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Quality of aggregates for the preparation of asphalt mixtures from 4 processing companies in San José de Cúcuta, Colombia

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Abstract. Four asphalt mix processing companies were visited: Transivic S.A.S, Maquinteligente S.A.S, Copavicol S.A.S and Grupo Colpao S.A.S, companies located in the city of San José de Cúcuta, Colombia. Samples were taken of the stone material marketed by each of the companies for the preparation of asphalt mixtures, especially hot dense mixture-19. The stone aggregates taken from the processing companies were submitted to the analyses described by the “Instituto Nacional de Vías” 2013 for approval in the preparation of asphalt mixtures, regulations that apply in Colombia. The results obtained in the tests carried out with natural stone material were tabulated and analyzed comparatively in order to determine which of them is the most suitable for use in the preparation of the hot dense mixture-19. This provided interesting data on the quality of this material for the preparation of asphalt mixtures in each of the 4 processing companies. With the analysis of the results carried out, it was concluded that only 1 of the 4 material processing companies have high quality indexes. Research conclusion that provides information of interest to civil engineering contractors specialized in the construction of asphalt pavements, who will make important decisions regarding the acquisition of the ideal material for their next projects, thus constructing more durable works, a characteristic that contributes considerably to the economy of the project. In addition, a positive social and environmental impact is generated with the minimization of maintenance and repairs of the work carried out, an activity that leads to a reduction in the industrialized processes that generate polluting waste with respect to the preparation of construction materials for this type of projects.

1. Introduction

The construction industry has grown on average about 8% in the last five years as a result of various housing programs and infrastructure projects promoted by the national government [1]. This sector consumes large quantities of raw material [2] using various materials for the development of the various works that transform societies. These materials are selected according to the technical specifications of the project to be executed together with the analysis of the geographic, cultural, ethnic, environmental and other contexts, which will include the constructive project. The availability and proximity of the necessary materials in an engineering project with respect to its area of influence, plays an important role in its operational cost, making it or not viable in its execution and development for the contractor, an indispensable stage of the financial analysis of any company [3] considering that it is essential to recover the investment in the shortest period of time [4].

In addition to the cost of the materials needed in the execution of construction projects, the quality of the same is a fundamental requirement to ensure the stability and durability of the construction



carried out knowingly giving full support with efficient, safe, reliable and highly competitive processes [5]

Thus, as the origin of the materials, know production company, supplier, or place of extraction, as the case may be, is an essential information that gives confidence in the use and selection of the material to be implemented in the different works. These characteristics of origin not only give confidence in the use of materials, but also guarantee quality in the final result of their execution, leaving high the name and recognition of the construction company.

For this reason, giving true importance and attention to the quality of the materials that will be used in the different types of works developed in the area of civil engineering due to the increase in construction activities [6], is a fundamental part of the guarantee that the contractor-executor provides the society with the economic investment it is making to make its desire to obtain an enduring work a lasting reality. It is important to control even the times to preserve certain properties of the materials, as it happens with concrete since the passage of time from its production, reduces the work capacity [7].

Speaking of quality, the processes and analysis to which the materials implemented in the area of construction of civil works are subject are inherent. Analysis and tests standardized by international standards with their national counterparts, whose purpose is to determine the characteristics of the materials intervened to give part of their use or not in the projects. Processes those are essential for the reduction of waste of materials, work times and the maximization of value for customers [8].

In the construction industry there are 3 types of mixtures that are implemented according to the construction need, the first of which is called mortar, a mixture consisting of cementitious material, fine stone aggregate and water, the second called concrete whose mixture is made up by cementitious material, fine stone aggregate, coarse and water [9,10], and the third named asphaltic mixture, formed by an asphaltic emulsion and fine and thick stone aggregates. These mixtures, sometimes, in order to improve their characteristics and physical-chemical properties, are mixed with some type of additive, which according to the need, reacts favorably in them, optimizing their preparation, use and final result.

In the same sense, asphalt mixtures are widely used in the construction of pavements due to their advantages of comfort in driving and convenience in maintenance [11] and it is estimated that their use in the construction of this type of flexible pavements designed under aspects that contemplate the soil, support capacity and materials, contain approximately 70% to 75% of stone aggregates (SA) in relation to their total volume, a considerable figure that leads to pay great attention to the quality characteristics of this type of aggregate being the structure responsible for supporting the loads imposed by the vehicular flow and transmit them to the underlying layers in less intensity.

However, the analysis of the SA used in the preparation of the asphalt mix designs is of great importance for the behavior and operation of the mixture as a rolling layer. A layer that must consist of optimal durability, texture and mechanical resistance conditions in order to guarantee its quality. The latter is a determining factor in the evolution of damage mechanisms that affect them, such as rutting, fatigue, stripping and damage by humidity or when finally, the bitumen of asphalt is detached from the surface of the aggregate [12], situation that leads to the subsequent repair, rehabilitation and reconstruction of the deteriorated pavement [13], deterioration that, sometimes, is directly related with compatibility between asphalt and aggregates [14].

Indeed, the SA must have the appropriate granulometry, and the minimum quality requirements according to the international norms and their national homologues that govern in the country where the road project is carried out. Characteristics identified through the analysis and tests carried out in specialized laboratories.

The present research paper relates the quality of the SA used by 4 asphalt mix producing companies in the city of San José de Cúcuta, Colombia. The results were obtained by means of granulometry tests by sieving, wear test in the angels machine, elongation and flattening index, percentage of fractured faces, specific gravity and absorption, carried out in the soil laboratory of the Universidad Francisco de Paula Santander (UFPS) located in the city of San José de Cúcuta,

Colombia. Tests performed under the parameters described in the regulations of the “Instituto Nacional de Vías, Colombia”.

The results obtained by the tests carried out on the SA used by the companies producing asphalt mixtures, were tabulated and compared, obtaining interesting data with respect to their viability for the elaboration of the hot dense mixture-19 type (HDM-19). In this way, information of interest is offered to people who wish to deepen the subject under investigation, taking into account the local conditions of the components of the materials used in civil construction projects in the region [15,16]. The information presented here is of great importance for companies and individuals involved in the construction of asphalt pavements who will be able to select, with more technical criteria, the best quality materials to use in their road projects. In addition to guaranteeing the final result of the project to be executed and the reduction of financial costs related to unforeseen failures such as repairs or continuous maintenance.

2. Materials and methods

The project was carried out under the quantitative methodology with which a numerical relationship was established between the variables of the research with respect to the INVIAS-13 regulation [17]. Samples of SA were taken from 4 processing companies of asphalt mixtures from the city of San José de Cúcuta-Colombia; Transivic S.A.S (A) whose SA comes from the Táchira river, Maquinteligente S.A.S (B) SA from the Zulia river, Copavicol S.A.S (C) SA from the Pamplonita river, Colpao Group S.A.S (D) SA from the Táchira river. The SA was characterized under the parameters set forth in the INVIAS-13 regulation. The granulometric analysis was carried out according to testing standard of “Instituto Nacional de Vías” 123 from 2013 (INV-E-123-13) [18] with which the size of the particles that constituted each of the masses of material tested was known.

The wear resistance of the coarse aggregates was checked under the indications of INV-E-218-13 [19], they were determined the flattening and elongation indices with the supervision of INV-E-230-13, the percentage of fractured faces was indicated with the parameters of INV-E-227-13 [20] and the specific gravity and absorption was identified. as a guide, INV-E-223-13 [21] and 222-13 [22].

Table 1 shows the granulometric characteristics of the SA to be used in the design of HDM-19 asphalt mixtures according to INVIAS-13 parameters.

Table 1. Granulometry asphalt mixtures hot dense mixture-19 “Instituto Nacional de Vías” 2013.

Normal	Sieve	Percentage passing
	Alternating	Hot dense mixture- 19
37.5 mm	1 1/2"	00-00
25.0 mm	1"	00-00
19.0 mm	3/4"	100-0
12.5 mm	1/2"	80-95
9.50 mm	3/8"	70-88
4.75 mm	No. 4	49-65
2.00 mm	No. 10	29-45
425µm	No. 40	14-25
180µm	No. 80	08-17
75.0µm	No. 200	04-08

3. Results

3.1. Sieve granulometry

With the implementation of INV-E-123-13 [18] was determined the granulometric analysis of the SA used by each of the 4 companies’ processors of asphalt mixtures in the city of San José de Cúcuta, Colombia. The Figure 1 to Figure 4 shows the granulometric composition of asphalt mix processing companies A, B, C y D which obtained a deficient curve for both SA 3/4" and 3/8" in comparison with the parameters described in Table 450-6 of article 450 of INVIAS-13 for the HDM-19 [23].

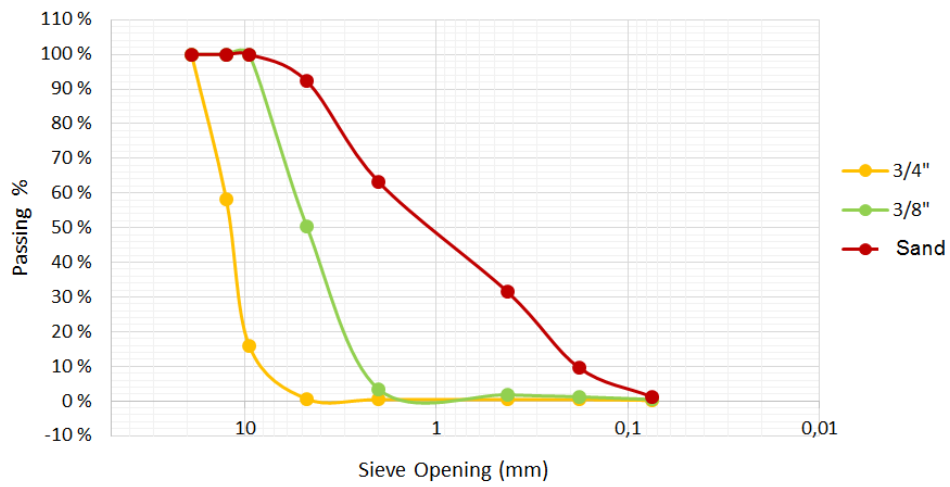


Figure 1. Transivc material granulometry S.A.S (A).

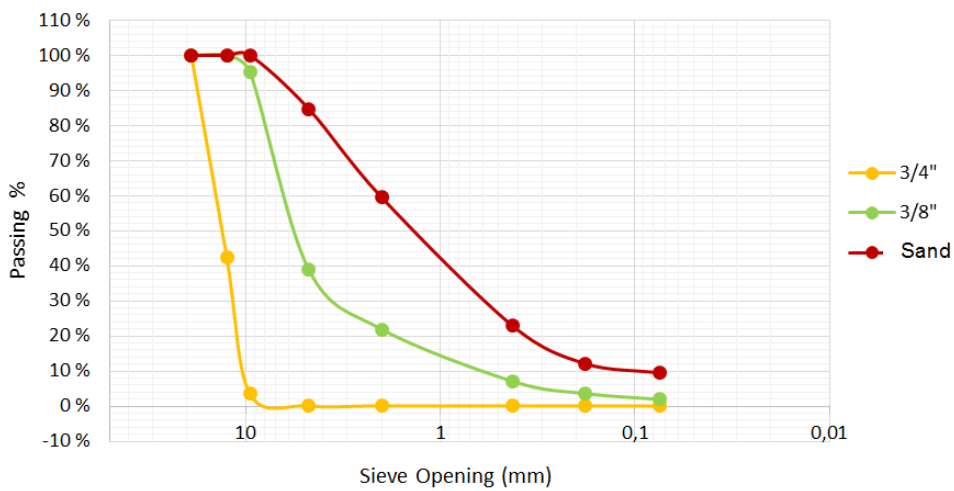


Figure 2. Maquinteligente material granulometry S.A.S (B).

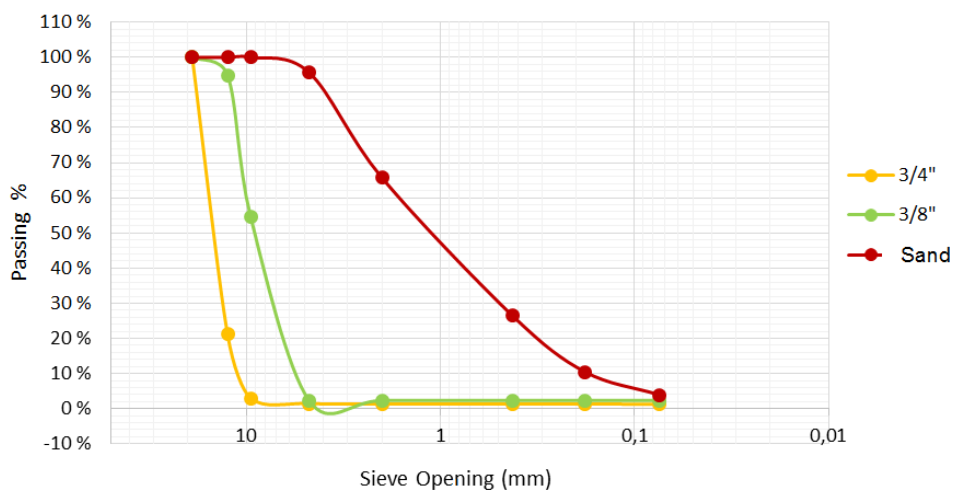


Figure 3. Granulometry of Copavicol material S.A.S (C).

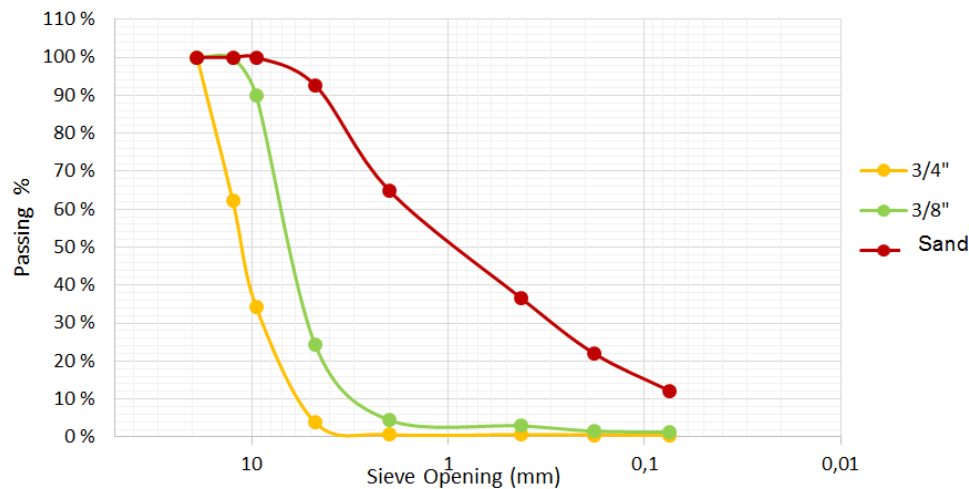


Figure 4. Material granulometry Grupo Colpao S.A.S (D).

3.2. Resistance to wear

By means of the material wear test carried out in the los angeles machine, according to the provisions of standard INV-E-218-13 [19], the percentage of material wear for each of the 4 companies was indicated.

Table 2 shows the results obtained by means of the wear test of the SA of the 4 analyzed companies, where the SA 3/8" at wear test to 100 revolutions, with 11 spheres, of company B approaches the maximum parameter allowed by the INVIAS-13 for the HDM-19 [23], the other companies processing asphalt mixtures deviate considerably from the established parameter. For the wear test to 500 revolutions, with the same number of spheres, only company B fulfills, the others over pass the maximum parameter of allowed wear. In the case of 3/8" aggregate, the only asphalt mix processing company that meets the permissible wear parameter is B.

Table 2. Stone material wear test.

Sample	Numbe spheres	Total mass	Wear test	Maximu parameter	% of wear			
					A	B	C	D
Aggregate 3/4"	11	4584±25	100 revolutions %	5.0	08.50	05.60	11.00	21.34
			500 revolutions %	25.0	34.90	25.50	36.60	35.18
			% wear	0.2	00.24	00.22	00.30	00.61
Aggregate 3/8"	8	3330±20	100 revolutions %	5.0	08.60	04.40	10.14	10.66
			500 revolutions %	25.0	34.90	23.84	37.24	38.88
			% wear	0.2	00.25	00.18	00.27	00.27

3.3. Percentage of fractured faces

The surface texture of the SA used in the 4 companies was determined by means of the indications set out in standard INV-E-227-13 [20]. Table 3 reflects the satisfactory results of this trial, in the 4 companies, as they comply with the minimum parameters established in INVIAS-13 for HDM-19 [23].

3.4. Specific gravity and absorption

Due to the importance of the calculation of the specific gravity and absorption of the stone aggregates for the design of the asphalt mixtures, the material data of the 4 companies was taken with the help of the standards INV-E-223-13 [21] and INV-E-222-13 [22], for the coarse and fine aggregate respectively, according to the characteristics of the materials [6].

Table 4 shows the values obtained for this type of test where a similar range is shown in terms of the specific gravity of the aggregates in the 4 companies. Regarding absorption, for the aggregate of

3/4" companies C and D present equal values, the companies A and B have a minimum difference of 0.10. For the aggregate 3/8", company B exceeds the others by doubling its value. As for sand, company C has the lowest rank, being 50% lower than other companies.

Table 3. Assay fractured faces stone aggregates.

Sample	% fractured faces (g)	Minimum Parameter	Asphalt mixing processing company			
			A	B	C	D
Aggregates 3/4"	Initial mass	70%	2000.00	2000.00	4889.00	3284.00
	Mass of particles with fractured faces		1849.00	1831.00	4652.00	3219.00
	Mass of non-fractured particles		0151.00	0169.00	0237.00	0065.00
	% Mass of fractured faces		0092.45	0091.55	0095.15	0098.02
Aggregates 3/8"	Initial mass		2000.00	2000.00	1371.00	1000.00
	Mass of particles with fractured faces		1788.00	1812.00	1254.00	0995.00
	Mass of non-fractured particles		0212.00	0188.00	0117.00	0005.00
	% Mass of fractured faces		0089.40	0090.60	0091.47	0099.50

Table 4. Specific gravity and absorption of intervened stone aggregates.

Test	Material	Standard INV	Asphalt mixing processing company			
			A	B	C	D
Specific gravity	Aggregate 3/4"	E-223	2.527	2.601	2.575	2.511
	Aggregate 3/8"		2.550	2.507	2.536	2.551
	Sand	E-222	2.568	2.552	2.562	2.560
Absorption	Aggregate 3/4"	E-223	1.200	1.300	1.500	1.500
	Aggregate 3/8"		2.400	5.500	2.700	2.100
	Sand	E-222	1.300	1.320	0.600	1.280

4. Conclusions

The granulometry carried out to the 4 companies did not comply with the parameters indicated in INVIAS 2013 for the HDM-19, in order to comply with the parameters indicated in the regulations it is recommended to improve the granulometric curves with mineral filler that comply with the technical specifications described in the regulations. The percentage of wear of the aggregates of companies A, C and D identified in the machine of the angels exceeded the maximum parameter allowed, only company B was in the range indicated. The material that best meets the parameters permitted by the standard with respect to the test of wear is that coming from company B, due to the geology of the source where the material was extracted that has better properties of resistance to the crushing and absorption, characteristic that makes it recommended for implementation in the design of HDM-19 asphalt mixtures. It was evidenced that the water sources of the Zulia river provide an SA of excellent quality that guarantees the parameters indicated in the INVIAS-13 standard for the preparation of asphalt mixtures, characteristics that help in an important way to the selection of the suitable material for the construction of flexible pavements on the part of the contractors in this type of engineering works, concrete actions that improve considerably the economy of the projects by means of the reduction of the unforeseen caused by the incorrect preparation of HDM-19. At the same time there is a positive impact both socially and environmentally, with the delivery of quality works that do not present any irregularity that generates extra production of asphalt mix, thus reducing harmful CO₂ emissions in ecosystems.

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