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Determination of the quality of coarse aggregates for the elaboration of concrete mixes from 3 water sources in the City of Cucuta-Colombia

O Hurtado Figueroa^{1,2}, J A Cárdenas Gutiérrez² and J P Rojas Suarez²

¹ Centro CIES, Servicio Nacional de Aprendizaje (SENA), San José de Cúcuta, Colombia

² Grupo GITOC, Universidad Francisco de Paula Santander, San José de Cúcuta, Colombia

E-mail: ohurtado8@misena.edu.co

Abstract. A comparative analysis was performed on the mineral material extracted from 3 water sources in the city of Cucuta, from the rivers Tachira, Pamplonita and Zulia to determine the viability of their incorporation in the concrete mixtures for the construction of rigid floors. There were visits to the companies *Preconcretos Trituradora la Roca y Concretos, and Tirurados*, in charge of the material extractions, where samples of the crushed material “coarse aggregate” from each of the water sources were taken respectively. The granulometry of the coarse aggregate was performed according to the arranged parameters in the NCT 174 whose results were determinant for the conclusions. The trial of degradation to abrasion to each of the samples was executed, taking as guide the indications described by the Colombian *INV-218-13* standard. The results obtained in the trial were analyzed and compared with the parameters stipulated by the *INV* standard described for the % of the degradation limit allowed for coarse aggregate for its usage as concrete material in the construction of rigid floors. It was concluded that each of the extracted materials from the water sources were viable according to the data obtained from their comparison.

1. Introduction

Concrete is a construction material of broad application around the world. The popularity of conventional concrete, or the ordinary concrete of Portland cement, is due to its advantages and applications, among them its high resistance to compression and its low cost [1].

Concrete is the most used construction material worldwide in engineering works, resulting from the heterogeneous mixture of an agglutinant element, mineral aggregate and water, converts the mixture in the main material for the development and execution of constructive activities that make part of an engineering project.

Among the aforementioned components, the aggregates occupy around 70%-80% of the total volume of the mix [2] and are commonly of natural origin. By itself, it has a proven resistance to compression and presents minimum flexure. For that reason, the construction of both vertical and horizontal elements traditionally have used steel rods to reinforce its resistance. The concrete, due to its availability, easy preparation and fabrication, is the most popular construction material. Currently, concrete is the second most used material after water, with almost three tons used per person annually [3].



The natural aggregate is a vital constituent material used for the design and the construction of civil infrastructure systems [4], it is conformed by granular particles, that establish a great percentage of the total volume of the concrete mixture, according to its design, these are generally classified in fine aggregate and coarse aggregate. The aggregate particle between the ranges of 0.074mm to 4.76mm is denominated fine aggregate, the particles superior to 4.76mm are identified as coarse aggregate [5].

The arid coarse aggregate occupies most of the concrete mixture in proportion to its volume [6] and form a matrix of particles as the main framework which supports the load in the structure of the concrete [7], these characteristics put on evidence the importance of coarse aggregate as the main component of the concrete, since it has a direct effect in the development of its resistance [8].

The texture and form that the aggregates have, considerably influence on both the mechanic resistance and the workability of the concrete mixture, these are identified characteristics in its fresh or solid state respectively. The workability of the concrete can be resumed in the quantity of internal work necessary to achieve the maximum compaction of the material [9].

The versatile usage of the concrete mixtures has generated important researches whose results create documents that suggest the implementation of a specific type of concrete mixture according to the work to be executed, where it is inherent the special characteristics that its aggregates must have for the obtention of the necessary resistance for each work to be executed, for example, the case of rigid floors.

The degradation of the material by friction or mechanical movement is denominated resistance to wear or abrasion, an important characteristic that puts on evidence the quality of the origin of the coarse material and its behavior to these types of actions, characteristics that make the material recommendable for its usage in the design of mixtures for rigid floors. From the total world production of crushed material for concrete, 99% is used for applications such as base material for road construction or filling material in the construction of pavements [10], this massive use points the importance of the quality of the material in these types of constructions.

The present research work leaves on evidence the values obtained in the trial from wear to abrasion, using the Los Angeles abrasion machine, of the crushed material that is currently extracted from 3 water sources of the city of Cucuta, River Tachira, River Pamplonita and River Zulia, by companies dedicated to the commercialization of this type of material. This way determining the quality of the material for its usage in the design and elaboration of concrete mixtures for the construction of rigid floors. The data obtained was compared with the parameters described in the standards of the National Roads Institute INVIAS (INV) [11], that regulate in Colombia, these indicate the requisites and characteristics of the aggregates for the concrete mixtures used in construction for these types of pavements.

2. Materials and methods

The Project contemplated a quantitative focus where physical properties of the aggregates from the rivers Tachira, Pamplonita, and Zulia of the city of Cucuta extracted by local companies *Preconcretos*, *Trituradora la Roca (TR)*, *Concretos y Triturados Zulia (CTZ)* respectively, were studied. At the same time, a descriptive study was performed, about the quality of the mineral aggregates for their evaluation as material for usage in the design of concrete mixtures for construction of rigid floors through trials described in the INV standards and the Colombian Technical Standards (NTC).

Companies that extract the material from the 3 rivers were visited, 20 kilos of crushed material were taken from each of the companies, following the indications described by the standards INV-E-201-13 [12]. The samples were transported in plastic bags to impede contamination and loss of particles during its transportation to the laboratory of resistance of materials of the University *Francisco de Paula Santander UFPS* in the city of Cucuta. For the development of the analysis the method of reduction of samples was implemented through the quartering method guided by the standard INV-E-202-13 [13]. The granulometric analysis that allowed to determine quantitatively the distribution of the particle sizes of the aggregates in the sample, though sieving, was performed under

technical specifications represented in the NTC-174 [5]. The trial of resistance to erosion was performed following the indicated parameters in the standard INV-E-218-13 [14].

In Tables 1, 2 and 3 reports the granulometric analysis of the crushed material from the Tachira, Pamplonita and Zulia rivers, respectively.

Table 1. Granulometric analysis 5000g coarse aggregate Preconcretos.

mm	Sieve	Inferior lim	Superior lim	Retained weight	% Retained	% Ret accumulated	% Pass
64.9	2.1/2			0.00	0.00	0.00	100.00
50.8	2			0.00	0.00	0.00	100.00
38.1	1.1/2"			0.00	0.00	0.00	100.00
25.4	1"	100	100	0.00	0.00	0.00	100.00
19	3/4"	90	100	0.00	0.00	0.00	100.00
12.7	1/2"			0.00	0.00	0.00	100.00
9.51	3/8"	20	55	49.31	0.99	0.99	99.01
4.76	4	0	10	4203.36	84.07	85.05	14.95
2.38	8	0	5	688.32	13.77	98.82	1.18
1.19	16			47.39	0.95	99.77	0.23
0.595	30			0.00	0.00	99.77	0.23
0.292	50			0.00	0.00	99.77	0.23
0.149	100			0.00	0.00	99.77	0.23
0.074	200			0.00	0.00	99.77	0.23
		Bottom		11.62	0.23	100.00	0.00
				5000			

Table 2. Granulometric analysis 5000gr coarse aggregate Trituradora la Roca (TR).

mm	Sieve	Inferior lim	Superior lim	Retained weight	% Retained	% Ret accumulated	% Pass
64.9	2.1/2			0.00	0.00	0.00	100.00
50.8	2			0.00	0.00	0.00	100.00
38.1	1.1/2"			0.00	0.00	0.00	100.00
25.4	1"	100	100	0.00	0.00	0.00	100.00
19	3/4"	90	100	0.00	0.00	0.00	100.00
12.7	1/2"			339.76	6.80	6.80	93.20
9.51	3/8"	20	55	2194.00	43.88	50.68	49.32
4.76	4	0	10	2287.00	45.74	96.42	3.58
2.38	8	0	5	125.75	2.51	98.93	1.07
1.19	16			14.79	0.30	99.23	0.77
0.595	30			0.00	0.00	99.23	0.77
0.292	50			0.00	0.00	99.23	0.77
0.149	100			0.00	0.00	99.23	0.77
0.074	200			0.00	0.00	99.23	0.77
		Bottom		38.70	0.77	100.00	0.00
				5000			

Table 3. Granulometric analysis 5000gr coarse aggregate Concretos y Triturados Zulia (CTZ).

mm	Sieve	Inferior lim	Superior lim	Retained weight	% Retained	% Ret accumulated	% Pass
64.9	2.1/2			0.00	0.00	0.00	100.00
50.8	2			0.00	0.00	0.00	100.00
38.1	1.1/2"			0.00	0.00	0.00	100.00
25.4	1"	100	100	0.00	0.00	0.00	100.00
19	3/4"	90	100	0.00	0.00	0.00	100.00
12.7	1/2"			1163.74	23.27	23.27	76.73
9.51	3/8"	20	55	2477.74	49.55	72.83	27.17

4.76	4	0	10	1315.74	26.31	99.14	0.86
2.38	8	0	5	34.51	0.69	99.83	0.17
1.19	16			0.00	0.00	99.83	0.17
0.595	30			0.00	0.00	99.83	0.17
0.292	50			0.00	0.00	99.83	0.17
0.149	100			0.00	0.00	99.83	0.17
0.074	200			0.00	0.00	99.83	0.17
		Bottom		8.27	0.17	100.00	0.00
				5000			

3. Results

3.1. Degradation of coarse aggregate Tachira river

The results of the degradation analysis of the 3 samples from the Tachira river have an average of 32.5% of material loss are shown in Table 4.

Table 4. Average degradation of coarse aggregates Preconcretos.

Degradation loss % sample 1	Degradation loss % sample 2	Degradation loss % sample 3	Degradation average % samples	Standard deviation(σ)
31.40	31.70	34.50	32.5	± 1.71

3.2. Degradation of coarse aggregate Pamplonita river

In Table 5 report the results of the degradation analysis of the 3 samples from the Pamplonita river have an average of 28.5% of material loss.

Table 5. Average degradation of coarse aggregates Trituradora la Roca (TR).

Degradation loss % sample 1	Degradation loss % sample 2	Degradation loss % sample 3	Degradation average % samples	Standard deviation(σ)
30.60	26.90	28.10	28.50	± 1.54

3.3. Degradation of coarse aggregate Zulia river

The results of the degradation analysis of the 3 samples from the Zulia river have an average of 23.2% of material loss are shown in Table 6.

Table 6. Average degradation of coarse aggregates Concretos y Triturados Zulia (CTZ).

Degradation loss % sample 1	Degradation loss % sample 2	Degradation loss % sample 3	Degradation average % samples	Standard deviation(σ)
23.90	21.45	24.30	23.20	± 1.58

4. Conclusions

The material from the coarse aggregate fabricated by the company *Preconcretos*, although it presented the greatest loss to degradation due to abrasion with a 32.5%, its found within the limits allowed by the INV standards. This result is evident since the retained % in the sieve of 1/2" was of 0,00, while the other companies-maintained numbers in this cell. The quality of the material is reliable for its implementation in the elaboration of concrete for the construction of rigid floors. Being in the allowed levels by the standard, through a meticulous design of mixture the limits could be surpassed, optimizing even more the characteristics suggested by the design. The Pamplonita river, source of the material extracted from the company *Trituradora la Roca*, presented the intermediate result with only 28.5% of material loss by degradation, and it is with the limits allowed by the INV standard. The retained percentage in the sieve of 1/2" was of 6.80%. The material is recommendable and reliable for its usage in the elaboration of concrete mixtures for rigid floors, as well as the material extracted from the Tachira river, the suggested levels regarding resistance and durability are inherent to the design of

the mixture. The company *concretos and Triturados el Zulia*, which extracts the mineral materials from the Zulia river for its commercialization, presented the lowest % of material loss, with only 23.2% of degradation by abrasion, characteristic that positions it in a place of excellence for the acquisition of mineral materials, by its contracting companies, for the elaboration of concrete mixtures in paving works. Its retained % in the sieve of ½” was the highest with 23.27%. It was evidenced that the % of retained material in the sieve of ½” could influence in the results obtained by the trial of degradation. The retained % of the sieve of ½”, in each if the extraction sources of mineral aggregate, was inversely proportional to the % of degradation of these.

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