). The cylinders were tested on days 7 and 28 using the same procedure implemented to the mix of non-structural concrete. With the data obtained from the tests a comparative analysis was performed, identifying the presented characteristics of each.

Keywords: Waste, Concrete, Resistance

1 Introduction

Traditionally, construction works have used materials such as clay soils for the elaboration of stonework, wood, steel, cement elements, stony materials of alluvial or quarry terraces among others, for their implementation in construction works. All of these materials with or without industrialized process, for their transformation as construction material, are directly extracted from natural resources, generating collateral damage to the environment. Concrete, due to its availability, easy preparation and fabrication, is the most popular construction material in the World [1]. This composed material surges from the mix of cement, stony aggregates and water, characteristics that make it affordable for its implementation in construction works, making concrete the predominant structural material in engineering projects.

The mechanical properties of concrete are key for its implementation as construction material thanks to the characteristics of its composition materials, these materials also generate environmental controversy due to the great stony aggregate necessary for the elaboration of concrete, these aggregates make up 60 to 80% of the total volume of the concrete mix. These stony aggregates are generally classified as crushed stone, sand and gravel, which are obtained through the exploitation of natural resources and the opening of quarries [2]. Diverse variables can condition the mechanical properties of concrete, among them we can identify, form its internal composition, physical characteristics of the materials that compose concrete which are the basis for the elaboration of the mix design to use.

Concrete, as the most common structural material, is evolving towards more respectful forms with nature in the interest of global environmental protection and the conservation of resources [3], for this reason the usage of non-conventional materials replacing the traditionally used stony aggregates for the elaboration of concrete mixes has been the research focus of the experts on this subject, researches where the inclusion of waste from industrial processes is predominant.
The search for non-contaminant and friendly materials for the environment is the subject of interest in the scientific community of this subject, whose researches are directed the invention of innovative materials and the implementation of waste in concrete mixes, this way giving a useful, final disposition to waste material.
The use of hospital solid waste predominates in the replacement of stony aggregates for experimental concrete mixes due to the similarity of granulometric size and composition. Solid waste can be classified in different types according to their origin: a) domestic waste are generally classified as municipal waste; b) industrial waste as hazardous waste; and c) biomedical waste or hospital waste as infectious waste [4]. Hospital solid waste resulting from medical diagnosis or treat-

ments in humans or animals, according to research, are capable of producing infectious diseases, for this reason, their incineration has become an alternative to reduce their volume and destroy infectious organisms [5]. Waste material are a big environmental problem that threats the environment.

The main objective of managing hazardous waste is to minimize its environmental impact [6], for this reason, the implementation of material resulting from incineration and treatment as non-conventional material for the replacement of stony aggregates traditionally used in concrete mixes, is a feasible alternative for a final disposition of the waste. Hospital solid waste is a motive of concern and importance, mainly for its harmful effects for human health and the environment [7], the use of these type of waste as alternative materials on construction activities could generate a positive impact in the environment due to its useful disposition. Creating an ecological consciousness directed to the reduction of environmental impact in the processes of extraction and fabrication of raw material for the elaboration of concrete mixes, becomes the collective purpose for the interested, where active participation in research plays an important role for the development of new alternatives.

The present research evidences the results obtained for compressive resistance on days 7 and 28 of the experimental concrete mix designs resulting from the replacement of 2.5, 5 and 7.5% of the total stony aggregate weight of a non-structural concrete mix with a resistance of 14.5 Megapascals (MPa) with hospital solid waste, incinerated and treated in the Ecosteryl 250C machine, located in the environmental technology park Guayabal in the city of Cucuta, Colombia.

2 Methodology

The results of the project contemplated an experimental research which began with the elaboration of a non-structural concrete mix with a resistance of 14.5MPa. The mix was designed and elaborated according to the methodology guided by the standard ASTM-C31 [8]. Six mixing cylinders with the non-structural concrete mix were elaborated and these were tested to determine their compressive resistance, 3 cylinders were tested on day 7 and the rest were tested on day 28 under the stipulated in the standard ASTM-C39 [9], the results were averaged. The non-structural concrete mix was elaborated with the disposed material quantities in its design, the evaluation of its compressive resistance performed on day 7 and 28, respectively, was done in the universal machine IBERFEST located in the University Francisco de Paula Santander (UFPS), Cucuta.

The total stony aggregate weight for the design of the mix used in the non-structural concrete mix was replaced with 2.5, 5 and 7.5% of hospital solid waste. For each % of replaced stony aggregate an experimental concrete mix (EM) was made (EM-1, EM-2 and EM-3), respectively. Each EM lead to the elaboration of 3 mixing cylinders which were tested on day 7 and 28, averaging their results, as well as the non-structural concrete mix. The results obtained in the compressive resistance tests of the experimental concrete mixes with hospital solid waste were analyzed and compared to the results of the non-structural concrete mix. For the analysis of the results obtained in the mechanical resistance tests of the EM, the factorial experiment method was used, since there was an independent variable in each of the EM.

2.1. Design of 14.5 Megapascals non-structural concrete mix

For the elaboration of the non-structural concrete mix, Portland cement type I was used (AGROS brand) which met the nomenclature and classification described by the NTC30 [10] along with the methods NTC121 [11], 184 [12] and 321 [13] for its analysis. The stony aggregates came from the company Transmateriales, located in Cucuta. The methods guided by the NTC77 [14], 92 [15] and 176 [16] were applied to the stony aggregates for their evaluation; for the metering of the non-structural concrete mix the materials used were quantified with the purpose of determining the adequate proportions, in volume and weight, to meet with the characteristics established by the standard ASTM-C33 [17] for stony aggregates. The water added to the non-structural concrete mix met with the requirements of the standard NTC3459 [18].

Table 1. Mix design for $1m^3$ of 14.5 Megapascals of non-strucutral concrete mix

Material	Density Gr/cm^3	Dry weigth Kg/m^3	Dry volume Lt/m^3
Cement	1199773.41	317.70	264.80
Fine aggregate	1613944.88	784.70	486.20
Coarse aggregate	1347150.98	971.70	721.30
Water	1000000.00	197.00	197.00

2.2. Treatment of hospital solid waste

The procedures established in the integral management of hospital waste -ruled by the established regulation in the Colombian decree 2676 of 2000 [19] were applied. A thermic treatment of high efficiency was performed in the hospital solid waste with the machine Ecosteryl 250C, the hospital solid waste was crushed in particles not bigger than 20mm, according to the standardized procedure. The hospital solid waste was deactivated through incineration, process that lead to the disinfection of the material which was then manipulated and transformed without representing risks.

Figure 1. Ecosteryl 250C and particulate hospital solid waste

2.2.1. Characterization of the hospital solid waste

The particulate homogeneous material (not bigger than 20mm) was selected as obtained from the standardized crushed procedure, the hospital solid waste went under a moist content test according to the parameters described on NTC1495, its density was also taken.

Table 2. Hospital solid waste moisture content

	Weight	
Characteristic	Value (gr)	Value %
W Hospital solid waste+ Water	11.78	100
W Dry Hospital solid waste	6.57	55.77
Moisture	5.21	44.23

Table 3. Hospital solid waste density

Characteristic	Value	Unit
Mixing cylinder weight	4490	gr
Mixing cylinder volume	0.0054	m^3
Mixing cylinder weight + material	5551	gr
Hospital solid waste weight	1061	gr
Hospital solid waste density	0.19	gr/m^3

2.3. Experimental concrete mix designs

With the tabulated data of the material quantities when using the non-structural concrete mix design, along with the total weight of the stony aggregates in relation to the preparation of 1m3 of concrete, we calculated the weight of the hospital solid waste percentages that replaced their equivalents of stony aggregate materials. Table 4 describes the corresponding weight for each of the % of stony aggregate replaced with hospital solid waste, taking as reference the total weight of the dry stony aggregates in the non-structural concrete mix with resistance of 14.5MPa.

Table 4. Substituted weight of stony aggregate for hospital solid waste

Mix	% replaced stony aggregate	Weight (Kg)
EM-1	2.5	56.78
EM-2	5	113.55
EM-3	7.5	170.33

3 Results

With the results obtained in the mechanical resistance tests of the non-structural concrete mix and the 3 experimental mixes, comparative charts were made to describe the behavior of the EM compared to the non-structural concrete mix. The design of the EM-1 on day 7 obtained the most resistance compared to the other experimental mixes, also surpassing, the resistance of the non-structural concrete mix. EM-3 had the lowest resistance.

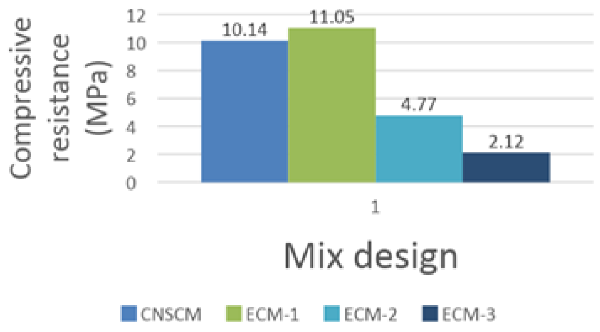

Figure 2. Compressive resistance Day 7

The comparative analysis of the obtained data from the compressive resistance test on day 28, showed that the design of EM-1 continued to be the design with the most resistance and the EM-3 maintained its low mechanical resistance.

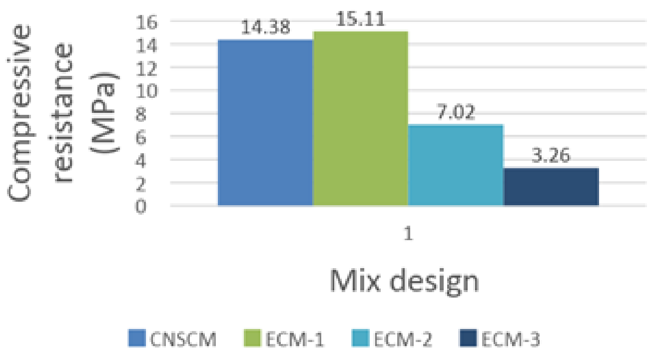

Figure 3. Compressive resistance Day 28

4 Conclusions

In the experimental research project of this paper, data of interest was presented for the efficient management of treated hospital solid waste. Its implementation in concrete mixes can be viable by incorporating percentages lower to 3% of hospital waste as replacement of stony aggregate present in the initial design of the non-structural concrete mix with a 14.5Mpa of compressive resistance. The moisture content of the hospital solid waste was 44.23%, putting on evidence the great quantity of water absorbed by this material, this means more malleability for the experimental mix, characteristic of humidity retention that benefits its curing process. The comparative analysis of the resistance of the mixes obtained on day 7, shows a favorable value for the EM-1 which reached 11.05MPa, surpassing the resistance obtained for the non-structural concrete mix. The resistance obtained for EM-1 on day 28 notoriously surpasses the other experimental mixes, its comparative advantage with the non-structural concrete mix was only 0.73MPa.
The incorporation of hospital solid waste superior to 3% of the stony aggregate weight used in conventional non-structural concrete mix, is not recommendable due to the low resistances obtained in the performed compressive resistance tests. In the visual and manual identification of the corresponding EM-2 and EM-3 flared cylinders, the lack of adherence of the cement to the hospital solid waste material was identified, characteristic that generated low resistance in these designs. The addition of 2.5% of hospital solid waste to non-structural concrete mixes decreases form 3 to 3.5% the total weight of the mix, favorable characteristics in the malleability and workability of the concrete.

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