# Influence of Milled Material and Construction Waste on the Properties of a Typical Soil of Iranduba City - AM / BR

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## Abstract

*The lack of stone material in the State of Amazonas and the possibility of using solid waste in the sublayers of pavements motivates the work in question, notably with the purpose of contributing as an alternative technical solution to the paving of the city of Iranduba / AM / BR. Compositions of soil mixed with waste from milled material (MM) and construction and demolition (CDW) were studied. The materials participating in the formulations were physically characterized, as well as the mechanical behavior of the natural soil (NS) and mixtures of soil-20% milled material (NS + 20MM) and soil-20% construction and demolition waste were determined. (NS + 20CDW). The results showed that the compositions with the participation of the milled material were the most efficient relative to the mixtures with the presence of the construction and demolition residue. It is noteworthy that both formulations, referring to natural soil, improved the expansion and presented an increase in the California Bearing Ratio, selection parameters for application in the base and subfloor layers.*

**Keywords:** Milled Material; Construction and Demolition Waste; California Bearing Ratio;

## 1. Introduction

The pavement consists of overlapping layers made of different materials, designed to suit the loads from traffic and weather conditions in a durable and cost effective manner. In the sublayers of this structure, soil may be used, provided it meets certain quality criteria, including those established by the California Bearing Ratio values (DNIT, 2006).

Allusive to asphalt pavements, in the process of surface revitalization of its coating (first layer), the milled material is generated, a residue that has a suitable particle size for use as an aggregate, in the geotechnical procedure of particle size stabilization. Kézdi and Rétháti (1988) mention that stabilization with this asphalt material aims to cover the soil particles, to cement them, but without reducing the friction between them. In this context, there are studies in the literature such as Garcês et al. (2014), Dias et al. (2015), Coppetti et al. (2018) and Ceolin et al. (2019), which present satisfactory results when using the aforementioned by-product for soil stabilization that, at first, did not have adequate characteristics for use in paving. Accordingly, according to the CBR percentage difference between the soil-milled material mixture and the natural condition, Garcês et al. (2014) and Ceolin et al. (2019) indicate gains of approximately 150% and 62%, employing the normal compaction energy, respectively. Dias et al. (2015) and Coppett, cite improvements of 15.15% and 4.84%, using modified energy, respectively. All the mentioned authors used a mixture with 30% of milled material and 70% of soil.

In another aspect, there are construction and demolition wastes, which according to the National Environment Council - CONAMA, are defined as those arising from construction, renovations, repairs and demolitions of civil works, and the resulting land preparation and excavation, such as: bricks, ceramic blocks, concrete in general, soils, rocks, paints, woods, ceilings, mortar, plaster, tiles, asphalt pavement, glass, plastics, pipes, etc. Studies by Amorim et al. (2013), Leite et al. (2016) and Tavares et al. (2018), with such residue have also shown improvements in the mechanical properties of natural soils. Particularly in relation to the aforementioned works, with the samples compacted in intermediate energy, and quantifying the percentage difference between the SSI of the mixtures and the natural condition, they pointed out: Amorim et al. (2013) refer to 2.12% gains by adding 35% CDW to natural soil; Leite et al. (2016), when studying the composition 60% of soil with 40% CDW, obtained a maximum gain, among the researched works, equal to 886.84%; and finally, Tavares et al. (2018), researching the 70% soil formulation with the addition of 30% CDW, showed an improvement of approximately 88%.

The influence of the addition of 20% of milled material (MM) and construction and demolition residue (CDW) as alternative coarse aggregates as a substitute for commonly used stone aggregates was evaluated. and mechanics of a superficial soil, characteristic of the city of Iranduba - AM / BR, for pavement construction.

## 2. Materials and Methods

Natural soil was collected at the margins of the AM 070 highway (Figure 1), and analyzed according to the standards of the Brazilian Association of Technical Standards - ABNT, according to the plasticity limit (NBR 7180, 2016), liquidity limit (NBR 6459, 2016) and granulometry (NBR 7181, 2016). The parameters of compaction, optimum humidity and maximum dry bulk density in accordance with NBR 7182 (2016) for intermediate energy, as well as the California Bearing Ratio following NBR 9895 (2016) were also determined.

Figure 1. Natural soil collection site.
Source: Maps, 2019

The milled material (Figure 2-A) was provided by a Manaus construction company responsible for the asphalt resurfacing of the Presidente Figueiredo road system, approximately 107 km from the Amazonian capital. The mentioned milled asphalt coating, which gave rise to the residue, was made with a Hot Machined Asphalt Sand (AAUQ) type asphalt mixture. Specific to CDW (Figure 2-B), it came from a private crushing plant located in the city of Manaus. Such materials were characterized according to National Roads Department (DNER, current DNIT) standards, according to particle size (DNER-ME 083, 1998), real density and coarse absorption (DNER-ME 081, 1998). Such materials participated in the composition with the soil, in the proportion equal to 20%. These formulations (NS + 20MM and NS + 20CDW) were analyzed according to the compaction parameters (NBR 7182, 1986) and the California Bearing Ratio (NBR 9895.1987).


Figure 2a. Milled material. Figure 2b. Construction waste (CDW) according to grade 2.
Source: Own Author

## 3. Results and Discussions

According to NBR 6502 (1995), according to NBR 6502 (1995), the particle size distribution shows the natural material containing 66% clay, 14% silt, 18% sand and 2% boulder. sandy, texture representative of the superficial soils of the region.

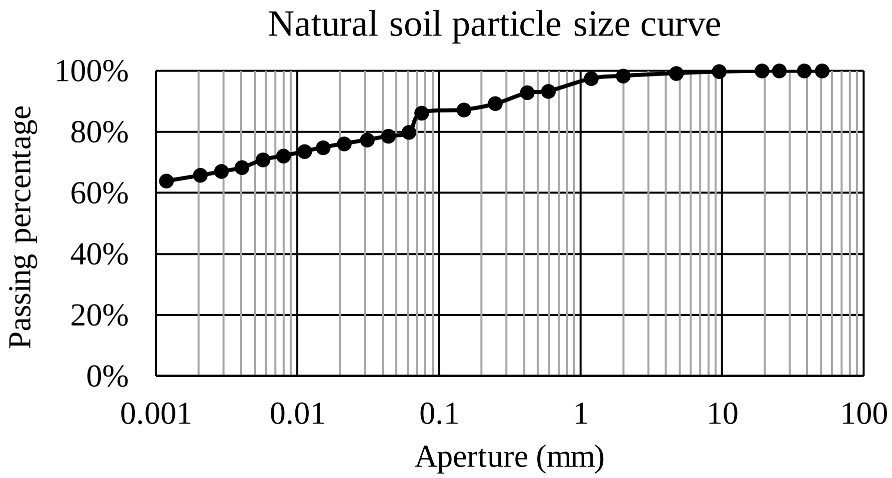


Figure 3. Granulometric curve of the natural soil.
Source: Own Author

The results of liquidity limit, plasticity limit and plasticity index showed values of 65%, 47.8% and 17.2%, respectively. Therefore, effecting, in accordance with Burmister (DAS, 2014), a soil with medium plasticity. Gathering this data with grain size, this material is classified as A-7-5 according to the Highway Research Board (HRB) classification and MH according to the Unified Soil Classification System (SUCS). Based on the obtained consistency indexes, the plasticity chart identifies the soil as being highly compressible, corroborated by the HRB system typification, resulting in a natural material unsuitable for the construction of the sublayers of a pavement.

Specific to the alternative large aggregates, Figure 4 shows the particle size distribution, while Table 1 shows the results of absorption and actual density. In the case of the milled residue, the texture indicates a greater amount of the sand fraction than the construction and demolition residue, therefore, a better workability of the mixture with the natural soil. Referring to Table 1, it should be noted that, although the CDW aggregate has a higher real density than the milled residue, it has higher porosity, a fact that can be confirmed by the absorption value, resulting in a lighter aggregate when compared to milled material (MM).

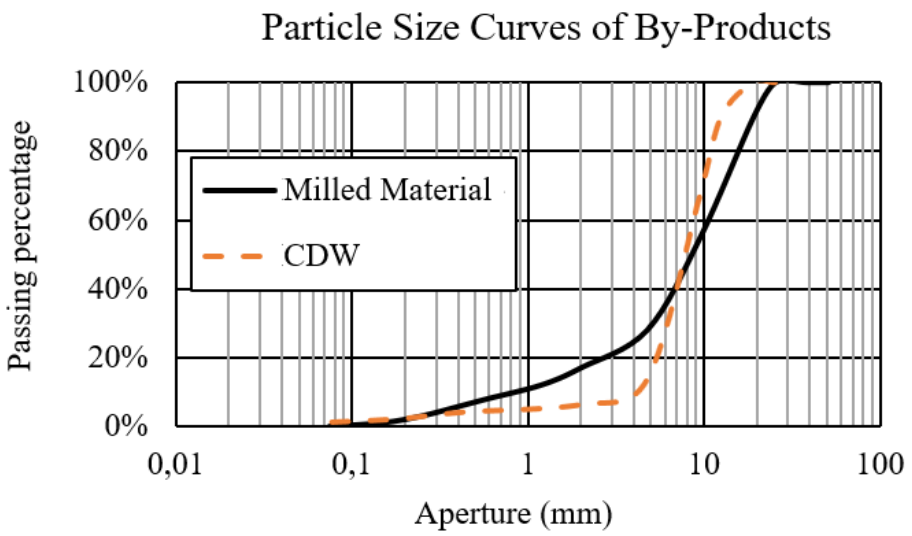


Figure 4. Grain size curves of the by-products.
Source: Own Author

Table 1. Characteristics of recycled aggregates

| Test | Method | Milled Material (MM) | Construction waste (CDW) |
|---|---|---|---|
| **Absorption (%)** | DNER ME 081 | 1,87 | 7,12 |
| **Real Density** | | 2,51 | 2,57 |

Source: Own Author

Figure 5 shows the natural soil allusion (NS) compaction curves and the NS + 20MM and NS + 20CDW compositions at intermediate energy. There is an increase of 11% and 24% in the apparent dry matter relative to natural soil (NS), due to the presence of CDW and MM residues, respectively. Concerning the optimum humidity, the addition of CDW reduced by 20%, while the participation of MM increased by 5% the mentioned parameter, taking as reference the natural condition.

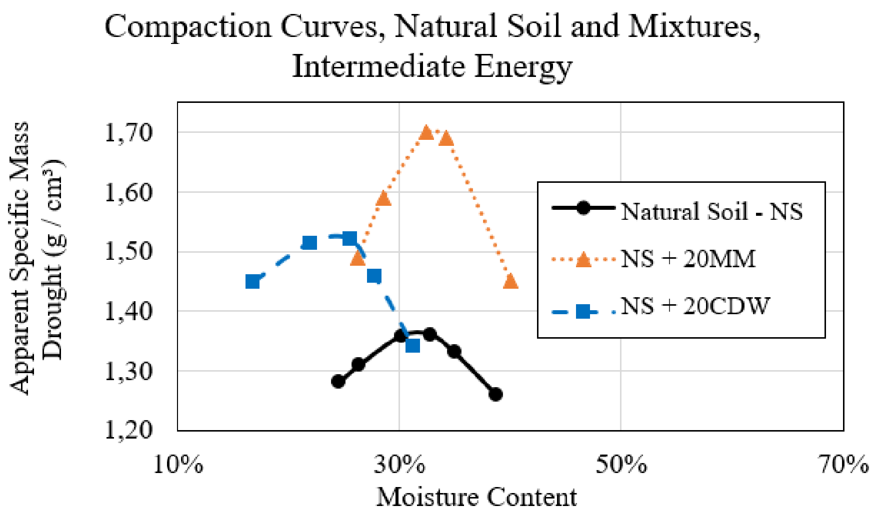


Figure 5. Compaction Curves, Natural Soil and Mixtures, Intermediate Energy.
Source: Own Author

The graph in Figure 7 shows the results of the California Bearing Ratio test for both pure soil and mixtures. Regarding the expansion and the CBR, it is noted that only the formulation NS + 20MM showed values according to the limits established by the National Department of Transport Infrastructure - DNIT for the base layers, i.e., expansion less than or equal to 1% and CBR greater than or equal to 20% (measured with 10 lb overload). From these results (Figure 7), it is found that, based on the value obtained in the natural condition, the addition of milled material and CDW to the ground generated an increase of 267% and 40% in the CBR, respectively. These gains were compared with those determined in the literature and shown in Figure 8. Note the significant value of the studied mixture NS + 20MM, as well as the satisfactory results of Tavares et al. (2018) for application in base layers, and the others, except COPPETTI et al (2018) and Amorim et al (2013), within the limits established by DNIT for use in sub-base layers.

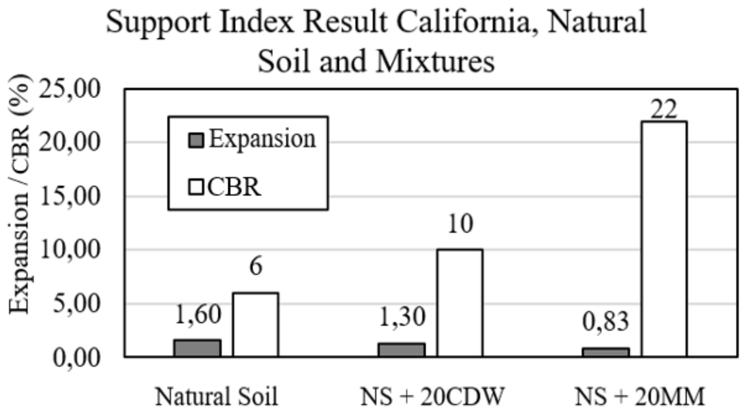


Figure 7. Support Index Result California, Natural Soil and Mixtures.
Source: Own Author

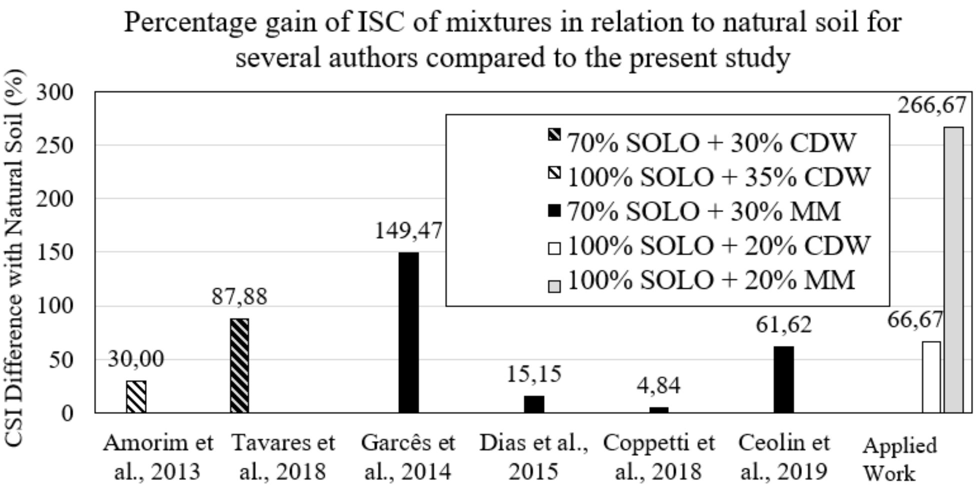


Figure 8. Percentage gain in CBR of mixtures in relation to natural soil for several authors, compared to the present study.
Source: Own Author

## 4. Conclusions

The soil in its natural state was characterized as a clay of high plasticity, therefore, not recommended for direct application in the sublayers of the pavement, either due to the expansion or penetration resistance. However, the 20% increase in CDW reduced its expansion by 19% and increased its penetration resistance index by 67%. The 20% increase in cutter residue reduced by 48% the expansion contributed to a 267% increase in the SSI. Finally, we concluded that Milled Material improved the physical and mechanical characteristics of natural soil, which did not have satisfactory properties for paving, thus generating indices compatible with a material with compatible technological characteristics for application in subfloor layers.

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