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Substitution of Natural Stony Material Aggregates in Conventional 17.5 Mpa Non-Structural Concrete Mixtures by Means of Percentage Addition of Hospital Solid Waste

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Abstract

An experimental character research was carried out. A conventional concrete mixture was made with the mechanical resistance to compression of 17.5 Mpa. The materials used in the concrete mixture were analyzed and selected based on the parameters established in the Colombian Technical Standards and the ASTM International Standards. They were made 6 test cylinders with the mentioned concrete mixture to which, the compressive strength of the concrete was checked it, 3 of them 7 days after they were made and the rest of them 28 days later, respectively. Thereafter, their drying process by immersion, the data thrown by the tests were averaged and tabulated. The Hospital waste solid incinerated and treated by Ecosteryl machine which is located at Guayabal environmental technology park in Cucuta city was collected. The material resulting from the incineration and treatment of the hospital solid waste was selected taking only the particles equal to or less than 20mm resulting from the crushing process by Ecosteryl. With the selected Particulate material, 3 experimental mix designs were made, which 2.5, 5 and 7.5% of the total weight of the natural stone aggregates present in the conventional concrete mixture was replaced. With each experimental mixture made, 6 cylinders were tested at 7 and 28 days, a process carried out in the same way as that implemented in the conventional concrete mix for both tests and data collection and analysis. The comparative tables showed that the experimental mixture I, where 2.5% of the total weight of the aggregate of the conventional concrete mixture was replaced, was the one that obtained the highest compressive strength surpassing the result of the conventional concrete mixture.

Keywords: concrete mixture, compressive strength, drying process, Ecosteryl

1. Introduction

The constant extraction of non-renewable resources for the direct manufacture of construction materials together with the consumption of fossil fuels in the different processes inherent to their elaboration, are the cause of the environmental deterioration both by the removal of vegetal layer and felling of forests as well as emissions pollutants that greatly affect the natural environment that we are part of. Obvious situation due to the accelerated economic development and the boom in the construction industry that considerably affects both the ecosystem and the environment [1].

Concrete is known as the most commonly used construction material [2] in engineering projects around the world, whose composition is the result of the mixture of natural crushed stone aggregates (APN), Portland cement, water and additives, the latter being able to be incorporated into concrete mixtures (MC) before and after mixing to improve their properties, characteristic that leads to today, the sea concrete the second material more than water, with almost three tons. person on the earth [3].

The NPCs conventionally used in the different MCs occupy around 60 to 80% of their total volume, making them an essential material and a priority for their preparation, which is why the rapid development and the need for large-scale infrastructure have resulted in the indiscriminate exploitation of natural rocks and alluvial terraces to meet the growing demand for NPCs in MCs [4].
The worrying projection of the increase of the world population in the next 30 years made by the UN in 2015, who estimate an approximate of 9700 million people who will inhabit the planet earth in the year 2050, keeps experts in the area of construction and environmentalists, professionals who know about the housing need that is coming. Construction works that will require large amounts of NPC, which translates into an intensification of the scarcity of natural resources and the difficulty of sustainable development [5].

Research aimed at the development of construction materials with low environmental impact has resulted in the implementation of processes and raw

materials that demonstrate the reduction of the carbon footprint in processes and operations throughout the execution of activities in its preparation and implementation.
The construction industry faces major challenges, since the global commission on environment and development defined the concept of sustainable development as "that development that is capable of meeting current needs without compromising the resources and possibilities of future generations" Research that launched research in search of environmentally sustainable alternatives in all activities and processes inherent to the execution of engineering projects. In addition, the construction sector is paying increasing attention to aspects of the complete life cycle of building materials as a component of the impact of the life cycle of a building [6].

The replacement of the NPCs that are part of a large% of the total volume of MCs has been the subject of interest of researchers who see the need for this replacement due to the limited disposition of natural resources.
The methods implemented for the replacement of the APN conventionally used in the MC vary according to the characteristics of the substitute material, a characteristic that should resemble the fine or coarse aggregate present in the mixture. However, experimental investigations have also been carried out where percentage of volume or weight of the total number of NPCs are replaced according to the characteristics of the replacement material. Most of the methods mainly include the partial or total replacement of the NPCs [7] by residual materials from industrial, waste and demolition processes.

Due to industrialization and population growth, the disposal of hospital solid waste (RSH), which includes a wide range of contagious hazardous contaminants, has turned out to be one of the most important environmental problems [8], which is why, its incineration becomes the effective alternative for the treatment of this type of hazardous waste. The incineration process destroys the pathogens and reduces the volume and weight of the waste but leaves behind solid material [9] that has no utility in its final disposal.
The present investigative work puts evidence the mechanical property of resistance to compression of a conventional non-structural concrete (CCNE) of 17.5 Mpa, by partial replacement of 2.5, 5 and 7.5% of the total weight of conventional APN by RSH resulting from its incineration.

The results of the tests of the mechanical resistance made to the experimental mixtures (ME) were compared with those obtained by the mixture of CCNE throwing information of interest that shows the viability of the use of the RSH in the CCNE mixtures of 17, 5 Mpa, thus helping the main objective of managing hazardous waste by minimizing its environmental impact [10].

2. Materials and methods

The research project contemplated the performance of experimental tests beginning with the conformation of a mixture of CCNE with compressive strength of 17.5 Mpa, for the preparation of the mixture was used Portland cement type 1 fulfilling the classification described in the Colombian Technical Standard (NTC) -30 for this type of material, its chemical analysis was carried out following the parameters stipulated in the NTC-180, as well as the specifications guided by the NTC-121, the analysis of the APN used for the elaboration of the mixture were subject to what was implemented by the NTC-174, the screening of the particulate samples was carried out with what was described in the NTC-32, this screening method was arbitrated by the NTC-77, the densities of the granular material was taken under the guidance of NTC-176 and 237 according to the characteristics of the material analyzed. The water used for mixing met the standards set by NTC-3459. The international homologous standards taken as a basis were the American Society for Testing and Materials (ASTM) together with the regulations of the American Concrete Institute (ACI).

With the mixture of CCNE, 6 test cylinder cylinders were carried out using the protocol guided by the NTC-550, the cylinders were tested in the IBERTEST machine located at the Francisco de Paula Santander University (UFPS) of the City of Cúcuta under the parameters described in NTC-673, the order of checking the compressive strength of the cylinders contemplated the test of 3 cylinders at 7 and 3 cylinders at 28 days, after curing in immersion, the results of the tests obtained were averaged and tabulated.
We collected material from RSH incinerated and treated by the Ecosteryl 250-C machine located in the environmental technology park Guayabal of the city of Cúcuta, with the waste material from the incineration of the RSH, three (3) MEs were elaborated by partially replacing the 2.5, 5 and 7.5% of the total weight of the APN present in the CCNE mixture, with each% of the aggregate replaced, 3 test cylinder cylinders were prepared that were tested, analyzed and whose results were averaged and tabulated with the same procedures made to the tests of the CCNE.

The tabulated data led to the development of a comparative table where the mechanical characteristics obtained by each of the EMs were evidenced in comparison with the CCNE mixture. The data of interest reached conclusions about the viability of the incorporation of the HRS treated in the CCNE mixtures of 17.5 Mpa.

2.1. Mix design 17.5 Mpa

Following the regulations in force for the preparation of concrete and after the data obtained by the different tests carried out on the materials that make up the mixture, the mix design for the CCNE with compression resistance of 17.5 Mpa was elaborated.

Material	Density Gr/cm3	Dry weight Kg/m3	Loose Volume Lt/m3
Cement	1200000,00	345,60	288,00
Fine Aggregate	1613737,55	761,20	471,70
Thick aggregate	1347150,98	971,70	721,30
Water	1000000,00	197,00	197,00

Table 1. Mix design for 1m3 of CCNE of 17.5 Mpa

2.2. Treatment of the RSH

The procedures established in the Colombian regulation of integral management of hospital and similar waste regulated in decree 2676 of 2000 that applies to Colombia, were implemented in the incineration and treatment of the RSH. After the incineration and treatment of RSH by the machine Ecosteryl 250-C, this same begins its crushing process, material that was selected for use in the ME, choosing particles not exceeding 20mm.

Figure 1. Ecosteryl 250-C machine and particulate RSH
Source: The authors

2.2.1. Characterization of the RSH

With the selection of the particulate material less than 20mm, we proceeded to its characterization by testing the moisture content according to the guidelines described in the NTC-1495, as well as taking its density.

Characteristic	Weight		Characteristic	Value	Unit
			Test tube weight	4490	gr
	Value (gr)	Value %	Test tube volume	0,0054	m3
W RSH + Water	11,78	100	Test tube weight + material	5551	gr
W RSH Dry	6,57	55,77	Weight RSH	1061	gr
Humidity	5,21	44,23	Density RSH	0,19	gr/m3

a) b)

Table 2. a) Moisture content of the RSH b) Density of the RSH

2.3. Designs of ME with the RSH

Taking the material resulting from the incineration and treatments of the selected RSH, we proceeded to the development of the 3 designs of ME (ME-I, ME-II, ME-III) corresponding to 2.5, 5 and 7.5% of the total weight of the APN used in the CCNE mixture with resistance of 17.5 Mpa. The replaced percentages were calculated with respect to the dry weight of the APNs of the CCNE mixture corresponding to 1732.9 kg.

Mix	% APN replaced	Weight (Kg)
ME-I	2,5	43,32
ME-II	5	86,64
ME-III	7,5	129,97

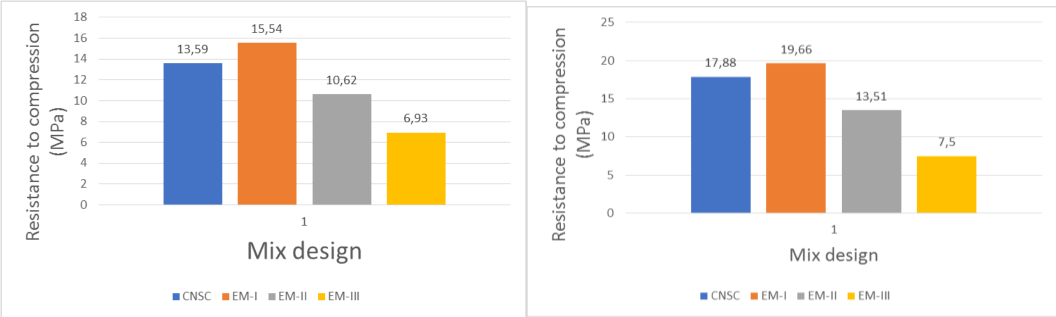
Table 3. Replaced weight of APN by RSH

3. Results and discussion

The mechanical test of resistance to compression performed at 7 days on the designs of mixtures showed the superiority of the design of ME-I over the other designs.

Design that exceeded by only 1.95 Mpa compared to the mix design for the CCNE.

The data obtained in the checking of the compressive strength of the mixtures, demonstrates the superiority of the design of ME-I, a design that was superior in the two tests carried out. The difference with respect to the mix design of CCNE indicated 1.78 Mpa. The design of ME-III maintained the lowest resistance.



a) b)

Figure 1. a) Resistance to compression at 7 days b) Resistance to compression at 28 days

4. Conclusions

The RSH have a significant impact on health and the environment. Currently there is an urgent need to increase public awareness and education about the management of this type of hazardous waste. However, research in the field has implemented relevant strategies for the management of the RSH from its source to its final disposal as one of the priority reasons for its proper management. Incineration is the most appropriate alternative to reduce the volume of this type of waste [9], but this activity, despite its advantages, generates a new solid waste that must be considered through investigations to give a correct and adequate disposal environmental.

The incineration of the RSH is one of the most effective methods to reduce its volume. Among the different types of solid waste resulting from incineration, some of them may contain toxic elements [11], which is why the adequate disposal of these treated wastes, which even with their incineration remain a residual problem, is crucial for the environment where we live.

The experimental research project that was carried out demonstrated the feasibility of replacing the NPCs that have conventionally been used in MCs treated by RSH resulting from their incineration. With the addition of percentages corresponding to the total weight of the APN present in the CCNE mixture, it was possible to determine the appropriate% of RSH to be incorporated in the mixture.

The ME-III proved to be the design with the lowest mechanical resistance to compression in the two tests carried out, the large amount of RSH material present in the mixture did not allow the cement paste to adhere to the other aggregates present in the design, situation that weakens its mechanical behavior significantly.

The design of ME-II despite its medium resistance compared to the other designs, maintained an interesting behavior. The designs of mixtures with this percentage of added replaced, could be used for the elaboration of concretes used as flooring or support of structural concrete in engineering works, in this way an adequate disposition would be given to a large amount of residual material benefiting the works and environment.

The ME-I maintained the superiority in its mechanical behavior in the resistance to compression, exceeding the mixture of CCNE at 7 days at 1.95 Mpa and with 1.79 Mpa at 28 days, results that demonstrates the viability of this material in its implementation in the MC with resistance of 17.5 Mpa.
The optimum percentage of APN replaced in a mixture of CCNE with compressive strength of 17.5 Mpa should not exceed 3% of the total weight of the APN present in the mixture, replacement amount reflecting resistance increases at 7 and 28 days.

The optimum percentage of APN replaced in a mixture of CCNE, which is desired to be used as a base or floor of structural concrete, should not exceed 5%, replacement ranges that showed significant resistances for this type of concrete that, although not structural, are of great importance. Utility in engineering works.
The selected particles of the treated and incinerated RSH that are intended to be used in the designs of CCNE mixtures, should not exceed 20mm, a characteristic that allowed the resistance shown in the tests carried out at the ME. A size greater than 20mm supposes the decrease of the adherence of the paste of the concrete with the other aggregates present in the mixture, a situation that diminishes its mechanical resistance as well as what happened with the ME-III.

Although RSH are considered dangerous, due to their infectious and / or toxic characteristics [12], the scientific community has currently directed their interest in the proper management of these residual materials while minimizing their environmental impact. This management is evidenced in the different investigations carried out to implement the solid waste as a partial or total replacement of some type of raw material conventionally used for a specific activity, as is the case of the NPCs for MCs, object of study of the previous investigative work.

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