Comparison between granulometric analysis of the sand from the Acre river and normal sand from the Tietê river

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1 INTRODUCTION

The emergence of the main cities of the Amazon, including the State of Acre, occurred on the banks of rivers. In the region, the sand used in the buildings has always been, and continues to be, until today, removed directly from the river beds, from the dredging process, without any control, of both the places of withdrawal and the places of sand deposits, let alone with the quality of the sand.

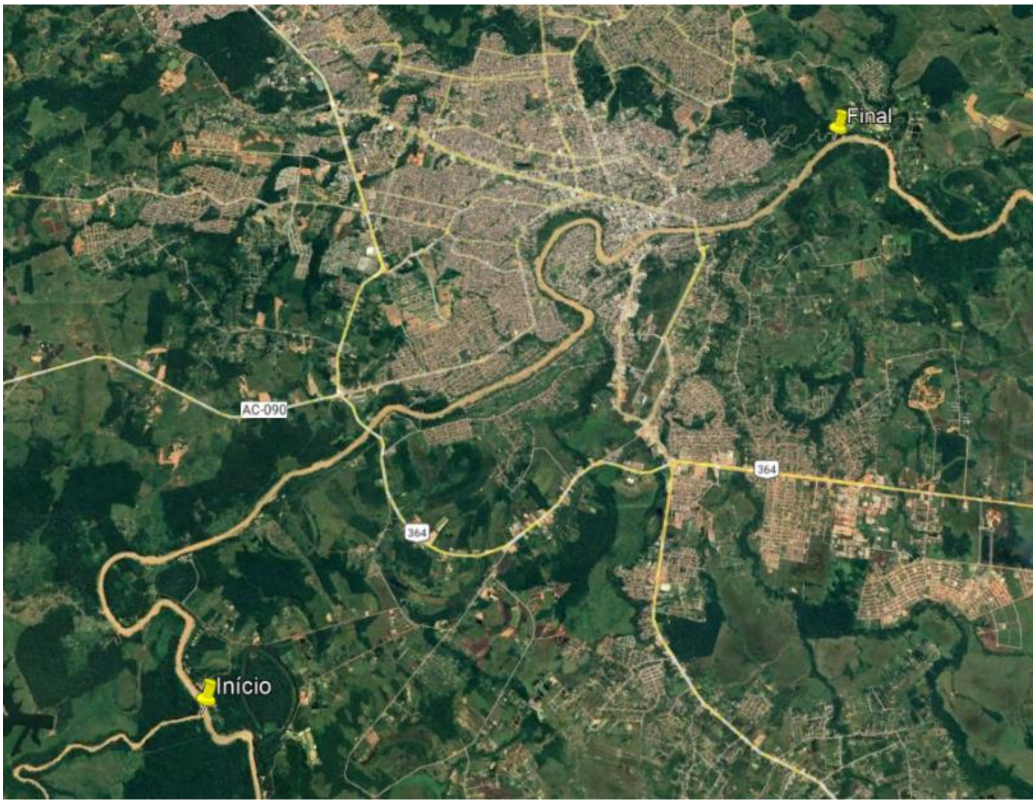
In the municipality of Rio Branco, associated with a growing increase in the urban population, there has also been an increase in the demand for sand, causing the number of dredgers that exploit sand on the Acre River to increase considerably over the last twenty years.

And this research aimed to study a comparison between the granulometry of the sand samples collected in the Acre River with the granulometry of the Normal Sand of the Tietê River. A mixture with other types of aggregates was also proposed to improve the granulometric quality of acre river sands for use in civil construction. For these mixtures, the sand collected in the Madeira River, located in the State of Rondônia, approximately 240 kilometers from Rio Branco, was used.

2 METHODOLOGY

The research area is located, in an extension of approximately 20 km, along the Acre River, in the municipality of Rio Branco, state of Acre. It is located between latitudes 9°57'22" at 10°03'18" S and longitudes 67°46'31" W at 67°52'40" W (Figure 1).

Figure 1: Location map of the search area.



Source: Google Earth (2021) - Adapted by the authors (2022).

The Acre River is a watercourse that has a total length of about 1,190 km, has its source in Peru in the order between 300 and 400 m of altitude and water in Brazil, on the right bank of the Purus River, next to the Amazonian city of Boca do Acre, approximately at the quota of 130 m. It is one of the most famous rivers in the Northern region of Brazil, for it crosses and gave its name to the state of Acre, bathing municipalities such as Assis Brasil, Brasiléia, Epitaciolândia, Xapuri, and Porto Acre (BESER DE DEUS, 2013; ACCORSI, 2014; SILVA, 2015; NETO et al., 2017).

In the city of Rio Branco, the Acre River, within the urban perimeter, has an extension of 15.83 km in length, passing through the central part of the city, dividing it into two districts, referring to the left side, known as the first district, and the right side, as the second district (BONFANTI et al., 2020).

The methodology of the work consisted of fieldwork, from the collection of samples from the places where the pulp (mixture of water, sand, silt, and clay) taken from the river is stored to go through the decanting process and, later, be commercialized. These decanting sites are technically called storage yards, "decanting wells" or "decanting boxes".

All 15 samplings were carried out on the Acre River between July and September, at the time of year in which the river has its lowest volumes of water. Samples were collected from both the right bank and the left bank, from the mouth of the Riozinho do Rola to the mouth of the São Francisco Stream, covering the entire research area, totaling approximately 20 km (Table 1).

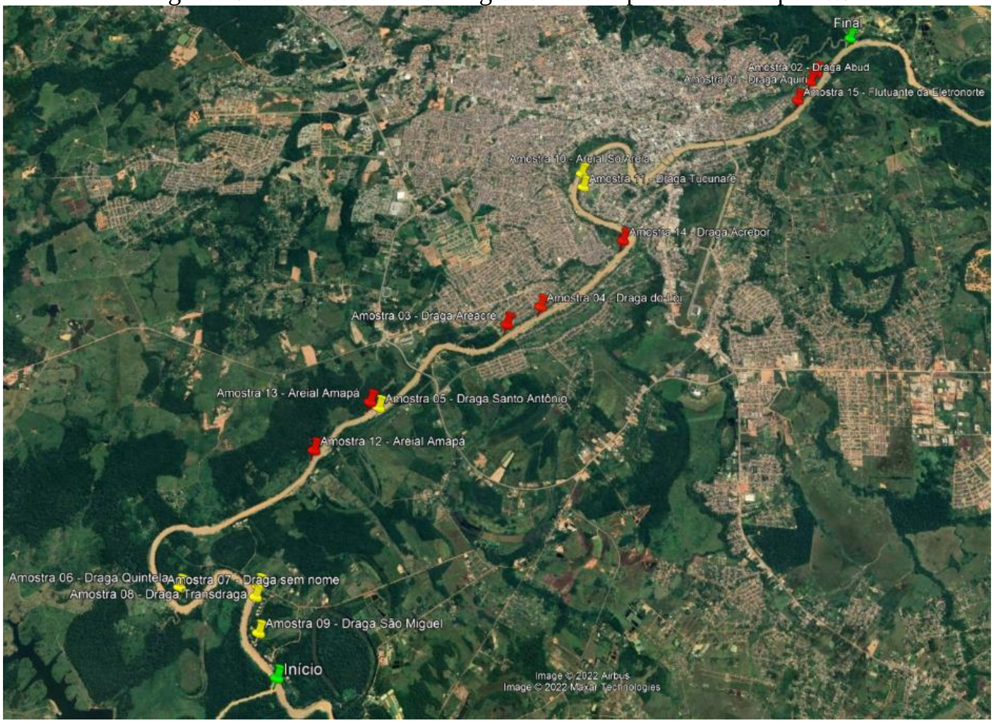
Table 1: Information about the 15 sand samples collected.1

Sample	Collection Site (margin)	Depth (m)	Collection Point	Coordinates	
				Latitude (South)	Longitude (West)
1	left	3,9	Draga Aquiri	9th 57' 50"	67th 47' 02"
2	left	2,7	Draga Abud	9th 57' 56"	67th 47' 06"
3	left	2,4	AREACRE	10th 00'	67th 49' 54"
4	left	3,4	Draga do Lói	10th 00'	67th 49' 22"
5	right	3,9	Draga Santo Antonio	10th 01'	67th 50' 58"
6	right	3,2	Draga Quintela	10th 02'	67th 52' 22"
7	right	3,4	Próximo a Draga	10th 02'	67th 51' 52"
8	right	3,1	TRANSDRAGA	10th 02'	67th 51' 47"
9	right	3.0	Draga São Miguel	10th 02'	67th 51' 49"
10	right	3,8	Areial Só Areia	9th 58' 54"	67th 49' 14"
11	right	3,3	Draga Tucunaré	9th 59' 02"	67th 49' 14"
12	left	3,7	Areial Amapá	10th 01'	67th 51' 30"
13	left	3,5	Areial Amapá	10th 01'	67th 51' 05"
14	left	3.0	ACREBOR	9th 59' 34"	67th 48' 53"
15	left	3.0	Flutuante da Eletronorte	9th 58' 08"	67th 47' 14"

Source: Accorsi (2001).

The location of the collection points was performed from geographic coordinates (latitude and longitude), obtained by GPS (Figure 2).

Figure 2: Identification/Marking of sand sample collection points.



Source: Google Earth (2021) - Adapted by the authors (2022).

15 samples were collected. Being a group of depth samples and another surface group, distributed as well: 12 samples in sand deposit sites (storage yards) that were empty and 3 samples in places that are not associated with sand deposits. Depth samples were collected manually at the depth at which the hydrostatic level was found. Surface samples were collected directly from the surface part of the ravines.

The samples after collection were sent to the Laboratory of Technological Tests (LET) of the Center for Exact and Technological Sciences (CCET) of the Federal University of Acre (UFAC), where in addition to other characterization tests, a complete Granulometric Analysis was performed, both by Sieving and Sedimentation.

The analyses were carried out according to the Brazilian Standards (NBR) of the Brazilian Association of Technical Standards (ABNT), adopted by the National Department of Transport Infrastructure (DNIT), since the preparation of the samples, carried out from the NBR-06457/86, as the determination of the granulometry performed by the sieving and sedimentation process, using the densimeter. These analyses were performed according to NBR-07181/84 and the sedimentation test was based on Stokes' Law.

From the individual particle size analyses, both from the sand of the Acre River and the sand of the Madeira River, dosages of the mixtures of 40%, 35%, 30%, and 25% of the sand of the Acre River, with 60%, 65%, 70% and 75% of the sand of the Madeira

River, were proposed to obtain the mixture that most closely approximated the granulometric characteristics of the Normal Sand of tietê, accordance with NBR 7214/82.

3 CONCLUSION

The results of the granulometry tests (sieving and sedimentation) took into account the granulometric scale of the ABNT in which the sands (coarse, medium, and thin) presented a granulometry ranging from 5.0 mm to 0.05 mm, the silt from 0.05 mm to 0.005 mm and the clays a granulometry < 0.005 mm (Figure 3).

Considering the percentages of sand, silt, and clay, according to the granulometric classification of soils proposed by FOLQUE (1988), the 15 samples taken in depth were classified as sand (4 samples), siltose sand (2 samples), sandy silt (1 sample), clay sand (1 sample), clay silt (3 samples), sandy clay (2 samples) and clay (2 samples) (Figure 4).

All surface samples were classified, based on the same classification proposed by FOLQUE (1988), as sands (Figure 5).

In the sampled places where the sands predominate, the soils have a higher possibility of suffering erosive processes, due to the low cohesion of the sands.

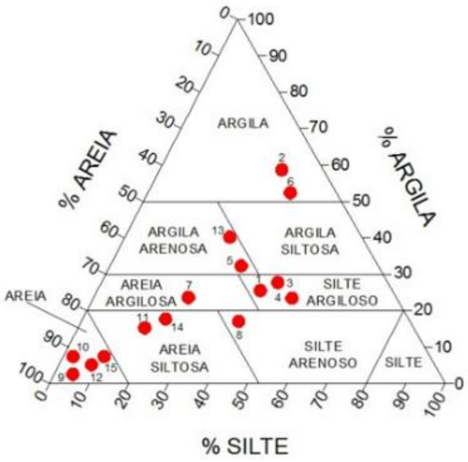
Figure 3: Granulometric scale of ABNT /NBR 6502/1995.

Pedregulho	Areia Grossa	Areia Média	Areia Fina	Silte	Argila

5,0 mm 2,0 mm 0,4 mm 0,05 mm 0,005 mm

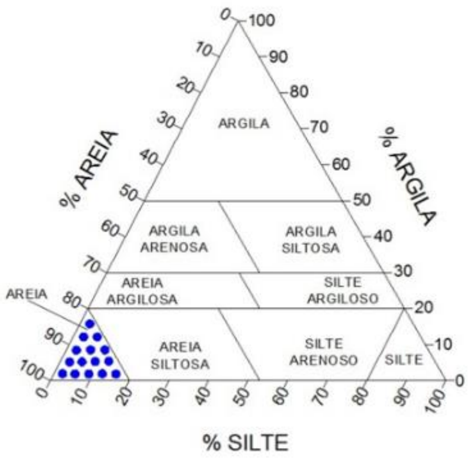
Source: ABNT (1995) - Adapted by the authors (2022).

Figure 4: Depth samples.1



Source: Accorsi (2001).

Figure 5: Surface samples.



Source: Accorsi (2001).

Although analyses were performed in surface and depth samples, which presented differentiated granulometric constitutions, the other results obtained from the physical indicators presented values within the limits of sand, silt, and clay. Thus they did not serve as useful indicators for differentiation and geotechnical characterization and stability according to their indicators.

However, it was possible to make some inferences about the stability of these soils, due to their granulometry, whereas in the surface samples, with a predominance of sands, which present lower stability and are more subject to erosive processes.

In in-depth samples there is a heterogeneity of materials, where the occurrence of clayey materials is observed, which confer greater cohesion and stability of the soils, waiting for these sites to lower environmental damage.

From the analysis of sand samples extracted by suction from the Acre River, collected in the decanting yards and which are used directly in civil construction in the State of Acre and especially in the municipality of Rio Branco, it was observed that, in granulometric terms, the samples have a granulometry that varies, for the most part, between 0.042 mm in diameter, which characterizes the granulometric upper limit of fine sands, up to granulometry smaller than 0.053 mm corresponding to silts or clays.

The granulometry of the Normal Sand of the Tietê River, produced and supplied by the Institute of Technological Research (IPT) of São Paulo, for technological tests has granulometry that presents the following percentages about the weight of the sample, as observed in Table 2.

Table 2: Granulometry of the normal sand of the Tietê River.2

Nominal opening in mm	Accumulated retained percentage
2,4	0
2,0	5 ± 5 %
1,2	25 ± 5 %
0,6	50 ± 5 %
0,3	75 ± 5 %
0,15	97 ± 5 %

Source: ABNT/NBR7214 (1982) - Adapted by the authors (2022).

When we delimit the granulometry of the normal sand of the Tietê River, they correspond to the following limits: coarse sand (2.4 to 1.2 mm), medium sand (1.2 to 0.6 mm), fine medium sand (0.6 to 0.3 mm), fine sand (0.3 to 0.15 mm) and silts and clays (< 0.15 mm).

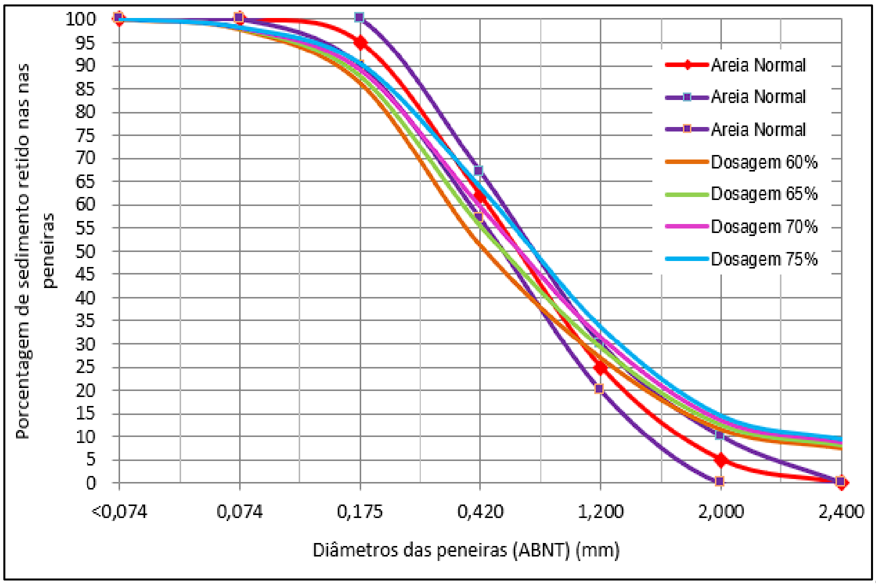
When comparing the granulometric curves of the 15 samples analyzed, with the granulometric curve of the normal sand of the Tietê River and considering the lower limit of the normal sand (sieve opening of 0.15 mm) and taking into account the maximum and minimum limits of the accumulated percentage retained in each sieve, it was observed that none of the 15 samples of the Acre River are within the normal sand patterns of the Tietê River, even considering the tolerance limits of the accumulated retained percentages, always presenting very fine granulometry, predominantly silts and clays.

The NBR 7214/82 standard establishes criteria for sand to be considered standard, among these criteria, are granulometry, powder material content, moisture, clay conglomerates, feldspars, micas, and organic matter.

In this work, we took into account only the granulometric analysis and the amount of powder material, where the granulometric curves of the samples taken from the Acre River were compared, with the granulometric curve of the normal sand of the Tietê River. It can be seen that the sands of the Acre River presented much thinner granulometry than the normal sand of the Tietê River. The powder material content in the samples of the Acre River is extremely high, which can be observed by a large amount of silt and clay present in the samples.

Having performed individual granulometric analyses for a sand sample taken from the Acre River, and one from the Madeira River, and aiming at the adequacy of these particle sizes, we tried to perform several percentages of dosages combining the two materials, to obtain the one that best suited the standard (Figure 6).

Figure 6: Granulometric curves of the normal sand of the Tietê River and percentages of dosages.



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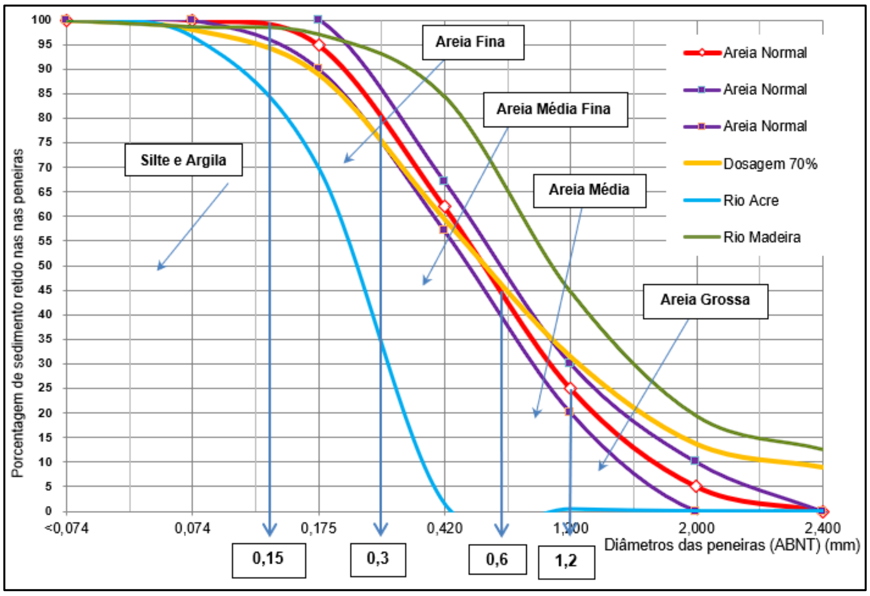
Source: By the authors (2022).

It was observed that the one that came closest was the dosage with 30% of sand from the Acre River and 70% with sand from the Madeira River, obtaining the behavior observed in Figure 7, which can be compared with the granulometric curves of the materials under study individually.

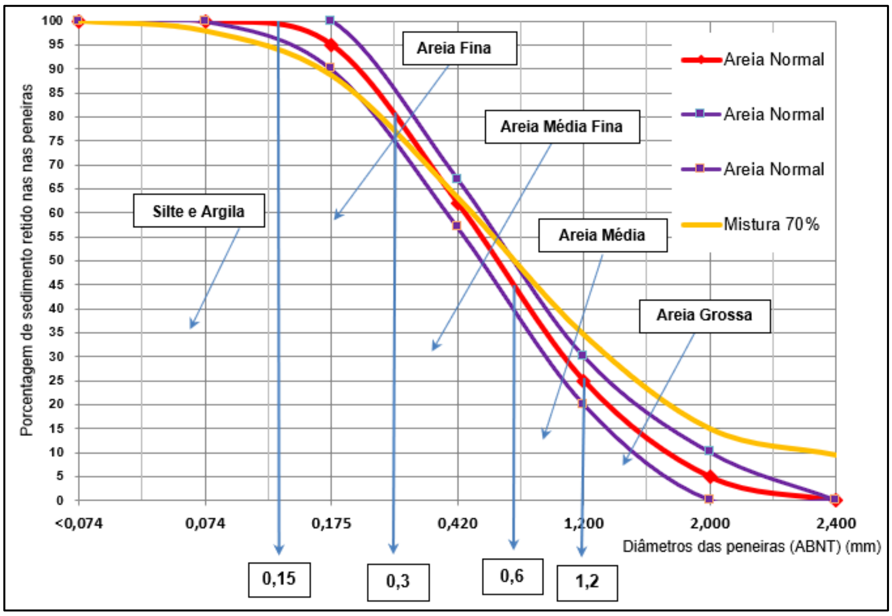
Figure 7: Comparison between the granulometric curves of the normal sand of the Tietê River, acre river sand, Madeira river sand, and 70% dosage.



Source: By the authors (2022).

Thus, in the laboratory, the effective mixture of the materials was performed at the proposed dosage of 30% sand from the Acre River and 70% sand from the Madeira River, and after the sieving and granulometric assay was performed, the curve was obtained as observed in Figure 8.

Figure 8: Comparison between the granulometric curves of the normal sand of the Tietê River and the mixture in a laboratory of 70%.



Source: By the authors (2022).

A slight difference is observed between the granulometric curves of the dosage and the mixture, but both present the same behavior. This difference is expected since the dosage was elaborated after calculations and the mixture was obtained after laboratory tests were performed with the proposed materials.

The sands of the Acre River have much finer particles than the normal sand of the Tietê River, which are adopted for technological tests. Thus, the civil construction procedures, when using the sands of the Acre River should be adapted, and it is not possible to use procedures defined by national technical standards.

From the various dosages of mixtures made, with different materials, the one that most appropriated the norm was the mixture of 30% of sand of the Acre River, with 70% of sand of the Madeira River, being the fine sand, fine and medium, practically within the limits of the normal sand of the Tietê River, and only in the strip of coarse sand is outside the granulometric limits of the norm.

In the case of the Acre River, as dredging sand extraction is not carried out intensively and uninterruptedly, carried out only for six months of the year and the natural deposition process occurs throughout the year, a balance is observed between the accumulation and extraction of sand since the dredges are installed in activity in the same places over many years. Therefore, if the management of sand mining activities meets the appropriate practices and procedures, it is perfectly possible to coexist this essential economic activity, with the preservation of the environment, a relationship currently disseminated as Sustainable Development.

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